

# Utilization of HDPE (High Density Polyethylene) Plastic Waste as A Substitute for Some Cement in the Compressive Strength of Paving Blocks

Syarifah Umi Qurani Alaydrus\*, Kuku Ary Wicaksono, Ety Rabihati & Qalbi Hafiyyan

Department of Civil Engineering, Politeknik Negeri Pontianak, West Kalimantan, Indonesia.

## Email address:

umyquranyalaydrus@gmail.com

\*Corresponding author

## To cite this article:

Alaydrus, S. U. Q., Wicaksono, K. A., Rabihati, E., & Hafiyyan, Q. (2026). Utilization of HDPE (High Density Polyethylene) Plastic Waste as A Substitute for Some Cement in the Compressive Strength of Paving Blocks. *International Journal of Research in Vocational Studies (IJRVOCAS)*, 5(4), 83–88. <https://doi.org/10.53893/ijrvocas.v5i4.300>.

Received: 10 19, 2025; Revised: 11 24, 2025; Accepted: 12 18, 2025; Published: 01 30, 2026



IJRVOCAS is licensed under a [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/).

**Abstract:** Even in Indonesia, people are starting to take notice of the growing problem of plastic waste in the environment. West Kalimantan is one of many areas in Indonesia that still struggles with garbage management. Waste production will rise in tandem with the population. Hence, one possible solution to this insufficient waste problem is the production of paving blocks from plastic waste. Based on the findings, high-density polyethylene (HDPE) plastic material can replace some of the cement in paving block production. This study employs an experimental approach by fabricating paving blocks with plastic as a partial substitute for cement. A type of plastic known as High Density Polyethylene (HDPE) is utilized. As part of the curing process, two kinds of water PDAM water and peat groundwater are used. Paving blocks made with 0%, 2.5%, 5%, 7.5%, 10%, or 12.5% HDPE plastic as a partial cement substitute have a significant impact on the compressive strength of the finished product. At 14 days, the highest compressive strength value was achieved with a 2.5% plastic mixture curing in PDAM water at 21.163 MPa, followed by 20.472 MPa with peat soil water; at 28 days, the highest value was 19.403 MPa with 0% PDAM water, and at 19.32 MPa with 2.5% peat water. Paving blocks made with plastic as a partial cement substitute have an even greater absorption capacity after 14 and 28 days. The plastic paving block with a 2.5% peat variation absorbed 5.1% of the groundwater and the plastic mixture with no PDAM absorbed 4.6% of the water. It follows that high-density polyethylene (HDPE) plastic is not very good at absorbing water.

**Keywords:** Compressive Strength, Paving Block, HDPE Plastic

## 1. Introduction

Plastic waste is a growing environmental problem around the world, including in Indonesia. Many regions in Indonesia are still struggling to deal with plastic waste, especially in West Kalimantan. Population growth will lead to an increase in waste production. Waste will continue to be a challenge if

the community does not have sufficient information. The community plays an important role in minimizing waste, categorizing waste, and facilitating recycling efforts. Plastic is a material that is very difficult to decompose, taking decades to break down. Plastic consumption in Indonesia has increased

significantly. This is due to activities and changes in lifestyle as well as socio-economic conditions. The secretary general of the Indonesian Olefin, Aromatic, and Plastic Industry Association (INAPLAS) reported that plastic consumption increased from 4.5 million tons in 2015 to 4.8 million tons in 2016, or a growth of 5.2%. [5].

To overcome the problem of inadequate waste management, one of the proposed solutions is the production of paving blocks from plastic waste. This innovation is considered very effective in reducing the volume of plastic waste because of the use of cost-effective and easily accessible tools and materials in the manufacturing process. The production of paving blocks not only provides a practical and sustainable method of dealing with plastic waste but also improves the quality of the environment and generates economic benefits for the community. Initiatives to tackle waste, particularly plastic waste, involve converting plastic waste into creative economic activities to increase community income. The characteristics of plastic make it difficult to replace with alternative materials for various applications, especially in everyday life, including food packaging, household appliances, children's toys, electronics, and automotive components. The long-term utilization of plastic waste aims to improve efficiency, reduce environmental impact, and produce innovative building materials. West Kalimantan is the province with the fourth largest peatland area in Indonesia. The total area of wetlands in West Kalimantan reaches 3.14 million hectares, with peatland covering 1.79 million hectares or more than 57% of the total wetland area. Wetlands offer various ecosystem services for humans, such as improving water quality, reducing flooding, maintaining coastlines, and protecting wildlife. [6].

This paper uses High Density Polyethylene (HDPE) plastic as a substitute for cement in the production of paving blocks. In addition, during the curing and soaking process, the paving blocks utilize two types of water, namely PDAM water and peat groundwater. The researchers produced paving blocks in West Kalimantan, an area with extensive peatlands. In the final project of the Applied Housing and Settlement Planning program at the Pontianak State Polytechnic, the title was "Utilization of HDPE (High Density Polyethylene) Plastic Waste as a Substitute for Part of the Cement in the Compressive Strength of Paving Blocks."

## 2. 2. Literatur Review

### 2.1. Paving Block

One of the building materials often used for sidewalks, yards, road paving, and other applications is paving blocks. The materials used to make paving blocks are the same as those used to make concrete: cement, aggregate (sand), and water. Compressive strength, water absorption, and maintenance techniques up to a specified age are also tested. Concrete blocks and cone blocks are other names for paving blocks.

Paving blocks are one of the building materials that are widely needed for construction activities. The use of paving

blocks can be used as an alternative to concrete, and the advantage of paving blocks is that they can absorb water into the ground, thus providing a solution to waterlogging caused by heavy rainfall in a location. This study uses High Density Polyethylene (HDPE) as a substitute for some of the cement in the manufacture of paving blocks.[8].



Figure 1. Paving Block

### 2.2. Plastic

Plastic takes decades to decompose in landfills, making it a material that is very difficult to break down. Plastic use in Indonesia is also increasing rapidly. The growing population, changing activities, changing lifestyles, and changing socioeconomic conditions of society will all contribute to the continued increase in plastic use. Plastic consumption increased by 5.2%, from 4.5 million tons in 2015 to 4.8 million tons in 2016, according to the Secretary General of the Indonesian Olefin, Aromatic, and Plastic Industry Association (Inaplas). As a business opportunity in a prosperous society, % . [5].

The rise of the food and beverage sector, which is highly dependent on plastic for product packaging, is the main cause of this increase in consumption. The amount of plastic waste generated will increase as a result of this plastic consumption. Overall, in 2015, 64.5 million tons of solid waste was generated. Household waste accounted for 48%, followed by traditional markets (24%), roads (7.5%), business areas (9%), schools (4%), offices (6%), and other sources (1.5%). Approximately 8.96 million tons or 14% of the total waste produced was plastic waste. [5].

Plastic waste can cause a number of problems, including flooding due to clogged drains and rivers, the release of harmful gases into the atmosphere when plastic is burned, and many more. In addition to reducing environmental pollution, plastic recycling can help avoid wasting natural resources. Communities can even reap economic benefits from recycling plastic waste. Using plastic waste as concrete aggregate to make building materials and as a cement mixture to make plastic cement composites is an attractive alternative for plastic recycling. There are eleven key qualities of plastic that can be used separately or in composites as building materials: strength, corrosion resistance, good heat, cold, and sound insulation, economy, energy efficiency, durability, and lightness. Construction materials made from plastic can be made lighter by reducing density and increasing elasticity and durability. Furthermore, it is anticipated that the utilization of plastic waste will result in the production of construction materials at a lower cost. In addition, the availability of

alternative methods for managing and utilizing plastic waste is essential in preventing environmental pollution.

### 2.3. HDPE (High Density Polyethylene)

HDPE plastic, such as milk bottles, detergent bottles, and cosmetic bottles, is often made from HDPE (high density polyethylene), a plastic with a moderate level of risk and difficulty in decomposition. Similar to PET, this plastic is not recommended for repeated use.

1. Because it can stop chemical reactions between HDPE plastic packaging and the food or drink it contains, HDPE is one of the safest plastics to use.
2. Compared to PET-coded plastic, HDPE is stronger, more opaque, harder, and more heat-resistant.
3. Although HDPE plastic containers are relatively safe, it is best to avoid using them too often as they continuously release antimony trioxide compounds

### 2.4. Sand

Sand is a fine aggregate in the form of grains with a size that has been determined based on technical standards. Although it has certain size limitations, sand consists of various types that are distinguished based on their physical characteristics and functions in construction. These variations in sand types affect the properties of the grains and their application in building materials. Referring to [2].



Figure 2. Sand

### 2.5. Water

One of the main components in making concrete bricks is water, which is needed for a chemical reaction with cement to wet the aggregate and lubricate it so that it is easy to handle. Drinking water is usually suitable for use in concrete. However, because water contains various potentially harmful elements, not all water can meet these requirements. Water that can be used as a building material is needed for [2].

#### 2.5.1. PDAM Water

BPDAM water is water provided by the Regional Water Company (PDAM), in accordance with (PBI-1971). [1]

The water used in this article comes from PDAM or drinking water treatment in Pontianak, which is a local government-owned enterprise. This water is usually treated from sources such as rivers, lakes, or reservoirs, through a

purification process involving filtration, coagulation, sedimentation, and disinfection to ensure its quality is safe.

The raw water used by PDAM Kota Pontianak at IPA I meets the quality standards for class I raw water according to PP.No. 82 of 2001. The TDS parameter of 22 mg/L is below the quality standard of 1000 mg/L, iron at 0.09 mg/L is below the quality standard of 1.0 mg/L, and sulfate at 10 mg/L is below the quality standard of 400 mg/L. However, the color parameter of 248 Pt.Co is above the quality standard of 50 Pt.Co, and the turbidity of 48 NTU is above the quality standard of 25. NTU. [9] [10]



Figure 3. PDAM Water

#### 2.5.2. Peatland Water

Peat groundwater, particularly peat formation, begins when shallow lakes are gradually filled with wetlands and aquatic vegetation. Gradually, dead and decaying plants create a layer that acts as a transition layer between the peat layer and the mineral soil layer below.



Figure 4. Peatland Water

Determination of peat water characteristics in the city of Pontianak and Kuburaya district. The results obtained from several test methods show that peat water has a pH of around 4 to 5.7, conductivity of around 1.31  $\mu\text{S}/\text{cm}$  to 82.2  $\mu\text{S}/\text{cm}$ , turbidity of 1.31  $\mu\text{S}/\text{cm}$  to 82.2  $\mu\text{S}/\text{cm}$ , and all peat water is brown in color. The measurement parameters for organic content were determined using the titrimetric method, ranging from approximately 11 mg/L to 16 mg/L, and total hardness ranging from approximately 590 mg/L to 1302 mg/L. The Fe content was determined using an atomic absorption spectrophotometer, ranging from approximately 2 mg/L to 5 mg/L. Thus, it can be concluded that the characteristics of peat water are different, even though the sampling locations are  $\leq 3.5$  km apart. [7]

## 2.6. Portland Cement

Cement is a binding material that has the ability to bind solid materials into a compact and strong unit. Portland cement is a hydraulic cement produced by grinding Portland clinker, which mainly consists of hydraulic calcium silicate ( $x\text{CaO.SiO}$ ) and is ground together with additives in the form of one or more crystals of calcium sulfate ( $\text{CaSO}$ ) compounds and may be supplemented with other additives (mineral components). The function of cement is to fill the air voids between the gaps in the aggregate and bind the aggregate together to produce a strong and compact mass in concrete. In addition, Portland cement, which is often used in construction work, is a type of hydraulic cement, meaning that it hardens when exposed to water. It is also undeniable that when placed in an open space and exposed to direct sunlight, it can accelerate the hardening process of the cement. [4]

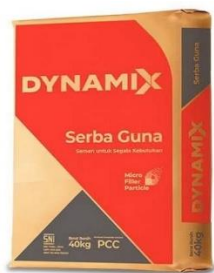


Figure 5. Portland Cement

## 2.7. Compressive Strength Test

One mechanical test that is useful for determining the resistance of an object to compressive forces is the compression test. When external forces or pressures are applied in the same direction as the sample axis, the compression test is categorized as a destructive test. The mechanical characteristics and maximum compressive load that can be withstood by the object or test sample are the objectives of this compression test.



Figure 6. Compression Test Equipment

Because compression testing machines have a visible breaking point during testing, they are typically used on brittle samples or objects. Since different forces and force directions are tested to determine the strength of an object, the mechanical requirements that must be met vary due to the various features and dimensions of compression testing. When tested with a compression testing machine, some older

tools being inspected will bend.

The following formula can be used to determine compressive strength.

$$f_c' = \frac{P}{A}$$

Ket :

P = Pressure load, N

A = Area,  $\text{mm}^2$

For users of compression testing equipment, this testing tool promises quality and performance, featuring advanced equipment that is both heavy and powerful. The strength of an object can be determined using this compression testing tool, regardless of its size. To achieve the desired standardization perfectly, compression testing will produce measurement results of the object's strength in relation to the measurement size in relation to the material to be tested. The compression testing machine will also stabilize the object, regardless of its size, to ensure optimal performance and more accurate results. In Indonesia, paving block compression testing generally [3].

which regulates the specifications for concrete paving blocks. This standard covers the quality and compressive strength requirements for paving blocks to meet the needs of field use. By conducting compression tests, the quality of paving blocks can be ensured, so that construction projects involving paving blocks can run safely and in accordance with technical requirements

## 3. Methodology

The experimental method is the method used in this paper to solve a problem. Writing that uses the experimental method aims to compare the results of the writing and establish a cause-and-effect relationship between the two. The literature study examines the results of human writing that has been published and is used as a benchmark for comparison and reference. In this study, reducing the amount of cement in the paving block design by 0%, 2.5%, 5%, 7.5%, 10%, and 12% of the cement weight is one way to create variations in HDPE plastic bottle waste. The purpose of reducing cement is to save cement by substituting HDPE plastic waste so that plastic bottle waste can be reduced annually in Indonesia.

## 4. Result And Discussion

Compressive strength testing was conducted on paving blocks measuring 20 cm x 10 cm x 6 cm. The results of the testing showed the average compressive strength of paving blocks at 14 and 28 days of age with variations of 0%, 2.5%, 5%, 7.5%, 10%, and 12%. With variations in PDAM water and peat soil water in the soaking process.

Table 1. Compressive Strength Data at 14 and 28 Days

	Preservation Media	14-Day Strength (MPa)	28-Day Strength (MPa)
0%	Peat Soil Water	17,95	15,20
0%	PDAM Water	15,97	19,40

2,5 %	Peat Soil Water	20,47	19,32
2,5 %	PDAM Water	21,16	15,23
5%	Peat Soil Water	14,40	9,04
5%	PDAM Water	11,47	7,39
7,5%	Peat Soil Water	8,14	5,85
7,5%	PDAM Water	3,97	5,97
10%	Peat Soil Water	4,05	3,55
10%	PDAM Water	4,37	3,54
12%	Peat Soil Water	5,77	7,55
12%	PDAM Water	5,36	5,01

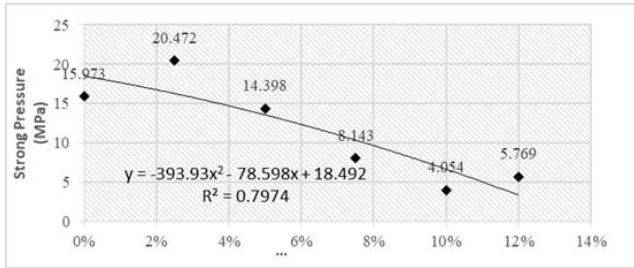


Figure 7. Graph of 14-day compressive strength test of peat soil water

The template will number citations consecutively within Based on the compressive strength test results, the addition of plastic to the mixture showed a decrease in compressive strength. The highest compressive strength was achieved at a variation of 2% at 20.472 MPa, while the lowest value occurred at 10% at 4.054 MPa. This shows that the higher the plastic content, the lower the compressive strength produced. The regression equation shows a quadratic relationship with an R<sup>2</sup> value of 0.7974, indicating a fairly good fit of the data.

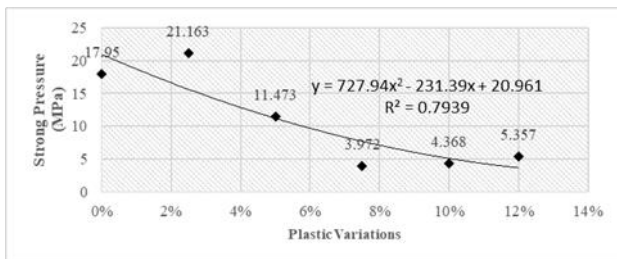


Figure 8. Graph of 14-day compressive strength test of PDAM water

The compressive strength test results show that the addition of plastic variations affects the decrease in compressive strength. The highest value was obtained at a variation of 2% at 21.163 MPa, while the lowest value occurred at a variation of 8% at 3.972 MPa. In general, compressive strength decreases as the plastic content increases. The quadratic regression equation has an R<sup>2</sup> value of 0.7939, which indicates a fairly strong relationship between plastic variation and compressive strength.

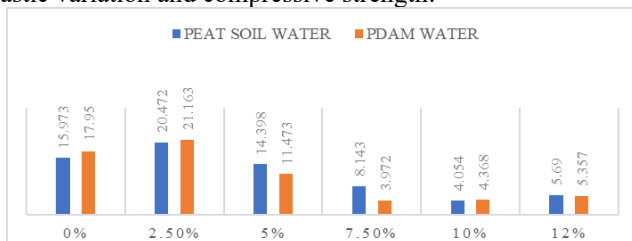


Figure 9. Comparison chart of 14-day compressive strength tests for peat soil water and PDAM water

Based on the comparison analysis above, peat groundwater was found to have the highest comparative value. According to the researcher's assumption, peat groundwater contains acidic compounds. This can slow down water evaporation and prolong the cement hydration process, thereby increasing the compressive strength of paving blocks.

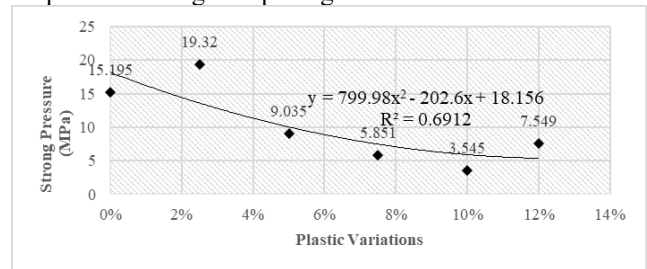


Figure 10. Graph of 28-day compressive strength test of peat soil water

Compressive strength testing shows that an increase in plastic variation has an impact on the decrease in material compressive strength. The highest compressive strength was achieved at a variation of 2% at 19.32 MPa, while the lowest value occurred at a variation of 10% at 3.545 MPa. Although there was a slight increase at a variation of 12%, overall there was a decrease in compressive strength. A quadratic regression equation with an R<sup>2</sup> value of 0.6912 describes a fairly good relationship between plastic content and compressive strength.

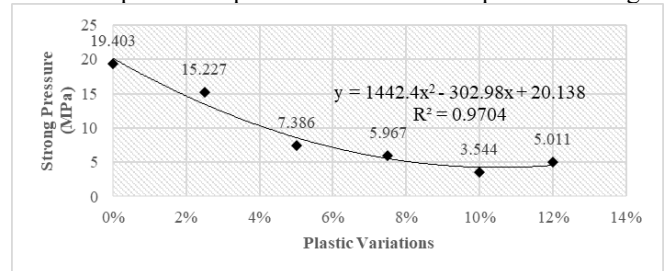


Figure 11. Graph of 28-day compressive strength test of PDAM water

The compressive strength test results show that an increase in plastic variation causes a significant decrease in the compressive strength of the material. The highest compressive strength value was obtained at 0% variation, which was 19.403 MPa, and the lowest value was recorded at 10% variation, which was 3.544 MPa. Although there was a slight increase at 12% variation, overall there was still a decrease. The quadratic regression equation showed an excellent level of fit with an R<sup>2</sup> value of 0.9704.

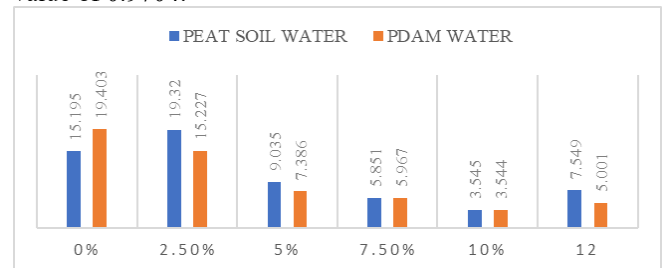


Figure 12. Comparison chart of 28-day compressive strength tests for peatland water and PDAM water

It can be concluded from the comparative analysis above that peat groundwater has the highest comparative value.

According to the researcher's assumption, peat groundwater contains acidic compounds. This can slow down water evaporation and prolong the cement hydration process, thereby increasing the compressive strength of paving blocks

## 5. Conclusion

From these results, higher values than those planned were obtained. The results for the 2.5% variation on day 14 showed the highest compressive strength values of 20.472 MPa for peat soil immersion and 21.163 MPa for PDAM water immersion. The results for the 28-day variation showed the highest compressive strength of 19.320 MPa for peat soil water immersion and 15.227 MPa for PDAM water immersion. With these compressive strength values, the quality of the concrete produced has met and even exceeded the requirements for class B concrete, which is in the range of 17–20 MPa.

## Acknowledgements

We would like to express our sincere gratitude to the Concrete Laboratory of Universitas Tanjungpura for providing us with the opportunity and facilities to conduct our testing activities. The support and assistance from the laboratory staff have been invaluable throughout the testing process.

Your contribution has greatly supported our research, and we deeply appreciate the hospitality and professionalism shown during our time at the laboratory.

---

## References

- [1] Badan Standardisasi Nasional, Peraturan Beton Bertulang Indonesia (PBI-1971), Jakarta: BSN, 1971
- [2] Badan Standardisasi Nasional, SK SNI S-04-1989-F, Jakarta: BSN, 1989
- [3] Badan Standardisasi Nasional, SNI 03-0691-1996: Bata Beton (Paving Block), Jakarta: BSN, 1996.
- [4] Badan Standardisasi Nasional, SNI 15-2049-2004: Semen Portland, Jakarta: BSN, 2004.
- [5] Jurnal, "Pengelolaan Sampah Plastik Menjadi Paving Block sebagai Prospek Bisnis pada Masyarakat Pra-Sejahtera," 2021.
- [6] Jurnal, "Penentuan Karakteristik Air Gambut di Kota Pontianak dan Kabupaten Kubu Raya," 2021.
- [7] Jurnal Kimia Khatulistiwa, "Penentuan Karakteristik Air Gambut di Kota Pontianak dan Kabupaten Kubu Raya," 2018.
- [8] Jurnal Teknologi dan Rekayasa Sipil, "Penggunaan Limbah Plastik Polypropylene sebagai Substitusi Semen pada Paving Block," 2023.
- [9] Pemerintah Republik Indonesia, Peraturan Pemerintah Nomor 82 Tahun 2001 tentang Pengelolaan Kualitas Air dan Pengendalian Pencemaran Air, Jakarta, 2001.
- [10] Perusahaan Daerah Air Minum (PDAM) Kota Pontianak, "Evaluasi dan Optimalisasi Kinerja IPA I PDAM Kota Pontianak," Jurnal, 2013