

Madani: Jurnal Ilmiah Multidisiplin
Volume 1, Nomor 12, Desember 2023, Halaman 110-116
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E-ISSN: [2986-6340](https://doi.org/10.5281/zenodo.10428700)
DOI: <https://doi.org/10.5281/zenodo.10428700>

Paving Block Quality With Several Types of Plastic Waste on Compressive Strength

Risti Indah Cahyani¹, Dina Irfaniyah¹, Ahmad Fikri Alfarizki^{1*}, Fuji Hernawati Kusumah¹

¹Prodi Tadris Fisika, Fakultas Ilmu Tarbiyah dan Keguruan, Universitas Islam Negeri Syarif Hidayatullah Jakarta

*Email korespondensi: fikri.alfarizki21@mhs.uinjkt.ac.id

Abstrak

Pollution in Indonesia has increased over time due to the large amount of waste that is not managed properly, one of which is plastic waste which has a negative impact on the environment, where it can pollute oceans, rivers and other environmental areas. On the other hand, the increase in natural resources and community needs are also increasing rapidly. So, based on these problems, this research aims to utilize plastic waste as a mixture to form paving blocks and analyze the quality of paving blocks better. The method used in this research is experimental which is carried out by making paving blocks with different types of plastic, namely PET (*polyethylene ethylene terephthalate*), PP (*polypropylene*) and PS (*polystyrene plastic*) with a mixture of gravel with a weight volume ratio of 50: 50. Model The paving blocks studied were paving blocks in the form of blocks with object dimensions measuring 14.5 × 9.5 cm x 3.5 cm. The results of the research showed that the compressive strength of PP, PET and PS plastic types were 33.8 MPa, 18 MPa, and 9 MPa respectively. Thus, it can be concluded that the PP (*polypropylene*) plastic mixture has the best quality in handling quite heavy loads.

Keyword: *Environmental pollution; paving blocks; plastic waste*

Article Info

Received date: 30 November 2023

Revised date: 12 December 2023

Accepted date: 22 December 2023

INTRODUCTION

One type of waste that has a negative impact on the environment is plastic, where this waste is often not managed properly. The impacts that occur can pollute oceans, rivers and other environmental areas, threaten marine wildlife and cause health problems. In an effort to minimize plastic waste, it can be overcome by recycling it. Apart from that, waste pollution can be reduced by avoiding waste of natural resources (SDA). Recycling plastic waste can have a positive impact on the use of the community's economy (Rai & Duggal, 2012). Currently, only around 5-10% of total plastic waste is recycled. The plastic recycling process is very important to reduce environmental pollution and prevent waste of natural resources (Indrawijaya, 2019).

Apart from that, recycling plastic waste can also provide economic benefits to society. One interesting option for recycling plastic is to use plastic waste as a mixture in the production of plastic cement composites or as an aggregate in the manufacture of concrete construction materials (Putra & Yuriandala, 2010). Based on this problem, one alternative that can reduce the amount of waste that is not managed properly is recycling plastic waste. One way is to use it as an alternative main ingredient for making paving blocks. There have been several studies related to the use of recycled plastic as an alternative main material for making paving blocks.

Research on the quality of Paving Blocks on compressive strength was carried out by (Erdin *et al*, 2021) regarding the manufacture of paving blocks using PP (*Polypropylene*) plastic waste and fine aggregate with variations in the composition of the PP

(Polypropylene) mixture with sand. Obtaining a mixture of 30% PP (Polypropylene) and 70% sand has the best compressive strength according to national standards, namely 16.11 MPa, which is categorized as quality C.

Research on compressive strength, tensile strength, flexural strength, and sound attenuation of lightweight concrete wall panels with PET plastic waste aggregate. What has been done by Pitra A and Achmad B (2014) regarding making paving blocks using PET plastic waste (polyethylene ethylene terephthalate) as this plastic waste is made into 100% coarse aggregate. From this research, the compressive strength results were 6,187 MPa, which was categorized as quality D (Ardhiantika *et al*, 2014).

So from previous research, the author wants to develop research by using several types of plastic in making *Paving Blocks* in order to determine better quality by calculating the compressive strength value of Paving Blocks. According to (Jassim, 2017) plastic has important properties that can be used independently or in composite form as construction materials. These properties include durability, resistance to corrosion, ability as an insulator for both cold, hot and sound temperatures, energy savings, economy, long service life and light weight.

In this context, the use of plastic waste in the construction industry becomes an interesting research topic. One of the construction products that is often used in the construction of roads, sidewalks and parking areas is paving blocks. The use of plastic waste has high potential as a raw material for reducing the amount of waste that pollutes the environment, reducing dependence on limited natural resources, and creating environmentally friendly construction materials. There are various types of plastic, including PET (*polyethylene ethylene terephthalate*), PP (*polypropylene*) and PS (*polystyrene*). PP (*Polypropylene*) plastic is a thermoplastic polymer produced by the chemical industry and finds applications in various fields. These include packaging, textiles (such as rope, thermal underwear, and carpets), stationery, reusable containers of various types, plastic components, laboratory equipment, loudspeakers, automotive parts, and polymer banknotes. This additional polymer is derived from propylene monomer and exhibits an uneven surface with excellent resistance to most chemical solvents, bases and acids. The melting point of polypropylene plastic ranges from 160°C to 165°C (Gunawan & Yenie, 2017).

The type of plastic used to make mineral water bottles, juice bottles, food containers is PET plastic or PETE (*polyethylene ethylene terephthalate*). This type of PET bottle is only recommended for single use, if it is used too often, especially when used to store warm water, it will cause the polymer layer on the bottle to melt and release substances called carcinogenic substances, which can cause cancer in the long term (Trisunaryati, 2018). PS (*Polystyrene*) is a type of plastic that is widely used in everyday life, such as plastic bags, food containers and tires. PS has the properties of heat resistance, hardness, flexibility, and opacity to light (Onwudili & Williams, 2009).

Commonly known as styrofoam, PS is a synthetic hydrophobic polymer with a high molecular weight that is a type of thermoplastic. Although PS can be recycled, it is difficult to biodegrade. At room temperature, PS is solid, but can melt when heated and return to solid state when broken (Ghosh, 2013). The advantages of PS include high optical transparency, excellent electrical insulation, high thermal resistance, low stiffness, good mechanical durability, and ease of processing and printing. Therefore, PS has many applications in the market, such as product packaging, extruded sheets, and electronics. However, PS has weaknesses as a barrier to oxygen and water vapor (Mansour *et al*, 2013).

According to the Indonesian National Standard (SNI) 03-0691 (1996), paving blocks are defined as a building material composition consisting of a mixture of Portland cement or similar hydraulic adhesive, water, aggregate, and possibly other additional materials that

do not reduce the quality of the paving block. the. Paving blocks are classified into several qualities, namely quality A which is used for road construction, quality B for parking lots, quality C for pedestrian areas, and quality D for parks and other uses (National Standardization Bodies, 1996).

Paving national standards (Indra Basuki, 2019) blocks quality A used Forroad with an average compressive strength of 40 MPa and a maximum average water absorption of 1%. Quality B paving blocks are used for parking lots with an average compressive strength of 20 MPa and a maximum average water absorption of 6%. Paving Block with quality C is used for pedestrians with an average compressive strength of 15 MPa and a maximum average water absorption of 8%. Quality D paving blocks are used for parks and other uses with an average compressive strength of 10 MPa and a maximum average water absorption of 10%.

METHODE

According to (Jassim, 2017) plastic waste can be used as a strong construction material and has a light weight compared to other construction materials, therefore the author uses plastic waste as an alternative material for making *Paving Blocks*. The compressive strength of concrete bricks, according to Indonesian National Standard (SNI) 03 – (1996), refers to the load per unit area that causes failure of the concrete test object when pressure is applied from a compression device. The compressive strength test of paving blocks was carried out by comparing the use of PP (*polypropylene*), PET (*polyethylene ethylene terephalate*) and PS (*polystyrene*) plastic types at a level of 50%, with a mixture of gravel as the other main ingredient.

The tool used in this compressive strength test is a simple maximum load. The research method used in this research is an experimental method. Which is illustrated through (Figure

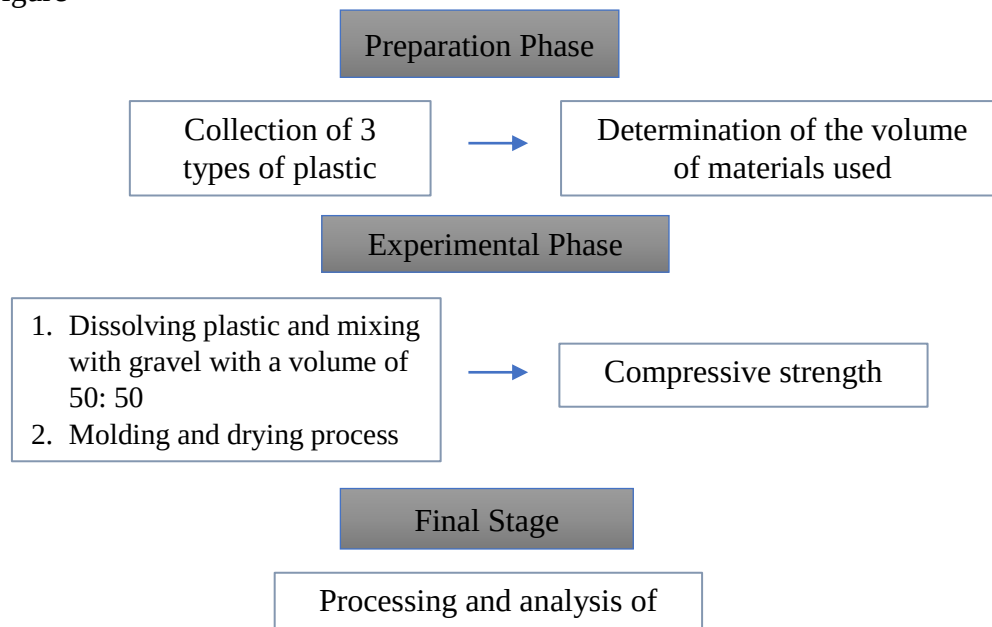


Figure 1. Flowchart of research methods

The stages carried out are as follows.

- a. Preparation of tools and materials. This stage involves preparing all the equipment and materials that will be used in the process of making paving blocks in the form of PET

(polyethylene ethylene terephthalate), PP (polypropylene) and PS (polystyrene) plastic, gravel, oil, firing tools and molds.

- b. Sample Preparation Process. A mixture of plastic materials such as PET (polyethylene ethylene terephthalate), PP (polypropylene) and PS (polystyrene) with gravel. Mix planning between the composition of plastic types, namely 50: 50. Before making a test sample, the first step taken to find 100% plastic in a mold size of $9.5 \times 14.5 \times 3.5$ cm is to provide 300 grams of PET (polyethylene ethylene terephthalate) plastic. PP (polypropylene) and PS (Polystyrene) which have been cleaned

Tabel 1. Mixture Planning Between the Compositions of Each Type of Plastic

Plastic Type	Volume Weight of Plastic Mixture : Gravel
PET (polyethylene ethylene terephthalate)	50 : 50
PP (polypropylene)	50 : 50
PS (Polystyrene)	50 50

- c. Sample Making Process. The first step is to light a fire and heat the pan. Add the plastic that has been cut into small pieces until it melts. Once the plastic has melted, mix the gravel into the pan and stir until evenly distributed. After the plastic and gravel are mixed evenly, put them into a $9.5 \times 14.5 \times 3.5$ cm mold and smooth the surface. Cool the sample for 5 - 10 minutes, and put it in water for 3 minutes and remove it from the mold making sure the object is completely dry. Put a mark on the sample to differentiate sample 1 from the others. Stored in a storage box at room temperature.
- d. Sample Testing Process. Tests were carried out in a room using various loads, namely 4 kg, 5 kg, 10 kg, 40 kg, 50 kg, and 65.5 kg. For samples that are 7 days old. There are 2 samples to be tested with a variety of different types of plastic. This test was carried out to obtain compressive strength values for the samples in accordance with (SNI 03-0691, 1996). After the sample is pressed until it is crushed by a compressive strength machine, it is recorded and documented.

According to SNI 03-0691, (Erdin *et al*, 2021) states that the formula used to carry out compressive strength testing, the compressive strength test results obtained can be calculated using the following formula:

$$f'c = \frac{P}{L}$$

Information:

f'c : Compressive strength in brackets (MPa)
 P : Maximum load (N)
 L : Surface area (mm²)

RESULTS AND DISCUSSION

Making paving blocks is an effort to reduce the environmental impact of plastic use, reduce the overall use of single-use plastic and choose more environmentally friendly alternatives such as using cloth shopping bags that can be used repeatedly, refillable drinking bottles, or other environmentally friendly packaging. Additionally, recycling and disposing of plastic properly is also important to reduce its impact on the environment. The following is data resulting from compressive strength testing.

Table 2. Compressive Strength of Paving Blocks with Different Types of Plastic

Plastic Type	Maximum Load (N)	Compressive Strength (MPa)
PP (<i>Polypropylene</i>)	1500	33.8
PET (<i>polyethylene ethylene terephthalate</i>)	800	18.0
PS (<i>Polystyrene</i>)	400	9.0

Table 3. Condition of Paving Blocks Against Object Loads

Plastic Type	4 kg	5 kg	10 kg	40 kg	50 kg	65.5 kg
PP (<i>Polypropylene</i>)	K	K	K	K	K	K
PET (<i>polyethylene ethylene terephthalate</i>)	K	K	K	K	SR	R
PS (<i>Polystyrene</i>)	K	K	R	L	-	-

Information:

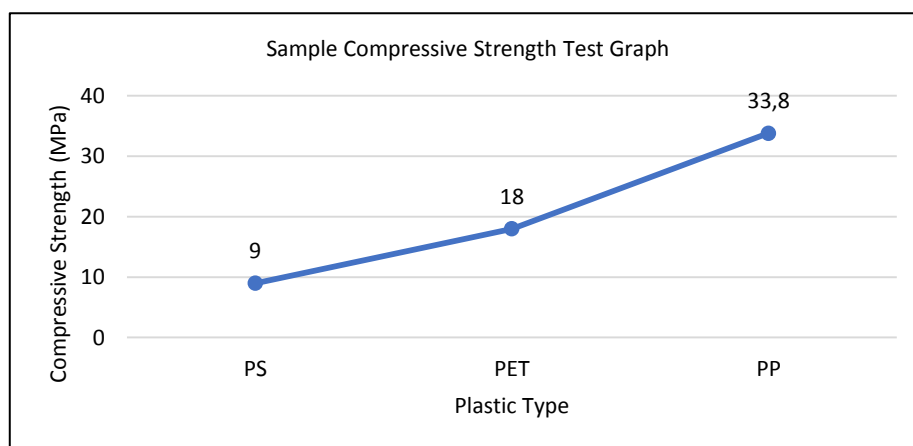
K : Strong

SR : Slightly cracked

R : Crack

L : Melt

Based on data from trials with several heavy loads given to each type of plastic waste, it was found that paving blocks were made with a mass ratio of 50%: 50% between gravel and plastic waste used. PP (*polypropylene*) plastic has the highest compressive strength compared to PET (*polyethylene ethylene terephthalate*) and PS (*polystyrene*) plastic when tested with the same load.

**Graph 1.** Sample pressure test on plastic types

Paving blocks using PP (*polypropylene*) plastic produce a compressive strength of 3.38 MPa, where when the paving block is given a load of 65.5 kg no damage or cracks occur, so it is estimated that the paving block is able to withstand a load of up to > 100 kg. This shows that PP plastic provides better compressive strength in withstanding pressure than PET (*polyethylene ethylene terephthalate*) and PS (*polystyrene*) plastic types. PP

(polypropylene) plastic has more flexible and elastic properties compared to PET and PS plastic, which allows it to withstand loads better. This property makes it more suitable for use in paving block making applications that require resistance to high pressure.

Apart from that, PP plastic has properties that are resistant to extreme weather conditions and exposure to harsh environments, including UV rays, humidity and temperature changes. This has also been researched in the research of Dr. Donald R. Paul, a professor of chemistry and chemical engineering at the University of Texas, stated that PP plastic has good stiffness, providing the structural strength required in many applications (Paul, 2006).

Dr. Roger Rothern, a researcher at the University of London, stated in his study of the thermal properties of polymers that PP plastic can withstand high temperatures without melting or deforming (Rothern, 1994). In the burning process, PP plastic is very easy to process, so paving blocks made from PP plastic are easily made according to your needs and desired specifications. In this trial, PS (*Polystyrene*) plastic had the lowest compressive strength, this is because PS plastic has very light properties, besides that PS plastic tends to be more brittle and susceptible to physical damage compared to several other types of plastic. This can cause paving blocks made of PS plastic to easily crack or break if exposed to excessive load or pressure.

PS plastic has limitations in resistance to heat, it still has limitations in withstanding high temperatures so that PS plastic has a relatively low melting point and is susceptible to deformation and damage when exposed to high temperatures. This was also stated by (Mansour *et al*, 2013) that PS plastic has very low stiffness. Thus, paving blocks made from PS plastic are placed in areas that are often exposed to direct sunlight or high temperatures. Under such conditions, the PS plastic in paving blocks can soften or undergo undesirable changes in shape.

Making paving blocks using PET (*polyethylene ethylene terephthalate*) plastic has a compressive strength below PP (*polypropylene*) plastic. Paving blocks using the PET type are only able to withstand loads of up to 50 kg, if > 65.5 kg of paving blocks experience cracks. This is because PET plastic has limited resistance to low temperatures. At low temperatures, PET plastic can become brittle and susceptible to cracking or breaking. This is based on Sudarman's (2022) explanation that PET plastic has the disadvantage of not being impact resistant so it is easily damaged, more difficult to shape and easily changes shape when in contact with hot temperatures (Abdi, 2022).

When there is a high enough impact or pressure, PET plastic can break into small fragments. During the burning process it was a little difficult, where during the burning process the PET plastic hardened more quickly, this caused the printing process not to have maximum time, causing the paving blocks to crack easily. Based on table 1, it can be seen that the types of plastic PP (*polypropylene*) and PET (*polyethylene ethylene terephthalate*) have compressive strength values of 33.8 MPa and 18.0 MPa, where the quality of paving blocks is included in group B which is used for parking lots while the plastic type PS *Polystyrene* has the lowest compressive strength value, namely 9.0 MPa, where PS plastic is included in group C. For paving blocks, this group is usually used for pedestrians only. This is in accordance with the Indonesian National Standard (SNI 03-0691, 1996).

The burning process in the tests carried out has a drawback, namely the smoke caused by burning plastic causes air pollution, this is because the tools used for the burning process are still simple with tools and materials that are easily found in the environment. Thus, it is recommended that the plastic waste processing process use adequate technology and infrastructure to ensure safe and efficient processing of plastic waste. Apart from that, in the printing process a press machine is needed so that the density of the paving blocks is better and it is recommended to use laboratory press testing equipment in the press test.

CONCLUSIONS

Based on research testing the compressive strength of paving blocks made from PP, PET and PS plastic types with a ratio of 50:50 between the plastic type and a mixture of gravel, respectively, it is 33.8 MPa, 18 MPa and 9 MPa. Thus, it can be concluded that the PP (*polypropylene*) plastic mixture has the best quality in handling quite heavy loads. This compressive strength test value is included in the quality requirements for paving blocks with quality B and can be used for parking lots according to (SNI 03-0691, 1996). Suggestions for further research are to use laboratory compression test equipment in the tests to produce more accurate compression test strength values.

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