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# Analysis of Concrete Compressive Strength by Adding Plastic Waste as an Additional Material Mixed in Cement for Manufacturing Paving Blocks

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**Abstract:** The increasing population causes the use of plastic to also increase and plastic waste to increase. The uncontrolled increase in plastic waste will harm land and marine ecosystems because this waste is difficult to decompose. Reducing the amount of plastic waste can be done in various ways. One way is to utilize plastic waste as an additive in the cement mixture to make paving blocks. The use of plastic waste in paving block mixtures will certainly affect the quality of the paving blocks. Therefore, this study conducted an experiment to determine the effect of adding plastic waste on the compressive strength and water absorption of paving blocks. The variations in addition to plastic waste used are 0%, 2.5%, 5%, and 7% of the weight of cement. The results of the experiment showed that paving blocks with a 2.5% plastic mixture had the highest average compressive strength at the age of 21 days, namely 23.23 Mpa. In addition, the lowest average water absorption value was possessed by a 2.5%, 5%, and 7% plastic mixture of 4.89%. Based on SNI 03-0691-1996, paving blocks with a 2.5% plastic mixture can be classified as B quality and can be used for parking equipment. Finally, this study is expected to be a reference in the use of plastic waste as an additional material in paving block mixtures and become one of the solutions for reducing plastic waste.

**Keywords:** Concrete, Compressive Strength, Plastic Waste, Paving Block

## 1. Introduction

With the increasing population, the amount of plastic waste in the city of Pontianak is also growing. Current data shows that Pontianak generates an average of 400 tons of waste per day, both organic and non-organic. On certain days, particularly Saturdays and Sundays, waste production can reach the capacity of two containers per day. To address this issue, research has been conducted to reduce plastic waste by utilizing it become substitute object cement in the process of creating paving blocks.

This study focuses on using discarded plastic materials additive in concrete mixtures. By incorporating plastic waste, an alternative method is proposed to reduce the over use of cement in concrete production while maintaining the strength of the paving blocks. The material used in this study involves heating plastic from drinking bottles. Polyethylene Terephthalate (PTE) are generally used to package mineral

water, be it glass cups or bottles waste to serve as an additive or substitute for cement in the concrete mixture.

We believe this research is highly beneficial for practical application, as the increasing use of plastic waste is causing environmental pollution and unsightly surroundings. By incorporating plastic waste into the mixture, the resulting paving blocks are expected to be of excellent quality. Additionally, this method helps reduce plastic waste and transforms it into a valuable and functional resource.to create these components, incorporating the applicable criteria that follow.

The absorption capacity of a paving block is important to determine its ability to manage water when applied. This property helps reduce water puddles in areas where the paving blocks are used, especially during rainfall, thus minimizing the impact of water accumulation.

## 2. Literature Review

### *2.1. State of the Art*

Concrete is a combination of filler and binder materials [10], such as gravel, sand, cement, and water, mixed in specific proportions [1;13;16]. However, these basic materials alone are insufficient to produce high-quality concrete. Over time, advancements have introduced various new concrete materials and chemical combinations to produce concrete with superior qualities. These contain ultrahigh-performance concrete and self-compacting mixtures [2;3;16], high ductility [13], and high durability.

### *2.2. Concrete*

Concrete is an extensively used construction material. It is made by blending cement, water, and aggregates in specific proportions, which, over time, will harden [4].

### *2.3 Plastic*

Plastic is a material that was broadly advanced and utilized starting in the century of 20th era, with its function growing enormously from just several hundred tons during the 1930s to a total of 150 million tons per year in the decade of the 1990s, with a total of 220 million tons every year in 2005. Plastic material can be classified into two types: thermoplastic and thermosetting. Thermoplastic refers to plastics that melt when heated to a certain temperature and can be molded into the desired shape. In contrast, thermosetting plastics are those that, once solidified, cannot be melted again through heating [14]. The type of plastic drinking bottles PET is widely used in everyday life and is one of the most common types of plastic waste. This PET plastic has transparent and clear properties and is resistant to gas and air. However, this type of plastic should only be used once and is difficult to decompose in the soil.

### *2.4 Paving Block*

Paving blocks made of concrete type pertaining to building materials composed of a mixture of Portland cement or hydraulic binders, water along with aggregates (stone dust/sand), containing or not containing other additives in specific proportions [8]. The standard size of paving blocks is 20 cm x 10 cm x 6 cm. Below is an illustration of the concrete mold to be used:


***Figure 1.*** *Paving block Mold*

## 3. Research Methodology

### *3.1. Research roadmap*

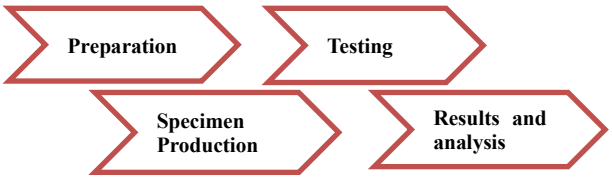


***Figure 2****. Research Roadmap*

The above describes the Research Roadmap to be carried out, starting from the preparation phase to the testing phase, in accordance with the specified timeline.

### *3.1. Research timeline*

The research activities will be conducted within the planned timeframe, taking into account the current conditions and situations. This flexible approach ensures that adjustments can be made, if necessary, while still maintaining the integrity and objectives of the study.

### *3.2. Equipment and materials*

The instruments utilized in this research include:

Tools for Making Paving Blocks: Vibration Press Machine, Bucket, Shovel, Storage Container for Paving Blocks, Other Tools: Other supporting tools such as concrete mixers, moisture meters, and measuring devices for materials.

Tools for Testing: CTM (Compression Testing Machine): Used to test the ability of the paving blocks to withstand compression after curing. The device assesses the pressure resistance of concrete to ensure the paving blocks comply with the specified strength requirements.

Materials for Making Paving Blocks: Cement, Sand, Plastic Waste, Iron Rod, Gloves and Masks. These tools and materials will serve to produce paving blocks with varying plastic compositions and to test the durability and structural integrity of the resulting paving bricks.

### *3.2. Data Collection*

The data collection process is carried out by collecting the data needed for the research. The required data is obtained from primary and secondary sources:

Primary Data: Primary data refers to data collected directly from the field, such as the collection of plastic waste samples.

Secondary Data: Secondary data consists of supporting data obtained from books, journals, and other sources related to the research.

### *3.3. Research Stages*

The stages of this research start with determining the research topic. Then continued with identifying the problem. The third stage is determining the objectives to be achieved from this research. Details of the stages of this research can be seen in Figure 3.

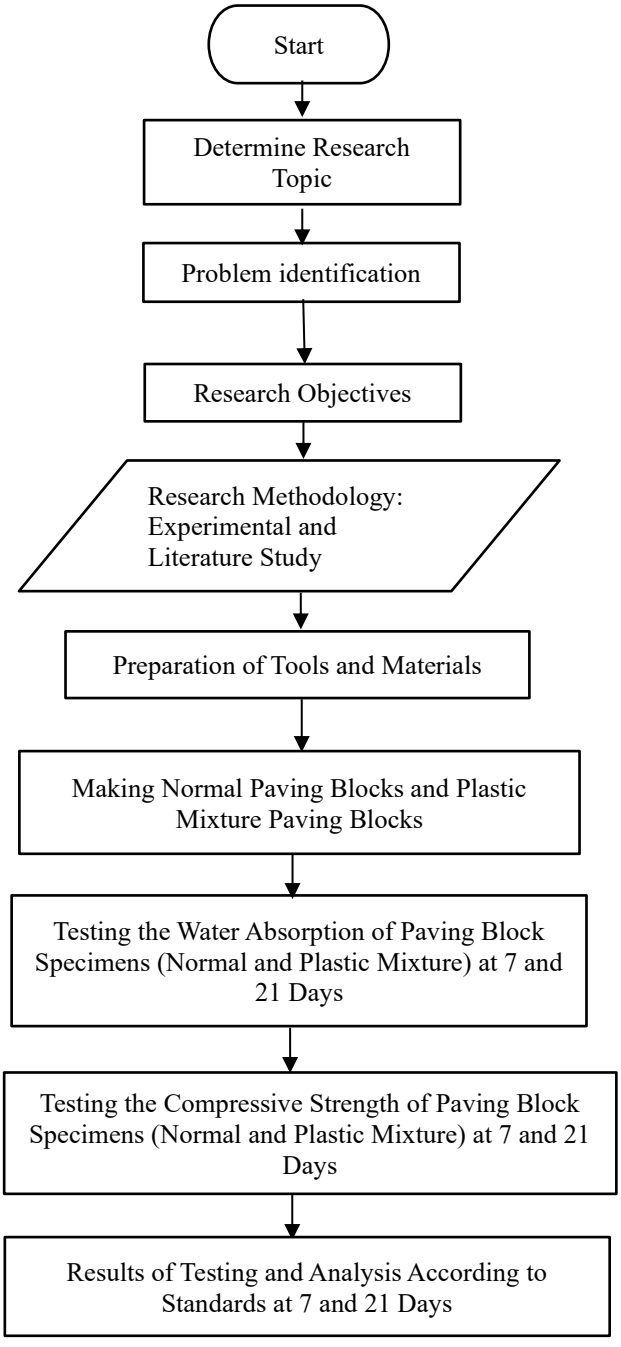


***Figure 3.*** *Research phases*

### *3.4. Job Mix Design*

The ratio of cement and sand mixture for making paving blocks is 1:2, with a water composition of around 0.975 liters. The levels of plastic waste added to the paving block mixture are 0%, 2.5%, 5%, and 7.5% of the weight of cement. In this study, paving block molds were used with a length of 20 cm, a width of 10 cm, and a height of 6 cm.

## 4. Result and discussion

### *4.1 Normal Paving Block Absorption Data Resistance to Compression Test Containing Normal Paving Bricks*

The results of water absorption and compressive strength tests of paving blocks with a 0% plastic mixture (normal) can be seen in Table 1 and Figure 4, respectively. Table 1 shows that the lowest water absorption is 2,60% and the average water absorption is 3.15% for 7 days and 5.22% for 21 days. The compressive strength test results in Figure 4 show that the maximum compressive strength at 21 days is 22.6 MPa. The average compressive strength of the three paving block samples at 21 days is 22.13 MPa. The test results show that paving blocks with a 0% plastic mixture can be classified as quality B according to SNI 03-0691-1996.

***Table 1.*** *Water absorption test on normal Paving block*

| Model | Initial Weight (kg) | Water Absorption (%) | |
|---|---|---|---|
| | | 7 days | 21 days |
| 1 | 2,40 | 2,60 | 4,02 |
| 2 | 2,30 | 4,17 | 6,12 |
| 3 | 2,40 | 3,23 | 5,51 |
| **Average** | 2,37 | 3,15 | 5,22 |

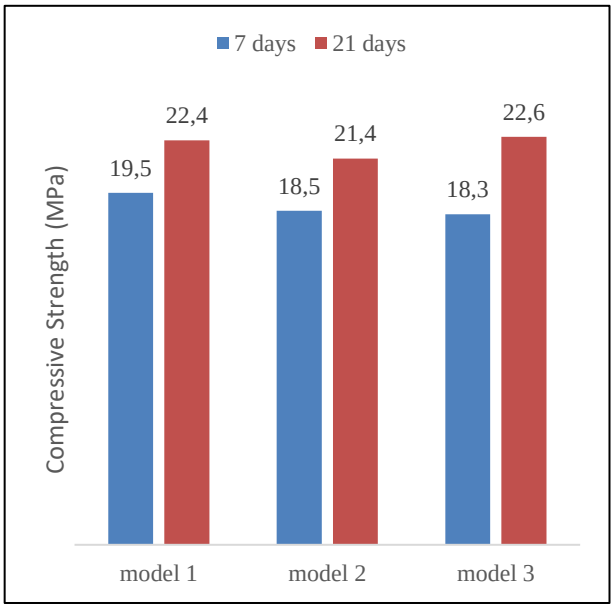


***Figure 4.*** *Compressive Strength of Normal Paving Blocks*

### *4.2 Water Absorption and Compressive Strength Results of Paving Blocks with 2,5% Plastic Mixture*

Table 2 shows the results of water absorption tests for paving blocks with a mixture of 2.5% plastic waste. The table shows that the lowest water absorption is 2.08% and the average water absorption is 2.49% for 7 days and 4.89% for 21 days. Furthermore, the results of the compressive strength test of paving blocks with a mixture of 2.5% plastic waste can be seen in Figure 5. Based on the figure, it can be seen that the highest compressive strength is 26.2 MPa at the age of 21 days. The average compressive strength of paving blocks with a mixture of 2.5% plastic waste is 18.40 MPa for 7 days and 23.23 MPa for 21 days. These results indicate that paving blocks with a mixture of 2.5% plastic waste can be categorized into quality B according to SNI 03-0691-1996.

***Table 2.*** *Water absorption test on Paving block with 2.5% Plastic Mixture*

| Model | Initial Weight (kg) | Water Absorption (%) | |
|---|---|---|---|
| | | 7 days | 21 days |
| 1 | 2,70 | 2,08 | 4,04 |
| 2 | 2,70 | 3,17 | 6,12 |
| 3 | 2,70 | 2,23 | 4,51 |
| **Average** | 2,70 | 2,49 | 4,89 |

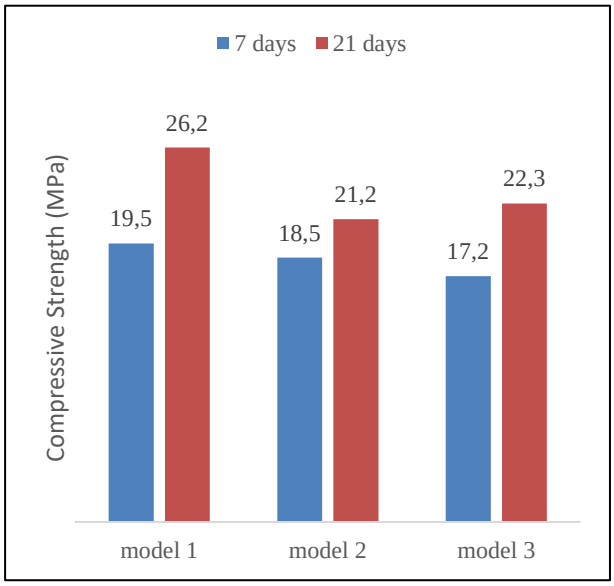


***Figure 5.*** *Compressive strength of paving block with 2,5% plastic mixture*

### *4.3 Water Absorption and Compressive Strength Results of Paving Blocks with 5% Plastic Mixture*

The test results of paving blocks mixed with 5% plastic waste are shown in Table 3 and Figure 6. Table 3 shows the results of the water absorption test of paving blocks mixed with 5% plastic waste. The table shows that the lowest water absorption is 2.08%. In addition, the table also shows that the average water absorption is 2.49% for 7 days and 4.89% for 21 days. Furthermore, Figure 6 shows the results of the compressive strength test of paving blocks with a 5% plastic waste mixture. From the figure, it can be seen that the highest compressive strength on 21 days is 15,60 MPa. Meanwhile, the average compressive strength is 9.93 MPa for 7 days and 12,88 MPa for 21 days. These results indicate that paving blocks with a 5% plastic waste mixture can be categorized into quality C according to SNI 03-0691-1996.

### *4.4 Water Absorption and Compressive Strength Results of Paving Blocks with 7% Plastic Mixture*

The last mixture variation is paving blocks with a mixture of 7% plastic waste. The test results for this variation are presented in Table 4 and Figure 7. Table 4 shows the results of the water absorption test of paving blocks with a mixture of 5% plastic waste. Meanwhile, Figure 7 shows the results of the compressive strength test of paving blocks with a mixture of 5% plastic waste. From Table 4, it can be seen that the lowest water absorption is 2.08%. In addition, the table also shows that the average water absorption is 2.49% for 7 days and 4.89% for 21 days. Next, Figure 7 shows the highest compressive strength is 26.2 MPa at 21 days. Meanwhile, the average compressive strength is 18.40 MPa for 7 days and 23.23 MPa for 21 days. These results indicate that paving blocks with a mixture of 7.5% plastic waste can be categorized into quality B according to SNI 03-0691-1996.

***Table 3.*** *Water absorption test on paving block with 5% plastic mixture*

| Model | Initial Weight (kg) | Water Absorption (%) | |
|---|---|---|---|
| | | 7 days | 21 days |
| 1 | 2,30 | 2,06 | 4,02 |
| 2 | 2,40 | 3,15 | 6,14 |
| 3 | 2,30 | 2,22 | 4,50 |
| **Average** | 2,33 | 2,48 | 4,89 |

***Table 4****. Water absorption test on paving block with 7% plastic mixture*

| Model | Initial Weight (kg) | Water Absorption (%) | |
|---|---|---|---|
| | | 7 days | 21 days |
| 1 | 2,50 | 2,04 | 4,06 |
| 2 | 2,50 | 3,12 | 6,10 |
| 3 | 2,80 | 2,24 | 4,52 |
| **Average** | 2,60 | 2,47 | 4,89 |

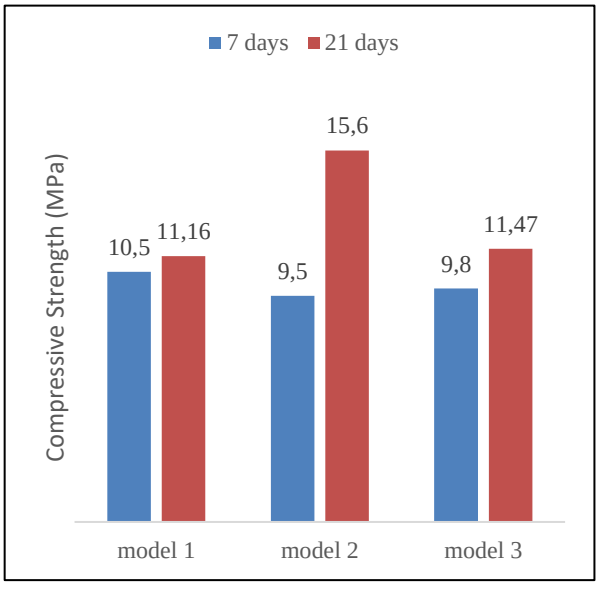


***Figure 6.*** *Compressive strength of paving block with 5% plastic mixture*

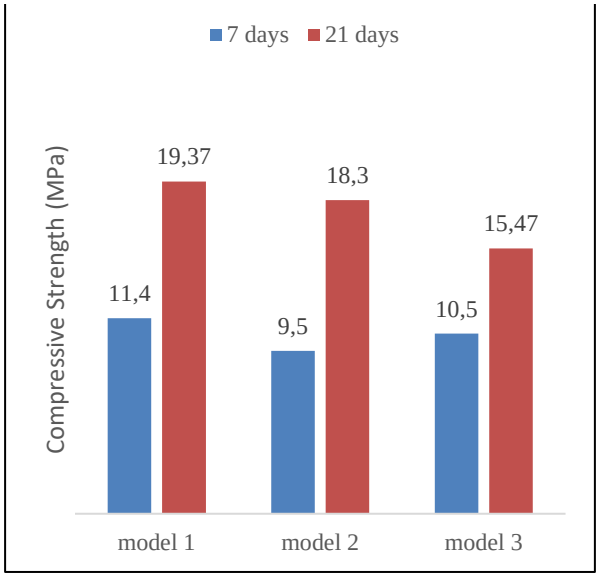


***Figure 7.*** *Compressive strength of paving block with 7% plastic mixture*

### *4.5 Comparison of Various Paving Block Compositions*

To obtain the optimal plastic waste content in paving blocks, a comparison was made between the compressive strength and water absorption results of each mixture. Figure 7 shows the results of the comparison of compressive strength for each mixture of plastic waste. The results show that the maximum average compressive strength at 21 days is owned by paving blocks with a mixture of 2.5%, which is 23.23 MPa. The comparison of the absorption capacity of paving blocks is presented in Figure 8. From the figure, it can be seen that the lowest average water absorption capacity at the age of 21 days is owned by paving blocks with a mixture of 2.5%, 5%, and 7% plastic waste, which is 4.89%. Based on the results of the comparison, the optimal plastic waste content is 2.5% because it has high durability and low water absorption. Paving blocks with a mixture of 2.5% plastic waste can be classified as quality B with an average compressive strength of 23.23 MPa and an average absorption capacity of 4.89%.

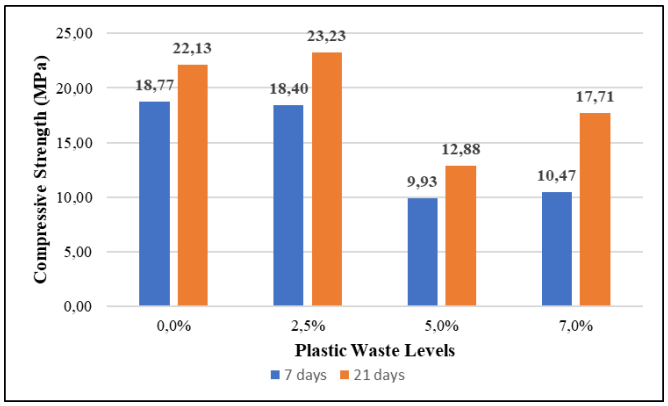


***Figure 7.*** *Comparison of the compressive strength of paving blocks at the age of 7 and 21 days*

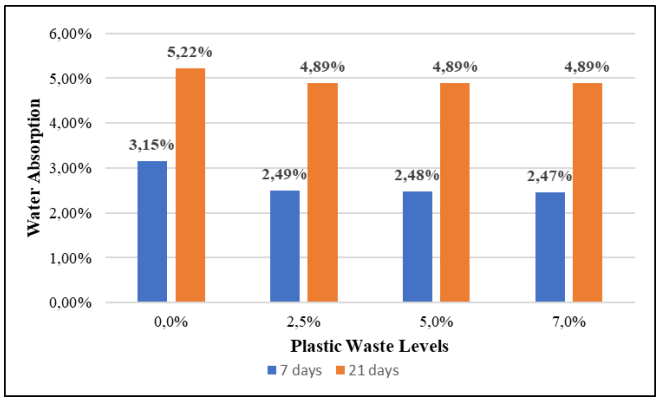


***Figure 8.*** *Comparison of the water absorption of paving blocks at the age of 7 and 21 days*

## 5. Conclusion

The study revealed that polyethylene terephthalate (PTE) plastic waste can be used to manufacture paving blocks. Paving blocks mixed with 2.5% PTE showed the highest compressive strength of 26.2 MPa after 21 days. The lowest water absorption was achieved with a mixture of 2.5%, 5%, and 7% plastic with an average absorption of 6.14%. The best performance was achieved with the 2.5% plastic blend, which offers the best balance between strength and low water absorption. Moreover, the compressive strength of paving blocks using this mixture exceeded the design compressive strength of 20 MPa based on the SNI 03-0691-1996 standard, so it is suitable for use in parking lots with Class B quality.

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