Addition of Gravel in the Manufacture of Paving Block with Water Absorption Capability

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Abstract. Paving block is one of elements that normally used in the pavement. Paving block can be easily made and apply to the road, parking area and yard. Innovations for paving block are carried out according to their intended application. One of them is paving block with water absorption capability to overcome the problem of flooding in Indonesia, especially in urban areas and densely populated during the rainy season. The production of paving block must follow the methods and materials as required by SNI 03-0691-1996, especially in the preparation of mixture, cement: sand/gravel: water. Paving block was designed to absorb water. The use of the materials is adjusted to achieve the quality of paving block. Specimens of sand paving block (PN) were prepared using sand (69.5\%) + cement (30\%) + water (0.05\%). Meanwhile, specimens of gravel paving block (PK) were prepared using gravel (59.5\%) + sand (10\%) + cement (30\%) + water (0.5\%). The results indicate that gravel paving block able to absorb water within 4 seconds/litre/cm\textsuperscript{2} and the compressive strength meet the requirement of SNI 03-0691-1996.

1. Introduction

Indonesia, as known as one of the developing countries in Asia, is required to be more creative and innovative in the field of construction. Especially, in the concrete manufacturing technology. Some innovations were carried out in the manufacturing of paving block to overcome puddles. Many factors cause the occurrence of stagnant water and flooding, namely the amount of rain and water infiltration to the ground. If the amount of rain is greater than the power of land absorption, then there will be puddles and floods. Surface water conditions are influenced by macro and micro land use, where if the land use in the upper area does not support water infiltration into the soil it will cause flooding [1]. Various studies on innovation paving have been done in the manufacture of environmentally friendly paving between a mixture of plastic, bamboo, polyolefin fibres and others [2-15]. Paving is very easy to make and construct which basically use for parking lots and so on. The use of technology will make it easier to construct paving. Researchers are interest in making new breakthroughs to overcome the water in the road, garden and yard which often leaves water in the rainy season. This study aims to determine the absorption capacity of paving block to reduce inundation water and to evaluate the compressive strength of paving block at the age of 14 and 28 days. The benefits of this study to promote paving block that can be used by communities to reduce rainwater as it has a good water absorption.
2. Paving block

2.1. Definition

The paving block, as shown in Figure 1, is a concrete block pavement. It is a modern version of granite block. Paving block is generally used for small roads or vehicle alignments. If paving block is used for many services, fractional or surface recovery problems can be minimized.

![Figure 1. Paving block.](image)

2.2. Classification of paving block

The classification of paving block is based on the making method or production, which can be named as (i) Paving block press manual/hand, (ii) Paving block press vibras/vibrating machine, and (iii) Paving block press hydraulic. Paving block press manual/hand is basically produced manually by hand. This type of paving block includes the type of concrete class D (K50-100). In accordance with its low quality, this type of paving block has a low selling value. While for its use, paving block press manual/hand generally used for non-structural such as home pages, sidewalks and environmental treatments with low loads. Figure 2 shows the paving block press manual/hand.

![Figure 2. Paving block press manual/hand.](image)

On the other hand, paving block press vibras/vibrating machine is produced with a vibrating system press machine and generally has a concrete quality class C-B (K150-250). Figure 3 shows the paving block press vibras/vibrating machine, while Figure 4 shows the mixer for paving block. In its use, paving block press vibras/vibrating machine is widely used as an alternative pavement in the house garage and parking lot. Pervious concrete is identified under this type of paving block [1]. Pervious concrete is a mixture of concrete by reducing or eliminating fine aggregate in its mix proportion. According to ACI 522 R-10 [16], pervious concrete has an air cavity between 15% to 25%, the drain rate of 81 to 703 litres/min/m² and maximum value of 28 MPa compressive strength. Therefore, pervious concrete can
serve as a water catchment area and pavement. Previous concrete is associated with standard paving grade D with average limit compressive strength of 100 kg/cm$^2$ for the park and has porosity value/drain rate of 247.37 and 226.76 litres/min/m$^2$.

Meanwhile, paving block press hydraulic is manufactured by using hydraulic press machines with compressive strength above 300 kg/cm$^2$. This type of paving block can be categorized as paving block with mutton grade B-A (K300-450). The use of paving block press hydraulic is for non-structural and structural purposes that has function for the heavy blocks above, such as road area to the surface of the ground plate.

![Figure 3. Paving block press vibras/vibrating machine.](image)

2.3. Quality and its application

Based on SNI 03-0691-1996 [17], paving block (concrete brick) is a composition of building materials made from a mixture of Portland cement or hydraulic adhesive material like water and aggregates with or without other material that does not reduce the quality of concrete brick. The quality of paving block can be specified by the compressive strength, wear resistance and water absorption. Table 1 shows the quality of paving block as required by SNI 03-0691-1996 [17].

Paving block with good quality has high strength and low absorption rate (percentage of water absorption). Therefore, larger quality characteristics is for strong pressure, while smaller for the
percentage of water uptake. The higher the value of strong pressure, the better the paving block. As for the percentage of water absorption, the lower its value, the stronger the paving block that can produced. Based on SNI 03-0691-1996 [17], paving block with the lowest quality (quality D) at least has compressive strength of 8.5 MPa and maximum percentage of water absorption of 10%. Through the design of the level setting on the top layer of paving block with additional ingredient of rice husk ash, it is expected to increase the strong pressure value and reduce the percentage value of its water uptake.

| Table 1. The quality of paving block. |
|--------------------------------------|
| Type | Compressive Strength (MPa) | Wear Resistance | Water Absorption |
|------|----------------------------|----------------|------------------|
|      | Average | Minimum | Average | Minimum | (Average Maximum) |
| A    | 40      | 35      | 0,090   | 0,103   | 3                |
| B    | 20      | 17      | 0,130   | 0,149   | 6                |
| C    | 15      | 12,5    | 0,160   | 0,184   | 8                |
| D    | 10      | 8,5     | 0,219   | 0,251   | 10               |

SNI 03-0691-1996 [17] recommended that the quality requirements of paving block (concrete brick) as follows: (i) Visible nature - concrete brick is required to has flat surface with no cracks and defects, as well as the corners and ribs are not easily trimmed with the strength of the fingers, (ii) Size - the shape and size of concrete brick for the floor depends on the agreement between the consumer and the manufacturer but the minimum nominal thickness size is 60 mm with ± 8% tolerance, (iii) Physical properties - concrete brick for the floor must have physical strength that can be calculated using Equations (1) and (2), and (iv) Resistance to sodium sulphate - concrete bricks must be tested and not allowed to be disabled, where the maximum allowable weight loss is 1%.

\[
f_c = \frac{P}{L}
\]  
\[
W_A = \left(\frac{A - B}{B}\right) \times 100
\]

where \(f_c\) is the compressive strength, \(P\) is compressive load (N) and \(L\) is the area width press (mm²).

3. Methods and materials

The methods used in this study are specified as follows: (i) The specimens are made with 2 variations, each of which consists of 4 test objects using normal paving and paving test specimens with increased tank, (ii) The test on paving block includes the compressive strength and water absorption, (iii) The sand used is ordinary sand which has a mudflow of 2% (Figure 5), (iv) The aggregate used is gravel from sand screens which usually unused with a size of 20mm (Figure 6), (v) The water used is PDAM water, (vi) The cement used is the Gresik Portlandtozzolan Cement (PPC) (Figure 7), and (vii) The tests are carried out at the age of 14 days (4 holes) and 28 days (4 holes). Figures 8 and 9 display the tests in term of compressive strength and water absorption.

The preparation of specimens starts with an examination of the materials (sand, cement and gravel). In this study, the water content for the SSD condition is 4.2%. The production of paving block in divided into sand paving block (PN) using sand (69.5%) + cement (30%) + water (0.05%) and gravel paving block (PK) using gravel (59.5%) + sand (10%) + cement (30%) + water (0.5%). The details of mix proportion for sand paving block (PN) and gravel paving block (PK) can be referred in Tables 2 and 3, respectively.
Figure 5. Sand.  

Figure 6. Gravel aggregate.  

Figure 7. Cement.  

Table 2. Mix proportion for sand paving block (PN).

| Material | Composition (%) |
|----------|-----------------|
| Sand     | 69,5            |
| Cement   | 30              |
| Water    | 0,5             |

Table 3. Mix proportion for gravel paving block (PK).

| Material     | Composition (%) |
|--------------|-----------------|
| Sand         | 10              |
| Cement       | 30              |
| Aggregate    | 59,5            |
| Water        | 0,5             |

Figure 8. Test for compressive strength.  

Figure 9. Test for water absorption.
4. Results and discussion

Figure 8 shows the physical condition of paving block with the addition of gravel. The addition of gravel is intended to enhance the water absorption ability. It was found that the presence of gravel on gravel paving block (PK) influences the amount of water that able to flow at 1 litre/4 seconds. The greater the composition of gravel, the more cavities can be obtained but contribute to the smaller value of compressive strength. On the other hand, Figure 9 shows the compressive strength of paving block for sand paving block (PN) and gravel paving block (PK). The test for compressive strength was conducted using a hydraulic press machine. It can observe that the obtained compressive strength is comply with the requirement of SNI 03-0691-1996. As paving block is produced manually, the compressive strength for sand paving block (PN) achieved 158 kg/cm² at the age of 14 days and 259 kg/cm² at the age of 28 days. Gravel paving block (PK) has the compressive strength of 81 kg/cm² at the age of 14 days and 111 kg/cm² at the age of 28 days. Sand paving block (PN) consists of dense materials which directly affect the compressive strength compared gravel paving block (PK) which has cavities.

![Physical condition of paving block](image1)

Figure 10. Physical condition of paving block.

![Compressive strength of paving block](image2)

Figure 11. Compressive strength of paving block.

5. Conclusion

The tests on the paving block revealed the results of compressive strength with value of 111 kg/cm². This is reached the target of compressive strength as lowest requirement by SNI 03-0691-1996 is setup at 100 kg/cm². Based on the results, gravel paving block (PK) that can permeate water is classified into quality D. This type of paving block can be applied to non-structural parts in the construction such as land cover in city parks, home yards and other places.
6. References

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Acknowledgments
Thanks to the Ministry of Research, Technology and Higher Education and Coordination of Private University Region VII which has funded and provide full support in conducting this study.