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# Characteristics of Paving Blocks with Addition of Mask Waste Fiber

I Putu Agus Putra Wirawan [a)]*, I Gede Gegiranang Wiryadi [a)], I Kadek Ardi Putra[b)], I Made Wahyu Wijaya [b)], I Nyoman Waisnawa Budiswara [b)], Dewa Agung Dibyacitta [b)], Ida Bagus Gede Mahardika [a)]

Author Affiliations
[a]*Civil Engineering Department, Universitas Mahasaraswati Denpasar, Bali, Indonesia, 80223*
[b]*Environment Engineering Department, Universitas Mahasaraswati Denpasar, Bali, Indonesia, 80223*

*Author Emails*
*Corresponding author: agusputrawirawan2020@unmas.ac.id

**Abstract.** An increase in the generation of disposable mask waste during a pandemic causes environmental pollution if it is not handled immediately. One of the handling efforts that can be an alternative is to add mask waste fibers into a mixture of paving blocks. This study was to define the characteristics of paving blocks with the addition of mask waste fibers. Parameters tested in this study include compressive strength, absorption, and permeability according to (1) testing standards. A paving block of 20x20x6 cm was used as a test object for absorption and permeability. Meanwhile, the compressive strength test was carried out on smaller specimens (6x6x6 cm). Variations in the addition of mask fibers used were: 0%, 0.125%, 0.25%, 0.375%, 0.50%, and 0.75% of the specimen's weight. The compressive strength test showed a decrease of 30.93% - 60.68%. The absorption of paving blocks with the addition of mask fibers increased in all specimen by 0.86% to 1.71%, respectively, for variations of 0.125% - 0.75%. The highest permeability was found in the specimen with a fiber content of 0.25%, which was 0.22 mm/minute. The addition of mask fibers to the paving block also prevents the paving from breaking instantly when the maximum load is exceeded. In other words, the ductility increases. With these characteristics, the mask fiber can be an additional material in the paving block mixture with the recommended optimum fiber content of 0.125%. The estimated mask waste used in 1 m3 of mixed paving block material is 2.42 kg or about 603 masks.

**Keywords**: absorption, compressive strength, mask fiber, paving block, permeability

## INTRODUCTION

During the coronavirus disease (Covid-19) pandemic, the application of health protocols using medical masks is not only used by medical personnel but also by the entire community. The medical masks used by the community are disposable medical masks and are simply thrown away. This causes an increase in the generation of mask waste in the surrounding environment without adequate special management. Moreover, disposable masks are infectious if used by someone who has Covid-19 (2). The use of masks based on a survey conducted (3) obtained two masks/person/day. These disposable medical masks are made of polypropylene (plastic) material with the characteristics of being challenging to decompose naturally (4).

The control of single-use medical mask waste generally carries out is destruction with an incinerator and compaction (solidification) and recycling into other physical materials (5). The method of compaction (solidification) has been widely used in construction materials, one of which is material with the addition of natural, artificial, steel, plastic, and other fibers, which in civil engineering is called fiber concrete. This polypropylene mask material is a type of plastic fiber used as a mixture of fiber concrete and paving blocks. The use of fiber has been

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widely developed, such as strengthening structural elements, repair materials, recycled materials, and other construction needs (6). A paving block with fiber used as a road surface cover is a mixture of cement, sand, and water. The results of (7) increased the compressive strength value, 516%, and increased absorption. There are several studies related to the use of fiber in construction materials, including the use of recycled rubber, plastic, wood, and steel fibers (8), (9) and (10) conducted a study of the characteristics the use of natural fibers, (11) studied paving blocks with coconut fibers. (12) conducted a study related to bagu leaf fiber. (13,14) conducted a test on road pavement materials with the addition of fiber, the results obtained were an increase in strength with a percentage of fiber addition of 1-2%.

Polypropylene is a category of plastic fiber which is the main ingredient in the preparation of disposable medical masks. To overcome the problem of mask waste, the use of mask fibers to mix paving blocks as a construction material that is in great demand and needed by the community is one solution. Therefore, it is necessary to test the characteristics of paving blocks with disposable medical mask fibers to determine the optimum level used in the mixture. The method of making mask fibers can be seen in (3). The fiber content of the mask in the mixture was calculated based on the total weight of the paving block specimen. Characteristic tests carried out are compressive strength, permeability, absorption, and comparison of specimen weight.

## SIGNIFICANT RESEARCH

There is no special handling of medical mask waste during the pandemic, resulting in significant waste generation. Moreover, medical mask materials are tough to decompose naturally. Medical masks consist of polypropylene, a plastic material to be used as plastic fiber as a paving block mixture. Therefore, it is necessary to test characteristics such as compressive strength, permeability, absorption, and weight of the test object. In addition to the characteristics, this research is expected to be used as a guide in manufacturing paving blocks with optimum mask fiber content.

## METHOD

The mask fibers collected only come from household waste. Medical or hospital activity mask waste is not recommended because it is an infectious waste of B3 waste. Even though it comes from household waste, this research is still carried out with strict health protocols. The first treatment was sterilization of the mask waste, followed by separating the rope and wire contained in the mask. After that, the mask layers are shrunk, and the mask fibers are taken, ready for paving block mixtures (3).

*Sterilization* | *Separation of wire and rope* | *Fiber extraction* | *Mask fiber*

**Figure 1.** The process of taking the mask fiber

The main ingredients for using paving blocks are natural materials originating from Karangasem Regency, including sand and stone ash. The material was first examined in this study, namely specific gravity, absorption or water content, sand content, and gradation based on the two types of material. The tests were carried out based on (15) on material testing standards and the manufacture of paving blocks and referring to ASTM (American Standard Testing of Materials) testing of aggregate materials (1), fine aggregate in which all the grains pass through a 4.75 mm sieve while the WCF (water-cement factor) based on (16).

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**Figure 2.** Pictures of sand (left) and stone ash (right)

After testing the materials, a mixed design was made with a design quality of K250 or 21 MPa. Still, because the paving blocks at the factory were made at that time with a quality of K200 or 17 MPa, the proportion of mix for paving blocks with a quality of K200 was 1:2:2 for cement, sand, and rock ash, respectively. After the proportion of the paving mixture is obtained, the fiber content of the mask to be used is calculated. Mixing of mask fibers was calculated based on the total weight of one specimen with percentages of 0%, 0.125%, 0.25%, 0.375%, 0.5% and 0.75%. The number of test objects to be made is 18 paving blocks measuring 20x20x6 cm.

**TABLE 1.** Quantity of specimens

| Code | Variation in fiber content | Quantity of specimens |
|---|---|---|
| K1 | 0 % | 3 |
| K2 | 0,125% | 3 |
| K3 | 0,25% | 3 |
| K4 | 0,375% | 3 |
| K5 | 0,50% | 3 |
| K6 | 0,75% | 3 |
| | Total | 18 |

The compressive strength test was carried out at the age of 28 days with a universal test tool with a capacity of 2000 kN. Each variation was tested by 3 (three) test objects whose test results were sought for the average value. Before testing the compressive strength of the specimen, it is necessary to cut it into 6x6x6 cm cubes. It is tested with water absorption, permeability, and weight using intact paving. The absorption test was carried out by measuring the dry and wet weight of the paving blocks that were soaked for 24 hours. Permeability testing is testing the speed of water that can penetrate the paving. Paving is placed in the center of a glass container with glue on the edges in direct contact with the glass wall to avoid water seeping through the gap. The puddle in Figure 5. is given as high as 40 mm, and its decrease is measured for one hour. The comparison of the weight of the specimen was carried out by being weighed to determine the effect of weight due to the addition of mask fibers into the mixture of test objects.

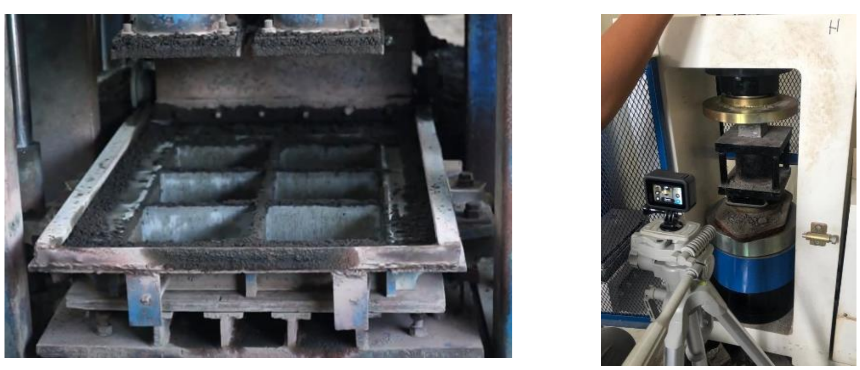

**Figure 3.** Specimen mold (left) and universal test equipment (right)

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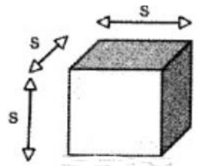


$$\sigma' = \frac{P}{A} \quad (1)$$

$$\sigma'_{rata-rata} = \frac{\Sigma\sigma'}{n} \quad (2)$$

**Figure 4.** Testing scheme of compressive strength

**Figure 5.** Absorption (left) and permeability testing (right)

## RESULTS AND DISCUSSION

### Testing concrete constituent material properties

The proportion of the paving block mixture is based on the properties of the constituent materials. The paving blocks were tested for cement, sand aggregate, and stone ash. Tests based on (1) to determine the characteristics of the fine aggregate, (15) to determine the fas and (16) to determine the specifications to achieve the target. The test results of cement, sand, and rock ash are shown in Table 2, Table 3, and Table 4. The properties of these constituent materials are used as the basis for making paving block mixtures.

**TABLE 2.** Properties of cement

| No | Parameter | Value | Unit |
|---|---|---|---|
| 1 | Fill weight | 1.294 | $g/cm^3$ |

**TABLE 3.** Properties of fine aggregate (sand)

| No | Parameter | Value | Unit |
|---|---|---|---|
| 1 | Fill weight | 2,56 | g/cm3 |
| 2 | Moisture content | 14,81 | % |
| 3 | Water absorption | 2,88 | % |
| 4 | Gradation | zone 3 | |

**TABLE 4.** Properties of fine aggregate (Stone Ash)

| No | Parameter | Value | Unit |
|---|---|---|---|
| 1 | Fill weight | 2,6 | $g/cm^3$ |
| 2 | Moisture content | 17,63 | % |
| 3 | Water absorption | 3,73 | % |
| 4 | Gradation | zone 3 | |

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## Mix designs and additional proportions of mask fibers

The procedure for making a mixture of paving blocks based on (16) which refers to (1), can be seen in Figure 7. The proportion of the mixture of constituent materials is determined from property testing results. The proportions of each material can be seen in Table 5. The weight of the paving block for the quality of 17 MPa or K200, which is 5040 gr, is used as a reference for comparing materials and the addition of mask fibers. Three intact specimens were made for each variation, which can be seen in Table 6. One of the specimens was cut into four cubes, and the rest were used for absorption, permeability, and weight testing.

**TABLE 5.** Material proportion

| Mixed by weight (SSD) | water | cement | sand | Stone ash |
|---|---|---|---|---|
| Weight of material per one paving | 443,52 | 1008 | 2016 | 2016 |
| per concrete mixing ratio | 0,44 | 1 | 2 | 2 |

**TABLE 6.** The mask fiber for each specimen

| Specimen Code | Variations of masks fiber | Number of specimens | Mixture weight (g) | mask fiber required weight (g) |
|---|---|---|---|---|
| K1 (1-3) | 0% | 3 | 15.120 | 0 |
| K2 (1-3) | 0,125 | 3 | 15.120 | 19 |
| K3 (1-3) | 0,25% | 3 | 15.120 | 38 |
| K4 (1-3) | 0,375% | 3 | 15.120 | 57 |
| K5 (1-3) | 0.50% | 3 | 15.120 | 76 |
| K6 (1-3) | 0,75% | 3 | 15.120 | 113 |

**FIGURE 6.** paving mixing (left) and molding process (right)

**FIGURE 7**. Whole block paving test object

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**FIGURE 7.** The paving cutting process and the shape of the paving block cube test object

## Compressive strength of paving blocks

The test for compressive strength of paving blocks refers to (15) for testing cube paving blocks. Observations were made, starting from mixing to strength testing. The first observation, a visual assessment of the mixture, was carried out by holding the mixture whether it was thoroughly mixed. The addition of mask fibers causes the mixture to become drier. Thus, it is necessary to add more water to accept the visual assessment. A universal machine tested all the cube-shaped specimens for compressive strength after 28 days. Before testing, all specimens were weighed first.

**TABLE 8.** Compressive strength

| Specimen Code | Level of Fiber (%) | Compressive Strength (MPa) | | | Average | Decrease |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | | (%) |
| K1 | 0 | 109.55 | 136.52 | 121.26 | 122.44 | 0.00 |
| K2 | 0.125 | 81.48 | 84.48 | 87.75 | 84.57 | 30.93 |
| K3 | 0.25 | 57.50 | 82.30 | 51.78 | 63.86 | 47.85 |
| K4 | 0.375 | 85.02 | 108.73 | 58.59 | 84.11 | 31.31 |
| K5 | 0.5 | 83.66 | 100.28 | 70.31 | 84.75 | 30.79 |
| K6 | 0.75 | 44.42 | 53.41 | 46.60 | 48.14 | 60.68 |

The results of testing the compressive strength of paving blocks due to the addition of mask fibers experienced a significant decrease, namely 30.93% - 60.68%, can be seen in Table 8 and Figure 8. The decrease was not linear because there was an increase in the K4 and K5 test objects and decreased again in the test specimens. K6. There is also an increase in ductility in paving blocks where the test results show the additional mask fibers are not crushed (brittle) like paving blocks without mask fibers. The strength value still acceptable is the mask fiber content of 0.125%.

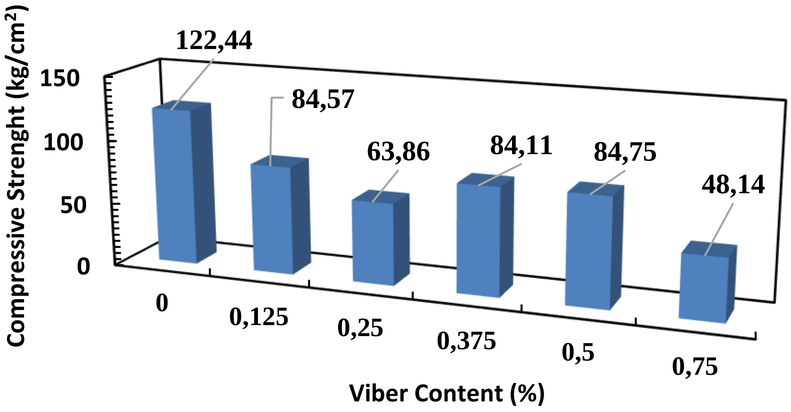


**FIGURE 8.** Graph of compressive strength

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*(without fiber)* *(with fiber)*

**FIGURE 9.** Compression strength test failure ratio

The absorption of paving blocks added with mask fiber increased 0.86% - 1.71%, respectively, from the test specimens K2 to K6. The increase in absorption occurred along with the increase in the fiber content of the added mask.

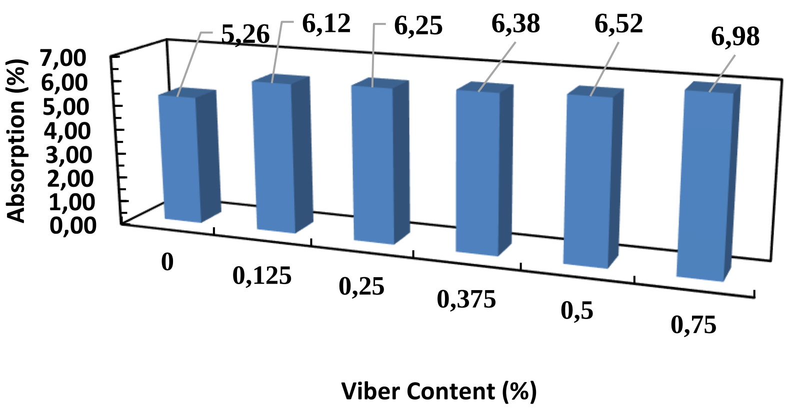


**FIGURE 10**. Graph of water absorption

The K3 test object indicates the maximum permeability with a mask fiber content of 0.25%. The increase in permeability occurred in the test objects K2, K3, and K4, while the test objects K5 and K6 only increased slightly.

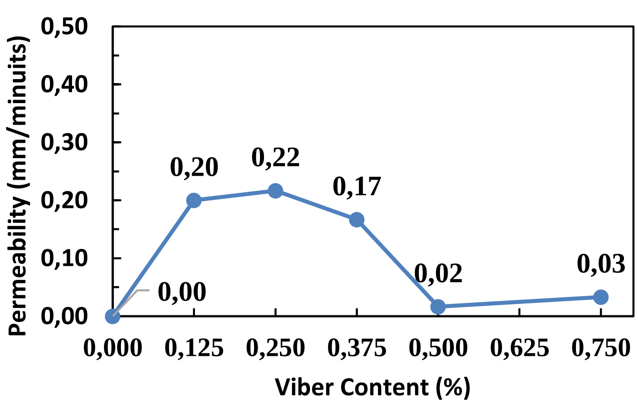


**Figure 11**. Graph of permeability

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The following compares the weight of paving blocks without and with mask fibers presented in the form of tables and graphs.

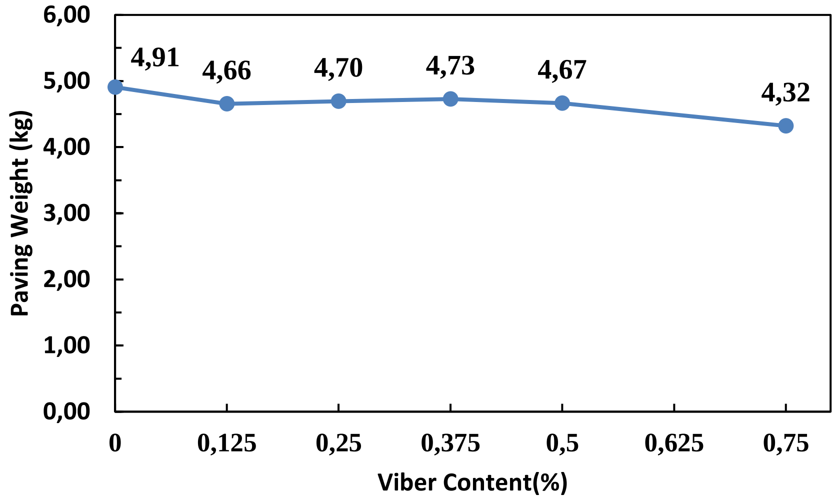


**FIGURE 12.** Graph of Paving Weight

## CONCLUSION

As a step to reduce the waste of disposable medical masks during the pandemic, it is possible to use mask fibers into a mixture of paving blocks with an optimum level of 0.125% of the total weight of one test object. There was a decrease in strength of 30%, an increase in absorption of 0.86%, and a permeability of 0.2 mm/min. Ductility increases with the addition of mask fibers to prevent sudden disintegration (brittle). With these characteristics, the mask fiber can be an additional material in the paving block mixture with the recommended optimum addition value of 0.125%. The estimated amount of mask waste used in 1 m3 of mixed paving block material is 2.42 kg or the equivalent of 603 masks.

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