

Design and Prototype of Paving Block Making Machine

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ABSTRACT

Paving Block (Conblock) is a kind of the building materials used for footing or roads. As same as bricks, paving block made from a mixture of cement, sand and water. Currently, home industries generally still use manual paving block printing tools. Where the paving block dough is put into the mold, then closed and after that, it is beaten to compact the dough. Although there are many paving block making machines in the markets, the cost is still expensive. So, efforts are still being made to find paving block making machines that are cheap, have low operating costs and low maintenance costs, as well as adequate production speed. This research attempts to increase production speed with simple and cheap equipment.

Keywords: *paving block, conblock*

1. INTRODUCTION

Paving Block is a building material product made from a mixture of cement, sand, and soil which is used as an alternative to cover or harden the soil surface. Based on Indonesian National Standar 03-0691-1996, a paving block is a composition of building materials made from a mixture of Portland cement or other hydraulic adhesives, water, and aggregate with or without other additives that do not reduce the quality of the concrete. The classification of paving blocks based on Indonesian National Standar 03-0691-1996 is differentiated according to the class of use:

1. A quality concrete brick is used for roads
2. B-quality concrete bricks is used for parking lots
3. C-quality Concrete brick is used for pedestrians
4. D-quality Concrete quality is used for gardens and other applications

Paving blocks that are produced generally use D quality concrete bricks with a composition of cement and sand 1: 5. Besides, several things need to be considered in determining the quality of paving blocks which must meet the requirements of SNI 03-0691-1996, including the following:

- a. Appearance
 - a paving block must have a flat surface, without cracks and defects, the corners and edges are not easily trimmed.
- b. Shape and Size

Paving blocks must have a minimum nominal thickness of 60 mm with a tolerance of $\pm 8\%$.

c. Physical Properties

Paving blocks for floors must have the following physical strength:

Tabel 1. Paving Block Physical Strength Standards

| Quality | Strength (Mpa) | | Wear resistance (mm/menit) | | Water Absorption |
|---------|-------------------|------|----------------------------------|-------|---------------------|
| | Ave | Min | Ave | Max | Max (%) |
| 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 |

Source: Indonesian National Standar 03-0619-1996

In terms of usage, the shape and pattern of paving blocks can be adjusted to the needs of pavement construction on roads with moderate to heavy traffic (for example roads, industrial areas, public roads, and so on).

(Kuipers, 1984 in Artiyani, 2010) in his research concluded that use for medium and heavy traffic is more suitable when using a paving block with a rectangular shape because of its constant locking properties and

easy to pull out if at any time there will be repairs. Apart from that, for light construction purposes, for example for sidewalks, plazas, parking lots, neighborhood roads, rectangles or multi-facets can be used.

At this time, home industries generally still use manual paving block printing tools. Where the paving block dough is put into the mold, then closed and after that, it is beaten to compact the dough. Although there are many paving block printing machines in circulation, the cost to buy them is still relatively expensive. So that efforts are still being made to find a paving block molding machine that is cheap, low operating costs and low maintenance costs.

Rudi et al (2002), made a brick-forming machine with a hydraulic system with six molds. In the process of operation, the machine uses a 100-watt electric motor power. The motor power serves to relieve the bricklayers' workers during the production process so that the power output by the bricklayers is not too big. In addition to increasing the wages of brick-making workers, the machine can also help brick-making workers simplify the brick-making process.

Hardjuno et al (2013), designed a paving block molding machine with a capacity of 7 paving blocks per pressing. Paving block molding machines are designed to use a manual pressing mechanism to print paving blocks. The paving block molding machine uses a "sand carrier" to transfer the sand from the hopper into the paving mold.

Meri Rahmi et al (2018), made a paving block-printing machine with a pneumatic system for the Home Industry in Indramayu Regency. One printing process produces two paving blocks at once and reduces the process stages, from the manual method with six stages to four stages. The time required is 52% faster and productivity yield increases to 60% within one working day (8 hours of work / normal shift).

Sandi (2019), researched the effect of the vibration frequency of a paving block making machine on the compressive strength of paving blocks. In the research conducted, Sandi (2019) concluded that the frequency of machine vibrations will affect the compressive strength of paving blocks. Where the higher the vibration frequency is given, the higher the compressive strength that the paving block can withstand.

Yanita (2017), from her research, concluded that there is a pressure strength conversion factor in the paving block manufacturer with the test object standard in the ASTM C39 standard press tool test. Without the conversion factor, the results obtained will be greater than it should be. This will endanger the construction because the material obtained has a compressive strength value that is below standard.

Besides, research was also carried out by Helmahera, et al. (2016) on paving blocks made with a mixture of soil and limestone which was carried out by a curing process. The result is that the curing process will affect the compressive strength of the paving blocks, where the longer the curing process will increase the compressive strength of the paving blocks.

Nurzal, et al. (2016) examined the effect of pressure variations during the printing process on the results of testing the compressive strength of paving blocks with the addition of 5% fly ash. The results obtained are (1) the addition of 5% fly ash will increase the compressive strength of the paving block, (2) the addition of pressure will increase the compressive strength of the paving block, where the pressure of 95 kg / cm² will provide a compressive strength of 36.1 Mpa.

Nurzal, et al (2014) have also examined the effect of time variations used for the drying process of paving blocks with the addition of 5% fly ash on water absorption and specific gravity. The research, which was carried out by providing variations in drying time with time ranges of 7, 14, 21, 28, and 35 days, concluded that the longer the drying time, the absorption of paving blocks to water will also increase, while the density will decrease. Dalam hal pemakaian, bentuk dan pola *paving block* dapat disesuaikan dengan keperluan konstruksi perkerasan pada jalan dengan lalu lintas sedang sampai dengan lalu lintas berat (misalnya : jalan raya, kawasan industri, jalan umum, dan lain sebagainya).

2. PAVING BLOCK MOLDING TOOLS PLANNING

The paving block molding tool is a tool used to print a combination of sand, cement, and water using a special mold assisted by the pressing process of the dough mold that has been made according to the percentage ratio of the composition between mixing sand, cement, and water to form a finished object. according to the form of the mold that has been made previously.

2.1. Material Selection

In planning a tool or machine, considerations for choosing materials are very important before making calculations. In the maintenance of this material, it must also be considered the capability of the material, the function and force received from the material and the stresses that the object can withstand during operation, and whether or not the material is easily available on the market. The choice of this material has the aim of making efficient use of materials so that the selling price of the product can compete in the market.

The things that need to be considered as a factor in the selection of this material are:

1. Following the function

The material chosen must be adapted to the function of the components to be made, for example, the components that are directly related to the material or dough to be molded must be resistant to corrosion. Because it can affect the results of printing (perfect or not).

2. Easy to get

The material chosen must also be considered whether the material is easily available in the market. This is because, even though the materials we are planning are ripe, but if they are not supported by market availability, our planning will be difficult to realize.

3. Cheap

The selected component materials should be sought for materials with relatively low prices. This also aims to reduce production costs and the selling price of this product or tool to compete in the market.

4. Easy to work with

The components to be worked should be as easy as possible with conventional machines which are common.

5. Efficiency in planning and usage

The advantages of using a substance should outweigh the disadvantages. As far as possible the tools are made simple, easy to operate, maintenance and repair costs are relatively low but provide satisfactory results.

2.2. *Materials Used*

In planning a tool, considerations for selecting materials are very important before making calculations. In the maintenance of this material, it is also necessary to consider the capability of the material, the function and force received from the material, and the stresses that the object can withstand during operation.

The materials in the planning of a paving block molding tool using a hydraulic jack include:

1. Iron Plates

2. Bolts and nuts

3. Order

4. Spring

5. Shaft

6. Bushing

7. Hydraulic jack

2.3. *Expenses That Occur*

In making paving block molding tools using hydraulic jacks, the loads that occur are:

1. Shear Stress

The shear stress that occurs due to load (F) at a load is perpendicular to the shaft axis and parallel to the cross-sectional area (A).

2. Surface Bending Tension

If an object is subjected to a load (F) whose direction is perpendicular to the cross-sectional area (A) and there is a contact area, then the object experiences surface bending stress.

3. Tensile Stress

Objects subjected to or subjected to a large load (F) leading outward. The direction is parallel to the axis of the rod and perpendicular to the cross-sectional area (A), then the object experiences tensile stress.

4. Compressive stress

An object that experiences a large load (F) and goes inward, is parallel to the axis of the stem and is perpendicular to the cross-sectional area (A), then the object experiences compressive stress.

5. Voltage Bending

An object that is subjected to or is subjected to a load (F) whose direction is perpendicular to the axis of the rod and parallel to the cross-sectional area (A) and the distance (L), then the object experiences bending stress.

6. Buckling stress

Binding or bending is the event of bending a beam or rod due to a load or compressive axial force.

2.4. *Manufacture and Assembly*

Based on the consideration of material selection, and calculation of the load that occurs, the design is as follows to the fig. 1 as below:

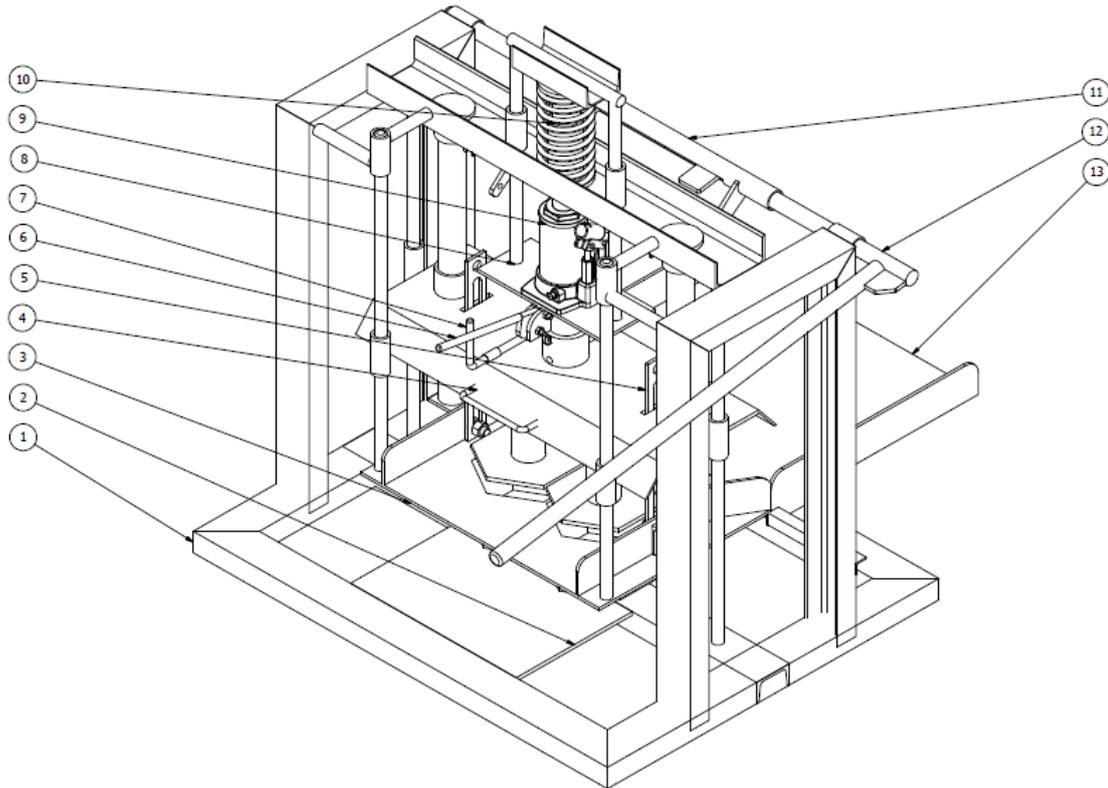


Fig. 1. Paving Block Molding Tools Design

The parts of paving block molding tools are:

1. Frame
2. Mold Table mount plate
3. Table Mold
4. Transport Plate
5. Stopper Lever
6. Lock Lever
7. Mold Pressing Plate
8. Mount Jack
9. Jack
10. Spring
11. Lifting Pipe
12. Lifting Shaft
13. Dough Table

3. TOOL'S TESTING

Tool testing is the most important step in making a tool. With a test, we will find out the advantages and disadvantages of the tools that we make, so that when the tools are made, they meet the requirements and can be accepted on the market and ready to be used for production.

3.1. Testing Method

A test is carried out with a variety of methods, this time the test is carried out using the sampling method. The sampling method was chosen because the research was more aimed at collecting data in the field related to the amount of time, effort, cost, and pressure required in

the testing process. Therefore, it needs to be realized that sampling must be carried out appropriately and appropriately because this is related to the conclusions to be made. The data collection step was carried out, starting from the preparation of the raw material for the mix, followed by filling the material into the mold until the paving blocks that had been printed were taken.

After being designed and made, the tool is tested using the following tests:

1. Prepare a mixture of sand, cement, and water with a predetermined composition referring to SNI 03-0691-1996.
2. Put the prepared mixture in the container that has been prepared on the appliance.
3. Stir the sand and cement until the mixture is cooked then add water and stir again until blended.
4. Put the dough using a mixing carrier into the mold until blended and fill all the spaces in the mold.
5. After stirring evenly on the mold, do the pressing process. Close the lock on the hydraulic jack. Then open the lock on the mold lid.
6. Lock the stopper by pulling the lever provided.
7. Press the jack as much as thirteen to fifteen times until the dough is solid.
8. Then open the jack lock to cause the jack to return to its original position and raise the mold cap.
9. Then unlock the stopper by pushing the lever provided.

10. Next is the process of making the dough from the mold by pressing the lifting lever that has been provided until the mold cover and bottom mold are lifted. Then close the lock again on the lid of the mold.
11. The paving block dough that has been printed is ready to be taken and dried in the sun.
12. The finished paving blocks are ready to be tested for strength in the laboratory.
13. Sampling is done by carrying out the production process 15 times.

3.2. Testing Process

In the manufacturing process in the field, mass-produced paving-blocks, and marketing, usually the ratio of the dough composition between Portland sand and cement is one to nine (1: 9), where one sack of cement and nine sacks of sand. Marketers choose this mix because it reduces the capital cost of making these paving-blocks.

However, in this testing process, it is better if the form of composition ratio between the mixture of dough is one to six (1: 6) using a water bucket as a reference for the volume of the composition. This is following SNI 03-0691-1996 concerning the composition of the paving-block making mix and SNI 03-6882-2002 concerning the compressive strength of type N Mortars, namely portland cement mixtures with medium compressive strength which have a minimum compressive strength of 5.2 Mpa. and used for open pairs on the ground.

3.3 Test Results

3.3.1. Paving Block Thickness Shrinkage

The process of putting the dough into the bottom mold is carried out until it is full and even then

compacted, causing the dough to be depressed and experience shrinkage. The shrinkage that occurs between the paving-block molds and the finished paving block prints of course varies.

To fill in the height of the finished paving-block results, it is taken from the average results in the experiment.

Table 2. Paving Block Thickness Data

| No. | Paving-Block Thickness | Thickness Reduction | Percentage Reduction |
|---------|------------------------|---------------------|----------------------|
| 1 | 7.2 cm | 2,8 cm | 28% |
| 2 | 7.3 cm | 2,7 cm | 27% |
| 3 | 7.2 cm | 2,8 cm | 28% |
| 4 | 7.3 cm | 2,7 cm | 27% |
| 5 | 7.4 cm | 2,6 cm | 26% |
| 6 | 6.8 cm | 3,2 cm | 32% |
| 7 | 7.0 cm | 3,0 cm | 30% |
| 8 | 7.0 cm | 3,0 cm | 30% |
| 9 | 6.9 cm | 3,1 cm | 31% |
| 10 | 6.7 cm | 3,3 cm | 33% |
| 11 | 6.8 cm | 3,2 cm | 32% |
| 12 | 6.6 cm | 3,4 cm | 34% |
| 13 | 6.7 cm | 3,3 cm | 33% |
| 14 | 6.7 cm | 3,3 cm | 33% |
| 15 | 6.4 cm | 3,4 cm | 34% |
| Average | 6.9 cm | 3,1 cm | 31% |

Based on table 2, a graph can be made as shown in Figure 5.2 below. The highest compaction is in the 15th printing process with a thickness reduction of 34%, the final thickness is 6.4 cm. while the lowest thickness reduction was 26% in the 5th printing process with a final thickness of 7.4 cm.

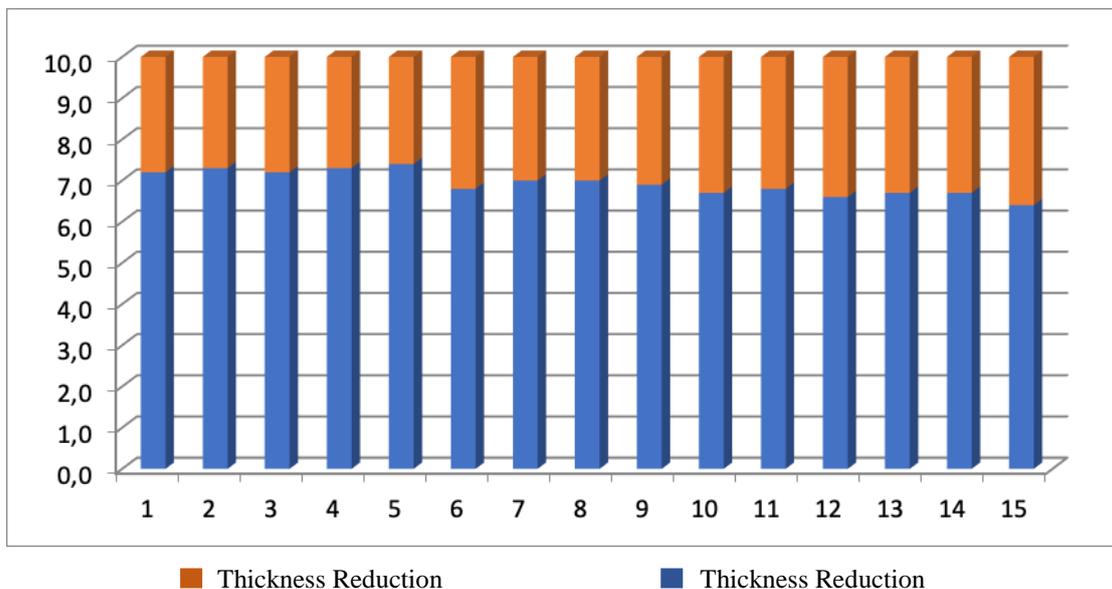


Figure 2. Paving Block Thickness Data

3.3.2. Compressive Strength of Paving Blocks

After 15 times the molding process, 30 paving block samples were obtained which were tested for strength in the laboratory. The test was carried out at the Material Testing Laboratory, Civil Engineering Department of Sriwijaya State Polytechnic. Of all the samples tested, the results of the load that can be withheld by each paving block produced by the Paving Block Molding Tool were obtained in this study. The results data obtained from the tests carried out can be seen in Table 3.

Table 3. Paving Block Sample Test Results

| No. | Paving-Block Thickness | Compressive strength of Mold A (kN) | Compressive strength of Mold B (kN) |
|---------|------------------------|-------------------------------------|-------------------------------------|
| 1 | 7.2 cm | 32 | 29 |
| 2 | 7.3 cm | 31 | 33 |
| 3 | 7.2 cm | 38 | 39 |
| 4 | 7.3 cm | 31 | 34 |
| 5 | 7.4 cm | 34 | 35 |
| 6 | 6.8 cm | 33 | 34 |
| 7 | 7.0 cm | 32 | 31 |
| 8 | 7.0 cm | 49 | 38 |
| 9 | 6.9 cm | 34 | 33 |
| 10 | 6.7 cm | 34 | 35 |
| 11 | 6.8 cm | 31 | 33 |
| 12 | 6.6 cm | 35 | 35 |
| 13 | 6.7 cm | 32 | 32 |
| 14 | 6.7 cm | 33 | 35 |
| 15 | 6.4 cm | 41 | 40 |
| Average | 6.9 cm | 34,7 | 34,4 |

3.3.3. Production Cycle Time

In the process of paving-block dough molding using a hydraulic jack with a five-ton capacity. The data obtained from the test results are as follows:

| No. | Production Steps | Time (second) |
|-----|--|---------------|
| 1. | Put the dough on the mold using a sand-carrier. | 20 |
| 2. | Flatten the dough on the mold using a cement spoon. | 15 |
| 3. | Locking jack. | 5 |
| 4. | Unlock the mold lid. | 2 |
| 5. | Close the stopper lever. | 5 |
| 6. | Perform compaction using a jack. (average time on fifteen tests) | 15 |
| 7. | Unlock the jack. | 5 |
| 8. | Unlock the stopper lever. | 5 |
| 9. | Pressing the mold cover lifting lever and the bottom mold. | 10 |
| 10. | Close the mold lid lock. | 3 |

| | | |
|------------|----------------------------|----|
| 11. | Lifting paving-block dough | 5 |
| Cycle Time | | 90 |

So the time needed to carry out the paving-block printing process from inserting the dough to removing the dough from the mold is 90 seconds for one cycle production with the result of 2 paving blocks.

If the working time is calculated as 8 hours per day, then in a day it can produce 640 pieces of paving blocks.

4. CONCLUSION

Based on the final results of the design, the following conclusions are obtained:

1. Paving block molding equipment has been designed and manufactured that meet the production criteria.
2. The height of the paving block dough obtained is 6.9 mm, with a shrinkage percentage of 31%, and compressive strength of 13.282 kgf/cm².
3. The production of paving blocks per day that can be produced by using a paving block molding tool is 640 paving blocks.

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