Addition of Cold Milling Waste to Increasing Compressive Strength and Water Absorption in Batako

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ABSTRACT

The development of construction in Indonesia drives the need for more efficient and environmentally friendly building materials. One of the proposed innovations is the utilization of cold milling asphalt waste as a mixture of fine aggregate in making bricks. This study aims to determine the effect of variations in the addition of asphalt waste on the compressive strength and water absorption of bricks. The problems raised in this study include how variations in the addition of asphalt waste to bricks affect their mechanical properties. The study was conducted experimentally by making 12 brick samples measuring 30 x 15 x 10 cm using variations in asphalt waste mixtures of 0%, 20%, 25%, and 30%. Testing included compressive strength and water absorption tests at the ages of 7 and 28 days. The results showed that the addition of asphalt waste affected the characteristics of bricks. In a mixture of 30%, bricks showed the highest compressive strength value of 7.9 MPa after 28 days, while water absorption increased with increasing percentage of asphalt waste. These results indicate that asphalt waste can be used as a partial substitute for sand in making bricks without significantly reducing their structural strength. The novelty of this research lies in the use of cold milling asphalt waste which has not been widely applied to brick materials. This study concludes that cold milling asphalt waste can be used as a mixture in brick production to reduce construction waste while supporting the concept of sustainable development. This innovation provides a solution for construction entrepreneurs in creating more economical and environmentally friendly products.

Keywords: asphalt waste, bricks, compressive strength, water absorption, cold milling.

INTRODUCTION

The development of technology in the construction sector in Indonesia continues to increase, this is inseparable from the demands and needs of the community for increasingly advanced infrastructure facilities, such as bridges, high-rise buildings, and other facilities [1]. Many studies and research have been carried out to obtain strong and efficient construction specifications, including bricks which are components that are almost always used in every construction [2].

Bricks or concrete molding stones are building material elements obtained by mixing fine aggregate (sand), coarse aggregate (gravel), or other types of aggregate and water, with the help of cement or other hydraulic cements, sometimes with additional materials (addictives) that are chemical or physical in certain proportions, until they become a homogeneous unit. The mixture will harden like a rock. Hardening occurs due to the chemical reaction between cement and water [3]-[6]. Bricks are also considered to have better soundproofing than red bricks. Bricks are currently very popular because they are considered more efficient in making and working on walls. In its manufacture, bricks do not require a firing process like making red bricks [7]-[9].

Bricks must be designed with a mixture proportion to produce the required average compressive strength. At the construction implementation stage, bricks that have been designed with a mixture must be produced in such a way as to reduce the frequency of bricks with lower compressive strength than that required [5], [8].

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Bricks consist of two types, namely hollow bricks and solid bricks. From the drying results, it can be seen that solid bricks are denser and have better strength. Hollow bricks have a cross-sectional area of holes and the contents of each hole do not exceed 5% of the total surface area [5], [7], [9].

Types of bricks according to SNI 03-03-0349-1989, namely solid bricks and hollow bricks from research results [3], [4] solid bricks have a denser structure because they have better strength from the composition of their composition and good bricks to use are those whose surfaces are flat and perpendicular to each other.

Solid bricks are bricks that have a solid cross-section of 75% or more of the total cross-sectional area and have a solid volume of more than 75% of the total brick volume. Solid concrete bricks are classified based on their compressive strength which varies from 25 kg/cm² to 100 kg/cm². Quality requirements include external appearance, dimensions, tolerances and physical requirements [3], [4].

Bricks (Hollow Concrete Bricks) are concrete without coarse aggregate which is composed of cement and fine aggregate only. During the mixing process, these materials should not be mixed with soil, therefore a clean place is needed, has a roof and uses a base. To prevent evaporation due to high temperatures, during the process of making the bricks, it is recommended that the surrounding area remain moist. This evaporation can cause significant water loss which will result in the cessation of the hydration process, with the consequence of reduced strength increase. Evaporation can also cause premature and rapid dry shrinkage, which will result in tensile stress which will cause cracking [10], [11].

Cold milling asphalt is asphalt waste from roads that have been damaged and have holes so that it needs to be repaired and the old asphalt (cold milling) is replaced with new asphalt. The availability of cold milling asphalt is quite a lot because every year many roads have holes and are damaged so that road repairs are needed [12], [15].

Compressive strength is a material that is a comparison of the maximum load that can be supported with the cross-sectional area of the material experiencing the force. The compressive strength of bricks identifies the quality of a structure. The higher the desired level of structural strength, the higher the quality of the bricks produced [2]-[4], [15]-[18].

This study aims to determine the compressive strength and water absorption by utilizing cold milling asphalt waste as a mixture for making bricks in different compositions. It is expected that bricks mixed with cold milling asphalt waste have better compressive strength than ordinary bricks and also have good quality and are durable.

RESEARCH METHOD

Materials

The materials needed in making bricks are type I potland cement which is still in good condition which is used in a hollow concrete brick factory that has gone through a specific gravity inspection stage, cold milling asphalt waste, Merapi sand and water.
Material testing is carried out to ensure that the materials used have followed the required standards, both from fine aggregate material in the form of sand (SNI ASTM C136 2012).

Test Objects

This study is about the manufacture of lightweight bricks with the addition of asphalt waste material (cold milling) as a mixture of fine aggregate. This study made 12 samples using the experimental descriptive analysis method. Using a 30 x 15 x 10 cm brick mold, the manufacture of these bricks with variations in material mixing of 0%, 20%, 25% and 30%. For test objects with 0% (without cold milling) used as control test objects.
Manufacture of Test Objects
The manufacture of test objects refers to the manufacture of concrete bricks (SNI 03-0348-1989), as well as the stages of making brick test objects, including the calculation and weighing of each material, mixing the materials and casting in the mold. The steps in making brick paste are as follows:

1. Prepare the materials (sand, cement, water, and Cold Milling Asphalt waste) and equipment that will be used for the brick mixture.
2. Prepare the brick mold.
3. Weigh each material based on the calculation (mix design).
4. Make the brick mixture manually, add asphalt waste according to the percentage. Then mix it with the sand and cement that has been stirred and add water.
5. Stir the mixed material using a trowel.
6. Then place the base under the brick mold and pour the brick mixture into the mold that has been smeared with oil so that the mixture does not stick to the mold so that it is easy to remove.

7. Then compaction is carried out, after the mold is completely filled, the surface is leveled and left until half dry, then remove the brick from the mold and mark each sample.

8. The molded brick is then placed in the place provided until it hardens and dries until the testing time is 7 days and 28 days.

Brick Testing

Brick Compression Strength Test

Testing was carried out at the age of 7 days and 28 days. From the tension test carried out with the Compressing Testing Machine, the maximum load was obtained, namely when the brick was destroyed receiving the load (maximum P).

Water Absorption Test

Bricks made from Cold Milling Asphalt waste were tested for absorption to determine the ability of the test object to absorb water through its pores. In this water absorption test, several test objects were used to obtain well-validated results, and using bricks made from cement and sand that were >14 days old as a comparison.

Method

This research is experimental in nature by conducting research at the Civil Engineering Laboratory of Veteran Bangun Nusantara University, Sukoharjo, Jl. Letjend Sujono Humardani No.1, Gadingan, Jombor, Bendosari District, Sukoharjo Regency, Central Java. The purpose of this research is to determine the compressive strength value of bricks and the water absorption capacity of bricks using additional asphalt waste from Cold Milling.

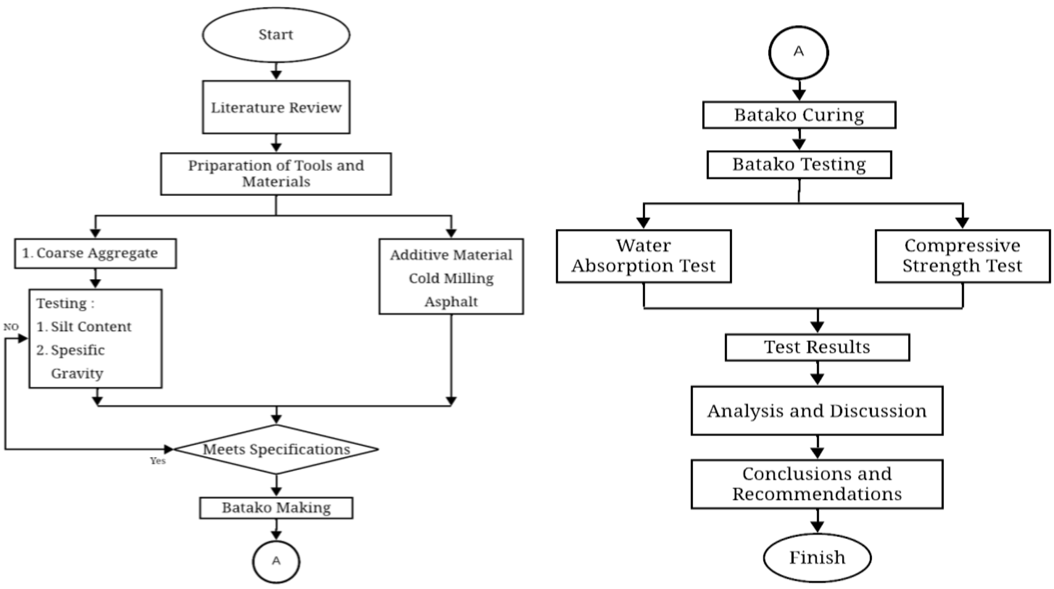

Figure 1. Research Flowchart

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Data Analysis Stage

This test uses a compression test machine at the age of 7 days and 28 days with the formula:

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

This study not only tests the compressive strength, but also tests the water absorption capacity. The amount of water absorption by bricks is greatly influenced by the pores or cavities contained in the bricks. The more pores contained in the bricks, the greater the water absorption will be so that their resistance will decrease. The cavities (pores) found in bricks occur due to the inaccurate quality and composition of the constituent materials (Umar et al., 2017). To measure the water absorption of bricks, you can use the standard formula SNI 03-0349-1989 with the following equation:

$$\frac{mb - mk}{mk} \times 100\% \quad (2)$$

RESULTS AND DISCUSSION

Sand Zone Inspection Results

Fine aggregate is a filler in the form of sand. Good fine aggregate must be free from organic materials and clay. The sand used in mixing concrete, when viewed from its source, can come from rivers or from mining excavations.

The sand zone test is carried out to determine the distribution of variations in the size of sand grains expressed as a percentage of the total weight. The results of the sand zone test calculations are shown in Table 1 and Table 2.

Table 1. Sand Zone Calculation Results

Sieve holes(mm)	Zone 1		Cumulative weight %	Cumulative weight passing through the sieve %
	gr	%		
4.75	37	3.70	3.70	96.30
2.36	152	15.20	18.90	81.10
1.18	107	10.70	29.60	70.40
0.6	381	38.10	67.70	32.30
0.3	265	26.50	94.20	5.80
0.15	52	5.20	99.40	0.60
0,075	6	0.60	100.00	0.00
Total	1000	100	313.50	286.50

From Table 1. are the calculation results:

Table 2. Sand Zone Test Results

Sieve holes (mm)	Zone 1		Zone 2		Zone 3		Zone 4		Test results
4.75	10	0	10	0	10	0	15	0	3,90
2.36	20	5	30	8	40	12	50	15	20,80
1.18	34	15	59	35	79	60	100	80	44,10
0.6	70	30	90	55	100	75	100	90	73,40
0.3	95	60	100	75	100	85	100	96	91,10
0.15	100	90	100	90	100	90	100	95	98,30
0,075	100	100	100	100	100	100	100	100	100

Table 2. Is the result of sand zone test from zone 1 to zone 4 using sieve with holes of 4.75mm to 0.075mm. From the data obtained, a sand zone graph is then made as shown in Figure 2.

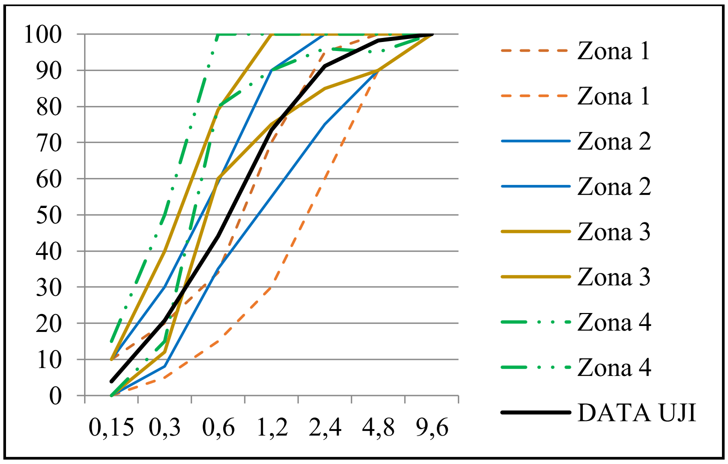

Figure 2. Sand Zone Graph

Proportion of Brick Mixture Materials

From the results of laboratory analysis of fine aggregates, the proportion of the brick mixture can be calculated as follows:

a. The volume of bricks for 1 brick is:

= P x W x H

= 30 x 10 x 15 = 4500 cm^3

= 0.00045 m^3

To avoid lost materials during molding, a safety factor (SF) = 1.2 is applied, so the volume for one brick is:

1) Volume = 0.00045 x 1.2 = 0.00054 m^3

then the materials for one brick with a volume of 0.0054 m^3 are as follows.

2) Cement = 0.00054 m^3 x 250 kg/m^3 = 1.35 / 1.4 kg

Table 3. Comparison of material requirements for 1 brick for each variation

No	Mixing percentage (%)	Cement (Kg)	Sand (Kg)	Asphalt waste Cold Milling (Kg)
1	0	1,35	8,1	0
2	20	1,35	6,48	1,62
3	25	1,35	6,075	2,025
4	30	1,35	5,67	2,43

From table 3, the mix design comparison for one normal brick is 1(pc): 6(ps) with a material requirement of 1.35 kg of cement and 8.1 kg of sand without a mixture of Cold Milling asphalt waste.

a. Calculation of material requirements for 6 bricks in each mixing variation
1) Normal Brick and Hollow Brick (Without the use of Asphalt Waste)
Cement = 1.35 x 6 = 8.1 kg
Asphalt Waste = 1.62 x 6 = 9.72 kg
Sand = 8.1 x 6 = 48.6 kg
Water = 0.7 x 6 = 4.2 L
2) Brick with the use of 20% Asphalt Waste as a reduction in sand:

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Cement = 1.35 x 6 = 8.1 kg

Asphalt Waste = 20 x 100 8.1 = 1.62 kg

Total Asphalt = 1.62 x 6 = 9.72 kg

Sand = 8.1 – 1.62 = 6.48 kg

Total Sand = 6.48 x 6 = 38.88 kg

So the material requirements for making bricks can be seen in table 4 of the following mixture plan.

Table 4. Mixture Plan.

No	Mixing percentage (%)	Cement (Kg)	Sand (Kg)	Asphalt waste Cold Milling (Kg)
1	0	6,75	40,5	0
2	20	6,75	32,4	8,1
3	25	6,75	30,38	10,125
4	30	6,75	28,35	12,15

Compressive Strength of Bricks

Compressive strength testing was carried out when the bricks were 7 days and 28 days old, with 5 test objects for each variation. The data obtained from the compressive strength research are displayed in graphical form, to state the relationship between the percentage and the compressive strength of bricks mixed with cold milling asphalt waste can be seen in Figure 3 and Table 5.

Table 5. Compressive Strength of Bricks Aged 7 Days

Test specimens	Variations (%)	Surface area (mm²)	Age of test specimen	Compressive strength (KN)	Compressive strength (MPa)
Solid concrete block	0	30000	7	88	2,93
	20	30000	7	160	5,33
	25	30000	7	180	6,00
	30	30000	7	217	7,23

Table 5 shows the results of the compressive strength test of 7-day-old solid bricks, with the lowest compressive strength value in bricks with 0% cold milling asphalt waste variation of 88 kN. The compressive strength value increases with increasing levels of cold milling asphalt waste.

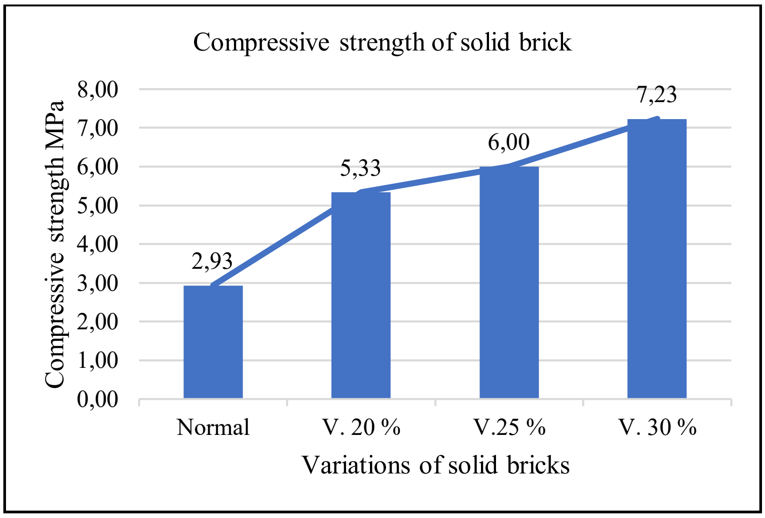

Figure 3. Compressive Strength Graph of 7-Day-Old Bricks

The results of the compressive strength of solid bricks and hollow bricks at the age of 28 days can be seen in table 6 and figure 4

Table 6. Compressive Strength of 28-Day-Old Bricks

Variations	Test specimens (%)	Surface area (mm²)	Age of test specimen	Compressive strength (KN)	Compressive strength (Kg/cm³)
Solid brick	0	30000	28	225	7,50
	20	30000	28	194	6,47
	25	30000	28	211	7,03
	30	30000	28	237	7,90
Perforated bricks	0	30000	28	114	3,80
	20	30000	28	92	3,07
	25	30000	28	77	2,57
	30	30000	28	76	2,53

Table 6 shows the results of the compressive strength test of solid bricks and perforated bricks aged 28 days, with the results of the compressive strength value of solid bricks with a variation of 20% still low compared to 0%, a variation of 25% is still low compared to 0%, but for a variation of 30% it increases with increasing levels of cold milling asphalt waste. For the results of the compressive strength value of perforated bricks, the highest value is obtained at a content of 0% of 114 kN, the compressive value decreases with increasing levels of cold milling asphalt waste.

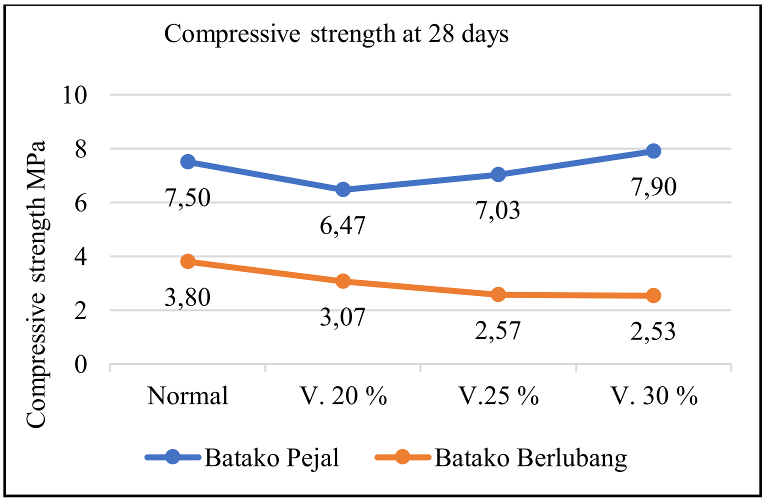

Figure 4. Graph of Compressive Strength of 28-Day-Old Brick

Water Absorption Capacity of Brick

The test was conducted on 7-day and 28-day-old bricks, each sample consisted of 5, then the average water absorption capacity of each sample was taken. The test method was by soaking the bricks for 1 x 24 hours. This test was conducted in the Civil Engineering Study Program Laboratory, Faculty of Engineering, Veteran Bangun Nusantara University, Sukoharjo

Table 7. Results of water absorption capacity of solid bricks at 7 days

Variations	Percentage (%)	Age of test specimen	Dry weight (Kg)	Wet weight (Kg)	Absorption capacity (%)
Solid brick	0	7	8,70	9,06	4%
	20	7	8,38	8,82	5%
	25	7	8,39	8,88	6%
	30	7	8,47	9,23	9%

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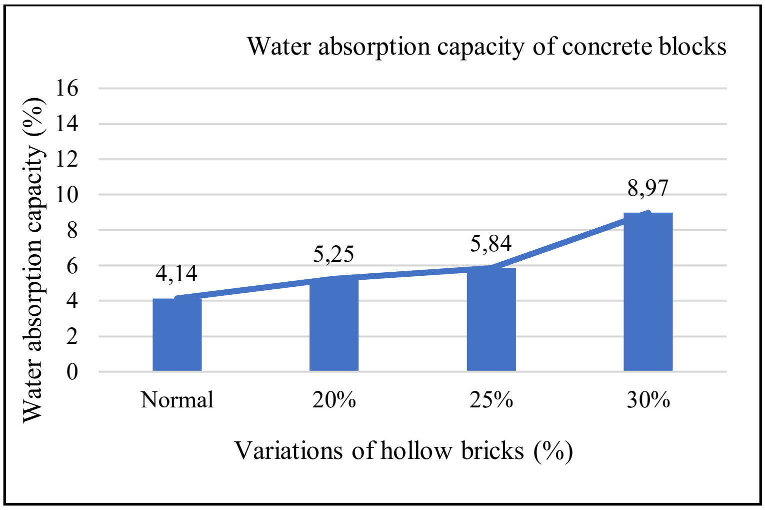

Figure 5. Graph of Water Absorption Capacity of 7-Day-Old Bricks

Based on the graph of water absorption capacity above, solid bricks and innovative bricks, the results show that the water absorption capacity of normal bricks is an average of 4.00% and that of innovative bricks is 6.07%.

Table 8. Results of water absorption capacity of hollow bricks at 28 days

Variation	Percentage (%)	Age of test specimen	Dry weight (Kg)	Wet weight (Kg)	Absorption capacity (%)
Solid brick	0	28	8785	8990	2%
	20	28	8300	9020	9%
	25	28	8475	9100	7%
	30	28	8640	9290	7%
Perforated bricks	0	28	6970	7580	8%
	20	28	7095	7745	9%
	25	28	7055	7815	10%
	30	28	7045	7995	13%

From table 8 above, the largest solid brick absorption value is in the 20% innovation brick mixture composition with a water absorption value of 9%, while the smallest water absorption value is in the

0% mixture composition with a water absorption value of 2%. In hollow bricks, the largest absorption value is in the 30% innovation and the smallest absorption value is in the 0% innovation.

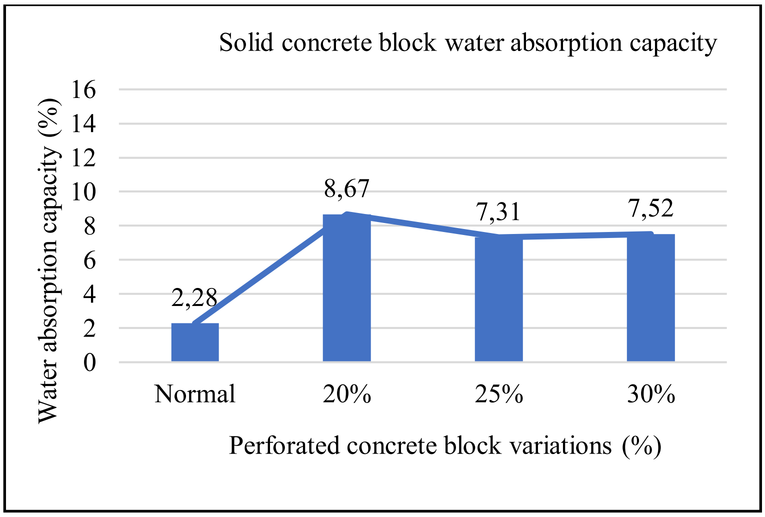

Figure 6. Graph of Water Absorption Capacity of Solid Bricks at 28 days.

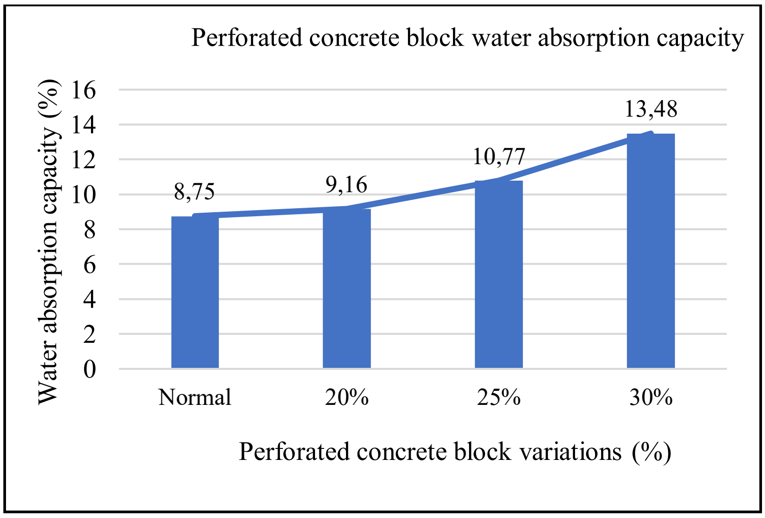

Figure 7. Graph of Water Absorption Capacity of Hollow Bricks at 28 days.

CONCLUSION

Based on the results of the research from the absorption and compressive strength tests that have been carried out, it can be concluded that the samples made used 2 (two) types, namely hollow bricks and solid bricks aged 7 days and 28 days. A total of 15 samples which then carried out water absorption tests on each sample. The test of these bricks was aged 7 days and 28 days where the old bricks were put into water or soaked for 1 x 24 hours. The results of the average absorption capacity of the innovation solid brick at the age of 7 days were 6.07% and the average innovation solid brick aged 28 days was 28.9%, for the average perforated brick at the innovation age of 28 days the absorption capacity was 10.66%, In this case, it increased because asphalt waste has the characteristics of high-water content and has quite large pores in the additional materials for making bricks. The results of the compressive strength test of 30 cm x 15 cm x 10 cm bricks. Each sample was tested for compressive strength at the age of 7 days as a comparison of the age of 28 days. The results of the average compressive strength of solid bricks aged 7 days were 21.49% and for the average compressive strength of solid bricks aged 28 days 28.9% and for the compressive strength of hollow bricks at the age of 28 days 2.72%, in this case, solid bricks aged 7 days with 28 days experienced an increase in compressive strength because the longer the age of the concrete or bricks, the stronger and denser they will be. However, hollow bricks experienced a decrease in compressive strength due to the addition of materials and the shape of the object.

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