Pore Block Non Cement As Solution To Rain Founding

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Abstract. In general, the manufacture of paving blocks uses a mixture of cement, coarse aggregate, fine aggregate and water which is mixed into one and then shaped. The results of previous studies showed that the coefficient of runoff that occurred on land with ordinary paving block covers was 0.41 - 0.46 or there was an increase in surface runoff by 171% - 215% compared to hard soil without paving block covers. This indicates that there is a potential for increased puddles when it rains. Based on this, it is necessary to increase the ability to pass water from paving blocks in the form of modifying the character of the existing paving blocks by making porous paving blocks coupled with the application of innovative materials without cement. This research was conducted with the aim of designing a porous paving block material without cement which is expected to be a solution in overcoming the inundation that occurs. The result of this research show that the test results get a permeability value of 77.36% or in other words a runoff coefficient of 0.22, an infiltration rate of 1.15 cm/s and an average compressive strength of 106.886 kg/cm2.

1. Introduction

The cover changes with pavement layers have occurred massive recently, not only on large and medium-sized infrastructure development projects, but also occur on a residential scale. A lot of land that was originally a water catchment when it rained, was immediately covered with a layer of pavement, such as concrete, asphalt, cement mortar, paving blocks and so on. It has become a common view when the office yard, school yard or even the yard of the house is covered with a layer of pavement in the form of paving blocks.

Previous research shows that the value of the runoff coefficient (C) of land with a cover in the form of paving blocks without pores is 0.41 to 0.45 [1].

Another study showed that the runoff coefficient (C) on soil with a cover in the form of paving blocks stacked bricks was 0.42 to 0.46 [2].

When compared with the value of the runoff coefficient (C) on heavy soil with a flat slope of 2% which is 0.13 to 0.17, it can be said that the use of paving block material on soil will increase the runoff coefficient value or in other words that the soil surface covered with paving blocks becomes more resistant to the passage of water.

Based on the above, it is necessary to make improvements to the characteristics of the existing paving blocks so that their capacity to pass water into the soil below is getting better. The technology of concrete pore is an alternative that can be applied in the production of paving blocks so that the performance of paving blocks is better for passing puddles of water into the subsoil.

Research conducted by [3], concluded that the innovation of composite paving blocks (a combination of paving blocks and porous concrete) can be used as a pavement layer that has the ability to pass water (permeable pavement) with an infiltration rate of 2.78 mm/sec.

Another study conducted by [4], who designed the manufacture of porous paving with the addition of coal waste fly ash with a composition of 10-50% of the cement weight gave the result that with an infiltration rate of 3.5 mm/s with the ability to pass water by 87%.

The results of research published by [5] in his publication entitled "Concrete with Little Portland Cement and No Portland Cement by Utilizing Fly Ash from Coal Power Plants", concluded that the use of cement can be replaced with a material called geopolymer (binder). by using a mixture of fly ash, sodium hydroxide (NaOH) and sodium silicate ($Na2SiO3$).

Based on the above, a study was conducted that applied geopolymers in the manufacture of porous paving as a solution to overcome puddles.

2. Methods

This study uses an experimental type of research to produce pavement material in the form of porous paving blocks without cement as a solution to overcome rainwater puddles in an area. The research activities are designed in a form of research activity design as presented in Figure 1.

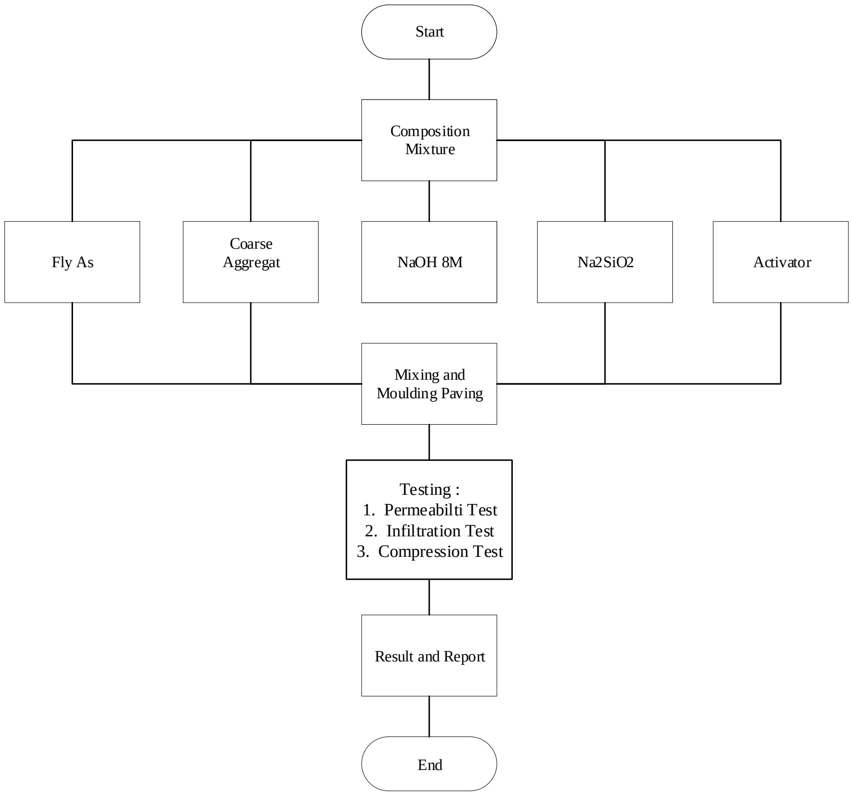

Figure 1. Flow Chart Of Research Implementation

2.1 Tools and Material

The materials used in this research activity consisted of the F-Class Fly Ash, coarse aggregat, NaOH 8 M, NaSiO3. While the tools used in this research activity are compression machine, stopwatch,paving press machine.

2.2 Stages of Research Implementation

The research stages include: (i) conducting a research concept followed by a literature study and material collection and equipment preparation, (ii) mixing all materials used as porous paving materials, (iii) molding and drying and maintenance processes, (iv) carry out a testing process which includes the process of testing volume weight, specific gravity, absorption, infiltration rate and compressive strength at the age of 28 days of paving.

2.2.1 Research Concepts and Literature Studie

The research was conducted using quantitative methods by conducting experiments in the Highway Laboratory of the Road and Bridge Construction Engineering Technology Study Program, with the design of porous paving without cement which refers to several literatures in the form of published results of previous studies. The number of test samples that were tested were 5 for each test parameter, so that the parameter value of the test results was the average value of all the sample tests.

2.2.2 Composition and Mixing Process

The composition that will be used for the manufacture of porous paving refers to research [5] on the manufacture of concrete without cement. Modifications were made by removing fine aggregate (sand) and replacing all sizes of aggregate used in the cement-free concrete study with coarse aggregate of 1 size in the form of screen stone. As for the research based on the cement-free concrete, the composition used is as follows:

Table 1. Reference Composition in Porous Paving

Material		Mass, Kg/M^3
	20 mm	277
Coarse Aggregates	14 mm	370
	7 mm	647
Fine sand		554
Fly ash (low-calcium ASTM Class F		408
Sodium silicate solution (SiO2/Na2O=2)		103
Sodium hydroxide solution (8 Molar)		41
Super Plasiteseiser		6

2.2.3 Moulding, drying and Curring

Moulding with press and vibration models using a paving machine. While the drying process is carried out by drying naturally by placing the moulding paving material in a cool place not exposed to direct heat. For the treatment of porous paving impression materials without cement, the treatment is the same as conventional concrete. The types of treatment (curing) on concrete include watering, soaking, coating (wet covering), steam curing, liquid membrane, and others.

2.2.4 Testing

The measured paving block characteristics include:

1. **Permeability Test.** This test is the most important part of all types of porous paving. Permeability testing is the ability of paving to pass water that passes through the paving through the pores contained in the paving itself. From this permeability test data, a permeability coefficient can be determined which indicates a rate of liquid seepage in the porous paving period. The permeability coefficient for the flow test is calculated by Darcy's formula

$$k = \frac{pgLQ}{PA} = \frac{LV}{hAt}$$

   With :
   k = water permeability coefficient (cm/s) V = volume of water used (cm3).
   L = thickness of specimen (cm) A = area of specimen cut (cm2)
   t = time required to drain the water (seconds)
   h = height of water to the sample (cm)

2. **Infiltration Rate.** Water velocity testing of porous paving specimens was carried out at the age of 28 days. This test is carried out by covering the side surface of the test object so that water does not seep out during the water velocity testing process. The procedure for carrying out the infiltration rate test is carried out by pouring water on the surface of the paving that has been conditioned on the side, then measuring the time of the water droplets coming out of the bottom surface of the porous paving, With :

3. **Compressive Strength Test.** The compressive strength of the test object is defined as the ability of a concrete test object to withstand a load or mechanical force until it exceeds the maximum point capability, causing failure. The compressive strength of hollow paving has a compressive strength value of between 400 – 400 psi or 2.8 – 28 MPa (ACI 522R, 2010). The compressive strength measurement can be calculated by the following equation (SNI 03-0691-1996):

$$Compressive\ strenght = {}^{P}/_{L}$$

Compressive strength = P/L
P = compressive load (kg)
L = area of compression (cm^2)

3. Results and Discussion

3.1 Coarse Aggregate (Screen Stone 6 – 10 mm)

Coarse aggregate used in the manufacture of porous paving is black stone screen type. Screening stone or also known as screen stone, usually this type of stone is 5-10 mm in size.

Figure 3. Coarse Aggregat

3.2 Fly Ash

Fly ash is a by-product of the coal combustion process in power generation equipment. The current availability of abundant fly ash, as well as its condition as a waste material, makes fly ash one of the basic materials of choice for the manufacture of porous paving without cement. Besides its practical use (without the calcination process), its use is also very beneficial for the environment. According to ACI Committee 226, the size of fly-ash grains that pass the No. sieve. 325 (45 millimicrons) ranges from 5-27%, with a specific gravity between 2.15-2.8. The chemical composition of fly ash consists of unburned carbon, mullite, quartz and hematite. The fly ash used in this study came from PT Bukit Asam Tarahan, which belongs to class F.

Figure 3. Fly Ash Class F Form PTBA Tarahan

3.3 Aktivator

The activator solution commonly used in geopolymerization is a combination of sodium hydroxide (NaOH) or potassium hydroxide (KOH) and sodium silicate or potassium silicate (Rangan, 2008). In this research activity, sodium hydroxide (NaOH) and sodium silicate activator solutions were used.

3.3.1 Sodium hydroxide

NaOH is available in 2 forms, namely in the form of flecks (flakes) or liquid. This compound is the cheapest and easily available compound among other metal hydroxide compounds. Sodium hydroxide (NaOH) is a compound commonly used as an activator in the manufacture of concrete without cement (geopolymer). These compounds can be used to activate fly ash which is used as a geopolymer precursor. Concentrated NaOH solution has corrosive properties so handling must be appropriate. The addition of silicate is one way of handling the corrosive nature of NaOH (Provis et. all 2009). The molarity of NaOH which is commonly used in several studies ranges from 6 M – 15 M. In principle, the higher the molarity of NaOH, the better the mechanical strength. However, it depends on the basic material used. Several studies have shown that fly ash material has good mechanical strength as the molarity of the NaOH used increases.

Figure 4. Sodium Hydroxide

3.3.2 Sodium Silcate

Sodium Silicate (Na2SO3) or more commonly known as waterglass is one of the silica derivative compounds which is quite abundant in Indonesia. The raw material for the manufacture of sodium silicate generally uses quartz sand. The presence of sodium silicate in the activator solution serves to increase the amount of silica in the porous paving mixture without cement. . The ratio of the activator liquid to the source material is in the range of 0.25- 0.30 (Rangan, et.al, 2005). Sodium hydroxide is available in 2 forms, namely in the form of flecks (flakes) or liquid. This compound is the cheapest and easily available compound among other metal hydroxide compounds. Sodium hydroxide (NaOH) is a compound commonly used as an activator in the synthesis of geopolymers. These compounds can be used to activate fly ash which is used as a binder in porous paving without cement.

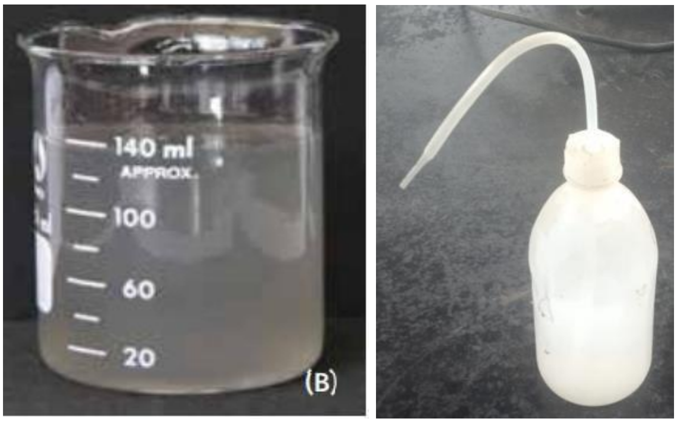

Figure 5. b. Sodium Silicate (Na2SiO3)

3.3.3 Composition of Porous Paving Mix Without Cement

The composition that will be used for the manufacture of porous paving stones is based on a combination of coarse aggregate and fly ash from coal waste, NaOH 8 M and Na2SiO3. If referring to the research (Irawan et al., 2015) as listed in Table 4.1, then if all coarse aggregate and fine aggregate are replaced with screen stone, then the composition ratio between each component (in kg/m3) is

Screen stone aggregate	:	Fly Ash	:	NaOH	:	Na_2SiO_3	:	Super Plastitizer
1884 kg	:	408 kg	:	103 kg	:	41 kg	:	6 kg
				Or				
76.81%	:	16.96%	:	4.28%	:	1.70%	:	0.25% (Weight Ratio)
SAG	:	FA	:	NaOH	:	Na2SiO3	:	SPL

3.3.4 Sample Making

Porous paving in this study is composed of of the composition of screen stone aggregate, fly ash type F, activator and super plastitizer with the ratio of 76% SAG: 16,69% FA : 4,28% NaOH : 1,70% Na2SiO3 : 0,25% SPL. Results of porous paving research can be seen in Fig 2 and Fig 3.

Figure 6. Moulding Porous Paving

Figure 7. Moulding Porous Paving

The characteristics of the resulting porous paving with the composition as referred to are presented in Table 2

Table 2. characteristics of Porous Paving

No	Properties	Unit	Value
1	Weight Volume	gr/cm^3	1.978
2	Spesific Gravity	gr/cm^3	2.087

Permeability test on porous paving using a sample of porous paving specimens with using 1000 ml of water. Testing process the permeability of the test object is by cover all the side surfaces of the cylindrical test object with duct tape, so that water does not seep to the side of the object test. Furthermore, testing the percentage of water passes is carried out. Table 3 is the result of water pass percentage test:

Table 3. Permeability Test Result

Sample	Sample High (cm)	Time (s)	Rate (cm/s)	Avarage (cm/s)
1	5	5	1.00	
2	5	6	0.83	
3	5	3	1.67	1.15
4	5	4	1.25	
5	5	5	1.00	

From the table above, if referring to SNI 03-0691-1996 and ACI 522R-10, namely the permeability value of 1.14- 1.22 cm/s, then the infiltration rate is in accordance with the requirements of porous paving [6]. Compressive strength test results porous paving for the five samples are as follows:

Sample	Weight (gr)	Compression (Mpa)	Compression (kg/cm^2)	Avarage (kg/cm^2)
1	2073.75	10.4	106,05	
2	2164.25	9.81	100,03	
3	2067.20	10.2	104,01	106,886
4	2102.30	10.8	110,13	
5	1975.50	11.2	114,21	

From the table above, it can be seen that the average compressive strength of the sample is 106.886 kg/cm2, which, when compared with SNI 03-0691-1996, is included in class D paving blocks used for gardens and other uses [6].

4. Conclusions

Based on the results of the analysis and discussion, it can be concluded several things, namely the percentage of water that will absorb is 76.36%, which means that the runoff water is 22.64% or the runoff coefficient is 0.2264. The value of the infiltration rate of the porous paving is 1.15. this value is included in the standard of SNI 03-0691-1996 and ACI 522R-10. The compressive strength of the porous paving sample without cement shows a figure of 106k,886 kg/cm2. this indicates that the resulting paving can only be used for garden purposes as stated in SNI 03-0691-1996 and ACI 522R-10.

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