

Comparison of compressive strength of paving block with a mixture of Sinabung ash and paving block with a mixture of lime

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Abstract. Paving block is one of the material used as the top layer of road structure besides asphalt and concrete paving block is usually made of mixed material such as Portland cement or other adhesive material, water, and aggregate. People nowadays prefer paving block compared to other pavement such as concrete or asphalt. Their interest toward the use of paving block increase because paving block is an eco-friendly construction which is very useful in helping soil water conservation, can be done faster, has easier installation and maintenance, has a variety of shades that increase the aesthetic value, also costs cheaper than the other. Preparation of the specimens with a mixture of Sinabung ash and a mixture of Sinabung ash and lime are implemented with a mixture ratio of cement : sand : stone ash is 1 : 2 : 3. The mixture is used as a substitute material by reducing the percentage amount of the weight of the cement with the composition ratio variation based on the comparative volume category of the paving block aggregate, i.e. 0%, 5%, 10%, 15%, 20%, and 25%. The result of this research shows that the maximum compressive strength value is 42.27 Mpa, it was obtained from a mixture of 10% lime with curing time 28 days. The maximum compressive strength value which is obtained from the mixture of sinabung ash is 41.60 Mpa, it was obtained from a mixture of 15% sinabung ash. From the use of these two materials, paving blocks produced are classified as paving blocks quality A and B (350 – 400 Mpa) in accordance to specification from SNI 03-0691-1996.

1. Introduction

Sinabung alongside Mount Sibayak nearby are two active volcanoes in North Sumatra and the highest peak in the province. The height of this mountain is 2,460 meters. This mountain has never recorded erupted since 1600, but suddenly active again by erupting in 2010. Until now in 2017 the mountain is still actively releasing lava and hot ash clouds around the site. The eruption of Mount Sinabung has caused damage to facilities and infrastructures such as plantations, houses, roads, and the cessation of normal activities of the community. This will certainly have a negative impact on the economic development of communities around the location of Mount Sinabung. The volcanic ash caused by this eruption covered almost all villages around Mount Sinabung, so there is a need to find ways to overcome the problem of the build-up of volcanic ash.

In addition to increase soil fertility, volcanic ash also contains silica and quartz that makes it can be classified into pozzolan materials. Pozzolan material is defined as non-cement material containing silica and alumina. While the classification of pozzolan material is divided into two parts, natural pozzolan (natural) and artificial (synthetic), natural pozzolan example is: tuff, volcanic ash, diatomaceous soil, and trass is a famous natural pozzolan name in Indonesia. Further examples of



artificial pozzolan is the result of burning clay, rice husk ash, ash bagasse and the result of burning coal (fly ash)[6].

Paving block is a building material made of a mixture of Portland cement or similar hydraulic binder, water and aggregate with or without other additives (SNI 03 - 0691 - 1996). In order to improve the quality of paving block, we can use materials that contain pozzolan ingredients such as silica, alumina and calcium.

Aggregate materials that are often used in the manufacture of paving blocks are sand which is derived from quarrying sand or river. Based on SNI 03-0691-1996 paving block (concrete blocks) can be classified into four qualities, quality A used for pavement, quality B used for parking areas, quality C used for pedestrian, and quality D used for parks or other uses. Paving block which is produced manually are usually classified as paving block quality C and D, these types of paving blocks are used for garden and other uses that are not required to withstand the load on it. The quality of the paving block using a press machine can be categorized into concrete quality C to A with a compressive strength above 125 kg/cm² depending on the ratio of the mixture of materials used.

A good concrete is a concrete that has a high compressive strength, in other words it can be said that the quality of concrete is reviewed only from the compressive strength alone [3]. Several factors affecting the strength of concrete:

(1) Water Cement Ratio (WCR) and density

The function of the cement water ratio is to allow chemical reactions that cause binding and hardening, as a lubricant of the mixture of gravel, sand and cement to make it easier in concrete molding.

The strength of concrete depends on the ratio of the cement water ratio. The higher the WCR, the lower the strength of the concrete, however, the lower WCR does not always mean the higher the strength of the concrete. There is a limit in this case, the low WCR value will cause difficulty in the process, i.e. the difficulty in the implementation of compaction which will eventually cause the quality of concrete declines. Generally, the minimum WCR value is about 0.4 and the maximum WCR value is about 0.65. So it can be concluded that almost for all purposes, concrete that has a minimal WCR and enough to provide the specific workability required for perfect compaction without excessive compaction work, is the best concrete.

(2) Age of concrete

The compressive strength of concrete will increase in accordance with the age of concrete. Comparison of concrete compressive strength can be seen in Indonesia Reinforced Concrete Rules 1971.

(3) Type and quantity of concrete

The type of cement affects the compressive strength of the concrete in accordance with the intended use. The type of cement can be seen in SK SNI M-106-1990-03

(4) Aggregate properties

Surface Hardness: on aggregate with a rough surface there will be a good bond between the cement paste and the aggregate.

2. Method

2.1 General

The method used in this research is experimental research method. While the factor studied is the composition factor of the ash mixture of Sinabung and lime on the paving block of quality A, with the aim to know the effect of Mount Sinabung ash and lime as the additive materials by reducing the amount of cement in the compressive strength. Research flowchart is depicted in Figure 1.

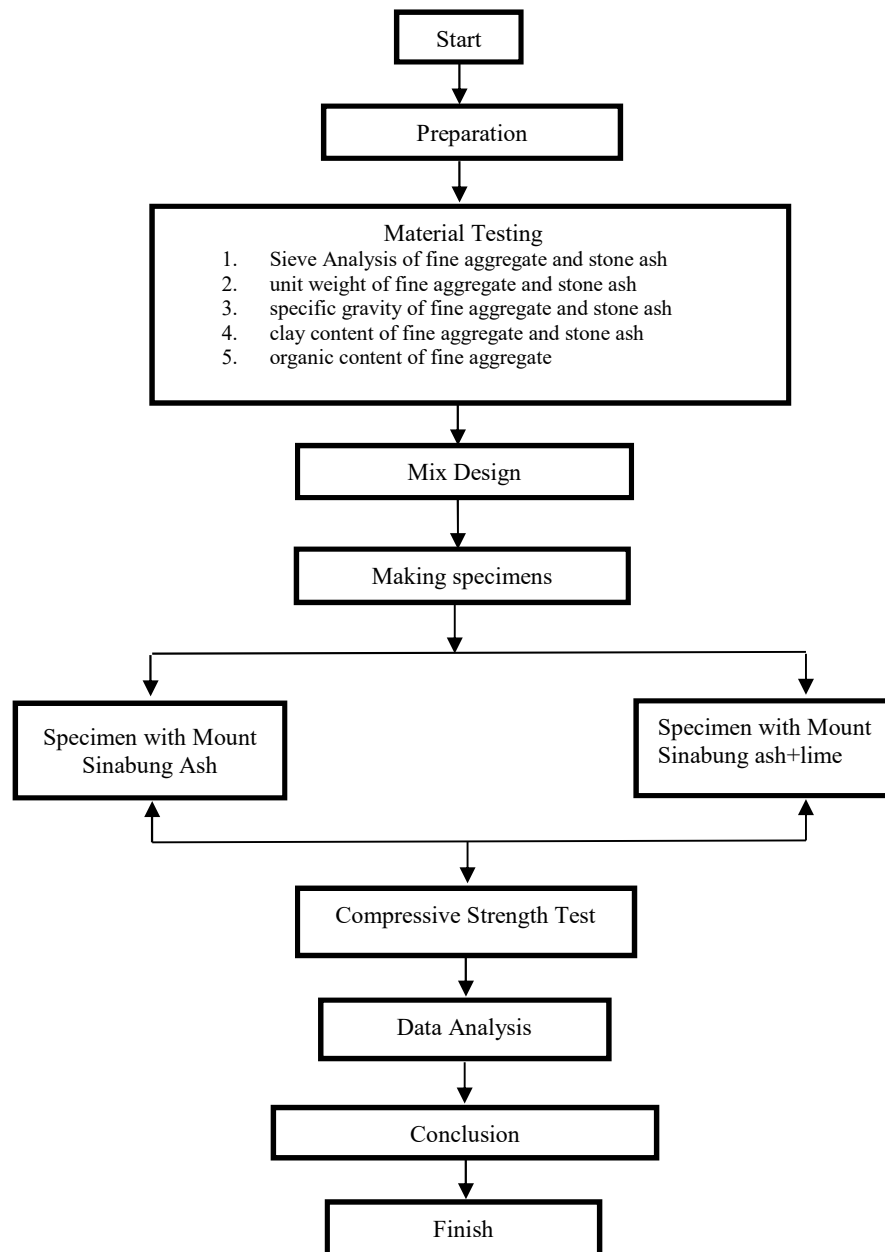


Figure 1. Flowchart Research

2.2 Materials Preparation

- (1) Cement, the cement used in this research is Portland Cement type I
- (2) Sand, the sand used in this research was taken from Sei Wampu quarry, Binjai.
- (3) Water, the water used as the materials mixer was taken from Laboratory of Engineering Material, Departement of Civil Engineering, Faculty of Engineering, University of North Sumatera.
- (4) Sinabung Volcanic Ash. The Sinabung volcanic ash was taken directly from Gurukinayan village which is only about 2.2 miles from Mount Sinabung and included as disaster-prone area II [6].

Table 1. Chemical composition of Sinabung Volcanic Ash

No.	Parameter	Unit	Result
1	Silica (SiO ₂)	%	74.3
2	Aluminium oxide (Al ₂ O ₃)	%	3.31
3	Calcium (CaO)	%	1.79

Source: Laboratory of Research Center and Industrial Standardization, Medan

(5) Lime

Lime used as a stabilizing material is Tohor lime with a chemical composition as shown in Table 2.

Table 2. Chemical composition of Lime

No.	Parameter	Result
1.	Silica (SiO ₂)	3.03 %
2.	Aluminium oxide (Al ₂ O ₃)	1.53 %
2.	Iron (III) Oxide (Fe ₂ O ₃)	0.54 %
3.	Calcium (CaO)	51.8 %
4.	Magnesium (MgO)	0.81 %

Source: Laboratory of Research Center and Industrial Standardization. Medan

3. Results and Discussions

The test results of material can be seen in Table 3.

Table 3. Material Test Data

No.	Test	Result	Unit
1	Sieve Analysis of Fine Aggregate	FM = 2.68	
2	Sieve Analysis of Stone Ash	FM = 4.83	
3	Unit Weight of Fine Aggregate	1.663	g/cm ³
4	Unit Weight of Stone Ash	1.543	g/cm ³
5	Unit Weight of Sinabung Ash	1.342	g/cm ³
6	Specific Gravity of Fine Aggregate	2.52	g/cm ³
7	Specific Gravity of Stone Ash	2.52	g/cm ³
8	Specific Gravity of Sinabung Ash	2.36	g/cm ³
9	Clay Content of Fine Aggregate	2.53	g/cm ³
10	Clay Content of Stone Ash	3.70	%
11	Organic Content of Fine Aggregate	0.80	%

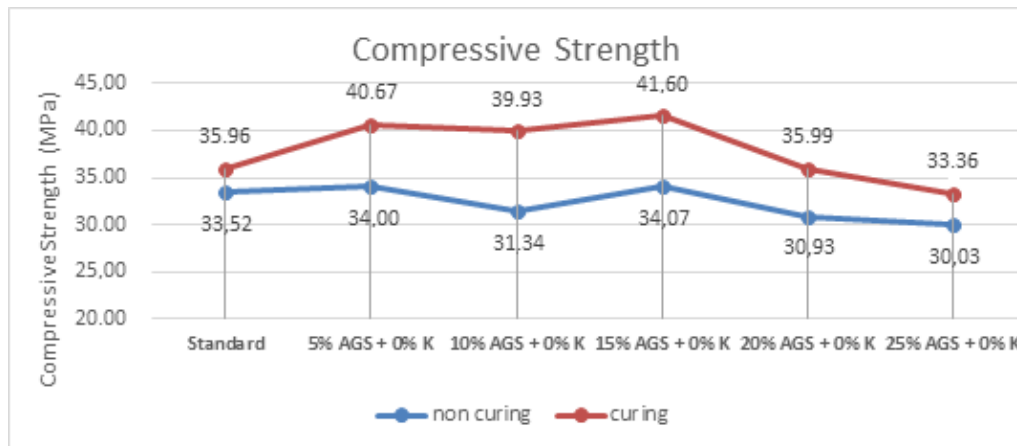


Figure 2. Compressive Strength Test with Sinabung Ash

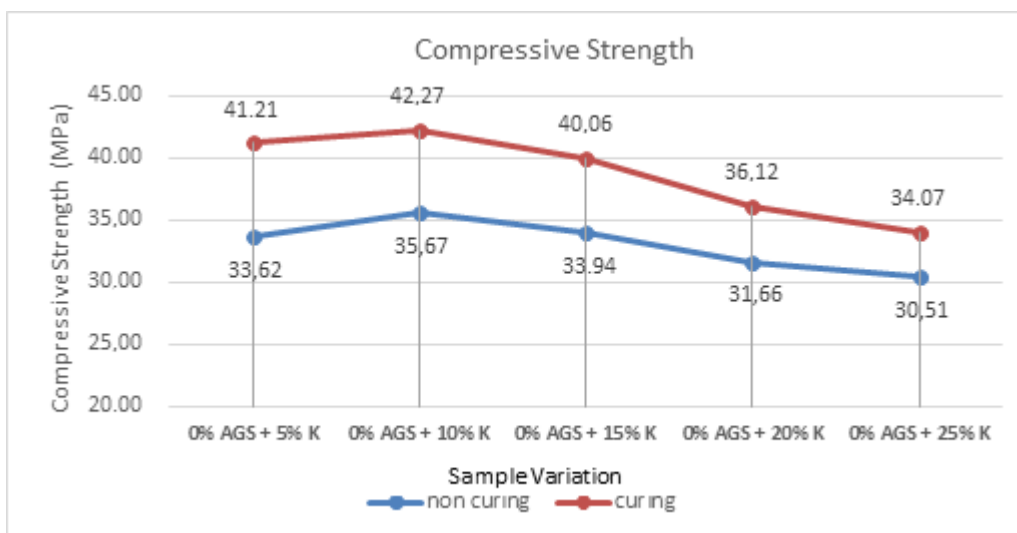


Figure 3. Compressive Strength Test with lime

From Figure 2, the highest compressive strength value is obtained on the use of 15% Sinabung ash with curing and from Figure 3, it is shown that the compressive strength value of a mixture of 10% lime with curing time 28 days is 42.27 Mpa. Figure 1 shows that normal concrete (with curing) without the addition of sinabung ash and lime has a compressive strength value which is equal to 35.96 Mpa. The increasing of paving block quality is caused by the use of Sinabung and Lime ash, which is known as Sinabung ash has Silica content of 73.4% and Lime has CaO content equal to 51.8%.

Silica gives effect as a filler on the manufacture of paving block where the filler contributes to the paving block density that occurs at the beginning when the chemical reaction is still running slowly. The very fine particles fill the empty cavities containing water and $\text{Ca}(\text{OH})_2$ between the aggregate and the binder. With fine particles filling the cavities, the layers of the paving block are saturated so as to increase the compressive strength of the paving block [5]. Lime is also able to improve the quality of paving block, this is due to the pozzolan properties of lime which quickly react to the silica which is released by cement during the process of hydration and forming compounds that are binding at normal temperatures in the presence of water.

4. Conclusions

Based on the test results it can be concluded as follows:

1. The use of Sinabung ash and lime as a cement substitution material can increase the compressive strength of the paving block.
2. The maximum compressive strength value which is obtained from the mixture of sinabung ash is 41.60 Mpa. it was obtained from a mixture of 15% sinabung ash.
3. The optimum compressive strength value which is obtained from the mixture of lime is 42.27 Mpa. it was obtained from a mixture of 10% lime.

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