Abstract. Paving block is one of the building materials used as the top layer of the road structure besides asphalt and concrete. Paving block is made of mixed materials such as portland cement or other adhesive materials, water and aggregate. In this research, the material used as the additive of cement and concrete is volcanic ash from Mount Sinabung, it is based on the results of the material testing, Sinabung ash contains 74.3% silica (SiO₂). The purpose of this research aims to analyze the behavior of the paving blocks quality A and B with and without a mixture of Sinabung ash, to analyze the workability of fresh concrete using Sinabung ash as an additive in concrete, and to compare the test results of paving blocks with and without using Sinabung ash.

The samples that we made consist of four variations of the concrete mix to experiment a mixture of normal sample without additive, samples which are mixed with the addition of Sinabung ash 5%, 10%, 15%, 20% and 25% of the volume of concrete/m³. Each variation consists of 10 samples of the concrete with 28 days curing time period. We will do the compressive strength and water absorption test to the samples to determine whether the samples are in accordance with the type needed. According to the test result, paving blocks with Sinabung ash and curing time reach quality A at 0%, 5% and 10% mixture with the compressive strength of each 50.14 MPa, 46.20 MPa and 1.49 Mpa, and reach quality B at 15%, 20 %, 25% mixture with curing time and 0%, 5%, 10%, 15%, 20% and 25% mixture without curing time. According to the absorption values we got from the test which are 6.66%, 6.73%, 6.88%, 7.03%, 7.09% and 7.16%, the entire sample have average absorption exceeding SNI standardization which is above 6% and reach quality C. Based on compressive strength and absorption data obtained Sinabung ash can’t fully replace cement as the binder because of the low CaO content.

1. Introduction

Paving block is one of the building materials used as the top layer of the road structure other than asphalt or concrete. Paving blocks are usually made with mixed materials such as portland cement or other adhesive materials, water and aggregate. Today, many consumers prefer paving blocks compared to other pavement such as concrete or asphalt. Customer interest toward the use of paving block increases because paving block is an eco-friendly construction which is very good in helping the soil water conservation, can be done faster, has easier installation and maintenance, has a variety of shapes that add aesthetic value, and the price is not expensive. However, consumers demand for paving is not matched with the availability of adequate quality in terms of strength, lifespan and durability. Many paving encountered on the road surface suffered cracked, broke easily, overgrown by moss, because the
Paving was brittle. These problems happen due to the materials quality that are not appropriate, rainwater scouring, the composition which is not in accordance with the standard, the different levels of compaction (pressing), even shock loads (impact resistance) which is very large on the track wheels of the vehicle.

Paving block is a building material composition made from a mixture of Portland cement or other kind of hydraulic binder, water and aggregates with or without other additives [2]. Improving the quality of paving blocks can be done by using a mixture of material which contains pozzolan like silica, calcium, and aluminate.

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. In this study, another material used for the mixture of cement and concrete is volcanic ash from Mount Sinabung. Based on the results of the material testing, Sinabung ash contains 74.3% silica (SiO₂), contains 4.52% Al₂O₃ and contains 5.10% CaO.

| Quality | Strength (Mpa*) | Wear Resistance | Absorption (maximum average) |
|---------|----------------|----------------|-----------------------------|
|         | Average | Minimal | Average | Minimal |                      |                      |
| 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                     |                      |

Table 1: Classification of Paving Block According to SNI Compressive Strength

Nb: *MPa = Mega Pascal (1 MPa = 10 kg/cm² = K 10)

2. Research Methods
The method used in this study is experimental research method. The factor studied in this research is the mixture composition of Sinabung Volcanic Ash on Paving blocks quality A and B. This study aims to determine the effect of Sinabung Ash as additive material by reducing the amount of cement in amount, water absorption and compressive strength. The ratio of cement, sand, and stone ash in this research is 1:2:3 wherein the Sinabung ash will be added as substitute material by reducing the percentage of cement with variation 0%, 5%, 10%, 15%, 20% and 25% Sinabung Ash of the amount of cement. The specimens making and testing procedure is in accordance with the quality specified in the Indonesian National Standard.
Figure 1. Research Flow Chart

1. Sieve Analysis of fine aggregate and stone ash
2. Unit weight of fine aggregate and stone ash
3. Specific gravity of fine aggregate and stone ash
4. Clay content of fine aggregate and stone ash
5. Organic content of fine aggregate
3. Results and Discussions

The test results of material can be seen in Table 4.

| No. | Test                              | Result       | Unit       |
|-----|-----------------------------------|--------------|------------|
| 1   | Sieve Analysis of Fine Aggregate | FM = 2.62    | gr/cm³     |
| 2   | Sieve Analysis of Stone Ash       | FM = 4.87    | gr/cm³     |
| 3   | Unit Weight of Fine Aggregate    | 1,657        |            |
| 4   | Unit Weight of Stone Ash          | 1,548        |            |
| 5   | Unit Weight of Sinabung Ash       | 1,342        | gr/cm³     |
| 6   | Specific Gravity of Fine Aggregate| 2.45         | gr/cm³     |
| 7   | Specific Gravity of Stone Ash     | 2.49         | gr/cm³     |
| 8   | Specific Gravity of Sinabung Ash  | 2.26         | gr/cm³     |
| 9   | Clay Content of Fine Aggregate    | 3.87         | %          |
| 10  | Clay Content of Stone Ash         | 0.8          | %          |
| 11  | Organic Content of Fine Aggregate | No.3         |            |

| No. | Sample Variation | Average Compressive Strength (Mpa) | Compressive Strength (Mpa) base on SNI 03-0691-1996 | Compressive Strength (Mpa) base on SNI 03-0691-1996 |
|-----|------------------|-----------------------------------|-----------------------------------------------------|-----------------------------------------------------|
|     |                  | With Curing Time                  | Without Curing Time                                 | Quality A                                           | Quality B                                           |
| 1   | 0%               | 50.14                             | 36.49                                               | 35 - 40                                             | 17 – 20                                             |
| 2   | 5%               | 46.20                             | 35.53                                               | 35 - 40                                             | 17 – 20                                             |
| 3   | 10%              | 41.49                             | 34.61                                               | 35 - 40                                             | 17 – 20                                             |
| 4   | 15%              | 37.98                             | 31.73                                               | 35 - 40                                             | 17 – 20                                             |
| 5   | 20%              | 35.67                             | 31.20                                               | 35 - 40                                             | 17 – 20                                             |
| 6   | 25%              | 34.61                             | 30.05                                               | 35 - 40                                             | 17 – 20                                             |
4. Conclusions

According to the research analysis and calculation of paving block characteristics with Sinabung ash as additive, it could be concluded as follows:

1. The quality of paving block obtained from the research we have done with paving block and Sinabung ash as the additive material:
   
   - Quality A (average compressive strength 40, min 35 Mpa): 0%, 5%, 10% of Sinabung ash with curing, can be used for pavement.
   - Quality B (average compressive strength 20, min 17 Mpa): 15%, 20%, 25% of Sinabung ash with curing and 0%, 5%, 10%, 15%, 20%, 25% of Sinabung ash without curing, can be used for parking area.

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**Table 4. Absorption Test Result**

| No | Sample Variation | Average Absorption (%) | Absorption base on SNI 03-0691-1996 Quality A | Absorption base on SNI 03-0691-1996 Quality B |
|----|------------------|------------------------|-----------------------------------------------|-----------------------------------------------|
| 1  | 0%               | 6.66                   | 3                                             | 6                                             |
| 2  | 5%               | 6.73                   | 3                                             | 6                                             |
| 3  | 10%              | 6.88                   | 3                                             | 6                                             |
| 4  | 15%              | 7.03                   | 3                                             | 6                                             |
| 5  | 20%              | 7.09                   | 3                                             | 6                                             |
| 6  | 25%              | 7.16                   | 3                                             | 6                                             |
2. After pressing, it can be seen that the surface of paving blocks look flat, there are no crack in the corner and ribs, also paving blocks are not easily trimmed with finger strength.

3. The thickness of paving blocks are 60 mm thick ± 8% in accordance with SNI specifications.

4. According to the absorption test, the entire samples have average absorption exceeding SNI standardization which are above 6%.

5. Based on the compressive strength and absorption data obtained, Sinabung ash can’t fully replace cement as the binder. It is because of the low CaO content in it which causes the bond between material become weak.

6. Increasing value of the absorption happens because of the high silica content. Silica has a role as the filler meanwhile CaO as the binder.

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