The influence of using volcanic ash and lime ash as filler on compressive strength in self compacting concrete

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Abstract. Self Compacting Concrete (SCC) is a technology which is developing today in which concrete solidifies by itself without using vibrator. Casting conventional concrete which has a lot of reinforcement bars sometimes finds difficulty in achieving optimal solidity. The method used to solve this problem is by using SCC technology. SCC was made by using filler, volcanic ash, and lime ash as the filling materials so that the concrete became more solid and hollow space could be filled up. The variation of using these two materials was 10%, 15%, 20%, and 25% of the cementitious mass and using 1% of superplasticizer from cementitious material. The supporting testing was done by using the test when the concrete was still fluid and when it was solid. Malleable concrete was tested by using EFNARC 2002 standard in slump flow test, v-funnel test, l-shaped box test, and j-ring test to obtain filling ability and passing ability. In this malleable lime concrete test, there was the decrease, compared with normal SCC concrete without adding volcanic ash and lime ash. Testing was also done in solid concrete in compressive strength, tensile strength, and concrete absorption. The result of the testing showed that the optimum tensile strength in Variation 1, without volcanic ash and lime ash- with 1% of superplasticizer was 39.556 MPa, the optimum tensile strength in Variation 1, without volcanic ash and lime ash- with 1% of super-plasticizer was 3.563 MPa, while the value of optimum absorption which occurred in Variation 5 (25% of volcanic ash + 25% of lime ash + 50% of cement + 1% of superplasticizer) was 1.313%. This was caused by the addition of volcanic ash and lime ash which had high water absorption.

1. Introduction
Self-compacting Concrete (SCC) is defined as a type of concrete which can pour, flow, and solidify under its own weight without hardening process with any mechanical vibration or other methods. Besides that, malleable concrete of SCC type is cohesive and can be done without segregation or bleeding. The advantages of using SCC are as follows:

(1) Reducing labor time and the cost of construction;
(2) Using vibrator for solidifying the concrete can be reduced;
(3) Increasing the solidity of structural element in the parts which are difficult to reach by using solidifying device like vibrator;
(4) Increasing the quality of concrete structure as a whole.
SCC has high flowable ability at the value of slump-flow of minimally 650-800 mm. Grainy and fine aggregate composition can increase flowable power of malleable concrete; however, the more fine aggregate is, the more the decrease in concrete tensile strength. Excessive grainy aggregate will increase the risk for segregation [1].

SCC is concrete which can solidify under its own weight, while from its quality point of view, it has many advantages: high workability and flow ability, good concrete homogeneity, being able to reduce permeability, and having high level of durability. SCC needs admixture to reduce water; it also needs fine materials which function as lubricant so that it can increase its flow ability and workability; it can also be used as filler which functions to fill hollow spaces in the concrete [2].

2. Review on related literature

2.1. Volcanic Ash
Volcanic ash is formed during the volcanic eruption which occurs when gas is dissolved in magma which breaks out and explodes to the air, and also when water is heated by magma and suddenly breaks out into the water gas. Meanwhile, gas which expands also pushes magma and explodes in the air, and when it freezes and is formed in volcanic particles and glass. While it is on the air, the wind blows the ash particles a few kilometers from the eruption center.

In general, the composition of volcanic ash consists of silica and quartz so that it is categorized into the material which has pozzolan material. Pozzolan material is actually not cement which contains silica and alumina. Small particles will chemically react against calcium hydroxide (CH). Normal temperature and the existence of water will form insoluble product, Calcium Silica Hydrate (C-S-H) which has the characteristic of cement [4].

| Table 1. Volcanic Ash Content |
|-----------------------------|
| Parameter                  | Unit | Result    |
| Water Content              | %    | 1,43      |
| Silica (SiO₂)              | %    | 85,6      |
| Aluminum (Al₂O₃)           | %    | 0,95      |
| Calcium (CaO)              | %    | 4,78      |
| Magnesium (MgO)            | %    | 4,48      |

Source: Yahya Rangkuti, 2016

Lime reacts with various fine pozzolan components to form cement silica calcium. Silica is the main mineral of fly ash; if it reacts against lime, it will form gel [(Ca(Si)₃]. Fly ash has the characteristic of pozzolan so that when it is mixed with lime and water, it will react by forming Calcium Silicates Hydrate (C-S-H).

The lime used in the research was natural lime which slips off from the sieve No. 200; it was taken from Sipoholon, North Tapanuli.

| Table 2. Lime Ash Content |
|---------------------------|
| Parameter                 | Unit | Result     |
| Amount of Carbonate (CO₃) | %    | 97         |
| Calcium Oxide (CaO)       | %    | 29,77-55,5 |
| Magnesium (MgO)           | %    | 21-31      |
| Silica (SiO₂)             | %    | 0,14-2,41  |
| Alumina (Al₂O₃) & Iron Oxide | %    | 0,5        |

Source: Yoseph Purnandani, 2007
3. Research Methode

![Flow Chart]

4. Result and Discussion

4.1. Filling Ability

![Figure 2. V – Funnel Test]
4.2. Passing Ability

In the testing of malleable concrete, it had met the requirement of EFNARC 2002, but the testing of L Shaped Box, it did not because of the erroneous testing device. The adding of volcanic ash and lime ash in the mixture of malleable concrete had caused workability of the concrete but it can still be used because it had met the requirement. From the Passing ability and filling ability tests, it was found that using more volcanic ash and lime ash would influence malleable concrete which could be used because volcanic ash and lime ash could absorb a lot of water during the casting [5][6].
4.3. Concrete Absorption

The increase in volcanic ash and lime ash causes the increase in absorption value. This is in accordance with the result of the previous researches which stated that the absorption from the use of lime was very great.

4.4. Compressive Strength Test

Compressive strength test were conducted at 28 days, having size of 150 mm in diameter and 300 mm in height.
For Variation 3, there was the parity of compressive strength in variation 4, and it decreased in variation 5. The use of SCC concrete without using lime ash and volcanic ash had more compressive strength, compared with the increase. During the maintenance, concrete secretes calcium; in this research there was the excessiveness of calcium in the concrete which influenced its compressive strength. Compressive strength which had been planned for 35 Mpa in each concrete variation which was 28 days old was not achieved although it used superplasticizer. In concrete, there was the increase in lime ash and volcanic ash since their absorption was very high. This was strengthened in Chapter 2 of this research which discussed that the reaction of lime ash with volcanic ash would form silica-alkali gel. The final result of silica-alkali gel showed that it could absorb water and caused particle aggregate and crack in cement. The equation of chemical reaction was as follows.

\[
\text{SiO}_2 + 2\text{NaOH} + \text{H}_2\text{O} \rightarrow \text{Na}_2\text{SiO}_3 \cdot 2\text{H}_2\text{O}
\]

Silica Alkali Water Alkali-silica Gel

From this reaction, it was found that the increase in volcanic ash and lime ash would decrease the quality of SCC concrete tensile strength.

**Conclusion**

Based on the result of the assay in the laboratory, it could be concluded as follows:

| Sample | Slump Flow (mm) | L - Box (0.8-1) | V – Funnel (detik) | J – Ring (mm) |
|--------|----------------|----------------|------------------|--------------|
| 1      | 745            | < 0.8          | 11.35            | 0.3          |
| 2      | 730            | < 0.8          | 11.52            | 0.5          |
| 3      | 710            | < 0.8          | 11.65            | 0.5          |
| 4      | 685            | < 0.8          | 11.76            | 0.7          |
| 5      | 665            | < 0.8          | 11.97            | 0.8          |

Slump flow, l shaped box, v funnel, j ring value underwent the decrease, along with the use of the variation of the increase in volcanic ash and lime ash, compared with normal SCC concrete. This indicated that the supplementary materials in the malleable concrete could cause the decrease in workability, filling ability, and passing ability of malleable concrete [11][13].

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