The stability of clay using mount Sinabung ash with unconfined compression test (uct) value

Ika Puji Hastuty1*, Roesyanto1, Ronny Hutauruk1 and Oberlyn Simanjuntak2
1 Department of Civil Engineering, Universitas Sumatera Utara
2 Department of Civil Engineering, Universitas HKBP Nommensen

E-mail: ika.hastuty@usu.ac.id

Abstract. The soil has a important role as a highway’s embankment material (sub grade). Soil conditions are very different in each location because the scientifically soil is a very complex and varied material and the located on the field is very loose or very soft, so it is not suitable for construction, then the soil should be stabilized. The additive material commonly used for soil stabilization includes cement, lime, fly ash, rice husk ash, and others. This experiment is using the addition of volcanic ash. The purpose of this study was to determine the Index Properties and Compressive Strength maximum value with Unconfined Compression Test due to the addition of volcanic ash as a stabilizing agent along with optimum levels of the addition. The result showed that the original soil sample has Water Content of 14.52%; the Specific Weight of 2.64%; Liquid limit of 48.64% and Plasticity Index of 29.82%. Then, the Compressive Strength value is 1.40 kg/cm². According to USCS classification, the soil samples categorized as the (CL) type while based on AASHTO classification, the soil samples are including as the type of A-7-6. After the soil is stabilized with a variety of volcanic ash, can be concluded that the maximum value occurs at mixture variation of 11% Volcanic Ash with Unconfined Compressive Strength value of 2.32 kg/cm².

Keywords: clay, Mount Sinabung ash, soil stabilization, compressive strength

1. Introduction
Clay minerals consist of alumina or iron silicates and magnesium. Some of them contain alkali as its basic component. Clay minerals show an affinity characteristic with water and produce plasticity which is not describes by any other material although the material may have clay or a smaller size. Clay is almost always hydrated, surrounded by layers of water molecules called adsorbed water. Water determines the plasticity properties of clay. In laboratory experiments for the Atterberg limit, ASTM determined that the water used was only added as needed. The main phenomenon of clay is that its dry mass from the initial moisture content has a considerable strength. If the clay is broken up into small particles, the material will behave as a non-cohesive material. When the water is added back, the material will become plastic with a smaller strength than the strength of the dry lump [Das, 1991][1]. Due to the high plasticity of clay soils, for the clay to meet the technical requirements to be used as a construction material such as pile, the soil needs to be stabilized.
Soil stabilization can be categorized as mechanical stabilization such as compact the soil with various types of mechanical equipment, using additive materials such as mixing with cement, fly ash and so on and physical stabilization such as adding grains or gravel to certain fractions considered inadequate to get a dense gradation.

Compaction is an attempt to increase the density of the soil by using mechanical energy to produce compression of particles. In the laboratory, the test performed for this compaction process is called the Proctor Standard test. Laboratory compaction is intended to determine the value of optimum water content ($w_{opt}$) and maximum dry unit weight ($\gamma_d^{max}$) of soil which is compacted with a certain compaction method. The optimum water content obtained from laboratory experiments will be used as a guideline for the implementation of soil compaction in the field, while $\gamma_d^{max}$ will be used for the standard in controlling the quality of compaction in the field [2].

![Graph between water content ($w_{opt}$) and maximum dry unit weight ($\gamma_d^{max}$)](image)

**Figure 1.** Graph between water content ($w_{opt}$) and maximum dry unit weight ($\gamma_d^{max}$)

The Unconfined Compression Test (UCT) is a simple soil compressive test intended to determine the magnitude of the Unconfined Compressive Strength of soil and cohesive rock samples in both undisturbed and remoulded conditions. What is meant by unconfined compressive strength is the axial load per unit area at the time of the test specimen collapsed when the axial strain reaches 20%.

2. Methods

2.1. Materials Preparation

a. Soil

Soil samples from PTPN II, Patumbak, Deli Serdang, North Sumatra. In this study, the samples that we used are disturbed soil. The samples were taken by digging the soil using a hoe and then inserting it into the sacks. Then dried the soil in the air and pulverized it with a mechanical breaking tool.

b. Volcanic Ash (AGV)

Volcanic ash used is Mount Sinabung Ash taken from Guru Kinayan Village, Karo District, North Sumatra. Then the volcanic ash was filtered using a sieve no. 200.

2.2. Implementation of Testing

The test performed was divided into 2 parts, they are soil testing and volcanic ash testing. The tests for soil are water content test, specific gravity test, atterberg limits test, sieve analysis test, compaction test and Unconfined Compression Test (UCT). As for volcanic ash, the tests which will be tested are specific gravity test, sieve analysis test, and atterberg limits test.

2.3. Laboratory Data Analysis

After all the data from both physical and mechanical properties were obtained, then collect and analyze the data. All the results obtained from the implementation of the research will be shown in tables and graphs, meanwhile the explanations will be shown in conclusion.
3. Results and Discussions

3.1 Testing of Original Soil

| No. | Testing          | Soil  | Mount Sinabung Ash |
|-----|------------------|-------|--------------------|
| 1.  | Water Content    | 14,52%|                    |
| 2.  | Specific Gravity | 2.64  | 2.62               |
| 3.  | Liquid Limit     | 48,64%| Non Plastis        |
| 4.  | Plastic Limit    | 18,81%| Non Plastis        |
| 5.  | Plasticity Index | 29,82%| Non Plastis        |
| 6.  | Sieve Analysis   | 50,04%| 11.40%             |

According to the classification system of USCS, this soil is included in the CL (Clay - Low Plasticity) group which is inorganic clay with low to medium plasticity. And according to the classification system of AASHTO, the sample of soil could be classified as type of A-7-6 soil.

3.2 Tests of Physical and Mechanical Properties of Soil with Additive Materials

The results obtained from the test of samples that have been mixed with additive materials show that cement and volcanic ash can improve the physical and mechanical properties of the soil.

Figure 2 shows that with the addition of additive material, the Liquid Limit value of soil will decrease. The more percentage of AGV, the smaller its liquid limit. Meanwhile Figure 3 shows that the value of plastic limit is increasing. Figure 4 is a graph of the Plasticity Index value of each mixed variation. The decline in value of the plasticity index may reduce the potential of soil to expand and shrink.

![Figure 2. Graph between Liquid Limit (LL) with mixed variation of AGV](image)
Figure 3. Graph between Plastic Limit (PL) with mixed variation of AGV

Figure 4. Graph between Plasticity Index (PI) with mixed variation of AGV

Figure 5. Graph between Maximum Dry Density ($\gamma_{d,max}$) with mixed variation of AGV
The results of the Unconfined Compression Test are shown in graphical form in Figure 7. In this test we will find the relationship between the Unconfined Compression value (qu) on the undisturbed and remoulded soil as well as the Unconfined Compression value (qu) on each variation of soil mixed with volcanic ash with curing time for 1 and 14 days. Furthermore, from the results obtained cohesion value (cu) which is equal to ½ qu.

The unconfined compression value of undisturbed soil obtained from the test is 1.10 kg/cm², and 0.50 kg/cm² for remoulded soil. There is a substantial decrease caused by the treatment received by remoulded soil which broke the structure of soil. The reduced soil strength due to soil structure damage is called sensitivity. This sensitivity value will determine the soil classification according to its sensitivity [3].

Based on Atterberg limits test, Volcanic Ash has Non-Plastic properties [4][6]. It also can be seen from the results of all tests after mixing the ash into the soil, its physical character and soil bearing capacity has improved. After obtained the optimum mixture, then there is a decrease in the value of Compressive Strength. It happened due to excessive amount of volcanic ash which has been added to the soil, resulting the cohesion between soil grains and water is getting smaller, when the soil is given pressure, the soil will be easily broken and failure.

Conclusions
Based on the research that has been done on the effect of stabilizer material and Volcanic Mountain Ash against clay soil with predetermined mixed content and curing time for 1 and 14 days, it can be concluded:

1. Based on the classification system of Unified Soil Classification System (USCS), soil is included in the group of CL which is inorganic clay with low to medium plasticity. And after it is being
mixed with volcanic ash, the soil remains included in the group of CL.

2. Based on the classification system of American Association of State Highway and Transportation Officials (AASHTO), this soil could be classified as type of soil A-7-6. And after it is being mixed with volcanic ash, the soil be classified as type of soil A-7-5.

3. Based on proctor standard test obtained optimum water content and maximum dry weight volume of original soil are 21.38 % and 1.32 g/cm³. While the highest maximum dry weight value obtained from a mixture of 10%AGV with 14 days of curing time which is equal to 1.490 g/cm³ with optimum water content 19.35%.

4. From the Unconfined compression Test obtained Compressive strength (qu) of undisturbed soil is 1.40 kg / cm², while compressive strength (qu) of remoulded soil is 0.50 kg / cm².

5. The test results show that the addition of 11%AGV with 14 days of curing time has the highest Compressive strength (qu) which is equal to 2.32 kg/cm.

6. Based on Atterberg limits test on the volcanic ash, obtained that volcanic ash is a non-plastic material. This also can be seen from all the test result after mixing volcanic ash into the soil, the physical character and bearing capacity of the soil get improved.

7. After obtaining the optimum mixture, then there is a decrease in the value of Compressive Strength. It happened due to an excessive amount of volcanic ash which has been added to the soil, resulting the cohesion between soil grains and water is getting smaller, so the soil becomes easily broken when it is given vertical pressure.

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