The Utilization of Volcanic Ash and High Rusk Ash as Material Stabilization in Clay by Unconfined Compression Test (UCT) and California Bearing Ratio (CBR)

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Abstract. Clay is a type of soil which needs to be stabilized. The method often used is stabilization by adding additive to the soil. In this study, the additive materials that we use are Volcanic ash from Mount Sinabung and rice husk ash. The selection of these materials as additive is based on their silica content. Volcanic ash has a high silica content that is equal to 82.04%, and rice husk ash also has a high silica content which is equal to 89.8%. This study aims to improve the physical and mechanical properties of soil. Clay used in this study was taken from Patumbak, Deli Serdang, the volcanic ash was taken from Mount Sinabung, and the rice husk ash was produced from the bricks burning outcome in Stabat Langkat. The tests for soil are water content test, specific gravity test, Atterberg limits test, sieve analysis test, compaction test, CBR (California Bearing Ratio) laboratory test, and Unconfined Compression Test (UCT). The test results show that the value of liquid limit in addition of volcanic ash and rice husk decreased gradually. So does the plasticity index, the value decreased from 26.33% to 5.31% on the addition of 2.5% volcanic ash + 22.5% rice husk ash. While on the mechanical properties, the optimal CBR value obtained in the addition of 75% soil + 25% volcanic ash is 15.48%, and the addition of 25% volcanic ash causes soil increases the compressive strength from 1.38 kg/cm² to 2.23 kg/cm². Unconfined Compression Test result shows that the compressive Strength (q_u) of original soil is 1.38 kg/cm² value, meanwhile the Compressive Strength (q_u) of remoulded soil is 0.58 kg/cm².

1. Introduction
Soil has an important role in a construction, besides as a building material in a wide variety of civil engineering works, soil is also used as supporting foundation of the building. Initially, soil engineering was performed only based on past experience. But with the development of science and technology, design and implementation of a better and more economical structure is indispensable.

Soil stabilization is an attempt to change or improve the engineering properties of soil in order to qualify certain specification. Soil stabilization process is divided into three ways, they are mechanical, physical and chemical stabilization. Stabilization performed in this study is chemical stabilization by adding additive materials into the soil. Additive materials selected for this study are volcanic ash from Mount Sinabung and rice husk ash. The selection of these materials as additive is based on their high silica content, also because these materials are still underutilized by the people.
This study aims to determine the physical properties of the original soil, then to determine the effect of volcanic ash and rice husk ash to the soil stability, and to find the effective percentage of rice husk ash and volcanic ash addition toward the bearing capacity and maximum compressive strength of soil.

2. Method

2.1 Preparation work

a. Materials Preparation
   Soil samples used in this study were taken from PTPN II, Patumbak, Deli Serdang, North Sumatra. This study used 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. Rice husk ash
   Rice husk ash used in this study was the bricks burning outcome from Lubuk Pakam, Deli Serdang, North Sumatera. Then the rice husk ash was filtered using a sieve no. 200. Based on the results of the material testing, rice husk ash contains 89.9% silica (SiO$_2$), contains 2.24 % Al$_2$O$_3$ and contains 0.1% MgO.

c. Sinabung Volcanic Ash
   Sinabung ash used was taken from Tiganderket Village, Karo, North Sumatera. The volcanic ash was filtered using a sieve no.200. Based on the results of the material testing, Sinabung ash contains 74.3% silica (SiO$_2$), contains 4.52 % Al$_2$O$_3$ and contains 5.10% CaO.

2.2 Implementation of Testing

The test performed was divided into 3 parts, they are soil testing, volcanic ash testing, and rice husk ash testing. The tests for soil are water content test, specific gravity test, Atterberg limits test, sieve analysis test, compaction test, CBR (California Bearing Ratio) laboratory test, and Unconfined Compression Test (UCT). As for volcanic ash and rice husk 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 analyse 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 Soil Testing
### Table 1. Soil Physical Properties Data

| No | Test                         | Result     |
|----|------------------------------|------------|
| 1  | Water Content                | 12.35%     |
| 2  | Spesific Gravity            | 2.65%      |
| 3  | Liquid Limit                 | 46.73%     |
| 4  | Plastic Limit                | 20.42%     |
| 5  | Plasticity Index            | 26.33%     |
| 6  | Passes Percentage of Sieve No.200 | 49.16% |
| 7  | Optimum Water Content        | 21.25%     |
| 8  | Maximum dry Weight Volume    | 1.31 gr/cm³ |

### 3.2 Volcanic Ash and Rice Husk Ash Testing

#### Table 2. Volcanic Ash Physical Properties Data

| No | Test                        | Result Volcanic Ash | Result Rice Husk Ash |
|----|-----------------------------|---------------------|----------------------|
| 1  | Specific Gravity            | 2.62                | 2.54                 |
| 2  | Liquid Limit                | Non Plastic         | Non Plastic          |
| 3  | Plastic Limit               | Non Plastic         | Non Plastic          |
| 4  | Plasticity Index            | Non Plastic         | Non Plastic          |
| 5  | Passes percentage of sieve no. 200 | 13.80 % | 8.56 % |

### 3.3 Physical and Mechanic Properties Test of Soil with the Addition of Stabilizer.

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

#### Table 4. Compaction and CBR Test Data And The Result Of Unconfined Compression Test With Different Mixture Variety

| Sample                        | $γ_d$ max (gr/cm³) | $W_{opt}$ (%) | CBR (%) | $q_u$(kg/cm²) | $c_u$(kg/cm²) |
|-------------------------------|-------------------|---------------|---------|--------------|--------------|
| Soil                          | 1.31              | 21.25         | 12.87   | 1.38         | 0.69         |
| T 75% + 25% AGV               | 1.52              | 25.53         | 15.48   | 2.23         | 1.11         |
| T 75% + 25% ASP               | 0.93              | 43.16         | 7.42    | 0.63         | 0.31         |
| T 75% + 2.5% ASP + 22.5% AGV  | 1.49              | 26.22         | 11.28   | 2.19         | 1.09         |
| T 75% + 5% ASP + 20% AGV      | 1.45              | 28.34         | 10.50   | 2.10         | 1.05         |
| T 75% + 7.5% ASP + 17.5% AGV  | 1.43              | 29.96         | 9.62    | 1.99         | 1.01         |
| T 75% + 10% ASP + 15% AGV     | 1.41              | 30.17         | 8.69    | 1.88         | 0.94         |
| T 75% + 12.5% ASP + 12.5% AGV | 1.40              | 32.29         | 8.43    | 1.63         | 0.81         |
| T 75% + 2.5% AGV + 22.5% ASP  | 1.21              | 39.17         | 7.38    | 0.57         | 0.28         |
|          | CBR % | 5% Soil | 12,5% Soil | 75% Soil | 0 % | 20% Soil | 10% Soil | 15% Soil | 7,5% Soil | 17,5% Soil | 5% Soil | 22,5% Soil | 2% Soil | 5% Volcanic Ash | 2,5% Rice Husk Ash
|----------|-------|---------|-------------|----------|-----|----------|----------|----------|-----------|------------|--------|------------|---------|----------------|--------------------|
| T 75% + 5% AGV + 20% ASP | 1,23  | 38,62   | 7,73        | 0,64     | 0,32|
| T 75% + 7,5% AGV + 17,5% ASP | 1,27  | 36,21   | 7,96        | 0,97     | 0,48|
| T 75% + 10% AGV + 15% ASP | 1,28  | 34,26   | 8,16        | 1,24     | 0,62|
| T 75% + 12,5% AGV + 12,5% ASP | 1,40  | 32,29   | 8,43        | 1,63     | 0,81|

Remoulded Soil

0,58
0,29

**Figure 1.** The Graph of Relationship Between CBR Value and 75% Soil With The Addition of 25%-12,5% Volcanic Ash + 2,5%-12,5% Rice Husk Ash

**Figure 2.** The Graph of Relationship Between CBR Value and 75% Soil With The Addition of 25%-12,5% Rice Husk Ash + 2,5%-12,5% Volcanic Ash
4. Conclusions
From the research that has been done, it can be concluded as follows:

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. Meanwhile 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.

2. Obtained that the value of water content and specific gravity of original soil is 12.35% and 2.65, while specific gravity value of volcanic ash and rice husk ash is 2.62 and 2.54.

3. Based on Atterberg limits test on original soil obtained that the liquid limit and plasticity index of soil are 46.73% and 26.33%. The addition of 75% soil + 2.5% volcanic ash + 22.5% rice husk ash has the lowest plasticity index which is equal to 5.31% and liquid limit value which is equal to 30.11%.

4. Based on proctor standard test obtained optimum water content and maximum dry weight
volume of original soil are 21, 25 % and 1,31 gr/cm³. While the highest maximum dry weight value obtained from a mixture of 75% soil + 25% volcanic ash is equal to 1, 52 gr/cm³ with optimum water content 25,53% and 14 days of curing time.

5. CBR laboratory test shows that the CBR value of original soil is 12,87% and the optimum CBR value obtained on the addition of 75% soil + 25% volcanic ash is 15,48%.

6. Unconfined Compression Test result shows that the compressive Strength (qu) of original soil is 1.38 kg/cm² value, meanwhile the Compressive Strength (qu) of remoulded soil is 0,58 kg/cm².

7. The addition of 75% soil + 25% volcanic ash has the highest compressive Strength (qu) value which is equal to 2,23 kg/cm².

8. According to Atterberg limits test, the result shows that volcanic ash and rice husk ash is a non-plastic material. It also can be seen from all the tests result, the physical character and compressive strength of the soil become improved.

9. After the optimum variation of mixture has obtained, there is a decrease in the value of compressive strength. It happens because there was too much addition of rice husk ash which caused the bond between soil and water was getting smaller, so that the soil becomes friable when it is given vertical pressure.

Acknowledgments

The support is under the research grant TALENTA USU of Year 2016

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