Study of stabilized soil clay soil characteristics using vulcanic ash and tailing as subgrade layers

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Abstract. Soft clay is soil that need microscopic to sub microscopic size originating from the chemical weathering of rock compilers. Clay soil is very hard in a dry state and is plastic at moderate water content. At higher water contents the clay soil is sticky (cohesive) and very soft. Soil stabilization is an effort to improve the quality of the soil by using certain materials to increase soil strength. Soil stabilization is the process of mixing soil with certain materials to improve the technical properties of the soil and is an attempt to change or improve the technical properties of the soil to meet certain technical requirements of the soil carrying capacity. This research is an experimental study to determine the carrying capacity of clay soil stability using volcanic ash deposits and tailings instead of cement. The research variables are volcanic ash deposits which is locked of 8% and tailings with the variation of 4%, 5%, 6% and ripening for 3 days, 7 days and 14 days. The benefits of this experimental study are expected to get the carrying capacity of the soil from stabilized soil greater than the carrying capacity of the original soil by the unconfined compression test (UCS).

1. Introduction
Soil stabilization is the process of mixing soil with certain materials to improve the technical properties of the soil and is an attempt to increase or improve the technical properties of the soil to meet any technical requirements of stabilization that can increase the carrying capacity of the soil. The process of soil stabilization depends on mixing the soil with the soil others to get the desired gradation, or mixing the soil with factory-made added materials, so that the technical properties of the soil are better in order to improve the technical properties of the soil such as carrying capacity, compatibility, permeability, ease of work, potential for development and sensitivity to change moisture content, then it can be done by the easiest way, such as compaction and mixing the soil with other materials such as volcanic ash and tailings. This research tries to reduce dependence on cement as a stabilizing material used, so that it can save costs when viewed from the economic side of infrastructure development. The purpose of this study was to study the majority of the mixture of Volcanic Ash and Tailings as a stabilizing agent for subgrade improvement efforts based on UCS values. for a better understanding of the durability and strength performance of these materials against weathering conditions. In general, there are several scholars who have examined the utilization of different types of waste and recycled materials as a stabilizing agent to enhance the strength of weak soil [1-6].

2. Methodology
The Research Stages to be carried out based on the General Flowchart in Figure 1 below:
2.1. Soft clay soil
Soft clay soils are aggregates of microscopic and submicroscopic sized particles that originate from chemical decomposition of rock constituents, and are plastic in moderate to wide water content intervals. According to Terzaghi in a very hard dry state, and not easy to peel off only with the fingers. Clay permeability is very low. Mineral particles from clay are the main source of cohesive soil cohesion [7]. Clay soils are microscopic to sub-microscopic soils derived from weathering rock-forming chemical elements, clay soils are very hard in dry conditions and are plastic at moderate water levels. At higher water contents the clay is sticky (cohesive) and very soft. According to Chen clay minerals consist of 3 main components namely montmorillonite, illite, and kaolinite [8].

2.2. Soil stabilization
The stability of expansive soils that is cheap and effective is to add certain chemicals, with the addition of chemicals can bind clay minerals into solids, thereby reducing the expansion and expansion of shrinkage shrinkage clay [9].

Durability and environmental properties of stabilized soil gypsum were investigated in previous studies to solve such challenges and reasonable results were obtained [10-12]. These stabilization procedures are used throughout the world with certain modifications that are adapted to the local weather and soil. The percentage of the mixture is usually within the following limits:

Cement : 3 % - 12 % for soil A-1 to A-4,
          8 % - 16 % for soil A-4 to A-7
LFA    : 12 % - 30 % with a greater percentage for worse land

Figure 1. Research flow chart.
Soil testing consists of testing physical properties and testing technical properties. Testing physical properties including testing the limits of Atterberg, and testing hydrometer analysis while testing the technical properties is compaction testing, and UCS testing.

2.3. Physical property testing

2.3.1. Moisture content testing. According to SNI 03-1965 groundwater content is the ratio between the weight of the water contained in the soil and the weight of the soil grain expressed in percent

2.3.2. Content weight testing. According to SNI 03-1964 soil weight is the ratio between the weight of the soil and its volume in its original state on the ground. The greater the dry weight of the soil, the higher the density level.

2.3.3. Specific gravity testing. According to SNI 03-1964 soil specific gravity or Specific Gravity (Gs) is the ratio between the weight of soil grains and the weight of distilled water with the same contents at a certain temperature. The value of specific gravity will affect several things such as soil strength, soil self weight, etc.

2.3.4. Atterberg limits testing. The known Soil Consistency limits are liquid, plastic and shrinkage limits.

2.4. Mechanical properties test

2.4.1. Compaction test. Compaction is a process where air from the soil pore is excluded by using mechanical method to bind the soil. The purpose of compaction test in the laboratory is to determine maximum dry mass content and optimum soil water content.

2.4.2. Unconfined compression test. UCS used in addition to assessing the free compressive strength of a cohesive type of soil.

3. Analysis and discussion

In this section explained the results of research conducted, namely the results of testing the characteristics of the subgrade (physical and mechanical properties) before and after mixing with stabilization materials. The following explanation:
3.1. Test results of mixed subgrade physical characteristics

| Index Properties               | Value on the mixture  |
|--------------------------------|------------------------|
|                                | 0                      | 1 | 2 | 3                      |
|                                | Soft Clay Soil         | 100% Soil + 8% ABVK + 4% TL | 100% Soil + 8% ABVK + 5% TL | 100% Soil + 8% ABVK + 6% TL |
| Moisture Content Testing       | 43%                    |    |    |                        |
| Plastic limit PL %             | 37%                    | 80% | 68% | 62%                    |
| Liquid limit LL %              | 80%                    | 51% | 49% | 37%                    |
| Plasticity index PI %          | 43%                    | 28% | 20% | 25%                    |

**Figure 3.** Test results of subgrade physical characteristics.

Based on the test results of the physical characteristics of the mixed subgrade described in figure 3, the results of the testing of the Plasticity Index of the original soil (0) were 43%. Based on Pd T-10-2005-B shows that a subgrade with a Plasticity Index> 32% is classified as a clay which has very high development properties. It can be concluded that in the mixture (2) it can reduce the Plasticity Index by 88.00% from the condition of the Plasticity Index mixture (0), while the results of BJ testing on native soil (0) were 2.65 and decreased by 77.00% in the mixture (1).

3.2. Test results of mixed subgrade mechanical characteristics

**Figure 4.** Test results of subgrade mechanical characteristics.

Based on figure 4, native soil has a compressive strength (qu) of 8.22 kg / cm². While in the mixed soil curing time 3 days mixed 1 has hard soil properties as well as mixed 2 and 3 but the greatest carrying capacity is in curing 3 days mixed 3 of 13.45 kg / cm².
Figure 5. Relationship between Addition of 8% ABVK + Variation of% TL to the soil carrying capacity (qu).

In figure 5 can be seen in ripening 7 days and 14 days mixture of 1.2 and 3 also has hard soil properties where the highest carrying capacity is a mixture of 3 from 12.25 and 17.04. In terms of strength, a larger tailings mixture can increase bearing capacity in subgrade.

4. Conclusion

From the elaboration above, it may conclude that:

- There is a change in the decrease in density of soil specific gravity with stabilized soil.
- There was a change in impairment of the Plasticity Index by 80.43% in the mixture (2) from the mixture condition (0).
- There was a change in the maximum increase in UCS condition at 14 days per hour by 10.65% from 8.22% in the mixture (1) from the original soil condition (0), but the biggest increase occurred in the condition of UCS Peram 14 days which was 17.04 at mixture (3) of mixed conditions (0) during the 0 day peram period.
- There is also a change in the increase in the maximum value of soil cohesion in the mixture (3) curing of 14 days in which the original soil value of 4.11% during the 0 day peram period increased by 8.52% during the 14 day peram period.
- There is an almost identical trend between an increase in the amount of stabilization mixture and the results of each test, both physical and mechanical testing.

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