Utilization of palm kernel shell ash as stabilization materials for clay to settlement consolidation

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Abstract. Consolidation is a change in soil volume at the time of loading due to pore pressure dissipation. The consolidation parameter is a parameter that determines the consolidation process and magnitude of the settlement consolidation in soil. The process of consolidation in clay takes a long time and the settlement consolidation that occurs is relatively large, so it is necessary to improve soil stability on clay. Palm kernel shell ash is used in this research to enhance clay stability. Clay was mixed with palm kernel shell ash with varying levels of 5%, 10%, and 15% of the soil the dry weight. The Consolidation test was carried out on a mixture of clay and palm kernel shell ash to obtain consolidation parameters like the values of consolidation coefficient ($C_v$), compression index ($C_c$), and settlement of consolidation ($S_c$).

The results of this research showed that the consolidation coefficient value increased with increasing levels of palm kernel shell ash. The Compression index and settlement of consolidation decreases with increasing levels of palm kernel shell ash. Based on the research, it can be concluded that the addition of palm shell ash to clay can accelerate the process of consolidation and reduce the value of settlement of consolidation.

1. Introduction

During the construction of a structure, the soil will be got a certain amount of compression [1]. When soil is stressed, they deform. Deformation caused a change of shape or change of volume or both [2]. Changes in soil volume at the time of loading due to pore pressure dissipation are called consolidation. Potential consolidation settlement due to load stresses of building structures [3].

Some soil requires a relatively long time for deformation to occur; this is especially true for clay [2] because clay has a low coefficient of permeability [1]. Besides that, the settlement consolidation that occurs is relatively large, so it is necessary to improve soil stability on clay. Reduction of settlement consolidation can be done by adding stabilizing material on the clay [4-8].

Oil palm plantations and management are very extensive in Indonesia. Management of oil palm increasing so as to produce more and more waste. Not all of oil palm shell waste is utilized by the manager optimally. Agricultural waste can be utilized as a soil stabilizing material. The Use of stabilizers from agricultural wastes has the potential of reducing the amount of waste. Palm oil fuel ash, palm kernel shell ash, rice husk ash, seashell powder, and sawdust ash, are effective modifier of subgrade soil [9]. Palm kernel shell ashes and sawdust ashes have effects on strength properties of the soil as well as stability of soil [10],[11]

Palm kernel shell ash is the waste from burning palm shells that contain a lot of silica, with SiO2 is 59.15 %, Al2O3 is 11.72%, Fe2O3 is 0.04%, CaO is 7.96%, MgO is 5.03 % [12]. The use of palm kernel shell ash as a soil stabilization material can increase soil strength [13-19]. Apart from
being used as a soil stabilization material, palm kernel shell ash was also used in concrete mixtures to increase the strength of concrete [20-22].

Based on the availability and advantages of palm kernel shell ash, it was used as a stabilizing material in this research. This research focuses on the effect of the addition of Palm Kernel Shell Ash to clay to the parameter of soil consolidation as the coefficient of consolidation (Cv), compression index (Cc) and settlement of consolidation (Sc)

2. Research Method
2.1 Materials
The soils were used as a sample in this study from Kacang Pedang Pangkalpinang. Based on the USCS method, the soil is classified in Inorganic Clays with low plasticity (CL). Index properties of soil as given in table 1. Soil parameters were obtained from laboratory tests according to Indonesia National Standards (SNI)

| Table 1. Index Properties of Soil |
|----------------------------------|
| Specific Gravity gr/cm³ | Natural moisture Content (%) | Liquid Limit (%) | Plastic Limit (%) | Maximum Dry Density gr/cm³ | Optimum Moisture Content (%) |
|--------------------------|-----------------------------|-----------------|------------------|-----------------------------|-----------------------------|
| 2.66                     | 29.01                       | 34.08           | 20.58            | 1.78                        | 18.2                        |

Clays were mixed with palm kernel shell ash with varying levels of 5%, 10%, and 15% of the dry weight of the soil, three samples for each mixture, then it was taken the average value of the analysis results. Mixing of clay and palm kernel shell ash uses water with optimum moisture content based on soil compaction results testing, as given in table 1. Furthermore, a consolidation test was carried out on the stabilized clays

2.2 Consolidation Test
One dimensional consolidation test was carried out in accordance with the Indonesian National Standard (SNI) 2812: 2011. From the results of the consolidation test, coefficient of consolidation (Cv), compression index (Cc), and settlement of consolidation (Sc) were obtained. The coefficient of consolidation (Cv) can be determined from laboratory observation of time vs. dial reading; the graphical procedures were used the Square Root of Time Method by Taylor (1942). The slope of the e vs. log \( \sigma \) from laboratory observation is referred to as the compression index (Cc). Settlement consolidation (Sc) was calculated by equation 1 base on the result of the consolidation test.

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S_t = C_t \frac{H}{1+e_0} \log \frac{P_t}{P_o}
\]  

Figure 1. Consolidation Test
3. Result

3.1 Coefficient of Consolidation (Cv)
The coefficient of consolidation relates to how long soil will take for an amount of consolidation to take place [23]. The coefficient of consolidation (Cv) were obtained based on the analysis of variation of dial gauge readings at various time intervals for a particular stress level with respect concerning to square root of time. The coefficient of consolidation (Cv), for all stabilized clay samples, increases with increasing palm kernel shell ash content as given in figure 1.

![Figure 2 The Effect of Adding Palm Kernel Shell Ash to Coefficient of Consolidation (Cv)](image)

The coefficient of consolidation of original clay without palm kernel shell ash is 0.0417 cm²/s; it is increased after being added palm kernel shell ash. After adding palm kernel shell ash to clay with levels of 5%, 10%, and 15%, the coefficient of consolidation increased sequentially 0.0530 cm²/s; 0.0547 cm²/s and 0.0549 cm²/s. The increase in the value of the coefficient of consolidation results in the faster time needed in the consolidation process. The addition of palm kernel shell ash to clay can increase the value of the coefficient of consolidation [24].

3.2 Compression Index (Cc)
The compression index (Cc) is an important parameter, it is related to the amount of consolidation settlement. Compression index (Cc) values were obtained based on the analysis of pressure-void ratio curves on a semi-log plot i.e. virgin compression curves. Compression index (Cc) values for all stabilized clay samples decrease with increasing palm kernel shell ash content, as given in figure 2.

![Figure 3. The Effect of Adding Palm Kernel Shell Ash to Compression Index (Cc)](image)
The compression index of original clay without palm kernel shell ash is 0.0555; it is decreased after being added palm kernel shell ash. After adding palm kernel shell ash to clay with levels of 5%, 10%, and 15%, the coefficient of consolidation decreased sequentially 0.0553; 0.0279 and 0.0265. Addition of palm kernel shell ash to fill the soil pores, thereby reducing the soils’ compression index value. Addition of palm kernel shell ash to clay can decrease the value of the compression index [24]

3.3 Settlement of Consolidation (Sc)
If the soil layer is burdened, the soil will experience strain or settlement. The strain that occurs in the soil is caused by changes in the composition of the soil and reduced pore cavities in the soil due to vertical loading. Based on the consolidation parameters, the value of the settlement consolidation of soil can be determined. The settlement of consolidation (Sc), for all stabilized clay samples decreases with increasing palm kernel shell ash content as given in figure 3.

![Figure 4. The Effect of Adding Palm Kernel Shell Ash to Settlement of Consolidation (Sc)](image)

The settlement of consolidation of original clay without palm kernel shell ash is 0.31 cm; it is decreased after being added palm kernel shell ash. After adding palm kernel shell ash to clay with levels of 5%, 10%, and 15%, the settlement of consolidation decreased sequentially 0.23 cm; 0.16 cm and 0.14 cm. The decrease in the value of the compression index resulting in a decrease in the value of settlements consolidation of soil.

4. Conclusion
Based on the results of this research it can be concluded that the addition of palm kernel shell ash in the clay can increase the value of the coefficient of consolidation and decrease the compression index with increasing levels of palm kernel shell ash to a content of 15%. It can be concluded that the addition of palm shell ash to clay can accelerate the process of consolidation and reduce the value of settlement consolidation.

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