Use of Gypsum Waste and Tin Tailings as Stabilization Materials for Clay to Improve Quality of Subgrade

Y Apriyanti, F Fahriani and H Fauzan

Department of Civil Engineering, Engineering Faculty, Universitas Bangka Belitung, Kampus Terpadu UBB Balunijuk, Merawang Bangka Regency Bangka Belitung Province 33172, Indonesia

E-mail: yayukapriyanti26@gmail.com

Abstract. Clay is a soil with low stability, so an effort is needed to improve soil stability in order to improve the quality of subgrade. In this study, an effort was made to improve soil stability by adding gypsum waste and tin tailings as a mixture in clay. Gypsum waste and tin tailings have not been utilized optimally in Bangka Belitung Province, so the research needs to be done to determine the effect of using gypsum waste and tin tailings as a material for stability of clay. The tests of soil characteristics carried out in this study were sieve analysis, soil specific gravity, compaction and direct shear test. In this study, the addition of gypsum waste and tin tailings in soft soil with 4 variations, namely clay with additional 8% gypsum waste and 20% tin tailings, clay with additional 8% gypsum waste and 30% tin tailings, and clay with addition 8% gypsum waste and 40% tin tailing, besides that, testing of the original soil was also carried out. The results of sieve analysis test showed that the addition of gypsum waste and tin tailings to clay soils could change the gradation of clay. Addition of gypsum waste and tin tailings on clay soil increases cohesion (c) dan shear angel value so that increases soil shear strength. From the results of the study, the addition of gypsum waste and tin tailings can improve the stability of clay so Improve Quality of Subgrade.

1. Introduction

The clay is a soil that consists most of microscopic and sub-microscopic particles (not clearly visible only with ordinary microscopy, shaped plate and consists of particles from mica, clay minerals, and other very fine minerals [1]. High plasticity clay has characteristics such as soft at high moisture content, low soil bearing capacity, high soil compressibility, easily shrinking and swelling. This soil condition is less reliable as a subgrade civil construction. Therefore, efforts are needed to improve clay characteristics. These efforts are often referred to as soil stabilization.

Soil stabilization is the process of mixing soil with soil or other materials to obtain gradations to be used, so that the mechanical properties of the soil get better. Stabilization is carried out to change the soil mechanical properties such as: bearing capacity, compressibility, permeability, swelling potential and sensitivity to changes in moisture content. There are two ways of soil stabilization is mechanical and chemical methods. In this study, stabilization was carried out mechanically and chemically. Tailings and gypsum are materials used as clay stabilization in this study.

Tin mining activities in Bangka Belitung produce waste in the form of tailings which are the result of the process of mining or processing mineral seeds. Tailings are always a serious problem which is...
commonly considered to be a main cause of environmental damage. In fact, tailing is also utilized to be good advantage. In Bangka Belitung, there are a large number of tin tailings, and it is not used an optimal by government and community yet. Tin tailing is a by-product of mining. The form of tailing is similar with a sand, therefore, it is called ‘tailing sand’. Sand has used as a soil stabilization [2]. Granules of relatively fine tin tailings are expected to be pore fillers to increasing soil shear strength. Addition of tin tailings on subgrade can increase soil shear strength thereby increasing bearing capacity of shallow foundation [3].

In some cases, the production of solid wasted is experiencing an uncontrolled and continuous increased [4]. In gypsum waste, the most commonly found content is the type of calcium sulphate hydrates with the CaSO4H2O chemical formula. This calcium functions to absorb water and fill the soil pores so that Gypsum can be used as a soil stabilization material [5]. The research showed that Gypsum had a good influence in increasing characteristic of clay, mixing gypsum with other materials as soil stabilization material causes an increase in the strength of clay [6-9]. So that the gypsum waste and tailings were mixed in this study. Besides being used as a clay stabilization material, gypsum is also used as a stabilization material for peat [10]. Based on the availability and advantages of gypsum and tin tailings, a study was conducted to determine the effect of adding gypsum and tin tailings on clay to the characteristics of clay.

2. Research Method
This research was conducted in a laboratory with testing according to Indonesia National Standards (SNI) [11]. This research uses tin tailing and gypsum waste, both of materials are mixed as clay stabilization materials. First step of this study was taking original soil. Soil classification is done at original clay using the USCS and AASTHO methods [1] based on the results of the sieve analysis and consistency limits (liquid limit and plastic limit) the soil classification is obtained. Then the density and compaction testing are done using the modification method. After that direct shear test and sieve analysis was carried out. In this study, the addition of gypsum waste and tin tailings in clay with 4 variations, namely original clay, clay with additional 8% gypsum waste and 20% tin tailings, clay with additional 8% gypsum waste and 30% tin tailings, and clay with addition 8% gypsum waste and 40% tin tailing.

3. Result
Based on the results of sieve analysis and consistency limits test, classification of clay from the USCS method, including CL classification and based on the AASTHO method this soil includes classification A-7-6. Based on the results of specific gravity and compaction tests, specific gravity values of clay is 2.639, value of OMC (Optimum Moisture Content) is 19.31% and Maximum Dry Density (MDD) value is 1,739 gr/cm³. These values can be seen in Figure 1.

![Figure 1](image_url)
In sieve analysis test, changes in the gradient of clay soil were obtained. In sieve analysis experiment, the original clay passed to the sieve no.200 was 54.511%. After being mixed with 8% gypsum waste and tin tailing with variations of 20%, 30%, and 40%, the clay passed to the sieve no.200 was decreased in a row to 50.23%, 47.31%, and 44.75%. So it showed that the addition of gypsum waste and tin tailings to clay can change the gradation of clay.

Based on the results of the direct shear strength test, cohesion \((c)\) and shear angle \((\phi)\) have increased with the increase in the percentage of tin tailings as shown in Figures 2 and 3.

![Figure 2: The effect of adding tailings and gypsum to the value of shear angle \((\phi)\)](image)

![Figure 3: The effect of adding tailings and gypsum to the value of cohesion \((c)\)](image)

Based on the value of cohesion \((c)\) and the shear angle \((\phi)\), the shear strength can be determined. The increase in soil shear strength can be seen in Figure 4. In the direct shear test, the shear strength of the original clay was 21.77 KN/m². After adding 8% gypsum and tin tailing’s variation of 20%, 30%, and 40%, the shear strength value has increased, the values respectively of 33.517 KN/m², 41.593 KN/m², and 49.447 KN/m², then the addition of gypsum 8% and 40% tin tailing produce the largest shear strength value. The shear strength is increase caused tin tailings to have coarse grain properties causing clay grains, which are fine-grained soils to change gradations into fine and coarse graded, as well as gypsum waste containing calcium which is useful as a binder for clay so that the soil becomes stiffer. These factors increase the cohesion value and soil shear angle so that the value of the soil shear strength increases.
Figure 4. The effect of adding tailings and gypsum to the value of shear strength

4. Conclusion
Addition of gypsum and tailings can increase the value of clay characteristics, namely the value of cohesion, shear angle, and shear strength. Furthermore, the addition of the material also changes the gradation of clay, from fine gradations to coarse gradations.

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