

Utilization of Industrial Waste as Soil Stabilizer to Enhance Direct Shear Strength

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ABSTRACT

A problem that often occurs in industrial areas is roads damage that are caused by the low carrying capacity of their subgrade as well as by over capacity of heavy vehicles passing through those roads. A lot of waste that is produced in industrial areas, which also another problem, can be used as soil stabilizers. This study proposed a method using industrial waste as stabilization material to improve the carrying capacity of the soil. Testing materials are prepared for both original and stabilized soil using three types of industrial waste, namely Silica Sand waste, and Dust Sand Foundry. One of mechanical property tests, i.e., direct shear test, was conducted with different percentage of waste for each sample. Result showed that there was 36.8% increase in the internal shear angle of the modified soil with 2.5% Dust Sand Foundry additives without the addition of Silica sand waste compared to the internal shear angle of the original soil.

Keywords: Industrial Waste, Direct Shear, Clay, Dust Sand Foundry, Silica Sand.

1. INTRODUCTION

Nowadays, industrial waste management is a challenge for every company that produces waste, in particular the specific waste. A special rule is needed to handle the waste (e.g., Dust Sand Foundry waste and Silica Sand waste). So far, such wastes have been widely used as materials for making brick [1]. However, the brick-making process using these two types of waste needs a long process. Therefore, it is necessary to treat this waste in a concise and easy way. This paper describes the feasibility study of utilizing two industrial wastes, namely Dust Sand Foundry (DSF) and Silica Sand waste (SS) as a soil additive construction material through laboratory experiments.

The effect of adding Dust Sand Foundry and Silica Sand waste to the Direct Shear strength of the clay soil will be discussed in this study. Previous studies on clay soil stabilization using Dust Sand Foundry and Silica sand waste have been carried out [2]-[5]. The results showed that there was a significant soil improvement on the California Bearing Ratio, Unconfined Compressive Strength and Triaxial Value. Research [6] on the use of two industrial wastes, namely heavy clay waste and Foundry Sand Blends as construction materials reported

an increase in friction angle through direct shear test. This research used two types of waste with a special compound as a soil stabilizer mix to replace lime. The purpose of this study was to find the best composition of the waste mixture based on the highest Direct Shear Strength value, and to find the value of the improvement that occurred. This research focuses on the Direct Shear Strength Value without discussing the changes in chemical structure that occur. The research contributes to method of combining two types of waste, i.e., Silica Sand waste and Dust Sand Foundry which have benefit to each other in a particular mixture in regard to the highest Direct Shear Strength Value. The impact of this research is the innovation of an additives-stabilizer combination from industrial waste to improve soil carrying capacity. Therefore, it can provide technical and economic benefits.

2. METHOD

For laboratory experiment, some percentages of waste were needed, namely 2.5% of Silica Sand waste with 5% of the dry soil weight, and 2.5% of Dust Sand Foundry waste with 5% of the dry weight of the soil. Direct Shear testing was carried out on soil with Optimum Moisture Content (OMC) conditions. In this

study, the clay type gathered at a depth of 20-50 cm from the original soil surface in disturbed conditions was used. Air-dry clay is mixed with Silica Sand waste and Dust Sand Foundry wastes to form a homogeneous mixture before left it in a closed bag for three days at room temperature. The test object was made before direct shear test was done based on the ASTM D-3080-04 standard. This test was done in Maximum Dry Density and Optimum Moisture Content conditions following the results of the Proctor standard compaction test. Table 1 shows the variation in the mixture composition.

Table 1. Additive Composition

Varian Number	Additive SS ^a (%)	DSF ^b (%)
1 ^c	0	0
2	0	2.5
3	0	5
4	2.5	0
5	2.5	2.5
6	2.5	5
7	5	0
8	5	2.5
9	5	5

Table 2. Direct Shear test Result

Variant Number	Additive Composition		OMC ^c (%)	Direct Shear	
	SS ^a (%)	DSF ^b (%)		C ^d (kg/cm ²)	ϕ ^e (°)
1	0	0	29.75	0.0565	19
2	0	2.5	29.42	0.0566	26
3	0	5	29.06	0.05	26
4	2.5	0	29.2	0.032	23
5	2.5	2.5	29.35	0.032	25
6	2.5	5	29.3	0.041	23
7	5	0	29.21	0.052	23
8	5	2.5	29.2	0.052	22.5
9	5	5	29.0	0.0515	20.5

^aSilica Sand Waste

^bDust Sand Foundry Waste

^cOptimum Moisture Content

^dCohesion

^eInternal Friction Angle

3.2. Discussion

The cohesion value of soil mixed with 2.5% Dust Sand Foundry without Silica Sand waste experienced a less significant increase in Silica sand waste addition as shown in Figure 1. Soil mixtures with 2.5% Dust Sand Foundry showed the cohesion value (c) increase for 2.5% Silica Sand waste mixture, but the cohesion value decreased for 5% Silica Sand waste mixture compared to the cohesion value of the original soil because more

^aSilica Sand Waste

^bDust Sand Foundry Waste

^cOriginal Clay

3. RESULT AND DISCUSSION

The results show the laboratory test for each additive composition. Some finding will be discussed.

3.1. Results

Soil sample from Universitas Islam 45 Bekasi has a specific gravity value (Gs) of 2,510 and the type of this soil is the organic clay [7] - [8], based on [9] classification. The results of the direct shear test are in the form of cohesion (c) and internal friction angle (ϕ) values. Table 2 shows Optimum Moisture Content results for all variants. The Optimum Moisture Content value of stabilized soil from the compaction test result tends to decrease to the Optimum Moisture Content value of the original clay. However, the change is not significant since it was only about 0.01% to 0.02% range.

Silica Sand waste content causes less bonding/bonding between grains due to the chemical bonding process [10].

As an information, the cohesion value of the original soil is 0.565 kg/cm². The highest cohesion value (0.566 kg/cm²) was found in the composition of the soil mixture of 2.5% Dust Sand Foundry without Silica Sand waste. This means that the cohesion value has increased by 0.18% from the cohesion value of the original clay soil. There was no cohesion value increase compared to the of the original soil for other variants. Figure 2 is a graph of the cohesion value to the percentage addition of Silica

Sand waste. The cohesion value (Fig.2) shows a large decrease in the 2.5% Silica Sand waste grade against the cohesion value of the original soil.

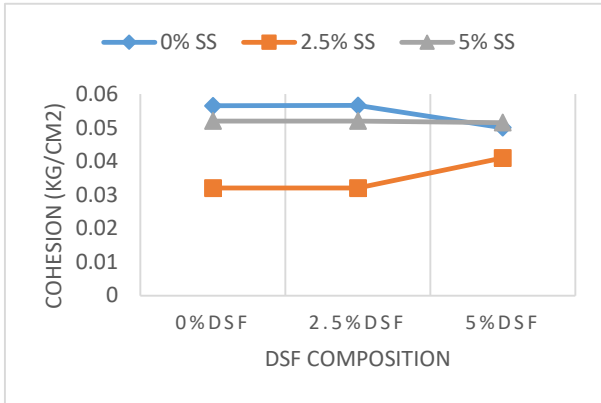


Figure 1 Cohesion values based on dust sand foundry addition

Small or large amount of silica sand waste in clay soil causes the soil mixture to lose cohesion so that the cohesion value in the direct shear test is smaller than the original soil cohesion value. Likewise, the large amount of dust sand foundry on clay soils (i.e. 5%) causes the cohesion value to decrease from the original soil cohesion value in the direct shear test.

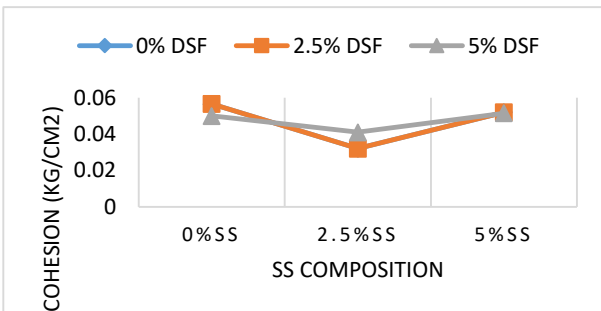


Figure 2 Cohesion values based on silica sand waste addition

Soil without Silica Sand waste mixture showed an increase of the internal friction angle (ϕ) value for 2.5% and 5% Dust Sand Foundry (36.84% increase compared to the original soil ϕ value as shown in Figure 3). It means the presence of Dust Sand Foundry waste as a clay stabilizer additive was able to increase the shear strength of the original soil. Therefore, it provides some benefits for the industry (technical and economic). For the next research, the changes in the chemical properties of clay soils which are stabilized using lesser grade Silica Sand waste and fixed grade Dust Sand Foundry will be conducted, including the environmental feasibility testing. Other tests are needed such as the California bearing ratio test and the unconfined compressive strength test to complete this research. Micro analysis on stabilized soil needs to be done to be able to measure changes in soil minerals that occur during the stabilization process.

found that the best waste composition was the original soil mixed with 2.5% Dust Sand Foundry without Silica Sand waste. Figure 3 shows ϕ values for the addition of dust sand foundry levels and Figure 4 shows ϕ values for the addition of silica sand waste levels.

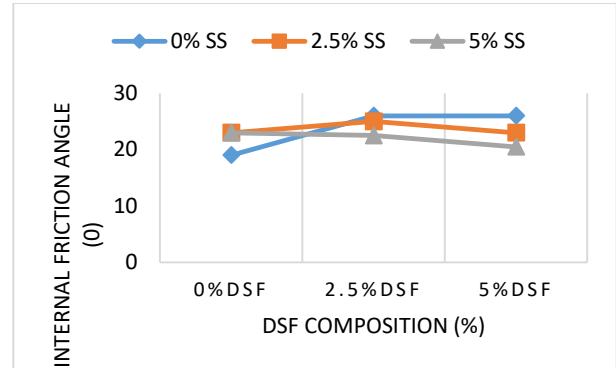


Figure 3 ϕ values for the addition of dust sand foundry levels

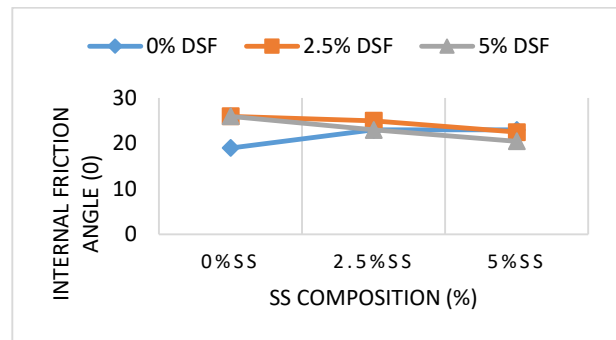


Figure 4 ϕ values for the addition of silica sand waste levels

4. CONCLUSION

The cohesion (c) and the internal friction angle (ϕ) values on stabilized soil were improved by 0.18% and 36.84% compared to the cohesion and ϕ values of the original soil for the original soil variants that used 2.5% Dust Sand Foundry (from the dry weight of the original soil). This shows that Dust Sand Foundry waste as a clay stabilizer additive was able to increase the shear strength of the original soil. Therefore, it provides some benefits for the industry (technical and economic). For the next research, the changes in the chemical properties of clay soils which are stabilized using lesser grade Silica Sand waste and fixed grade Dust Sand Foundry will be conducted, including the environmental feasibility testing. Other tests are needed such as the California bearing ratio test and the unconfined compressive strength test to complete this research. Micro analysis on stabilized soil needs to be done to be able to measure changes in soil minerals that occur during the stabilization process.

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