Godong expansive soil stabilization using sugar cane and sikacim concrete additive

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1. Preliminary

Land is a basic material, on which a structure such as building foundations, highways, dykes dams and etc. Damage that occurs in buildings such as elevation or descent of a foundation, cracks in the walls, and surging road surfaces are caused by soil under the structure [1].

Good soil has a large carrying capacity to withstand the burden posed by buildings on the ground with variety of grains. Gravel or sand has relatively large grains, with a relatively small absorption area, while clay soils have small grain size, with a greater area of water absorption. This shows that the nature of clay is influenced by interactions between the grains. Clay is divided into two, namely expansive clay soil which is composed of material that expands and shrink according to the water content and non-expansive clay. The soil shrinks in dry conditions and expands in wet conditions owing to the large surface area of water absorption in expansive clay [2].

Expansive clay is often found in Indonesia such as in the Godong area, Grobogan Regency, and Central Java. To overcome these problems, several alternatives are used, such as reducing the value of the plastic index and increasing its CBR.

One way to improve soil stabilization problems such as subgrades is by mixing it with a mixture (additive). In this case the additive material used is sugar cane which was previously conducted by Ibrahim and M. Arfan in their journal entitled Stabilizing Clay Soil with Stillage for Soil Layer. Sugar cane is used because it contains silica which functions to bind water to lower the plastic limit while increasing the CBR value of subgrade. In addition, SikaCim concrete additive is added to accelerate the binding reaction between the soil and sugar cane.

2. Research Material

Expansive soil samples were taken at KM-49, Godong District, Grobogan Regency, while samples were taken at a depth of 0.5-1 m from the ground surface. Furthermore, sugar cane is obtained from WASERDA KUD MEKAR, Ungaran while SikaCim concrete additive is from CV Geonika Beton Utama.

3. Research Method

3.1 Soil Properties

Physical properties tests conducted on expansive soils include: Soil Classification (ASTM D2487-17), Water Content Test (ASTM D2216-19), Specific Gravity Test (ASTM D854-14), Grain Size Analysis (ASTM D422-12), and Atterberg Limit (ASTM D4318-17).

3.2 Standart Compaction Test (Proctor)

Standard Compaction Test (ASTM D698-12) is performed on native soil to obtain graph of the relationship between dry weight and optimum moisture content (OMC). This OMC number is used as reference in mixing expansive soil sample with sugar cane and SikaCim concrete additive.

3.3 Mixing Soil Expansive with Sugar Cane and SikaCim Concrete Additive

The soil was mixed using sugar cane materials at a percentage of 2.5%, 5%, 7.5%, and 10% with SikaCim concrete additives of 1% respectively. The physical properties of soil mixed with these additives, are tested as follows ASTM D2216-19 (Water Content Testing), ASTM D854-14 (Specific Gravity Testing), ASTM D422-12 (Grain Size Analysis), and ASTM D422-12 (Grain Size Testing), and ASTM D4318-17 (Atterberg Limit). The test results are compared with the tests carried out on native land.

3.4 Swell Test Oedometer

The soil shrinkage test is carried out on native soil and those mixed with sugar cane and SikaCim concrete additive. After being mixed the soil is compacted (Proctor), and remolded on a ring (Steel Ring). It is also burdened and given water around the soil sample using 2 types of measurements, which is swelling potential and swelling pressure.

3.5 CBR (California Bearing Ratio)

CBR testing is carried out on native soil and those mixed with sugar cane + SikaCim concrete additive liquid. Test on this native soil, was compared on subsequent results with variations in the amount of sugar cane mixture + SikaCim concrete additive. CBR testing carried out includes CBR not submerged (Unsoaked) and CBR submerged (Soaked) based on AASHTO T-193-99 and ASTM D1883-16.

4. Result And Analysis

4.1 Soil Properties

Soil properties is carried out to determine characteristics of native soil and mixed expansive soil with sugar cane and SikaCim concrete additive.

4.1.1 Soil Classification

From the results of soil classification, a filter analysis and consistency limit test were obtained. The results of the filter analysis show that the percent of land retained in filter no.200 is 1.38%, while the consistency limits test results is 93.65%. According to the USCS (Unified Soil Classification System) classification the tested soil included in the clay soil category is high in plasticity.

4.1.2 Water Content and Specific Gravity

From the original test soil samples, water content (w) of 55.027% for testing the density of the original soil obtained specific gravity (Gs) of 2.69 kg/m^3. The results of specific gravity test with a variation of percentage soil mixture and sugar cane + SikaCim concrete additive showed a tendency to decrease the specific gravity with the addition of sugar cane compared to the original soil specific gravity value due to the presence of organic matter, thereby, making the value smaller. The value of specific gravity decreases as seen in figure 1.

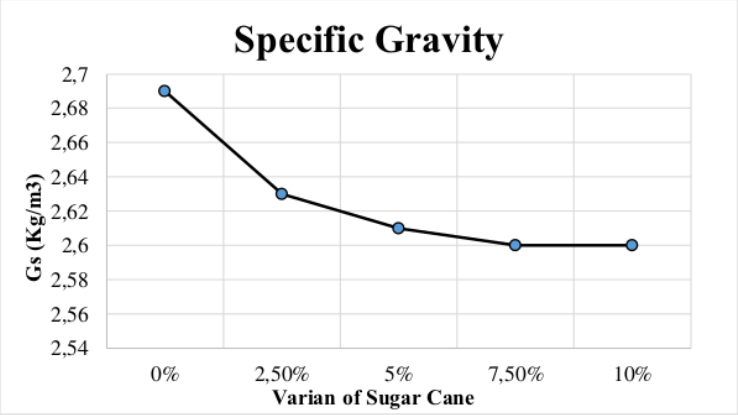

Figure 1. Relation between Specific Gravity and Varian Sugar Cane

4.1.3 Grain Size Analysis. The undisturbed expansive soil samples obtained from the analysis of grain size passed using sieve number 200 was 87.80% consists of 39% clay, 48.80% silt, 10.86% sand, and 1.84% gravel. While for expansive disturbed soil samples, the analysis results of the grain size passed on sieve number 200 was 90.48% consist of 34% clay, 56.48% silk, 7.36% sand, and 2.16% gravel. While the gradation test results which was due to the addition of sugar cane and SikaCim concrete additive showed that the percentage of gravel, and silt granules increased, while the sand grains clay granules decreased, compared to the native soil shown in figure 2.

The behavior of adding sugar cane is due to the sugar cane is about 0.05 - 5 mm in diameter and ESS with the characteristics of a crystal structure therefore it contributes to the number of soil grains in both fine and coarse fractions.

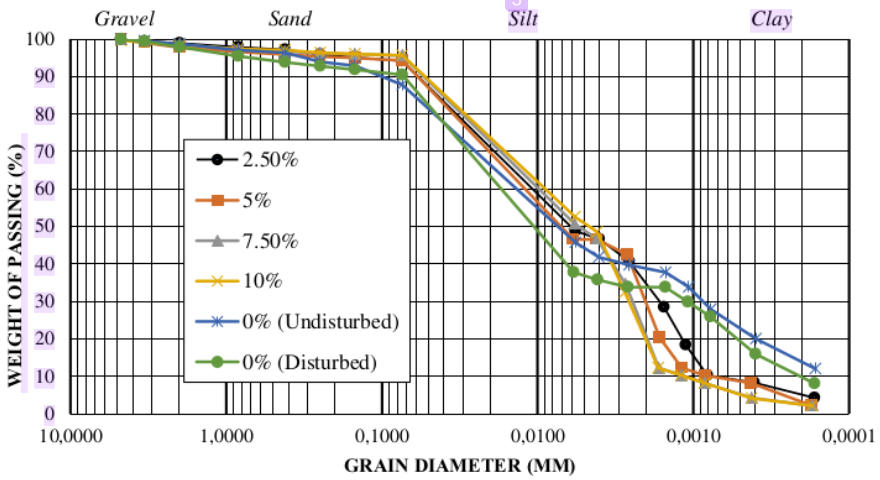

Figure 2. Relation between Grain Size and Varian Sugar Cane

4.1.4 Atterberg Limit. The consistency limit test is a liquid limit test (LL), plastic limit (PL), and plasticity index (PI). Based on the results of the liquid limit test (LL), the addition of sugar cane and SikaCim concrete additive shows a decrease compared to the original liquid soil limit. This shows occurs caused the sugar cane merges with clay granules.

Based on the plastic limit test (PL) the addition of sugar cane and SikaCim concrete additive shows an increase compared to the original plastic limit.

The Plasticity Index (PI) obtained from LL-PL, shows that it depends on PI values. In addition, sugar cane and SikaCim concrete additive causes a decrease in LL value and an increase in PL therefore, PI value becomes smaller. Behavior boundaries of consistency with the addition of sugar cane and SikaCim concrete additives are seen in figure 3.

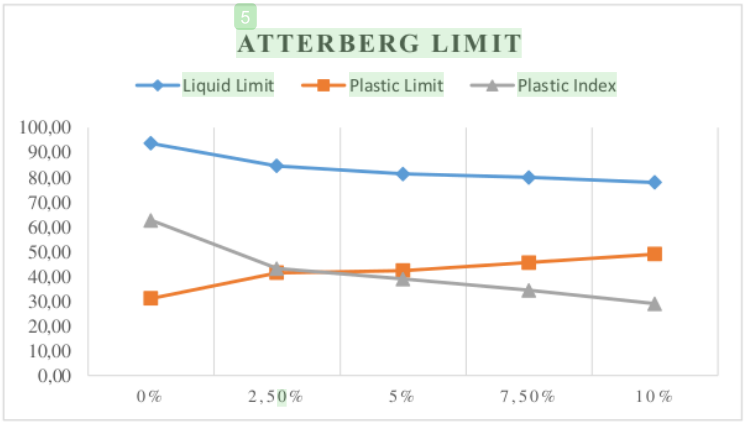

Figure 3. Relationship between Atterberg Limit and Varian Sugar Cane

4.2 Standard Compaction Test (Proctor)

Proctor compaction results are seen in figure 4. Samples for further testing which is based on dmax is 1.33 gr / cm3, optimum moisture content (Wopt) = 29.31%.

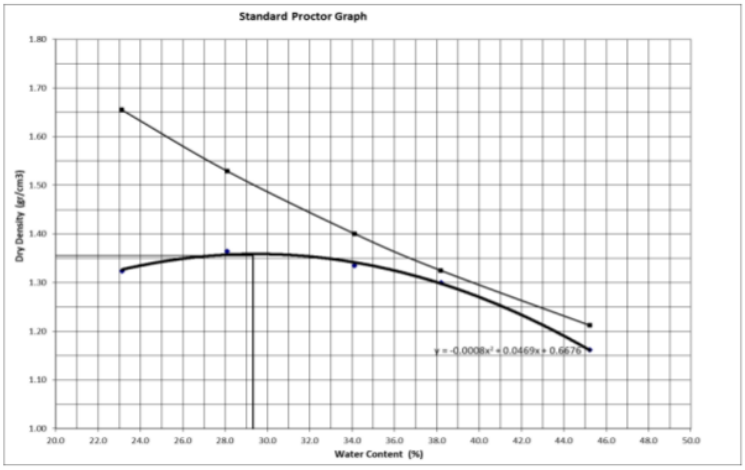

Figure 4. Relation between Dry Density and Optimum Moisture Content

4.3 Swell Test Oedometer

The results of potential shrinkage test obtained according to figures 5 and 6.

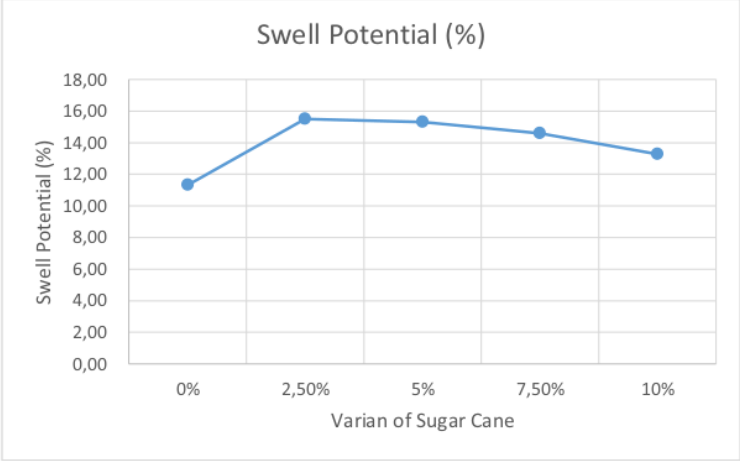

Figure 5. Relation between Swell Potential and Varian Sugar Cane

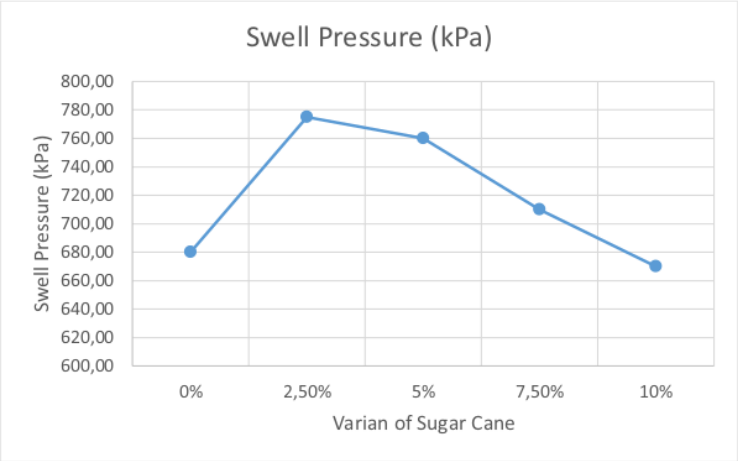

Figure 6. Relation between Swell Pressure and Varian Sugar Cane

4.4 CBR (California Bearing Ratio)

CBR value is one way to determine strength of the soil. The amount of soil bearing capacity is influenced by the quality of the material, attachment between grains, and density.

The CBR test conducted in this study is the same as the variation of the mixture in the compressive strength test. It is intended to determine whether the addition of sugar cane and SikaCim concrete additive influences the CBR value in accordance with the results of the compressive strength test. There are two types in CBR testing, namely Unsoaked and Soaked (4 Days). Graph of CBR Unsoaked and Soaked is seen in figures 7 and 8.

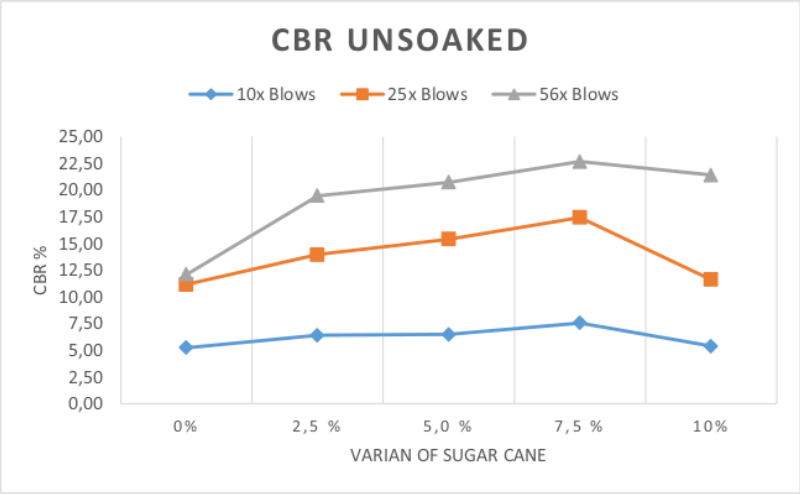

Figure 7. Result CBR Unsoaked

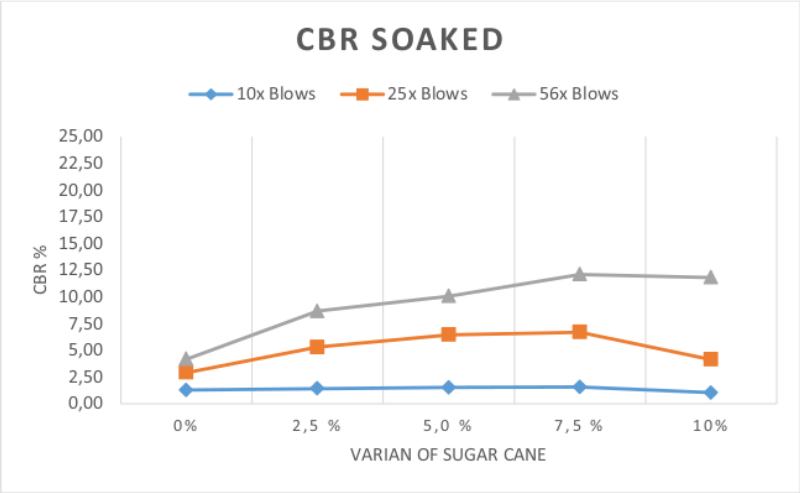

Figure 8. Result CBR Soaked

5. Conclusion

Based on the test results conducted, The original soil test results obtained the value of maximum dry weight content (d) = 1,355 gr / cm^3, optimum moisture content (Wopt) = 29.31%, LL = 93.65%, PL = 31.08%, PI = 62.57% containing 90.48% fine fraction with specific gravity (Gs) = 2.69.

The test result of the consistency limit of the soil mixture was obtained by adding the percentage of sugar cane and SikaCim concrete additive to the original soil which shows a decrease in the liquid limit (LL), the plastic limit (PL) increased, thereby, decreasing the Plasticity Index (PI). Grain grading behavior increased the percentage of sugar cane and SikaCim concrete additive, which shows that the percentage of gravel granules increased. The sand grains decreased, silt granules increased, and clay granules decreased compared to the original soil. The addition of sugar cane and SikaCim concrete additive is not capable of improving soil shrinkage. CBR immersion test results with the addition of sugar cane and SikaCim concrete additive, tends to increase and reach the optimum point at a percentage of 7.5%.

6. Acknowledgments

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