ISSN: 2686-4878, E-ISSN: 2686-4886

The Analysis of Soil Chemical and Mineralogy to Compression Strength of Expansive Soil with Sugar Cane (Study Case: KM 49-Godong, Grobogan District)

SPR Wardani[1][2], ARA Setiaji[1][3], CD Pavitasari[1][4], GD Ramadhani[1][5]
[1] Department of Civil Engineering, Diponegoro University

Email: [2]wardani_spr@yahoo.com, [3]andiretno_as@yahoo.com, [4]carolinapavitasari@gmail.com, [5]gebydian.ramadhani@gmail.com

Abstract. Expansive soil is a soil type with high shrinkage properties, thereby, causing many construction problems. Its behavior is strongly influenced by the water content and constituent minerals it contains. This study, therefore, aims to analyze the relationship between mineralogy and soil chemistry using expansive soil strength (UCS) in KM 49-Grobogan. In addition, a variety of cane in percentages of 2.5%, 5%, and 7.5%, as well as SikaCim concrete additive mixture of 1% are used to stabilize the expansive soils. Mineralogical and soil chemical testing in this study was carried out using XRD and XRF tests. The results obtained show that the increase in the compressive strength of the soil was influenced by the increasing percentage of the molasses mixture used, because the smaller the crystal size, the greater Si and Ca elements.
Keywords: expansive soil, sugar cane drops, minerals, compressive strength

1. Introduction

Land is the basis of a building, road, and other types of construction. One type of soil with many construction problems and high shrinkage fluctuations is the expansive clay (Sudjianto 2006). The expansive clay to be tested comes from KM 49-Godong, Grobogan Regency.

Due to its ability to easily expand and shrink, stabilization is carried out by adding a mixture of sugar cane drops and SikaCim Concrete Additive. To determine the changes that occur in the soil, the compressive strength test and XRD (X-Ray Diffraction) and XRF (X-Ray Fluoresence) tests are performed. The choice of sugar cane drops is based on the success of previous research conducted by Ibrahim and Muhammad Arfan. In addition, sugar cane drops, contain a lot of silica which is water binding, reduces the plasticity index and increases the compressive strength of the soil. While the addition of SikaCim concrete additives aims to speed up its reaction in the soil mixture.

Good soil has a large compressive strength to withstand the burden posed by buildings. The minerals that make up the soil also affect its compressive. When viewed from mineralogy, clay consists of various constituent minerals, including clay (kaolinite, montmorillonite and illite group) and others with sizes according to existing restrictions (Hardiyatmo, 2018).

In XRD mineralogy testing (X-Ray Diffraction) only an analysis of crystal size is performed, with changes in crystal size able to indicate the crystallization speed in the soil. While XRF (X-Ray Fluoresence) soil clams were analyzed for the composition of elements and compounds.

2. Research Material

Expansive soil samples were taken at KM-49, Godong District, Grobogan Regency, at a depth of 0.5-1 m from the ground surface. Cane molasses (molasses) were obtained from WASERDA KUD MEKAR, Ungaran and SikaCim concrete additives obtained from CV Geonika Utama Concrete.

3. Research Method

3.1 XRD (X-Ray Diffraction) and XRF(X-Ray Fluoresence) Test

XRD is a characterization method used to determine the main features of crystals, such as its lattice parameters and structure types. In addition, it is also used to determine other details such as the arrangement of various types of atoms in the crystal, the presence of defects, orientation, and defects (Smallman, 2000).

XRF soil chemical testing is carried out to determine the composition of elements and compounds contained in soil material. Its chemical testing and XRD mineralogy were carried out on expansive soils with a mixture of 2.5%; 5%; 7.5% molasses and 1% SikaCim concrete additive. Soil chemical and mineralogy testing was carried out at the Bandung Geological Survey Center Laboratory.

3.2 Unconfined Compression Test

The unconfined Compression Test aims to determine the compressive strength of cohesive soil-free in intact conditions using axial load voltage control applications in accordance with ASTM D2166 (ASTM International, 2006).

Compressive testing is carried out on native soil and those mixed with 2.5% molasses; 5%; 7.5% + 1% SikaCim concrete additive. Its result which tests the original soil are used as a comparison with a variation of the cane + SikaCim concrete additive mixture.

4. Result And Analysis

4.1 XRD (X-Ray Diffraction) and XRF (X-Ray Fluoresence) Test

XRD mineralogical testing is performed to determine the crystal size of a mixture, which affects its size and crystallization speed. Crystallization is the process of forming a solid and settling a solution, therefore, when rapid, the size of the crystal increases. Whereas when the crystallization lasts a long time, the crystal size shrinks (https://docplayer.info/62950191-Kristal-dan-Kristalografi-i.html). XRD test results in the form of crystal size are seen in Table 1. Figure 1 shows the comparison of XRD test results (crystal size) with mixed variations.

Table 1. Crystal Size

Sample	Crystal Size (A)
Sugar cane	20.230
Soil native	47.920
Soil+2.5% SC+1% Sika	161.208
Soil+5% SC+1% Sika	41.960
Soil+7.5% SC+1% Sika	30.978

ISSN: 2686-4878, E-ISSN: 2686-4886

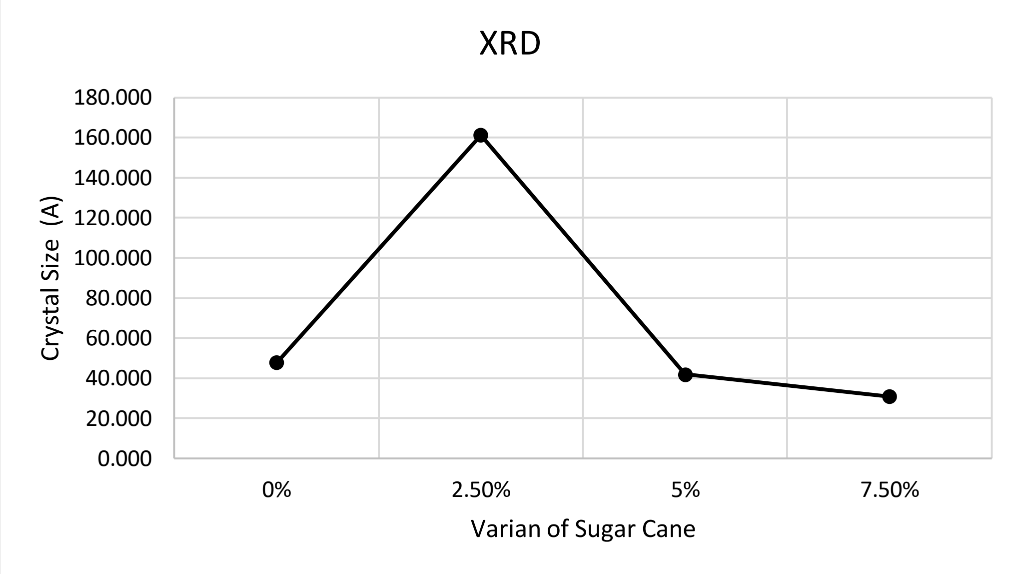

Figure 1. Comparison of XRD (Crystal Size) Test Results with Mixed Variations.

From the XRD test results in the form of crystal size, the largest crystal size in the mixture of sugar cane drops is 2.5%, and the smallest size in the mixture of sugar cane drops is 7.5%. Therefore the speed of the crystallization process occurs most rapidly in a 7.5% molasses mixture.

In XRF soil chemical testing, its conditions mixed with sugar cane 2.5%; 5%; 7.5% and 1% SikaCim concrete additive tends to increase / reduce the elements which in turn changes the amount of compounds contained in the soil. The beneficial elements for soil compressive strength are Si (Silicate), Fe (Ferrum), and Al (Aluminum) elements, while the elements capable of reducing the compressive strength are elements K (Potassium), Na (Sodium), and Mg (Magnesium). The XRF test results in the form of elemental content are shown in Table 2, while the compound content is shown in Table 3.

Table 2. Element Content.

Sample	Si	Ca	Mg	K
Soil native	22.03	2.85	1.21	0.82
Soil + sugar cane 2.5% + SikaCim 1%	21.44	2.98	1.20	0.84
Soil + sugar cane 5% + SikaCim 1%	23.81	3.44	1.32	0.97
Soil + sugar cane 7.5% + SikaCim 1%	22.95	4.46	1.38	0.94
Note	(orange)	: decrease on native soil		
	(blue)	: increase on native soil		

ISSN: 2686-4878, E-ISSN: 2686-4886

Table 3. Compound Content

Sample	SiO_2	CaO	MgO	K_2O
Soil native	47.12	3.98	2.00	0.92
Soil + sugar cane 2.5% + SikaCim 1%	45.87	4.18	1.99	1.02
Soil + sugar cane 5% + SikaCim 1%	50.93	4.81	2.19	1.17
Soil + sugar cane 7.5% + SikaCim 1%	49.09	6.24	2.28	1.13
Note	(orange)	: decrease on native soil		
	(blue)	: increase on native soil		

4.2 Unconfined Compression Test (UCS)
One of the tests used to determine the parameters of the soil shear is the free compressive strength. The results of this test are the compressive strength of free soil (qu) on native, and on each soil variations mixed with molasses and SikaCim concrete additives.

Comparison of the results of UCS native and mixed soils is seen in Figure 2. While the maximum free compressive strength obtained (qu) in each variation of the mixture is in Table 4.

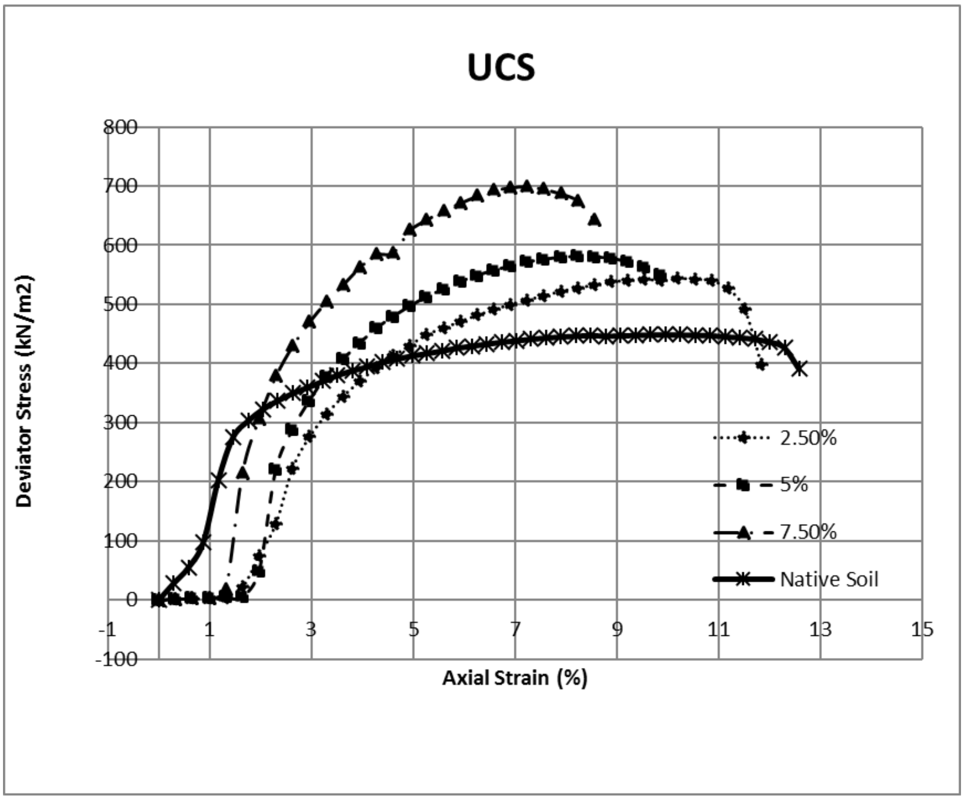

Figure 2. Comparison of UCS Original Soil Results with Mixed Soil.

ISSN: 2686-4878, E-ISSN: 2686-4886

Table 4. Result of Unconfined Compressive Test.

Sample	Qu (kN/m2)
Soil native	446.454
Soil+2.5% SC+1% Sika	546.570
Soil+5% SC+1% Sika	582.699
Soil+7.5% SC+1% Sika	701.141

From the data of the free compressive strength test results it is seen that the soil with a mixture of sugar cane 7.5% + 1% SikaCim concrete additive *has* the highest compressive strength.

4.3 The Relationship Between Soil Chemistry and Crystal Size With Free Compressive Strength (UCS)
From the results of soil chemical testing (XRF), the crystal size (XRD) and free compressive strength (UCS) are analyzed as follows:

The soil with a mixture of sugar cane 2.5% + 1% SikaCim concrete additive obtained the results of chemistry which decreases the elements of Silica (Si), Ferrum (Fe), Aluminum (Al), Magnesium (Mg) and increases elements of Calcium (Ca). The XRD test results showed that the largest crystal size compared with other variations of the mixture of sugar cane drops. Therefore, the speed of the crystallization process in this mixture is the longest.

The soil containing a mixture of 5% sugar cane + 1% SikaCim concrete additive obtained increased chemical results of Silica (Si), Ferrum (Fe), Aluminum (Al), Magnesium (Mg) and Calcium (Ca). XRD test results show that the crystal size is smaller when compared to the variation of the mixture of 2.5% molasses.

The soil with a mixture of sugar cane molasses 7.5% + 1% SikaCim concrete additive obtained chemical results that increases the elements of Silica (Si), Aluminum (Al), Magnesium (Mg), Calcium (Ca) and decreases Ferrum (Fe). The XRD test results show that the crystal size is the smallest compared to other variations of the molasses mixture. Therefore the speed of the crystallization process in this mixture is the fastest.

Based on soil chemical testing (XRF), those with lots of silica are water binding which increases its compressive strength. Therefore, based on the results of soil chemistry, the mixture with the highest compressive strength is 7.5%. Caused the 7.5% mixture has a cumulative amount of Silica and Calcium elements greater than the 5% mixture. Similarly, in terms of crystal size (XRD) the soil with a mixture of 7.5% has the smallest crystal size and greatest compressive strength.

5. Conclusion

Based on the testing conducted, the following conclusions were made as follows The more the percentage of molasses mixture used for soil stabilization, the freer the compressive strength. The smaller the crystallite size, the faster the crystallization process and free compressive strength. The number of elements affects the free compressive strength. The more beneficial elements, the stronger the soil and the more harmful, the weaker.

References

[1] Hardiyatmo H C 2018 *Tanah Ekspansif Permasalahan dan Penanganan* Gadjah Mada University Press.
[2] Smallman RE and Bishop R J 2000 *Metalurgi Fisik Modern dan Rekayasa Material* Edisi Keenam Erlangga Jakarta.
[3] Das B M 1988 *Mekanika Tanah: Prinsip-prinsipRekayasaGeoteknis* 283.
[4] Sudjianto AT 2006 Studi Potensi dan tekanan Pengembangan Pada Tanah lempung Ekspansif Pada variasi Kadar Air, *Laporan Penelitian Hibah Dikti Depdiknas Skim PDM*, Fakultas Teknik Universitas Widyagama Malang.

ISSN: 2686-4878, E-ISSN: 2686-4886

[5] ASTM International 2006 *Standard Test Method for Unconfined Compressive Strength of Cohesive Soil 1* January.

[6] Ibrahim Muhammad Arfan Clay Stabilitation with Stillage for Subgrade *17th Annual Scientific Meeting Jakarta* 13-14 November 2013.