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Shear Strength Characteristics of Stabilized Sedimentary Soil with *Bacillus Subtilis* Bacteria

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Abstract. Sedimentary soils are formed from deposits resulting from weathering of rocks through natural processes. One way to increase the bearing capacity of sedimentary soil is by stabilizing it. The purpose of this study was to determine the effect of variations in the mixture of *Bacillus Subtilis* bacteria on the characteristics of sedimentary soils and to determine the effect of the curing period on the shear strength of the sediment stabilized by *Bacillus subtilis* bacteria. Based on the results of physical properties testing, the original soil was classified as ML, which is silt with low plasticity based on the USCS classification system, and classified as soil group A-4, namely silty soil according to the AASHTO classification system. The addition of *Bacillus Subtilis* bacteria mixed with urea and CaCl₂ was proven to increase the value of shear stress, cohesion, and shear angle of the soil. The addition of *Bacillus Subtilis* with a mixture of urea and CaCl₂ to the sedimentary soil accompanied by a curing period was shown to increase the shear stress at the percentage of adding stabilizing agent 8% from 1.25 kg/cm², 1.45 kg/cm², and 1.77 kg/cm² at the beginning to 1.73 kg/cm², 2.09 kg/cm², and 2.39 kg/cm² at 28 days of curing, with an average increase of 35 percent. The cohesion value continued to increase from the initial value of 0.72 kg/cm² to 1.57 kg/cm² at 28 days of curing, resulting in an increase in cohesion value of 118 percent. For the value of the shear angle in the soil, there was an increase from the original soil shear angle of 22° to 31° in a mixture of 8% bacteria with a curing period of 28 days so that there was an increase in the value of the shear angle by 40 percent.

Keywords: Dam, Sedimentary Soils, Soil Stabilization, Shear Strength, Cohesion *Bacillus Subtilis*.

1. Introduction

Soil is a very important component in the field of civil construction because it is a determining factor for the success of a construction work, but the availability of land for large-scale construction such as road embankment requires a large amount of land, while the supply of land with good bearing capacity is sometimes limited. One alternative to overcome these obstacles is to use waste soil (sedimentary soil) to become embankment soil.

Sedimentary soils are formed from deposits resulting from weathering of rocks through natural processes such as water, wind, and others. One example of sedimentary soil can be found at the Bili-bili Dam, Gowa Regency, South Sulawesi Province. Sedimentary soil at this location is quite abundant and has not been used generally, so that it can be investigated its use in stability against the influence of external forces on the bearing capacity of the sedimentary soil. One way to increase the bearing capacity of sedimentary soil is through stabilization. Stabilization can be carried out by adding a certain material or composite to increase the strength of the soil. One of the environmentally friendly stabilization methods is to use bacteria, for example *Bacillus Subtilis* bacteria. *Bacillus* belongs to the group of rods and cocci bacteria that form endospores with the characteristics of having a stem cell shape, motile with one flagellum, gram-positive, aerobic, forming endospores, having habitats in the soil, water, aquatic environment, as well as animal digestion. including humans), some species are pathogenic to humans



and other animals [1]. Some of the stabilization measures are increasing soil density, adding inactive material to increase cohesion and/or shear resistance, adding material to cause chemical and physical changes in soil material, lowering the water table and replacing poor soil [2].

The purpose of soil stabilization is to increase the bearing capacity of the soil and to increase its stability. The basic principle of soil improvement is that poor soil capacity (in various aspects) can be improved through improving the properties of the soil, in accordance with the desired improvement objectives. If what is desired is to increase the bearing capacity and shear strength of the soil, then several soil parameters need to be improved, such as soil volume weight (γ), soil cohesion (c), angle of shear in the soil (Φ). In addition, the principles in sustainable development focus that development will only be sustainable and natural resources can also be utilized by future generations only if the aspect of protecting the environment remains a priority in every stage of planning, implementation, and operation of infrastructure. One of soil improvement studies using *Bacillus Subtilis* bacteria on clay soils resulted in an increase in the value of shear angle along with the addition of the volume of bacteria into the soil sample [3]. Investigated the shear strength characteristics of the soil using the biogrouting stabilization method of *Bacillus Subtilis* bacteria in which the clay sand soil sample was mixed with *Bacillus Subtilis* bacterial stabilizing agent [4]. This study analyzed the optimum stabilization of microorganisms with variations in solution and curing time. *Bacillus Subtilis* bacteria were injected into the soil with a variation of the solution 1x, 2x and injection or 2 cc, 4 cc and 6 cc. The soil that had been injected with microorganisms was cured for 3 days, 7 days, 14 days, 21 days, and 28 days. The mechanical characteristics that were evaluated were the shear angle and the cohesion values derived from direct shear testing. The results obtained were an increase in the cohesion value of 297% to the original soil sample value and an increase in the value of 6.86% to the value of the shear angle in the original soil.

The application of soil improvement techniques must always be accompanied by considerations of environmental sustainability, so that the goal of soil stabilization is not only focused on achieving technical requirements but must also meet environmental safety requirements. Therefore, it is very important to look for alternative methods of stabilization that are environmentally friendly, namely by using microorganisms derived from microbes. In a previous study, namely a study of the mechanical characteristics of stabilized organic soils with *Bacillus subtilis* bacteria with curing times of 7, 21, and 28 days, it resulted in continuous soil shear strength parameter values, especially at 28 days of curing [5]. While in research using expansive soil samples stabilized by the remediation method, the compressive strength of the soil has increased by 430 times [6]. So that this study intends to examine the effect of *Bacillus subtilis* bacteria as a stabilizing agent for sedimentary soils on the shear strength of the soil.

2. Literature Review

2.1. Definition and Soil Classification

In a general technical sense, soil is defined as a material consisting of aggregates (granules) of solid minerals that are not cemented (chemically bonded) to each other and from solid particulate organic matter that has weathered accompanied by liquid and gaseous substances which fill the empty spaces between the particles. Soil is useful as a building material in various kinds of civil engineering work, besides that the soil also functions as a support for the foundation of the building [7]. Soil is a collection of minerals, organic matter, and relatively loose deposits, which are located on top of bedrock. The formation of soil from its parent rock can be a physical or chemical process. The process of soil formation physically changes rock into smaller particles, occurs due to the influence of erosion, wind, water, ice, humans, or the destruction of soil particles due to changes in temperature or weather [8].

The following is a grouping of soil types based on a mixture of grains according [9]:

- Coarse-grained soil is soil with large grains of soil in the form of sand and gravel.
- Fine-grained soils are soils where most of the soil grains are clay and silt.
- Organic soil is soil that contains quite a lot of organic matter.

2.1.1 Classification System by Texture²

In a general sense, what is meant by soil texture is the state of the soil surface. Soil texture is influenced by the size of each grain in the soil. Several classification systems based on soil texture have been developed long ago by various organizations to meet their own needs, some of these systems are still in use today such as the classification system based on soil texture developed by the United States Department of Agriculture (USDA).

This system is based on the boundary size of the soil grains as described by the USDA system, namely:

- Sand: granules with a diameter of 2.0 to 0.05 mm.
- Silt: granules with a diameter of 0.05 to 0.002 mm.
- Clay: granules with a diameter smaller than 0.002 mm.

2.1.2 Classification System by Usage⁴

At present there are two more soil classification systems that are always used by civil engineers. Both systems consider the grain size distribution and Atterberg limits. These systems are the AASHTO Classification System and the Unified Classification System [10].

2.2. Clay Characteristics

Silts are generally formed from crushed quartz crystals that are the size of sand. Sometimes silt is also called dust in some literature. Deposits that float on the surface of the water or that sink are usually formed by silty soil material. Natural rock breaking involves chemical weathering of rocks and regolite as well as physical weathering through frost haloclasty. The main process involves abrasion, either solid (by glaciers), liquid (river deposition), or by wind [11].

2.3. Soil Stabilization⁵

Soil stabilization in principle is to improve poor soil quality. If a soil found in the field is very loose or easily compressed, or if it has an inappropriate consistency index, too high permeability, or other undesirable properties that are not suitable for a civil construction project, then the soil must be stabilized. Stabilization may consist of any of the following measures [12]

- Increasing soil density.
- The addition of inactive material to increase the cohesion and frictional resistance that arises.
- The addition of materials to cause chemical and physical changes in the soil.
- Lowering of ground water level (soil drainage).
- Poor ground replacement.

2.4 *Bacillus Subtilis* Bacteria²⁶

Bacillus subtilis is a gram-positive, rod-shaped bacterium that is catalase-positive. At first this bacterium was named *Vibrio subtilis* by Christian Gottfried Ehrenberg and its name was changed by Ferdinand Cohn to *Bacillus subtilis* in 1872 (*subtilis* is Latin for 'good'). *Bacillus subtilis* cells are usually rod-shaped, about 4-10 micrometers (μm) long and 0.25-1.0 μm in diameter. Other bacteria from the genus *Bacillus*, namely *Bacillus subtilis* can form endospores, to survive in environmental conditions even from temperature and drying [13].

2.5 Direct Shear¹¹

Soil shear strength parameters are needed in analyzing soil bearing capacity, slope stabilization and thrust stress for retaining walls. Soil shear strength is the resistance force exerted by soil particles against pressure or pull. On the basis of this understanding, when the soil is subjected to loading it will be held back by soil cohesion and friction [14].

3. Methodology

3.1 Data Collection

Several types of data collection activities have been carried out on the test objects: the first stage of soil selection, and then visually identified and its availability factors in nature, then by identifying the characteristics of the soil to ensure its suitability with the stabilizing material to be used with the composition referring to the research objectives.

3.2 Material

The following are the soil investigated in this research:

3.2.1 Sedimentary Soil

The soil used in this study, as shown in Figure 1, is a sedimentary soil located in the Bili-Bili Dam, Gowa Regency, South Sulawesi. The color of the soil is gray and fine grained.

3.2.2 Bacillus Subtilis Bacteria

The bacteria used in this study were Bacillus Subtilis bacteria which were bred separately, and a bacterial growth culture test was carried out to determine the growth characteristics of a type of bacteria through a growth curve marked by turbidity in liquid media with the help of a shaker and incubator which can be seen in the Figure 2.



Figure 1. Sedimentary Soil from Bili-Bili Dam



Figure 2. Bacillus Subtilis Bacteria

3.3 Testing Standards

The characteristics of the material used in this study were tested based on the reference to the standards issued by ASTM, as shown in Table 1:

Table 1. Testing Standards

Testing	Standards
Water content	D2216 – 98
Specific Gravity	D854 – 14
Atterberg Limits	D4318 – 05, D4943 – 08
Sieve Analysis and Hydrometer	D422 – 63
Compaction	D698 – 07
Direct Shear	D3080

3.4 Sample Testing

Sample testing is divided into 2 types of tests, namely testing of physical properties and mechanical properties of the soil:

3.4.1 Physical Characteristics Testing

Physical properties test aims to determine the index properties needed in the classification and determination of stabilizing materials and the composition of stabilizing materials and their effects on the soil. In this study, the physical properties tests carried out on sedimentary soils were as follows: water content, specific gravity, sieve and hydrometer analysis, and Atterberg limits.

3.4.2 Mechanical Characteristics Testing

The purpose of testing the mechanical properties of the soil is to determine the behavior of the soil or the resistance of a soil that has been mixed with stabilizing material against a given pressure or load. The soil mechanical properties test is a parameter that can be seen to determine the bearing capacity of the soil. The mechanical properties test carried out in this study was a direct shear and compaction test.

4. Result and Discussion

4.1. Compaction with a standard proctor apparatus

4.1.1 Water Content

Based on the results of testing the water content value, the water content value for the sedimentary soil used in the study was 14.6%.

4.1.2 Specific Gravity

Based on the results of the specific gravity test for sedimentary soil, the density value for the Bili-Bili Dam sedimentary soil is 2.66. So that based on the specifications for the distribution of specific gravity based on soil type, the soil sample is classified as inorganic silt, with the specific gravity value being in the range of 2.62-2.68.

4.1.3 Sieve Analysis and Hydrometer

Tests for the percentage of soil grains can be done through sieve analysis and hydrometer. The results of this test can display the soil classification of the soil samples used. From the test results, the percentage of soil grains for gravel is 0.20%, sand is 2.60%, silt is 94%, and clay is 3.20%. From these

results the soil used in this study is silty soil. The following is a graph of the results of the filter analysis and hydrometer analysis which can be seen in Figure 3.

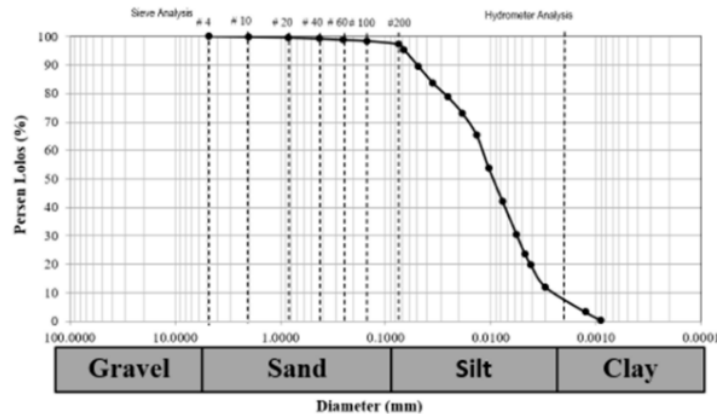


Figure 3. Graph of Sieve Analysis

4.1.4 Atterberg Limits

The Atterberg limit test was carried out to determine the nature of the soil to changes in the given water content. This test includes the Liquid Limit, Plastic Limit, and Shrinkage Limit testing. From the test, the following results were obtained:

- Plastic Limit

The plastic limit is the lowest water content at which the soil begins to become plastic. The plastic limit value obtained was 28.8%.

- Liquid Limit

The liquid limit is the water content at which the behavior of the soil changes from a plastic state to a liquid state. The liquid limit value obtained from the test results was 38.1%. The liquid limit graph can be seen in Figure 4

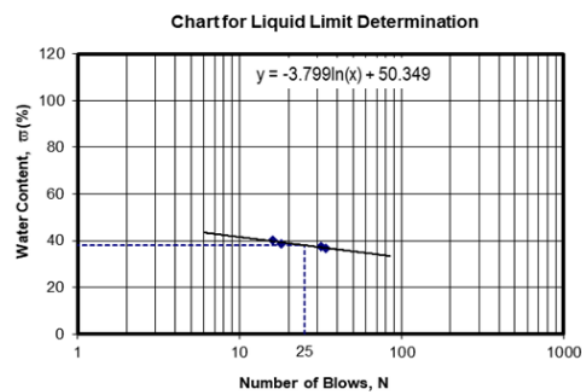


Figure 4. Liquid Limit Graph

24

- Shrinkage Limit

The shrinkage limit is the water content limit where the soil with a water content below the obtained water content does not cause a change in volume (shrinkage) again in the soil. The value of the shrinkage limit obtained was 8.6%.

6

- Plasticity Index

The plasticity index is the value of the difference between the liquid limit and the plastic limit. From the test results, the plasticity index value was 9.3%.

4.2 Soil Classification

From the test for the physical properties of the soil used in the study, the following classification is for the sedimentary soil of the Bili-bili Dam, Gowa Regency:

4.2.1 AASHTO

For sieve analysis, hydrometer and Atterberg boundary, the percentage of native soil grains that passed the No. 200 sieve was 97.2%. The liquid limit value was 38.1%, and the plasticity index was 9.3%.

From the values that have been obtained, it can be determined the type of soil based on the classification of the AASHTO system. The determination of the type of soil was found as a silty soil.

4.2.2 USCS

By connecting the plastic limit value and the plasticity index value, it is obtained that the soil type belongs to the ML (Milt with low plasticity) group, which means silty soil with low plasticity. There has been a relationship that shows the liquid limit value and the soil plasticity index to determine the classification of soil types. The relationship that shows these values can be seen in Figure 5.

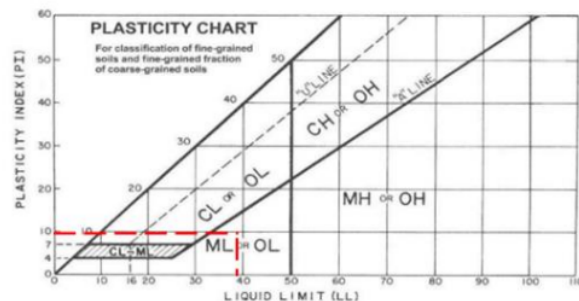


Figure 5. USCS Classification

4.3 Mechanical Characteristics

4.3.1 Compaction

In this test, compaction was carried out using the standard proctor compaction method, namely by inserting the soil into the mold and compacting it using a standard compactor. Compaction was carried out 25 times in every 3 layers of soil. The following is a graph of the relationship between water content and dry density in soil samples which can be seen in Figure 6.

Based on the results of the compaction test, the maximum dry density value was obtained, namely 1.34 g/cm³ which was achieved at the optimum moisture content of 30.25%. The purpose of compaction testing is to increase the volume weight of the soil, which means increase the strength of the soil to support the load on it, increase slope stability, and reduce soil compression [15]. It is indicated that the

initial density of the natural soil is sufficient to apply as a stabilized soil material. Also, the moisture content on the origin soil indicated that the water content was set to the normal condition. The compaction value was important parameter in preparing the sample. All the sample were prepared at the mximum density and optimum moistute content.

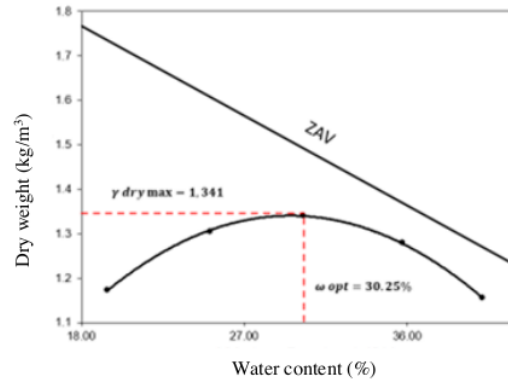


Figure 6. Graph of the relationship between moisture content and dry density of the compaction test results

4.3.2 Cohesion

From the test results, it can be seen that the cohesion value of the sedimentary soil mixed with bacteria with a curing period of up to 28 days, the highest increase in cohesion value reached 1.57 kg/cm² with the addition of 8% bacteria with a curing period of 28 days. However, in the curing period of 0 day the mixed cohesion value was soil with 8% bacteria was 1.09 kg/cm² and without the addition of bacteria (untreated soil) was 0.72 kg/cm² which can be seen in Figure 7. It can be seen that the improvement soil by adding the bacteria was found optimum in bacteria content of 8% with maximum curing time was 28 days. Moreover, the improvement of cohesion for 28 day curing time was not significant with the percentage of the bacteria from 4% to 12%. The most improvement of the cohesion value was found for 3 and 7 days. This is due to the calcite precipitation mainly developed at the early stage of curing time. The curing time for 14, 21 and 28 days showed the improvement of cohesion value insignificant compared to the short curing time. In practical application, the bacteria content and 7 days of curing time was sufficient value to apply in the field.

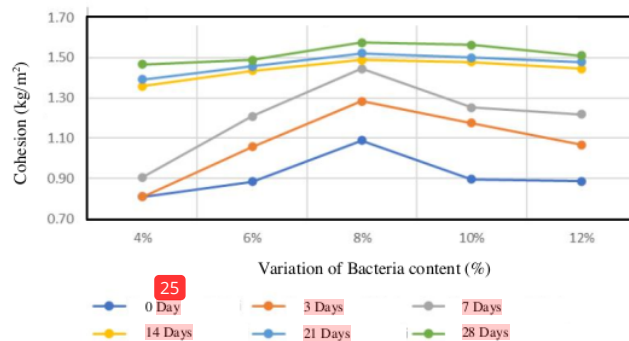


Figure 7. Variation of cohesion value with different curing time

5. Conclusions

Based on the results of physical properties testing, the sedimentary soil of the Bili-bili Dam is classified as ML, namely silt with low plasticity based on the USCS classification system, and classified as soil group A-4, namely silty soil according to the AASHTO classification system.

The addition of Bacillus Subtilis bacteria mixed with urea and CaCl₂ was proven to increase the value of shear stress, cohesion, and shear angle in the soil.

From the test results, curing time of 0, 3, 7, 14, 21 and 28 days increased the value of shear stress, cohesion, and shear angle in the soil. In this case, the maximum value was achieved at 28 days of curing with the addition of 8% bacteria. For the value of shear stress increased by 35%. The cohesion value increased by 118%. For the value of the shear angle in the soil there is an increase from the original soil shear angle value of 22° to 31° so that there is an increase of 40%.

6. References

- [1] Holt, John G., N.R. Krieg, P.H.A. Sneath, J.T. Staley dan S.T. Williams. 2000. *Bergey's Manual of Determinative Bacteriology*. Ninth Edition. Williams & Wilkins. Philadelphia.
- [2] Bowles, J.E. (1993), *Alih Bahasa Ir.Johan Kelana Putra Edisi Kedua, Sifat-Sifat Fisis Dan Geoteknis Tanah*, Penerbit Erlangga, Jakarta.
- [3] Iffah Fadiah (2013). *Studi Eksperimental Stabilisasi Biogrouting Bacillus Subtilis pada Tanah Lempung Kepasiran*. Program Studi Magister Teknik Sipil, Fakultas Teknik, Universitas Hasanuddin.
- [4] Lynda, Angelina (2013), *Karakteristik Kuat Geser Tanah Dengan Metode Stabilisasi Biogrouting Bakteribacillus Subtilis*, Fakultas Teknik, Universitas Hasanuddin, Makassar
- [5] Imelda Vera Tumanan (2014). *Studi Karakteristik Mekanik Tanah Organik Terstabilisasi Bakteri Bacillus Subtilis*. Jurnal Tugas Akhir. Program Studi Teknik Sipil, Fakultas Teknik, Universitas Hasanuddin.
- [6] Rio Alvin Arfandy (2017). *Stabilisasi Tanah Ekspansif dengan Metode Bioremediasi*. Jurnal Tugas Akhir. Program Studi Teknik Sipil, Fakultas Teknik, Universitas Hasanuddin.
- [7] Das, Braja M. 1995. *Mekanika Tanah 1*. Erlangga. Jakarta.
- [8] Hardiyatmo Christady. (2001). *Prinsip-prinsip Mekanika Tanah dan Soal Penyelesaian*. Yogyakarta : Universitas Gadjah Mada
- [9] Santosa, et al. (1996). *Seri Diktat Kuliah : Dasar Mekanika Tanah*. Gunadarma. Ankum, P., Koga, K., Segeren, W.A. and Luijendeijk, J., 1988. *Lessons from 1200 years impoldering in the Netherlands*. Proc. Int. Symposium on Shallow Sea and Lowland, Institute of Lowland Technology, Saga Univ. Saga: 102-108.
- [10] Das, B. M. (1995). *Mekanika Tanah (Prinsip-prinsip Rekayasa Geoteknik) Jilid I*. Jakarta : Erlangga.
- [11] Darwis, H. (2017). *Dasar-Dasar Teknik Perbaikan Tanah*. Yogyakarta : Pustaka AQ.
- [12] Bowles, J. E. (1986). *Sifat-Sifat Fisis Dan Geoteknis Tanah*. (J. K. Hainim, Trans). Jakarta: Erlangga.
- [13] Bergey, D.H. dan Boone, D.R. 2009. *Bergey's Manual of Systematic Bacteriology*. Second Edition. Volume Three: The Firmicutes. Springer. United States of America.
- [14] Harianto, T., Yunus, M. and Walenna, M.A. (2021) *Bearing Capacity of Raft-Pile Foundation using Timber Pile on Soft Soil*. International Journal of GEOMATE, Vol. 21(86), pp. 108-114. doi:10.21660/2021.86.j2294.
- [15] Harianto, T. (2022). *Performance of Subbase Layer with Geogrid Reinforcement and Zeolite-Watergrass Stabilization*. Civil Engineering Journal vol. 8(2), pp. 251-262. doi: 10.28991/CEJ-2022-08-02-05.

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