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Stabilization of Expansive Clay with Sand on CBR Value

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ABSTRACT

Soil properties and environmental conditions are factors that can affect the volatility of expansive soils, namely the expansion and shrinkage properties of the development in expansive soils consisting of clayey soils with a very large shrinkage. Many areas in Indonesia have expansive soil types, including those found in western areas, including Cikampek, Cikarang, Bandung, and Serang. The objectives of this research are to identify the properties of expansive soil by finding the physical and mechanical properties of soil. The method used is to find the values of index properties and engineering properties, which will be correlated with the soil minerals contained therein. Based on the test results, there is an effect of sand addition to compacted expansive soil on stability (CBR); expansive soil undergoes positive changes after mixing with sand, and optimization is achieved at the addition of sand reaching 20%.

Keywords: CBR, soil mechanical, expansive soil, soil load-bearing capacity, soil stabilization

INTRODUCTION

Soil properties and environmental conditions are factors that can affect the volume change of expansive soils, namely the expansion and shrinkage properties (Abdila et al., 2020). Changes in the development and shrinkage of expansive soils are influenced by the rainy and dry seasons, which result in dry soil conditions, or, in other words, a change or reduction in moisture content (Abdila et al., 2020). Soft soil problems are common in civil engineering projects (Isradi & Baskoro, 2021). Pavement construction, for example, requires a subgrade that is capable of supporting the pavement above it (Isradi et al., 2021). Problems will occur when the bearing capacity of the soil is insufficient to support the pavement load, resulting in inadequate pavement construction such as grooves, cracks, etc. (Abdila et al., 2021).

Many areas in Indonesia have expansive soil types, including those found in western areas, including Cikampek, Cikarang, Bandung and Serang. This confronts us with the option of constructing buildings on soils that are less favorable from a geotechnical point of view. Expansive soils have low bearing capacity under high water table conditions, high shrinkage and plasticity (AASHTO, 1993). In addition, the large expansion capacity of expansive soils results in settlement that is often not adapted to be carried by the strength of the structure above it. If the local soil does not have good bearing capacity, it is costly and inefficient to extract soil from outside the area (AASHTO, 2008).

Soil stabilization is one option to improve soil characteristics and increase soil bearing capacity (Hardiyatmo, 2011). Soil stabilization is also defined as the process of improving the

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physical quality of soil by adding additives to the soil to increase soil strength and maintain shear strength (Rifai et al., 2023). Soil stabilization can be implemented mechanically or by using certain materials. Soil stabilization is performed mechanically by changing the gradation of soil grains and then by compaction. Soil gradation is followed by compaction, while stabilization with certain materials can be applied by adding these elements to the soil. By incorporating these components into the soil to stabilize it, specific materials can be created (AASHTO, 2008; Bina Marga, 2017).

Unstable soil will be restored to normal condition (Nasional, 2008). Soil stabilization purposes are to bind and unite the aggregates of existing materials to produce dense soil. Fine-grained soils, especially clay soils, will be greatly affected by water. The development properties of compacted clay soils will be greater in clay soils compacted at optimum dry conditions than those compacted at optimum moist conditions. Clay soils compacted under optimum dry conditions are relatively water deficient; therefore, these clays have a greater tendency to absorb water as a result of their tendency to absorb water as a result of their ability to expand (DGH, 2017; Ministry of PUPR, 2011).

Sand is a type of non-cohesive soil. Non-cohesive soils have qualities that fall somewhere between loose grains, as seen by soil grains separating when dry and only sticking together when surface tensile stresses are present (Isradi, Hidayat, et al., 2020). Sand is classified as well-graded, weakly graded, evenly graded, or unequally graded. Adding sand to clay soils is one approach to stabilizing them. The reason for using sand as a material is that it is relatively cheap, easy to produce, and acts as a reinforcement, increasing soil strength. Reinforcement that can increase soil strength (Lian et al., 2011; Xu et al., 2018).

RESEARCH METHODS

In general, every research project is carried out with a "research method" so that all processes that must be completed can be fulfilled as planned and the research can be concluded at the point of decision-making (Noor, 2008; Savira & Suharsono, 2013). The data collection technique used is a direct observation technique of the object to be studied (Isradi, Arifin, et al., 2020). The data collection carried out includes data collection in the field carried out to obtain soil data in the research location so that the condition and nature of the soil can be known with certainty. Field data collection is carried out at the location of expansive soil, namely in Lippo Cikarang, with a direct collection method 2 meters below the ground surface and as much as 3 sacks.

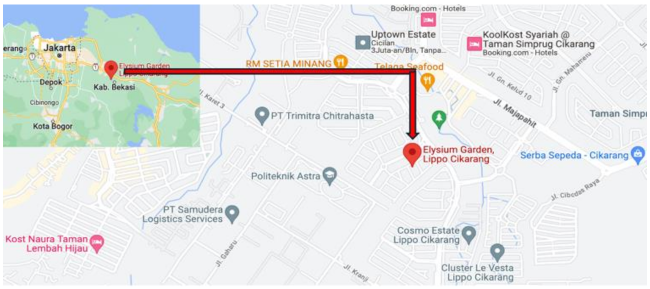

Figure 1: Research location

Laboratory data collection can be taken from the results of soil testing in the laboratory. The purpose is to obtain data on soil physical properties and soil mechanical properties. Tests conducted in the laboratory include soil mineral tests, specific gravity, Atterberg limits, sieve analysis, compaction, and CBR (California Bearing Ratio) testing (Sudrajat et al., 2023). The equipment used in this study includes tools for consistency limits, moisture content, hydrometer analysis, sieve analysis, consolidation, shear strength, standard proctors, and

CBR in the soil mechanics laboratory. The method to be used is by mixing soil samples with sand. The levels of sand mixture to be used are 10%, 20%, 30%, 40%, and 50%.

Soil compaction testing is carried out with reference to ASTMD 698. This test is carried out to determine the relationship between moisture content and soil density by compacting samples in a cylinder mold of a certain size using a 2.5 kg pounder and a 30cm drop height. Standard CBR Testing Laboratory CBR (California Bearing Ratio) examination refers to AASHTO T-193-74 and ASTM-1883-87, intended to determine the CBR value of soil compacted in the laboratory at a certain water content (AASHTO, 2008). CBR is the ratio between the penetration load of a standard material and the depth at a certain penetration speed. The swelling value is the percentage of the development of the test specimen due to the increase in moisture content due to curing (Ministry of PUPR, 2018).

RESULTS AND DISCUSSION

The physical parameters of the original soil were determined by testing the moisture content, specific gravity, volume weight, grain analysis, and Atterberg limits. After that, mechanical testing was carried out in the form of normal proctor testing and California Bearing Ratio (CBR) testing. Based on the results of sampling and laboratory testing of soil taken from the Lippo Cikarang project, the following test results were obtained:

Original Soil Gradation Analysis Test

To find out the composition of the grains of a soil, the sieve analysis can be seen in Figure 2 below:

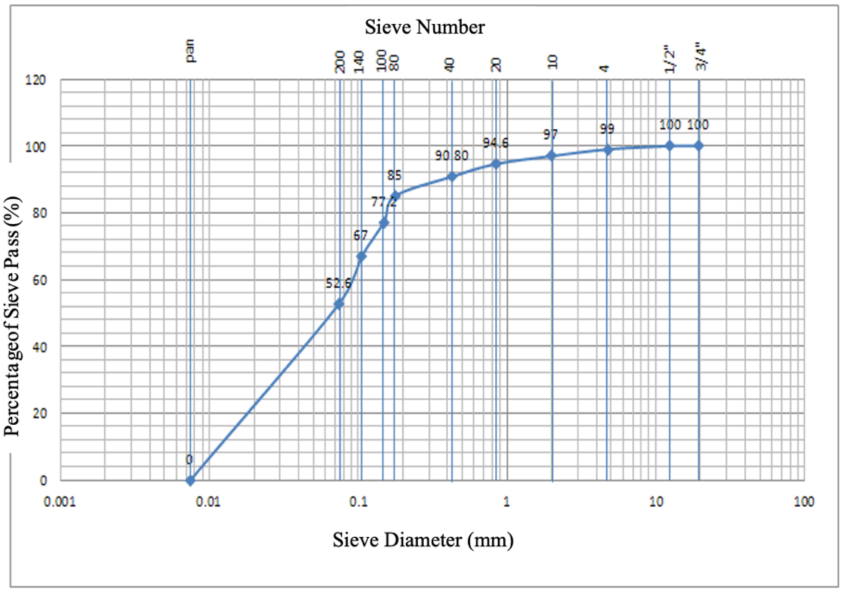

Figure 2: Sieve Analysis Test Results Chart

Based on Figure 2 above, the test results from the sieve analysis show that the percentage of gravel is 1%, sand is 46.40%, and fine grains (silt and clay) are 52.60%.

Test of Atterberg Limits in the Original Soil

Atterberg limits testing consists of testing the liquid limit and the plastis limit. In this study, Atterberg Limits testing was carried out to determine the LL, PL, and PI parameters in fine-grained soil. This test is carried out on soil that passes sieve no. 200. Liquid limit testing measures the moisture content of the soil at the state of the transition from liquid to plastis.

The usefulness of the liquid limit test results can be applied to determine the consistency of material and properties in expansive soils. The results of this soil test can be seen in Figure 3, which shows the results of the liquid limit test.

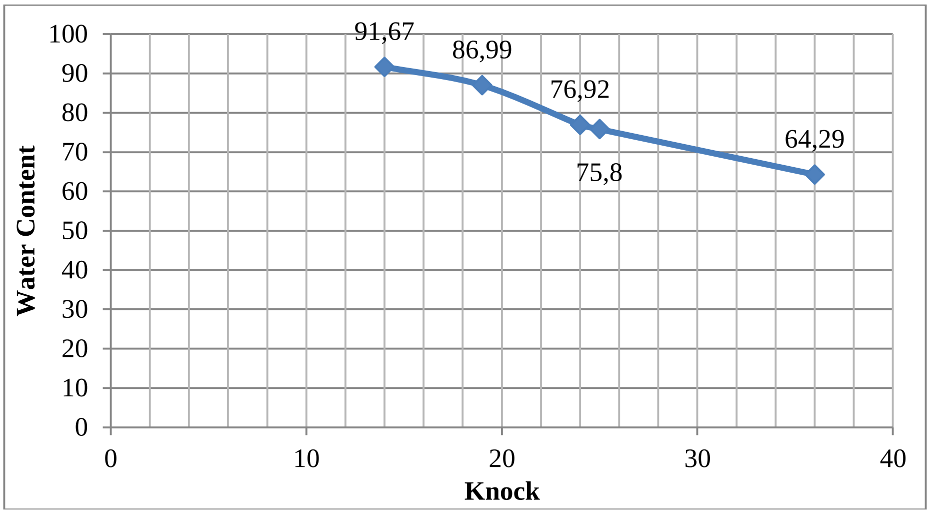

Figure 3: Relationship between Water Content and Punches

From Figure 3 above, at beat 25 of the liquid limit test, the water content is 75.8%, which is the liquid limit price. As for the plasticity limit test, the result of the plasticity limit is 42.86%; the original soil tested is included in the soil group with a high plasticity index. The plasticity index number is the difference between the liquid limit number and the plastic limit. Once the liquid and plasticity limit values are known, the plasticity index (PI) can be calculated (PI = LL - PL). In this soil, the plasticity index value is 32.94%.

Furthermore, the results of the shrinkage limit are obtained; this test is intended to determine the soil moisture content in the shrinkage limit condition. The results of the shrinkage limit processing on this fine-grained soil are obtained at 13.5%. And when viewed from the shrinkage value of 13.5, according to the USBR Table, the original soil tested is included in the group of soils with moderate shrinkage. The original soil tested, when viewed from the values of the liquid limit, plasticity limit, and plasticity index, is included in the high plasticity soil group of 32.94% and the high liquid limit with a liquid limit rating of 75.8%.

Consistency Limit Test (Atterberg Limit) on Stabilized Soil

Atterberg limits testing consists of testing the liquid limit, plasticity limit, and shrinkage limit. In this study, Atterberg limit testing was carried out to determine the price of LL, PL, and PI in the fine-grained soil after the soil was mixed at 10%, 20%, 30%, 40%, and 50% sand content. The following results of the Atterberg test values after stabilization with sand can be seen in Table 1:

Table 1: Atterberg Limit Test

Percentage of sand	Soaking	Sample	Consistency Limit Values		
			LL (%)	PL (%)	PI (%)
10	7 days	1	46,20	28,72	17,48
20	7 days	1	46,64	33,37	13,03
30	7 days	1	42,6	32,34	10,26
40	7 days	1	42	30,60	11,40
50	7 days	1	41,8	20,84	20,84

From the Atterberg limit test results as presented in Table 1 above, it was found that there was a decrease in the liquid limit by 41.8% and a decrease in the plasticity limit by 20.84. For more details, we can see the liquid limit in Figure 4 below:

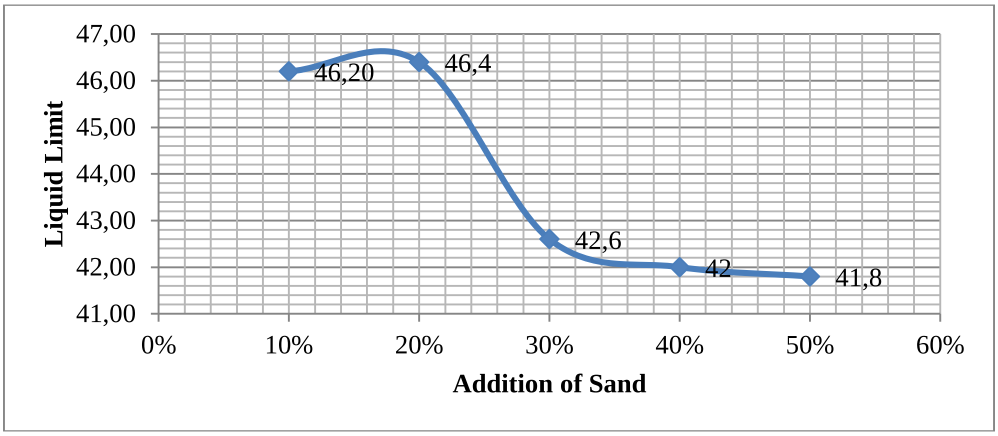

Figure 4: Liquid Limit Curve Based on Percentage of Sand Addition

Liquid limit testing is performed to determine the limit of water content where a soil changes from a liquid state to a plasticity state. From Table 1, it can be seen that the decrease in liquid limit in the soil is 20.84%.

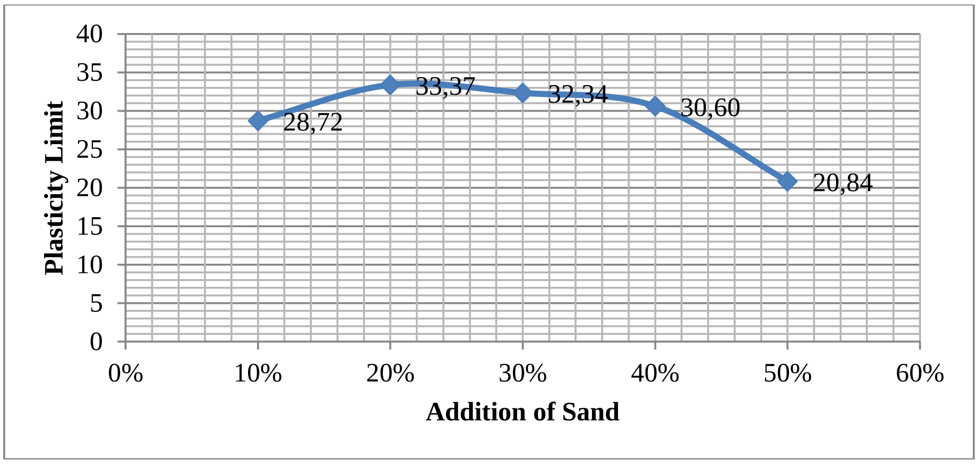

Figure 5: Plasticity Limit Curve Based on Sand Addition

With the results of Atterberg Limit testing by mixing original soil with 10%, 20%, 30%, 40%, and 50% sand content, it can reduce the liquid limit value, which will also affect the plasticity index of the soil. The smaller the liquid limit value of the soil, the smaller the plasticity index value, so the original soil after stabilization is included in the low plasticity group.

Compaction Test

Standard compaction testing is used to determine the relationship between moisture content and soil density by compacting soil in a cylinder of a certain size using a mold. Soil samples pass sieve no. 4. The use of standard proctor testing to find the maximum density value and optimum moisture content of a soil sample.

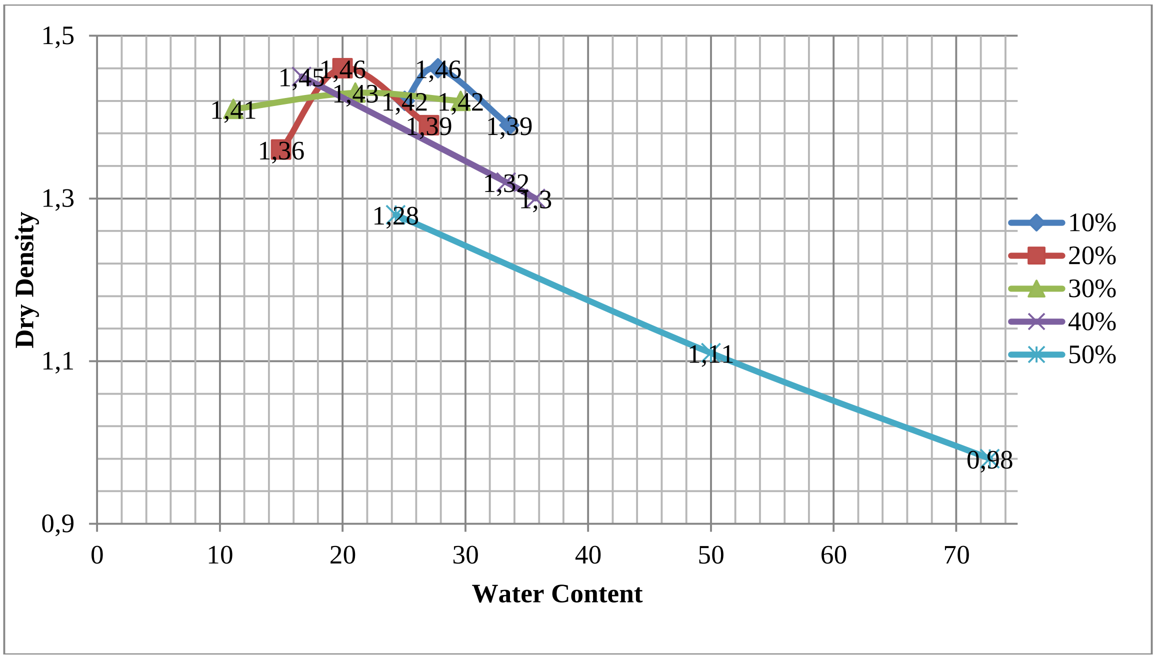

Figure 6: Relationship Curve of Moisture Content to Dry Volume Weight of Soil

Based on Figure 6 above, the relationship curve between moisture content and dry soil volume weight is obtained from each mixing of sand in the original soil. In mixing 10% sand, the optimum water content is 27.73%, and the dry density is 1.46. In mixing 20% sand, the optimum water content is 20% with a dry density of 1.46. In mixing 30% sand with the original soil, the optimum water content was 21.05% with a dry density of 1.43. In mixing 40% sand with the original soil, the optimum water content is 16.67% with a dry density of 1.45. And in mixing 50% sand with the original soil, the optimum water content is 24.32% with a dry density of 1.28.

Therefore, the CBR test used is the optimum water content in each sand mixing. For original soil with 10% sand mixing, the water content was 27.73%; for original soil with 20% mixing, the optimum water content was 20%; for original soil with 30% mixing, the optimum water content was 21.05%; for original soil with 40% mixing, the optimum water content was 16.67%; and for original soil with 50% mixing, the optimum water content was 24.32%.

CBR Test on Stabilized Soil

Before CBR testing, the soil had been compacted to the optimum moisture content obtained from standard compaction testing. CBR testing was carried out by mixing sand levels of 10%, 20%, 30%, 40%, and 50% of the weight of the soil.

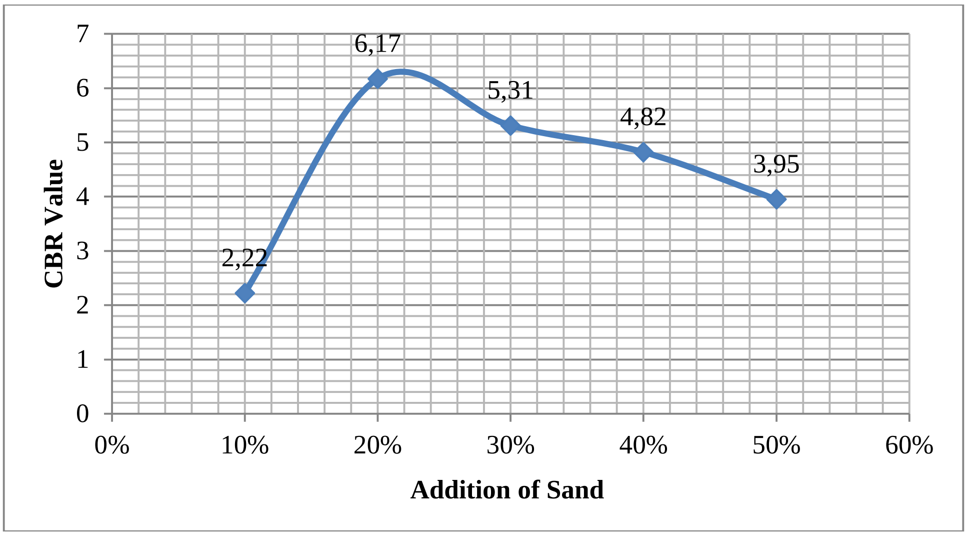

Figure 7: Unsoaked CBR Value Based on Percentage of Sand Addition

From Figure 7 above, the unsoaked CBR value based on the percentage of sand addition shows that the highest CBR value is at 20% sand mixing with a CBR value of 3.70%. Soil development is influenced by the plasticity index and clay fraction content. The greater the plasticity index value and the percentage of clay fraction, the greater the development potential, and it shows that the addition of sand results in a reduced potential value of soil mixture development.

CONCLUSION

From the results of the research that has been carried out, the following conclusions are obtained:

a. In general, there is an effect of sand addition to compacted expansive soil on CBR stability.
b. Expansive soil undergoes positive changes after mixing with sand; optimization is achieved with the addition of around 20% sand.

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