

Improvement of The Gradation of Basic Soil Grains With The Addition of Cement and Clay Soil Against Cbr Values (Hukurila-Seri Ring Road Case Study)

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Abstract.

The condition of the subgrade soil on the Hukurila-Seri Ring Road section, Ambon City has the potential to experience a decrease in carrying capacity due to the abandonment of construction projects. To overcome these problems, efforts are made to improve the soil using the stabilization method using additional materials in the form of cement and clay soil. This study aims to determine the classification of soil at the location, as well as evaluate the effect of the addition of cement and clay soil on soil grain gradation and CBR (California Bearing Ratio) value. The test was carried out in the laboratory using native soil taken from the research site, then mixed with variations of cement (4%, 7%, and 10%) as well as a combination of optimum cement + clay soil (2%, 9%, and 24%). The results of the study showed that the addition of cement significantly increased the CBR value of the soil. The optimum mixture is obtained at the 10% cement variation which provides the highest increase in CBR value.

Keywords: Soil stabilization, grain gradation, clay soil, cement, CBR value and Hukurila-Seri Ring Road.

I. INTRODUCTION

In the field of construction and infrastructure, soil conditions are one of the factors that greatly determine the success of a project, especially in road and building works. Sandy soils are often found as subgrade soil materials in various locations. However, low cohesion, high porosity, and poor bonding ability between grains make sandy soils susceptible to settlement, particle shift, or instability, especially under traffic loads or vibrations. This can result in serious damage to the construction built on it. Therefore, improving and improving the quality of subgrade soil is an important step in ensuring the sustainability and safety of an infrastructure.

One of the commonly used methods to improve soil quality is soil stabilization using additives. Conventional materials such as cement, lime, bitumen, synthetic polymers, and other chemicals have been widely used and successfully improved the mechanical properties of soils. However, the use of these materials often faces obstacles in terms of high cost. Therefore, other stabilization material alternatives are needed that are more economical and easy to obtain.

One of the local materials that has the potential to be a stabilizing material is soil with different gradations, which can be found in the Ambon Island area. Clay soils have a finer grain size as compared to sandy soils. These physical properties make it a potential natural material in improving soil grain gradation and increasing carrying capacity if used as a stabilizing material. Several previous studies have proven the effectiveness of clay soil as a mixing material in soil stabilization, especially when combined with cement as a binding agent.

This condition is very relevant to the Hukurila-Seri ring road construction project in Ambon City, Maluku Province. The road is designed to open up the isolation of the coastal area between Hukurila and Seri Hamlet, as well as encourage the development of local potentials such as fisheries and tourism. The project began construction in 2016 and is planned to be completed in 2018. However, the project has been halted until now after completing the excavation and soil leveling stage, due to a number of unresolved problems.

The suspension of the project for a long time causes the basic soil on the road section to be abandoned, so it has the potential to experience a decrease in the carrying capacity of the soil. Based on these conditions, this study was conducted to evaluate the effectiveness of cement and clay soil as soil stabilization materials to regulate soil grain gradation and increase the CBR (California Bearing Ratio) value. The goal is

to obtain an optimal mixture composition that can be used in the improvement of the base soil on the Hukurila-Seri Ring Road Section, so as to support the sustainability of road infrastructure development in the area.

II. METHODS.

The research method used in this final project is an experimental method that aims to analyze the effect of the addition of cement and clay soil on the carrying capacity of the soil. The research began with sampling disturbed soil from three locations in Hukurila Village, South Leitimur District, Ambon City, then continued with the preparation of materials in the form of original soil, Portland cement type I, and clay soil from Hutumuri Village. Furthermore, testing of the physical properties of the soil was carried out in the laboratory which included moisture content, volume weight, specific gravity, filter analysis, and Atterberg limits. After that, a variation of the sample mixture was carried out with the addition of cement (4%, 7%, and 10%) to obtain the maximum CBR value as the basis for determining the optimum cement percentage (n). The mixture was then combined with variations in the addition of clay soil of 2%, 9%, and 24%. All samples were tested through compaction testing and laboratory CBR in unsoaked conditions to determine the increase in soil carrying capacity. The test results are analyzed to determine the effect of mixture variation on soil CBR characteristics and values so that the most optimal mixture composition can be obtained

III. RESULT AND DISCUSSION.

Soil Physical Properties Testing

Testing of the physical properties of the soil is carried out to understand the basic character of the soil before stabilization. One important parameter is water content, which is the ratio between the weight of water and the weight of dry soil. From the test results, the average moisture content in sample 1 was 8.52%, sample 2 was 10.91%, and sample 3 was 7.01%. This value indicates that the soil conditions are relatively dry to slightly moist, which is generally still good for use as subgrade soil, especially if supported by an adequate carrying capacity value (CBR).

Volume weight testing is performed to determine soil density under natural conditions. Volume weight is a comparison between the total soil weight and its volume. The test results showed that the average volume weight of sample 1 was 1.72 gr/cm³, sample 2 was 1.79 gr/cm³, and sample 3 was 1.76 gr/cm³. This value is in the range of dense sandy soil (1.60–1.80 gr/cm³), so it can be concluded that the soil has a fairly good density level and has the potential to be used as a layer of road bedsoil.

Furthermore, specific gravity testing was carried out to determine the ratio between the weight of soil grains and the weight of water at the same volume. The average specific gravity values obtained were 2.64 for sample 1, 2.74 for sample 2, and 2.68 for sample 3. This value is still in the general range of sandy to silty soils, which indicates that the mineral composition of the soil is relatively normal and does not contain excess organic matter.

The sieve analysis test aims to determine the distribution of soil grain size. Based on the test results, the percentage of soil that passed the No. 200 filter in samples 1, 2, and 3 was 4.67%, 4.29%, and 5.07%, respectively. This value indicates that most of the soil grains are coarse in size (sand), as only a few are fine in size. Meanwhile, clay soil has a percentage that passes the No. 200 filter of 17.20%, which indicates that the content of fine grains is higher than the original soil.

In tests with the addition of stabilizing materials such as cement and clay soil, there was no significant change in the grain size distribution. The pass percentage of the No. 40 filter remains below 50% and the No. 200 filter below 25%. This shows that the main characteristics of the soil are still dominated by the original soil which is sand, so the change in gradation is not too large despite the addition of materials.

Atterberg boundary testing was carried out to determine the properties of soil plasticity, which is the ability of soil to change shape without cracking. The test results showed that the liquid limit (LL) value ranged from 19.73% to 22.73% for the original soil, while the plastic limit (PL) ranged from 22.16% to 29.27%. In clay soils, the values of LL and PL are higher, which indicates a more pronounced plastic nature than the original soil.

The calculation of the plasticity index (PI) showed negative results in all original soil samples, namely -6.54%, -2.40%, and -3.25%. This negative value indicates that the soil is not plastic (non-plastic/NP) and contains almost no clay. In contrast, clay soils have a PI value of 8.55% which shows moderate plastic properties. In general, non-plastic soil like this can have a fairly good carrying capacity in dry and dense conditions, but it can experience a decrease in strength if it is in water-saturated conditions, so it needs to be stabilized to improve its performance as a base soil.

Soil Classification

Soil classification is carried out to find out the type and characteristics of soil based on the standard system, namely USCS (Unified Soil Classification System) and AASHTO. The determination of this classification uses test results data such as filter analysis, Atterberg limits, and gradation parameters (Cu and Cc). With this classification, the feasibility of soil as a subgrade in road construction can be known.

Based on the USCS system, soils are divided into two main groups, namely coarse-grained soils and fine-grained soils. Soil sample 1 included coarse-grained soil because more than 50% of the grains were retained in sieve No. 200, which was 95.33%. This suggests that most soil particles have a relatively large size, such as sand or gravel.

Furthermore, coarse-grained soil is further divided into gravel and sand. From the results of the filter analysis, it is known that 100% of the soil grains of sample 1 passed sieve No. 4, so it is included in the sand group. This means that the soil is dominated by sand-sized particles instead of gravel.

The next stage is to determine the type of soil gradation based on the values of the coefficient of uniformity (Cu) and coefficient of curvature (Cc). From the calculation, the Cu value was 4.62 and the Cc was 0.42. Because the Cu value is less than 6 and the Cc value is not in the range of 1–3, the soil is categorized as poorly graded sand with the symbol SP. This type of soil generally has an uneven distribution of grain size.

In addition, based on the results of the Atterberg limit, the original soil had a negative plasticity index (PI) value, indicating that the soil was non-plastic (NP) or did not contain clay. In contrast, clay soil as an additive has a positive PI value, thus showing plastic properties. When the values of the liquid limit and plasticity are plotted on the USCS plasticity diagram, the clay soils belong to the SC (sand clay) group, which is a mixture of sand and clay.

Here's a summary of the land classification based on the USCS system:

Tab. 1. Classification of Land Based on the USCS System

Sample	% Passed No. 200	Soil Type	Cu	Cc	USCS Classification	Remarks
1	4,67%	Sand	4,62	0,42	SP	Poorly graded sand
2	4,29%	Sand	-	-	SP	Poorly graded sand
3	5,07%	Sand	-	-	SP	Poorly graded sand
TL	17,20%	Mix	-	-	SC	Clayey sand

Based on the AASHTO classification system, soils are divided into two main groups, namely granular soils and fine-grained soils. Soil sample 1 is a granular soil because the percentage that passes the No. 200 filter is only 4.67%, which is less than 35%. This shows that the soil is dominated by coarse particles such as sand and gravel.

In the AASHTO system, granular soils are classified into groups A-1 to A-3. Based on the test results, soil sample 1 is included in group A-1-b because it has a percentage that passed filter No. 40 of 37.56% (<50%) and a percentage that passed filter No. 200 of 4.67% (<25%). Group A-1-b soils generally consist of a mixture of sand and gravel with good quality as a base soil.

The following is a summary of the classification of soils based on the AASHTO system:

Tab. 2. Soil Classification Based on the AASHTO System

Sample	% Passed No. 200	% Pass No. 40	AASHTO Classification	Soil Type	Quality
1	4,67%	37,56%	A-1-b	Sand and gravel	Excellent
2	4,29%	45,18%	A-1-b	Sand and gravel	Excellent
3	5,07%	40,16%	A-1-b	Sand and gravel	Excellent
TL	17,20%	52,80%	A-2-4	Clayey sand/clay	Good

Overall, the classification results showed that the original soils (samples 1, 2, and 3) fell into the category of good to very good quality sandy soils as subgrades, according to both USCS and AASHTO. Meanwhile, clay soil as an additive has plastic properties and functions to improve soil characteristics, especially in the stabilization process to increase the carrying capacity of the soil.

Testing of Soil Mechanical Properties

Soil mechanical properties tests are carried out to determine the strength of the soil against loads, especially through compaction tests and CBR tests. In compaction testing, the main goal is to obtain optimal moisture content (OMC) and maximum dry density (MDD). The results show that each sample has different OMC and MDD values, where the higher the moisture content to a certain point, the soil density will increase until it reaches the maximum condition.

Based on the results of the compaction test, sample 1 had an MDD of 1.74 gr/cm³ with an OMC of 5.71%, sample 2 of 1.82 gr/cm³ with an OMC of 6.71%, and sample 3 of 1.93 gr/cm³ with an OMC of 7.14%. This value shows that the soil is quite dense and dominated by sand, so in general it is quite good to use as a subgrade soil.

Original soil CBR testing showed an average value of 5.71%. This value is still below the minimum standard ($\geq 6\%$) for subgrades, so the original soil is not yet eligible and needs to be repaired or stabilized.

After the addition of cement, the CBR value increased significantly. The greater the percentage of cement, the higher the CBR value obtained. This shows that cement effectively increases soil strength because it functions as a bonding agent between soil grains.

However, when clay soil is added to the soil + cement mixture, the CBR value actually decreases. The more clay soil is added, the lower the CBR value. This is due to the nature of clay which tends to absorb water and reduce the strength of the soil.

Overall, it can be concluded that cement is an effective stabilizing material to increase the carrying capacity of the soil, while the addition of a large amount of clay soil actually decreases the strength of the soil. The best composition of this study is the use of cement up to 10% without or with little added clay.

IV. CONCLUSION.

Based on the results of the analysis of laboratory test data regarding soil stabilization in Hukurila Village, Ambon City, it can be concluded that the type of soil used, including sand material with soil conditions, is classified as very good to good. Based on the AASHTO classification, the soil falls into subgroup A-1-b with zero plasticity, while according to the USCS system it belongs to the SP group, which is poorly graded sand that can contain little gravel and has almost no fine grains. The results of the sieve analysis test showed that the addition of cement and clay soil did not provide a significant change in the distribution of soil grain size, where the percentage of passing of sieve No. 40 remained below 50% and sieve No. 200 was below 25%. This indicates that the soil remains dominated by coarse fractions such as sand and gravel, so it is still classified as group A-1-b according to AASHTO. However, the soil is not fully optimal as a roadbed, especially in changing water content conditions. From the results of the CBR test, the original soil value of 5.71% shows that the carrying capacity is still low. The addition of cement was proven to be able to significantly increase the CBR value, namely by 3.65% in a mixture of 4% cement, 5.46% in 7% cement, and 7.16% in 10% cement. However, the addition of clay soil to the mixture of soil and cement actually decreased the increase in the CBR value, where in the mixture of 10% cement + 2% clay soil there was an increase of 5.59%, then decreased to 2.91% with the addition of 9% clay soil, and only 0.73% with the addition of 24% clay soil. This shows that cement is effective as a stabilizing material to increase the carrying capacity of the soil, while the addition of large amounts of clay soil tends to reduce the strength of the soil.

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