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The Effect of Addition of Coral as a Stabilizing Material to the Value of Soil Bearing Capacity

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ABSTRACT

The type of clay that is very sensitive to changes in water content because it can cause changes in the volume of the soil is also known as expansive soil. The comprehensive nature of the soil is identical to the swelling potential of the soil. The potential for development on the soil can also be a problem in the subgrade layer of the road, which will later have a low carrying capacity or CBR value, causing issues on the road. This study aims to increase the carrying capacity of the soil by using coral from Arso 1 and quicklime, using five different grain sizes and using an additional composition of 10% of the original soil weight in each test, in the form of testing the Arterberg limits, standard proctor compaction, and CBR testing. The use of coral helps improve the quality shown to reduce the plastic index, increase soil density and CBR values in the subgrade layer of roads.

1. Introduction

Soil is one of the materials directly available in the field; if a soil to be used does not meet the criteria required for a particular purpose, the soil properties must be improved because the properties of the soil in the field do not always meet the requirements. The soil must be stabilized to complete the necessary technical needs (Pamuttu & Betaubun, 2018).

The problem with soil that we often encounter in the field is the change in water content which results in changes in soil volume so that during the rainy season, the soil tends to expand due to rainwater infiltration and shrinks during the dry season due to the evaporation process in the surface layer and due to a decrease in groundwater level (Cui, Lee, Choi & Khim, 2018).

The type of soil found in Papua is clay; clay itself is one of the significant geotechnical problems that must be addressed immediately. The community has suffered several losses since it was realized that the damaging effects on several roads built on clay were due to the low CBR value of the subgrade road sections. The soil sample used in this test is a type of clay taken from the location of the Koya Timur village, Muara Tami District, Jayapura City.

Mixing lime with soil results in higher soil strength, reduced swelling potential, and increased durability (Brand, Singhvi & Tutymluer, 2020). For this purpose, the mixture must be compacted and given time for a chemical reaction to occur, which results in a highly cemented combination (Barbier, Hacker & Silliman, 2011). Cementation in the soil-limestone system occurs gradually at a specific temperature, so it is best practice to obtain the ultimate strength in the summer. Soil-lime stabilization is very suitable for use in tropical climates (Kalkan, 2020). However, lime in the soil stabilization process is obtained through industrial methods, lime burning, or pounding (Fisher & Barron, 2019).

The choice of coral material itself is because coral has lime properties which are used for stabilizing mixtures on the soil and the abundance of corals in Papua; previously, soil stabilization itself has been widely carried out using soil-cement in the form of a mix of coral, cement, and additives that use relatively low costs. Expensive and must be imported from outside Papua and with unsatisfactory work results with a service life of less than one year. So the author feels the need to conduct research using coral material abundant in Papua, especially in Jayapura and kab. Keerom as a subgrade stabilizing agent on the road. The corals used were obtained from quarry arso 1, Keerom district.

2. Method

The research method used in problem-solving includes analytical methods. Picture captions are placed as part of the picture title (figure caption), not part of the picture. The methods used in completing the research are listed in this section.

In Research Methods, small and non-mainstream tools (which are common in the lab, such as scissors, measuring cups, pencils) do not need to be written down, but only the primary set of equipment, or the main tools used for analysis and or characterization, even need to get to the type and accuracy; Write down in full the research location, the number of respondents, how to process the results of observations or interviews or questionnaires, how to measure performance benchmarks; The general method does not need to be written in detail, but it is enough to refer to the reference book. The experimental procedure must be written in a news sentence, not a command sentence (Tao, Yuan, Chen & Basack, 2021).

This stage is activity before starting data collection and processing. This preparatory stage includes the following actions: Determine the need for primary and secondary data: a. Literature study on clay soil stabilization as a reference and additional knowledge; b—final Project Proposal Making; and c. The research process is arranged in stages of testing in the following order: 1) Sampling of clay and coral soils; 2) Testing the properties of clay; 3) Making a mixed composition of clay and coral; 4) Atterberg test, and standard proctor compaction; 5) Testing CBR (California Bearing Ratio) at optimum moisture content with a soaking period of 4 days.

Sampling and material in the test were taken from a different quarry. The original soil sample was taken from Koya Timur, Muara Tami district, and coral material from the Arso 1 coral quarry, Keerom district. The location map can be seen in Figure 1. and Figure 2.

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Fig 1. Map of Native Soil Sampling Locations
Source: Google Maps 2018

Fig 2. Map of Coral Stabilization Material Collection Locations
Source: Google Maps 2018

This laboratory research is intended to determine the grain size of clay and coral to obtain stiffness. All of these experiments were carried out in the laboratory of the Faculty of Engineering, University of Cenderawasih. From the research results, data will be obtained about the physical and mechanical properties of the soil before and after stabilization with corals. The coral percentage was given at 15% of soil weight in each test.

The test results will be obtained to overview the changes in physical and mechanical properties that occur when the soil is stabilized with coral content (Pamuttu & Betauban, 2018).

This test is carried out based on the following references: a. Water content test equipment (SNI 03-1965-1990); b. Specific gravity test equipment (SNI 03-1965-1990); c. Atterberg limits test equipment: 1) Liquid limit test (SNI 03-1967-1990); and 2) plastic limit test (SNI 03-1966-1990); d. Grain size analysis tool (SNI 03-3423-1994); e. Proctor standard test equipment (SNI 03-1742-1989); f. CBR (California Bearing Ratio) test equipment (SNI 03-1738-1989); and g. Filter analysis procedure (SNI 03–968–1990).

3. Result and Discussion

Soil characteristics are taken from the location of Koya Timur, Muara Tami District can be known by conducting several types of tests in the laboratory; soil characteristics are needed to identify soil types and physical properties that will be used to analyze the shrinkage and density properties of the soil.

Initial tests were carried out on the original soil in initial water content, plasticity index, liquid limit, plastic limit, density, and Proctor standard compaction. The results of the actual soil test can be seen in:

Table 1.
Characteristics of East Koya Soil, Muara Tami District

No.	Test Type	Test result
1.	Water content	30.083%
2.	Liquid Limit	58.66%
3.	Plastic Limit	19.69%
4.	Plasticity Index	38.978%
5.	Specific gravity	2.65
6.	Soil Compaction (Proctor)	1.35 gr/cm3

Source: Primary Data Results, 2018

Based on the data shown in table 1. above, the soil originating from Koya Timur is included in the category of expansive soil, soil which is categorized as expansive soil is soil with high plasticity because, with high plasticity, the soil will easily experience changes in volume due to changes in water content in the soil.

The test results of the Atterberg boundaries on the original soil show a plastic index value of 38.976%; with this, the development potential of the original soil is very high (Lee, Cui, Son & Khim, 2021).

Meanwhile, to identify the types of soil that exist in East Koya can be done using several methods, namely by classification according to Unified and AASHTO (American Association of State Highway and Transportation Officials Classification) of these two classification systems using the properties of plasticity & grain size as a reference in carrying out the classification of the land.

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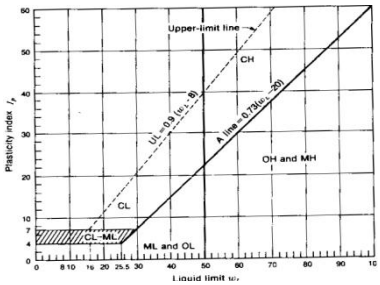

Fig 3. Graph of Soil Classification According to AASHTO
Source : Harry, C 2007

The results of the soil classification according to the USCS obtained the results of the East Koya soil type in the form of clay because, from the results of the liquid limit test, the liquid limit value of the original East Koya soil was 58.66%. This value proved the condition of the original ground of East Koya in the central division in the form of silt and liquid limit clay > 50% with the symbol OH in the form of organic clay with medium to high plasticity. We use the OH group itself based on the specific gravity test carried out and categorized based on the particular gravity table. Meanwhile, according to the AASHTO soil classification, the soil from the test site is clay - clay.

Soil classification according to AASHTO is done by classifying groups based on sieve analysis tests, liquid limit, and plastic index values; from the test value for the original soil it shows the liquid limit value with a minimum value of 41%, while the liquid limit value in the original Koya Timur soil is 58.66 % with a plastic index value that has also passed the minimum value of the AASHTO soil classification of at least 11%, which is 38.98%.

The results of the soil classification graph according to AASHTO based on the relationship between the liquid limit value and the plastic index show that the original soil of East Koya is in the soil category A – 7 – 6. as subgrade, which is in moderate to poor condition.

Soil classification can also be done by testing the specific gravity of the soil, which aims to determine the soil category based on the specific gravity of the material. For the soil density test results, the specific gravity value of 2.65 is included in the type of organic clay.

For the results of the compaction test carried out by the standard Proctor method, this test was carried out to determine the optimum moisture content and dry volume weight of the clay; the test results are presented in Figure 4. 1.35%.

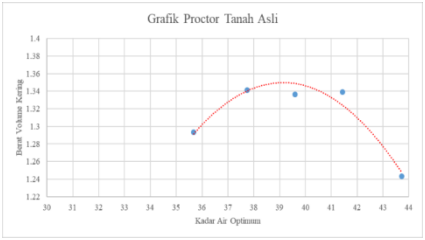

Fig 4. Proctor Standard Compaction Test Results on Native Soil
Source: Primary Data Results, 2018

Expansive clay is soil with a high expansion factor and will provide maximum swelling pressure when exposed to water. This is also influenced by the dry volume weight of the clay (Chen, 1975), said directly related to the initial moisture content; the dry density of the clay is another expansion index. Soil with a dry thickness of more than 110 pcf (1.76 gr/cm3) generally shows a high development potential, while the dry volume weight of the native soil of East Koya, which is only 84.28 pcf (1.35 gr/cm3), is not classified as a category of earth with high expansive properties.

From several soil physical tests and CBR testing carried out on the original soil of East Koya, the experimental results show that the value of the bearing capacity of the soil is minimal; this is caused by the physical properties of the soil itself, which shows the liquid limit value (LL) = 58.66%, the value of the plastic index (IP) = 38.976%, soil density = 2.65, dry volume weight from the results of the proctor test = 1.34 gr/cm3 proves that the soil is clayey with high plasticity which has a risk of shrinkage due to changes in volume and water content in the soil so that the original Koya Timur soil is hazardous while the CBR value of the original Koya Timur soil is terrible to be used as subgrade Subgrade) on a road section because with a CBR value = 1.36%, according to (DoT, 1994) the subgrade layer is better to be dismantled and replaced with better material.

The depth of soil replaced typically ranges from 50 – 100 cm. Although this substitute material is quite strong, in the design, the subgrade is still considered to have a CBR = 2%, and therefore a cover thickness of 600 mm is required. If the CBR of the subgrade is less than 2%, then laying using heavy equipment and compacting the overburden becomes difficult, especially if the subgrade is soft clay. For this, above the subgrade, geotextiles should be used to separate the subgrade from the overburdened material. In this way, the implementation of the overburdened material laying and compaction becomes more accessible and faster. So that the construction of roads will cost more and work in the field will be difficult so that it will also affect the productivity of the tools and the cost of using the tools. Therefore it is necessary to improve the soil to increase the value of the bearing capacity of the ground on the subgrade.

Soil stabilization is the mixing of soil with specific materials to improve the technical properties of the earth, or soil stabilization can also be defined as an attempt to change or improve the engineering properties of the soil to meet specific technical requirements. In carrying out soil stabilization on the original soil of Koya Timur, Muara Tami district, the addition

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of stabilizing material used was coral taken from the Arso 1 Coral Quarry.

The use of coral for stabilization of the native soil of East Koya because the rock or limestone contains good lime (CaO) for stabilization, the use of this rock is also due to the availability of abundant materials in the field and the physical properties of the stone itself which has natural properties. This is similar to lime (CaO), and with the results of physical tests carried out in the coral laboratory that do not contain refined grains and have no plasticity value, this is also proven by the Atterberg limit experiment, in the liquid limit test, the investigation that was carried out failed because the coral did not have plastic content in the granules that pass sieve no. 40. Lime content in coral rock can also change soil texture, resulting in higher soil strength, reduced development potential, and increased durability. The clay will vary to behave close to silt or sand due to the clumping of particles.

Mixing the soil with lime showed a significant reduction in clay particle size (<0.002 mm) compared to the original clay; this is why coral is suitable as an admixture for soil stabilization. Crude lime or quicklime in principle consists of calcium oxide CaO. Quicklime is obtained from burning limestone (limestone) at a temperature of approximately 1000˚C.

The results of the CBR test on the native soil of Koya Timur and the original soil with the added coral mixture for stabilization, the CBR value of the original soil also increased with the presence of a mix of coral in the CBR test. The bearing capacity of the soil on the subgrade, which was initially only 1.36% of the original soil CBR value, increased to 5.77%. However, with a CBR value of 5.77%, it turns out that it is still tiny because, according to (Rogger, 2008) the CBR value of 15% must use a capping layer or in the form of granular material, whereas according to (DoT, 1994) if the subgrade has a CBR between 2.5 to 15%, then for flexible pavement (including the flexible composite pavement) selected from the 2 points above is point (b) with a CBR value = 3.5%. One of two can be selected: 150 mm foundation layer using a 33cm cover. Or only use a sub-base layer with a thickness of 280 mm. From the above statement, it is possible that the stabilization results do not have too much effect on increasing the bearing capacity value of the subgrade of the road but compared to the original soil bearing capacity value without stabilization at the CBR value, which is only 1.36%, according to (DoT, 1994).) in point (5) says.

If the subgrade has a CBR < 2%, it is better to dismantle it and replace it with better material. The depth of soil returned typically ranges from 50 – 100 cm. Although this substitute material is quite strong, in the design, the subgrade is still considered to have a CBR = 2%, and therefore a cover thickness of 600 mm is required. If the CBR of the subgrade is less than 2%, then laying using heavy equipment and compacting the overburden becomes difficult, especially if the subgrade is soft clay. For this, above the subgrade, geotextiles should be used to separate the subgrade from the overburdened material. In this way, the implementation of the overburdened material laying and compaction becomes more accessible and faster.

This, of course, will cost more and reduce tool productivity time because of the difficulty of working in the field and excavating the subgrade and replacing it with a new and better layer. Therefore, mixing corals on the native soil of East Koya is more feasible to be used as a stabilizing material. After all, it will further reduce the cost of work and tool productivity because it reduces plasticity risk, whichh can be difficult in fieldwork by heavy equipment working to make subgrade layers (Subgrade).) road section later

4. Conclusion

From the results of testing and analysis, several conclusions were obtained from the test results: a) The effect of adding coral to the plasticity of the soil is that it can reduce the original soil plasticity index value, which was initially 38.97% down to 12.58%. And the effect on the density value is proven by increasing the dry volume weight of the soil and decreasing the optimum water content in the ground. Meanwhile, in the CBR value, there was an increase in the carrying capacity of the original soil, from the initial 1.36% it increased to 5.77%; and b) The effect of mixed coral grain size on the expansive clay soil of Koya Timur, Muara Tami District has an impact on the plasticity, density, and CBR values in the original soil with a decrease in the IP value in the original soil from any variations for maximum yield shown by grain size that passes sieve No. 10/100, with an IP value of 12.58%. The density value is proven by increasing the dry volume weight value of 1.525 kg, and the same grain size indicates this value. The CBR value of grain size also affects the increase in the carrying capacity of the soil by 5.77% from the initial 1.36%, and this value is shown by the grain size that passes the No. 10 sieve and is retained by the No. 100 sieve.

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