Addition Of Quick Lime To The Stabilization Of Humbang Hasundutan's Soil Peat Through The California Bearing Ratio Laboratory Test

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Abstract.
This research is a research on the development and utilization of peat soil material that is often found in the Humbang Hasundutan district, where peat soil that has been stabilized with lime can later become new soil parameter data that can be used for road subgrade construction improvements. The purpose of this study was to stabilize the Humbang Hasundutan peat soil mixed with lime to meet the standards for road subgrade construction, which will be tested with the California Bearing Ratio (CBR). This study used experimental methods carried out in the laboratory, by conducting tests to obtain new soil parameter data by trying variations of 10%, 20% and 30% initial lime. From the results obtained, the results of the CBR test of peat soil with a lime mixture variation of 20% have met the specifications of Highways for road construction subgrade, which is 5.5%.

Keywords: *CBR Laboratory Test, Quick Lime, Soil Peat.*

I. INTRODUCTION

Indonesia is one of the countries that has the third largest peatland in the world, which is around 265,500 km2, the peatland is spread over the islands of Sumatra, Kalimantan and Papua. (Istomo, 2018) One of the districts in North Sumatra that has peatland is Humbang Hasundutan's district which is located at an altitude of about 1,400 m dpl (Hutagaol, 2021). The peatland in Humbang Hasundutan's district spread around 2,988 ha. The peatlands are spread over three sub-districts, namely Doloksanggul (1,578 ha or 52.81%), Pollung (931 ha or 31.16%), and Lintong Nihuta (479 ha or 16.03%). The Peatlands in Humbang Hasundutan's district generally have a medium depth (100-<200 cm) covering an area of 2,118 ha. depth (200-<300 cm) covering an area of 870 ha. These peatlands are generally still in the form of shrub and swamp grass and have not been widely used for agricultural activities (BBSDLP, 2022) Peatland is a mixture of organic materials which are derived from plant decay, which have varying levels of decomposition (SNI 7925:2013, 2013) soil peat is generally colored of dark brown to black, because it is formed from the process of weathering and plant decay, so peat has a distinctive odor. Soil Peat is soil that is not good for construction or development of infrastructure, which has poor bearing capacity and has low value of CBR, but if the parameters of the physical properties of the soil can be improved, it will become a strong soil base (Tecnikal et al., 2016).Subgrade is the foundation for road pavement work, which is located under the lowest layer of soil which has function as a place for laying the pavement layer and supports the construction of the road pavement above it (Devavath & S, 2018). Subgrade that has low strength causes the pavement to be easily cracked. To obtain a strong foundation layer, a good subgrade is also needed (Dwina et al., 2021). The development of civil infrastructure is growing along with the number of human needs.

As an example, in the process of building physical road infrastructure, technical problems often occur related to soil characteristics, for example, If this soil peat is used as landfill for the subgrade road must have a carrying capacity that meet the standard tested by the CBR test (Waruwu et al., 2022). Then if soil peat is used as a (subgrade) road, it is necessary to improve the soil properties so that it has a good carrying capacity. The method of improving soil peat has been done a lot, it is included by soil stabilization.Hardiyatmo (Hardiyatmo, 2017) also explains in his book with the title is "Stabilisasi Tanah Untuk Perkerasan Jalan raya", one of the chemical stabilizations is lime. The reason for using lime is because it has pozolanic properties and also has self-cementing properties (the ability to harden and increase strength when if it reacts with water) so that it can change the soil properties, can reduce the stickiness and softness of the soil so that it expands and shrink due to reduce water conditions (Dwina et al., 2021). Lime

(CaCO3) is a sedimentary rock consist of the mineral calcite (calcium carbonate). The main source of this calcite is marine organisms. This organism secretes a shell that escapes into the water and it is deposited on the ocean floor as a pelagicooze (see lysocline for information on calcite dissolution) (Santosh Dhakar, 2016). Based on (Indonesian National Standard, 1996), lime is divided into: (a) Type I lime is lime which contains of high calcium hydrate; with the highest level of Magnesium Oxide (MgO) 4% by weight; (b) Type II lime is Magnesium or Dolomite lime which contains more than 4% Magnesium Oxide and a maximum of 36% by weight; and (c) quicklime (CaO) is the result of burning limestone at a temperature of ± 90°C, with the composition mostly Calcium Carbonate (CaCO3); extinguished lime is the result of extinguishing quicklime with water, thus it forms hydrate [Ca(OH)2].According to (Craig, 1991) in (Munawir et al., 2012) soil compaction is the process of increasing soil density by reducing the distance between particles so that air reduction occurs. The laboratory test is developed by R.R. The proctor of the 1920s and these elements of the standard compaction test are shown in Table 1. For the purposes of road subgrade, the CBR score is used as an indicator. The greater of CBR score, then the greater the ability of the soil to withstand traffic on it. These are the categories of CBR score for the strength of road subgrade that are classified in the Guide Highways Maintenance (Territories, 2000).

Table 1. Categories of CBR score (Territories, 2000)

CBR Score	Strength of subgrade	Description
< 3%	Bad	Compaction required
3% - 5%	Normal	Compaction depends on the road category
5% - 15%	Good	Normal compaction is not required except for heavy traffic

The CBR score that is used in the calculation of the strength of the subgrade is the CBR score that is used in the calculation of the strength at 0.1" penetration and 0.2" penetration for laboratory test (SNI1744, 2012). The calculation formula in determining the CBR score based on SNI 1744 in 2012 is as follows:

$$CBR\ Score\ on\ penetrasi\ 0{,}1" = \frac{A}{3000}\ x\ 100\%$$

$$CBR\ Score\ on\ penetrasi\ 0{,}2" = \frac{A}{4500}\ x\ 100\%$$

II. METHODS

The type of soil that will be stabilized is soil peat that is taken in the Nagasaribu Village area, Lintong Nihuta sub-District, Humbang Hasundutan district. Soil Peat samples are taken from several points at the soil sampling location by using a hoe with a depth of 50 cm, this is done in order to remove plant roots. Soil samples that are taken, represent soil samples at the sampling location. The sampling location is an vacant land that is generally used by the community as a place to collect firewood, it is shown in the Figure 1 below.

Fig 1. Area Of Taking Soil Peat Sample

Research Method

This research is carried out by two treatments, namely variation which is done by original soil and soil that has been mixed with quick lime in the variations of 10%, 20% and 30%, as in the Diagram below:

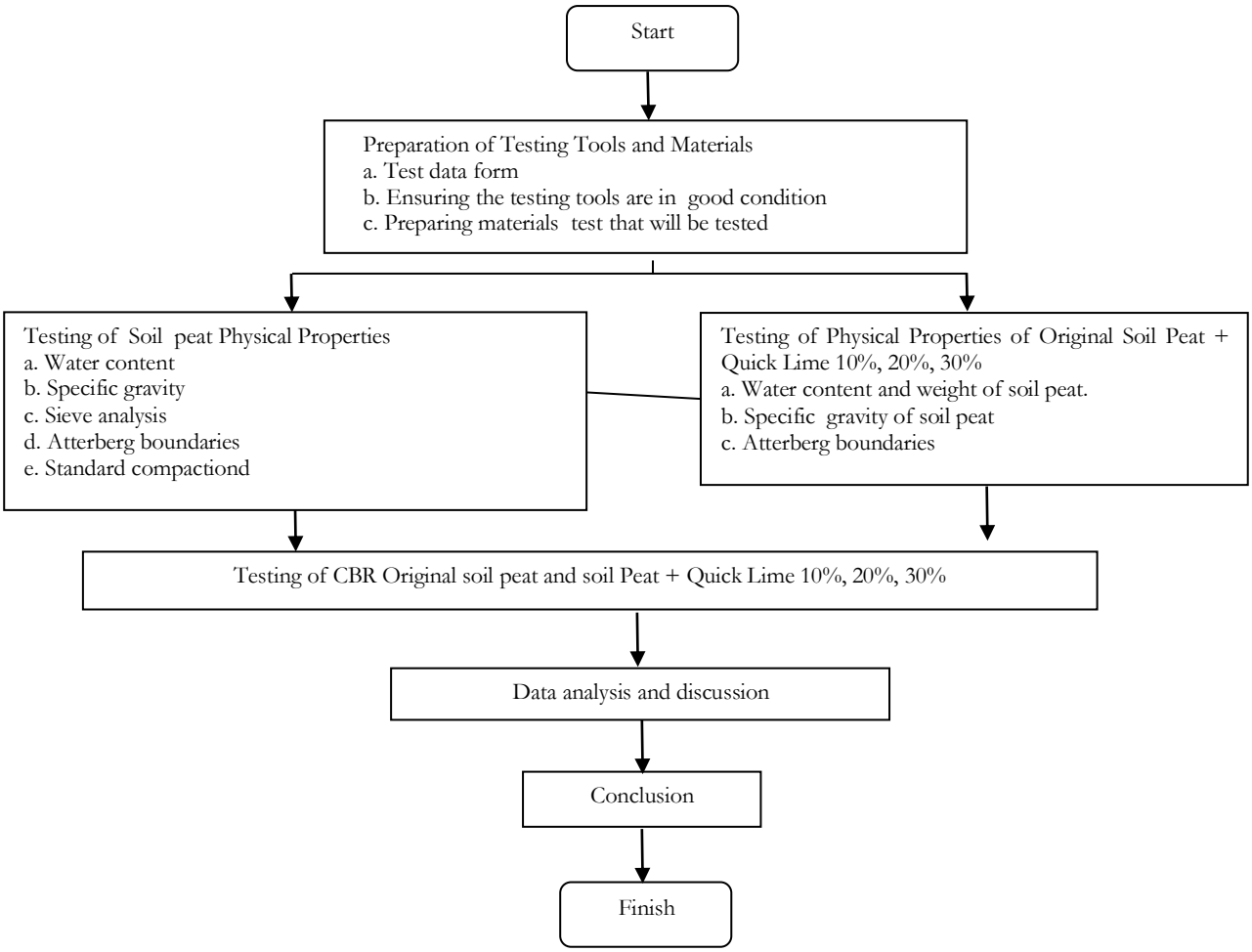

Fig 2. Research Flowchart

Research Procedure

Testing Stage

a. Soil peat that has been taken from Nagasaribu Village, Lintong Nihuta sub-District, Humbang Hasundutan district is prepared first by cleaned , crushed from the lump of land, dried and filtered through sieve no. 4 (4.75 mm).
b. Doing the physical properties test of the soil on the original soil peat which consists of testing the soil water content (1965:2008, 2008), testing the soil specific gravity (1964:2008, 2008), testing the Sieve Analysis (03-1968-1990, 1990)Testing Liquid limit and plastic limit (1966:2008, 2008; 1967:2008, 2008).
c. Doing soil mechanical properties test on the original soil peat that consist of density test (1742:2008, 2008) and CBR test (1744:2012, 2012).
d. Doing the physical properties test of the soil peat by mixing lime at the variations of 10%, 20% and 30%.
e. Doing a soil Peat CBR Test with mixing lime
f. Analysis of the results of the CBR test, on the variation of the lime mixture that is used.

III. RESULT AND DISCUSSION

Peat Properties

Soft soil is generally soil loam with high water content or soil peat (organic soil). Illustrations of various physical properties of soft soil are shown in Table 2 ((Rollings, M.P;Rollings JR, 1996). The test that is carried out in the laboratory includes the results of the physical properties of the original spil peat, it is shown in the Table 4.1. which includes: (a) water content, (b) specific gravity, (c) liquid limit, (d) sieve analysis test.

Table 2. Data on Physical Properties of Soil

No	Properties of Soil	Results	Test Method	Physical Properties of Peat
1	Water Content, w	130,26 %	SNI 1965:2008	100 – 1800
2	Specific Gravity, GS	1,4	SNI 1964:2008	1,5 – 1,75
3	Liquit Limit, LL	85,12 %	SNI 1966:2008	50 - 200
4	Pass Filter no.200	3,158 %	SNI 03-1968-1990	-

a. Testing of Original soil Peat Compaction

The results of the research that is carried out are obtained in the form of a curve that shows the relationship between optimum water content and maximum dry density, in this research uses the method of the SNI 1742:2008 (1742:2008, 2008) with the tool that is used is mold. pounder weight and soil peat samples that pass filter no. 4 and get the test results are shown in the Figure 3 below:

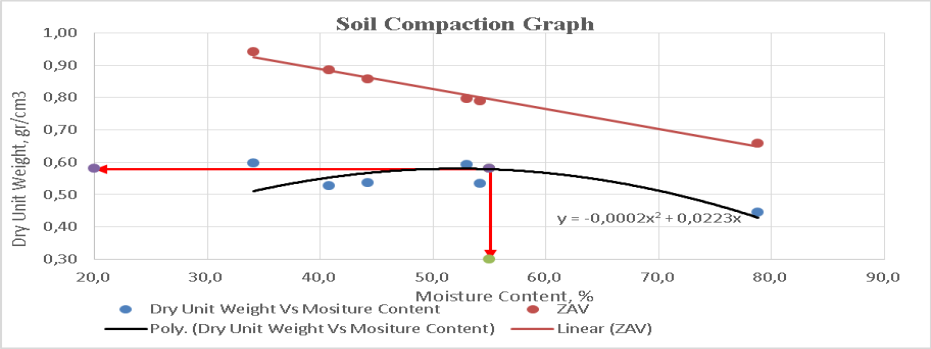

Fig 3. Soil Compaction Graph.

From the graph on figure 3 above, it can be seen that the optimum water content (w_{opt}) is 55% and the maximum dry weight (γd_{max}) are 0.58 gr/cm3. And From Figure 3 also can be seen in Under any circumstances when if the soil has compacted, the compaction curve is impossible to cut the ZAV line. The score that is obtained will be used as a reference for the use of water content in mixing lime with variations in lime mixtures of 10%, 20%, 30% and 40%.

b. Testing of California Bearing Ratio (CBR) Laboratory

This research uses the method of the SNI 1743:2008 (SNI 1743:2008, 2008) with the tool that us used is mold. pounder weight and soil peat samples that pass filter no. 4. CBR test is described in the form of a curve. The data that is described show the response of with dry density between the specified minimum and the resulting dry density by compaction within the specified water content that is range. It is Such as in the Picture of 4 Below:

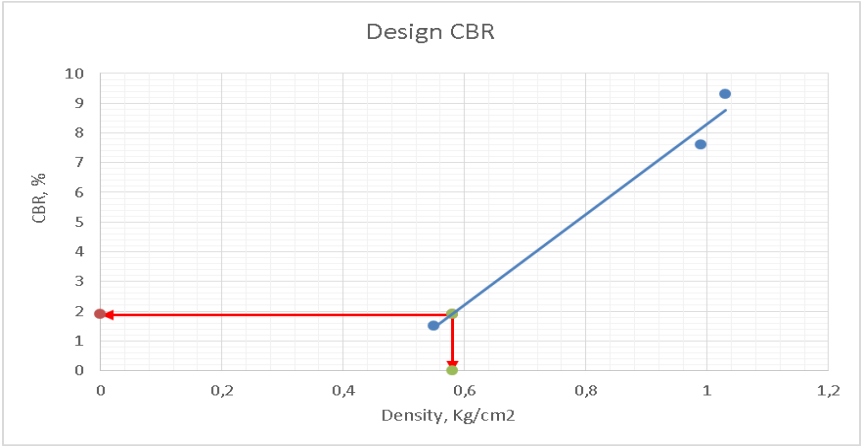

Fig 4. Design CBR

From the graph (figure 4) above, it can be seen that with a Density score of 0.58 kg/cm2 and a design dry density (95% d max) of 0.55 kg/cm2, then it is obtained the design CBR score is 1.9%. Based on the CBR score that is obtained, then for the original soil peat is still classified as soft soil and does not meet the Bina Marga specification that can be used as a road construction subgrade (the CBR subgrade requirement must be in the min > 5% category).

The Results of soil Peat test With Quick Lime Mixture

Lime is one of the materials that can be used for soil improvement and it is a chemical soil improvement process (Saberian & Rahgozar, 2016). The lime that is used is calcium oxide (CaO) which is the result of burning limestone at a temperature of ± 90°C, with the composition mostly Calcium Carbonate (CaCO 33) (03-4147-1996, 1996). The percentages of lime variations that are used are 10%, 20% and 30% from the weight of soil peat that is used

a. Water content test, Specific Gravity, and Atterberg boundaries with quick lime Mixture.

The results of water content test on the soil peat wich is mixed by lime are shown in Table 3.

Table 3. Peat Soil Test Data With Quick Lime Variant

No	Mixed Variation	unit	Water Content (w) (%)	Specific Gravity (Gs) (%)	Liquid Limit (LL) (%	Plastic Limit (PL) (%)	Plasticity Index (PI)
1	Soil Peat + Quick Lime 10%	gram	123,71	1,6	140,765	120,00	20,765
2	Soil Peat + Quick Lime 20%	gram	106,82	1,59	117,894	98,79	19,104
3	Soil Peat + Quick Lime 30%	gram	78,28	1,75	84,847	77,05	7,937

From the results of physical testi show that:

1) Soil peat has a high water absorption capacity and depends on the degree of decomposition. But the water content will decrease drastically when if it is mixed with organic materials. In this research, the greater the variation of the lime mixture thst is used, then the smaller the water content that is obtained.
2) The effect of adding lime to high organic soils, namely soil peat in general can reduce the Plasticity Index (IP), a decrease in soil IP is caused by an increase in the plasticity limit score and accompanied by a decrease in the liquid limit, so that the soil becomes loose and the grains are larger and not sticky. (Bowles, 1984) in (Braja,M, 2010), states that the plasticity index (IP) is the most important soil score in the soil consistency index. The greater the IP score of soil, the greater that the problems caused by the soil in the construction sector, because there is a large change in the ability of the soil in resisting the shear forces on the soil.
3) The plasticity index also has a close relationship with the potential for soil development so that the potential for soil development can be classified based on the plasticity index (Chen, 1975), if the IP score is at 0 -15 then the potential to expand is low, the IP score is at 15-35 then the potential to expand is modium, the IP score is at 35-55 then the potential to expand is high, and the IP score is at > 55 then the potential to expand is very high. With the addition of stabilization in the form of lime, the plasticity index decreases along with the addition of the content of the mixture of these materials. This occurs due to the ion exchange reaction that occurs, resulting in changes in Ca+ ions to reduce the expansiveness of the soil peat .

b. California Bearing Ratio (CBR) Laboratory Test Of Soil Peat With Quick Lime

(Ranggaesa, 2017) The pozzolanic process occurs between calcium hydroxide from the soil reacting with silicate (SiO2) and aluminate (AlO3) from additives to form a soil binding material consist of calcium silicate or aluminate silicate. The reaction of Ca2+ ions with silicates and aluminates from the surface of the clay particles forms a cement paste (hydrated gel) so that binds the soil particles. The reaction of cementation that occurs in the soil mixture with additives form new grains wich is harder so that are stronger to withstand the given load, in other words, the addition of lime will strengthen the original soil by increasing the CBR score.

CBR is depicted in the form of a curve. The data depicted show the response of the soil over a specified range of water content with dry density between the specified minimum and the resulting dry density by compaction within the specified range water content. it is As in the Table 4 below

Table 4. CBR of Soil Peat With Quick Lime Mixture

No	Mixed Variation	CBR Value			Density			CBR Design
		10	25	65	10	25	65	
1	Soil Peat + Quick Lime 10%	3,5	6,7	9,5	0,52	0,78	0,94	3,8
2	Soil Peat + Quick Lime 20%	4,1	7,4	10,2	0,47	0,65	0,88	5,5
3	Soil Peat + Quick Lime 30%	6	7,8	10,8	0,43	0,63	0,76	7,4

With the addition of stabilization in the form of lime, the CBR score increases along with the addition of the content of the mixture of these materials. Based on the CBR score that is obtained, then for the soil peat that has been stabilized, in the soil peat with variation of lime mixture is 20% can meet the specifications of Bina Marga to be used as a road construction subgrade (subgrade CBR requirements must be in the min > 5% category).

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IV. CONCLUSION

1) Humbang Hasundutan's, soil peat has a water content (w) of 130.26%, specific gravity (Gs) of 1.4, Liquid Limit score of 85.12% with non-plastic soil conditions, the results of the standard proctor compaction test produce water content Optimum (Wopt) is 55% and maximum dry volume weight (γd max) = 0.58 gram/cm3.

2) Characteristics of physical properties of soil peat with variations of lime mixture 10%, 20% and 30% result in smaller water content score, due to soil peat has been mixe by lime, addition of stabilization in the form of lime, plasticity index decreased along with the addition of the content of the material mixture. It is because of the ion exchange reaction that occurs resulting in a change in Ca+ ions to reduce the expansiveness of the soil peat so that the soil peat has the potential to expand low in the lime mixture variant of 30%.

3) The results of the CBR test. soil peat with a lime mixture variation of 20% has been able to meet the specifications of Bina Marga to be used as a road construction subgrade, which is 5.5%

V. ACKNOWLEDGMENTS

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