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Study of Soil Improvement and Slope Protection on the Double Track Engineering Design Between Giham-Martapura

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Abstract

The train is a means of transportation favored by the community because the train is one of the modes of transportation that has special characteristics and advantages. Along with the development of infrastructure development in Lampung Province and South Sumatra Province, the planning and design of a building must be done carefully and well, one of them is by building a double track between Giham - Martapura, South Sumatra because the application of one track has many obstacles. It is hoped that the addition of the double track can make the train schedule more accurate and can improve the quality of the trip. Therefore, for the construction of this double track railroad, one of them is needed a layer of soil that is able to support the load and can improve the physical and mechanical properties of the soil. Based on the results of the Atterberg boundary test the soil originating from the undisturbed soil sample of the Giham-Martapura railroad gets an PI value <LL-30 (26.51% <27.95%), then the land based on the AASHTO system is classified into A -7-5 that is clay soil and as subgrade material has normal to poor evaluation. Based on the calculation results, the peel depth (excavation) for the improvement of subgrade in STA 188 + 300 - STA 188 + 600 is as deep as 1.7 m, but after using additional reinforcement with geogrid material with strength specifications 19 KPa/m^2 the peel depth (excavation) to repair subgrade to 0.5 m. So that there is an excavation efficiency of 70.5%.

Keywords: Railroad; Land; Double Track; Slope Protection.

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1. Introduction

The train is a means of transportation that people enjoy doing because the train is a mode of transportation that has special characteristics and advantages. Along with the development of infrastructure development in Lampung Province and South Sumatra Province, planning and designing a building must be done carefully and properly, one of which is the construction of a double track between Giham - Martapura, South Sumatera because the application of one route has many obstacles. Therefore, for the construction of this double track railway, one of the ways is needed a layer of soil that is able to support loads and can improve the physical and mechanical properties of the soil. Not all subgrade conditions have a dense soil layer but there is a subgrade with a soft soil layer. Seeing such soil conditions, it can be seen that the basic soil has a low bearing capacity, large compression and a small permeability coefficient. Therefore, it is necessary to pay attention to the embankment planning and to improve the land which can increase the carrying capacity and accelerate the construction of double track railways. Soil improvement is used to improve the strength of loose sand to mitigate liquefaction [1]. Some methods are applied such as soil cement wall, deep mixing, which are eco-friendly [2,3]. Other ways applied are microbe induced calcite precipitation (MICP) method [4] and enzyme induced carbonate precipitation (EICP) method [5]. It mixed Polyvinyl alcohol (PVA) fiber, polypropylene (PP) fiber, and basalt-fiber have been applied for this purpose to improve bio-cemented soils [6,7]. At several points in the construction of the Giham-Martapura railroad, earthworks are required because the elevation and position of the planned new railroad tracks are different from the existing rail elevations. One of the things that should be paid close attention to is the elevation of the elevation of the railroad tracks for the new lines, thus affecting the old lines to be elevated so that they can still achieve the geometric feasibility of the railroad. In the design plan of the Ministry of Transportation of the Republic of Indonesia, the calculation of soil strength at critical points is included. Therefore, it is necessary to verify the bearing strength of the soil against the load of the train that passes during the construction period at that point. Furthermore, the results of this study can be used as a reference to the implementing party whether they can use the design plan from the Ministry of Transportation or need adjustments so that the strong structure supports the train load.

1.1 Soil

Soil is a collection of minerals, organic matter, and relatively loose deposits, which are located on top of the bedrock. It also has biotic interactions and interspecific trade-offs [8]. It contains deterministic process with soil water content, and microbial community [9,10]. The relatively weak bonds between the grains can be caused by carbonates, organic substances, or oxides that settle between the particles [11,12,13,14]. Subgrade (Subgrade) A layer of soil 150-100 cm thick where the subgrade will be placed on it is called subgrade which can be compacted original soil (if the original soil is good), land imported from other places and compacted or soil stabilized with lime or other materials. Before the other layers are laid, the subgrade is compacted first so that high stability is achieved against volume changes, so it can be said that the strength and durability of the pavement construction is largely determined by the properties of the subgrade bearing capacity. Many methods are used to determine the bearing capacity of the subgrade, for example checking the CBR (California Bearing Ratio), DCP (Dynamic Cone Penetrometer), and k (modulus of subgrade reaction). In Indonesia, the carrying capacity of subgrade for pavement thickness planning is determined by CBR inspection. Soil stabilization is a process to improve soil properties by adding something to the soil, in order to increase soil strength and maintain shear strength [15,16]. Soil stabilization with lime is very commonly used in road construction projects and buildings with a wide variety of soil types, from ordinary loam to expansive soil. The lime used in this study was powdered lime (CaO) purchased at a material store. The lime comes from limestone which has been burned at temperatures up to 1000℃. The lime from combustion when added with water will expand and crack. A lot of heat is released (such as boiling) during this process, the result is calcium hydroxide Ca (OH) 2. When lime with clay minerals or other fine minerals react, it will form a strong and hard gel, namely calcium silicate that binds the grains. grain or soil particles [10]. The definition given by ASTM states that a geotextile is a material that absorbs water, both above the surface and that penetrates the material. Geotextile functions as a separation layer, filter layer ("filtration"), and water distribution ("drainage"). Soil reinforcement and a protective layer ("moisture barrier") when covered by bitumen. On railway lines, geotextile can be used as a separator between subgrade and broken stones (ballast), so that the thickness and characteristics of the ballast layer are maintained. And finally, the path became strong.

1.2 Soil Bearing Capacity

Soil bearing capacity is the ability of the soil to withstand stresses or building loads on the ground safely without causing shear failure and excessive settlement [17,18,19,20]. The value of the subgrade carrying capacity is strongly influenced and determined from the CBR value. The greater the CBR value of subgrade in a road construction, the greater the value of the soil bearing capacity obtained from the test results of soil samples that have been prepared in the laboratory or directly in the field. According to AASHTO T-193-74 and ASTM D-1883-73, the California Bearing Ratio is the ratio between the penetration load of a load against a standard load with the same penetration depth and speed. The CBR value will be used to determine the thickness of the pavement layer. The determination of the CBR value that is commonly used to calculate the strength of a road foundation is a penetration of 0.1 "and a penetration of 0.2" with the following formula:

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

CBR Score on penetration 0,2" = $\frac{P2}{3000}$ x 100%

Where:

P_1 = penetration load 0,1"

P_2 = penetration load 0,2"

The CBR value obtained is the smallest value between the calculation results of the two CBR values. The following is a table of loads used to penetrate standard materials.

Table 1: Standard Material Penetration Load

Penetration (inch)	Standard Load (lbs)	Standard Pressure (lbs/inch)
0.1	3000	1000
0.2	4500	1500
0.3	5700	1900
0.4	6900	2300
0.5	7800	6000

2. Dynamic Cone Penetrometer (DCP) is used to measure the resistance of the material (soil) or resistance to penetration when the cone of this tool is attached to the soil material sample [21,22,23,24]. DCP is a sharpened object or steel that is emphasized on the ground by pounding it, namely in the form of a steel cone with a diameter of 20 mm with a tapered tip with a taper angle of 60 ° for fine-grained soils and another model with a 30 ° taper angle for coarse grained soils.

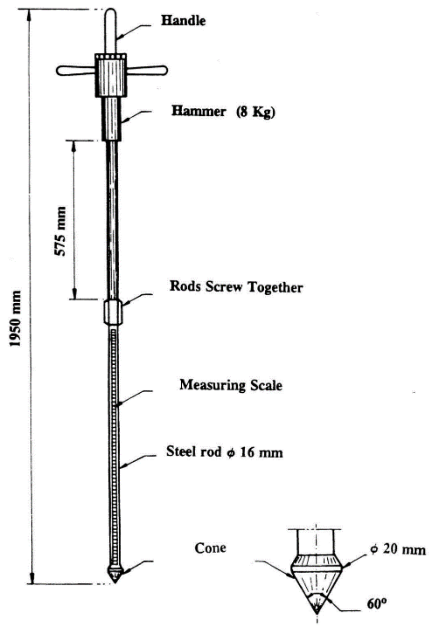

Figure 1: Dynamic Cone Penetrometer (DCP)

1.3 Development

DCP testing is carried out by penetrating the soil being tested, the tip of the DCP cone is inserted into the ground by pounding it, namely dropping the collector load as high as 575 mm dropping distance on the DCP stem. The collision is carried out several times to the desired depth, with a maximum depth of 1000 mm. The DCP value is calculated from the total depth of penetration of the cone tip in units of mm divided by the number of collisions (mm/collision). Very intensive research has been conducted to produce an empirical relationship between DCP and CBR. In the book Pavement Lentur Jalan Raya, published by Publisher Nova, by Silvia Sukirman, with the relationship between DCP and CBR charts for an angle of 30 ° and an angle of 60 °, as follows:

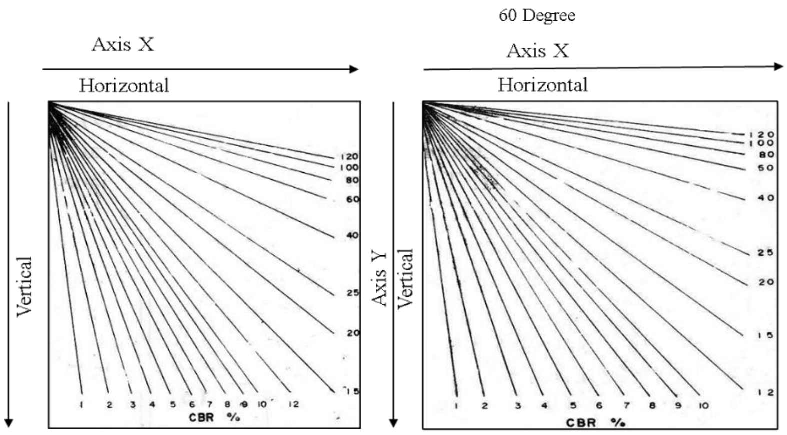

Figure 2: Correlation between DCP and CBR Examination

Source: Sukirman, Silvia, 1993 Edition, "Highway Flexible Pavement", Bandung: Nova. Nova, Bandung

From the logarithmic equation above, an example of the equation of the relationship between gravel, cohesive, various types of soil, to unknown soil type materials. However, until now the DCP tool that is widely known and used is the DCP introduced by the TRL reported in the Overseas Road Note 31, the relationship graph used is the formulation of Smith and Pratt, 1983 for a cone angle of 30° with the equation Log CBR = 2.503 – 1.15 (Log DCP), and TRL, 1990 for a 60° cone angle with the equation Log CBR = 2.48 - 1.057 (Log DCP).

2. Methodology

The location of this research was conducted in the area of Giham-Martapura segment Way Pisang Station STA 188 + 300 - STA 188 + 600 which is the location of the double track railway construction of Way Kanan regency, Lampung Province.

Figure 3: Research Site

Source: Google Maps

Primary data used is in the form of soil sampling which is done by direct sampling of soil samples from the Giham-Martapura area of Way Pisang station STA 188 + 300 - STA 188 + 600. Soil was taken using disturb sample and undisturbed sample. The research stages carried out in analyzing the stability of the slopes is schematic in the flow diagram. The research diagram is as follows:

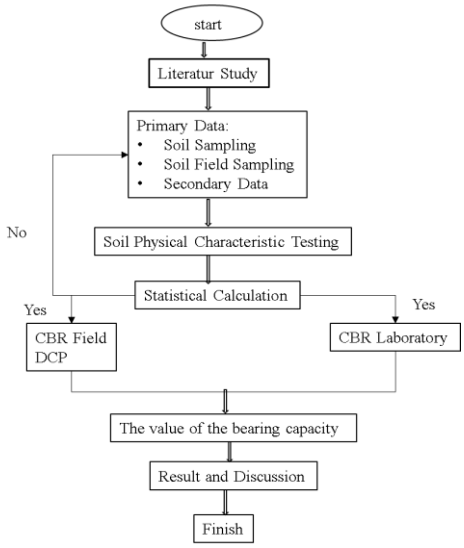

Figure 4: Research Flow Diagram.

3. Results

The surface and underground leakage losses under different rainfall intensities and slope gradients. As shown, only underground leakage loss occurs under low rainfall intensity conditions (15 and 30 mm/h), and soil erosion on slope land only exists via underground leakage loss under these conditions. At a rainfall intensity of 50 mm/h, the total soil loss is dominated by underground leakage loss, and under these conditions, the soil erosion on the karst slope farmland includes surface erosion and underground leakage loss, except for the 5° slope condition, where surface erosion does not occur. At greater rainfall intensities (70 and 90 mm/h), the proportion of underground leakage loss to total soil loss decreases except for the 5° and 10° slope conditions where soil erosion on the karst slope farmland is dominated by surface erosion. This variation shows that soil erosion on a karst slope farmland is a process of transition from underground leakage to surface erosion that occurs with an increase in rainfall intensity. Rainfall intensity has a clear influence on the amount of surface and total soil loss, both of which increase with an increase in rainfall intensity. Rainfall intensity also has some effect on underground leakage loss, which first increases and then decreases with increasing rainfall intensity under the same slope conditions. The underground leakage loss of soil is maximal at a rainfall intensity of 50 mm/h, which is the critical rainfall intensity for soil underground leakage loss. The slope gradient affects the production of surface sediment to a certain extent. The greater the slope gradient is, the more conducive the conditions are for surface erosion. Moreover, with an increase in slope gradient, the proportion of surface loss to total soil loss increases. Under low-slope conditions (5°), surface loss does not occur except for under rainfall intensities of 90 mm/h. The underground leakage loss presents a trend that first increases and then decreases with increasing slope gradient, and underground leakage loss is maximal at a slope gradient of 15°.

3.1 Laboratory Testing Research

Through tests conducted showed that the water content contained in the undisturbed soil sample was 33.13% in the disturbed soil sample of 17.32%. The results of testing the 3 samples above, obtained the weight value of the soil volume of 1.51 gr / cm ^ 3. From the test results, the average density of the undisturbed soil sample is 2.55 g / cm ^ 3. and a disturbed soil sample was 2.50 gr / cm ^ 3. Based on the results of the Atterberg limit test, undisturbed soil sample above PI value <LL-30 (26.51% <27.95%), for disturbed soil sample above PI value <LL-30 (22.55%) <24.77%) then the land based on the AASHTO system is classified into A-7-5, namely clay soil and as subgrade has an ordinary to bad rating. The results of this test indicate that the soil sample has a high plastic index and clay soil type from the results of the sieve analysis test, the undisturbed soil sample had a pass percentage of No. 200 (0.075 mm) of 63.13%. While the disturbed soil sample had a percentage of passing through the filter No. 200 (0.075 mm) of 56.00%.

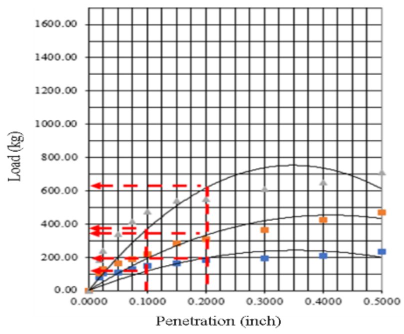

Figure 5: Laboratory CBR values unsoaked

From the experiments in the laboratory, the results of CBR unsoaked value were 3.9% for 10 blows, 6.43% for 25 blows, and 12.33% for 55 blows. So that the smallest CBR value is taken, which is 3.9%, this value comes from CBR laboratory, which is then plotted on the 5 graphs.

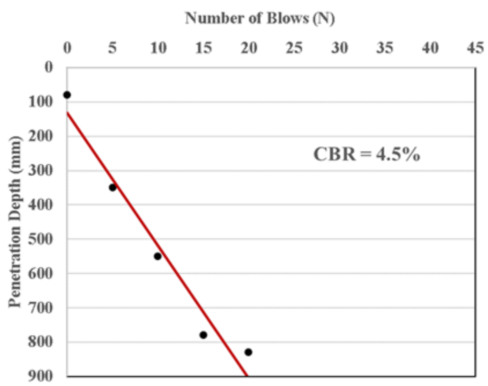

Figure 6: Dynamic Conus Penetrometer Test Value Point 1.

From the graphic image above, the test value of the Dynamic Conus Penetrometer (Dynamic Conus Penetrometer) is 4,9%.

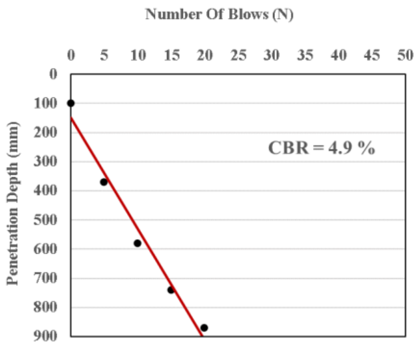

Figure 7: Dynamic Conus Penetrometer Test Value Point 2

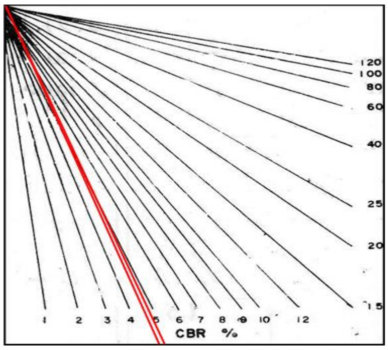

Figure 8: Graph of DCP Value with 60 ° Conical Angle, Sukirman, S. 1989

Source: Silvia Sukirman, 1992

From the graphic image above, it is obtained that the test value of the Dynamic Conus Penetrometer (Dynamic Conus Penetrometer) is 4.5%. From the picture, the CBR value at point 1 is 4.9%, point 2 is 4.5%. Then the smallest CBR value is 4.5%. According to PM No. 60 of 2012 the CBR value of the land must be not less than 6%, so that in this research location the CBR value of the soil has not met the predetermined standard. From the graph below, it is obtained that the CBR value represents 4.5%, then from Figure 7 it is obtained that the CBR value in situ is 4.9%.

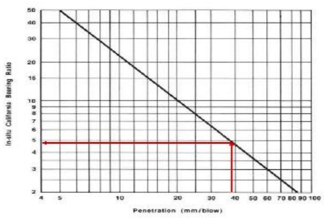

Figure 9: Correlation Graph of DCP and CBR Value

Graph 9 shows the relationship between DCP and CBR values originating from the 1987 NAASRA pavement design, where the Laboratory DCP value is 3.9%, so the CBR value is 4.9%. The value of the correlation relationship is given in table 2.

Table 2: Result of CBR Laboratory Score, DCP, CBR and DCP Correlation Score

CBR Laboratory Score	DCP Score	CBR and DCP Score Correlation
3.9 %	4.5%	4.9%

3.2 Loading Analysis

Based on the Regulation of the Minister of Transportation Number 60 of 2012, the maximum axle load for a railroad width of 1067 mm in all permitted static classes is Ps = 18 tons. The location under study is in an embankment area on the train line between Giham-Martapura station at Way Pisang station STA 188 + 300 - STA 188 + 600 in South Sumatra Province. The conus value at a depth of 1.6 m is 15 kg / cm2. Subgrade thickness using the Boussinesq method, using the iteration method, the $\Delta\sigma z$ value is obtained as follows:

From the table above, it can be seen that the value close to 2380 kg / m2 is 2239.96 kg / m2 at a depth of 1.7 m. Thus, the depth of stripping (excavation) for subgrade improvement at STA 188 + 300 - STA 188 + 600 is 1.7 m deep. After that, if you use additional reinforcement with a geogrid material with a strength specification of 19 Kpa / m2 which is commonly used on embankments and slopes, there will be a reduction in the value of the stress caused by the load on it. Thus, the thickness of the peel can be minimized.

Table 3: Results of the Calculation Iteration $\Delta\sigma z$

Depth (m)	$\Delta\sigma z$
0.50	7257.48
0.75	5332.03
1.00	4082.33
1.25	3225.55
1.50	2612.69
1.70	2239.96
1.75	2159.25
2.00	1814.37
2.20	1594.66
2.30	1499.48

From table 3, it can be seen that the value close to 2380 kg/m2 is 2239.96 kg/m2 at a depth of 1.7 m. This value of 2380 kg/m2 is a conversion from the Cone Penetrometer Test (CPT) to the value of the bearing capacity of the soil at a depth of 1.6 m. Thus, the depth of stripping (excavation) for subgrade improvement at STA 188 +

300 - STA 188 + 600 is 1.7 m deep. After that, if you use additional reinforcement with a geogrid material with a strength specification of 19 KPa/m2 which is commonly used on embankments and slopes, there will be a reduction in the value of the stress caused by the load on it. Thus, the thickness of the peel can be minimized.

Table 4: Calculation of bearing capacity with the aid of reinforcing geogrid materials

Depth (m)	**Δσz**
0.5	5320.012
1.0	2144.86
1.1	1765.33
1.2	1436.36
2.2	1594.66

From table 21 it can be seen that the value that is close to the number 4177.4280 kg/m^2 is 5320.012 kg/m^2 at a depth of 0.5 m. Thus, the depth of peel (excavation) for subgrade improvement after using additional reinforcement with a geogrid material with a specific strength of 19 KPa/m2 is 0.5 m deep. From the results of research and field observations, that the research location is above the embankment soil. Embankment placed on soft soil tends to spread due to the load it carries. The treatment requires the subgrade reinforced with other materials such as geotextiles or geogrids, see figure 10.

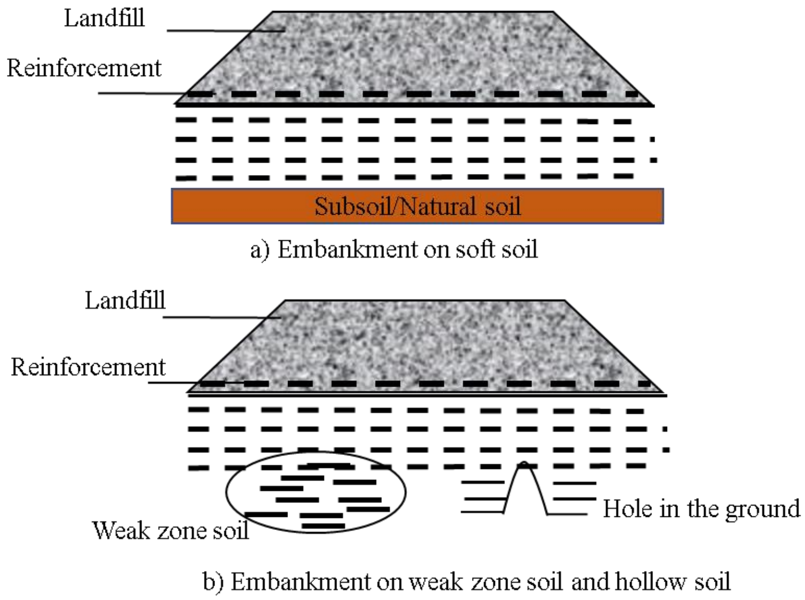

Figure 10: Application embankment reinforced with geotextile

On the Railway, the Geotextile is placed between the ballast layer and the soft subgrade. The aim is not to mix the grained, fine subgrade with a layer of ballast gravel. Also, in the event of flooding in the ballast body, it can prevent the runoff of subgrade fine particles to the ballast layer. Here the geotextile functions as a separator and filter, as shown below.

Figure 11: Use of Geotextiles on Railways

Woven Geotextile (woven) is a type of woven Geotextile. The basic material for making it is usually Polypropylene (PP). To make visualization easier, this Woven Geotextile is similar to a rice sack (not burlap) but in black. The function of Woven Geotextile is as a stabilization material for subgrade (especially soft subgrade), because this type of Geotextile has a higher Tensile Strength compared to Non-Woven Geotextile (about 2 times for the same gramasi or weight per m2). The working method of Geotextile Woven is membrane effect, which only relies on tensile strength, so it does not reduce the occurrence of local settlement (differential settlement) due to soft or bad subgrade. Some of the local brands of Woven Geotextile commonly used in infrastructure projects are: Multitex (M series), HaTe Reinfox (HRX series), G-Tex, GKTex.

Figure 12: Application of Woven Geotextiles (woven)

4. Conclusion

Based on the results of the tests and discussions that have been carried out, the land originating from the Giham-Martapura double railroad at Way Pisang station STA 188 + 300 - STA 188 + 600 in South Sumatra Province obtained the following conclusions: a. The correlation between the value of field CBR test and laboratory CBR test has a value of 4.9%. This can be due to non-uniform soil conditions, differences in the accuracy of laboratory equipment with the tools used in the field, and differences in the shape of the penetration character in CBR testing. b. CBR values from field and laboratory tests do not meet the requirements according to PM No. 60 of 2012, so that the improvement of the basic soil is needed at this research location at STA 188 + 300 - STA 188 + 600. c. Based on the results of the Atterberg limit test, undisturbed soil sample obtained PI value <LL-30 (26.51% <27.95%), for disturbed soil sample obtained PI value <LL-30 (22.55% <24 , 77%), according to the AASHTO system, the land is classified into A-7-5, namely clay soil and as subgrade has a normal to bad rating. d. Based on the calculation results, the depth of peel (excavation) for subgrade improvement at STA 188 + 300 -

STA 188 + 600 is 1.7 m deep, but after using additional reinforcement with geogrid material with a specific strength of 19 Kpa / m2 the depth of peeling (excavation) for improvement of subgrade to 0.5 m. So that there is a digging efficiency of 70.5%

5. Limitations

This study is limited to the soil loss on slope land which is a process that transitions from underground leakage to surface erosion with the increase in rainfall intensity. Rainfall intensity influences the amounts of surface and total soil loss, which increase with the increase in rainfall intensity. The slope gradient also affects the production of surface sediment to a certain extent.

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6. Recommendations

A more beneficial strategy for soil improvement in slope area is indicated in this study, and this approach may be equally applicable to other degraded soil remediations. Utilizing the beneficial coexistence be-tween plants and the microbiome has much potential for the efficient remediation of degraded soils. The beneficial coexistence between plants and the microbiome is driven by stabilizing and equalizing mechanism, that is, reasonable nutrient supply, differential microbial benefits, and nutrient partitioning. Therefore, the combination of organic fertilizer and AMF has significantly positive effects on improving phytoremediation effectiveness of soil.

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