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Improvement of Soft Soil for Subgrade Stabilized with Emulsified Asphalt and Tailing

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ABSTRACT
Soil is one of the construction materials in civil works. Soft soil that has low bearing capacity becomes a problem in the construction process. To support the construction process, stable soil conditions are needed. The subgrade is the lowest layer of soil that serves as a place for laying the pavement layer and supports the road pavement construction above it. By stabilizing the soil, soil quality will increase. A more stable soil layer makes it able to distribute the load much better. The addition of emulsified asphalt and tailings to soft soil is intended to stabilize or improve the soil. One of the parameters to determine whether the bearing capacity of the soil is good or not is by knowing the CBR value. This study aims to analyze the change in CBR value with the addition of emulsified asphalt and tailings. In this study, the percentage of 8% emulsified asphalt and 5%, 6% and 7% tailings with curing of 0, 7, and 14 days were used. The tests in this study included soil physical properties, Compaction, Atterberg limit and CBR testing without immersion. The results showed that the use of emulsified asphalt and tailing increased the maximum dry density and reduced the optimum water content. It can reduce the Plasticity Index by 76.00% from soft soils. The CBR results show the optimum value of stabilization on a mixture of 8% emulsified asphalt and 6% tailings with a maximum dry of 1.67 gr/cm3, the optimum moisture content is 25.13%, and the CBR value is 7.10% with a curing time of 7 days. It can be concluded that the use of emulsified asphalt and tailings with an effective composition can be used as an alternative material to stabilize soft soil on road pavement structures.

Keywords: *Emulsified asphalt, tailing, stabilization, soft soil, Cbr.*

1. INTRODUCTION

Soil is a construction material that aggregate composition is very complex and heterogeneous. The strength of the soil depends on many things, such as density, soil type, weather conditions, and even soil strength testing methods also determine. In highway construction, the soil is the last part that receives the load distribution from the surface [1]. The bearing capacity of the subgrade greatly determines the thickness of the foundation pavement layer, which will greatly affect the high level of road construction. The use of soil as a highway subgrade must have a certain CBR strength. Soft soil properties that have low bearing capacity become a problem in the highway construction process. To overcome this problem on soft soil, there are several alternatives, namely reducing the plastic index value of the soil and increasing the CBR value [2]. Soil is a material consisting of solid mineral aggregates that are not cemented to each other from organic matter [4]. Soil stabilization is an effort to increase the stability and carrying capacity of the soil. According to stabilization may consist of one of the following actions [6]

1. Increase soil density
2. Adding active material to increase the shear strength of the soil
3. Adding materials that can cause changes in soil chemistry
4. Lowering the groundwater level (soil drainage)
5. Replacing poor soil

This study uses tailings material. Tailings are materials that are disposed of after the process of separating valuable materials from an ore [11]. This material will be used as soil stabilization because it can increase the CBR value of the soil [10]. Furthermore, it can also improve the characteristics of the soil material [5]. Other materials used for soil stabilization are emulsified asphalt, emulsified asphalt is a type of asphalt consisting of hard asphalt, water, and emulsifying agent, The stabilizing material in the form of asphalt will increase the cohesion between particles and the bearing

capacity of the soil and increase the soil's resistance to water[3].

2. LITERATURE REVIEW

2.1. Tailing

Soil stabilization with tailings variation has been carried out with a mixture of 5%, 10%, and 15% of the dry weight of the clay soil. Based on the tests carried out [5], the most significant change in the index properties and strength values among the variations used is shown by brown clay with a tailings content of 15%. The shrinkage limit increased from 10.14% to 11.04%, the liquid limit decreased from 86.13% to 83.44%, the plastic limit increased from 24.09% to 32.85%, the plasticity index decreased from 62.04% to 50.59%, and the fraction passed filter no. 200 experienced a decrease from 98.67% to 86.45%. Free compressive strength decreased from 0.955 kg/cm2 to 0.719 kg/cm2 and undrained cohesion decreased from 0.48 kg/cm2 to 0.359 kg/cm2. In general, it can be concluded that tailings reduce the swelling and shrinkage of clay soils and increase clay strength [5]. There is a similar trend between increasing the stabilization material mixture (tailings) and clay soils' engineering properties. The increase in the proportion of tailings substitution is directly proportional to the increase in the maximum dry weight and CBR value [10].

2.2. Emulsified asphalt

Study on soil stabilization uses emulsified asphalt with several variations, namely 4%, 6% and 8%. Based on the tests carried out, the value of the Plasticity Index has decreased from 10.63% to 9.96%, along with the increase in the percentage of asphalt. With this stabilization, the soil properties can be improved to meet the technical requirements [3]. Emulsified asphalt has been used for soil stabilization. Emulsified asphalt contains 25% -50% by weight of water ,50%-75% by weight of asphalt, and 0.5% -3.5% by weight of non-ionic emulsifying agent [8]. The content of asphalt emulsion that is good for stabilizing soil is between 6% to 8% and depends on the soil's plasticity. [9]

2.3. CBR (California bearing ratio

One of the parameters to determine whether the bearing capacity of the soil is good or not is by knowing the CBR value. If the bearing capacity of the soil is bad, the CBR value will also be low. To improve the bearing capacity of the poor soil, stabilization of the soil is needed. Stabilization aims to improve the poor properties of the soil and increase the CBR value of the soil and the bearing capacity of the subgrade [12].

3. BACKGROUND

Soil stabilization for road construction, especially on the Gedebage, is a current concern. Due to the increasing development in urban areas, utilization of local materials as an effort to stabilize the subgrade is a step that needs to be considered in the construction of a road. Soil stabilization aims to improve the physical properties of the local soil that is not good so that it can be used as a subgrade layer that can support the structure of the pavement layer above it.

Gedebage soil has a poor characteristic of soil, proofed by the high PI value. To solve this problem, stabilization is needed by decreasing the PI value and increasing the CBR value.

Many studies have been done by focusing on existing problem soil stabilization techniques at specific sites for road construction. This study focuses on subgrade improvement using emulsified asphalt and tailings.

4. METHODOLOGY

This research stabilized soft soil with a mixture of Emulsified Asphalt and Tailings. The percentage of Emulsified Asphalt used was 8%, and the percentages of Tailings were 5%, 6% and 7%. Before carrying out soil stabilization, it is necessary to test the Soft Soil to be classified using the Unified Soil Classification System (USCS). The research flow chart can be seen in Figure 1.

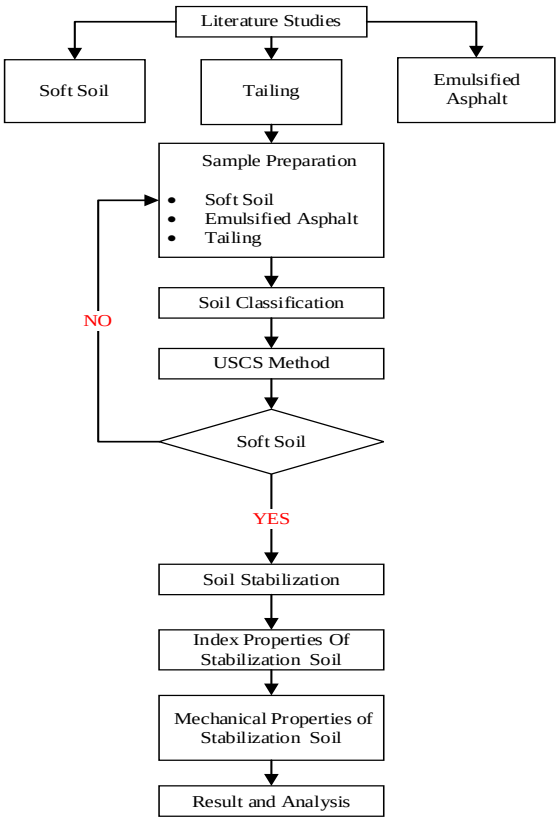

Figure 1 Flow Chart Diagram of Research

5. RESULT

5.1. Soft soil Index Properties Test

In this study, Gedebage Soil is classified by USCS Method. The USCS is based on identifying soils according to their textural and plasticity qualities. Gedebage soil is classified as soft soil with high plasticity or is often referred to as Fat Clay. The result of the Index properties Test can be seen in **Table 1,** and the properties index test can be seen in **Table 2**.

Table 1. Result of Index Properties Test on Soft Soil

No	Description	Result
Grain Size Analysis		
1.	Gravel	0%
2.	Sand	4.62%
3.	Silt	39.38%
4.	Clay	56.00%
Atterberg Limit		
1.	Plastic Limit (PL)	28.20%
2.	Liquid Limit (LL)	85.84%
3.	Plasticity Index	57.64%
Soil Classification		
1.	USCS Method	Fat Clay
Activity Level		
1.	Activty (A)	1.25%

Table 2. Index Properties Soil Test

No	Testing item	Testing Standar
1	Volume Weight	ASTM D2216
2	Water Content	ASTM D2216
3	Specific Gravity	ASTM D858
4	Atterberg Limit	ASTM D4318

Based on the Index Properties Test of soft soil described in Tabel 1, the result of the Plasticity Index of the Soft Soil was 56 %. Based on Pd T -10 - 2005, a subgrade with a Plasticity Index> 32% was classified as clay with very high swelling properties.

5.2. Atterberg Limits of Stabilization Soil

The result of the Atterberg Limits test on soil stabilization is shown in table 3. The material variant is Variant 0 (soft soil), Variant 1 (8%) Emulsified asphalt + (5%) Tailing, Variant 2 (8%) Emulsified asphalt + (6%) Tailing, Variant 3 (8%) Emulsified asphalt + (7%) tailing

Table 3. Result of Atterberg Limits test on The Soil Stabilization

Test Name	Variant (%)			
	0	1	2	3
Atterberg Limits				
Plastic Limit (PL)	28.20	34.60	35.70	32.47
Liquid Limit (LL)	85.84	62.00	63.00	57.35
Plasticity Index	57.64	27.40	27.30	24.88
Activity (A)	1.25	0.60	0.59	0.54

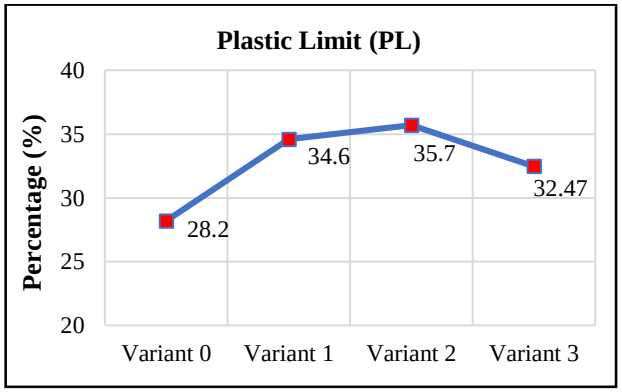

Figure 2 Plastic Limits (PL) Comparison Graphic.

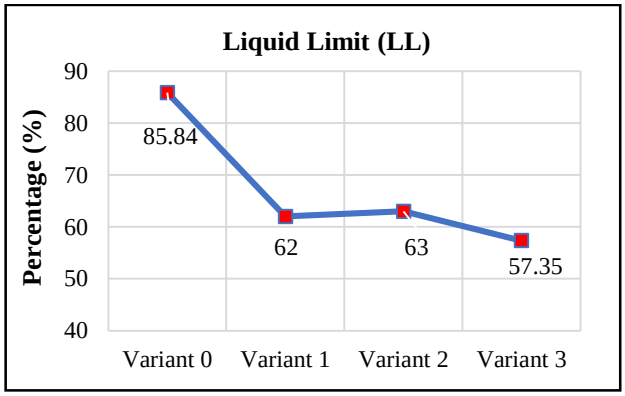

Figure 3 Liquid Limits (LL) Comparison Graphic.

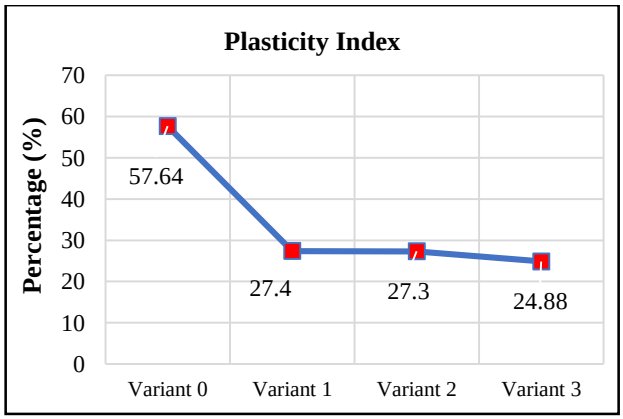

Figure 4 Plasticity Index Comparison Graphic.

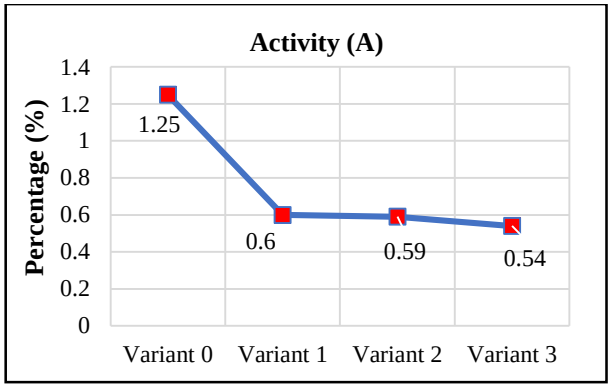

Figure 5 Soils Activity (A) Comparison Graphic.

Based on the Atterberg Limits test on soil stabilization with three variants, it was obtained that the optimum value of plasticity index reached 24.88 % on mixture 3 (Variant 3) and can reduce the Plasticity Index by 76.00% from the soft soil condition. At the same time, the result of Activity Level was 1.25%. Based on Pd T-10-2005 being classified as clay with very high activity, it can be concluded that the mixture (V3) can reduce the Activity Level by 47.00% from the soft soil condition. Based on Pd T-10-2005 is classified as clay which has inactive activity.

5.3. Compaction Test

The compaction test aims to obtain the optimum moisture content (w-opt) and maximum dry density (γd). The results of the compaction test are shown in **Table 4**

Table 4. Result of Compaction test on The Soil Stabilization

Technical Properties		Symbol	Stabilization Mixture (%)			
			0	1	2	3
1	Compaction	γd	1.18	1.67	1.67	1.68
		W_{opt}	29.5	25.3	25.1	25.0

Table 4 shows the result of the compaction test on soft soil and stabilization. The value of unit weight on soft soil (Variant 0) is 1.18%, while on the mixture (Variant 3), the value is 1,68%, there was an increase by 42% form of soft soil. The value of unit weight increase due to the stabilization material filling the void of soft soil,

The value of optimum moisture content on soft soil (Variant 0) is 29.5%, while on the mixture (Variant 3), the value is 25%. There was a decrease of 15% form of soft soil. The value of optimum moisture content decreases due to the addition of stabilization materials.

5.4. CBR Test

CBR compares the test load (test load) with a standard load (standard load) and is expressed as a percentage. The main purpose of CBR testing is to evaluate the strength of the road and pavement subgrade. The results of the CBR Unsoaked test are shown in **Table 5,** and the Mechanical Properties test can be seen in **Table 6**.

Table 5. CBR Unsoaked Test on The Soil Stabilization

Technical Properties		Unit	Stabilization Mixture			
			0	1	2	3
Unsoaked						
1	CBR Curing 0 Days	%	3.88	2.94	3.00	2.94
2	CBR Curing 7 Days	%	-	5.30	7.10	6.70
3	CBR Curing 14 Days	%	-	5.63	5.63	6.36

Table 6. Mechanical Properties Test

No	Testing item	Testing Standar
1	Compaction	ASTM D1557
2	CBR	ASTM D1883

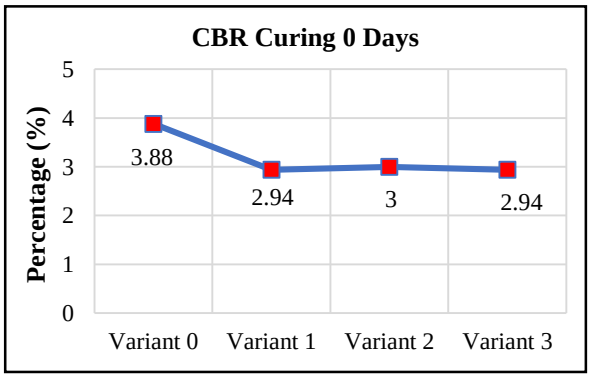

Figure 6. CBR Curing 0 Days Comparison Graphic

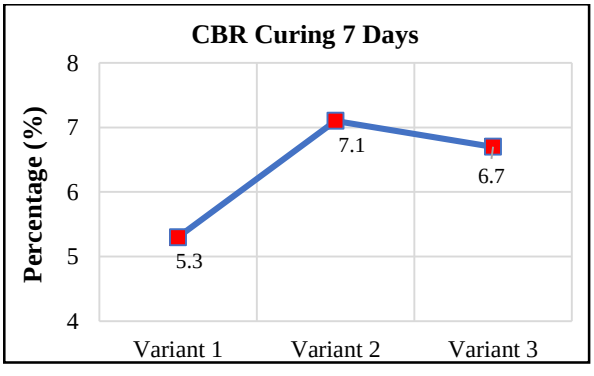

Figure 7. CBR Curing 7 Days Comparison Graphic

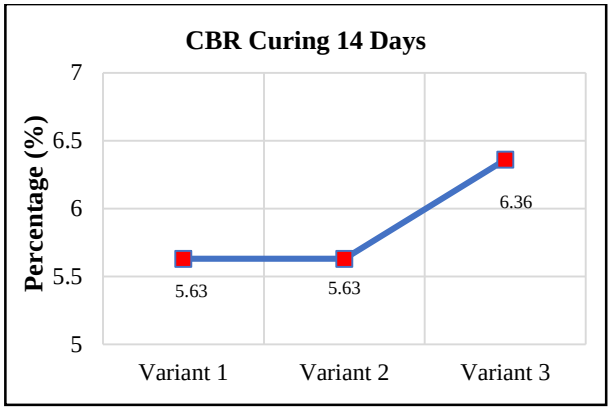

Figure 4. CBR Curing 14 Days Comparison Graphic

Table 5 shows the result of the CBR Unsoaked test on soft soil and stabilization. CBR value on soft soil (Variant 0) is 3.88% at 0 days. This value is higher than stabilization soil. The stabilization CBR value increases when increasing curing time at 7 days, and the maximum CBR value is obtained in the mixture (Variant 2) at 7.1 %, and the CBR value decreases at 14 days curing time.

5. CONCLUSION

1. The Classification of Gedebage soil according to USCS include High Plasticity Clay and Fat Clay (CH).
2. The mixing of asphalt emulsion and tailing can function as a stabilizing material for subgrade on soft soil. This is evident from the decreasing value of the stabilization (Variant 3) of groundwater content from 29.5% to the lowest of 25% and also increasing maximum dry density from 1.18 (Variant 0) to the highest 1.68 (Variant 3)
3. The Atterberg Limit test results from stabilization (Variant 3) soils show that it can reduce the Plasticity Index by 76.00% from soft soils (Variant 0).
4. CBR value also increases with the increasing curing time of the specimen. This is evident from the CBR value on soft soil (Variant 0) is 3.88%, while the stabilization CBR value increases when increasing curing time at 7 days, with a value of 7.1% (Variant 2)

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