Characteristics of Embankment Soil as Subgrade in Road Pavement Structure

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Abstract. Subgrade strength is a major factor in pavement design, construction, and performance. The subgrade for road pavement construction can be in the form of local soil (in-situ) which is stripped or cleaned after it is compacted, or it can be filled soil compacted according to the maximum density. Efforts are made to increase the bearing capacity of the subgrade or subgrade on soft soil, one of which is to physically improve the soil, meaning by replacing it with soil that has a good or adequate bearing capacity. The purpose of the study was to determine the characteristics of the embankment soil as a road subgrade. The method used is testing the physical and mechanical properties of the soil. Soil samples were taken from Kampar and Duri quarry. The results of the research on soil classification for the Kampar quarry, type ML, and the Duri quarry type CL. CBR value of Kampar quarry soil 23% and Duri 16.80%. Conclusion the characteristics of the embankment soil should not contain organic and high plasticity. For CBR value > 10% based on the specification of Bina Marga 2018 Revision 2.

Keywords: Embankment Soil · Pavemnet · Road · CBR · Clay · Quarry

1 Introduction

The road structure which is the most important part of road pavement construction is the subgrade or subgrade. The subgrade functions as load-bearing road construction and traffic load on it. The subgrade for road pavement construction can be in the form of local soil (in-situ) which is stripped or cleaned after it is compacted, or it can be filled soil compacted according to the maximum density [1]. Riau Province is one area that has soft soil, including clay soil which has a low bearing capacity. Riau Province is located in the coastal area and is located in the lowlands so it has poor soil conditions, this is because it consists of soft cohesive soil [2]. Soft and malleable clay is often a constraint in construction [3].

Efforts are made to increase the bearing capacity of the subgrade or subgrade on soft soil, one of which is to physically improve the soil, meaning by replacing it with soil that has a good or adequate bearing capacity. The type of soil used to replace it is called embankment soil [4]. The factor that indicates that the soil is good or not used for embankment is the density of the soil [5]. Soil compaction is a process carried out

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to reduce the pore voids in the soil. Reducing the void ratio makes it harder for water to flow through the soil [6].

Soil compaction is an important process to improve soil stability. Soil compaction can increase the density of the soil because the voids between particles are reduced. Therefore, it can improve soil properties [7]. The process by which the density of the soil increases to reduce the voids between the particles resulting in a loss of air volume is called soil density [8]. The choice of compacted embankment soil as subgrade or subgrade cannot be separated from the surface soil conditions in the field. The problem that is often encountered in road planning is if the type and nature of the soil to be used for embankment material, where the terms and quality, and parameter values of the soil are not known. Materials for the embankment soil to be used are very limited which meet the requirements and are difficult to find in the surrounding area, so they are imported from other areas [9].

Embankment soil originating from the Kampar quarry and Duri quarry, one of the stockpiles often used for subgrade. It is very necessary to test the characteristics, namely the physical and mechanical properties of the embankment soil so that it is declared suitable for use as a recommendation as a substitute for subgrade on soft soil.

1.1 Clay

Clay is a type of soil consisting of microscopic and submicroscopic particles with a size of less than 0.002 mm. These particles cannot be seen clearly and can be seen only by using an ordinary microscopic tool. The shape of the soil is a flat slab and is a type of particle of the minerals in it [10].

The characteristics of clay are influenced by two things, namely microscopic factors and macroscopic factors. The factor referred to in this term is the factor in the soil that forms clay due to the expansion of shrinkage. Meanwhile, macroscopic factors are the physical properties of the soil, including plasticity and soil weight [3].

Specific gravity values of various types of soil can be seen in Table 1.

Table 1. Soil density (Gs) [11]

Kind of soil	Specific gravity (GS)
Gravel	2.65–2.68
Sand	2.65–2.68
Inorganic silt	2.62–2.68
Organic clay	2.58–2.65
Inorganic clay	2.68–2.75
Humus	1.37
Peat	1.25–1.80

1.2 Embankment

Embankment soil is divided into two, namely ordinary embankment soil and selected embankment soil. Ordinary embankment soil is material that does not include high plasticity soil, which is classified from the AASTHO method, namely as A-7-6 or as CH in the Unified classification system. This embankment soil must have a CBR value of not less than 6% after 4 days of immersion when compacted at 100% maximum dry density (MDD) [12].

Selected embankment soil classified as preferred embankment must consist of sandy or rocky material that meets the requirements and in addition, must have certain properties depending on the intended use. The selected embankment soil must have a CBR value of at least 10% [12].

1.3 Soil Classification

Soil classification is a system of regulating several different types of soil but having the same properties both in groups and sub-groups based on their use [13]. Based on the results of the sieve analysis test and the Atterberg limit test, the soil can be classified into several groups contained in the AASTHO soil classification system and the USCS system (Unified Soil Classification System) [9].

The value of the Plasticity Index (PI) can be seen in Table 2.

1.4 Soil Compaction

Soil compaction techniques can be grouped into several categories, namely laboratory compaction methods, and field compaction methods [14]. Soil compaction is a method used to improve the physical and mechanical properties of the soil [15]. Soil compaction reforms the soil into lumps, thereby minimizing intergranular voids and ensuring reduced permeability and decreased consolidation of the compacted soil, as well as increasing the tensile and shear strength of the soil [14]. Soil compaction serves to increase the strength of the soil to provide support for the pavement layer above it and also serves to reduce unwanted soil subsidence [16].

Table 2. Plasticity index value and soil type [11]

PI	Nature	Kind of soil	Cohesion
0	Non plastic	Sand	Non cohesive
<7	Low plasticity	Silt	Partially cohesive
7–17	Medium plasticity	Silty clay	Cohesive
>17	High plasticity	Clay	Cohesive

2 Methods

The research method is testing physical properties, namely testing specific gravity, Waterberg limit, and sieve analysis. Testing the mechanical properties of proctor testing and CBR testing. Soil samples were taken from the Kampar Quarry and the Duri Quarry. The test is carried out with a laboratory approach with provisions for testing specific gravity using SNI 1946-2008, atterberg testing SNI 03-1966-2008, sieve analysis testing using SNI 3423-2008, proctor testing using SNI 1742-2008, and CBR testing using SNI 03-2008. 1744-2008Soil samples were taken using a hoe.

3 Result and Discussion

3.1 Clay

The results of testing the physical properties of the embankment soil carried out in the laboratory are the specific gravity test for the Kampar quarry 2.60 and the Duri quarry 2.61The value of the specific gravity of the soil obtained is 2.61. This value includes the type of inorganic clay [11]. Atterberg test obtained the Liquid Limit (LL) value for the Kampar quarry in Fig. 1 and the Duri quarry in Fig. 2 (Table 3).

Soil classification aims to determine the type of soil that we have tested in the laboratory. The USCS soil classification method can be seen in Fig. 3 for the Kampar quarry and Fig. 4 for the Duri quarry.

From the figure based on the Liquid Limit (LL) value and the Plasticity Index (PL) value, the soil is classified as ML or OL, namely inorganic silt [11]. Since the soil sample does not contain organic matter, the soil is a type of ML, namely silt with low clay content [9].

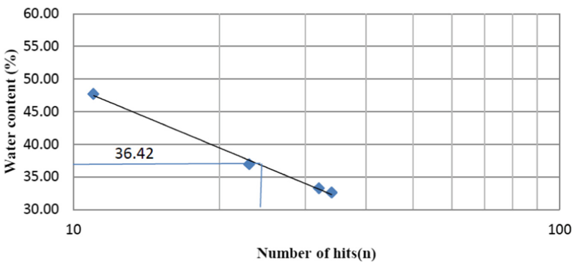

Fig. 1. The graph of the test for the liquid limit of the Kampar quarry embankment

Table 3. Testing the physical properties of the soil

No.	*Quarry*	Getaway # No.200 (%)	LL%	PI#	Soil classification	Nature
1.	Kampar	58,39	36,42	10,46%	ML	Medium plasticity
2.	Duri	50,21	28,93	10,16%	Silt	Medium plasticity

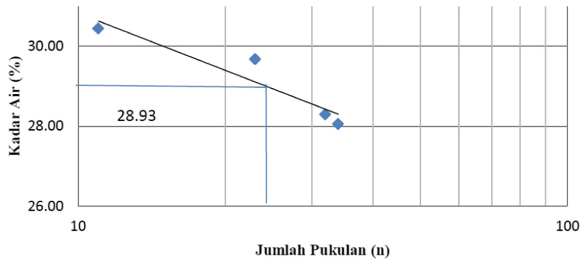

Fig. 2. The graph of the test for the liquid limit of the Duri quarry embankment

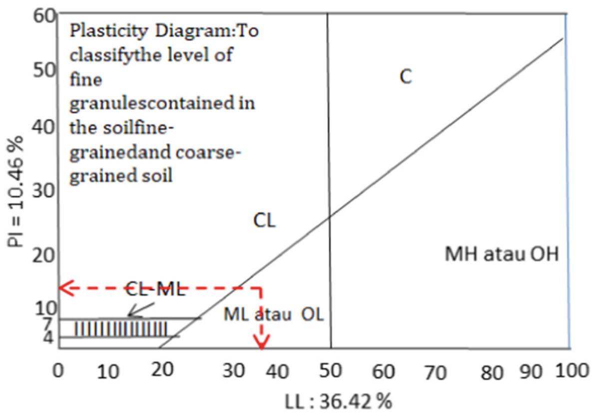

Fig. 3. Classification of Kampar quarry embankment soil USCS method

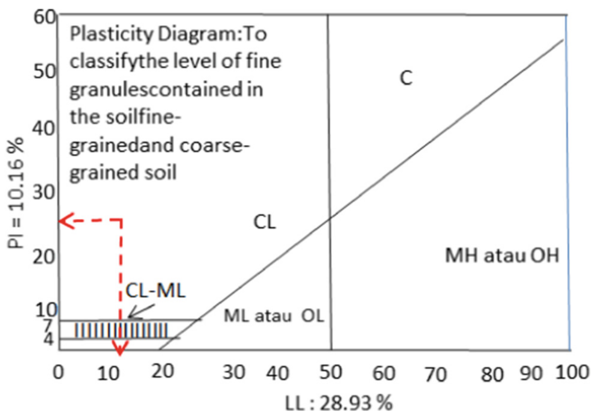

Fig. 4. Classification of Duri quarry embankment soil USCS method

From the figure, based on the Liquid Limit (LL) value and the Plasticity Index (PL) value, the soil is classified as CL classification, namely Inorganic Clay [11].

Table 4. The results of testing the mechanical properties of embankment soil

No.	*Quarry*	Proctor test		CBR test (%)
		Wopt (%)	ɤdrymaks (gr/cm^3)	
1	Kampar	20,50	1,30	23
2	Duri	13,60	1.18	16,80

Soil classification obtained can be used for embankment soil for subgrade. The embankment soil conditions selected should not include high plasticity soils, which are classified as A-7-6 according to AASTHO and as CH according to USCS [12]. For the Plasticity Index (PI) value, the embankment soil should not have a high Plasticity Index (PI) value [12]. Soil is classified as high plasticity if the PI value is > 17% [11].

3.2 Testing of the Mechanical Properties of the Embankment

The results of testing the mechanical properties of the embankment soil for each quarry are as follows (Table 4).

The CBR values obtained for each quarry are based, namely Kampar 23% and Duri 16.80%. The value obtained meets the 2018 Bina Marga Specifications Revision 2 division 3.2 for the selected stockpile requirements is the CBR value > 10% [12].

4 Conclusion

This study concludes that the classification and characteristics of embankment soil as a substitute for subgrade on soft soil, namely for soil classification, namely CL (Low plasticity clay) and ML (Low plasticity silt) can be used for subgrade replacement embankment soil. For the characteristics of the embankment soil based on the physical properties, the plasticity index (PI) value is not allowed to have high plasticity, and based on the mechanical properties the CBR value is based on the 2018 Highways Specification Revision 2 division 3.2 > 10%, where the Kampar and Duri quarry meet the specifications.

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