Identification of Soil Bearing Capacity for Polinela's New Campus Road Trace Planning using Dynamic Cone Penetrometer Test

Aniessa Rinny Asnaning[1], Mira Wisman[1], Tanya Audia Balqis[1]

[1]Teknologi Rekayasa Konstruksi Jalan dan Jembatan, Politeknik Negeri Lampung
*Email: aniessa.rinny@polinela.ac.id

Abstract. Along with the development of Polinela's campus followed by an increase in the number of students, a wider campus area is also needed to accommodate all lecture and practical activities at Polinela. Before starting the construction of buildings and other infrastructure, it is necessary to build a connecting road to access the points of development locations to be more connected. In road planning, it is required to investigate the bearing capacity of the subgrade first because it is the most crucial part of supporting road construction. This study aimed to measure variations in the value of the bearing capacity of the subgrade as the pavement's foundation. This study uses the Dynamic Cone Penetrometer Test (DCPT) to obtain predictive results from the bearing capacity of the subgrade in the form of the California Bearing Ratio (CBR) value. From six sampling points, the maximum CBR value was obtained at site 1 of 6.11% at a depth of 42 mm, site 2 of 1.21% at a depth of 365 mm, site 3 of 0.95% at a depth of 118 mm, site 4 of 2.08% at a depth of 535 mm, site 5 of 2.25% at a depth of 275 mm, and site 6 of 3.01% at a depth of 101 mm. The CBR value of the five points that did not reach the 6% standard was due to the location being cassava and corn plantations with subgrade soil that had undergone tillage so that the ground became loose and was no longer classified as the original soil.

1. Introduction

Lampung State Polytechnic (Polinela) is the first vocational college in Lampung Province, Indonesia. An increase follows the development of Polinela in the number of students, and a wider campus area is also needed to accommodate all lecture and practical activities at Polinela. Therefore, Polinela has a new campus area in Kota Baru, Lampung Province, Indonesia. The new campus is still vacant and only has a master plan of development plants. Before starting the construction of buildings and other infrastructure, it is necessary to build a connecting road to access the points of development locations to be more connected.

In road planning, it is necessary to investigate the bearing capacity of the subgrade first because it is the most crucial part of supporting road construction. This study aimed to measure the bearing capacity value of the subgrade excavation in the route plan for Polinela new campus. The way to get the value of soil's bearing capacity in the California Bearing Ratio (CBR) number is to do conventional laboratory CBR or field CBR testing. Still, this method requires a relatively long time, and CBR equipment is rather expensive.

The Dynamic Cone Penetrometer Test (DCP test) is one method to detect soil's bearing capacity. Until now, the DCP test is still the cheapest method of measuring CBR value in the field, and it is accurate enough to be carried out and is a non-destructive testing method [1]. The DCP test is also a procedure that is easy and fasts to carry out in the field to get the value of the bearing capacity of the soil in the CBR number and is an alternative if the area CBR is difficult to do [2].

2. Related Research

Dynamic Cone Penetrometer Test (DCP tets) is a method to estimate the subgrade bearing capacity, which is relatively cheap and accurate. This method is one of the non-destructive testing methods used to investigate crushed stone foundation layers, gravel foundations, soil stabilization with cement or lime, and subgrade soils [1]. The DCP is an instrument designed for rapid in situ measurements of existing road pavement structural components with unbound granular materials. Continuous measurements can be made to an 800 mm or 1,200 mm depth when an extension rod is installed [3].TRL introduced DCP technology for testing in tropical and sub-tropical conditions as reported in Overseas Road Note 31, Crowthorne, the United Kingdom, in 1993. Several formulations of CBR values summarized by TRL, obtained from various equations :

Van Vuuren, 1969, (Conus 60^0) : Log CBR = 2,632 – 1,28(Log DCP) (1)

Kleyn & Harden, 1983, (Conus 30^0) : Log CBR = 2,555 – 1,145(Log DCP) (2)

Smith dan Pratt, 1983, (Conus 30^0) : Log CBR = 2,503 – 1,15(Log DCP) (3)

TRL, Road Note 8, 1990, (Conus 60^0) : Log CBR = 2,48 – 1,057(Log DCP) (4)

In addition to obtaining the CBR value, the DCP test is also used as a new method for assessing liquefaction potential. This study results found that the DCP test can be used as a new method to evaluate liquefaction potential, which is as good as the SPT test [4]. The DCP test is also used to generate the soil N-SPT value for the design of the foundation for power transmission towers located in tropical forests and challenging to access by motorized vehicle. The SPT and DCP tests carried out side-by-side resulted in four data groups: coarse-grained soil, fine-grained soil, coarse-grained soil above the groundwater level, and fine-grained soil below the groundwater level. These four data are then connected to form a correlation equation that is then successfully applied to predict the N-SPT value for the area not accessible by motorized vehicles [5].

The results showed that combining GPR, DCP, and drilling tests could accurately estimate the road layer thickness. DCP testing combined with non-destructive techniques such as visual condition surveys, FWD, Ground Penetration Radar (GPR), and pavement drilling can evaluate pavements traversed by heavy truck traffic, connecting ports, major roads and highways, airports, and industrial roads. DCP testing can also determine the subgrade strength and sub-base layers. FWD testing can be used to evaluate the pavement structure [6]. Other studies also use the DCP test to estimate the CBR value in the subgrade and sub-base layer with seasonal variations. The results showed no significant difference in the subgrade reaction modulus and CBR values under freezing, thawing, and summer conditions [7]. DCP tests are also used to evaluate the engineering properties of sandy soils under laboratory conditions. The research result is the relationship between Dynamic Penetration Index (DPI), relative density (Dr), modulus of elasticity (E), shear modulus (G), subgrade reaction modulus (K.S.), and soil friction angle obtained with a high determination coefficient value (N90%). The test results repeatability is also evaluated by calculating the coefficient of variation (Cv), less than 30% for all tests [8].

Research on DCP testing is also widely carried out in subtropical areas, namely the Instrumented Dynamic Cone Penetrometer (IDCP) to measure the thickness of the active layer that undergoes freezing and thawing due to global warming. This process can damage the infrastructure of highways, railroads, and underground pipelines embedded in cold areas. The result is that IDCP, which can transfer energy to the cone and stem head, can be applied to evaluate variations in strength and thickness of the active soil layer [9]. The DCP test is also used to determine the vulnerability of shallow landslides in the slopes of the Alps, causing loss of agricultural land. The results are the relationship between superficial subsurface structures (regolith) and the occurrence of shallow landslides. This research also makes it possible to predict the potential for landslide development through the secondary launch process [10]. DCP and FWD were used to evaluate various stabilization technologies on unhardened soils damaged by the effects of freeze-thaw over two periods. This study shows that unpaved roads with Macadam Base Stone (MSB) produce the best freeze-thaw performance in terms of modulus of elasticity among all the stabilization methods examined [11].

3. Research Methods

This research was carried out by first conducting the DCP test to get the CBR value of the subgrade. DCP testing was carried out on Polinela's new campus in Kota Baru, Lampung Province, Indonesia. The research object is focused on the main road alignment plan in Polinela's new campus, which stretches for 1,178 meters. There are six DCP measurements points at the research site.

The data obtained from the DCP test will be used to calculate the CBR value of the subgrade. The calculation of the CBR value refers to the guidelines from the Circular Letter of the Minister of Public Works No. 04/SE/M/2010 concerning the Implementation of Guidelines for the California Bearing Ratio (CBR) Test with Dynamic Cone Penetrometer (DCP) as follows:

1. For conus 30^0
   Log CBR = 1.352 – 1.125(Log DCP) (cm/blow) (5)
2. For conus 60^0
   Log CBR = 2.8135 – 1.313(Log DCP) (mm/blow) (6)

This study used a DCP with conus 60^0, so the formula for calculating CBR value is as follows :

$$CBR = 10^{2.8135-1.313(\log DCP)} \text{ (mm/blow)} \quad (7)$$

The CBR value is a correlation of the soil bearing capacity. In the new pavement design, it is required that the subgrade has an effective CBR of not less than 6% [12].

4. Results and Discussions

The maximum subgrade CBR value obtained from the results of the DCP test is presented in Table 1.

Table 1. Maximum CBR Value

Site	**1**	**2**	**3**	**4**	**5**	**6**
Depth (mm)	42	365	118	535	275	101
DCP value (mm/blow)	35	120	145	80	75	60
Maximum CBR value (%)	6.11	1.21	0.95	2.06	2.25	3.01

For site 1, the maximum CBR value obtained is 6.11% at a depth of 42 mm. The maximum CBR value for site 2 is 1.21% at 365 mm depth. In site 3, the maximum CBR value is 0.95% at 118 mm depth. The maximum CBR value in site 4 is 2.06% at 535 mm depth. In site 5, the maximum CBR value is 2.25% at 275 mm depth. And last, in site 6, the maximum CBR value is 3.01% at 101 mm depth.

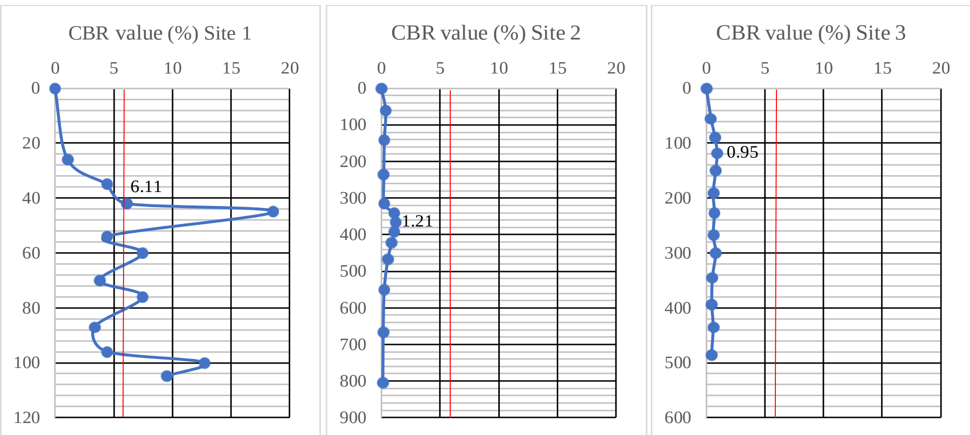

Figure 1. CBR Value at Site 1, Site 2, and Site 3

The red vertical line is the minimum required CBR value for the subgrade of 6%. As seen on the CBR value graph at Site 1, the minimum required CBR value is reached at a depth of 42 mm with a value of 6.11%. The maximum CBR value can reach 18.59% at a depth of 45 mm. A good CBR value is obtained because Site 1 is located on the perimeter of Polinela's new campus area, closer to the existing road. The soil condition at Site 1 is still the original undisturbed soil.

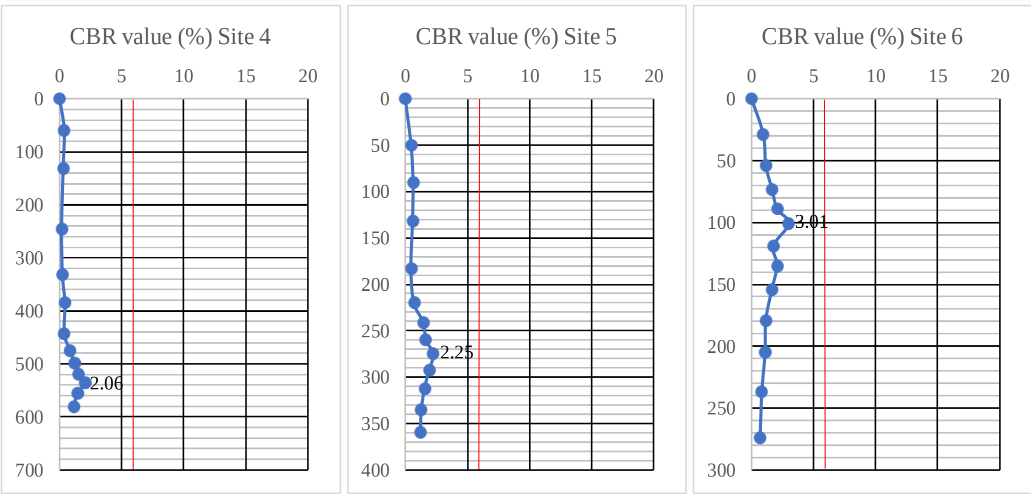

Figure 2. CBR Value at Site 4, Site 5, dan Site 6

At Site 2 to Site 6, the CBR value required for subgrade was not achieved. Even at Site 4, a maximum CBR value of 2.06 % was achieved at 535 mm depth. The other sites are located more profound into the area of Polinela's new campus. From the analysis results, it can be seen that the deeper land area, the CBR value does not meet the requirements, namely not less than 6%. The leak of CBR value is because the land area of Polinela's new campus is corn and cassava field that has undergone processing soil. Soil tillage is the process of loosening the soil to make it easier to plant and fertilize so that the soil grains become loose and not solid anymore. As a result of the tillage process, the soil's bearing capacity decreases to carry the load of the building on it.

5. Conclusions and Recommendations

From the results of the DCP test at six sites, the CBR value that meets the CBR requirements for subgrade is only found at Site 1, which is 6.01% at 42 mm depth. The CBR value at Site 2 to 6 did not reach the minimum required CBR value for subgrade. This is because Site 1 is close to the existing road and is still undisturbed soil. While Site 2 to Site 6 is located in an area temporarily used as corn and cassava fields planted by the community. The soil at Site 2 to Site 6 has undergone soil processing planted with corn and cassava. It is no longer undisturbed soil because the soil particles have become loose and reduced its bearing capacity.
Suggestions that can be given are to cut the soil to the depth of the roots of corn and cassava or obtain the subgrade, and then a DCP test is carried out so that the CBR value data obtained will be more accurate.

Acknowledgement
The author acknowledges the support from Politeknik Negeri Lampung (No. 209.27/PL15.8/PT/2021).

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