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ANALYSIS OF CBR VALUES BASED ON DCP TESTING ON THE PENUMANGAN–UNIT VI ROAD SECTION

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Abstract

The subgrade is an important component of the pavement structures as it receives and distributes the traffic loads thru the pavement layers. The bearing capacity of subgrade is low, which can accelerate the deterioration of pavement and reduce the service life of pavement. The objective of this research is to analyze the value of California Bearing Ratio (CBR) estimated from Dynamic Cone Penetrometer (DCP) testing and to evaluate the variation of subgrade bearing capacity in the Penumangan–Unit VI Road Section, West Tulang Bawang Regency. DCP testings were carried out at 24 observation points by using 8 kg hammer and 60° cone. The penetration data were converted to CBR values by using the appropriate DCP–CBR correlation provided in the Indonesian DCP testing guideline. The results indicate that the estimated CBR values are in the range of 5.87% to 8.26% with average value of 6.83%. The evaluation criterion of 6% indicates that there are 21 observation points (87.50%) that have a CBR value of at least 6% and there are three observation points (12.50%) that are below the criterion. The lowest values were recorded at STA 13+000 (5.87%), STA 14+600 (5.92%) and STA 16+600 (5.94%), while the highest value was observed at STA 14+800 (8.26%). These results indicate that the subgrade condition is generally adequate based on the chosen criteria, but there are still localized weak spots throughout the road section. Thus, DCP testing can be used as a rapid, low-cost field screening procedure to identify spatial variations of subgrade bearing capacity and to help prioritize further investigation and road maintenance.

Keywords: California Bearing Ratio; Dynamic Cone Penetrometer; pavement; road; subgrade.

INTRODUCTION

Road infrastructure plays an important role in supporting community mobility, distribution of goods and services and regional economic activities. The availability of roads with adequate structural performance is crucial to maintain the connectivity between areas and to facilitate movement of agricultural products, trade and other economic activities. Growing regional development and traffic activities require road infrastructure which is capable of providing the appropriate level of service during its service life. West Tulang Bawang Regency is a region that requires adequate transportation infrastructure for agricultural, trade and service activities. One of the road sections that support these activities is the Penumangan–Unit VI Road Section. The road is an interregional communication and provides for the mobility of the population and the delivery of agricultural products. Therefore, it is imperative to keep this road in a structure condition to ensure transportation accessibility and continuity of economic activities. The performance of pavement structures depends on the quality of pavement materials as well as the subgrade condition. The subgrade is a base that receives and distributes the load applied thru the layers of the pavement. Inadequate subgrade bearing capacity may result in excessive deformation, settlement, cracking and premature deterioration of the pavement. Therefore, the assessment of the bearing capacity of subgrade is an important part of road pavement planning and maintenance. The California Bearing Ratio (CBR) is one of the most common parameters used to evaluate the relative bearing capacity of subgrade soil. The higher the CBR value, the more resistant the soil is to penetration and the greater its ability to support the loads imposed on the pavement. However, lower CBR values suggest relatively poor subgrade conditions, which may necessitate further treatment or consideration in the pavement design. CBR testing can be performed in the laboratory or in the field. The Dynamic Cone Penetrometer (DCP) is one of the field methods available for estimating CBR. DCP tests measure the amount of penetration from repeated hammer blows. The penetration rate was subsequently related to CBR by means of an empirical relationship. DCP provides a relatively quick, simple and economical means of investigating the subgrade conditions at several locations compared with the conventional CBR testing. The previous research has shown the use of CBR and DCP test for the assessment of subgrade bearing capacity. Abdullah and Dhana [1] studied the relation between bearing capacity of soil and road damage at Bulutigo, Lamongan and got laboratory CBR value of 6.80%. Haryati and La Ode Malim [2] used DCP test to determine the bearing capacity of subgrade on the Kaulea road section, and obtained average CBR value of 8.88%. Octamal and Patriotika [5] studied CBR values on an agricultural access road and found a large spatial variation along the road section investigated. Despite the widespread use of DCP testing to estimate CBR, the average CBR value may not sufficiently represent localized weak points along a road section. Thus, it is important to identify locations with estimated CBR values less than the selected evaluation criterion to support maintenance prioritization. This condition is the basis of this study to analyze the estimated CBR values from DCP testing and to evaluate the spatial variation of the subgrade bearing capacity along the Penumangan – Unit VI Road Section. The results are expected to give technical information for the identification of further investigation locations, and to support a more targeted road maintenance and improvement planning.

LITERATURE REVIEW

2.1 California Bearing Ratio (CBR)

The California Bearing Ratio (CBR) is an index of the bearing capacity of soil relative to a standard material. The CBR test is often used in pavement engineering for the evaluation of subgrade and also as an aid in the design of pavement thickness. The CBR value is expressed in percentage. Higher values usually indicate greater resistance to penetration and lower values indicate relatively poor soil conditions. The CBR is affected by soil type, soil density, moisture condition, compaction and test conditions. Therefore, CBR results should be interpreted with the associated field conditions. In this study, CBR values are derived from DCP testing using an empirical correlation and should be interpreted as estimated field CBR values, not direct laboratory soaked-CBR values.

2.2 Dynamic Cone Penetrometer (DCP)

Dynamic Cone Penetrometer (DCP) is a field testing method used to investigate soil penetration resistance. The test is conducted by dropping a hammer of specified weight onto an anvil connected to a penetration rod and cone. The penetration produced by the hammer blows is recorded and processed to estimate the CBR value using an applicable empirical correlation.

$$\mathbf{Log_{10}\ CBR = 2.8135 - 1.313\ Log_{10}\ DCP}$$

DCP is particularly useful for road investigations because testing can be conducted directly in the field and repeated at many locations in a relatively short time. This characteristic makes DCP suitable for identifying spatial variations in subgrade bearing capacity along an existing road section.

2.3 Subgrade Bearing Capacity

The subgrade is the soil layer supporting the pavement structure. Its bearing capacity affects the ability of pavement layers to distribute traffic loads to the underlying soil. Poor subgrade conditions can increase deformation and reduce pavement structural performance. Subgrade evaluation should consider not only the average condition but also spatial variations. Localized low bearing capacity may become a potential source of pavement deterioration even when the overall average value appears adequate. Consequently, identifying the location and magnitude of CBR variation is important for road maintenance planning.

2.4 Previous Research and Research Gap

Abdullah and Dhana [1] conducted a study on soil bearing capacity in relation to road damage in Bulutigo, Lamongan. Their laboratory evaluation consisted of water content, Atterberg limits, CBR and direct shear testing. The study showed that features of the soil can influence road performance and that the CBR value was 6.80%. Haryati and La Ode Malim [2] conducted the DCP test to find out the bearing capacity of the subgrade on the Kaulea road section. The CBR results obtained were used to evaluate the subgrade conditions. The average value of CBR was 8.88%. The study showed the practical use of DCP for subgrade evaluation in the field. The research gap addressed in this research is the need to examine the variation of DCP derived CBR values along an existing road section and to explicitly identify the localized points that fall below the selected evaluation criterion. Therefore, the contribution of this study is not only limited to the determination of the average CBR value, but also to identify the specific stationing (STA) locations with relatively low CBR values, which can be considered for further technical investigation and road maintenance prioritization.

METHOD

3.1 Research Location and Data

The study was conducted on the Penumangan–Unit VI Road Section, West Tulang Bawang Regency. Primary data were obtained by conducting field DCP tests at 24 observation points from STA 12+400 to STA 17+250. Observation points are the estimations of the CBR condition of the subgrade at each tested stationing. The DCP testing was conducted using an 8 kg hammer and a 60° cone. At each observation point penetration from repeated hammer blows was recorded. The resulting DCP data were processed to calculate CBR values by using the relevant DCP-CBR correlation according to the field testing guideline (Kementerian Pekerjaan Umum, 2010).

3.2 Data Analysis

Data analysis consisted of: (1) compiling the DCP penetration results for each observation point; (2) determining the corresponding DCP penetration rate; (3) converting DCP values into estimated CBR values; (4) calculating the minimum, maximum, total, and average CBR values; (5) comparing each CBR value with the 6% evaluation criterion; (6) calculating the proportion of points meeting and not meeting the criterion; and (7) identifying stationing locations requiring further technical attention. The evaluation used a CBR value of 6% as the reference criterion. This study uses the 6% value as an evaluation threshold for screening potentially weak subgrade locations. A location below 6% does not, by itself, establish that reconstruction or a specific rehabilitation treatment is required; treatment decisions should also consider pavement condition, drainage, traffic loading, moisture, soil properties, and other relevant engineering factors.

RESULTS AND DISCUSSION

4.1 CBR Test Results

DCP testing at 24 observation points produced estimated CBR values ranging from 5.87% to 8.26%, with a total of 163.87% and an average of 6.83%. The complete estimated CBR values are presented in Table 1.

Table 1. CBR Values Based on DCP Testing

No.	Stationing	CBR (%)
1	12+400	7.82
2	12+600	6.47
3	12+800	6.01
4	13+000	5.87
5	13+200	6.51
6	13+400	6.51
7	13+600	8.10
8	13+800	6.16
9	14+000	6.59
10	14+200	6.06
11	14+400	7.85
12	14+600	5.92

13	14+800	8.26
14	15+000	6.62
15	15+200	8.13
16	15+400	6.33
17	15+600	7.53
18	15+800	7.08
19	16+000	6.74
20	16+200	7.02
21	16+400	7.14
22	16+600	5.94
23	16+800	7.08
24	17+250	6.13
	Total	**163.87**
	Average	**6.83**

The results indicate that subgrade bearing capacity varies along the road section. The average estimated CBR of 6.83% is above the 6% evaluation criterion. However, the minimum value of 5.87% demonstrates that localized weak points remain present. The difference between the minimum and maximum values is 2.39 percentage points, indicating that the subgrade is not completely homogeneous along the investigated section.

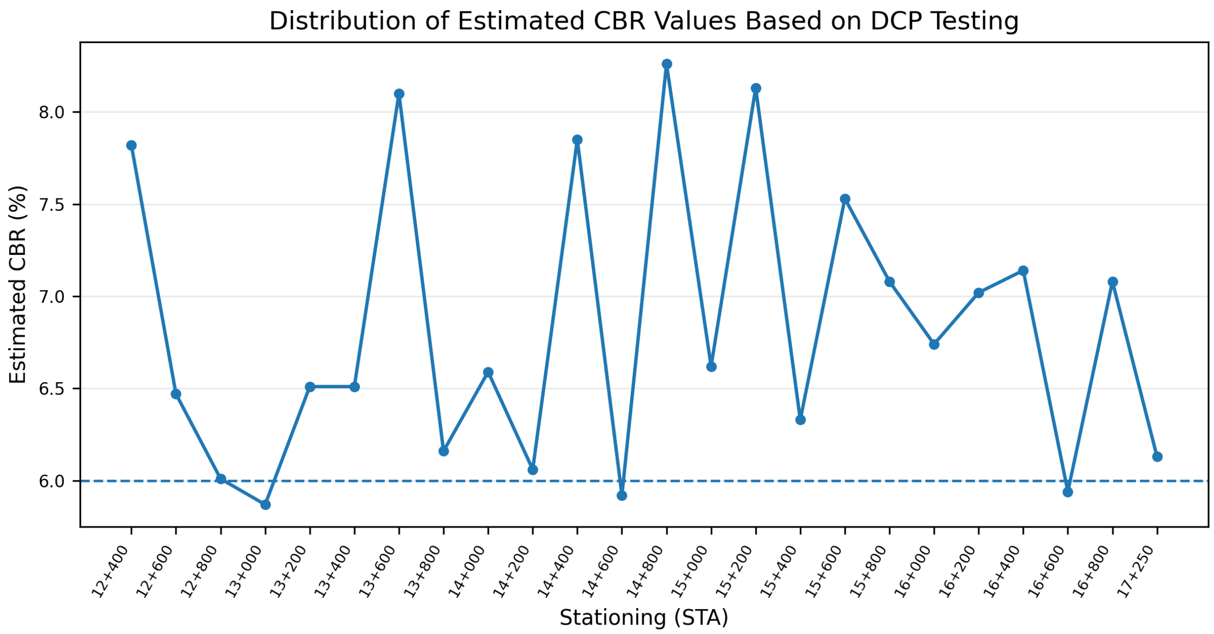

Figure 1. Distribution of Estimated CBR Values Based on DCP Testing

Figure 1 presents the distribution of the estimated CBR values by stationing and the 6% evaluation criterion. Most of the observations are above the criterion, but three points are below: STA 13+000, STA 14+600 and STA 16+600. The figure also shows that CBR values vary between stationing points indicating localized differences in subgrade conditions. The estimated CBR at STA 12+800 is 6.01 percent. The estimated CBR decreases to 5.87 percent at STA 13+000 and increases to 6.51 percent at STA 13+200. Another major variation is between STA 14+400 to STA 14+800, where CBR decreases from 7.85% to 5.92% and then increases to the maximum value of 8.26% found. A similar local decrease is noted at STA 16+600 where CBR drops to 5.94% before rising to 7.08% at STA 16+800. The patterns show the value of having several DCP observation points in road evaluation. If only the average CBR is taken into account, the local weak points may be missed. Thus, spatial interpretation of CBR values from DCP might contribute more useful information for recognizing sections that need further investigation.

4.2 Evaluation of CBR Against the Minimum Threshold

The evaluation was performed by comparing each observed CBR value with the 6% minimum threshold. The resulting distribution is presented in Table 2.

Table 2. Evaluation of CBR Values

Criteria	Number of Points	Percentage
CBR ≥ 6%	21	87.50%
CBR < 6%	3	12.50%
Total	24	100%

Of the 24 observation points, 21 points (87.50%) have estimated CBR values equal to or greater than 6%, while three points (12.50%) are below the criterion. This indicates that the overall subgrade condition is generally adequate according to the selected criterion. Nevertheless, the 87.50% compliance rate should not be interpreted as uniform performance along the entire road. The three points below 6% represent localized weak conditions that may be more vulnerable to deformation when subjected to traffic loading, particularly if drainage or moisture conditions are unfavorable. From a maintenance perspective, this result supports a targeted approach. Locations with estimated CBR values below the criterion can be prioritized for field verification, while locations with adequate values may be monitored through routine pavement condition assessment.

4.3 Locations with CBR Values Below 6%

Three observation points have CBR values below the 6% threshold and are therefore identified as locations requiring priority for further technical evaluation.

Table 3. Locations with CBR Values Below 6%

No.	Stationing	CBR (%)	Evaluation
1	13+000	5.87	Priority for further evaluation
2	14+600	5.92	Priority for further evaluation
3	16+600	5.94	Priority for further evaluation

STA 13+000 has the lowest estimated CBR value of 5.87%, which is 0.13 percentage points below the criterion. STA 14+600 has a CBR of 5.92%, while STA 16+600 has a CBR of 5.94%. The differences from the criterion are relatively small, but these locations should still be considered potential weak points. A low CBR value does not, by itself, establish that reconstruction is required. The appropriate treatment should be determined after considering pavement condition, drainage, traffic loading, soil moisture, density, soil classification, and other relevant field conditions. The DCP result is best used as an initial screening indicator for subsequent technical investigation.

4.4 Locations with High CBR Values

The highest CBR value was recorded at STA 14+800, followed by STA 15+200 and STA 13+600.

Table 4. Locations with the Highest CBR Values

No.	Stationing	CBR (%)
1	14+800	8.26
2	15+200	8.13
3	13+600	8.10

STA 14+800 has the highest estimated CBR value of 8.26%, indicating relatively greater penetration resistance and better subgrade bearing capacity than the other observation points. The high values at STA 15+200 (8.13%) and STA 13+600 (8.10%) also indicate relatively favorable subgrade conditions. However, a high CBR value should not be interpreted as proof that the pavement is free from failure. Pavement performance is also influenced by drainage, traffic loading, pavement material quality, construction quality, and the condition of the existing pavement layers.

4.5 Variation of Subgrade Conditions Along the Road

The estimated CBR distribution demonstrates that the subgrade condition changes spatially along the Penumangan–Unit VI Road Section. The most notable local changes occur around STA 12+800–13+200, STA 14+400–14+800, and STA 16+400–16+800. Such changes may be associated with differences in soil characteristics, moisture, compaction, drainage, or local environmental conditions. The available DCP data alone, however, are not sufficient to determine the exact cause of each variation. The finding is consistent with previous DCP-based studies. Haryati and La Ode Malim [2] showed that DCP can be used to characterize subgrade conditions at multiple locations, while Octamal and Patriotika [5] reported a broad range of CBR values along an agricultural access road. These studies reinforce the importance of considering spatial variability rather than relying only on a single representative value. The present study adds a maintenance-oriented interpretation by identifying the exact stationing locations where estimated CBR falls below the selected criterion. This information can support more focused field investigation and maintenance prioritization.

4.6 Implications for Road Maintenance

Based on the estimated CBR results, STA 13+000, STA 14+600, and STA 16+600 should be considered priority locations for further technical evaluation. Possible factors to be checked include drainage condition, surface distress, soil moisture, density, and the characteristics of the subgrade material. Potential treatment options should only be selected after the additional investigation. Depending on the verified causes, measures may include drainage improvement, subgrade compaction, soil stabilization, replacement of unsuitable material, or adjustment of pavement structure. The CBR results therefore provide an evidence base for prioritization rather than a standalone prescription for reconstruction. Using DCP data in this manner can help direct maintenance resources toward locations with relatively lower bearing capacity. This is particularly useful for long road sections where uniform treatment may be inefficient and where localized weak points can be identified through field testing.

4.7 Comparison With Previous Studies

Octamal and Patriotika (2026) reported CBR values ranging from 2.83% to 21.79% on an agricultural access road, demonstrating substantial spatial variability. In comparison, the range in the present study is narrower, from 5.87% to 8.26%. This indicates that although variation exists on the Penumangan–Unit VI section, the observed range is relatively limited within the investigated points. Abdullah and Dhana (2021) studied the condition of road subgrades in Bulutigo and reported that the laboratory CBR value was 6.80%. They correlated the condition of the soil to road damage. The average estimated CBR in the present study (6.83%) is numerically close to that reported value . However, the two studies used different testing approaches, locations and research objectives and therefore the values should not be interpreted as directly equivalent. Haryati and La Ode Malim (2022) found an average CBR of 8.88% from DCP testing on the Kaulea road section. The current average of 6.83% is lower, thus a comparatively lower average estimated CBR than the study cited. However, a direct comparison should be made with caution because of differences in soil conditions, testing intervals, and field environments. CBR values from 2.83% to 21.79% were reported by Octamal and Patriotika (2026) on an agricultural access road, indicating a high spatial variability (Table

1). The range in this study is relatively narrow, between 5.87% and 8.26%. This shows that there is a variation on the Penumangan – Unit VI route, but the range detected is quite limited in the studied points.

CONCLUSION

DCP testing at 24 observation points on the Penumangan–Unit VI Road Section produced estimated CBR values ranging from 5.87% to 8.26%, with an average of 6.83%. The total of the 24 estimated CBR values is 163.87%, confirming the calculated average of 6.83%. Based on the 6% evaluation criterion, 21 locations (87.50%) meet or exceed the criterion, while three locations (12.50%) fall below it. The locations requiring priority for further technical evaluation are STA 13+000 with an estimated CBR of 5.87%, STA 14+600 with 5.92%, and STA 16+600 with 5.94%.

The highest estimated CBR value of 8.26% was recorded at STA 14+800, followed by STA 15+200 at 8.13% and STA 13+600 at 8.10%. These locations indicate relatively better subgrade bearing capacity based on the DCP results.
Overall, the subgrade condition is generally adequate based on the selected 6% criterion, but localized weak points remain. DCP testing provides a rapid and economical means of identifying these variations and can support the prioritization of further investigation and road maintenance. Future investigation should integrate estimated CBR results with pavement condition, drainage, traffic loading, soil properties, moisture condition, and other structural parameters before specific treatment decisions are made.

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