Correlation Between Indeks Plasticity (Pi) and California Bearing Ratio (Cbr) Value of Palangkaraya Soil

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Abstract. CBR (California Bearing Ratio) is an important parameter to determine the bearing capacity of the soil. CBR testing in the laboratory requires a relatively large amount of time and cost. Therefore it is necessary to simplify the determination of CBR value. One of the parameters of land that can be used to get the CBR value is the soil plasticity index (PI). It is expected that after knowing the PI value, the CBR can be known. This study aims to obtain a correlation between PI and CBR for the Palangkaraya clay. The test was carried out at the Soil Mechanics Laboratory of the University of Muhammadiyah Palangkaraya. Clay samples were taken at 6 (six) locations in the City of Palangkaraya. The clay test results then performed a correlation of PI values to CBR with analytical methods and linear graph methods. From the analysis conducted the results of the correlation obtained using analytical methods and linear graph CBR = -0.2854 + 8.4816PI. The result of the correlation value using linear regression graphs value at R = 0,801 and using analytical correlation methods worth R = 0,895. From the two results, the smallest value for R value is R = 0,801. It can be seen that the correlation equation of the result of this test has a very high relationship when viewed from the benchmark correlation results (R = 0,80-1,00).

1. Introduction
Structure soil construction, the bearing capacity (CBR = California Bearing Ratio) has an influence on planning. To find out the value of CBR, experiment must be carried out in the laboratory and in the field. If every time the planning has to be done the CBR test, it will certainly take a lot of time and money. Therefore, there is a desire to simplify parameter related to CBR. On of the soil parameters that can be used to get the CBR value is the soil plasticity index (PI). With accurate laboratory test results, with the help of related correlation between PI and CBR, then if the PI value can already be obtained, then the CBR can also be obtained.

As tested by Marwan and Sundary (2012) shows the relationship between PI and CBR on disturbed or undisturbed soil samples. Obtained a strong correlation between 0,708 – 0,887. Whereas Mego Purnomo (2011) in his research correlated CBR value with other parameters such as PI values, soil shear angel (φ) and cohesion value (c). The test shows that the CBR value can be determined with
several other parameters of the mechanical properties of the soil as long as it still has the same characteristics and classification.

But the correlation in previous studies is research on soil types outside the Palangkaraya area, which of course the structure and nature of the soil are likely to be different. While the correlation between PI and CBR for the Palangkaraya area has never been done. The condition background for conducting research on the correlation of PI values with CBR for soil conditions in Palangkaraya.

Based on the foregoing, an investigation will be conducted in order to obtain a correlation between the value of PI and CBR for Palangkaraya land. From the result of this study, it is expected that later if the PI value is known then the CBR value can be known without further testing in the laboratory.

2. Methods
2.1. Type of Research
This research is included in research with laboratory testing. Laboratory testing is carried out in the form of testing the physical properties of the soil and the soil mechanical properties. The most decisive test parameter results are soil PI and CBR values. Both parameters are the result of original unmodified soil testing.

2.2. Location of Research
Laboratory testing in this study was carried out in the Geotechnical Laboratory, Faculty of Engineering, Universitas Muhammadiyah Palangkaraya. As for the soil samples used, obtained from 6 (six) points in the sub-district in the city of Palangkaraya, among others: 1 point in Bukit Rawi Village, 2 points in Bereng Bengkel Village, 1 point in Kereng Bangkirai village, and 2 points in Tangkiling Village.

2.3. Research Stages
Stages of research to be carried out are starting from soil sampling in the field then proceed with testing the physical and mechanical properties of the soil. Before conducting correlation analysis, a soil investigation will be conducted to determine the classification of clay soils to be studied. After the required parameters have been obtained, then a correlation analysis of CBR values and PI values is performed. For the purpose of testing samples in this study are listed as the table below:

| No. | Testing                  | Number of Sample Needs | Total sample |
|-----|--------------------------|------------------------|--------------|
| 1.  | Grain size distribution  | 3                      | 18           |
| 2.  | Specific gravity         | 3                      | 18           |
| 3.  | Liquid limit             | 3                      | 18           |
| 4.  | Plastic limit            | 3                      | 18           |
| 5.  | Compacting               | 3                      | 18           |
| 6.  | CBR                      | 3                      | 18           |

3. Results and Discussion
After doing research in the Geotechnical Laboratory Faculty of Engineering UM Palangkaraya, the characteristics of clay from Palangkaraya city based on each sampling can be seen in Table 2 below:
Table 2. Characteristics of Clay Soils

| Test Type                  | Unit | Tangkiling Village | Bereng Bengkel Village | Bukit Rawi Village | Kereng Bengkirai Village |
|----------------------------|------|--------------------|-----------------------|-------------------|--------------------------|
|                            |      | T.1 | T.2 | T.1 | T.2 | T.1 | T.1 |
| Starting Water Rate        | %    | 2.23 | 2.23 | 2.45 | 2.35 | 4.47 | 5.27 |
| Specific Gravity           |      | 2.60 | 2.60 | 2.64 | 2.59 | 2.68 | 2.62 |
| Liquid Limit (LL)          | %    | 33.20 | 33.20 | 47.50 | 50.50 | 47.00 | 61.00 |
| Plastic Limit (PL)         | %    | 24.16 | 24.16 | 33.38 | 35.70 | 26.46 | 44.21 |
| Plasticity Index (PI)      | %    | 9.04 | 9.04 | 14.12 | 14.80 | 20.54 | 16.79 |
| Passed No.200 Filters      | %    | 65.69 | 65.69 | 96.68 | 97.07 | 97.13 | 95.79 |
| Max Dry Fill Weight        | gr/cm³ | 1.65 | 1.65 | 1.33 | 1.308 | 1.34 | 1.421 |
| Optimum Moisture Content   | %    | 19.00 | 19.00 | 33.35 | 34.20 | 30.50 | 27.20 |
| CBR 100%                   | %    | 6.90 | 6.90 | 4.15 | 4.05 | 3.60 | 3.30 |
| CBR 90%                    | %    | 6.56 | 6.56 | 3.94 | 3.85 | 3.42 | 3.14 |

CLASSIFICATION OF LAND

According to USCS
- Tangkiling Village: ML
- Bereng Bengkel Village: CL
- Bukit Rawi Village: CL
- Kereng Bengkirai Village: MH

According to AASHTO
- Tangkiling Village: A-4
- Bereng Bengkel Village: A-7-5
- Bukit Rawi Village: A-7-6
- Kereng Bengkirai Village: A-7-5

Sources: Result of Research (2019)

3.1 Relationship between Plasticity Index (PI) and California Bearing Ratio (CBR)

Based on the results of the tests that have been carried out, the CBR and PI values can be grouped based on the location of sampling in the field. In comparing both values, the CBR value used is the CBR Design or CBR or CBR value of 90%. The test results are shown in Table 3 below:

Table 3. Comparison of PI and CBR Values

| No  | Type of Land                      | PI (%) | CBR (%) |
|-----|-----------------------------------|--------|---------|
| 1.  | Tangkiling Village 1              | 9.04   | 6.56    |
| 2.  | Tangkiling Village 2              | 10.28  | 5.56    |
| 3.  | Bereng Bengkel Village 1          | 14.12  | 3.94    |
| 4.  | Bereng Bengkel Village 2          | 14.80  | 3.85    |
| 5.  | Bukit Rawi Village                | 20.54  | 3.42    |
| 6.  | Kereng Bangkirai Village          | 16.79  | 3.14    |

Sources: Result of Research (2019)

Based on the values in the comparison table, the PI and CBR values above can be outlined in the curve below.

Figure 1. Diagram Value Test Results PI and CBR

Source: Result of Research, 2019
Form the test results in Figure 1 shows an increase in CBR value inversely proportional to the PI value. When compared to each of the test results, it is known that the Clay Tangkiling Village clay has the highest CBR value but the PI is the smallest, likewise, in clay soil the Bukit Rawi Village has the lowest CBR value but the highest PI value. In general, each of the samples prepared has increased. As for the PI value of each sample arranged has decreased.

3.2 Correlation of Plasticity Index (PI) and California Bearing Ratio (CBR)

3.2.1 Graphic Way
As in previous studies, the correlation between the value of Plasticity Index (PI) and CBR can be made in a relationship contained in the equation \( y = a+bx \). In the implementation of this correlation, the relationship can be done using linear graphical analytical methods and linear equations. In the figure below, the correlation between PI value and CBR will be done graphically.

![Figure 2. Correlation Graph Value of PI and CBR (Result of Analysis, 2019)](image)

As seen in Figure 2, the correlation between PI (Plasticity Index) correlation to CBR (California Bearing Ratio) of six clay samples is correlated using linear regression. The result is made in a linear equation where the CBR value is represented by \( Y \) and the PI value is represented, then the linear equation \( y = -0.2854x + 8.4816 \) is obtained. If translate it means to form the equation \( CBR = -0.2854 \text{ PI} + 8.4816 \) or \( CBR = 8.4816 - 0.2854 \text{ PI} \).

For example in the use of this equation, if it is known that the PI value of the test results is obtained at 12\%, then the CBR value of the land can be determined using equation, \( CBR = 8.4816 - 0.2854 \times 12 \) or a CBR value of 5.057\%. In accord with the results of the tests conducted, it appears that the correlation between PI and CBR shows, if the soil PI value is high, the CBR value of the land will decrease. So that final results in this test state that the value of this correlation has a very strong relationship, according to the benchmark correlation calculation results \( R = 0.80 -1.00 \) in this test the final results obtained value \( R = 0.801 \).
4. Analytical Method

As a comparison, the correlation value of PI to CBR is calculated using an analytical method using the linear relationship formula to find the correlation value. The data used is the CBR value represented by Y as the dependent variable and the PI value will be represented by X as the independent variable. The linear equation that will be produced is \( y = a + bx \) or becomes \( \text{CBR} = a + b \cdot \text{PI} \). To facilitate obtaining the equation will be arranged in the table below.

| No.  | Jenis Tanah             | PI (X) | CBR(Y) | \( X^2 \) | \( Y^2 \) | X.Y  |
|------|-------------------------|--------|--------|-----------|-----------|-----|
| 1.   | Tangkiling Village 1    | 9,04   | 6,56   | 81,722    | 43,034    | 59,302 |
| 2.   | Tangkiling Village 2    | 10,28  | 5,56   | 105,678   | 30,914    | 57,157 |
| 3.   | Bukit Rawi Village      | 20,54  | 3,42   | 421,892   | 11,696    | 70,247 |
| 4.   | Bereng Bengkel Village 1| 14,12  | 3,94   | 199,374   | 15,524    | 56,980 |
| 5.   | Bereng Bengkel Village 2| 14,8   | 3,85   | 219,040   | 14,823    | 56,980 |
| 6.   | Kereng Bangkirai Village| 16,79  | 3,14   | 281,904   | 9,860     | 52,721 |
|      | **Total**               | **85,570** | **26,470** | **1309,610** | **125,849** | **352,039** |

Sources: Result of Analysis (2019)

The elaboration of the calculation gets the analytical linear regression equation as follows after the result in table 4 is obtained, then the next thing is to look for a linear regression equation \( y = a + bx \). The parameters of the equation include:

a. To get the value of b, use the following formula:
\[
b = \frac{(n \cdot \sum x \cdot y) - (\sum x \cdot \sum y)}{(n \cdot \sum x^2) - (\sum x)^2}
\]
b. After getting the value of b, then the value of a can be known using the formula:
\[
a = \frac{\sum y - (b \cdot \sum x)}{n}
\]
c. From the parameters that can be obtained a linear equation
\( y = 8,4816 - 0,2854x \), or \( \text{CBR} = 8,4816 - 0,2854 \cdot \text{PI} \)
d. After the result of the equation are obtained, it is necessary to check the correlation value by using the formula:
\[
R = \frac{(n \cdot \sum xy) - (\sum x \cdot \sum y)}{\sqrt{(n \cdot \sum x^2) - (\sum x)^2} \cdot (n \cdot \sum y^2) - (\sum y)^2}}
\]
\[
R = -0,89503
\]
e. An obtained r-value of 0,8950, or in the explanation has a very strong correlation between 0.8 and 1.

5. Comparison of Correlation Equations for Plasticity Index (PI) and California Bearing Ratio (CBR)

Based on some previous tests it can be concluded that there is a correlation relationship that is almost the same even though the soil being tested is not the same. The equations obtained in the previous test and care currently listed as in the table below.

| No.  | Equations                                      | R   | Condition   |
|------|-----------------------------------------------|-----|-------------|
| 1.   | CBR not submerged = -0.990 PI + 28.79         | 0.868| disturbed sample |
|      | CBR not submerged = -0.464 PI + 10.60         | 0.728| disturbed sample |
|      | CBR submerged = 0.673 PI + 15.88              | 0.706| undisturbed sample |
|      | CBR submerged = -0.132 PI + 3.625             | 0.887| undisturbed sample |
2. Mego Purnomo (2011)
   CBR = 137.86 – 6.792 PI
3. Penelitian (2019)
   CBR = 8.4816 - 0.2854 PI

6. Closing

6.1 Conclusions

The conclusions that can be drawn from the research carried out are as follows:

- In CBR testing the largest value in soil samples from Tangkiling 1 and 2 villages reached 6.56% and 5.56%. Whereas the lowest CBR value was obtained from Kereng Bengkirai village that is 3.14%.
- For PI value, the biggest value obtained in Bukit Rawi village is the largest, namely 20.54% and the smallest PI value obtained in Tangkiling village is equal to 9.01%.
- In general, it can be concluded that the CBR value of clay is inversely proportional to the value of PI, which is known that the greater the CBR value the smaller the PI value and vice versa.
- Overall correlation results of the value of PI (Plasticity Index) against CBR (California Bearing Ratio) obtained the result of correlation using linear and analytical graphs obtained by the correlation equation CBR = 8.4816 + 0.2854 PI. While correlation value based on analytical calculations obtained CBR = -0.2854 PI + 8.4816.
- The result of the correlation value using linear regression graphs valued at $R = 0.801$ and using analytical correlation methods worth $R = 0.895$. In the explanation of the correlation obtained has a very strong correlation between $0.8 – 1$.

6.2 Suggestions

Suggestions that can be given from the results of research that has been done are as follows:

- In order for better research data, it is better to do future research, then by increasing the number of samples, can also try various types of soil and look for other relationship that are still related to testing the mechanical properties of the soil or the relationship of the physical properties of the soil and other soil mechanical properties.
- In research and testing in the laboratory must be done more thoroughly and carefully so that there are no errors.

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