CBR Laboratory Analysis for Determining The Number of Compaction Tracks to Achieve Field CBR

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Abstract. Compaction is the process of grounding the soil by removing air from the pores of the soil mechanically (beaten, crushed and so on) Compaction is carried out with the aim of improving the technical properties of the soil, namely obtaining the densest soil conditions (maximum solid state). In the process of compaction water content also plays a significant role to achieve maximum density value. Water is a lubricant for the soil to help unify the aggregate and remove air in the compaction process. From the results of compaction in the laboratory can be seen how much compaction energy is given and optimum water content (Wopt) to achieve maximum compaction. From the results of compaction in the laboratory can be applied for maximum compaction in the field, from the calculation of compaction energy in labour from the hammer weight of 4.5 kg, 45.7 cm falling height, g = 10 m/s². The compaction energy is 1134 kg.m/s². To get the number of compaction paths needed to achieve maximum compaction can be determined from the equipment used, the amount of energy used as an example of a vibro roller capacity of 10500 kg, get the solidification energy 164.1 (kg.m2/s). So the trajectory required vibro roller tool as much as seven trajectories.

Keywords: CBR, energy compaction, Wopt

1. Introduction

Seeing from its development, industrial development continues to proliferate with the growing number of factory buildings along the coast. The soil should be able to support and sustain the load from the construction which is placed on it without any shear collapse and the excessive decline. The shear collapse occurs when the bearing capacity of the soil is exceeded (Srihandayani, 2018). In the case of industrial business, a solid construction and supported by a right access road, and having a long service life is essential because the industrial activity is a long-term business, therefore in an industry must also be supported with facilities and infrastructure good transportation.

Elastic force (flexible pavement), the layers of the building consist of the surface course, base course, lower foundation layer (subbase course), subgrade layer. Within these layers, the base course has a considerable role as a load supporting layer which is the surface layer to the
subgrade (Sukirman, 1993), then to produce bearing capacity by the CBR value, the plan requires the correct method of practice. In this study, I tried to analyse the amount of CBR labour and CBR field to get the CBR value of the plan (Wesley, 1997).

2. Literature review

The material of the ruling structure of the violence, such as the base course, the subbase course, and the surface layer shall consist of a granular mixture. The mechanically stable pavement forming structure generally consists of a mix of coarse aggregates (gravel, crushed stone, slag, etc.), fine aggregates (stone ash, sand, etc.), silt, clay, which are mixed in specific proportions and well compacted (Hardiyatmo, 2010).

The road pavement layer is a layer that is above the subgrade that has undergone a compaction process and aims to support the traffic load and flatten it to the road body so that the subgrade does not receive an amount that exceeds the allowable soil carrying capacity. The purpose of making the road strength layer is to achieve a particular strength so that it can support the traffic load and can distribute and spread the wheels of the vehicle received to the subgrade (Sukirman, 1993).

The Directorate General of Highways (1992) explained that the foundation layer must have a higher quality than the underlying soil. There are two different qualities of the aggregate foundation layer, namely, class A and class B. Generally the class A foundation layer is the quality of the foundation layer for the surface under the surface layer, and the class B foundation layer is for the lower foundation layer. While the required material properties must be free of organic objects and clumps of clay or useless objects.

3. Research methods

The tools needed for each test in this study are by the standard of the experiment, namely: A set of filtering test apparatus (ASTM D 421-72)
   a. A set of properties index tests (water content, content content, specific gravity) (ASTM D2216-71, ASTM 854-72)
   b. Compaction tool (Standard Proctor) (ASTM D 3441-86)
   c. CBR (California Bearing Ratio) test equipment for CBR laboratory (CBR laboratory) (ASTM D 1883-73)
   d. Tester wear tool with Los Angeles machine (ASTM C-131-55)
   e. Auxiliary tools that may be used in the study include an oven, weighing 0.01 with precision, stopwatch, 500 ml measuring cup, cup and others.

Materials needed in this study is the base course taken from the Bangkinang city. Furthermore, the base that has been made first is dried by means in an oven after the oven is sifted using a sieve to find out the gradual gradation.

To know precisely the physical properties of the foundation above can be seen from the results of laboratory experiments on the sample base.

4. Results and discussion

Several factors greatly affect the results of the compaction, namely:
   a. Water content
   b. Compaction energy
   c. The type of soil that is compressed
   d. How to compact it
4.1. Water Content Check
This examination is intended to determine soil water content. What is meant by water content is the ratio between the weight of water contained in the soil and the soil dryness expressed in per cent (%). From research, it was found out that the original moisture content of Base Bangkinang average was 9.63% and the results of the average original water content of Tanjung Balai is 24.31%.

4.2. Sieve Shaker
This examination is intended to determine the distribution of granules (gradations) of fine and coarse aggregates using a sieve. Based on the results of the laboratory filter analysis test can be seen in fig.1 for Base Bangkinang and fig.2 for Base Tanjung Balai.

Fig.1 Analysis of Bangkinang Base A Filter

Based on the results of laboratory analysis and data analysis, according to ASTM, the Aggregate that has been tested meets the Class A Aggregate requirements.

Fig.2 Analysis of Tanjung Balai Base A Filter
Based on the results of laboratory analysis and data analysis, according to ASTM, the Aggregate that has been tested meets the Class A Aggregate requirements.

4.3. Modified Proctor Laboratory Compaction Testing

The test method is the same as the Standard Proctor test, the difference is that the test equipment used is higher than that used in the standard analysis, the weight of the pounder hammer is 10 lbs (4.5 kg), the height of the hammer falls 18 inches (45.8 cm) and the ground in the mold is divided into 5 layers, each layer is pounded 25 times. From the results of the compaction testing, \( w_{opt} \) and \( \gamma_d \) can be seen in fig.3 for Base Bangkinang and fig.4 Base Tanjung Balai.

From the compaction test results obtained \( \gamma_d \) 2.3 gr/cm\(^3\) and \( w_{opt} \) t 4.5\%. From these results, we can determine the water content we use for the maximum compaction process. Fig.4 Compaction of Base Tanjung Balai.

While the results of compaction testing for Base Tanjung Balai obtained \( \gamma_d \) 2.2 gr/cm\(^3\) dan \( w_{opt} \) 8 \%.
4.4. Aggregate Abrasion Testing (Aggregate Resistance)
The results of the coarse aggregate wear resistance examination for Base Bangkinang in this study were 16% and for Tanjung Balai 19.4%. This value is obtained from the ratio of materials through a no.12 filter to the original total weight. This value meets the specifications of wear resistance specifications which is small than 40%.

4.5. CBR (California Bearing Ratio)
Based on the compaction test with the Modified Proctor method, the optimum moisture content of the original soil test sample was 4.5% for Base Bangkinang, and the optimum water content for Base Tanjung Balai was 8%. The optimum soil moisture content based on this compaction test will be used for further testing, namely the California Bearing Ratio test with the Modified Proctor method based on ASTM D 1557. This California Bearing Ratio test matches the optimum water content that has been previously determined unsoaked.
As for the CBR values as follows, for Bangkinang Base test results 10x punch 94%, for 25x blows with CBR value 100%, and 56x blows 121%. And for Base Tanjung Balai 10x blow 91%, for 25x 95% punch, and 56x 108% punch, Can be seen in fig.5 below.

![CBR Value Chart](image)

**Fig.5 CBR Value Chart of Bangkinang and Tanjung Balai Laboratories**

From this figure, it can be concluded that the CBR value has increased based on the more number of blows, the highest CBR value was found at 56x with a CBR value of 121% for Bangkinang and 108% for Tanjung Balai.

4.6. CBR Design
For CBR the plan is obtained from the compaction result and the result of the CBR Laboratory testing which the results received from the withdrawal of the graph. For the CBR result Base Bangkinang plan can be seen in fig.6 and for Base Tanjung Balai in fig.7.
From the drawdown of 95% $\gamma_d$ max between compaction and CBR Laboratory, the results obtained were 105% for the CBR value of the plan. For A Base SNI standard of 90%, then from the test results, Base Bangkinang meets the requirements of the Base A category.

From the 95% $\gamma_d$ max drawdown between compaction and CBR Laboratories obtained 99% worth of results for the CBR plan value. For A Base SNI standard of 90%, then from the test results, Base Bangkinang meets the requirements of the Base A Category.

4.7. Relationship of CBR Value to Bearing Capacity of Soil

CBR laboratories are generally used for planning new road construction. While this is recommended to base the carrying capacity of subgrade only to measure CBR values. The relationship between CBR and DDT values can not only be done by drawing graphs, but also by using $\text{DDT} = \text{formula (4.3 log CBR)} + 1.7$. In this case, the author tries to connect the results of research CBR laboratory Base Bangkinang and Tanjung Balai. Bangkinang CBR Base 105%, the DDT value is 10.4 kg/cm² and Base Tanjung Balai DDT value is 10.1 kg/cm².
4.8. Analysis of Compaction Energy Calculation (Energy Compaction)
Compaction energy in the field can be obtained from grinding machines, vibration compaction devices and heavy objects are dropped. In the laboratory used compaction soil test apparatus. The following are the results of the authors' research on the effects of compaction energy in laboratories and the field. Can be seen in table 1.

Table 1: Elements of CBR and Vibro Roller

| Description         | CBR Laboratory | Vibro Roller |
|---------------------|----------------|--------------|
| Tool weight         | 4.5 (Kg)       | 10000 (Kg)   |
| High Fall           | 45.7 (Cm)      | 36.7 (Hz)    |
| Number of Blouses   | 56             | -            |
| Speed               | 10 M/S         | 6.2 (Mph)    |
| Compaction Energy   | 1134 (Kg.m^2/s)| 164.1 (Kg.m^2/s) |

4.9. Water Content Needed For Compaction
In the process of compaction water content also plays a significant role for the maximum density value. Water is a lubricant for the soil to help unify aggregates and remove air in the compaction process.
But if too much water is given, when given the energy or mechanical load it becomes unfavourable because of the incidence of more pore water pressure and the hydrostatic pressure that makes the grain arrangement "loose" damage the soil density. The amount of water needed for Base Bangkinang per 1 m^3 (105.7 Liter) of water, and for Base Tanjung Balai per 1 m^3 (184 Liter) of water. This value is found from each wopt value.

5. Conclusions
Based on the results of the research and discussion that has been done, it can be concluded that:
The results of the analysis of the Base Bangkinang and Tanjung Balai sieve analysis entered the Base A. Category and for Compaction performed using modified proctor obtained the value of Optimum Water Content 4.5% for Base Bangkinang and 8% for Base Tanjung Balai. From the results of CBR Laboratory testing for reading CBR 2", obtained 121% for Base Bangkinang and 108% Base Tanjung Balai. From the calculation results found the number of compaction trajectories, namely seven trajectories for in the field compaction if using a vibro roller grinding machine capacity of 10500 Kg.

6. References
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