California bearing ratio test (CBR) – Procedure, formula, and Significance

Definition

California bearing ratio test (CBR) is defined as the ratio force per unit area which is required to penetrate a mass of soil with the standard circular piston at a rate of 1.25 millimeters per minute to that required for corresponding penetration of standard material.

\[ \text{CBR} = \frac{\text{Total load}}{\text{Standard load}} \times 100 \]

The table given below the standard loads adopted for a standard material with 100% CBR value for various penetrations.

<table>
<thead>
<tr>
<th>Percentage of plunger (mm)</th>
<th>Standard load (Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td>1370</td>
</tr>
<tr>
<td>5.0</td>
<td>2055</td>
</tr>
<tr>
<td>7.5</td>
<td>2630</td>
</tr>
<tr>
<td>10.0</td>
<td>3180</td>
</tr>
<tr>
<td>12.5</td>
<td>3600</td>
</tr>
</tbody>
</table>

This test is performed on remoulded specimens & undisturbed
specimens which may be compacted either dynamically or statically.

Objective

It is conducted for evaluating the stability of soil sub grade and other flexible pavement materials for the design of pavement thickness.

California bearing ratio test apparatus

- The laboratory CBR apparatus having of mould 150 millimeters internal diameter with base plate and a collar
- A loading frame with a cylindrical plunger of 50 millimeters diameter.

California bearing ratio test procedure – CBR

Briefly, the penetration test consists of causing a cylindrical plunger of 50 millimeters diameter to penetrate a pavement component material at 1.25 mm per minute.
The load values to cause 2.5 millimeters and 5 millimeters penetration are recorded.

These loads are expressed as a percentage of standard load values at respective deformation levels to obtain CBR value.

Standard pressure at 2.5 mm penetration = 70 Kg/cm²

\[
\text{Standard load at 2.5 mm penetration} = 70 \times \pi \left(\frac{50}{10}\right)^2 \times \frac{1}{4}
\]
\[
= 1370 \text{ Kg}
\]

Standard pressure at 5 mm penetration = 105 Kg/cm²

\[
\text{Standard load at 5 mm penetration} = 105 \times \pi \left(\frac{50}{10}\right)^2 \times \frac{1}{4}
\]
\[
= 2055 \text{ Kg}
\]

CBR value of soil at 2.5 mm

\[
= \frac{\text{Pressure on plunger @ 2.5 mm penetration of soil}}{\text{standard pressure (70 Kg/cm²)}} \times 100
\]

CBR value of soil at 5 mm

\[
= \frac{\text{Pressure on plunger @ 5 mm penetration of soil}}{\text{standard pressure (105 Kg/cm²)}} \times 100
\]

- Normally the CBR value of 2.5 mm penetration which is higher than that at 5 mm penetration is repeated as CBR value of material.
- But, if the CBR value at 5 mm is greater than at 2.5 mm penetration, repeat the test. If again test gives similar result then the higher value at 5 mm is reported as a CBR value of the material.
Correction

- The normal curve is with convexity upwards
- Sometimes a curve with initial upward concavity is obtained, then it should be corrected.

Pavement thickness determination

The soaked CBR value is evaluated of the soil sub grade.

Then appropriate design curve is chosen by tasking the
anticipated traffic or by taking the design wheel load into consideration.

Thus, the total thickness of the flexible pavement needed to cover the subgrade of the known CBR value is obtained.

The thickness of construction over subgrade could be obtained from the design chart knowing the CBR value of the sub-base.

Thickness of sub base course = Total thickness – thickness over the sub base

Similarly, find the thickness of the base course and wearing course with the help of corresponding CBR value.

The pavement thickness design formula developed by the U.S corps of Engineers is given by

$$t = \sqrt{\frac{P}{\rho n}} \left( \frac{1.75}{C_{BR}} \right)^{0.5}$$

$$t = \frac{1.75P}{C_{BR} \cdot n}$$

Where, \( t \) = pavement thickness in cm

\( P \) = Wheel load in Kg
CBR = California Bearing ratio in percent

\[ \times = \text{tyre pressure in Kg/cm}^2 \]

\[ A = \text{Area of contact in cm}^2 \]

Note: This formula is only applicable when the CBR value of sub grade soil is less than 12%.

**IRC Recommendation (IRC recommended CBR method)**

**Procedure:-**

- Estimate the design traffic

\[ A = P(1 + r)^{m+n} \]

Where,

\[ A = \text{no. of vehicles per day for design} \]

\[ P = \text{number of vehicles per day} \]
\( r \) = annual rate of increase of vehicles

\( m \) = Life period (10 years for major road)

\( n \) = no. of yrs between the last count & the completion year of construction.

- The suitable design curves should be chosen from the table given in the design chart according to design traffic.
- Thus the total thickness of flexible pavement needed to cover the subgrade of the known CBR value is obtained.
- The thickness of construction over the sub-base could be obtained from the design chart knowing the CBR value of the sub-base.

Thickness of sub base course = total thickness – thickness over the sub base
In a similar way, the thickness of the base course and wearing course is found with the help of corresponding CBR value.

**Uses and significance of California bearing ratio test**

- The CBR test is one of the most important tests which is a commonly used method to evaluate the strength of sub-grade soil, sub-base & base course material for the design of thickness of the highway.
- The CBR test is a penetration test meant for the evaluation of strength of sub-grade of roads & pavements. The results obtained from this method are used with the empirical curves to determine the pavement thickness and its component layers.
- The instruction sheet covers the laboratory method of undisturbed and remolded/compacted soil specimens for the determination of CBR, both in the soaked and un-soaked states.

I hope this article remains helpful for you.

Happy Learning – Civil Concept

Contributed by,

Civil Engineer – Pardeep Thakur
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