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Study on Relation Between CBR Value of Subgrade Soil and Moisture Content

* Mehul I. Patel Prof. **N.G.Raval

* A/41, Shrinath park Soc. Near-Jogeshwari Soc. Amraiwadi, Ahmedabad

** L.D. Engineering College, Ahmedabad Gujarat, India

ABSTRACT

The California Bearing Ratio Test (CBR Test) is a test developed by California State Highway Department (U.S.A.) for evaluating the bearing capacity of sub grade soil for design of flexible pavement. The CBR value of the sub grade soil is being used widely since a long time in design of pavement structure and is critical in deciding the overall thickness of the pavement.

In this study, laboratory investigations have been carried out on a number of soil samples procured from different roadwork sites. CBR tests have been conducted for same samples under various conditions of soaking, with due emphasis on moisture content parameters in the soil sample.

1. INTRODUCTION

The design of the pavement layers to be laid over subgrade soil starts off with the estimation of subgrade strength and the volume of traffic to be carried. Design of the various pavement layers are very much dependent on the strength of the subgrade soil over which they are going to be laid. Weaker subgrade demands thicker layers whereas stronger subgrade goes well along with thinner pavement layers. The Indian Road Congress encodes the exact design strategies of the pavement layers based upon the subgrade strength. Subgrade strength is mostly expressed in terms of CBR, the California Bearing Ratio. Hence, in all, the pavement and the subgrade together must sustain the traffic volume. The subgrade strength owing to its inconsistency or variable nature poses a challenge for the engineer to come up with a perfect design of pavement. For example, the subgrade is always subjected to change in its moisture content due to precipitation, capillary action, flood or abrupt rise or subsided of water table. Change in moisture content causes change in the subgrade strength. And it becomes quite essential for an engineer to understand the exact nature of dependence of subgrade strength on moisture content.

2. THE SUBGRADE

Subgrade can be defined as a compacted layer, generally of naturally occurring local soil, assumed to be 300 mm in thickness, just beneath the pavement crust, providing a suitable foundation for the pavement. The subgrade in embankment is compacted in two layers, usually to a higher standard than the lower part of the embankment. In cuttings, the cut formation, which serves as the subgrade, is treated similarly to provide a suitable foundation for the pavement. Where the naturally occurring local subgrade soils have poor engineering properties and low strength in terms of CBR, for Ex. In Black Cotton soil areas, improved subgrades are provided by way of lime/cement treatment or by mechanical stabilization and other similar techniques. The subgrade, whether in cutting or in embankment, should be well compacted to utilize its full strength and to economize on the overall pavement thickness. The Ministry of Road Transport and Highway Specifications require that the subgrade should be compacted to 100% Maximum Dry Density achieved by the Modified Proctor Test (IS 2720-Part 7). The material used for subgrade construction should have a dry unit weight of not less than 16.5kN/m³.

3. CALIFORNIA BEARING RATIO (The Actual Method)

The CBR test was originally developed by O.J. Porter for the

California Highway Department during the 1920s. It is a load-deformation test performed in the laboratory or in the field, whose results are then used with an empirical design chart to determine the thickness of flexible pavement, base, and other layers for a given vehicle loading. Though the test originated in California, the California Department of Transportation and most other highway agencies have since abandoned the CBR method of pavement design. In the 1940s, the US Army Corps of Engineers (USACE) adopted the CBR method of design for flexible airfield pavements. The USACE and USAF design practice for surfaced and unsurfaced airfields is still based upon CBR today (US Army, 2001; US Army and USAF, 1994). The CBR determination may be performed either in the laboratory, typically with a recompacted sample, or in the field. Because of typical logistics and time constraints with the laboratory test, the field CBR is more typically used by the military for design of contingency roads and airfields.

The thickness of different elements comprising a pavement is determined by CBR values. The CBR test is a small scale penetration test in which a cylindrical plunger of 5 cm in dia cross-section is penetrated into a soil mass (i.e., sub-grade material) at the rate of 0.05 in. per minute (1.25 mm/minute). Observations are taken between the penetration resistance (called the test load) versus the penetration of plunger. The penetration resistance of the plunger into a standard sample of crushed stone for the corresponding penetration is called standard load. The California bearing ratio, abbreviated as CBR is defined as the ratio of the test load to the standard load, expressed as percentage for a given penetration of the plunger.

$$CBR = (\text{Test load}/\text{Standard load}) \times 100$$

4. DATA COLLECTION

Five soil samples viz. A, B, C, D and E moulded at its optimum moisture content to its proctor density was tested for its CBR strength. Thus the process comprises of three parts.

1. Estimation of proctor density and optimum moisture content for each soil sample.
2. Moulding the soil sample into standard moulds keeping its moisture content and dry density exactly same as its optimum moisture content and proctor density respectively.
3. Determination of CBR strength of the respective soil samples in moulds using the CBR instrument.

Each soil sample is tested for its CBR strength after being soaked in water for 1 day, 2 days, 3 days and 4 days. Un-soaked CBR is also determined for each sample.

The maximum dry density and Optimum moisture content of various sample is described in below table.

Sample	MDD (kg/ m ³)	O.M.C. (%)
A	2272	6.5
B	2188	7.3
C	2356	7.6
D	2215	6.9
E	1880	8.6

Table 1 maximum dry density and Optimum moisture content of various sample

The CBR value of various samples is described in below table

Sam-ple	CBR value	Un soaked	1 day soaked	2 day soaked	3 day soaked	4 day soaked
A	CBR _{2.5}	24.1	17.5	8.2	4.9	4.29
	CBR _{5.0}	23.6	16.8	14.6	6.3	6.2
B	CBR _{2.5}	12.3	10.5	8.4	5.5	3.5
	CBR _{5.0}	11.5	9.6	6.5	5.1	2.9
C	CBR _{2.5}	12.6	10.5	7.6	5.2	3.2
	CBR _{5.0}	14.8	8.5	7.6	4.2	2.5
D	CBR _{2.5}	15.6	12.3	9.5	4.6	2.2
	CBR _{5.0}	14.9	11.2	8.5	6.5	2.6
E	CBR _{2.5}	10.5	6.5	5.5	4.6	2.6
	CBR _{5.0}	11.5	8.5	5.4	4.2	2.8

Table 2 CBR value of various samples

5. VARIATION OF CBR WITH 4 (four) DAYS OF SOAKING.
The variation of CBR value of different sample with respected to their soaking period is described in below table

Samples	Value of CBR				
	Un soaked	1 day soaked	2 day soaked	3 day soaked	4 day soaked
Sample A	24.1	17.5	8.2	4.9	4.29
Sample B	12.3	10.5	8.4	5.5	3.5
Sample C	12.6	10.5	7.6	5.2	3.2
Sample D	15.6	12.3	9.5	4.6	2.2
Sample E	10.5	6.5	5.5	4.6	2.6

Table 3 Variation of CBR value of different sample with respected to their soaking period

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This relation is described as a graphically in below figure.

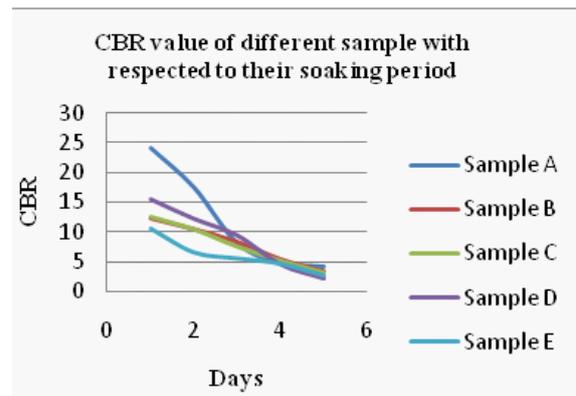


Figure 1 Variation of CBR value of different sample with respected to their soaking period

The Moisture content of different sample with different soaking day is described below

Days	0	1	2	3	4
Sample A	6.5	8.5	9.6	10.5	11.2
Sample B	7.3	9.5	10.2	10.6	11.3
Sample C	7.6	9.6	10.5	11.5	11.9
Sample D	6.9	8.5	9.7	11.5	11.9
Sample E	8.6	10.5	11	11.5	12.6

Table 4 Moisture content of different sample with different soaking day

This relation is described as a graphically in below figure.

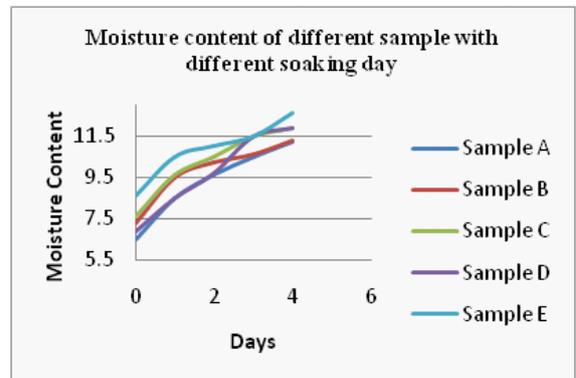


Figure 2 Moisture content of different sample with different soaking day

6. Conclusion

On increasing the number of days of soaking, CBR decreases due to higher ingress of water. Dramatic loss of strength is observed when unsoaked soil is soaked for 1 day under water and then tested for its CBR strength. On further increasing the number of days of soaking, gradual and not dramatic loss of strength is observed. Hence, the graph (CBR Vs soaking days) commences with a steep fall and then goes on with feeble falls. Rate of ingress of water decreases with days of soaking because it closes in towards saturation. Most amount of water is soaked on the 1st day and thus accounts for the highest drop in CBR strength of the soil sample.



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