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CBR Predicted by Index Properties for Alluvial Soils of South Gujarat

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ABSTRACT

California Bearing Ratio (CBR) is a commonly used indirect method to assess the stiffness modulus and shear strength of sub grade in pavement design. However; it is always difficult for transportation engineers to obtain representative CBR value for design of pavement. Type of soil is not the only parameter which affects the CBR value, but it also varies with different soil properties possessed by the soil. A method is proposed for correlating CBR values with the Liquid Limit, Plastic Limit, Plasticity Index, Optimum Moisture Content, and Maximum Dry Density of cohesive soils of various zones of Surat city of Gujarat state. These tests are much more economical and rapid than CBR test. The type of soil found in Surat region is mainly Alluvium which consists of clay, sand, silt. The correlation is established in the form of an equation of CBR as a function of different soil properties by the method of regression analysis. A study evolved to find the correlation between CBR values with soil index properties that are suitable for Surat city. Comparison is done between the experimental results and calculated results. Statistical Analysis is carried out using SPSS Software version 13.0 and programming language. Finally equations are derived for CBR unsoak and soak conditions which are applicable to the local region where the soil properties are within the specified ranges. The correlation can be used with experience for determining CBR value using basic soil properties for no of samples at 100m interval & checked by few CBR test representing a similar range of CBR..

1. INTRODUCTION

Indian road network consist of 33 lakh km. and is second largest in the world. India has large and extensive transportation system. About 65% of freight and 80% passenger traffic is carried by the roads. Number of vehicles has been growing at an average pace of 10.16% per annum over the last five years. Roads may be classified into: National Highways, State Highways, Major District Roads and other Roads (Urban, Village & Panchayat Roads). Geotechnical engineering should play one of the most important roles in early stage of Planning and Design of Infrastructure, due to the fact that incorrect geotechnics can result in unreasonably high cost.

For the design of pavement CBR value is one of the important parameters.CBR value can be measured directly in the laboratory test in accordance with IS 2720 part 16 on soil sample acquired from site. Laboratory test takes at least four 4 days to measure the CBR value for each soil sample. Civil engineers always encounter difficulties in obtaining representative CBR value for design of pavement. CBR value is affected by the type of soil and different soil properties. An attempt has been made to correlate the CBR with soil properties. It can be the alternate method for the time consuming tests. These tests are much economical and rapid than CBR test.

This paper gives and over view to obtain a correlation between CBR values with soil index properties that is suited for Surat City. It may be used for other alluvial deposits judiciously and after check tests.

2. EXPERIMENTAL WORK

The soil samples were collected from six different zones of Surat City, two samples from each zone. These zones are North Zone, South-East Zone, East Zone, South Zone, South-West Zone, and West Zone. The selected soil sample are tested for CBR value, optimum moisture content, maximum dry density, particle size distribution, plastic limit, liquid limit plasticity index, and shrinkage limit. These tests were performed according IS code specifications.

Table 1: Atterberg Limits for Soil Samples

Test	*LL*	*PL*	*SL*
1	52.98	18.54	16.7
2	63.63	26.8	8.03
3	58.79	19.7	9.78
4	70.78	24.68	16.7
5	59.57	20.07	9.7
6	50.58	18.86	17.2
7	61.77	18.75	9.24
8	64.87	17.09	10
9	44.7	20.51	19.55
10	53.47	19.26	12.38
11	49.58	20.31	19.5
12	64.39	19.81	14.74

Graphical Analysis

Various graphs in Figure 1, 2 and 3 are displayed showing linear trend line, which shows the effect of various soil properties with CBR value. As the plasticity index, maximum dry density and optimum moisture content increases the CBR value decreases. Comparison of the properties also shows that the ratio of unsoak CBR/ soak CBR is equal to 0.5 (approximately).

Table 2: Result of Laboratory Test for Soil Samples

Test	*MDD*	*OMC*	*Ip*	*CBR (Unsoak)*	*CBR (Soak)*
1	1.73	20.50	34.40	5.48	1.54
2	1.70	20.68	36.83	7.73	1.82
3	1.69	19.80	39.08	4.05	1.73
4	1.58	22.30	46.10	3.3	2.3
5	1.70	20.20	39.50	5.37	3.02
6	1.66	20.69	31.72	5.88	4.42
7	1.65	17.23	43.02	5.80	3.60
8	1.68	21.20	47.78	3.13	1.73
9	1.72	20.90	24.19	2.80	2.15
10	1.63	23.73	34.21	8.94	3.1
11	1.69	20.75	29.27	5.47	3.35
12	1.58	24.70	44.58	5.20	2.48

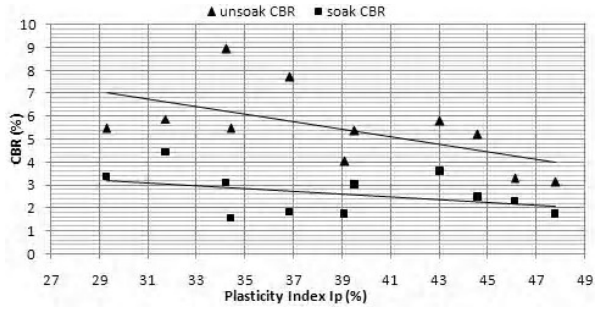

Fig. 1: Effect of Plasticity Index on CBR Under Soak and Unsoak Condition

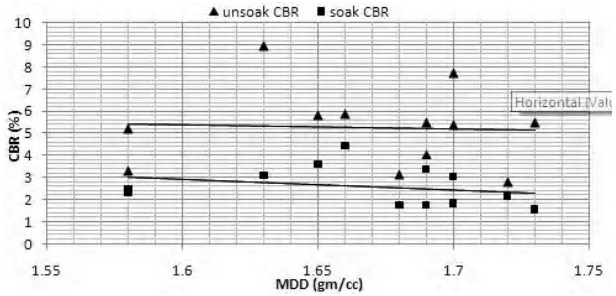

Fig. 2: Effect of Maximum Dry Density on CBR Under Soak and Unsoak Condition

Statistical Analysis

To fulfill the objective of the study, the results out of laboratory experiments carried out were studied and were analyzed statistically. To build the relation between California Bearing Ratio and the soil index properties linear Regression Model is used through excel and SPSS software.

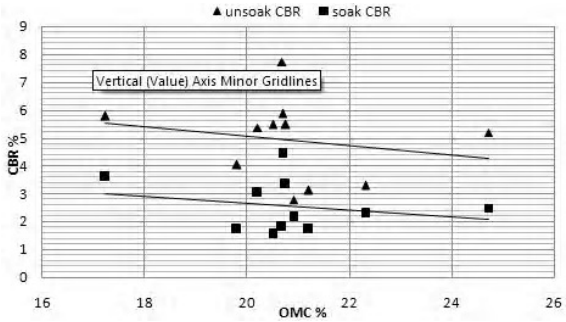

Fig. 3: Effect of Optimum Moisture Content on CBR Under Soak and Unsoak Condition

Equations

(1) CBR (unsoak) = 54.247 - 212.216 (LL) + 212.18 (PL) + 211.937 (Ip) - 0.467 (SL) - 20.903 (MDD) + 0.159 (OMC)

(2) CBR (soak) = 53.783 - 103.571 (LL) + 103.447 (PL) + 103.443 (Ip) - 0.077 (SL) -21.782 (MDD) - 0.304 (OMC)

(3) CBR (Unsoak) = 17.009 - 0.0696 (Ip) - 6.296 (MDD) + 0.0648 (OMC)

(4) CBR (Soak) = 43.907 - 0.093 (Ip) - 18.78 (MDD) - 0.3081 (OMC)

(5) CBR = 4.745 - 0.044 (LL) + 0.1508 (PL)

(6) CBR = 11.805 - 0.126 (LL) + 0.234 (PL) -0.246(SL)

(7) CBR = 64.187 - 0.278 (LL) + 0.272 (PL) - 0.406 (SL) - 25.666 (MDD)

(8) CBR = 5.176 - 0.028 (LL) - 0.047 (PL)

(9) CBR = 4.740 - 0.023 (LL) - 0.050 (PL) + 0.015 (SL)

(10) CBR = 34.852 - 0.110 (LL) - 0.011 (PL) - 0.076 (SL) - 14.754 (MDD)

Where, CBR = California Bearing ratio, LL = Liquid Limit, PL = Plastic Limit, SL = Shrinkage Limit, I_p = Plasticity Index, OMC = Optimum Moisture Content, MDD = Maximum Dry Density.

Excel Solution

The given problem can be solved in excel by multiple regression analysis with the help of linest function. After solving in excel we get two equations 1 and 2. These equations includes the correlation of the all the six parameters with CBR value. Many times it is not feasible to get all six parameters, so we can go for another set of equation where three input parameters can be considered for obtaining the equations. The three parameters are Plasticity Index, Maximum Dry Density and Optimum Moisture Content. The reason behind considering these parameters is CBR value is mainly affected by these parameters as studied in literature and laboratory results.

The equation 3 and 4 shows the relation between CBR soak and unsoak condition and Plasticity Index, Maximum Dry Density and Optimum Moisture Content.

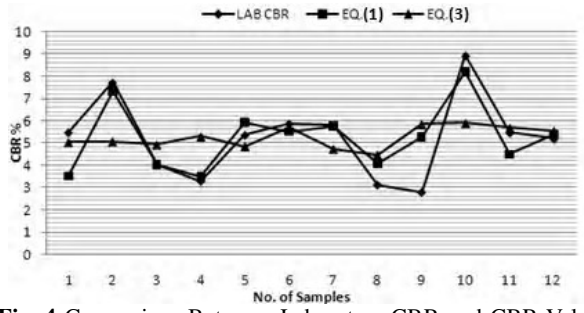

Fig. 4 Comparison Between Laboratory CBR and CBR Value Obtained from Equation 1 and 3 in Unsoak Condition

The Figure 4 shows the comparison between CBR values obtained from equation 1 and equation 3 and laboratory CBR for unsoak condition. It can be observed that results obtained from equation 1 and 3 are nearer to the laboratory results. The percentage error calculated is -6% for equation 1 and -12% for equation 3.

The Figure 5 shows the comparison between CBR values obtained from equation 2 and equation 4 and laboratory CBR for soak condition. It can be observed that results obtained from equation 2 and 4 are nearer to the laboratory results. The percentage error calculated is -2.5% for equation 2 and -5% for equation 4.

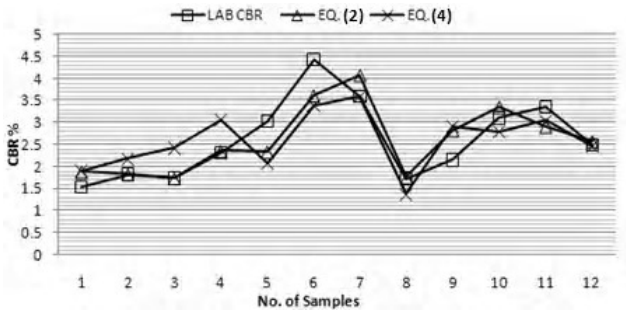

Fig. 5: Comparison Between Laboratory CBR and CBR Value Obtained from Equation 2 and 4 in Soak Condition

SPSS Solution

SPSS Software is used to determine the multiple linear regression models. Linear Regression estimates the coefficients of the linear equation, involving one or more independent variables that best predict the value of the dependent variable. Regression analysis gives the different equations by correlating CBR values with different groups of soil properties.

Equations for unsoak CBR analysed gave equation no. 5 which is correlation with Liquid limit and plastic limit. Equation no. 6 which is correlation with liquid limit, plastic limit and shrinkage limit. Equation no. 7 is correlation with liquid limit, plastic limit, shrinkage limit and maximum dry density.

Similarly equations for soak CBR analysed are equation no. 8 which is correlated with Liquid limit and plastic limit. Equation no. 9 which is correlates CBR with liquid limit, plastic limit and shrinkage limit. Equation no. 10 is correlation with liquid limit, plastic limit, shrinkage limit and maximum dry density.

The percentage errors are also calculated in this equation. For unsoak condition CBR equations, error is -23.5% for equation 5, -25% for equation 6, and -42% for equation 7.

For soak condition CBR equations, the error is -10.2% for equation 8, -10.5% for equation 9 and -5.7% for equation 10.

After comparing the excel solution and SPSS solution it is observed that the percentage error in SPSS model is high in comparison to Excel model. In excel solution the equation results are nearer to laboratory results with very less percentage of error. Hence it is preferable to use excel solution than SPSS solution.

3. CONCLUSION

Total soil data obtained was 12 numbers and it belonged to fine-grained soils. Observing the results from the SPSS software and programming language these equations were formed.

The first preferable model is in the form of equation 3 and 4 which shows the relation between plasticity index, optimum moisture content, maximum dry density and CBR (soak) value with an error of -2.5% for equation 3 and -5% for equation 4. The second preferable model is in the form of equation 1 and 2. In these equations the correlation in developed between CBR value and the group of soil index properties which include, liquid limit, plastic limit, plasticity index, shrinkage limit, maximum dry density and optimum moisture content. For the fine grained soil ranges unsoak CBR ranges from 2.5 % to 9.0 % and soak CBR ranges from 1.5 % to 4.5 %. Effect of soil properties on CBR value can be explained as Liquid Limit and Plastic Limit has low influence

on CBR value. But CBR value varies with Plasticity Index, when Plasticity Index increases CBR value decreases and when Plasticity Index decreases CBR value increases. This shows that there is relation between CBR value and Clay content of the soil. As the clay content is high or low it directly affects the CBR value. Also there is an improvement in CBR value with increasing Shrinkage Limit. From the comparison made in Graphical Analysis of soil data, It can be concluded that the ratio of unsoak /soak CBR= 0.5 (approximately). The type of soils obtained for this study is mostly the alluvium soil since it consists of gravels, sands, silts and clays. It will be interesting to obtain different types of soil such as alluvium soils, marine clays, silty clay etc. for further study.

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