PREDICTION OF CBR VALUE BY USING INDEX PROPERTIES OF SOIL

Ravichandra A H[1], Shivakumar K[2], Vinaykumar H[3], Md. Khalid. S[4], Basavaraj B[5]

[1,2,3,4,5]Assistant Professor, Civil Department BITM Ballari, Karnataka

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Abstract - *Sub grade strength is mostly affected by thickness of pavement, in Highway design. California Bearing Ratio (CBR) is the one of the method to determine the sub grade strength. CBR test is laborious and time consuming hence a method is proposed for correlating CBR value with the LL, PL, SL, PI, OMC and MDD. In the present study, different soils samples (having 20<LL<70) were collected from different locations. Various laboratory tests including Atterberg limit, Specific Gravity, Gradation Analysis, CBR and compaction were performed on the samples. Various linear relationships between index properties and CBR of the samples were investigated using simple linear regression analysis and also predictive equation estimating CBR from the experimental index values were developed.*

*Key Words***:** CBR, LL, PL, PI, OMC, MDD

1. INTRODUCTION

All civil engineering works such as the construction of highway, building structure, dam and other structure have a strong relationship with soil. All those structures need a strong layer of soil to make sure the structure are strong and stable. The weakness and failure of soil may capable make the structure which builds above of it become weak and collapse or fail. Therefore, the proper analysis of soil is necessary to ensure that these structures remain safe and free endue settling and collapse. A comprehensive knowledge of the soil in specific location may also be important in order contexts, including the use of soil as a source of construction material. In order to obtain the knowledge, soil sample must be collected from a required site and tested it to evaluate the engineering properties of soil.

Soil conditions vary from one location to another location; hence, virtually no construction site present soil conditions exactly like other site. In general, soils are blends or mixtures of particles of many sizes, shapes, and parent materials. Hence it is difficult to predict the behaviour of soil. As a result, soil conditions at every site must be thoroughly investigated for proper design.

Most of the Indian highways system consists of flexible pavement. There are different methods of design of flexible pavement. The California Bearing Ratio (CBR) test is an empirical method of design of flexible pavement [1]. Sub grade soil bearing capacity plays very important role for the design of highway structure. It determines the thickness of the pavement [2]. In other words, sub grade that has lower CBR value will have thicker pavement compared with the sub grade that has higher CBR value. CBR values can be measured directly in the laboratory test in accordance with IS 2720 part-XVI on soil sample obtained from the site [3].

However, to conduct a CBR test, representative soil sample has to be collected from the location selected, from which a remoulded specimen has to be prepared at predetermined Optimum moisture content and maximum dry density with standard proctor compaction, for the test to be conducted. To obtain soaked CBR value of a soil sample, it takes about a week, making CBR test expensive, time consuming and laborious [4]. Improper handling and poor quality of testing conditions in hurriedly established field laboratories for temporary purposes in sites may have some reservations about accuracy of the results produced.

1.1 PROBLEM STATEMENT

Civil engineers always encounter difficulties in obtaining representative CBR values for pavement design.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.

2. OBJECTIVES OF THE STUDY

1. To understand relationship between CBR values and physical properties of soil (liquid limit, plastic limit, shrinkage limit, plasticity index, maximum dry density, Optimum moisture content) samples collected from different location.
2. The main objective of the study is to carry out regression analysis from laboratory experimental results.

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3. MATERIALS AND METHODOLOGY.

3.1 SAMPLE COLLECTION

Ten soil samples were collected from in and around the Ballari region which is having Latitude 15010'09"N and Longitude 76051'06"E .The selected sample consists of both coarse as well as fine grained soil. Soil samples were collected at a depth of 0.5- 1m below ground level to avoid organic matter. The selected soil samples tested for CBR value, Optimum moisture content, maximum dry density, particle size distribution, plastic limit and liquid limit. Based on Indian Standard optimum moisture content and maximum dry density was carried out on soil samples that collected by bulk samples. All the soil samples are having different Liquid Limit.

Fig 1 Study area

3.2 METHODOLOGY

In this chapter, all the laboratory test results are presented and discussed. Regression analyses carried out to meet the objective of the study based on laboratory tests results of ten soil samples collected from different locations of Ballari region.

Regression analysis is a statistical technique for modelling and investigating the relationship between two or more variable. A variable whose value is predicted is called dependent variable. A variable used to predict the value of dependent variable is termed as independent variable.

SIMPLE LINEAR REGRESSION ANALYSIS (SLRA)

SLRA has been carried out to develop the correlation between individual basic soil property and soaked CBR value. SLRA can be carried out by using standard statistical software like Data Analysis Tool Bar of Microsoft Excel in order to derive the relationship statistically. Statistical parameters of soaked CBR value predicted by various SLRA models are presented.

In this study soaked CBR quality is considered as free variable and one of the parameter, for example, Gravel (G), Fines (F), Sand(S), LL, PL, MDD and OMC are considered as the dependent variables. Basic Linear Regression Analysis (SLRA) has been completed to build up the connection between one soil property and soaked CBR value Suitable Trend-Line Method

In this method a simple XY scatter graph is plotted by keeping individual soil properties on X-axis and CBR value on Y-axis and suitable trend-lines were selected based on higher coefficient of determination

RESULTS AND DISCUSSION

4.1 RESULTS OF INDEX PROPERTIES OF THE SOIL

Table 1 Experimental results or Laboratory Test Results

Sl No	Description	Sample Number				
		1	2	3	4	5
1	**Sieve Analysis**					
	Gravel (%)	27.73	1.86	0	2	5.23
	Coarse Sand (%)	36.55	0.76	5.3	8	12.64
	Medium Sand (%)	7.25	30	6.62	4	25.1
	Fine Sand (%)	8.51	19.69	2.96	15.73	14.98
	Coarse Grained Soil (%)	80.04	52.31	14.88	29.73	57.95
	Fine Grained Soil (%)	19.96	47.69	85.12	70.27	42.05
2	**Atterberg limits**					
	Liquid Limit (%)	29	43.5	78	72.5	47
	Shrinkage Limit (%)	6.25	9.6	16.23	20.02	17.85
	Plasticity Index (%)	11	25.36	35	44.5	25.5
3	**Compaction Characteristics**					
	Optimum Moisture Content (%)	12.6	20	29.8	28.6	20
	Maximum Dry Density (kN/m^3)	22	17	14.2	14.5	16.6
4	**Specific Gravity**	2.59	2.63	2.82	2.8	2.5
5	**Void Ratio**	0.177	0.547	0.986	0.931	0.506
6	**Soaked *CBR* (%)**	9.2	3.33	0.48	1.33	3.16

CORREALTION BETWEEN DIFFERENT PROPERTIES OF THE SOIL

4.1 Correlation between CBR and Liquid limit

$$y = 35.23e^{-0.05x}$$
$$R^2 = 0.955$$
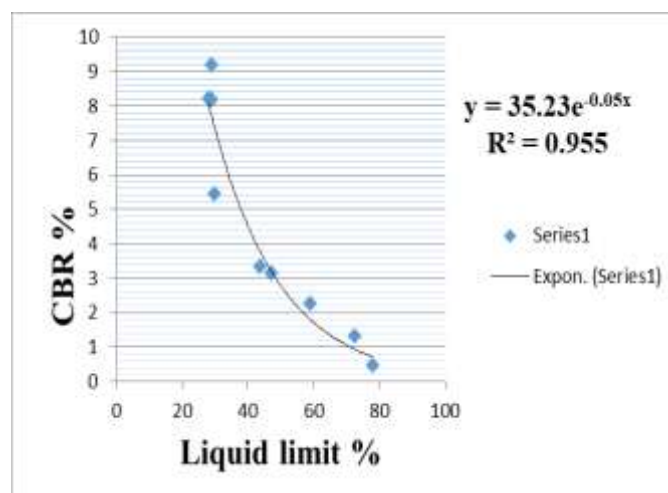
Fig-2 Correlation b/w CBR and liquid limit

The variation between soaked *CBR* and liquid limit is shown in fig 2 and the suitable trend line obtained is exponential equation 4.2.1

The variation between soaked *CBR* and plasticity index is shown in fig 4.1 and the suitable trend line obtained is exponential equation 4.2.1
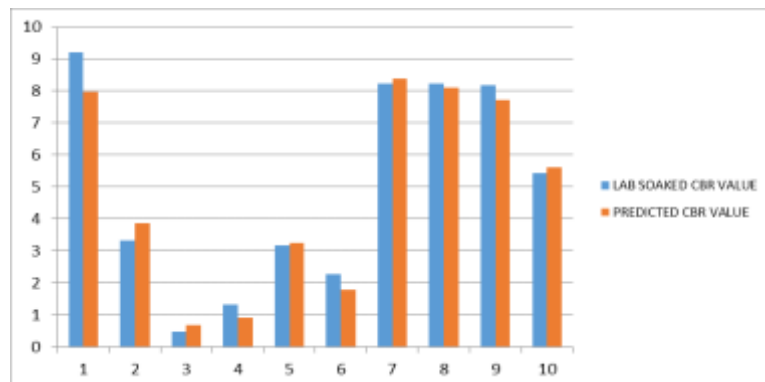
$$CBR = 35.23e^{-0.05LL}$$

Determination coefficient obtained is 0.955 and predicted *CBR* value is compared with laboratory *CBR* value

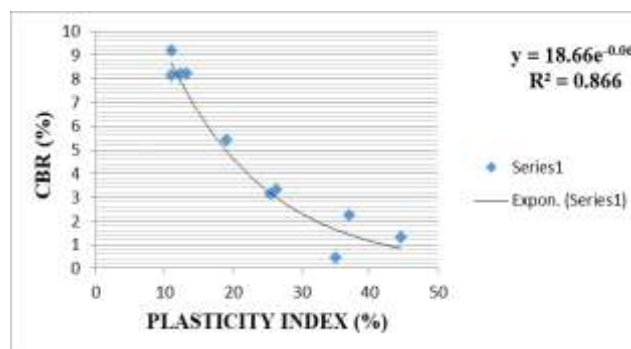Determination coefficient obtained is 0.955 and predicted *CBR* value is compared with laboratory *CBR* value

Table-2 Comparison of lab CBR value with predicted CBR obtained by equation

Sample no	Liquidlimit (%)	Lab soaked *CBR* (%)	*CBR* obtained from equation	Difference *CBR*	% Difference
1	29	9.2	7.98	-1.22	13.29
2	43.5	3.33	3.86	0.53	16.03
3	78	0.48	0.69	0.21	43.42
4	72.5	1.33	0.91	-0.42	31.85
5	47	3.16	3.24	0.08	2.64
6	59	2.26	1.78	-0.48	21.24
7	28	8.24	8.39	0.15	1.78
8	28.7	8.24	8.10	-0.14	1.72
9	29.6	8.17	7.72	-0.45	5.48
10	36	5.44	5.62	0.18	3.34

Fig-3: Predicted CBR from equation-4.2.1 and laboratory CBR.

4.2 Correlation between CBR and Plasticity Index.

Fig-4 Relation between CBR with Plasticity Index

The variation between soaked CBR and Plasticity Index is shown in fig 4.3 and the suitable trend line obtained is logarithmic equation
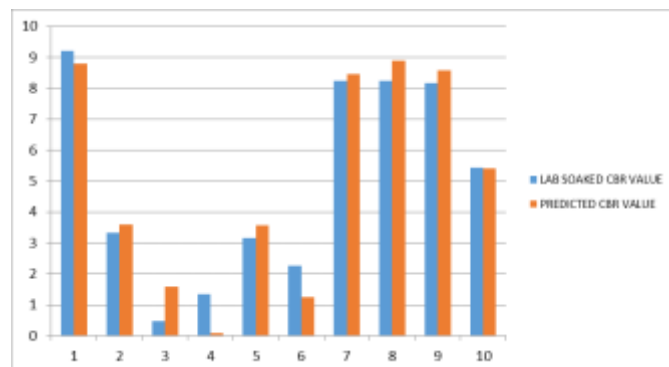
CBR = 18.66e−0.06P   ----(4.2.2)

Determination coefficient 0.866 and predicted CBR value is compared with laboratory CBR
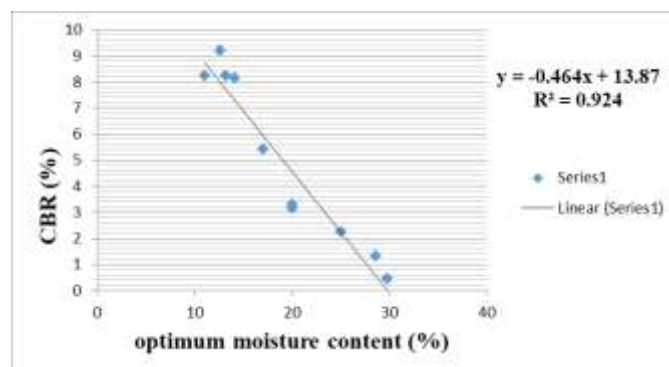
Value in table No-3 and variation is plotted in fig-5

Table-3 Comparison of lab CBR value with predicted *CBR* obtained by equation-4.2. 2

Sample no	OMC (%)	Lab soaked CBR (%)	CBR obtained from equation	Difference CBR	% Difference
1	12.6	9.2	10.07	0.87	9.46
2	20	3.33	3.32	-0.01	0.34
3	29.8	0.48	0.76	0.28	58.97
4	28.6	1.33	0.91	-0.42	31.31
5	20	3.16	3.32	0.16	5.03
6	25	2.26	1.57	-0.69	30.63
7	13.2	8.24	9.20	0.96	11.70
8	13	8.24	9.48	1.24	15.10
9	14.11	8.17	8.03	-0.14	1.72
10	17	5.44	5.20	-0.24	4.32

Fig-5 Predicted CBR from equation-4.2.2 and laboratory CBR.

4.3 Correlation between CBR and Optimum Moisture Content

Fig-6 Relation between CBR with optimum moisture content

The variation between soaked *CBR* and optimum moisture content is shown in fig 4.5 and the suitable trend line obtained is liner equation
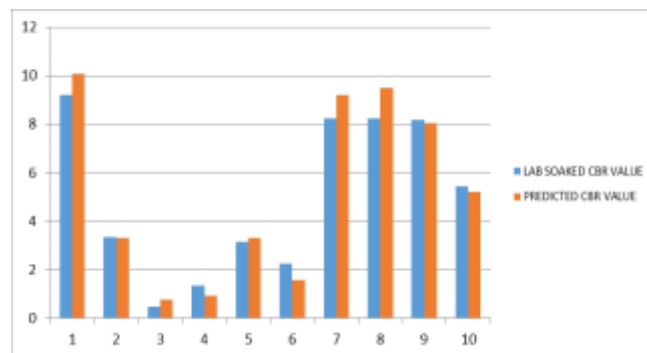
CBR = -0.464x+13.87   ----- (4.2.3)

Determination coefficient is 0.924 and predicted *CBR* value is compared with laboratory

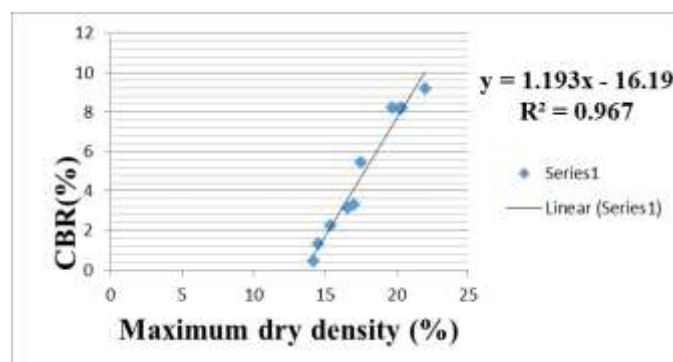*CBR* value in table No-4.5 and variation is plotted in fig-4.6.

Table-4 Comparison of lab CBR value with predicted CBR obtained by equation-4.2.3

Sample no	Plasticity index (%)	Lab soaked *CBR* (%)	*CBR* obtained from equation	Difference *CBR*	% Difference
1	11	9.2	8.80	-0.40	4.34
2	25.36	3.33	3.60	0.27	8.03
3	35	0.48	1.59	1.11	31.29
4	44.5	1.33	0.09	-1.24	92.92
5	25.5	3.16	3.56	0.40	12.75
6	37	2.26	1.24	-1.02	44.96
7	13.2	8.24	8.45	-0.65	7.88
8	12.34	8.24	8.89	-0.65	7.88
9	11.4	8.17	8.58	0.41	5.00
10	19	5.44	5.40	-0.04	0.81

Fig-7 Predicted CBR from equation-4.2.3 and laboratory CBR

4.2.4 Correlation between CBR and Maximum Dry Density

Fig 8. Relation between CBR with Maximum dry density.

The variation between soaked CBR and Maximum Dry Density is shown in fig 4.7 and the suitable trend line obtained is liner equation

$CBR = 1.193 MDD - 16.19$ ----- (4.2.4)

Determination coefficient is 0.967 and predicted CBR value is compared with laboratory

CBR value in table-4.6 and variation is plotted in fig-4.8

Table-5 Comparison of lab CBR value with predicted CBR obtained by equation-4.2.4

Sample no	Maximum dry density (kN/m³)	Lab soaked *CBR* (%)	*CBR* obtained from equation	Difference *CBR*	% Difference
1	22	9.2	10.59	1.39	15.13
2	17	3.33	4.41	1.08	32.49
3	14.2	0.48	0.95	0.47	98.17
4	14.5	1.33	1.32	-0.01	0.60
5	16.6	3.16	3.92	0.76	23.97
6	15.4	2.26	2.43	0.17	7.72
7	19.7	8.24	7.75	-0.49	5.96
8	20.4	8.24	8.61	0.37	4.54
9	20.2	8.17	8.37	0.20	2.41
10	17.5	5.44	5.03	-0.41	7.54
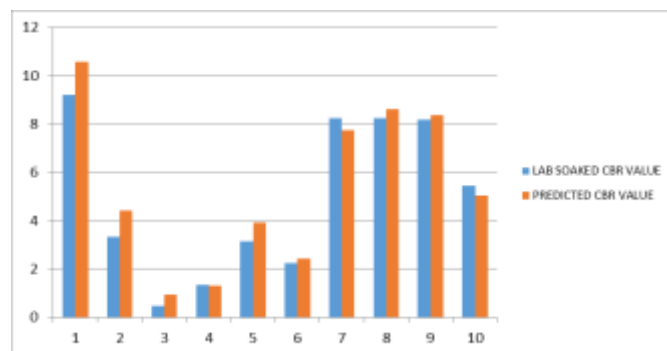
Fig-9 Predicted CBR from equation-4.3.4 and laboratory CBR.

5. CONCLUSIONS

Based on above test results and discussions the following conclusions may be made

From regression method CBR can be predicted using soil properties.

MDD is considered as higher priority for predicting soaked CBR value followed by PI, LL and OMC, based on assessment factor $R^2 = 0.95$.

The model generated using Liquid limit also provides good result with $R^2 = 0.941$ as the test requires small quantity of sample and less time consuming.

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