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Prediction of CBR value from Physical properties of coarse grained soils

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Abstract: ***California Bearing Ratio (CBR) has been recommended as one of the important parameter to determine the strength of sub grade soil of, road embankments, airport runways, bridge abutments and pavements. Technically, the CBR test can be carried out in the laboratory or in the field. The CBR test is time-consuming, laborious and expensive; hence a method is proposed to correlate CBR value with index properties and compaction properties of coarse grained soil. The laboratory test for estimation of OMC, MDD and Grain size distribution are easy and can be perform quickly. The correlation is established using data analysis tool pack of Microsoft excel.***
Keywords: Coefficient of correlation (R) 2, MLRA, Regression, Soaked CBR value, SLRA.

I. INTRODUCTION

Strong foundation is always necessary for the construction of any kinds of engineering projects, such as construction of highway, building, dams and other structures, all those involving large quantities of earth works. Therefore, it is necessary to have reliable methods to access the engineering properties of such projects. In India and all over the world California Bearing Ratio (CBR) test is the most common test adopted for the design of flexible pavements.

In India the design of flexible pavement is made primarily other basis of the sub grade strength which is based on CBR value. It determines the thickness of the pavement. 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 calculated directly in the laboratory test as per the specification provided in IS 2720 part-XVI. For this study soil samples were collected from different locations of Jabalpur city of Madhya Pradesh India.

CBR test is quite time consuming, expensive and tedious test but it is necessary to perform multiple tests throughout the length of pavement in order to get a proper idea about strength of sub grade material. This leads to serious delay in project and also increases cost of project. It is therefore necessary to predict CBR values from simpler basic soil test in order to achieve economy in time and money.

With these objectives as the prime focus in this paper an attempt has been made to correlate the CBR values with simple soil index properties and compaction properties from data generated in the laboratory. Pradeep Muley and Jain (2013) developed a correlation to predict *CBR* of stone dust mixed poor soil. Roy *et.al*; 2010, Mukesh and H S Patel established a correlation between physical properties and CBR value both in soaked and unsoaked condition. Patel *et.al* (2010), Venkatasubramanian and Dhinakaran (2011), Ramasubbarao and Siva Sankar (2013), Akshay (2013), and Dilip Kumar Tulukdar (2014) had developed multiple liner regression analysis models *(MLRA)* for correlating *CBR* with index properties of soil.

This paper gives and over view to obtain a correlation between CBR values with soil index properties and compaction properties of coarse grained soil.

II. EXPERIMENTAL WORK

Eight no of disturbed soil samples are collected from different region of Jabalpur city. Three major tests are performed on each of the collected soil sample, grain size distribution, modified proctor and soaked California Bearing Ratio (CBR) test. All these tests are performed as per the IS code specifications. Outcomes of these tests are used to perform regression analysis. Simple and multiple linear regression analysis are done to predict soaked cbr value from physical properties of coarse grained soils. Multiple linear regression analysis is performed by considering CBR value as dependent variable and D_{30}, D_{60}, Cu, MDD and OMC as independent variables.

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Table 1: Test results obtained from various laboratory tests.

S No	D_{30} (mm)	D_{60} (mm)	D_{10} (mm)	C_C	C_u	OMC %	MDD (g/cc)	CBR %	SOIL TYPE
1	7.1	13.44	1.15	3.26	11.2	10.8	2.14	18	GP
2	8.2	30.2	2	1.11	15.1	8	2.2	32	GW
3	5.1	18.62	1.4	1	13.3	9	2.17	21	GW
4	5	13.2	1.2	1.57	12	9.2	2.15	20	GW
5	.46	1.1	.17	1.13	6.47	9.8	2.06	12	SW
6	.49	1	.247	0.97	4.04	10.5	2.05	11.4	SP
7	.5	.8	.33	0.94	2.42	11.2	2.03	9.2	SP
8	.48	.7	.32	0.96	2.18	12	2	8.4	SP

III. RESULTS AND DISCUSSION

Results of experimental works are shown in table 1.Outcomes of laboratory test are used to develop regression models for the prediction of California bearing ratio using simple linear regression analysis on Excel as shown below in figures 1 to 6.

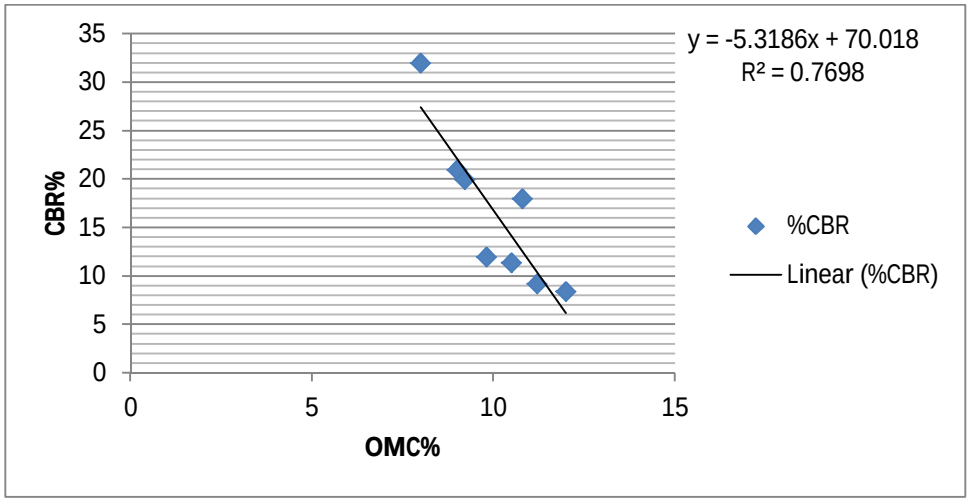

Figure 1: Optimum moisture content verses Soaked CBR value

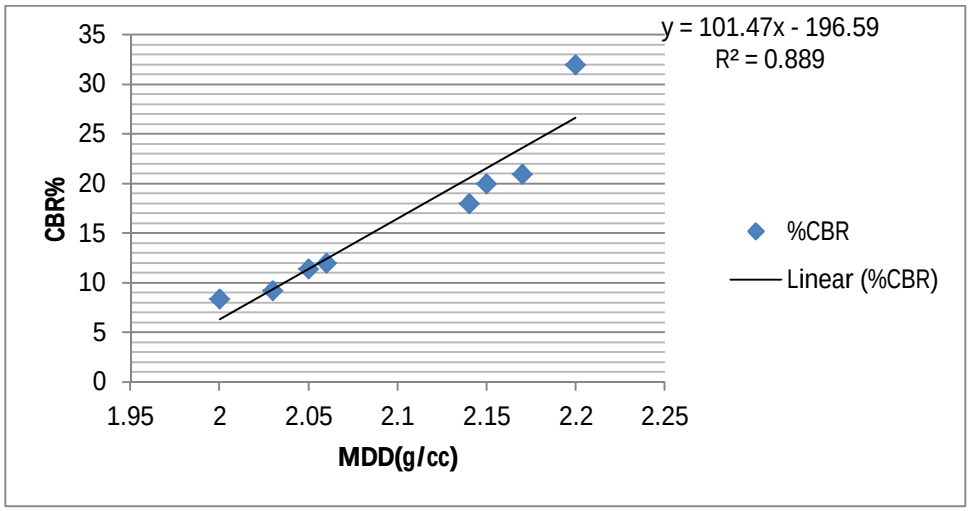

Figure 2: maximum dry density verses soaked cbr value

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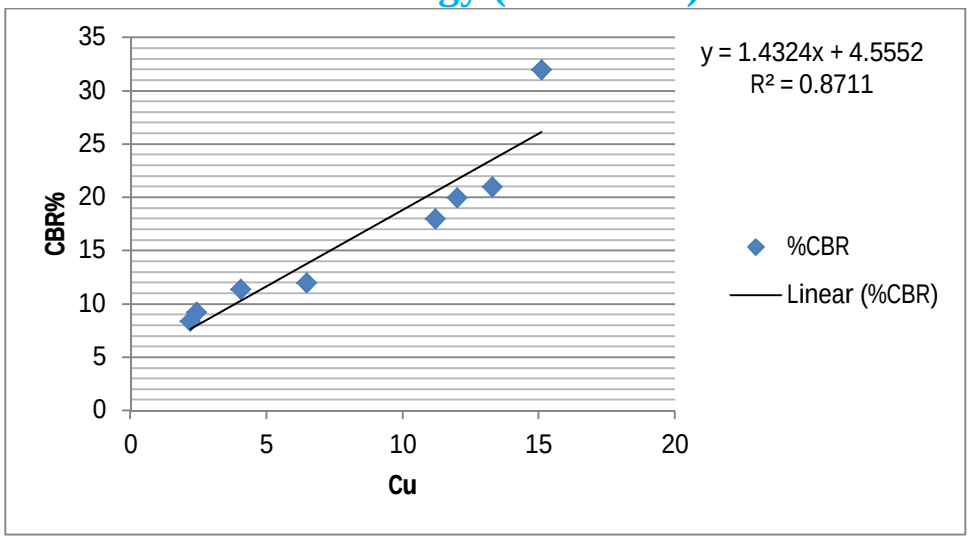

Figure 3: Cu verses Soaked CBR value

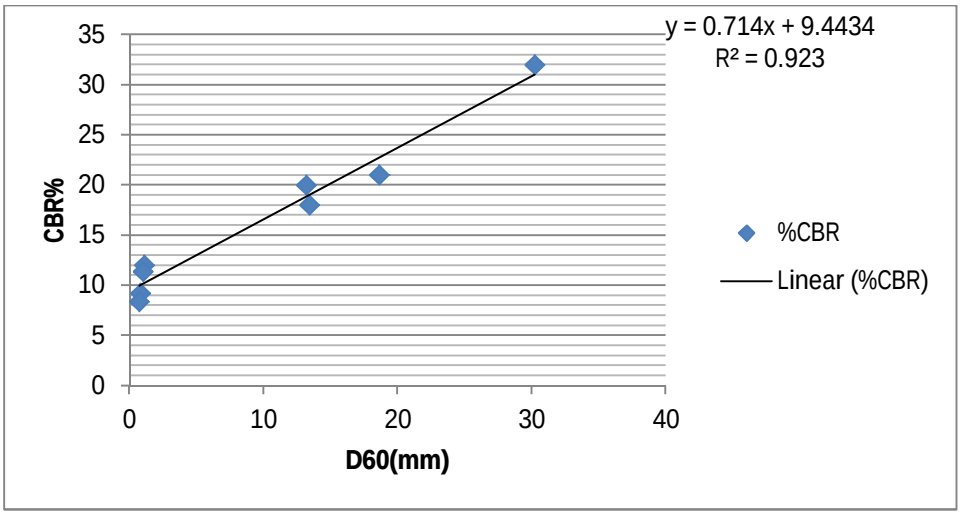

Figure 4: D_{60} verses Soaked CBR value

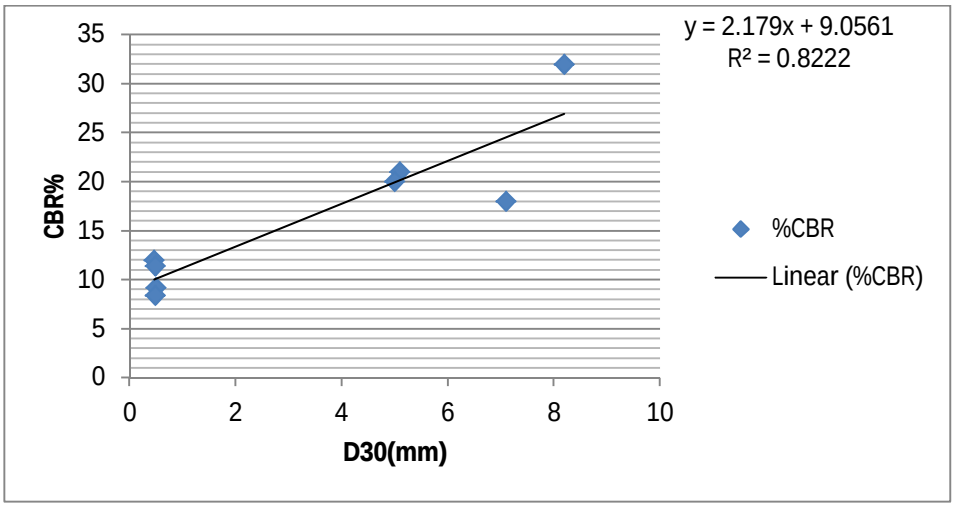

Figure 5: D30 verses Soaked CBR value

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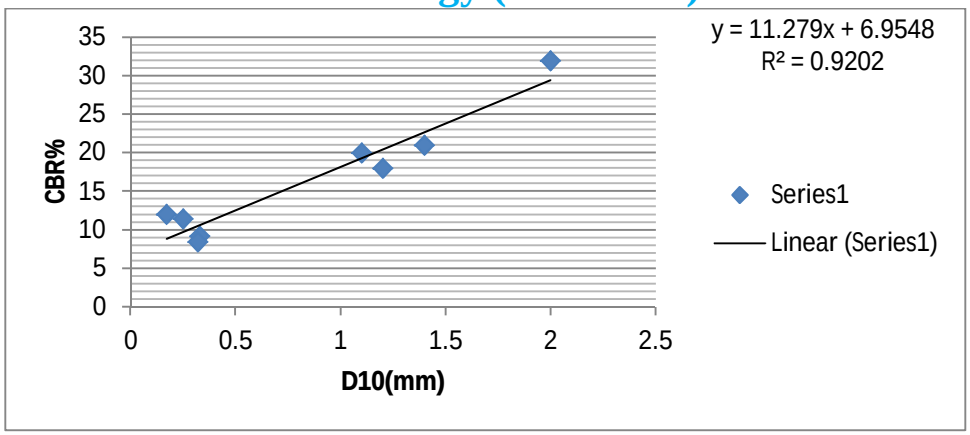

Figure 6: D10 verses Soaked CBR value

As the main aim of this study is to establish a relation of CBR value of soil with D_{30}, D_{60}, MDD and OMC, a multiple linear regression model was developed by using Data Analysis tool pack of Microsoft Excel software. The Mathematical relationship is shown in equation 1, with coefficient of correlation (R^2)=0.9728, hence the equation holds good in correlating the CBR value with other soil properties

CBR= 198.63-3.78*OMC-73.37*MDD+0.34*D_{60}+1.64 *D_{30}

A comparison is made between experimental and predicted CBR values shown in table 2 and figure 7.

Table 2: COMPARISON OF LAB AND SOAKED CBR

CBR(%) from laboratory test	CBR(%) from mathematical equation
18	17
32	30.692
21	20.09
20	18.796
12	11.57
11.4	9.675
9.2	8.445
8.4	7.552

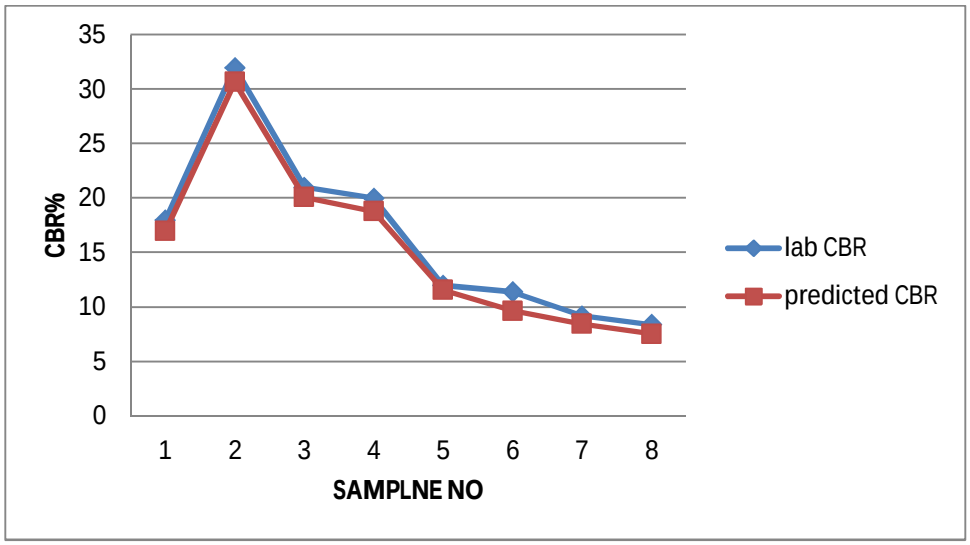

Figure 7: Comparison between predicted and experimental results

IV. CONCLUSIONS

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

A. It is concluded in this research that there is good relationship between index properties/classification test parameters and soaked CBR values for coarse grained soil.

B. CBR value decreases with the increase in the optimum moisture content of soil but increases with the increase in the maximum dry density and grain size.

C. Prediction Models developed using simple linear regression analysis and multiple linear regression models with good (R^2) value.

D. From the formula and table 2, it can be concluded that the correlation equation can be used for evaluating different values of CBR.

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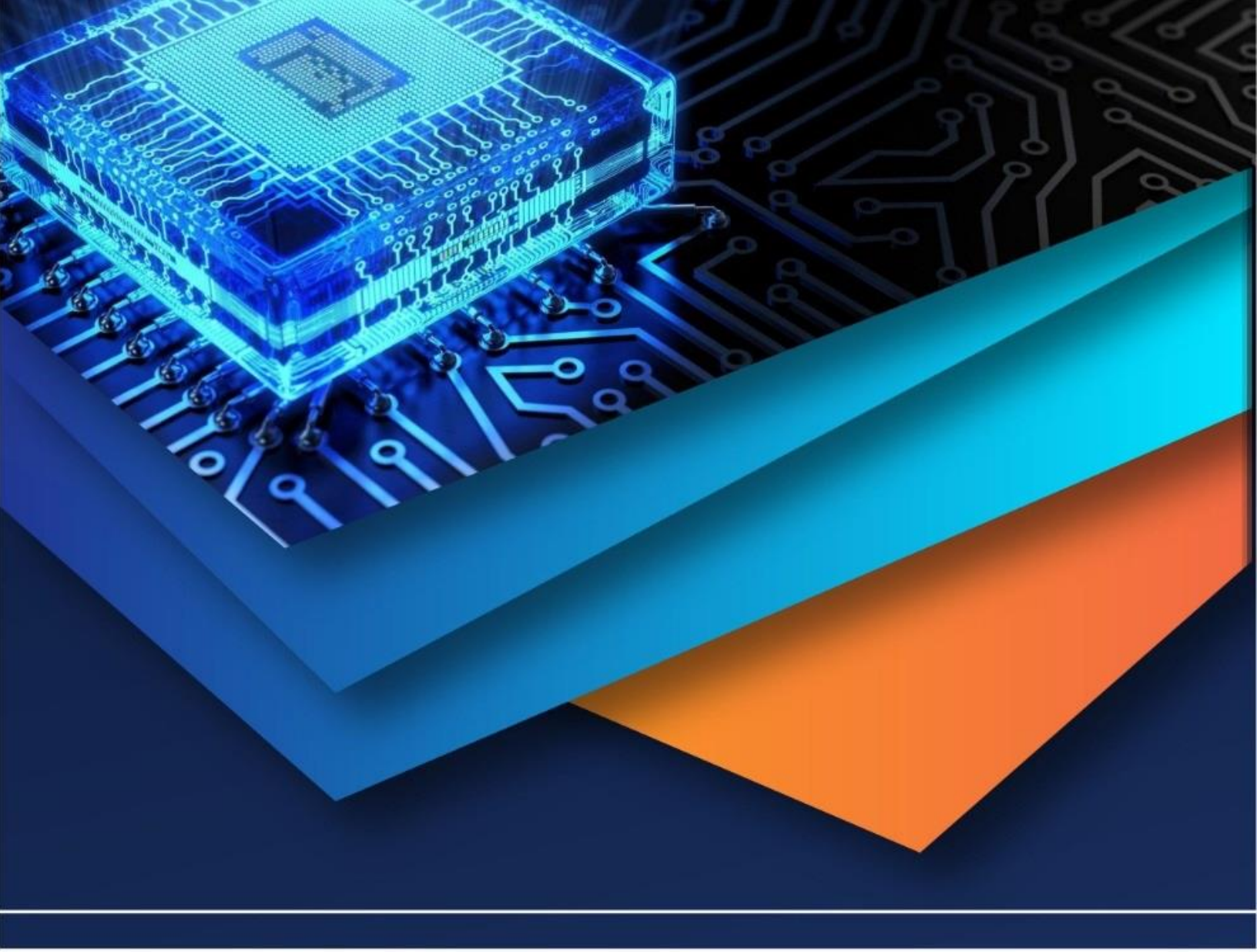

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