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Prediction of Cbr Values From Compaction, Gradation and Plasticity Characteristics of Red Soils

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ABSTRACT:
CBR is an important parameter in assessing the strength of flexible pavement layers. Estimation of CBR values from laboratory methods are time consuming and laborious. In this aspect indirect methods play useful role in supporting the quality of estimation of CBR values. In the present study red soil samples of coarse grained nature are used in predicting compaction characteristics such as optimum moisture content and maximum dry density. These models with R2 values are in the range of 0.51 to 0.58 have obtained using grain size distribution, consistency as independent variable.
KEYWORDS: CBR, Strength, Correlation, Variables

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I. INTRODUCTION:

Visakhapatnam region is a rapid developing area w.r.t economical and industrial growth. These require number of civil engineering structures to support economical development. Road networking is one such which consists of pavements, embankments etc. Several geotechnical parameters like compaction characteristics, grain size distribution and plasticity charateristics are essential to explain their supporting soil. These parameters directly influence the strength and deformability characteristics of the soils. CBR is a parameter explains the strength of supporting soils w.r.t vehicle loading. To assist the laboratory test data are in estimating CBR values, In direct methods like correlation are also help estimating CBR values. Some of the thinkers contributed in estimating CBR values are listed below

1. Agarwal and Ghanekar (1970)
CBR=2-16log (OMC) +0.07(LL)
2. Vinod, Reena and Cletus (2008)
CBR=-0.889(W_{LM})+45.616,
R^2=0.98
3. Patel and Desai (2010)
$(CBR)_S$=43.907-0.093(PI)-18.78(MDD)-0.3081(OMC)
4. The National co-operative highway research program (NCHRP) (2003) [3]
CBR = 75/ 1+0.728(WPI)
5. Yildirim and Gunaydin (2011)
CBR = 0.62 OMC + 58.9 MDD+ 0.11 LL + 0.53 PL – 126.18, R^2=0.63
CBR=0.22 G+0.045S+4.74MDD+0.122 OMC, R^2=0.88
6. A.A. Bello (2012):
CBR = 13.56 + 1.04 (PL)
CBR = 28.87 + 0.22 (LL)
CBR = -70.22 + 50.28 (MDD)
Following correlation for CBR un- soaked value with index properties of lateritic soils:
CBR_u= 65.31 + 0.8 (PL)
CBR_u = 83.19+ 0.031 (LL)
CBR_u= 65.88+ 8.66(MDD)
7. Rama Subba Rao G.V and Siva Sankar G (2013**)**

$(CBR)_S$=0.064 F+0.082 S+0.033 G-0.069 LL+0.157(PL)-1.810MDD-0.061 OMC, R^2=0.96
. In the present study 112 no of Red soils of coarse grained nature have been tested for geotechnical characterization as per IS 2720.

II. MATERIALS AND RESULTS:

To study the inter-relationship 112 red soil samples were collected from different regions of north coasted districts of AP and tests like grain size distribution (Dry and Wet analysis) (IS 2720 part 4). Plasticity characteristics (W_L, W_P, &I_P) soaked CBR tests have been conducted and the results are as shown in the table 1.

S.NO	S	F	Wl	Wp	Ip	OMC	MDD	CBR
1	68	32	29	19	10	10.2	1.82	6
2	73	27	27	19	8	10	1.83	6
3	67	33	30	19	11	10.5	1.82	6
4	70	30	28	19	9	10.2	1.84	5.5
5	72	28	27	18.5	8.5	10	1.85	6
6	65	35	30	19	11	10.6	1.82	6
7	60	40	34	20	14	11	1.8	5.8
8	63	37	33	19	14	11	1.81	5.7
9	65	35	32	19	13	10.7	1.82	6
10	68	32	29	19	10	10.4	1.84	6
11	64	36	29	19	10	10	1.83	5.6
12	60	40	32	19	13	10.5	1.82	5.8
13	68	32	30	18	12	10.2	1.84	6
14	63	37	33	19	14	10.7	1.82	6
15	67	33	30	19	11	10.4	1.83	5.8
16	65	35	33	19	14	10.8	1.81	6
17	62	38	33	20	13	10.7	1.82	6
18	60	40	34	20	14	10.9	1.81	6
19	58	42	34	19	15	11	1.8	6
20	64	36	31	19	12	10.4	1.82	5.5
21	68	32	26	18	8	9.8	1.84	5.4
22	64	36	32	19	13	10.6	1.85	6
23	63	37	31	19	12	10.5	1.84	6
24	70	30	28	19	9	10	1.85	5.8
25	68	32	28	18	8	9.8	1.83	5.5
26	62	38	32	19	13	11	1.84	6
27	67	33	30	19	11	10.6	1.86	5.8
28	60	40	33	20	13	11.2	1.83	6
29	65	35	30	19	11	10.5	1.85	5.5
30	70	30	28	19	9	10	1.86	5.5
31	72	28	27	18	9	9.8	1.87	6
32	66	34	32	10	12	11	1.84	5
33	63	37	34	20	14	11.5	1.82	6
34	70	30	30	20	10	10.6	1.84	5
35	73	27	29	19	10	10.4	1.85	5.5
36	69	31	27	18	9	10.2	1.86	5.2
37	62	38	30	20	10	10.7	1.84	5.4
38	73	27	29	19	10	10.3	1.85	5.5
39	67	33	29	19	9	10.5	1.84	5
40	68	32	30	20	10	10.7	1.84	5.5
41	60	40	34	20	14	11.3	1.83	6
42	66	34	32	20	12	10.8	1.85	5.3
43	73	27	28	19	9	10.3	1.84	5.5
44	68	32	28	19	9	10.4	1.83	5

45	68	32	32	19	13	12	1.86	5.4
46	56	44	34	20	14	12.5	1.84	5.5
47	60	40	32	20	12	12.2	1.85	5.2
48	72	28	28	19	9	11.2	1.88	5
49	65	35	30	19.5	10.5	11	1.88	5.5
50	78	22	26	18	8	10	1.9	5
51	80	20	25	18	7	9.8	1.9	4.8
52	62	38	33	20	13	12.2	1.83	5.3
53	75	25	27	19	8	10.8	1.88	4.8
54	70	30	25	18.5	6.5	9.3	1.85	5.5
55	72	28	24	18	6	9	1.84	5
56	66	34	25	19	6	9.5	1.85	5.5
57	69	31	25	19	6	9.2	1.86	5
58	74	26	23	18	5	9	1.84	5
59	68	32	26	19	7	9.8	1.83	6
60	65	35	25	18	7	9.4	1.84	6
61	68	32	25	19	6	9.6	1.85	6
62	70	30	24.5	18.5	6	9.4	1.84	5.5
63	76	24	24	18	6	8.8	1.86	5.2
64	80	20	23	18	5	8.5	1.83	5
65	73	27	24	18.5	5.5	9	1.84	5.2
66	78	22	23	18	5	8.4	1.8	4.8
67	72	28	24	18	6	9	1.88	5
68	70	30	25	19	6	9.2	1.86	5.4
69	74	26	24	18	6	8.8	1.86	5.5
70	70	30	25	18.5	6.5	9.3	1.87	5.5
71	68	32	25	19	6	9.5	1.88	5.6
72	75	25	24	18.5	5.5	9.2	1.86	5
73	66	34	25	18	7	9.5	1.85	5.4
74	67	33	25	19	6	9.6	1.84	5
75	63	37	25	19	6	9.3	1.86	5.3
76	72	28	24	18.5	5.5	9.2	1.84	5
77	77	23	23.5	18.5	5	9.4	1.86	5.5
78	70	30	25	18.5	6.5	9.2	1.85	4.6
79	67	33	25	19	6	9	1.84	4.5
80	72	28	23	18	5	9.3	1.86	5.3
81	67	31	24	18	6	9.1	1.84	5
82	69	31	25	18.5	5.5	9.3	1.84	5.4
83	65	35	25	19	6	9.6	1.83	5.5
84	73	27	23	18	5	9	1.84	5
85	76	24	23.5	18	5.5	9.2	1.85	5.3
86	74	26	23	18	5	9.1	1.84	5.2
87	78	22	23	18	5	9	1.84	5.5

88	66	34	25	19	6	9.4	1.85	5.5
89	69	31	24	18	6	9.3	1.84	5
90	78	22	22	18	4	8.8	1.78	4.5
91	82	18	22	18	4	8.5	1.77	4.8
92	75	25	23.5	18.5	4	9	1.79	5
93	74	26	23.5	18.5	4.5	8.8	1.78	4.8
94	78	22	22	18	4	8.4	1.77	4.5
95	82	18	21	18	3	8.2	1.76	4.5
96	86	14	21	18	3	8	1.77	4.6
97	74	26	22	18	4	8.7	1.77	5
98	83	17	22	18	4	8.6	1.78	4.8
99	85	15	21	17	4	8.4	1.76	5
100	83	17	21	17	4	8.5	1.78	4.6
101	78	22	22	18	4	8.7	1.79	5
102	76	24	22	18	4	8.9	1.77	5
103	68	32	22.5	18.5	4.5	9	1.76	5
104	70	30	23	18.5	4.5	9.1	1.78	5.2
105	76	24	22	18	3	8.8	1.88	4.5
106	84	16	21	18	3	8.5	1.85	4
107	82	18	21	17	4	8.4	1.85	4
108	78	22	22	18	4	8.6	1.86	4.2
109	80	20	21	NP	NP	9	1.86	4.2
110	87	13	NP	NP	NP	8	1.8	4.4
111	85	15	NP	NP	NP	8.6	1.84	4.2
112	88	12	NP	NP	NP	8	1.82	4.6

S= SAND (%), F= FINES (%), WL=LIQUID LIMIT, W_P= PLASTIC LIMIT I_P= PLASTICITY INDEX OMC= OPTIMUM MOISTURE CONTENT MDD=MAXIMUM DRY DENSITY(g/cc) CBR=CALIFORNIA BEARING RATIO D_{10}= SIZE OF SOIL PARTICLES AT 10% FINERD_{60}= SIZE OF THE SOIL PARTICLES AT 60% FINER C_U= COEFFICIENT OF UNIFORMITY

III. PARAMETRIC ANALYSIS OF RED SOILS:

The following identifications are made from the test results of Red soils.

- Increasing the percentage of sand particles increases the CBR values whereas increasing the fine particles decreases CBR values.
- Increasing a small percentage of fines increases Dry density and CBR values. High densities and high CBR values are due to occupation of more solids, availability of wide range of particles and less plasticity characteristics which offer more shear resistance against penetration due to inter locking of particles soil particles
- Increasing the huge percentage of fines increasing plasticity index values highly there by reducing CBR under soaked condition. Increasing the percentage of fines increases the deformability conditions there by decreasing the shear strength and penetration resistance under condition.
- Domination of any single range of particles decreases dry density and CBR values and domination of wide range of particles increases dry density and CBR values.

IV. CORRELATION:

Based on the test results like grain size distribution i.e. (Gravel, Sand, Fine particles), their range in terms of gradation coefficients such as coefficient of uniformity (C_u) and coefficient of curvature (Cc), w.r.t soaked CBR values, various relationships are established. It is further included plasticity characteristics in terms of Liquid Limit and plasticity index are correlated with CBR values. Correlation models have generated by choosing

CBR as dependent variable and gradation characteristics. Plasticity characteristics as independent variables using excel Microsoft analysis. Simple linear regression analysis (SLRA), multiple linear regression analysis (MLRA) has been done and the following correlation equation are identified with R^2 values

TABLE NO: 2 CORRELATION EQUATIONS OF CBR LINEAR EQUATIONS

SNO	VARIABLE	EQUATION	R^2
1	f(S, F)	CBR = 0.195(S) +0.249(F) -15.864	0.51
2	f(S, F, IP, WL)	CBR = 0.164(S) +0.199(F) +0.194(IP) -0.125(WL) -10.360	0.55
3	f(S, F, MDD, OMC)	CBR = 0.158(S) +0.203(F) -0.614(MDD) +0.084(OMC) -11.531	0.52
4	f(S, F, IP, WL, MDD, OMC)	CBR = 0.169(S) +0.203(F) +0.173(IP) -0.06(WL) +0.76(MDD) -0.195(OMC) -11.834	0.56
5	f(S, F, D_{60})	CBR = 0.201(S) +0.246(F) -1.27(D_{60}) -15.649	0.52
6	f(S, F, D_{60}, IP)	CBR = 0.118(S) +0.147(F) +0.354(D_{60}) -0.062(IP) -7.994	0.53
7	f(S, F, D_{60}, MDD, OMC)	CBR = 0.164(S) +0.201(F) -1.055(D_{60}) -0.716(MDD) +0.081(OMC) -11.272	0.52
8	f(S, F, D_{60}, IP, WL, MDD, OMC)	CBR = 0.167(S) +0.203(F) +0.333(D_{60}) +0.173(IP)-0.06(WL) +0.808(MDD) -0.196(OMC) -11.916	0.56
9	f(S, F, D_{60}, Cu, MDD, OMC)	CBR = 0.179(S) +0.22(F) -1.244(D_{60}) -0.0002(Cu) -0.928(MDD) +0.094(OMC) -12.481	0.53
10	f(S, F, D_{60}, Cu, IP, WL, OMC, MDD),	CBR = 0.206(S) +0.250(F) -0.094(D_{60}) -0.0005(Cu) +0.193(IP) -0.072(WL) -0.187(OMC) +0.391(MDD) -14.857	0.58

The strength, effectiveness of these correlations can be represented by their R^2 values by performing multiple regression analysis. From the correlation it is identified that grain size distribution (S, F) has considerable influence on CBR values with R^2values as 0.51 whereas grain size distribution with gradation parameters (D_{60}) which representing range of particles further improved correlation coefficient (R^2) to 0.52.

It is also noted that inclusion of plasticity index with grain size distribution and gradation characteristics of rose correlation coefficient (R^2) to 0.55. Inclusions of plasticity characteristics (Ip) have high Influence of CBR characteristics. Inclusions of more number of effective parameters of improve the prediction of CBR values with high correlation coefficient. Inclusion of compaction characteristics such as OMC and MDD shows high values of correlation coefficients i.e., 0.58. It is further identified that involvement of more than one variable in the correlation analysis (Regression analysis) made more accurate in the prediction of CBR values. In the present study the predictive equations are simple and can be effectively used for the prediction of CBR values of Red soils are with high accuracy.

V. CONCLUSION:

1. Soil with wide range of particles with low percentage of fines exhibited high dry densities and high soaked CBR values.
2. The other models developed by MLRA for correlating soaked CBR value with gradation characteristics (S,F,D_{60}, C_u, I_p) have shown relatively with high R^2 values
3. The statistically better performance can be obtained from the model developed using multiple linear regression analysis (MLRA) by inclusion of compaction characteristics showing the highest R^2 value as 0.58.

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