Prediction of Compaction Characteristics Gradation and Plasticity Characteristics of Red Soil

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Abstract

Estimation of compaction characteristics such as optimum moisture content and maximum dry density values are essential for civil engineering projects especially soil structures. The strength and durability of these soil structures will depend on the quality of materials used. Compaction characteristics are the controlling parameters to assess the above features. To avoid various constrains related to estimation of compaction characteristics can be effectively strengthen by using indirect methods. Correlation is the prominent method in estimating compaction characteristics. The present investigation has 112 number of red soil samples used in estimating compaction characteristics. The parameters used are grain size distribution and plasticity Index. The correlation equations obtained are explained with high R^2 values show best and showed best relations between them.

Key Words - *Strength, durability, compaction characteristics, correlation*

I. INTRODUCTION

Civil Engineering structures such as buildings, retaining walls, bridges, roads etc., require good bearing soil bearing strata's as foundation material. The strength and durability of the foundation strata are depending on the quality of compaction i.e., method of compaction and the characteristics of the soils used. Therefore compaction characteristics have to plays a big role in deciding strength and durability of foundation material fill material etc. These compaction characteristics again depend on the nature of soil including grain size distribution and plasticity characteristics. Civil Engineering projects require number of compaction tests throughout of their construction period. These tests are time consuming laborious and effective sample representation is poor which is varying from location to location. All these demand the quick assessment of OMC and MDD values while work is in progress. Compaction test have valid correlations with strength parameters. Some of the thinkers contributed their research on developing the correlation between OMC and MDD as dependent variable and index properties as independent variables are listed below.

- Omar (2003) developed prediction models to estimate the compaction characteristics of granular soils in the UAE. The prediction models are

  $\gamma_{dmax}(kg/m^3)=[4804574G-195.55 W_L^2+156971(R\#4)^{0.5}-9527830]^{0.5}$

  $Log(W_O)=1.195x10^{-04}(W_L)^2-1.964G-6.617x10^{-03}(R\#4)+7.631$
- Sridharan & Nagaraj (2005) found that plastic limit can also give good estimates of compaction parameters.

  $\gamma_{dmax}=0.23(93.3-W_p)$

  $OMC=0.92W_p$
- Sivrikaya (2013) used two approaches named multiple linear regression anlaysis (MLR) and genetic expression program (GEP) to predict compaction characteristics of coarse grained soils.
- Mujtaba (2013) proposed correlations for granular soils to estimate compaction characteristics using gradation parameters and compaction energy (CE).

  $\gamma_{dmax}=4.49 \log(C_u)+1.51 \log(CE)+10.2$

  $Log (OMC) =1.67-0.193 \log (C_u)-0.153 \log (CE)$
- Noor (2012) collected 106 samples of fine-grained soils from various Indian Hydropower projects to develop prediction models for the estimation of compaction parameters

  $MDD=\sqrt{PL-0.089LL+33.97/(PL+1.37)+19.05}$

  $OMC=PI/G+3.424+0.462PL-G$

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) compaction tests have been conducted and the results are as shown in the table 1.

TABLE N0:1 Geotechnical characteristics of red soils of coarse-grained nature

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

43	73	27	28	19	9	10.3	1.84
44	68	32	28	19	9	10.4	1.83
45	68	32	32	19	13	12	1.86
46	56	44	34	20	14	12.5	1.84
47	60	40	32	20	12	12.2	1.85
48	72	28	28	19	9	11.2	1.88
49	65	35	30	19.5	10.5	11	1.88
50	78	22	26	18	8	10	1.9
51	80	20	25	18	7	9.8	1.9
52	62	38	33	20	13	12.2	1.83
53	75	25	27	19	8	10.8	1.88
54	70	30	25	18.5	6.5	9.3	1.85
55	72	28	24	18	6	9	1.84
56	66	34	25	19	6	9.5	1.85
57	69	31	25	19	6	9.2	1.86
58	74	26	23	18	5	9	1.84
59	68	32	26	19	7	9.8	1.83
60	65	35	25	18	7	9.4	1.84
61	68	32	25	19	6	9.6	1.85
62	70	30	24.5	18.5	6	9.4	1.84
63	76	24	24	18	6	8.8	1.86
64	80	20	23	18	5	8.5	1.83
65	73	27	24	18.5	5.5	9	1.84
66	78	22	23	18	5	8.4	1.8
67	72	28	24	18	6	9	1.88
68	70	30	25	19	6	9.2	1.86
69	74	26	24	18	6	8.8	1.86
70	70	30	25	18.5	6.5	9.3	1.87
71	68	32	25	19	6	9.5	1.88
72	75	25	24	18.5	5.5	9.2	1.86
73	66	34	25	18	7	9.5	1.85
74	67	33	25	19	6	9.6	1.84
75	63	37	25	19	6	9.3	1.86
76	72	28	24	18.5	5.5	9.2	1.84
77	77	23	23.5	18.5	5	9.4	1.86
78	70	30	25	18.5	6.5	9.2	1.85
79	67	33	25	19	6	9	1.84
80	72	28	23	18	5	9.3	1.86
81	67	31	24	18	6	9.1	1.84
82	69	31	25	18.5	5.5	9.3	1.84
83	65	35	25	19	6	9.6	1.83
84	73	27	23	18	5	9	1.84
85	76	24	23.5	18	5.5	9.2	1.85
86	74	26	23	18	5	9.1	1.84

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

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) D10= SIZE OF SOIL PARTICLES AT 10% FINER D_{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 MDD values, decreasing the percentage of sand particles decreases MDD values.
- Increasing a small percentage of fines increases MDD values and OMC values
- Increasing the huge percentage of fines increasing plasticity index values highly there by reducing MDD values.
- Increasing the percentage of fines increases liquid limit values
- Increasing the percentage of fines increases the deformability conditions there by decreasing the shear strength and penetration resistance under saturated condition
- High densities are due to occupation of more solids, availability of wide range of particles and less plasticity characteristics which offer more shear resistance and less deformation due to inter locking of soil particles
- Domination of any single range of particles decreases dry density and increases OMC values.
- Domination of wide range of particles increases dry density and decreases OMC 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 Compaction characteristics various correlation relationships are established. It is further included plasticity characteristics in terms of Liquid Limit and

plasticity index are correlated with compaction characteristics. Correlation models have generated by choosing OMC&MDD as dependent variable and gradation characteristics. Plasticity characteristics as independent variables using excel Microsoft analysis. Simple linear regression analyses (SLRA), multiple linear regression analysis (MLRA) have been done and the following correlation equations are identified with R^2 values.

Table No: 2 Correlation Equations Of Mdd&Omc Linear Equations

SNO	VARIABLE	MDD EQUATION	R^2
1	f(S,F)	MDD=-0.002(S)-0.001(F)+2.055	0.03
2	f(S,F,I_p)	MDD=-0.002(S)-0.002(F)+0.0002(I_P)+2.094	0.03
3	f(S,F,W_L)	MDD=-0.002(S)-0.0022(F)+0.0002(W_L)+2.093	0.02
4	f(S,F,D_{60},I_p)	MDD=-0.003(S)+0.002(F)-0.402(D_{60})-0.003(I_P)+2.095	0.07
5	f(S,F,D_{60},Cu,I_p)	MDD=0.003(S)+0.002(F)-0.428(D_{60})-5.5X10^{-05}(C_U)+0.0007(I_P)+1.727	0.11
		OMC EQUATIONS	
7	f(S,F)	OMC=0.42(S)+0.53(F)-36.125	0.62
8	f(S,F,I_p)	OMC=0.127(S)+0.146(F)+0.234(I_P)-5.413	0.85
9	f(S,F,W_L)	OMC=0.043(S)+0.04(F)+0.22(W_L)-0.676	0.87.
10	f(S,F,D_{60},I_p)	OMC=0.136(S)+0.145(F)-1.45(D_{60})+0.232(I_P)-5.408	0.85
11	f(S,F,D_{60},C_u,I_p)	OMC=0.149(S)+0.160(F)-1.539(D_{60})-0.0001(C_U)+0.236(I_P)-6.659	0.85

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 OMC values with R^2values as 0.62 whereas grain size distribution with gradation parameters (C_u) which representing range of particles further improved correlation coefficient (R^2) to 0.85.

It is also noted that inclusion of plasticity index with grain size distribution and gradation characteristics of rose correlation coefficient (R^2) to 0.85. Inclusions of plasticity characteristics (Ip) have high influence of OMC characteristics. Inclusions of more number of effective parameters of improve the prediction of OMC

values with high correlation coefficient. It is further identified that involvement of more than one variable in the correlation analysis (Regression analysis) made more accurate in the prediction of OMC values. In the present study the predictive equations are simple and can be effectively used for the prediction of OMC values of Red soils are with high accuracy.

In case of MDD models very small values of R^2 in the range of 0.03 to 0.11 with grain size distribution and inclusion of gradation parameters and plasticity index values. The lowest R^2 values are due to narrow range of MDD values for all the soils under study has been reported.

V. CONCLUSION

1. Soil with wide range of particles with low percentage of fines exhibited high dry densities and increasing the percentage of fines increases OMC values.
2. The models developed by MLRA for correlating OMC and MDD values with gradation characteristics (S,F,D_{60}, C_u) 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 plasticity characteristics showing the highest R^2 value as 0.85

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