

Role of Compaction Energy on Dry density and CBR

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Abstract - California Bearing Ratio (CBR) value is an important soil parameter for design of flexible pavements and runway of air fields. It is used for determining sub grade reaction of soil and for establishing thickness of the pavement. CBR value of soil depends on many factors like soaked and unsoaked conditions of soil, maximum dry density (MDD), optimum moisture content (OMC) etc. In this project soil sample collected from Thiruporur district in Chennai is used in the experimental study. Index properties of soil were determined to classify the soil by conducting tests like Sieve analysis, Hydrometer analysis, Specific gravity test, Atterberg's limit tests, Swell index test etc. Also Modified proctor test was conducted for 5 different no of blows to determine the effect of compaction energy on MDD & OMC of soil. CBR tests (both soaked and unsoaked) were carried out to establish a correlation of CBR value of soil with OMC. Thickness of pavement was also calculated and correlated with different CBR values. The equation arrived in this study will be useful to predict CBR value of soil based on the OMC value obtained from modified proctor compaction test, without need for conducting the CBR tests.

Introduction:

In compaction the particles are mechanically constrained closely, by expelling part of air from the voids so that the density and stability of soil is increased. It has been observed from Proctor Compaction Test that Maximum Dry Density (MDD) for a soil is obtained at Optimum Moisture Content (OMC). OMC and MDD are the most important parameters influencing California Bearing Ratio (CBR).

CBR is a penetration test used for evaluating the mechanical strength of subgrade soil and for determining the thickness of the pavement. CBR is the ratio expressed in percentage of force per unit area required to penetrate a soil mass with a circular plunger of 50 mm diameter at the rate of 1.25 mm/min to that required for corresponding penetration in a standard material. Determination of CBR value for soil is time consuming and laborious process. Hence in this project an attempt has been made to correlate soaked and unsoaked CBR value with MDD and OMC of soil sample so that based on MDD & OMC value, CBR value of soil can be predicted. The soil sample used in this project is collected from Thiruporur District in Chennai.

The following tests were carried out to establish the correlation between soaked CBR and unsoaked CBR with MDD & OMC

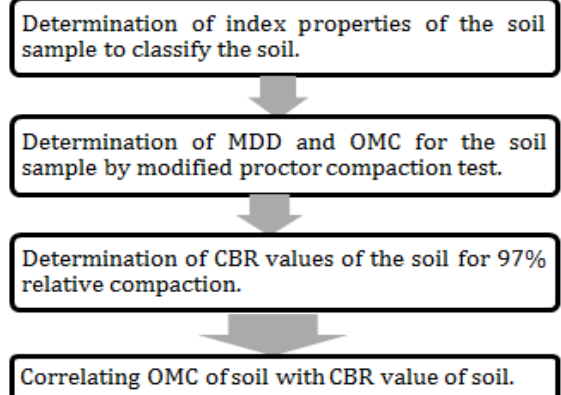
1. Specific gravity
2. Sieve analysis
3. Hydrometer analysis
4. Atterbergs limit
5. Free swelling index test
6. Modified proctor tests for five different compaction energy levels viz..10 blows, 25blows, 35blows, 45blows and 55 blows
7. CBR soaked for five different compaction energy levels
8. CBR unsoaked for five different compaction energy levels.

Objective:

1. To classify the soil based on the index properties of the soil.
2. To determine the effect of increasing number of blows in modified proctor compaction test on MDD and OMC.
3. To correlate the OMC with soaked and CBR value of soil for 97% of relative compaction.
4. To evaluate the thickness of pavement based on the observed CBR value of soil.

Methodology:

In this project, methodology given below was followed. All the tests were conducted as per the IS codes for the soil sample collected from Thiruporur District in Chennai.



Experimental Results and Discussions:

The collected soil has been classified based on the values of index properties such as Liquid Limit, Plastic Limit, Shrinkage Limit, particle size distribution, Specific gravity, Free swelling index. Values obtained from Modified Proctor Compaction Test and Soaked and Unsoaked CBR Test were tabulated and graphs were plotted in order to correlate CBR value of soil with OMC.

Results of Specific Gravity (Is 2720 Part-3)

Table 1-Results of specific gravity

Specifications	Trial-1	Trial-2	Trial-3
W_1 (g)	675.38	675.38	675.38
W_2 (g)	1337.23	1331.23	1338.8
W_3 (g)	661.85	655.85	663.42
W_4 (g)	1626.12	1620.89	1624.20
W_w (g)	324.63	315.84	324.39
Specific gravity of soil = W_s / W_w	2.038	2.076	2.045

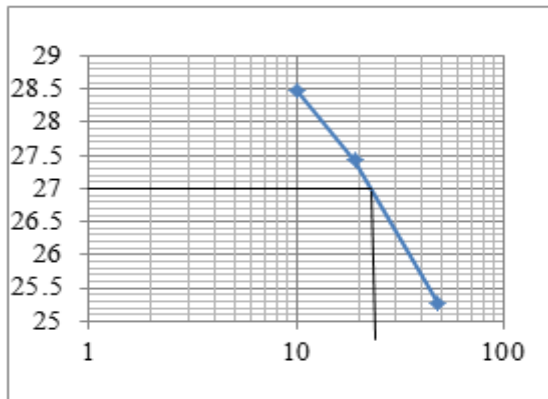


Figure 1-Graph between water content and number of blows

Weight of bottle = W_1 (g)
 Weight of bottle+soil = W_2 (g)
 Weight of dry soil = $W_s = W_2 - W_1$ (g)
 Weight of bottle+soil+water = W_3 (g)
 Weight of bottle+water = W_4 (g)
 Weight of equivalent volume of water
 $W_w = W_s + W_4 - W_3$ (g)
 Average specific gravity of the soil = 2.053

Results of Atterbg Limit (Is: 2720Part:5)

From the graph the liquid limit was found to be 27%.

Table 2-Results of shrinkage limit

Trial no.	1	2	3
Wt. of container(g)	66	69	62
Wt. of wet sample + container(g)	111	108	114
Wt. of dry sample+container(g)	97	99	106
Wt. of water(g)	14	9	8
Wt. of dry soil pat(w_d)	31	30	44
Water content in (%)	45.16	30	18.18
Wt. of mercury container(g)	45	45	45
Wt. of mercury displaced(g)	296	301	297
Volume of mercury displaced=volume of dry soil pat(V_d)	21.79	22.16	21.87
Volume of wet soil pat(v)	23.86	26.06	26.50
Shrinkage limit (W_s) (%)	38.48	17	7.66

Therefore Shrinkage limit = 38.48%

SIEVE ANALYSIS (IS: 2720 Part 4)

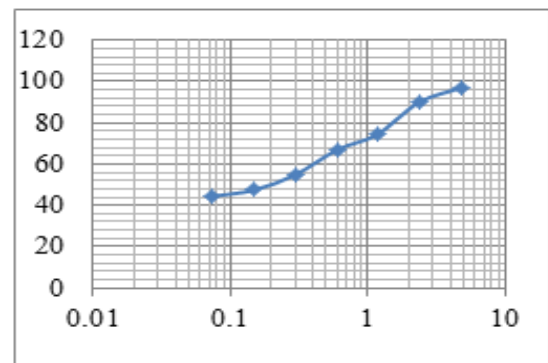


Figure 2-Graph between %finer and IS sieve sizes

From graph, % Gravel=3%, %Sand=52.5%, %silt and clay=44.5%

FREE SWELLING INDEX (IS:2720 PART:40)

Table 3-Results of free swelling index

S.NO	Observation in hrs	V_d	V_k	Percentage of swell
1.	24	11	9	22.22

Percentage of swell = 22.22

INFERENCES FROM INDEX PROPERTIES EXPERIMENTS

- 1.From specific gravity tests the specific gravity of soil was found to be 2.053
2. From Atterbergs limit test,

- Liquid limit of the soil = 26.99%
- Plastic limit of the soil = 13.04%
- Shrinkage limit of the soil = 38.48%
- Plasticity index of the soil = 14.2

Since plasticity index lies between 7&17 the soil is classified as silty clay

3. From free swell index test,% of swell was found to be 22.22

4. From Sieve Analysis,

- %Gravel=3
- %Sand=52.5
- %Silt and Clay=44.5.

MODIFIED COMPACTION TESTS (IS: 2720 PART-8)

For 25 blows

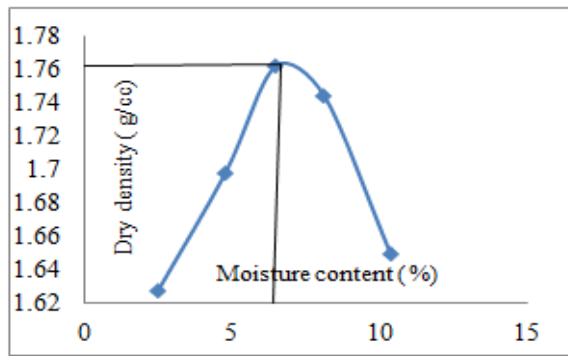


Figure 3- Graph between moisture content and dry density for 25 blows

From graph, max. dry density = 1.762 g/c optimum moisture content= 7.5%

FOR 10 BLOWS

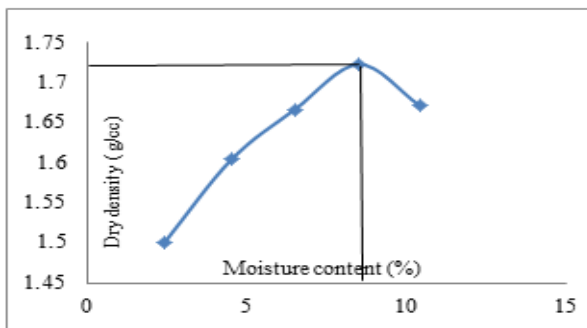


Figure 4-Graph between moisture content and dry density for 10 blows

From graph, the max. dry density = 1.723 g/cc optimum moisture content=9.4%

FOR 35 BLOWS:

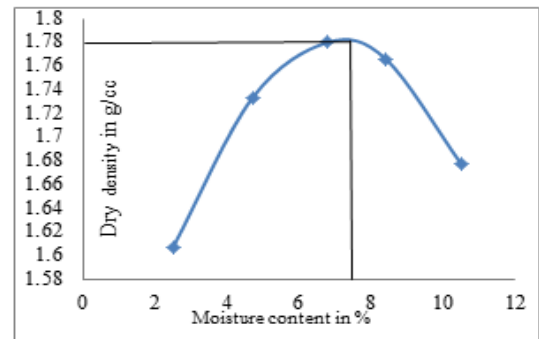


Figure 5- Graph between moisture content and dry density for 35 blows

From graph, Max. dry density=1.784g/cc optimum moisture content = 7.1%

FOR 45 BLOWS:

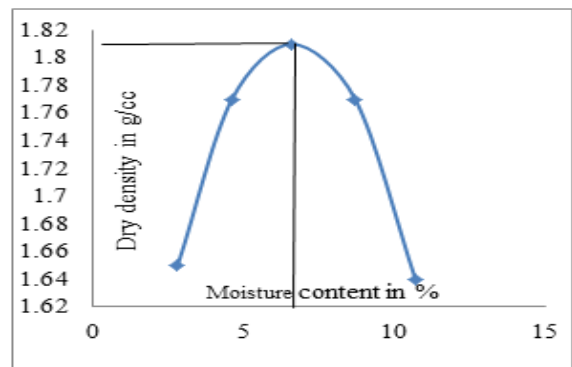


Figure 6-Graph between moisture content and dry Density for 45 blows

From graph , max. dry density = 1.81 g/cc optimum moisture content=6.6%

FOR 55 BLOWS:

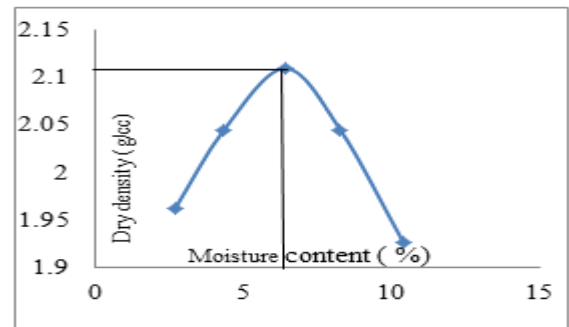


Figure 7-Graph between moisture content and dry density for 55 blows

From graph, max. dry density = 2.11g/cc
 optimum moisture content = 6.4%

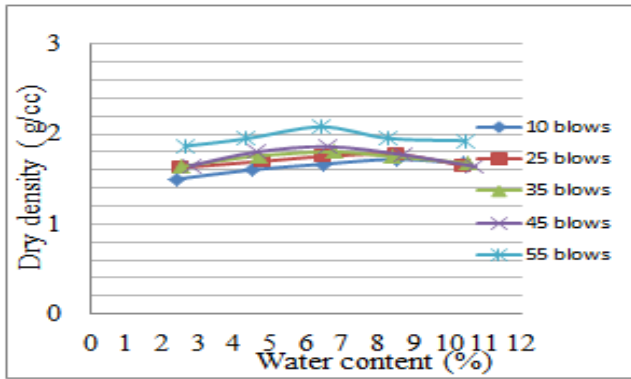


Figure 8 Combined graphs of modified proctor tests for 5 different no of blows

from modified compaction tests, for increasing no. of blows mdd was found to increase and omc was found to decrease which is in accordance with the statement in the journal "optimum water content and maximum dry unit weight of clayey gravels at different compactive efforts" by mehrab jesmani, a. nasiri manesh, volume 13/1-14

Table 4 - Number of blows and % decrease in Optimum moisture content w.r.t. 10 blows.

Number of blows	% Decrease in OMC w.r.t . 10 blows
10	0
25	1.9
35	2.3
45	2.8
55	3

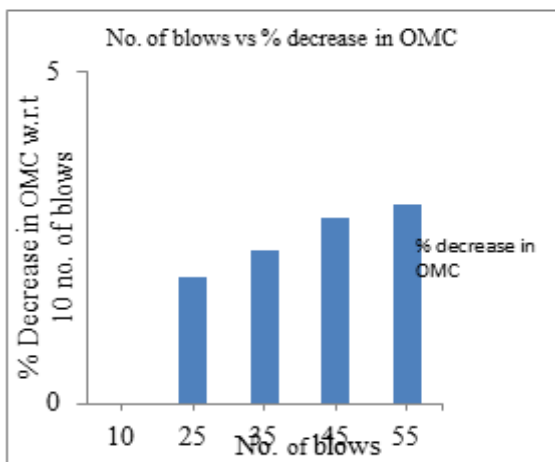


Figure 9-Graph between no. of blows and % decrease in OMC w.r.t 10 blows

Table 5 - Number of blows and % increase in maximum dry density w.r.t. 10 blows.

Number of blows	% Increase in MDD w.r.t . 10 blows
10	0
25	2.21
35	3.41
45	4.81
55	18.34

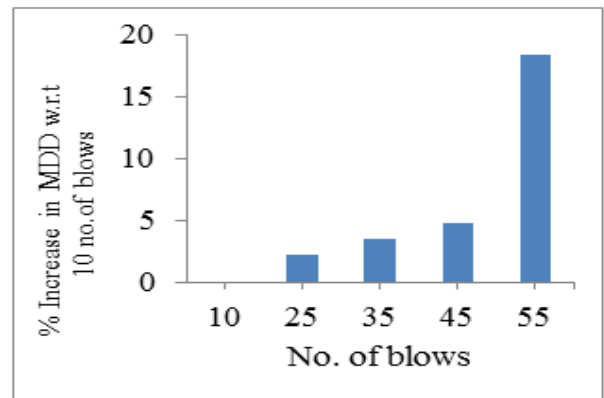


Figure 10- Graph between no. of blows and % increase in MDD w.r.t 10 blows

RELATIONSHIP BETWEEN CBR VALUE WITH OMC

Table 6- CBR value and optimum moisture content

OMC (%)	Unsoaked CBR value (%)
9.4	3.130
7.5	11.429
7.1	14.92
6.6	18.2
6.4	20.4

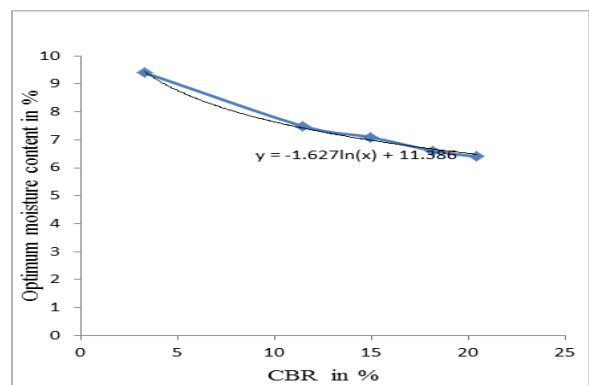


Figure 11-Graph correlating CBR value with OMC

CONCLUSION

1. Based on the index properties, soil is classified as silty clay
2. OMC was found to decrease and MDD was found to increase with increase in no. of blows as observed in Modified compaction test.
3. A new correlation has been proposed relating soaked and unsoaked CBR values with OMC of soil sample.
4. $CBR = -(e^{OMC} - e^{11.58})/1.62$
5. Thus based on the above correlation, soaked and unsoaked CBR values can be predicted from the OMC value of soil thus saving the valuable time.
6. With increasing compaction energy soaked and unsoaked CBR values were found to increase thus decreasing the thickness of pavement required

IS Codes Referred:

1. IS: 2720 (Part 4) -Grain size analysis
2. IS: 2720 (Part 3)-Determination of specific gravity
3. IS: 2720 (Part 5)-Determination of liquid limit and plastic limit
4. IS: 2720(Part 6)-Determination of shrinkage factors
5. IS: 2720(Part 40)-Determination of free swell index
6. IS: 2720(Part 8) - Determination of water content –dry density relation
7. IS: 2720(Part 16)-Laboratory determination of CBR.

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