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RESEARCH ARTICLE OPEN ACCESS

A Detailed Study of Cbr Method for Flexible Pavement Design

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ABSTRACT
As per IRC recommendation, California Bearing Ratio (CBR) value of subgrade is used for design of flexible pavements. California Bearing Ratio (CBR) value is an important soil parameter for design of flexible pavements and runway of air fields. It can also be used for determination of sub grade reaction of soil by using correlation. It is one of the most important engineering properties of soil for design of sub grade of roads. CBR value of soil may depends on many factors like maximum dry density (MDD), optimum moisture content (OMC), liquid limit (LL), plastic limit (PL), plasticity index (PI), type of soil, permeability of soil etc. Besides, soaked or unsoaked condition of soil also affects the value. These tests can easily be performed in the laboratory. the estimation of the CBR could be done on the basis of these tests which are quick to perform, less time consuming and cheap, then it will be easy to get the information about the strength of subgrade over the length of roads, By considering this aspect, a number of investigators in the past made their investigations in this field and designed different pavements by determining the CBR value on the basis of results of low cost, less time consuming and easy to perform tests. In this study, attempts have been made to seek the values of CBR of different soil samples and correlate their CBR values for the design purpose of flexible pavement as per guidelines of IRC: SP: 37-2001.

Keywords: California Bearing Ratio, correlation, soaked, unsoaked, flexible pavemet.

I. INTRODUCTION

California bearing ratio (CBR) is an empirical test and widely applied in design of flexible pavement over the world. This method was developed during 1928-29 by the California Highway Department. Use of CBR test results for design of roads, introduced in USA during 2nd World War and subsequently adopted as a standard method of design in other parts of the world, is recently being discouraged in some advanced countries because of the imperialness of the method [(Brown, 1996)]. The California bearing ratio (CBR) test is frequently used in the assessment of granular materials in base, subbase and subgrade layers of road and airfield pavements. The CBR test was originally developed by the California State Highway Department and was thereafter incorporated by the Army Corps of Engineers for the design of flexible pavements. It has become so globally popular that it is incorporated in many international standards ASTM 2000.

The significance of the CBR test emerged from the following two facts, for almost all pavement design charts, unbound materials are basically characterized in terms of their CBR values when they are compacted in pavement layers and the CBR value has been correlated with some fundamental properties of soils, such as plasticity indices, grain-size distribution, bearing capacity, modulus of subgrade reaction, modulus of resilience, shear strength, density, and molding moisture content [Doshi and Guirguis 1983] Because these correlations are currently readily available to the practicing engineers who have gained wide experience with them, the CBR test remains a popular one.

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 design. It is a load test applied to the surface and used in soil investigations as an aid to the design of pavements. The design for new construction should be based on the strength of the samples prepared at optimum moisture content (OMC) corresponding to the Proctor Compaction and soaked in water for a period of four days before testing. In case of existing road requiring strengthening, the soil should be moulded at the field moisture content and soaked for four days before testing. It has been reported that, soaking for four days may be very severe and may be discarded in some cases, [Bindra 1991]. This test method is used to evaluate the potential strength of subgrade, subbase, and base course material for use in road and airfield pavements. [Bindra 1991] reported that design curves (based on the curve evolved by Road Research Laboratory, U.K) are adopted by Indian Road Congress (IRC: 37-1970). As per IRC, CBR test should be performed on remoulded soil in the laboratory. In-situ tests are not recommended for design purpose [Bindra, 1991].

The design of the pavement layers to be laid over subgrade soil starts off with the estimation of subgrade strength and the volume of traffic to be carried. The Indian Road Congress (IRC) encodes the exact design strategies of the pavement layers based upon the subgrade strength which is most commonly expressed in terms of the California Bearing Ratio (CBR). For the design of pavement CBR value is invariably considered as one of the important parameter. With the CBR value of the soil known, the appropriate thickness of construction required above the soil for different traffic conditions is determined using the design charts, proposed by IRC. CBR value can be measured directly in the laboratory test in accordance with IS:2720 (Part-XVI) on soil sample procured from the work site. Laboratory test takes at least 4 days to measure the CBR value for each soil sample under soaked condition. In addition, the test requires large quantity of the soil sample and the test requires skill and experience without which the results may be inaccurate and misleading.

II. EXPERIMENTAL PROGRAM

For checking the properties of the soil, reported different properties like Grain Size Analysis, maximum dry density (MDD), optimum moisture content (OMC), liquid limit (LL), plastic limit (PL), plasticity index (PI), etc.

COLLECTION OF MATERIALS

The materials were obtained from the nearby borrow areas, where plenty amount of material is available for the construction purpose. The material which is collected for testing is different in quality and property, so that the material was separately tested in the laboratory so as to design the soil sub grade.

Grain Size Analysis (IS: 2720 - Part 4)

Grain size analysis is carried out to determine the relative percentages of different sizes of particles in the sample. These sizes control the mechanical behavior of coarse grained soil. Dry method of sieving is used for coarser fractions (retained on 4.75 mm sieve) and wet method is used for finer fractions (retained on 75micron sieve) and pipette method is used for fractions passing 75 micron sieve.

Figure 1: Sieve Shaking Appratus for Particle size analysis.

Results

Case I (Yellow soil (Clayey silt))
Dry Sieving

Weight of Soil Sample Taken: 1500(g)

I.S Sieve Designation	Weight of sample retained in (g)	Percentage of wt. retained	Cumulative percent of wt. retained (%)	Percentage of wt. passing
100 mm	-	-	0	100
75 mm	-	-	0	100
19 mm	-	-	0	100
4.75 mm	48	3.2	3.2	96.8
Pan	1452			

Table No 1: Sieve Analysis of Soil

Summary of Results
Percentage of Gravel in soil sample = 3.2 % (< 10%)

Case II (Kopra)
Dry Sieving

Weight of Soil Sample Taken: 3500(g)

I.S Sieve Designation	Weight of sample retained in (g)	Percentage of wt. retained	Cumulative percent of wt. retained (%)	Percentage of wt. passing
100 mm	-	0	0	100
75 mm	-	0	0	100
19 mm	-	0	0	100
4.75 mm	338	9.65	9.65	90.35
Pan	3142			

Table No 2 Sieve Analysis of Soil.

Summary of Results
Percentage of Gravel in soil sample = 9.65 % (< 10%)
.

Liquid Limit, Plastic Limit and Plasticity Index (IS 2720- Part 5)

Purpose

The Liquid and Plastic Limits (Atterberg Limits) of soil indicate the water contents at which certain changes in the physical behavior of soil can be observed. From Atterberg limits, it is possible to estimate the engineering properties of fine-grained soils. Plasticity is the property that enables a material to undergo deformation without noticeable elastic recovery and without cracking or crumbling. Plasticity is a major characteristic of soils containing an appreciable proportion of clay particles.

Figure 2: Liquid Limit Device.

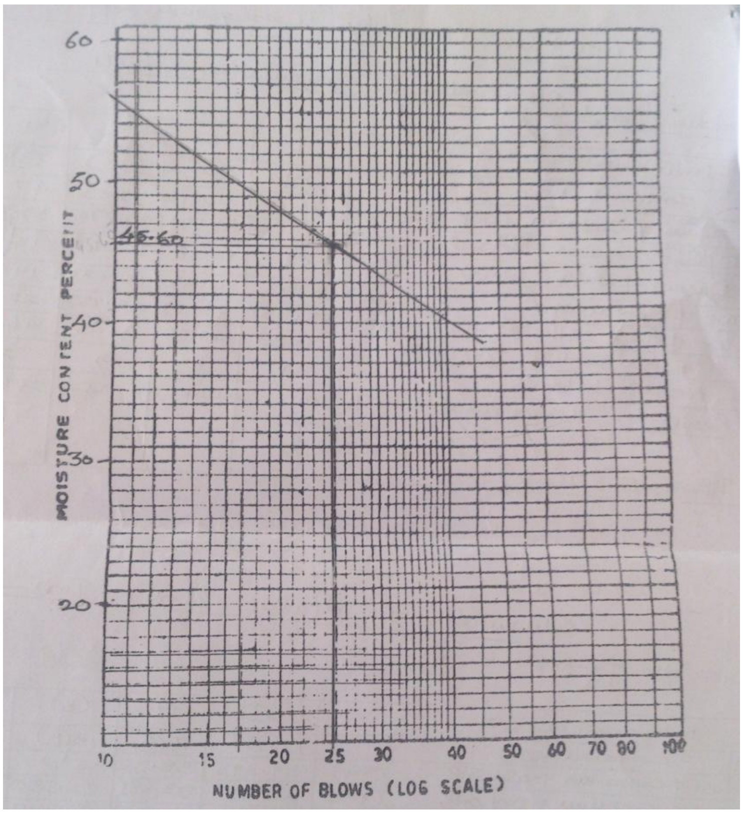
Case I Yellow soil (Clayey silt)

Atterberg Limits Test Determination of Liquid Limit (LL)

S.No	Determination No.	1	2	3	4	5	Remark
1	Container Number	31	32	33	34	35	
2	Weight of container + wet soil (gm)	46.770	47.920	47.53	47.760	49.130	
3	Weight of container + dry soil (gm)	37.180	37.740	37.270	37.23	38.18	
4	Loss of Moisture (gm)	9.53	10.18	10.26	10.53	10.95	
5	Wt. of container (gm)	13.843	14.370	15.033	14.625	14.727	
6	Wt. of dry soil (gm)	23.337	23.37	22.237	22.605	23.453	
7	Moisture content %	40.83	43.56	46.13	46.58	46.68	
8	Number of blows	39	33	27	23	27	

Table 3: Determination of Liquid Limit (LL).

Result: Moisture content at 25 blows from the graph.



Graph 1: Liquid limit test Curve.

Liquid Limit (LL) = 45.6 %

Determination of Plastic Limit (PL)

S.No	Determination No.	1	2	3	Remark
1	Container Number	12 B	14 B	18 B	
2	Weight of container + wet soil (gm)	39.895	38.350	36.920	
3	Weight of container + dry soil (gm)	34.835	33.685	32.580	
4	Loss of Moisture (gm)	5.06	4.665	4.340	
5	Wt. of container (gm)	15.285	14.825	15.321	
6	Wt. of dry soil (gm)	19.55	18.860	17.05	
7	Moisture content %	25.88 % (mc_1)	24.73% (mc_2)	25.45% (mc_1)	

Table 4: Determination of Plastic Limit (PL)

$$\text{Plastic Limit (PL)} = \frac{25.88(mc1) + 24.73(mc2) + 25.45(mc3)}{3} = 25.35\ \%$$

Plasticity Index (Pl) = LL - PL = 45.60 – 25.35 = 20.25 %

Case II (Kopra)

Atterberg Limits Test

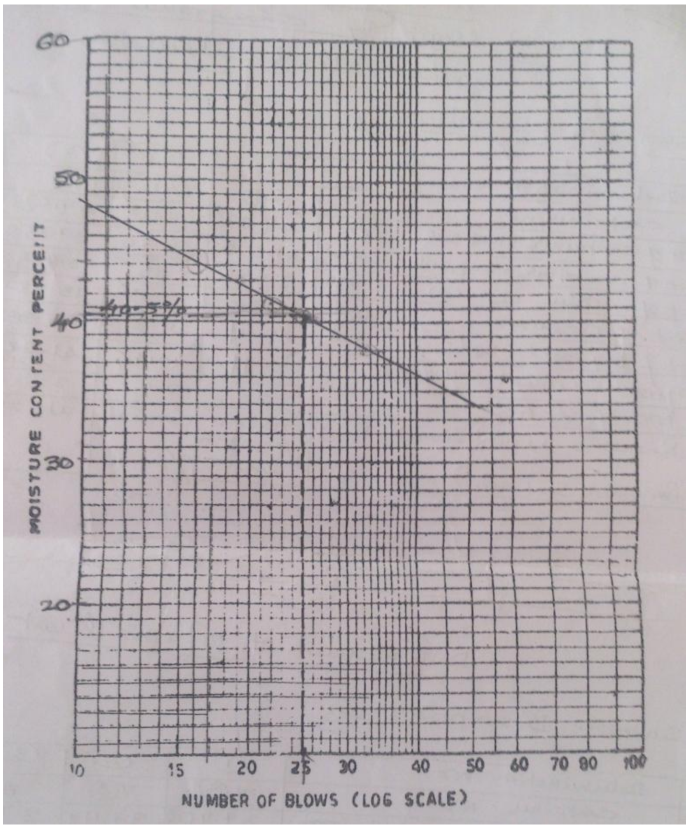
Determination of Liquid Limit (LL)

S. No	Determination No.	1	2	3	4	5	Remark

1	Container Number	41	42	43	44	45	
2	Weight of container + wet soil (gm)	49.336	48.125	49.673	48.346	49.94	
3	Weight of container + dry soil (gm)	39.650	38.26	39.250	38.050	39.03	
4	Loss of Moisture (gm)	9.686	9.865	10.423	10.296	10.91	
5	Wt. of container (gm)	14.240	13.870	13.950	14.150	14.380	
6	Wt. of dry soil (gm)	25.41	24.390	25.300	23.900	24.650	
7	Moisture content %	38.11	40.44	41.19	43.08	44.26	
8	Number of blows	33	26	22	19	16	

Table 5: Determination of Liquid Limit (LL)

Result: Moisture content at 25 blows from the graph.



Graph 2: Liquid limit test Curve.

Liquid Limit (LL) = 40.5 %

Determination of Plastic Limit (PL)

S.No	Determination No.	1	2	3	Remark
1	Container Number	9 B	7 B	6 B	

2	Weight of container + wet soil (gm)	39.408	39.119	37.294	
3	Weight of container + dry soil (gm)	34.820	34.800	33.25	
4	Loss of Moisture (gm)	4.588	4.319	4.04	
5	Wt. of container (gm)	14.72	15.14	14.868	
6	Wt. of dry soil (gm)	20.16	19.66	18.345	
7	Moisture content %	22.82 % (mc_1)	21.97 % (mc_2)	22.02 % (mc_1)	

Table 6: Determination of Plastic Limit (PL)

$$\text{Plastic Limit (PL)} = \frac{25.88\,(mc1) + 24.73(mc2) + 25.45(mc3)}{3} = 22.27\ \%$$

Plasticity Index (Pl) = LL - PL = 40.50 – 22.27 = 18.23 %

Proctor Density (IS: 2720 - Part 7)

Compaction is the process of densification of soil mass by reducing air voids. The purpose of laboratory compaction test is so determine the proper amount of water at which the weight of the soil grains in a unit volume of the compacted is maximum, the amount of water is thus called the Optimum Moisture Content (OMC). In the laboratory different values of moisture contents and the resulting dry densities, obtained after compaction are plotted both to arithmetic scale, the former as abscissa and the latter as ordinate. The points thus obtained are joined together as a curve. The maximum dry density and the corresponding OMC are read from the curve.

CALCULATION (Case I – Yellow soil (Clayey silt) :

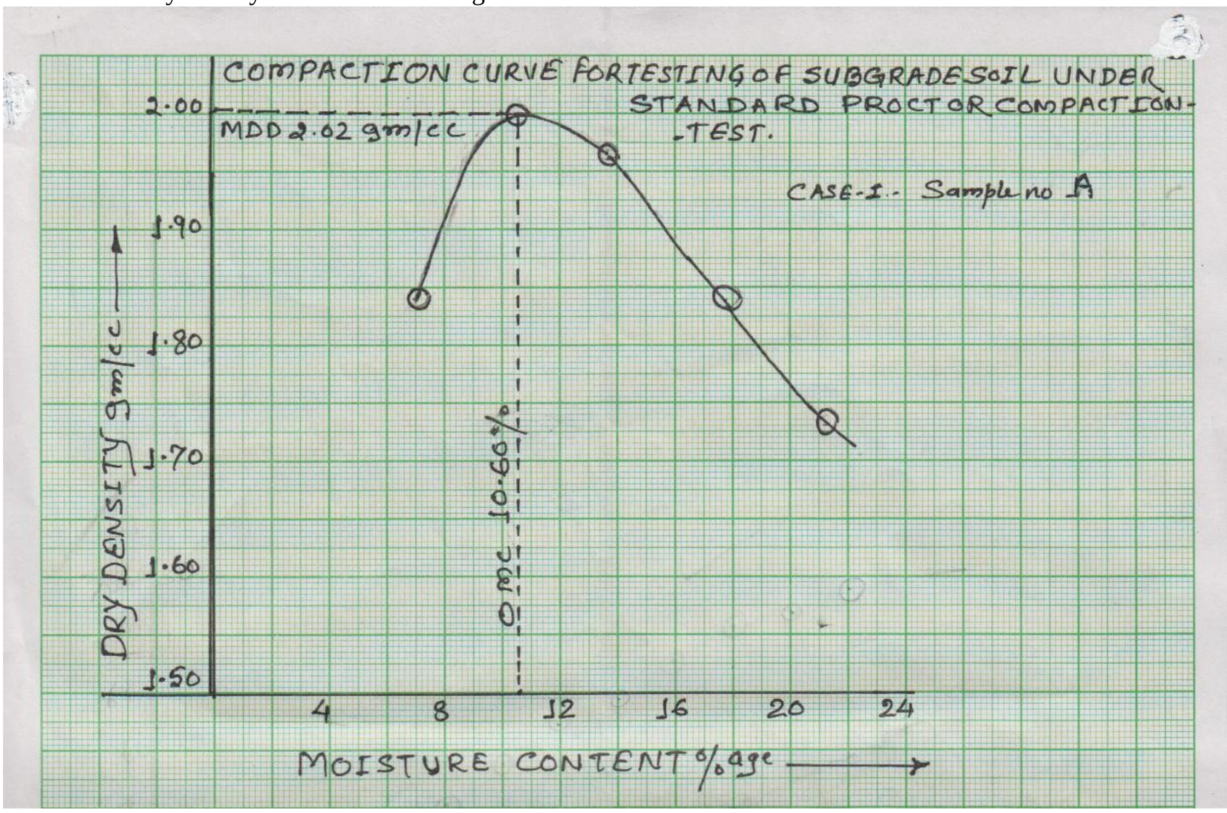
1. Description of Sample = Yellow soil (Clayey silt)
2. Weight of Mould = 2310 gm
3. Volume of Mould = 1000 cc
4. % retained on 20mm I.S Sieve = Nil

S. No	**Determination No.**	**1**		**2**		**3**		**4**		**5**	
1	Weight of Mould + Compacted soil (gm)	4037		4192		4415		4402		4391	
2	Weight of Compacted soil (gm)	1727		1882		2105		2092		2081	
3	Wet Density $\gamma_t = w_t/v$ (gm/cc)	1.727		1.882		2.105		2.092		2.081	
4	Crucible No	15	23	22	18	20	19	13	21	14	17
5	Weight of Crucible + wet Soil (gm)	92.120	87.780	91.800	81.550	99.710	88.650	88.240	93.950	91.280	103.90
6	Weight of Crucible + Dry soil (gm)	86.700	82.88	85.60	75.840	89.820	80.06	77.86	82.800	80.310	89.820
7	Weight of water (gm)	5.42	4.90	6.20	5.71	9.89	8.59	10.38	11.15	10.97	14.08
8	Weight of Crucible (gm)	21.958	23.570	23.87	23.376	23.408	21.131	20.769	24.308	26.248	23.110
9	Weight of dry soil (gm)	64.742	59.31	61.73	52.464	66.412	58.329	57.09	58.492	54.062	66.77
10	Water content (%)	8.37	8.26	10.04	10.88	14.89	14.57	18.18	19.06	20.29	21.10
	Dry Density $\gamma_d = \gamma_t/1+w$	8.315		10.46		14.73		18.62		20.695	

11	(gm/cc)	1.594	1.703	1.834	1.763	1.724

Table 7: Data Sheet for Proctor Compaction Test.

Results: (As per Graph Below)
1. Optimum moisture content = 14.73 %
2. Maximum dry density = 1.834 gm/cc



Graph 3: Proctor compaction test curve.

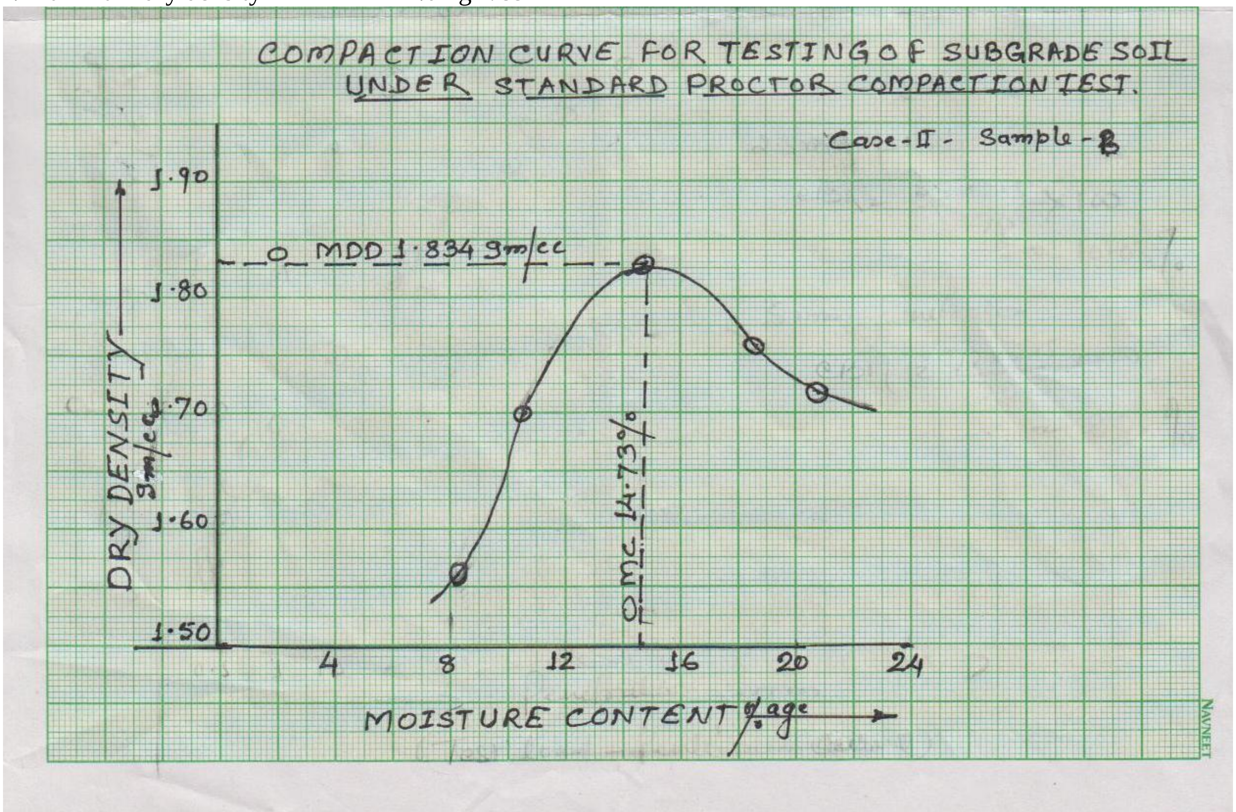
CALCULATION (Case II – Kopra)
1. Description of Sample = Moorum
2. Weight of Mould = 2310 gm
3. Volume of Mould = 1000 cc
4. % retained on 20mm I.S Sieve = Nil

S.No	Determination No.	1		2		3		4		5	
1	Weight of Mould + Compacted soil (gm)	4300		4550		4560		4480		4408	
2	Weight of Compacted soil (gm)	1990		2240		2250		2170		2098	
3	Wet Density $\gamma_t = w_t/v$ (gm/cc)	1.99		2.24		2.25		2.17		2.098	
4	Crucible No	4	5	6	7	8	9	10	11	12	3
5	Weight of Crucible + wet Soil (gm)	76.890	75.475	74.960	74.910	74.85	80.200	71.340	73.020	79.36	86.00
6	Weight of Crucible + Dry soil (gm)	72.780	72.00	70.05	69.75	6.14	6.92	7.25	7.45	9.83	11.01
7	Weight of water (gm)	20.769	26.248	4.91	5.16	23.110	23.376	23.408	23.308	21.980	23.870
8	Weight of Crucible (gm)	20.76	26.24	4.91	5.16	23.11	23.37	23.40	24.308	21.98	23.87

		9	8			0	6	8		0	0
9	Weight of dry soil (gm)	52.011	45.752	46.48	48.619	45.60	49.90	40.68	41.26	47.55	51.12
10	Water content (%)	7.90	7.58	10.56	10.61	13.46	13.86	17.82	18.05	20.07	21.53
11	Dry Density $\gamma_d=\gamma_t/1+w$ (gm/cc)	7.74		10.58		13.66		17.83		21.20	
		1.84		2.02		1.97		1.84		1.73	

Table 8: Data Sheet for Proctor Compaction Test.

Results: (As per Graph Below)
1. Optimum moisture content = 10.60 %
2. Maximum dry density = 2.02 gm/cc



Graph 4: Proctor compaction test curve.

The California Bearing Ratio Test (IS: 2720 - Part 16)

Need and Scope

The California bearing ratio test is penetration test meant for the evaluation of subgrade strength of roads and pavements. California bearing ratio is the ratio of force per unit area required to penetrate in to a soil mass with a circular plunger of 50mm diameter at the rate of 1.25mm / min. The results obtained by these tests are used with the empirical curves to determine the thickness of pavement and its component layers. This is the most widely used method for the design of flexible pavement.

Figure 3: CBR Testing of different Soil Samples.

CALCULATION (Case I – (Yellow soil (Clayey silt))

1. Sample = Yellow soil (Clayey silt)
2. Source of material =Quarry
3. Value of one Division of proving Ring = 2.5 Kg

Time of Penetration c/0.25 mm/min	Penetration in mm	Proving ring Reading No. Divisions			Test load/Corrected load 3 × Value of One division in (kg)			Standard load in (kg) on Plunger area 19.64 cm^2	Unsoaked /Soaked CBR % 4/5 × 100			Average CBR
1	2	3			4			5	6			7
		I	II	III	I	II	III		I	II	III	
0.0	0.0											
0.24	0.5	9	10	10								
0.48	1.0	16	15	15								
1.12	1.5	21	20	18								
1.36	2.0	25	24	23								
2.0	**2.5**	**28**	**28**	**27**	**70**	**70**	**67.5**	**1370**	**5.10**	**5.10**	**4.92**	**5.04%**
2.24	3.0	31	31	30								
3.12	4.0	34	34	34								
4.0	**5.0**	**38**	**37**	**37**	**95**	**97.5**	**92.5**	**2055**	**4.62**	**4.50**	**4.50**	**4.54%**
6.0	7.5	43	42	44								
8.0	10	46	45	47								
10.0	12.50	48	47	49								

Table 9: Data Sheet for CBR Test.

Results
Average CBR – 2.5 mm Penetration = 05.04 %
Average CBR – 5.00 mm Penetration = 4.54 %
I
2.5 mm Penetration
CBR = Test load/ Standard load × 100%
= (28×2.5/1370) × 100 = 5.10%
5 mm Penetration
CBR = Test load/ Standard load × 100%
= (38×2.5/2055) × 100 = 4.62%
II
2.5 mm Penetration
CBR = Test load/ Standard load × 100%
= (28×2.5/1370) × 100 = 5.10%
5 mm Penetration
CBR = Test load/ Standard load × 100%
= (37×2.5/2055) × 100 = 4.50%
III
2.5 mm Penetration
CBR = Test load/ Standard load × 100%
= (27×2.5/1370) × 100 = 4.92%
5 mm Penetration
CBR = Test load/ Standard load × 100%
= (38×2.5/2055) × 100 = 4.62%
Average CBR at 2.5 mm Penetration = (I+II+III)/3 = 5.04%

CALCULATION (Case II – Kopra)
1. Sample =Kopra
2. Source of material =Quarry
3. Value of one Division of proving Ring = 2.5 Kg

Time of Penetration c/0.25 mm/min	Penetration in mm	Proving ring Reading No. Divisions			Test load/Corrected load 3 × Value of One division in (kg)			Standard load in (kg) on Plunger area 19.64 cm^2	Unsoaked /Soaked CBR % 4/5 × 100			Average CBR
1	2	3			4			5	6			7
		I	**II**	**III**	**I**	**II**	**III**		**I**	**II**	**III**	
0.0	0.0											
0.24	0.5	22	24	18								
0.48	1.0	35	37	32								
1.12	1.5	44	46	42								
1.36	2.0	50	51	49								
2.0	**2.5**	**55**	**56**	**55**	**137.5**	**140**	**137.5**	**1370**	**10.03**	**10.21**	**10.03**	**10.09%**
2.24	3.0	57	59	60								
3.12	4.0	64	64	64								
4.0	**5.0**	**69**	**67**	**72**	**172.5**	**167.5**	**175**	**2055**	**8.39**	**8.15**	**8.51**	**8.35%**
6.0	7.5	79	80									
8.0	10											
10.0	12.50											

Table 10: Data Sheet for CBR Test.

Results:
Average CBR – 2.5 mm Penetration = 10.09 %
Average CBR – 5.00 mm Penetration = 8.35 %
I

2.5 mm Penetration
CBR = Test load/ Standard load × 100%
= (55×2.5/1370) × 100 = 10.03%
5 mm Penetration
CBR = Test load/ Standard load × 100%
= (69×2.5/2055) × 100 = 8.39%
II
2.5 mm Penetration
CBR = Test load/ Standard load × 100%
= (56×2.5/1370) × 100 = 10.21%
5 mm Penetration
CBR = Test load/ Standard load × 100%
= (67×2.5/2055) × 100 = 8.15%
II
2.5 mm Penetration
CBR = Test load/ Standard load × 100%
= (55×2.5/1370) × 100 = 10.03%
5 mm Penetration
CBR = Test load/ Standard load × 100%
= (70×2.5/2055) × 100 = 8.51%
Average CBR at 2.5 mm Penetration = (I+II+III)/3 = 10.09%

Flexible Pavement Design as per IRC-37-2001
Traffic Count Survey

The Calculation of vehicles is done with the traffic data and axle load survey as per IRC 37:2001. The design procedure given by IRC makes use of the CBR value, million standard axle concept, and vehicle damage factor. Traffic distribution along the lanes is taken into account. The design is meant for design traffic which is arrived at using a growth rate. Flexible pavements are considered to include the pavements which have bituminous surfacing and granular base and sub-base courses conforming to IRC/ MOST standards. These guidelines apply to new pavements.

TRAFFIC VOLUME COUNT SURVEY

DISTRICT Bhopal
ROAD Bhoapl To Berasia

TIME	HVC-Bus/Truck (Laden)			HVC-Bus/Truck (Unladen)			HVC-Bus/Truck (Overloaded)			MCV Agricultural Tractor Trailor (Laden)			MCV Agricultural Tractor Trailor (Unladen)			MCV Agricultural Tractor Trailor (Overloaded)			LCV Cars/Vans/Jeeps/Three Wheelers			HYWA(Laden)			HYWA(Unladen)			HYWA(Overloaded)		
DAY	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3
7.00 to 8.00 AM	5	4	4	2	3	0	0	0	0	5	4	3	3	5	3	2	0	1	1	2	1	0	0	0	0	5	0	1	2	1
8.00 to 9.00 AM	8	3	4	0	3	0	0	0	0	6	8	3	3	6	4	3	4	1	0	2	3	0	0	1	0	0	0	1	1	2
9.00 to 10.00 AM	3	4	1	3	3	1	0	0	0	4	9	3	3	3	4	2	0	0	3	2	3	3	1	0	0	0	0	0	1	0
10.00 to 11.00 AM	1	5	5	5	4	0	1	0	0	7	3	5	3	0	0	1	12	3	1	4	0	0	9	0	0	4	1	1	1	1
11.00 to 12.00 AM	2	6	6	3	2	0	0	1	0	9	0	0	4	1	4	1	3	3	2	2	1	1	6	7	4	0	0	0	0	1
12.00 to 1.00 PM	3	2	1	2	6	1	0	0	3	1	4	7	6	0	5	5	2	2	11	2	3	3	3	0	2	0	6	1	1	1
1.00 to 2.00 PM	4	2	7	6	4	0	1	1	0	2	7	2	0	0	2	9	1	8	8	3	3	4	8	14	3	3	0	0	0	1
2.00 to 3.00 PM	6	3	3	8	9	0	3	1	1	2	5	5	9	4	4	1	0	9	7	3	3	12	5	0	10	0	4	1	1	1
3.00 to 4.00 PM	7	1	2	4	3	1	0	0	0	2	6	0	7	6	3	0	4	3	5	7	1	3	6	0	7	0	0	1	0	1
4.00 to 5.00 PM	5	6	2	2	0	0	2	1	1	5	0	6	5	3	5	0	0	7	6	6	3	4	17	0	1	2	0	2	2	2
5.00 to 6.00 PM	4	7	4	5	4	1	1	4	0	6	8	5	4	6	6	6	2	1	14	8	2	2	11	18	0	0	4	2	1	0
6.00 to 7.00 PM	6	3	6	7	2	0	4	0	2	4	0	4	3	3	2	1	2	2	16	0	3	2	6	1	0	0	6	2	2	0
7.00 to 8.00 PM	3	5	0	4	1	0	2	6	0	7	1	7	2	1	9	3	0	3	8	1	2	0	8	2	0	6	5	2	2	2
TOTAL	**57**	**51**	**45**	**51**	**44**	**4**	**14**	**14**	**7**	**60**	**55**	**50**	**52**	**38**	**51**	**34**	**30**	**43**	**82**	**42**	**28**	**34**	**80**	**43**	**27**	**20**	**26**	**14**	**14**	**13**
	51			**33**			**12**			**55**			**47**			**36**			**51**			**52**			**24**			**14**		

Commercial vehicle per day = 277 nos.

Table 11: Traffic Volume Survey for Pavement Design.

Calculation of Pavement Thicknesses

Case I (Yellow soil (Clayey silt)):

Available Data:
1. Design of CBR of Subgrade Soil : 5%
2. Design Life of Pavement : 15 years
3. Annual Growth rate : 7.5 %
4. Distribution of Commercial vehicle for Single Lane : Double Lane
5. Computation of Design traffic for the end of Design life : 0.75

N = {365×[(1+r)^n-1]/r}×{A×D×F) }

N = The commulative no. of standard axles to be catered for in the design in terms of msa.
A = Initial Traffic in the year of completion of completion of construction in term of no. of CVPD
A = P (1+r)^x
P = No. of commercial vehicles as per last count
x = No. of years between the last count and the year of completion of construction
D = Lane distribution factor
F = Vehicle damage factor
n = Design Life in Years
r = Annual growth rate of commercial vehicles

Design Calculation of Pavement thickness:

1. Commercial Vehicle at last count "P" =277 CV/Day
2. r =7.50%
3. x =1
4. A =298
5. D =1
6. F =3.5
7. N =9.94 msa (say 10 msa)
8. Total thickness of pavement for design CBR 5% and Design traffic = 1 msa, of IRC 37, 2001 5% &

design traffic 10msa of IRC37, 2001
Total Thickness = 660 mm

9. Total thickness to be provided = 375-150 = 225 mm

10. Pavement composition interpolated as per MORT&H (IRC37-2001 page 24 plate 1)
(a) Granular Sub base = 300 mm
(b) Base course(wmm) = 250 mm
(c) DBM =70 mm
(d) BC =40 mm

Total Pavement Thickness = 660 mm

Case II (Kopra):
Available Data:
1. Design of CBR of Subgrade Soil : 10%
2. Design Life of Pavement : 15 years
3. Annual Growth rate : 7.5 %
4. Distribution of Commercial vehicle for Single Lane : Double Lane
5. Computation of Design traffic for the end of Design life : 0.75

N = {365×[(1+r)^n-1]/r}×{A×D×F) }

N = The commulative no. of standard axles to be catered for in the design in terms of msa.
A = Initial Traffic in the year of completion of completion of construction in term of no. of CVPD
A = P (1+r)^x
P = No. of commercial vehicles as per last count
x = No. of years between the last count and the year of completion of construction

D = Lane distribution factor
F = Vehicle damage factor
n = Design Life in Years
r = Annual growth rate of commercial vehicles

Design Calculation of Pavement thickness:

1. Commercial Vehicle at last count "P" =277 CV/Day
2. r =7.50%
3. x =1
4. A =298
5. D =1
6. F =3.5
7. N =9.94 msa (say 10 msa)
8. Total thickness of pavement for design

CBR 10% and Design traffic
= 1 msa, of IRC 37, 2001 5% &

design traffic 10msa of IRC37, 2001
Total Thickness = 540 mm

9. Total thickness to be provided = 540 mm
10. Pavement composition interpolated as per MORT&H (IRC37-2001 page 28 plate 1)

(a) Granular Subbase = 200 mm
(b) Base course(wmm) = 250 mm
(c) DBM = 50 mm
(d) BC = 40 mm

Total Pavement Thickness = 540 mm

III. Conclusion & Recommendations

General

The major conclusions drawn at the end of this work are as follows:

1. The thickness of crust varies with the change in the value of C.B.R. With higher value of C.B.R. the crust thickness is less and vice versa.
2. From this laboratory test it has been observed that the soil Kopra is suitable for the construction purpose for soil sub grade in comparision with the Yellow soil (Clayey silt) on the basis of higher values of C.B.R.
3. Due to the saving in crust less quantity of material will be applicable so that, huge amount of money can be saved.
4. Due to the higher values of C.B.R the kopra soil will be more durable in comparison to Yellow soil (Clayey silt).
5. Further this research work can be carried with the different soacking conditions of soil with respect to time, and improving the C.B.R values with the stabilization process with the different materials.

Pavement Thickness.

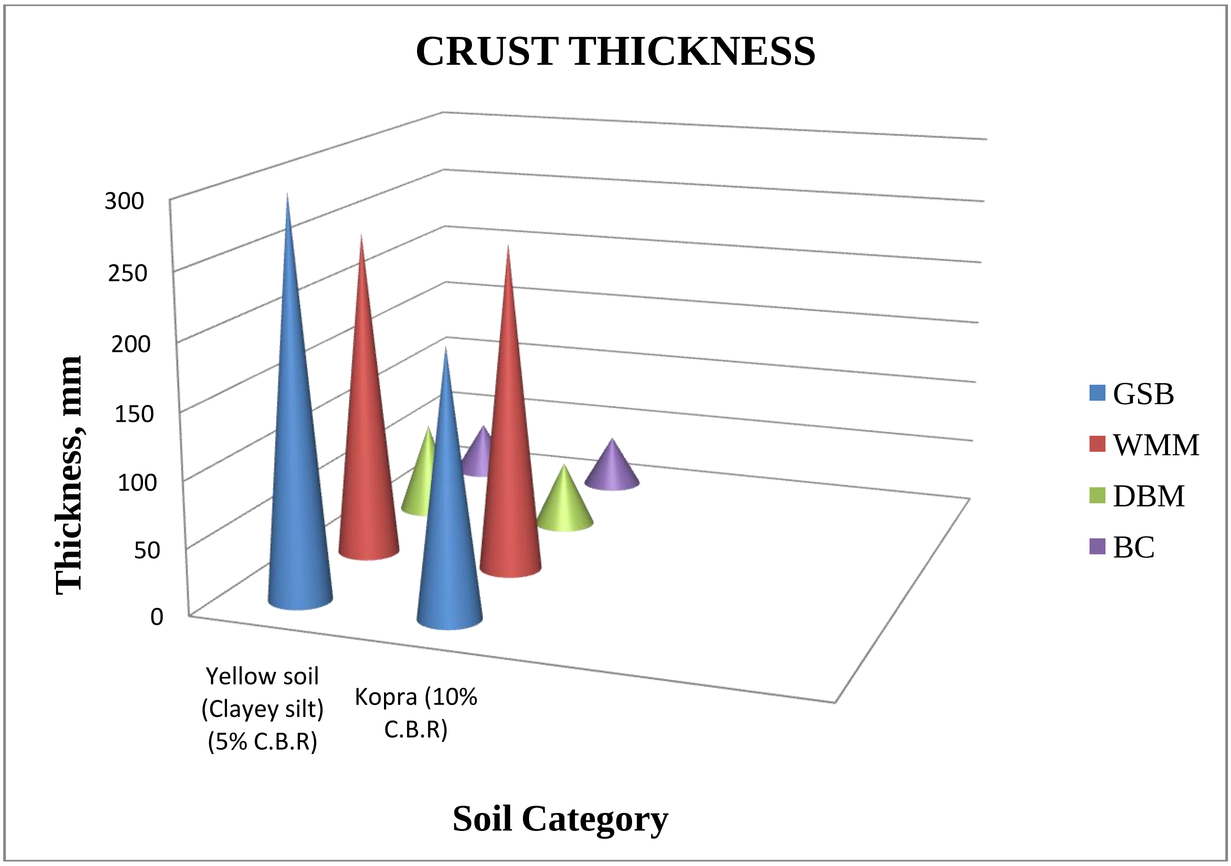
The thickness of crust varies with the change in the value of C.B.R, below shown are the crust thicknesses with different percentages of C.B.R.

Case I Yellow soil (Clayey silt):

S.No	Description	Layers	Layers Thickness (mm)
1	Yellow soil (Clayey silt) (5% C.B.R)	Granular Sub base	300
2		Base Coarse (WMM)	250
3		DBM	70
4		BC	40
Total Thickness			660mm

Case II (Kopra) :

S.No	Description	Layers	Layers Thickness (mm)
1	Kopra (10% C.B.R)	Granular Sub base	200
2		Base Coarse (WMM)	250
3		DBM	50
4		BC	40
Total Thickness			540mm



Graph 5: Crust thickness with different percentages of C.B.R.

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