UNIVERSITY OF MUSTANSIRIYAH-COLLEGE OF ENGINEERING –CIVIL ENGINEERING DEPARTMENT

Highway Pavement Lab4

Soil compaction, California Bearing Ratio (CBR) Test

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Lab of Highway Pavement

California Bearing Ratio (CBR) Test, ASTM D 1883

This test is commonly known as the CBR test and involves the determination of the load-deformation curve of the soil in the laboratory using the standard CBR testing.

The test is conducted on samples of soil compacted to required standards and immersed in water for four days, during which time the samples are loaded with a surcharge that simulate the estimated weight of pavement material the soil will support.

The objective of the test is *to determine the relative strength of a soil with respect to crushed rock, which is considered an excellent coarse base material.*

This is obtained by conducting a penetration test on the samples still carrying the simulated load and using a standard CBR equipment. The CBR is defined as the penetration resistance of a sub-grade soil relative to a standard crushed rock.

Purpose:

1. To get the bearing ratio which is used in design of pavement of highway and airports
2. Penetration due to known load (pressure)

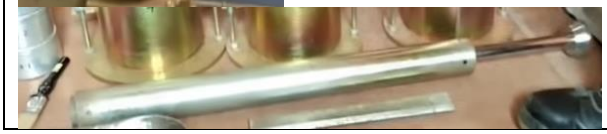
Apparatus

1. Loading machine:
   - capacity ≥ 1000 Ib (44.5 KN) with movable head rotate at a uniform rate of 0.05in/ min (1.27 mm/min)
   - penetration piston (Φ1.95in , L ≥ 4in, A=3 in^2)
   - Two dial gauges, one for load and other for penetration

2. Mold : (Φ6 in, h=7in with extension collar)

3. Perforated metal base plate of 3/8 in hight and 0.1 in hole dimeter

4. Hammer 10 Ib , 18 in drop



5. Spacer disk , Φ 5 15/16 in, h=2.416 in

6. Surcharge weight 2 wt=5 Ib , Φ 5 1/8 in, with center hole of 2 1/8 in diameter

7. Soil Sample = 5000 gm passing sieve No. 4 drying for 24 hr at 60 ^{o}C

8. Balance

Oven

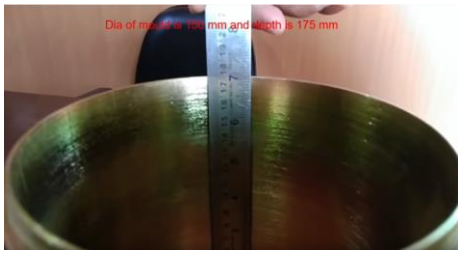
9. Others

Procedure:

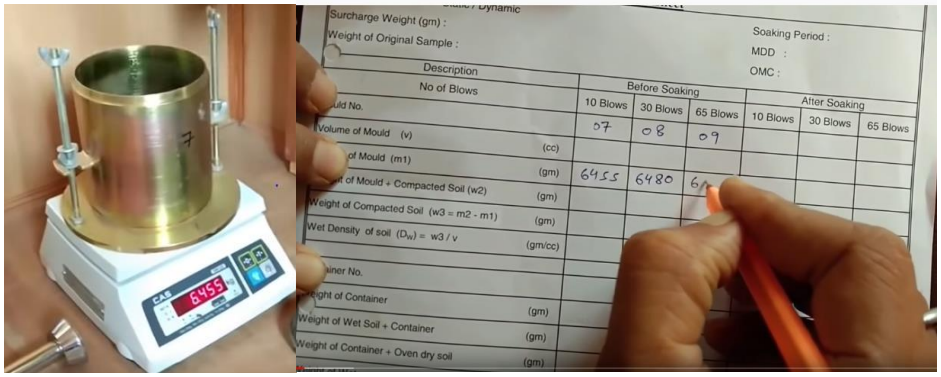
https://www.youtube.com/watch?v=0cAE4cSKo_s&t=2644s

1. Prepare a sufficient amount of dried soil for three trials of the CBR test (about 5 kg for each trial)

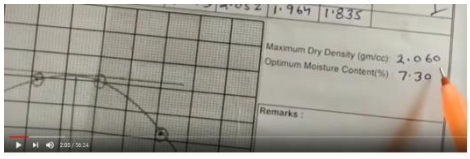
2. Measure the dimensions of three molds to find their volumes and record V

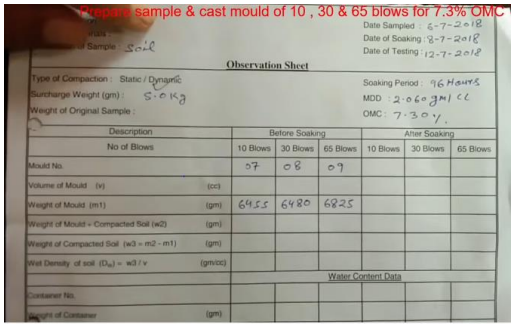


3. Weigh the three empty molds to record W1



4. Use the O.M.C found in proctor test to use in determining the weight of the used water





5. Mix the soil sample with The determined amount of water

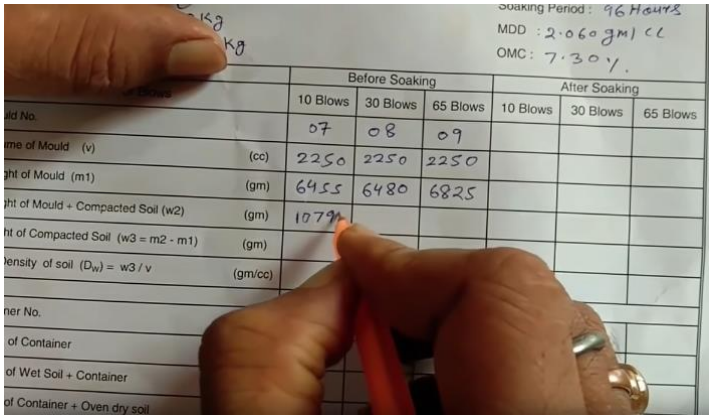
6. Place the spacer disk on the base plate together with the mold and the collar.

7. Divide the soil sample into five parts for five layers.

8. For the first layer, start to compact the soil sample by subjecting a number of blows (for example 10 blows) using the modified hammer. then repeat of the remaining four layers

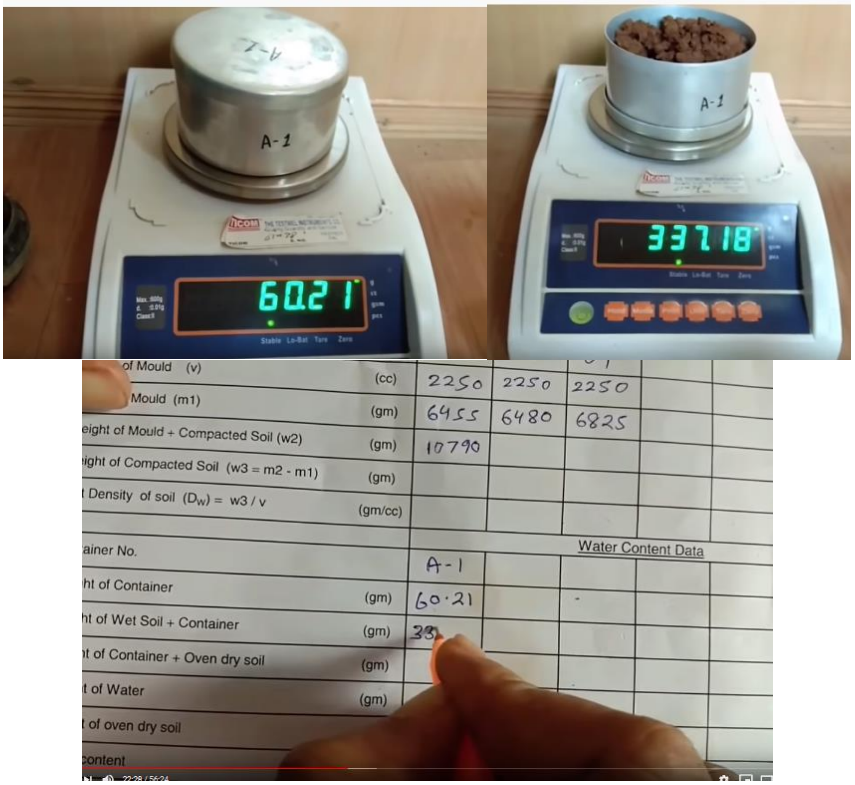
9. Remove the collar and use the straight edge

10. Weigh the mould+ wet compacted soil after removing the spacer disk to record W2



11. Place the Perforated metal base plate and the two Surcharge weights on the top of the mould filled with the wet compacted soil , and place the all on the loading machine

12. Weight the empty container then weigh with a sample of the used soil in the test to record (the weight of the empty container) and (the weight of the container +wet soil)



13. Repeat the steps from 4 to 13 twice for different number of blows (for example 30 and 56)

14. Put the wet soil samples in the oven for 24 hours

15. Record the weight of the container + dry soil

		Water Content Data					
Container No.		A-1	A-2	A-3	A-19		
Weight of Container	(gm)	60·21	60·85	60·71			
Weight of Wet Soil + Container	(gm)	337·18	316·08	339·82	360·08		
Weight of Container + Oven dry soil	(gm)						
Weight of Water	(gm)						
Weight of oven dry soil	(gm)						
Water content	(%)						
Dry Density of soil (D_d) = 100 x Dw / (100 + w)	(gm/cc)						

16. Immerse the mould and weights in water allowing free access of water to the top and bottom of the specimen. Take initial measurements for swell and allow the specimen to soak for 96 h.

    At the end of 96 h, take final swell measurements and calculate the swell as a percentage of the initial height of the specimen.

17. Remove the free water and allow the specimen to drain downward for 15 min

Description		Before Soaking			After Soaking		
No of Blows		10 Blows	30 Blows	65 Blows	10 Blows	30 Blows	65 Blows
Mould No.		07	08	09	07		
Volume of Mould (v)	(cc)	2250	2250	2250	2250		
Weight of Mould (m1)	(gm)	6455	6480	6825	6455		
Weight of Mould + Compacted Soil (w2)	(gm)	10790	10350	11890	10970		
Weight of Compacted Soil (w3 = m2 - m1)	(gm)						
Density of soil (D_w) = w3 / v	(gm/cc)						
Container No.		Water Content Data					
		A-1	A-2	A-3			
Wt of Container	(gm)	60.21	60.85	60.71			
Wt of Wet Soil + Container	(gm)	337.18	316.08	339.82			
Wt of Container + Oven dry soil	(gm)						
Wt of Water	(gm)						
Wt of oven dry soil							

18. Seat the penetration piston with the smallest possible load, but in no case in excess of 10 lbf (44 N). Set both the stress and penetration gages to zero. This initial load is required to ensure satisfactory seating of the piston and shall be considered as the zero load when determining the load penetration relation.
    Apply the load on the penetration piston so that the rate of penetration is approximately 0.05 in. (1.27 mm)/min. Record the load readings at penetrations of 0.025 in. (0.64 mm), 0.050 in. (1.27 mm), 0.075 in. (1.91 mm), 0.100 in. (2.54 mm), 0.125 in. (3.18 mm), 0.150 in. (3.81 mm), 0.175 in. (4.45 mm), 0.200 in. (5.08 mm), 0.300 in. (7.62 mm), 0.400 in. (10.16 mm) and 0.500 in. (12.70 mm).

No. of Blows	10			30			65		
Mould No.	Mould No.			Mould No.			Mould No.		
Penetration (mm)	Proving Ring Reading (Div)	Load in (kg)	Corrected Load (kg)	Proving Ring Reading	Load in (kg)	Corrected Load (kg)	Proving Ring Reading	Load in (kg)	Corrected Load (kg)
0.00	—	—	—						
0.50	16								
1.00	24								
1.50	26								
2.00	30								
2.50	33								
3.00	35								
4.00	38								
5.00	41								
7.50	56								
10.00	73								
12.50	85								

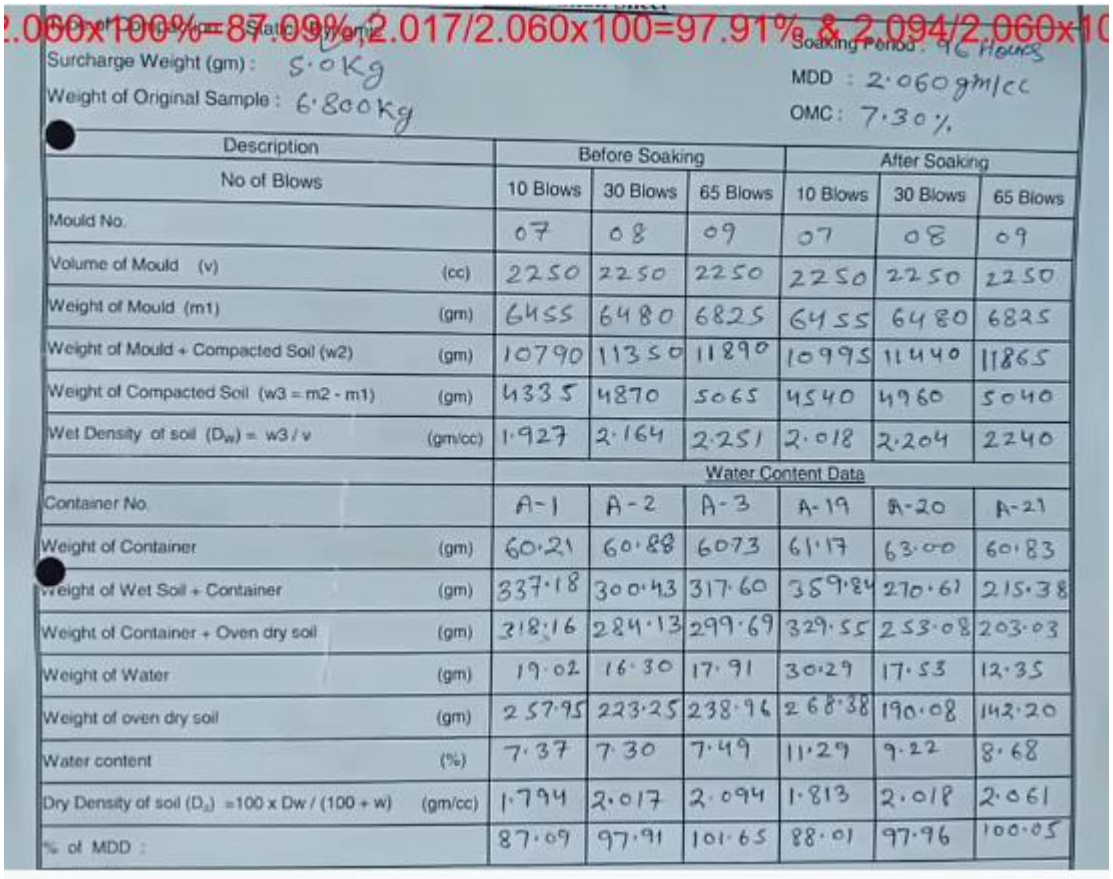
CALIFORNIA BEARING RATIO (CBR) TEST SOAKED (IS : 2720 PART 16 / ASTM - 1883-99)

Source/Description :

Proving Ring No. 01 Proving Ring Constant (kg/Div) : 5.876 Penetration Rate : 1.25 mm/min

No. of Blows	10			30			65		
Mould No.	Mould No.			Mould No.			Mould No.		
Penetration (mm)	Proving Ring Reading (Div)	Load in (kg)	Corrected Load (kg)	Proving Ring Reading	Load in (kg)	Corrected Load (kg)	Proving Ring Reading	Load in (kg)	Corrected Load (kg)
0.00	—	—	—	-	-	-	—	-	—
0.50	16			14			15		
1.00	24			28			37		
1.50	26			37			54		
2.00	30			45			66		
2.50	33			51			74		
3.00	35			56			84		
4.00	38			63			100		

19. If the sample was to be soacked , take other samples for determining Water content after compaction



2.060x100%=87.09% 2.017/2.060x100=97.91% & 2.094/2.060x10

Surcharge Weight (gm) : 5.0 Kg
Weight of Original Sample : 6.800 Kg
Soaking Period : 96 Hours
MDD : 2.060 gm/cc
OMC : 7.30 %

Description		Before Soaking			After Soaking		
No of Blows		10 Blows	30 Blows	65 Blows	10 Blows	30 Blows	65 Blows
Mould No.		07	08	09	07	08	09
Volume of Mould (v)	(cc)	2250	2250	2250	2250	2250	2250
Weight of Mould (m1)	(gm)	6455	6480	6825	6455	6480	6825
Weight of Mould + Compacted Soil (w2)	(gm)	10790	11350	11890	10995	11440	11865
Weight of Compacted Soil (w3 = m2 - m1)	(gm)	4335	4870	5065	4540	4960	5040
Wet Density of soil (D_w) = w3 / v	(gm/cc)	1.927	2.164	2.251	2.018	2.204	2240
		Water Content Data					
Container No.		A-1	A-2	A-3	A-19	A-20	A-21
Weight of Container	(gm)	60.21	60.88	6073	61.17	63.00	60.83
Weight of Wet Soil + Container	(gm)	337.18	300.43	317.60	359.84	270.61	215.38
Weight of Container + Oven dry soil	(gm)	318.16	284.13	299.69	329.55	253.08	203.03
Weight of Water	(gm)	19.02	16.30	17.91	30.29	17.53	12.35
Weight of oven dry soil	(gm)	257.95	223.25	238.96	268.38	190.08	142.20
Water content	(%)	7.37	7.30	7.49	11.29	9.22	8.68
Dry Density of soil (D_d) =100 x Dw / (100 + w)	(gm/cc)	1.794	2.017	2.094	1.813	2.018	2.061
% of MDD :		87.09	97.91	101.65	88.01	97.96	100.05

Calculation:

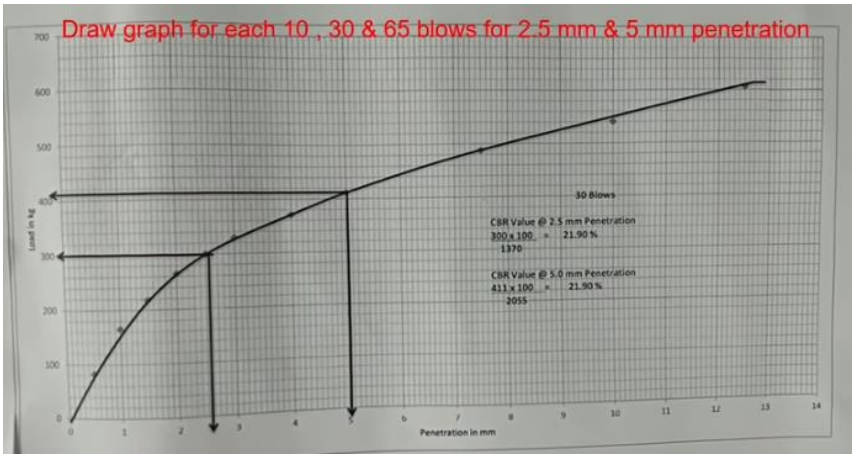
1. % swelling= $\frac{Change\ in\ sample\ height}{initial\ height\ of\ sample}$

2. Adjustment of the load penetration reading
   Load (KN) = reading *calibration factor
   Load (Ib) = Load (KN) * 224.8
   Penetration (mm) = reading * 0.001 in * 25.4167 mm/in

3. Weight of compacted soil = weight of (mold + compacted soil) – weight of empty mold
4. %W= (Weight of water / weight of dry soil)* 100
5. Find the average of the %W
6. Find the wet density of the soil = $\gamma wet\ \left(\frac{gm}{cm3}\right) = \frac{weight\ of\ the\ comacted\ soil}{Mold\ volume}$
7. Find the Dry density of the soil sample = $\gamma\ dry\ \left(\frac{gm}{cm3}\right) = \frac{\gamma wet}{1+\frac{w}{100}}$
8. Draw the standard curve connecting the penetration with load using the following data

Penetration (in)	Load (Ib)	Pressure (psi)
0.1	3000	1000
0.2	4500	1500
0.3	5700	1900
0.4	6900	2300
0.5	7800	2600

9. Draw the actual curve connecting the penetration with load using the actual data obtained from the lab test to determine the specified CBR
10. Draw the actual curve connecting the CBR values with dry unit weight to determine the specified dry density



11. CBR (0.1 in)= $\frac{Penetration\ load\ at\ 0.1\ in}{standard\ load\ at\ 0.1\ in}(100)$

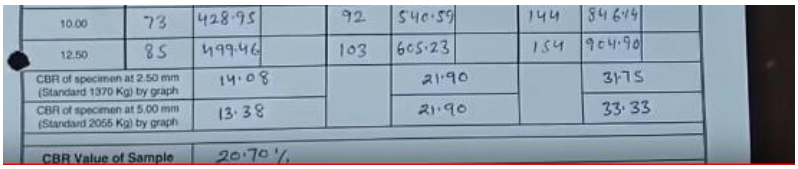
Standard load =3000 Ib = 1000 psi = 13.35 kN

12. CBR (0.2 in)= $\frac{Penetration\ load\ at\ 0.2\ in}{standard\ load\ at\ 0.1\ in}(100)$

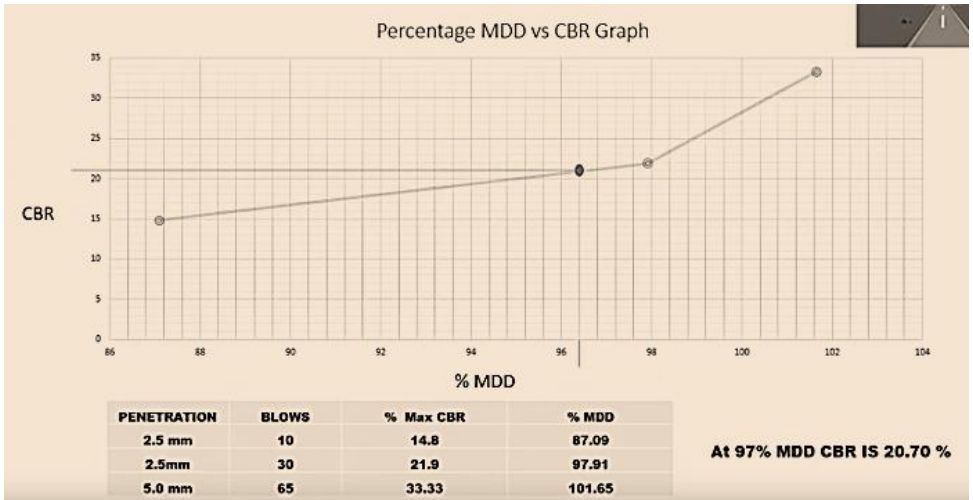
Standard load =5500 Ib = 1500 psi = 20.43 kN

13. Use the larger CBR

14. CBR used must be less than the calculated CBR



10.00	73	428.95	92	540.59	144	846.44
12.50	85	499.46	103	605.23	154	904.90
CBR of specimen at 2.50 mm (Standard 1370 Kg) by graph		14.08		21.90		31.75
CBR of specimen at 5.00 mm (Standard 2055 Kg) by graph		13.38		21.90		33.33
CBR Value of Sample		20.70 %				



PENETRATION	BLOWS	% Max CBR	% MDD
2.5 mm	10	14.8	87.09
2.5mm	30	21.9	97.91
5.0 mm	65	33.33	101.65

At 97% MDD CBR IS 20.70 %