

ment (as illustrated in Figure 2), which can be used to force the penetration piston into the specimen at a uniform rate of 0.05 in. per minute.

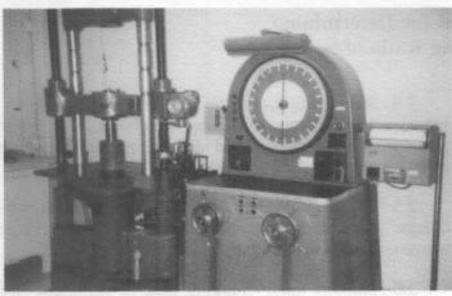


Figure 2. Laboratory CBR Test equipment

2.9 *General laboratory equipment.* General laboratory equipment specified in CRD-C 653.

2.10 *Loading device.* Loading device consisting of a mechanical screwjack to apply the load and a loaded truck to provide the resistance for the screwjack (see Figure 3).

2.1.1 *Proving rings.* Calibrated proving rings.

2.1.2 *Penetration piston.* Penetration piston, 1.95 in. in diameter, with internally threaded pipe extensions and connectors.

2.1.3 *Micrometers.* Dial micrometers and support.

2.1.4 *Steel plate.* Steel plate, 10 in. in diameter, having a 2.03-in.-diameter hole in the center and weighing 10 lb.

3. Procedure.

3.1 *Penetration test procedure.* The following penetration test procedure applies to laboratory and field in-place CBR tests. Satisfactory forms for recording penetration data for laboratory tests and field tests are shown in Figure 4 and Figures 5 and 6, respectively.

3.1.1 *Applying surcharge.* Apply sufficient penetration surcharge on the soil being tested to produce an intensity of loading equal to the weight (within ± 5 lb) of the base material and pavement that overlie the soil being tested, but the surcharge weight shall be not less than 10 lb. If the sample has been soaked previously, the penetration surcharge must be equal to the soaking surcharge. To prevent upheaval of soil into the hole of the surcharge weights, it is advisable to place one

5-lb annular disk surcharge weight on the soil surface prior to seating the piston and finally applying the remainder of the weights.

3.1.2 *Seating piston.* To seat the penetration piston, bring it into contact with the sample with sufficient pressure to cause the load dial to register a load of between zero and 1 lb.

3.1.3 *Applying loads.* Apply loads on the penetration piston so that the rate of penetration is approximately 0.05 in. per minute. Obtain load readings at 0.025-, 0.050-, 0.075-, 0.100-, 0.125-, 0.150-, 0.175-, 0.200-, and 0.300-in. deformation. In manually operated loading devices, it may be necessary to take load readings at closer intervals to control the rate of penetration.

3.1.4 *Determining moisture content.* Determine the moisture content in the upper 1 in., and in the case of

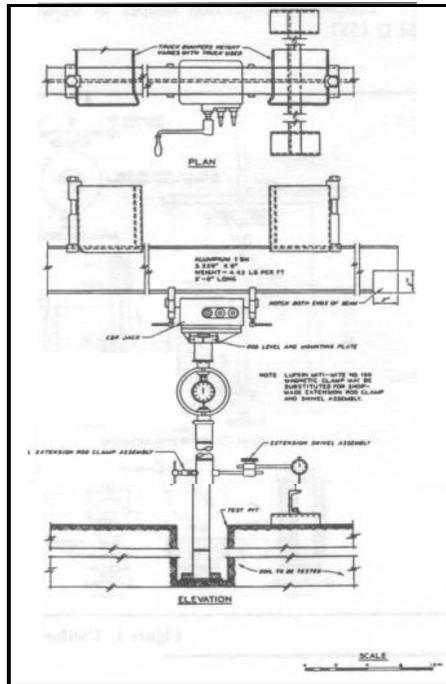


Figure 3. CBR testing equipment

FIELD CBR TEST

1. Date _____ 19__

2. Project _____ 3. Project Location _____

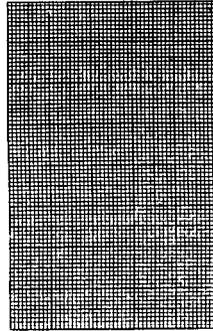
4. Test Location _____

5. Material _____

6. Depth, In. _____ 7. Failed / Unfailed _____ 10. Proving Ring No. _____

8. Pene.	9. Dial	8. Pene.	9. Dial	8. Pene.	9. Dial
.025"		.175"		.325"	
.050"		.200"		.350"	
.075"		.225"		.375"	
.100"		.250"		.400"	
.125"		.275"		.450"	
.150"		.300"		.500"	

9. Dial



CBR at 0.1"

11. Corrected Dial _____

12. CBR %

CBR at 0.2"

13. Corrected Dial _____

14. CBR = $\frac{\text{_____}}{1.5} = \text{_____} \%$

8. Penetration - Inches

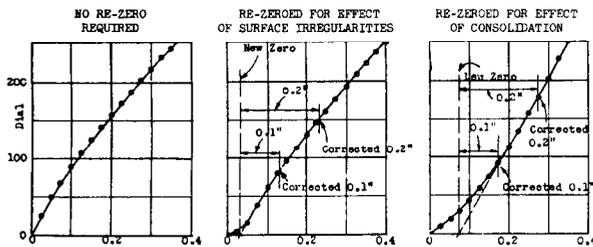
	15. Water Content for CBR	16. Water Content for Dens.	17. Density Sample	29. Sand Volume
18. Container No.	_____	_____	_____	30. Wt Filled _____
19. Wet Soil + Container	_____	_____	_____	31. Wt Empty _____
20. Dry Soil + Container	_____	_____	_____	32. Wt Sand _____
21. Wt Water	_____	_____	_____	33. Vol. Container _____
22. Wt Container	_____	_____	_____	34. Calibrated Dens. _____
23. Wt Wet Soil	_____	_____	_____	35. Wt After _____
24. Wt Dry Soil	_____	_____	_____	36. Wt Sand _____
25. Water Content	_____	<input type="text"/>	_____	37. Wt After _____
26. "K" Factor	_____	_____	_____	38. Wt Sand _____
27. Unit Wet Wt	_____	_____	_____	39. Wt Sand Used _____
28. Unit Dry Wt	_____	_____	<input type="text"/>	

40. Remarks _____

41. Field Test By _____ 42. Lab. Test By _____ 43. Comptd. By _____ 44. Chkd _____

Figure 5. CBR field record form

1. **Date.** Date field test is made.
 2. **Project.** Write name of job.
 3. **Project Location.** Give location of job.
 4. **Test Location.** Describe location of test pit on job.
 5. **Material.** Material being tested; base, subgrade, etc.
 6. **Depth.** Depth from surface in inches.
 7. **Failed or Unfailed.** Circle apt term.
 8. **Penetration.** Penetration of CBR piston into soil in inches.
 9. **Dial.** Reading on proving ring dial. When plotting the curve select the largest reasonable scale that will include the maximum value obtained in the test. Be sure to show this scale on the plot.
 10. **Ring No.** Serial number of proving ring (for selecting calibration sheet).
 11. **Corrected Dial.** Plot curve or dial readings versus penetration and re-zero curve as shown in samples below. Read dial at corrected 0.1 in.
 12. **CBR.** Read CBR from calibration curve (calibration curve reads direct CBR).
 13. **Corrected Dial.** Same as 11 except read dial at corrected 0.2 in. penetration.
 14. **CBR.** Same as 12 except divide reading from calibration sheet by 1.5. Show to nearest per cent.
 15. Use this column for the water content from the CBR test.
 16. Use this column for the water content from the density sample.
 17. Use this column for the soil part of sand volume/sample or for the entire computations in cylinder samples.
 18. Self explanatory.
 19. and 20. Show weight in grams.
 21. 22, 23, 24. For columns 15 and 16 obtain 24 first by subtracting 22 from 20. Then obtain 21 by subtracting 20 from 19. For column 17 obtain 23 by subtracting 22 from 19 when computing cylinder densities.
 25. Water content is 21 divided by 20 multiplied by 100 per cent. Show nearest 0.1%.
 26. "K" Factor for cylinder obtained by following formula; K equals 4.85 over diameter squared times height.
 27. For sand apparatus densities; 23 times 34 over 39. For cylinder densities; 23 by 26.
 28. 27 divided by 1 plus water content in hundredths. Example: 1 plus water content of 16.7 equals 1.167. May also be computed in the same manner as 27 by using the dry weight of soil 24 in place of the wet weight 23. Show to the nearest lb/cu ft.
 29. Use for sand part of sand volume density.
 30. Total weight of sand apparatus filled in grams.
 31. Total weight of sand apparatus empty in grams.
 32. Weight of sand used to fill cylinder; obtained by subtracting line 31 from line 30.
 33. Volume of sand apparatus used. Obtained by using formula: weight of water required to fill cylinder in pounds over unit weight of water in lb/cu ft.
 34. Density of sand in lb/cu ft obtained by multiplying line 32 by .002205 over line 33.
 35. Re-weigh for total weight of sand apparatus in grams after pouring sand for surface calibration.
 36. Total weight of sand used in surface calibration obtained by subtracting line 35 from line 30.
 37. Re-weigh after filling hole for amount of sand used in hole.
 38. Total weight of sand used in hole and surface calibration obtained by subtracting line 37 from line 35.
 39. Weight of sand used in hole obtained by subtracting line 36 from line 38.
 40. Explain any variations. Also use to record additional facts about test location.
 41. 42, 43, 44. Insert initials.
- Use figures in block for making tables and plots, except use underlined CBR (0.2 in.) when this figure is constantly higher for material being tested.



These curves show a case requiring no re-zeroing and two typical cases where re-zeroing is required. The curves themselves are not necessarily typical as the slope and shape of curves vary considerably. In general, the points should line up so that reasonable curves can be drawn with a French curve. Tests should be re-run where the points do not line up sufficiently well to permit drawing reasonable curves.

Figure 6. CBR field record form (reverse side)

3.3.3.2 *Obtaining design CBR data.* The data from a CBR test are plotted as in Figure 7, and the resulting family of CBR curves represents the characteristics encompassing a wide range of field conditions. The design CBR shall be based on the density and molding moisture content anticipated in the field. For example, assume that the lean clay soil, for which results are plotted in Figure 7, can be processed to an average moisture content of 13 percent to 16 percent and that it can be compacted to a density varying from 110.5 (95 percent of modified maximum density) to 115 lb/ft³ (see cross-hatched area on lower left-hand plot of Figure 7). If construction could be controlled so that the density and moisture content were within these ranges, the right-hand plot of Figure 7 indicates that the soils, after moisture conditions had become adjusted, would have a CBR (see cross-hatched area on right-hand lot of Figure 7) varying between about 11 (1105-lb/ft³ density and 13 percent moisture content) and 26 (1154lb/ft³ density and 15 percent moisture content). The design CBR selected should be near the

lower value, say 12. The right-hand plot in Figure 7 shows that close control of moisture content within those limits (13 percent to 16 percent) is necessary because low CBR values will be obtained if the moisture content is allowed to increase appreciably above the desired range.

3.3.4 *Swelling soils.*

3.3.4.1 *Test procedures.* The test procedures for highly swelling soils are the same as those previously described for cohesive soils; however, the objectives of the testing program are not exactly the same. Tests shall be performed on soils having expansive characteristics to determine a moisture content and a density which will minimize expansion. The proper moisture content and density are not necessarily the optimum moisture content and density for the CE 55 compaction effort. Generally, the minimum swell and highest soaked CBR will occur at a molding moisture content slightly wet of optimum. When testing highly swelling

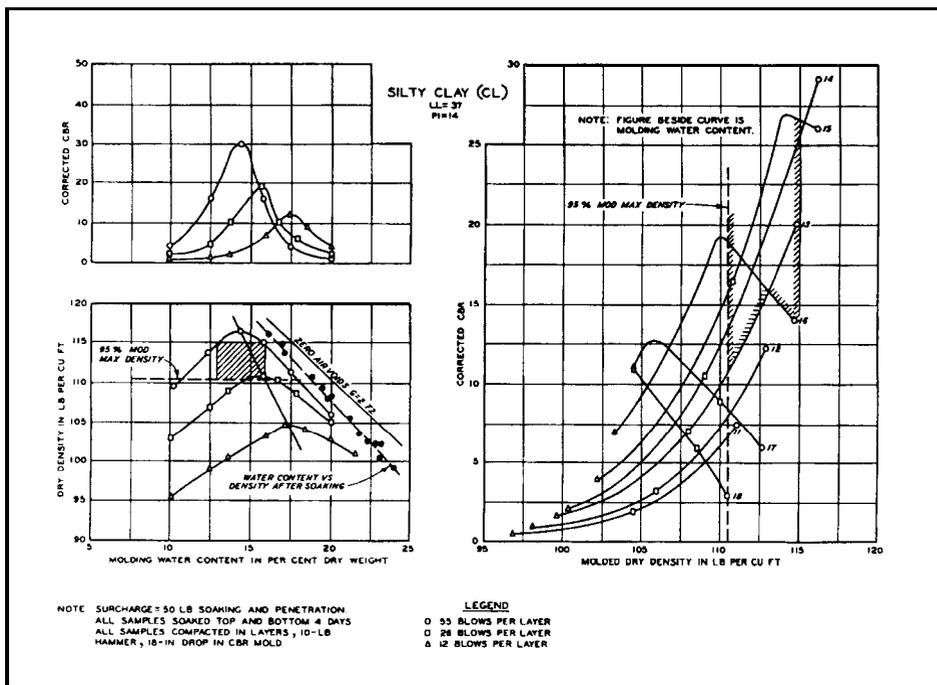


Figure 7. Recommended procedure for performing CBR tests for design

soils, it may be necessary to prepare samples for a wider range of moistures and densities than normally used to establish the relation between moisture content, density, swell, and CBR for a given soil. A careful study of the test results will permit the selection of the proper moisture content and density required in the field. It should be noted that the possibility exists that thickness design may be governed by the compaction requirements instead of the CBR in some cases.

3.4 *Field in-place tests* (see Figures 5 and 6 for data sheet). Field in-place CBR tests are used for design under any one of the following conditions: (a) when the in-place density and water content are such that the degree of saturation (percentage of voids filled with water) is 80 percent or greater; (b) when the material is coarse grained and cohesionless so that it is not affected by changes in water content; and (c) when construction was completed several years before. In the last-named case, the water content does not actually become constant but appears to fluctuate within rather narrow ranges, and the field in-place test is considered a satisfactory indicator of the load-carrying capacity. The time required for the water content to become stabilized cannot be stated definitely, but the minimum time is approximately 3 years.

3.4.1 *Penetration*. Level the surface to be tested, and remove all loose material. Then follow the procedure described in 3.1.1.

3.4.2 *Number of tests*. Three in-place CBR tests should be performed at each elevation tested in the base course and at the surface of the subgrade. However, if the results of the three tests in any group do not show reasonable agreement, three additional tests should be made at the same location. A reasonable agreement between three tests where the CBR is less than 10 permits a tolerance of 3; where the CBR is less than 10 permits a tolerance of 3; where the CBR is from 10 to 30, a tolerance of 5; and from 30 to 60, a tolerance of 10. For CBR's above 60, variations in the individual readings are not of particular importance. For example, actual test results of 6, 8, and 9 are reasonable and can be averaged as 8; results of 23, 18, and 20 are reasonable and can be averaged as 20. If the first three tests do not fall within the specified tolerance, the three additional tests are made at the same location, and the numerical average of the six tests is used as the CBR at that location.

3.4.3 *Moisture content and density*. After completion of the CBR test, a sample shall be obtained (a) at the point of penetration for moisture-content determi-

nation, and (b) 4 to 6 in. away from the point of penetration for density determination.

3.5 *Undisturbed specimens*. Because of the difficulty of obtaining reliable CBR test results on so-called undisturbed specimens, these tests will be performed only in special cases.

Note: The past practices of obtaining and testing samples in wooden boxes and of leaving an annular space between sample and container wall to be filled with plastic material such as paraffin shall be discontinued because these practices leave some doubt as to the adequacy of the lateral confinement of specimen during the CBR test.

4. Calculations.

4.1 *Calculation procedures*. The CBR shall be calculated immediately after completion of the test, as follows.

4.1.1 *Plotting load-penetration curve*. Calculate the penetration load in lb/in.* and draw the load-penetration curve. It is sometimes necessary to correct the CBR value because of surface irregularities and/or the concave-upward shape of the curve that characterizes samples on the wet side of optimum for certain soils. Figure 8 shows both the uncorrected and the corrected CBR curves. Correction can be made graphically by adjusting the zero point of the curve as

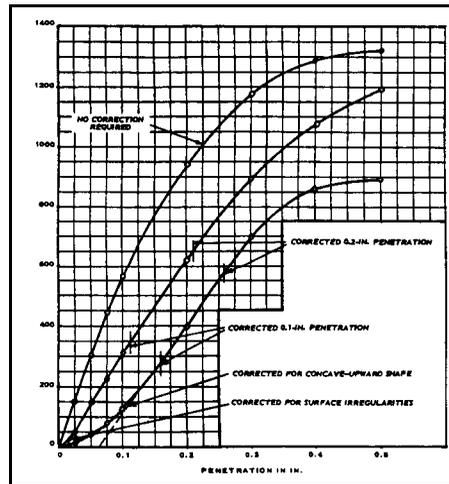


Figure 8. Correlation of stress-penetration curve

in Figure 8, or it can be made mathematically by selecting the largest CBR value based on load increase divided by the standard loads for any consecutive 0.1- or 0.2-in. penetration. The mathematical correction has the advantage of eliminating the personal error in drawing the corrected curve. However, the curve should be drawn in any case so that erratic data will be more easily recognized.

4.1.2 *Calculating CBR*. Determine the corrected load values at 0.1- and 0.2-in. penetration from which the CBR values are obtained by dividing the corrected

unit loads at 0.1 and 0.2 in. by the standard loads of 1,000 and 1,500 psi, respectively. Each ratio is multiplied by 100 to obtain the bearing ratio in percent. The CBR is usually selected at 0.1-in. penetration. If the ratio at 0.2-in. penetration is greater, the test should be rerun. If check tests give similar results, use the CBR at 0.2-in. penetration.

4.1.3 *Design CBR* value. The specific design CBR values from field test may be determined following procedures indicated in the appropriate flexible pavement design manuals.