A Simple Method for Obtaining Undisturbed Soil Samples for CBR Determination

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A simple arrangement for collecting undisturbed soil samples for determining the CBR value of road bases and subgrades has been developed by making use of hard steel core cutters of the same internal dimensions as the standard CBR molds. The percent-area ratio of the core cutters is 8.5. The method for collecting undisturbed samples by the new arrangement has been explained and illustrated and the results compared with in situ test results.

•THE California Bearing Ratio Test (CBR) is a comparative measure of the shearing resistance of a soil under controlled density and moisture conditions. It is widely used with empirical curves for designing flexible pavements. CBR is expressed as a percentage of the unit load required to force a piston of 3 sq in. surface area (1.954 in. diameter) into the soil at a rate of 0.05 in. per minute, divided by the unit load required to force the same piston the same depth at the same rate into a standard sample of crushed stone.

$$\text{CBR} = \frac{\text{test unit load}}{\text{standard unit load}} \times 100$$

The CBR used in design is the 0.1 or 0.2-in. penetration value, whichever is greater. For most soils, the 0.1-in. penetration value is the greater. Unless it is certain that the soil will not accumulate moisture after construction, CBR tests are performed on soaked samples. This test can be performed in the laboratory as well as at the actual work site.

EQUIPMENT AND PROCEDURE FOR CBR TEST

In the laboratory method, the soil to be tested is compacted at a certain moisture to the desired dry density in special cylindrical molds. These CBR molds have an internal diameter of 6 in. and an internal height of 7 in., with a detachable perforated base which can be fitted at either end. A displacer disk 2 in. deep and 5.93 in. in diameter provides a specimen exactly 5 in. long.

For testing CBR, the mold (after soaking if necessary) is placed on the base of a loading frame provided with a screw jack, and the standard plunger (having a circular cross section of 3 sq in.) is placed in the center of the specimen and load is applied by working the screw jack. Penetration of the plunger in the soil specimen and the force applied are indicated on the dial gages fixed on the apparatus. A complete setup of the equipment is shown in Figure 1.

Although CBR tests on laboratory compacted specimens are usually performed to obtain information which will be used for design purposes, the field test is considered more reliable for determining the load carrying capacity of in-place material. When a field test is performed on materials that during the life of the pavement may undergo

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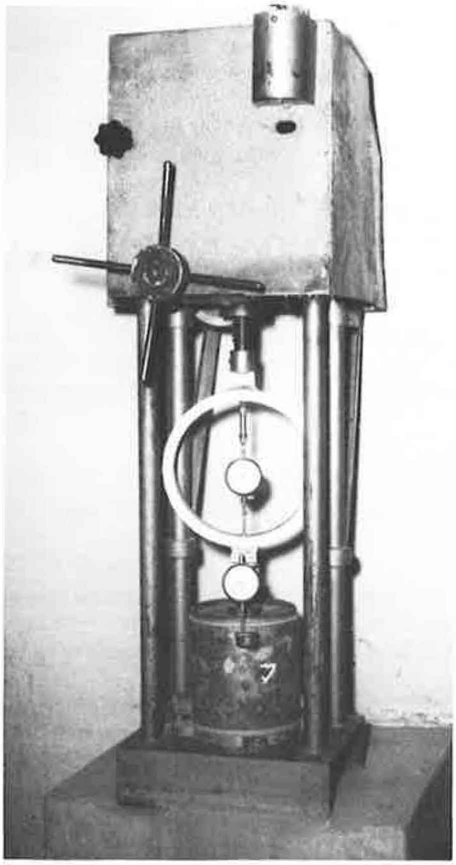

Figure 1.

moisture content changes, undisturbed samples of the field compacted material are tested in the laboratory.

EQUIPMENT FOR IN-PLACE FIELD TEST

A loaded truck has been found to be a convenient form of reaction load for testing CBR in situ. A screw jack is fitted to the back of the truck and the load is applied by working it in the same way as in the laboratory method. The dial gage for recording penetration is fixed with an independent long datum bar which is supported at ends on two stands. No specimen molds are required in this case. The test is done directly on the ground after it has been leveled. The general arrangement for this test is shown in Figure 2.

Drawbacks of the In Situ Test

The CBR in situ test has certain drawbacks which are briefly listed as follows:

1. During the test, the vibrations produced by the heavy traffic disturb the datum bar and thus the penetration value and the corresponding load cannot be measured accurately.
2. Test pits hinder the traffic particularly when the CBR is done under soaked conditions; the soaking has to be continued for at least 4 days. This is likely to cause accidents.

Figure 2.

3. Pits are likely to be disturbed by some external activities during soaking.
4. In situ soaking is done from the top to the bottom without any surcharge effect, whereas in actual practice the worst conditions of the subgrade below pavement are reached due to the rise of subsoil water.
5. In actual practice, the subgrade absorbs moisture under pavement surcharge and therefore the CBR value under in situ soaking may give a low value which in turn may be misleading.
6. A uniform soaking in situ is not possible and a proper check on soaking cannot be maintained if CBR values of many miles of road are to be determined.
7. For testing a pit under natural conditions and after soaking, the loaded truck has to go twice to the site. This makes the test very expensive and cumbersome.

In order to overcome these drawbacks, undisturbed samples of the field compacted material are obtained and tested in the laboratory for moisture conditions simulating those expected in the field. The testing equipment and arrangement are as shown in Figure 1.

METHOD OF OBTAINING UNDISTURBED SAMPLES

According to the presently accepted procedure of taking undisturbed samples, the standard CBR mold is used with a sampling collar having a sharp cutting edge. The ground surface is smoothed and the mold, with the sampling collar fixed at the bottom and the extension collar fixed at the top, is pressed into the soil with moderate pressure. Then a trench is excavated around the mold and the mold is pressed down firmly over the soil chunk. The soil is trimmed from the sampling collar with a knife by cutting downward and outward to avoid cutting into the sample. The trench is excavated deeper and the procedure is repeated until the soil is well into the extension collar. The sample is then cut off at the bottom of the mold with a knife, shovel or saw and removed from the hole. The extension and sampling collars are removed and the soil trimmed to the end of the mold on both sides. In order to get a specimen exactly 5 in. long, 2 in. of excess length can be removed by either scraping or pushing out, using the displacer disk and jack arrangement (Fig. 5a).

STUDY OBJECTIVE

This process of obtaining an undisturbed sample is, however, very laborious and time consuming. Besides, it needs elaborate and expensive equipment like a CBR mold, extension collar and sampling collar with cutting edge. In this age of rapid development when many miles of new roads have to be constructed and even greater lengths of old roads have to be reconditioned, a need for quicker and cheaper methods

TABLE 1

COMPARISON OF RESULTS OF DENSITY OF NATURAL GROUNDS AND AFTER TAKING UNDISTURBED SAMPLES WITH CORE CUTTERS NEAR THE SAME POINTS

Test Pit	Moisture (%)	Density of Natural Ground (gm/cc)	Density in Core Cutter (gm/cc)	Level of Natural Ground from Top Edge of Core Cutter (cm)			
				Core Cutter Half Filled		Core Cutter Nearly Filled	
				Inside	Outside	Inside	Outside
1	6.6	1.48	1.53	6.7	6.8	1.2	1.1
				7.5	7.3	1.6	1.4
				7.2	7.2	1.3	1.2
				7.4	7.5	1.3	1.2
2	17.5	1.52	1.52	7.4	7.6	1.3	1.4
				7.4	7.5	1.6	1.6
				7.8	7.9	1.5	1.55
				7.6	7.4	1.55	1.55
3	6.9	1.53	1.52	8.1	8.1	1.7	1.5
				8.3	8.1	1.6	1.4
				8.0	7.9	1.7	1.5
				8.3	8.2	1.8	1.7
4	18.1	1.45	1.48	—	—	2.3	2.2
						2.6	2.5
						2.3	2.2
						2.6	2.4

TABLE 2

COMPARISON OF CBR VALUES OBTAINED IN SITU AND ON UNDISTURBED SAMPLES TAKEN BY CORE CUTTER FROM NEAR THE SAME POINTS—AT NATURAL MOISTURE CONTENT

Test Pit	Dry Density (gm/cc)	Natural Moisture (%)	CBR	CBR of Undisturbed Sample in Core Cutter	CBR of Undisturbed Sample After Transfer to CBR Molds	Soil Characteristics		
						LL	PI	SC
1	1.60	14.4	5.1	4.5	—	39.0	19.5	8.2
			5.9	—	5.5	—	—	—
2	1.60	11.4	9.8	7.6	—	36.7	18.4	10
		7.3	19.3	—	14.8	—	—	—
3[a]	1.55	9.55	15.3	13.0	—	37.0	18.5	11.0
			14.1	—	15.6	—	—	—
4	1.5	18.1	3.1	3.7	5.8	38.0	19.0	9.4
5	1.55	11.1	8.7	12.7	15.3	38.0	19.0	9.4
6	1.65	8.5	24.7	25.3	—	36.7	18.4	10.5
7	1.58	14.1	14.6	14.6	—	36.7	18.4	10.5
8[b]	1.8	9.3	21.9	18.4	—	38.0	19.0	9.4
			19.1	17.0				
9[c]	1.8	10.9	14.6	15.3	—	26.9	9.2	51.5
			17.3	17.0				

[a]Natural subgrade.
[b]Clayey soil compacted to 1.8 gm/cc of dry density.
[c]Sandy soil compacted to 1.8 gm/cc of dry density.

TABLE 3

COMPARISON OF CBR VALUES OBTAINED FROM IN SITU TEST AND UNDISTURBED SAMPLES OF CORE CUTTER (AFTER SOAKING)

Test Pit	Dry Density (gm/cc)	In Situ Soaking			Undisturbed Samples in Lab			Undisturbed Samples Without Surcharge Weights		
		CBR	Moisture (%)		CBR	Moisture (%)		CBR	Moisture (%)	
			3 In.	6 In.		Top	Bottom		Top	Bottom
1[a]	1.6	1.4	20.5	22.0	2.3	22.1	23.0	1.4	23.4	24.5
2	1.6	2.9	20.7	20.8	3.4	21.0	22.0	1.98	22.5	24.0
3	1.55	2.0	24.2	21.7	2.3	22.0	22.0	2.0	22.6	23.4
4	1.55	1.6	24.2	24.8	1.8	24.1	24.5	1.7	22.0	22.6
5[b]	1.8	1.6	21.4	22.5	3.4	20.5	19.9	1.2	21.9	23.3
6	1.8	3.4	21.4	22.5						
7[c]	1.8	4.7	13.1	12.7	5.4	13.9	15.2	2.4	14.2	14.8
8	1.8	3.9	13.1	12.7						

[a]Natural subgrade.
[b]Clayey soil compacted to 1.8 gm/cc of dry density.
[c]Sandy soil compacted to 1.8 gm/cc of dry density.

TABLE 4

COMPARISON OF CBR VALUES TESTED IN SITU AND ON UNDISTURBED SAMPLES FROM THE STABILIZED SOIL BASE AFTER SOAKING IN SITU AND IN THE LABORATORY

Test Pit	Dry Density (gm/cc)	Soaked CBR			Soaked Moisture (%)				Soil Characteristics		
		In Situ Soaking		Lab Soaking	In Situ Soaking		Lab Soaking				
		In Situ Test	Undisturbed Sample	Undisturbed Sample	3 In.	6 In.	Top	Bottom	LL	PI	SC
1[a]	1.8	21.9	21.1	20.9	19.3	18.5	18.8	20.8	40.7	12.7	12.8
2	1.8	21.9	21.8	21.5	19.3	18.5	17.8	17.3	40.7	12.7	12.8
3	1.8	27.4	24.1	21.5							
4	1.8	19.5	22.6		19.3	18.5			40.7	12.7	12.8
5[b]	1.8	19.5	23.0	18.9	18.9	18.9	17.6	19.2	42.2	14.5	8.0
6	1.8	23.5	24.3	23.2	18.9	18.9			42.2	14.5	8.0
7	1.8	14.1	12.2								
8	1.8	26.1	23.8	24.9	18.9	18.9	16.6	19.8	42.2	14.5	8.0

[a]Stabilized with 2 percent lime and 7 days curing before soaking. Compacted at 1.8 gm/cc of dry density.
[b]Stabilized with 2 percent cement and 7 days curing before soaking. Compacted at 1.8 gm/cc of dry density.

of obtaining undisturbed samples for determining the load carrying capacity of natural subgrade and suitable pavement thicknesses is necessary.

To achieve this objective, thin-walled steel core cutters having a 6-in. internal diameter were used for obtaining the undisturbed samples. Results have been very satisfactory. A comparative study of CBR tests in situ and undisturbed samples obtained by the core cutter method was made to ascertain that the core cutter method and in situ CBR tests gave identical results. The actual results are given in Tables 1 to 4.

STEEL CORE CUTTER SPECIFICATIONS

The core cutter sampling arrangement consists of two parts: (a) a thin-walled open-ended steel cylinder with a 6-in. internal and 6.25-in. external diameter and a 5-in. length, with one end sharpened to serve as a cutting edge; and (b) a steel cap with an inside collar of the same dimensions as the core cutter so that when the cap is placed over the core cutter, the collar sits exactly on the rim. These parts along with other accessories are shown in Figure 3. The height of the cap is 1.5 in. and that of the internal collar 0.75 in., so that the soil specimen projects out this far from the core cutter to allow the finishing of the top. The percentage area ratio of the cylinder comes to only 8.5. Because it is less than 10, the distortion or disturbance of the sample obtained by such core cutters is almost negligible.

Procedure of Obtaining Undisturbed Samples

As in the case of obtaining undisturbed samples with the CBR mold, the ground surface is leveled and the core cutter with the steel cap is pressed vertically with the cutting edge downward (Fig. 4a). It is then carefully hammered down by an 18-lb rammer (Fig. 4b). A hard wooden block is placed over the cap to avoid damaging the steel cap. The hammering is continued until the edge of the cap just touches the ground; then some soil is excavated along the rim of the cap to a depth of about 2 in. and hammering is resumed to fill the core cutter (Fig. 4c). Care is taken that the soil coming into the cutter does not get pressed by the cap. This can be watched through a $\frac{1}{2}$-in. diameter hole in the top of the cap. The condition of the top of the soil specimen can be seen by removing the cap. If some disturbance of the soil has taken place, the upper layers,

Figure 3.

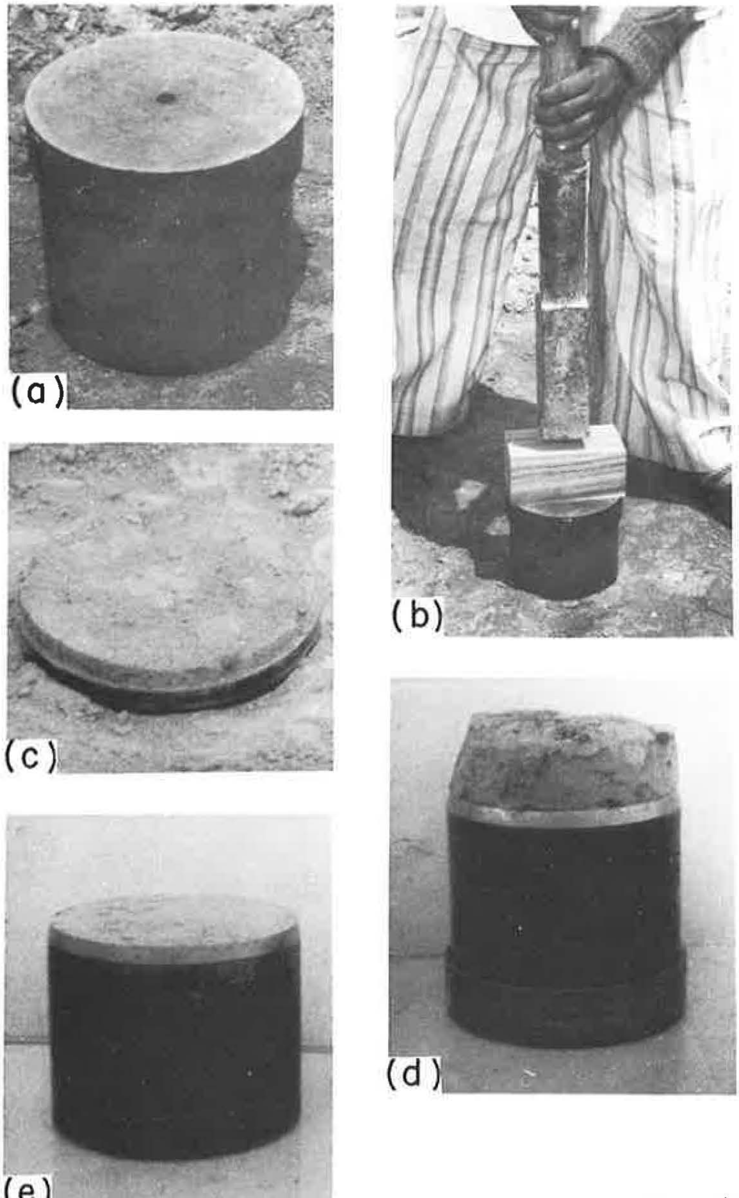

Figure 4.

which are projecting out of the core cutter due to the use of collared cap, are trimmed to the level of the cutter rim. If necessary, the cap can be replaced and the core cutter lowered further into the ground by resuming hammering until a clean and firm undisturbed specimen is obtained. The cutter is then removed from the ground by digging the soil from the sides and cutting the sample at the bottom in the same manner as mentioned in the CBR method. Figure 4d shows the result. The sample is trimmed to the rim on both sides (Fig. 4e). For determining CBR, undisturbed samples may be transferred to the CBR standard mold by means of a jack arrangement

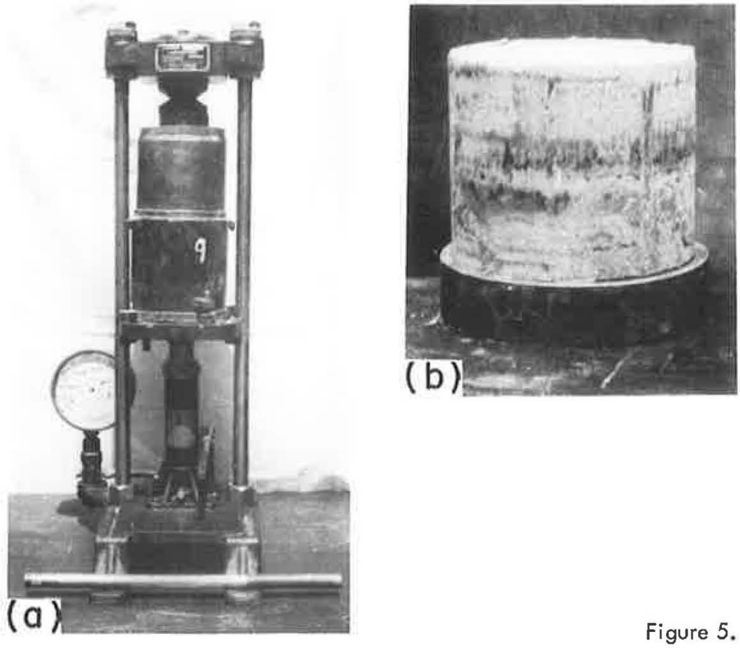

Figure 5.

(Fig. 5a). A CBR test can also be conducted on the specimen in the core cutter itself. Figure 5b shows the undisturbed soil specimen taken out of the cutter by the jack assembly.

DISCUSSION OF RESULTS

Table 1 compares the density of the natural ground with that of undisturbed specimens obtained from near the same place, in order to make sure that the use of the core cutter does not interfere with this property. Notice that there was no significant variation in the density of the ground and that of the undisturbed samples collected by core cutters. Similarly, the inside and outside depth as measured from the rim of the core cutter remained unchanged during the lowering of the cutter into the ground. These results confirm that the samples obtained by the core cutter method are not disturbed during the extraction process.

Table 2 compares the CBR values obtained in situ with undisturbed samples collected by core cutters after natural moisture content has been drawn. Eleven points having a CBR range varying from 3 to 25 were tested and results obtained by the two methods were in very close agreement.

Table 3 compares the soaked CBR value obtained in situ with undisturbed samples soaked in the laboratory. The undisturbed samples were soaked with and without using surcharge weights. Moisture content of the soil at a 3 and 6-in. depth (in situ test) and at the top and bottom of the soaked undisturbed samples (core cut) is also given in Table 3. The results of the 8 points tested were almost identical for the two test methods. The CBR test results of the undisturbed samples soaked without surcharge were closer to the in situ test.

In Table 4 soaked CBR test results of the soil bases stabilized with lime and cement, as obtained by the in situ and core cutter methods, are given. Table 4 also shows a comparison of CBR results of undisturbed specimens obtained after in situ soaking and laboratory soaking. In all cases, the results showed reasonable agreement with each other.

REFERENCES

1. Soil Mechanics for Road Engineers. DSIR, Road Research Laboratory, Harmondsworth, 1961, 541 pp.
2. Peck, R. B., Hanson, W. E., and Thornburn, T. H. Foundation Engineering. John Wiley and Sons, N.Y., 1953, 410 pp.
3. Bertram, George E., and Labaugh, W. C., Jr. Soil Tests. ARBA Tech. Bull. 107, 1964.
4. Soils Manual for Design of Asphalt Pavement Structures. Asphalt Institute, Manual Series 10, June 1961.