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Standard Test Method for CBR (California Bearing Ratio) of Soils in Place[1]

This standard is issued under the fixed designation D 4429; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This test method covers the determination of the California Bearing Ratio (CBR) of soil tested in place by comparing the penetration load of the soil to that of a standard material. This test method covers the evaluation of the relative quality of subgrade soils, but is applicable to subbase and some base-course materials. This test method is designed to test in-situ materials and corresponds to Test Method D 1883.

1.2 The values stated in inch-pound units are to be regarded as the standard.

1.3 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 1556 Test Method for Density of Soil in Place by the Sand-Cone Method[2]

D 1883 Test Method for CBR (California Bearing Ratio) of Laboratory-Compacted Soils[2]

D 2167 Test Method for Density of Soil in Place by the Rubber-Balloon Method[2]

D 2216 Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures[2]

D 2937 Test Method for Density of Soil in Place by the Drive-Cylinder Method[2]

D 3017 Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)[2]

3. Significance and Use

3.1 Field in-place CBR tests are used for evaluation and design of flexible pavement components such as base and subbase course and subgrades and for other applications (such as unsurfaced roads) for which CBR is the desired strength parameter. If the field CBR is to be used directly for evaluation or design without consideration for variation due to change in water content, the test should be conducted under one of the following conditions: (*a*) when the degree of saturation (percentage of voids filled with water) is 80 % or greater, (*b*) when the material is coarse grained and cohesionless so that it is not significantly affected by changes in water content, or (*c*) when the soil has not been modified by construction activities during the two years preceding the test. In the last-named case, the water content does not actually become constant, but generally fluctuates within a rather narrow range. Therefore, the field in-place test data may be used to satisfactorily indicate the average load-carrying capacity.

3.2 Any construction activities, such as grading or compacting, carried out subsequent to the bearing ratio test will probably invalidate the results of the test.

NOTE 1—Field in-place tests are used to determine the relative strength of soils, subbase, and some base materials in the condition at which they exist at the time of testing. Such results have direct application in test section work and in some expedient construction, military, or similar operations. Also, as indicated in 3.1, field in-place tests can be used for design under conditions of nominal stability of water, density, and general characteristics of the material tested. However, any significant treating, disturbing, handling, compaction, or water change can affect the soil strength and make the prior to test determination inapplicable, leading to the need for retest and reanalysis.

4. Apparatus

4.1 *Mechanical Screw Jack*—A manually operated mechanical screw jack equipped with a special swivel head for applying the load to the penetration piston, and designed with the following specifications:

4.1.1 Minimum capacity of 5950 lb (2700 kg),

4.1.2 Minimum lift of 2 in. (50 mm),

4.1.3 Detachable handle, 6-in. (150-mm) radius,

4.1.4 High-gear ratio, approximately 2.4 revolutions per 0.04 in. (1 mm) of penetration,

4.1.5 Medium-gear ratio, approximately 5 revolutions per 0.04 in. (1 mm) of penetration, and

4.1.6 Low-gear ratio, approximately 14 revolutions per 0.04 in. (1 mm) of penetration.

4.1.7 Other gear ratios may be used as desired if it is found to be more convenient to do so.

4.1.8 Other mechanical jacks with the same maximum load and lift may be utilized, provided that a uniform load-penetration rate of 0.05 in. (1.3 mm)/min can be achieved.

4.2 *Proving Rings*—Two calibrated proving rings having the following characteristics:

4.2.1 *Loading Range*—One proving load cell ring shall have a loading range of approximately 0 to 1984 lbf (8.8 kN), and the other proving ring shall have a loading range of approximately 0 to 5070 lbf (22.6 kN).

[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.10 on Bearing Tests of Soils in Place.

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[2] *Annual Book of ASTM Standards*, Vol 04.08.

4.3 *Penetration Piston*—The penetration piston shall be 2 ± 0.004 in. (50.8 ± 0.1 mm) in diameter (nominal 3 in.^{2} (2000 mm^2)) and approximately 4 in. (102 mm) in length.

4.3.1 *Piston Adapter and Pipe Extensions*—One piston adapter and internally threaded pipe extensions with connectors.

4.3.1.1 Pipe extensions shall be furnished in the following quantities and lengths (or other combinations of lengths totaling 8 ft (2.4 m)):

Number Required	Approximate Length
2	1.5 in. (38 mm)
2	4 in. (102 mm)
8	12 in. (305 mm)

4.4 *Dial Gages*—There shall be two dial gages for measuring proving-ring deflections reading to 0.0001 in. (0.0025 mm) and having approximately 0.25-in. (6.4-mm) travel, and one dial gage for measuring penetration reading to 0.001 in. (0.025 mm) and having approximately 1-in. (25-mm) travel, equipped with an adjustable dial clamp extension.

4.5 *Support for Penetration Dial*—One support made of 3-in. (76.2-mm) aluminum steel or wood channel approximately 5 ft (1.5 m) long.

4.6 *Surcharge Plate*—A circular steel plate 10 ± 0.02 in. (254 ± 0.5 mm) in diameter with a 2 ± 0.02-in. (50.8 ± 0.5-mm) diameter hole in the center. The plate shall weigh 10 ± 0.02 lb (4.54 ± 0.01 kg).

4.7 *Surcharge Weights*—Two "10-lb" (4.54 ± 0.01-kg) slotted surcharge weights 8.5 in. (216 ± 1 mm) in diameter, and two "20-lb" (9.08 ± 0.01-kg) slotted surcharge weights 8.5 in. in diameter.

4.8 *Truck (Reaction)*—A truck (or piece of heavy equipment) loaded sufficiently to provide a reaction of approximately 6970 lbf (31 kN). The truck shall be equipped with a suitable metal beam and an attachment, or attachments, at the rear end in order to provide a reaction for forcing the penetration piston into the soil. Suitable attachments or other provision shall be provided so that the truck may be jacked sufficiently to take the load off of the rear springs in order to permit the penetration test to be carried out without upward movement of the truck chassis. Approximately 2-ft (0.6-m) ground clearance is required to carry out the penetration test.

4.9 *Jacks*—Two truck-type jacks of 15-ton (14-Mg) capacity and having double-acting combination trip and automatic lowering.

4.10 *Miscellaneous Apparatus*—Other general apparatus such as sample containers for water and density determinations, spatula, straightedge, digging tools, etc.

NOTE 2—Fig. 1 shows a typical field setup for bearing ratio tests. Fig. 2 shows the disassembled bearing ratio apparatus.

5. Procedure

5.1 Prepare the general surface area to be tested by removing from the surface loose and dried material which is not representative of the soil to be tested. Produce a test area which is as smooth and horizontal as practicable. Where nonplastic base materials are encountered, extreme care shall be taken not to disturb the test surface. Spacing of the penetration tests shall be such that operations at one point will not disturb the soil at the next point to be penetrated. This spacing may range from a minimum of 7.0 in. (175 mm) in plastic soils to 15 in. (380 mm) in coarse granular soils.

5.2 Locate the truck so that the center of the bearing attachment is directly over the surface to be tested. Install the mechanical screw test jack with the swivel to the underside of the reaction attachment. Place the truck jacks under each side of the truck and lift the truck so that little or no weight rests on the rear springs, making sure that the truck is level across the back.

5.3 Position the mechanical screw jack to the correct position for the test, and connect the proving ring to the end of jack. Then, attach the piston adapter to the bottom of the proving ring, connect the necessary number of extensions to come within 4.9 in. (125 mm) of the surface to be tested, and

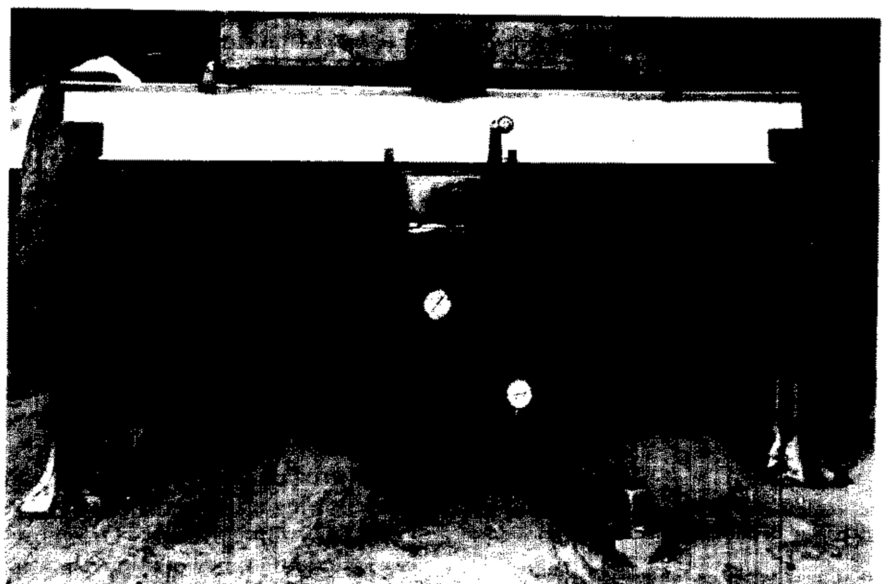

FIG. 1 Setup for Field In-Place Tests

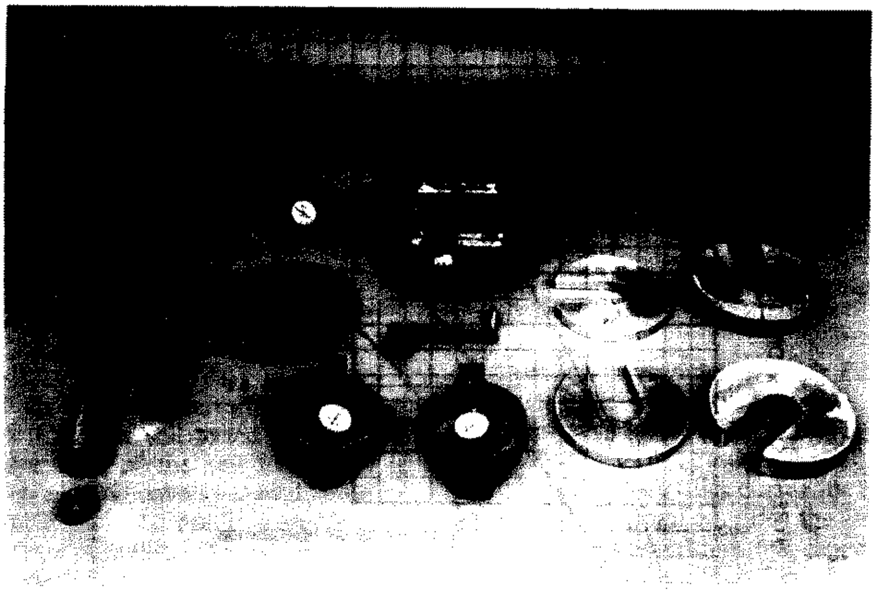

FIG. 2 Apparatus for Field In-Place Tests

connect the penetration piston. Clamp the jack in place. Check the level mounted on the jack to be certain the assembly is vertical and adjust it if necessary.

5.4 Place the "10-lb" (4.5-kg) surcharge plate beneath the penetration piston so that when the piston is lowered it will pass through the center hole.

5.5 Seat the penetration piston under a load of approximately 3 psi (21 kPa). For rapid setting, use the high-gear ratio of the jack. For base materials with an irregular surface, set the piston on the thinnest practical layer of fine limestone screenings (20–40 mesh) or plaster of paris.

5.6 If necessary in order to achieve a smooth surface, raise the surcharge plate while the seating load is on the piston and evenly spread clean fine sand to a depth of 0.12 to 0.24 in. (3 to 6 mm) over the surface to be covered by the plate. This serves to distribute the weight of the surcharge uniformly.

5.7 Add surcharge weights to the surcharge plate so that the unit load is equivalent to the load intensity of the material or pavement which will overlie the subgrade or base, or both, except that the minimum weight applied shall be the "10-lb" (4.5-kg) surcharge plate plus one "20-lb" (9-kg) surcharge weight.

NOTE 3—This minimum weight creates an intensity of loading equal to that created by the "10-lb" surcharge weight used in the 6-in. (150-mm) diameter mold in the laboratory CBR test (Test Method D 1883).

5.8 Attach the penetration dial clamp to the piston so that the dial rests upon the dial support.

5.9 Set the dial gages to zero.

5.10 Apply the load to the penetration piston so that the rate of penetration is approximately 0.05 in. (1.3 mm)/min. By using the low-gear ratio of the jack during the test, a uniform rate of penetration can be maintained by the operator. Record the deflection of the proving ring at each 0.025-in. (0.64-mm) increment of penetration, to a final depth of 0.500 in. (12.70 mm). In homogeneous soils, penetration depths greater than 0.300 in. (7.62 mm) frequently may be omitted. Compute the stress for each increment of penetration in percent (see Section 6 for calculations).

5.11 At the completion of the test obtain a sample at the point of penetration and determine its water content. A density determination should also be made at a location about 4 to 6 in. (100 to 150 mm) away from the point of penetration. The density and water content shall be determined in accordance with the applicable test methods listed in Section 2.

6. Calculation

6.1 *Stress Penetration Curve*—Calculate the penetration stress for each penetration increment as applied force divided by piston area. Plot the stress versus penetration curve for each increment of penetration, as shown in Fig. 3.

6.1.1 In some instances the stress - penetration curve may be concave upward initially because of surface irregularities or other causes, and in such cases the zero point shall be adjusted as shown in Fig. 3.

6.2 *CBR*—Using corrected stress values taken from the stress - penetration curve for 0.100 in. (2.54 mm) and 0.200-in. (5.08-mm) penetrations, calculate the bearing ratios for each by dividing the corrected stresses by the standard stresses of 1000 psi (6.9 MPa) and 1500 psi (10.3 MPa) respectively, and multiplying by 100. Also, calculate the bearing ratios for the maximum stress, if the penetration is less than 0.200 in., interpolating the standard stress. The CBR reported for the soil mixture is normally the bearing ratio at 0.100-in. (2.54-mm) penetration. When the bearing ratio at 0.200-in. (5.08-mm) penetration (or at maximum penetration if less than 0.200 in.) is greater, rerun the test. If the check test gives a similar result, the CBR is then taken as the bearing ratio determined at 0.200 in. (5.08 mm) or at maximum penetration. No other bearing ratios may be identified as CBR values.

7. Report

7.1 Report the following information on each test:

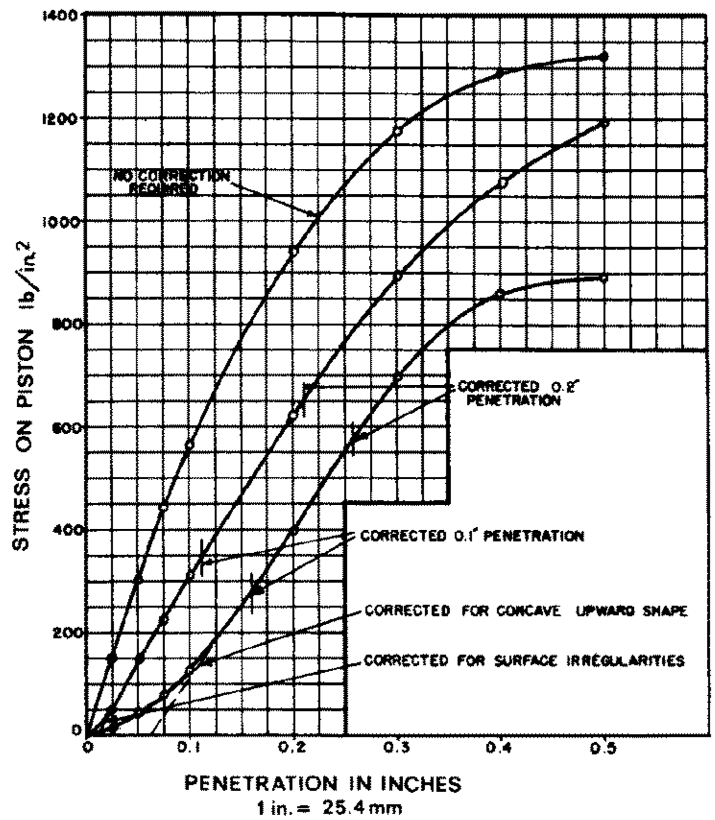

FIG. 3 Correction of Stress - Penetration Curves

7.1.1 Test location,

7.1.2 Material,

7.1.3 Depth of test,

7.1.4 Stress-penetration curve,

7.1.5 Corrected bearing ratio at 0.1-in. (2.54-mm) penetration,

7.1.6 Corrected bearing ratio at 0.2-in. (5.08-mm) penetration,

7.1.7 Water content, and

7.1.8 Density.

8. Precision and Bias

8.1 The precision and bias of this test method has not been determined. Soils and flexible pavement components at the same location may exhibit significantly different load deflection relationships. No method presently exists to evaluate the precision of a group of nonrepetitive plate load tests on soils and flexible pavement components due to the variability of these materials. The subcommittee is seeking pertinent data from users of this test method which may be used to develop meaningful statements of precision and bias.

9. Keywords

9.1 bearing ratio; CBR; deflection