Designation: D 3668 – 78 (Reapproved 1985)

An American National Standard

Standard Test Method for Bearing Ratio of Laboratory Compacted Soil-Lime Mixtures[1]

This standard is issued under the fixed designation D 3668; 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.

1. Scope

1.1 This test method covers the determination of the bearing ratio[2] of soil-lime mixtures when compacted and tested in the laboratory by comparing the penetration load of the soil-lime mixture to that of a standard material.

2. Referenced Documents

2.1 *ASTM Standards:*

D 698 Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 5.5-lb (2.49-kg) Rammer and 12-in. (305-mm) Drop[3]

D 1557 Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb (4.54-kg) Rammer and 18-in. (457-mm) Drop[3]

D 2216 Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures[3]

D 3551 Method for Laboratory Preparation of Soil-Lime Mixtures Using a Mechanical Mixer[3]

3. Apparatus

3.1 *Loading Machine*, having a capacity of at least 10 000 lbf (44.5 kN) and equipped with a movable head or base that travels at a uniform (not pulsating) rate of 0.05 in. (1.27 mm)/min, for use in forcing the penetration piston into the specimen. The machine shall be equipped with a load-indicating device that can be read to 10 lbf (44 N) or less.

3.2 *Mold*—The mold shall be of metal, cylindrical in shape, with an inside diameter of 6 ± 0.005 in. (152.4± 0.13 mm) and a height of 7 ± 0.005 in. (177.8 ± 0.13 mm). It shall be provided with a metal extension collar 2.0 in. (50.8 mm) in height, and a perforated metal base plate ⅜in. (9.53 mm) in height. The perforations in the base plate shall not exceed 1⁄16 in. (1.59 mm) in diameter.

3.3 *Spacer Disk*—A circular metal spacer disk (see Fig. 1) 5 15⁄16in. (150.8 mm) in diameter and 2.416 in. (61.4 mm) in height.

3.4 *Rammer*—A metal rammer as specified in either Test Methods D 698 or D 1557. Automatic rammers or the sliding weight rammer shown in Fig. 2 may be used, provided the compactive effort given is the same as that given by the comparable rammers described in Test Methods D 698 or D 1557.

3.5 *Expansion-Measuring Apparatus*— An adjustable metal stem and perforated plate, with perforations in the plate not exceeding 1⁄16 in. (1.59 mm) in diameter, and a metal tripod to support a dial gage for measuring the amount of swell during soaking (see Fig. 1).

3.6 *Surcharge Weights*—One annular metal weight and several slotted metal weights weighing 5 lb (2.27 kg) each, 5⅞ in. (149.2 mm) in diameter, with a center hole 2⅛ in. (54.0 mm) in diameter (see Fig. 1).

3.7 *Penetration Piston*—A metal penetration piston 1.95 in. (49.5 mm) in diameter (3 in.^{2} [19.35 cm^2] in area) and not less than 4 in. (101.6 mm) long. If from an operational standpoint it is advantageous to use a piston of greater length, the longer piston may be used (see Fig. 1).

3.8 *Gages*—Two dial gages reading to 0.001 in. (0.025 mm).

3.9 *Miscellaneous Apparatus*—Other general apparatus such as a mixing bowl, straightedge, scales, soaking tank or pan, oven, filter paper, and dishes.

4. Soil-Lime Mixture

4.1 The soil-lime mixture shall be prepared in accordance with Method D 3551.

5. Preparation of Test Specimen

5.1 If the specimen is to be soaked, take a representative sample of the material, for the determination of moisture in accordance with Test Method D 2216, at the beginning of compaction and another sample of the remaining material after compaction. If the test specimen is not to be soaked, take a representative sample of material from one of the cut faces after penetration, as described in 6.4 to determine the moisture content.

5.2 Clamp the mold (with extension collar attached) to the baseplate. Insert the spacer disk over the baseplate and place a disk of coarse filter paper on top of the spacer disk. Compact the soil-lime mixture into the mold in accordance with either Test Methods D 698 or D 1557. Compact the specimen at maximum density and optimum moisture as determined by

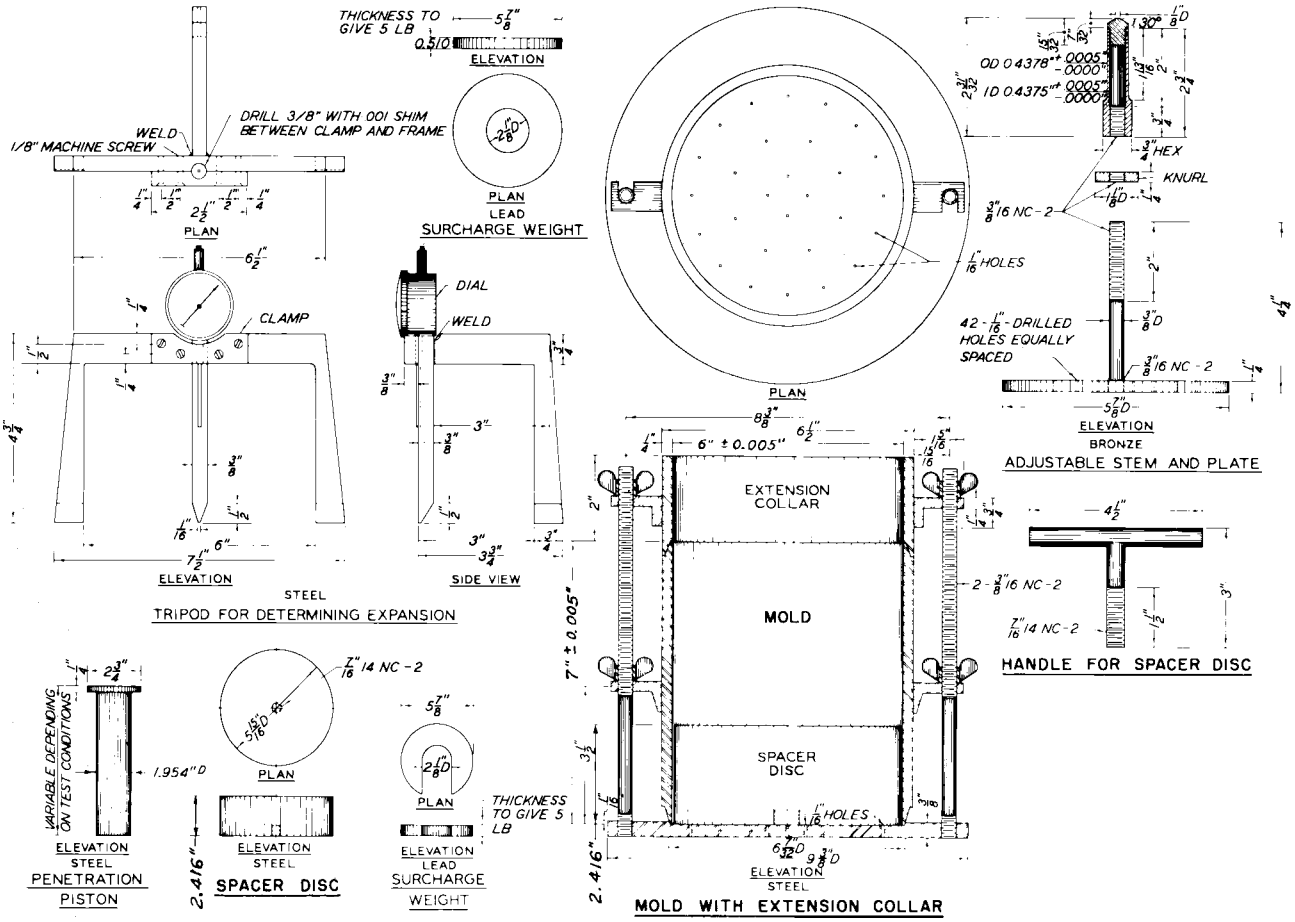
---

[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.15 on Stabilization With Admixtures.

Current edition approved Dec. 21, 1978. Published February 1979.

[2] Sometimes called California Bearing Ratio (CBR).

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



NOTE 1—See Table 1 for metric equivalents.

FIG. 1 Bearing Ratio Test Apparatus.

Test Methods D 698 or D 1557. Other densities and moisture contents which are desired may be used, if indicated in the report.

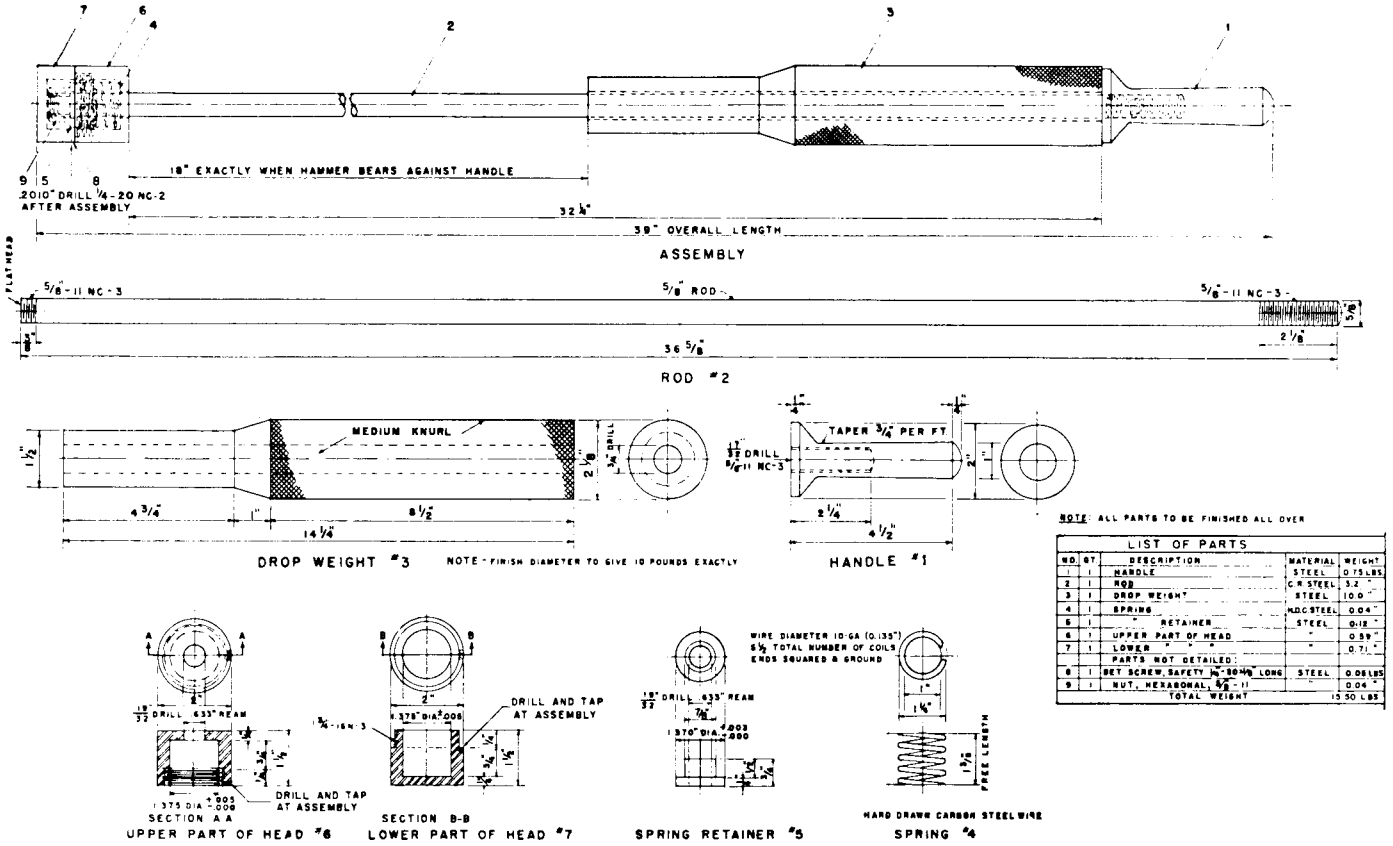
5.3 Remove the extension collar and carefully trim the compacted soil-lime mixture even with the top of the mold by means of a straightedge. Patch with smaller size material any holes that may have developed in the surface by the removal of coarse material. Remove the perforated base plate and spacer disk, weigh, and record the weight of the mold and compacted soil-lime mixture. The curing desired for the soil-lime specimen shall be done at this time. Conduct all curing in suitable sealed containers to prevent carbonation of the lime.

5.4 If the sample is to be soaked, place a disk of coarse filter paper on the perforated base plate, invert the mold and compacted soil-lime mixture, and clamp the perforated base plate to the mold with the compacted soil-lime mixture in contact with the filter paper. Place the adjustable stem and perforated plate on the compacted soil-lime specimen in the mold and apply the surcharge weights to produce a surcharge equal to the weight of the base material and pavement within 5 lb (2.27 kg), but in no case shall the total surcharge be less than 10 lb (4.54 kg). Immerse the mold 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. Maintain a constant water level during this period. A shorter immersion period is permissible for fine-grained soil-lime materials or granular soil-lime materials that take up moisture readily, if tests show that the shorter period does not affect the results. At the end of the soaking period, take final measurements and calculate the swell as a percentage of the initial height of the specimen.

5.5 Remove the free water and allow the specimen to drain downward for 15 min. Care should be taken not to disturb the surface of the specimen during the removal of the water. It may be necessary to tilt the specimen in order to remove the surface water. Remove the surcharge weights and perforated plate, weigh, and record the weight of the mold and soil-lime mixture.

6. Procedure

6.1 Place a sufficient number of surcharge weights on the specimen to produce a surcharge equal to the weight of the base material and pavement within 5 lb (2.27 kg) but not less than 10 lb (4.54 kg). If the specimen has been soaked previously, the surcharge shall be equal to that used during the soaking period. To prevent upheaval of soil-lime mixture into the hole of the surcharge weights, place the 5-lb (2.27-kg) annular surcharge weight on the soil-lime surface prior to seating the penetration piston, after which, place the remainder of the surcharge weights.



NOTE 1—See Table 1 for metric equivalents.

FIG. 2 Sliding Weight Rammer - Assembly and Details.

6.2 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 strain 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.

6.3 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 (0.64 mm), 0.050 (1.27 mm), 0.075 (1.91 mm), 0.100 (2.54 mm), 0.125 (3.18 mm), 0.150 (3.81 mm), 0.175 (4.45 mm), 0.200 (5.08 mm), 0.300 (7.62 mm), 0.400 (10.16 mm), and 0.500 in. (12.70 mm). Note the maximum load and penetration, if it occurs for a penetration of less than 0.500 in. (12.70 mm). With manually operated loading devices, it may be necessary to take load readings at closer intervals to control the rate of penetration (Note 1).

NOTE 1—The load readings at penetrations of 0.400 (10.16 mm) and 0.500 in. (12.70 mm) may be omitted.

6.4 Remove the soil-lime mixture from the mold and determine the moisture content of the top 1-in. (25.4-mm) layer in accordance with Method D 2216. Take a moisture content sample from the entire depth if the average moisture content is desired.

7. Calculations

7.1 *Load-Penetration Curve*—Calculate the penetration loads in pounds per square inch or megapascals and plot the load - penetration curve. In some instances the load - 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.

7.2 *Bearing Ratio*—Using corrected load values taken from the load - penetration curve for 0.100-in. (2.54-mm) and 0.200-in. (5.08-mm) penetrations (Note 2), calculate the bearing ratios for each by dividing the corrected loads by the standard loads 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 load, if the penetration is less than 0.200 in. (5.08 mm), by interpolating the standard load. The bearing ratio reported for the soil-lime mixture is normally the one at 0.100-in. (2.54-mm) penetration. When the ratio at 0.200-in. (5.08-mm) penetration is greater, rerun the test. If the check test gives a similar result, use the bearing ratio at 0.200-in. (5.08-mm) penetration.

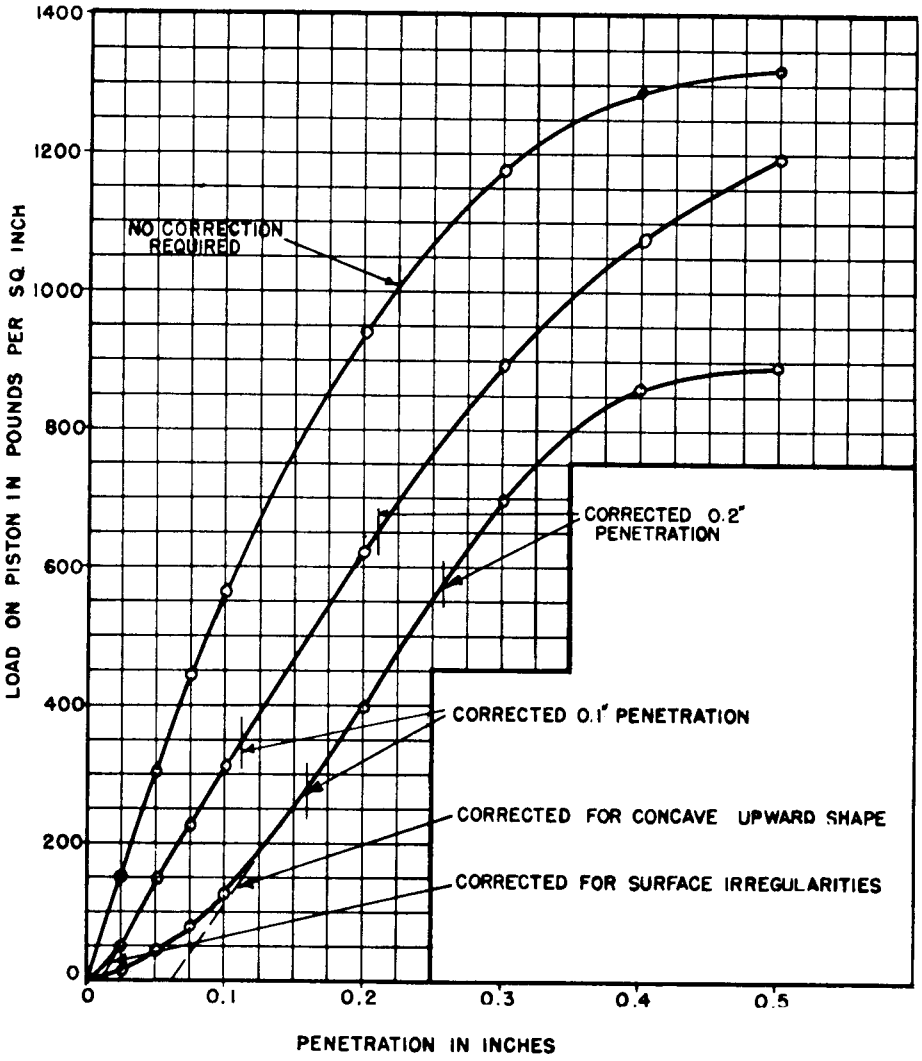
NOTE 2—If the bearing ratio values at penetration of 0.300 (7.62 mm), 0.400 (10.16 mm) and 0.500 in. (12.70 mm) are desired, the corrected load values for these penetrations should be divided by the standard loads of 1900 (13.1 MPa), 2300 (15.9 MPa), and 2600 psi (17.9 MPa), respectively, and multiplied by 100.

8. Report

8.1 The report shall include the following:

8.1.1 Method used for preparation and compaction of specimen (either Test Methods D 698 or D 1557),

8.1.2 Condition of test specimen (unsoaked or soaked),



NOTE 1—See Table 1 for metric equivalents.

FIG. 3 Correction of Load - Penetration Curves.

8.1.3 Dry density of specimen before soaking, lb/ft ^{3} (or kg/m^3),

8.1.4 Dry density of specimen after soaking lb/ft ^{3} (or kg/m^3),

8.1.5 Moisture content of specimen in percent, as follows: (*a*) Before compaction; (*b*) After compaction; (*c*) Top 1-in. (25.4-mm) layer after soaking; and (*d*) Average after soaking (optional).

8.1.6 Swell (percentage of initial height),

8.1.7 Bearing ratio of specimen (unsoaked or soaked in percent (Indicate the penetration for which the bearing ratio was determined),

8.1.8 Mixture identification (percent lime, soil sample identification, lime identification), and

8.1.9 Curing conditions (temperature,°C or °F; time, h, and description of curing container).

NOTE 3—Some cured soil-lime mixtures may have bearing ratios in excess of 100 % indicating that a substantial cementation has occurred. In such cases, the bearing ratio may not be the most appropriate strength evaluation procedure.

TABLE 1 Metric Equivalents

U.S. Customary Units, in.	Metric Equivalent, mm	U.S. Customary Units, in.	Metric Equivalent, mm	U.S. Customary Units, in.	Metric Equivalents, mm
0.003	0.076	19/32	15.08	3½	88.90
0.005	0.127	⅝	15.88	3¾	95.25
0.135	3.43	¾	19.10	4¼	108.0
0.201	5.11	15/16	23.81	4½	114.3
0.4375	11.11	1	25.40	4¾	120.7
0.4378	11.12	1⅛	28.58	5⅞	149.2
0.510	12.95	1¼	31.8	515/16	150.8
0.633	16.08	1⅜	34.9	6	152.0
1.370	34.60	1½	38.10	67/32	158.0
1.375	34.93	1¾	44.5	6½	165.1
1.954	49.63	113/16	46.04	7	177.8
2.416	61.37	115/16	49.21	7½	190.1
1/16	1.59	2	50.80	8⅜	212.7
7/32	5.56	2⅛	53.98	8½	215.9
¼	6.35	2⅕	55.9	9⅜	238.1
⅜	9.53	2¼	57.2	14¼	362.0
7/16	11.11	2½	63.50	18	457.2
15/32	11.91	2¾	69.85	32¼	719.2
½	12.70	231/32	75.41	36⅝	930.3
17/32	13.49	3	76.20	39	990.6

U.S. Customary Units, lb	Metric Equivalent, kg	U.S. Customary Units, psi	Metric Equivalent, MPa
0.04	0.02	200	1.4
0.05	0.02	400	2.8
0.12	0.05	600	4.1
0.59	0.27	800	5.5
0.71	0.32	1000	6.9
0.75	0.34	1200	8.3
3.20	1.45	1400	9.7
5.00	2.27		
10.00	4.54		