Standard Method of Test
for

Density of Soil In-Place by the Sand-Cone Method

AASHTO DESIGNATION: T 191-93
(ASTM DESIGNATION: D 1556-64 (1982))

1. SCOPE

1.1 This method of test is intended for determining the in-place density of soils. The apparatus described herein is restricted to tests in soils containing particles not larger than 50 mm (2 in.) in diameter.

1.2 The following applies to all specified limits in this standard: For the purposes of determining conformance with these specifications, an observed value or a calculated value shall be rounded off "to the nearest unit" in the last right-hand place of figures used in expressing the limiting value, in accordance with the rounding-off method of R 11, Recommended Practice For Indicating Which Places Of Figures Are To Be Considered Significant In Specified Limiting Values.

2. APPARATUS

2.1 *Density Apparatus*—The density apparatus shall consist of a 4 L (1 gal) jar and a detachable appliance consisting of a cylindrical valve with an orifice 12.7 mm ($^1/_2$ in.) in diameter and having a small funnel continuing to a standard G mason jar top on one end and a large funnel on the other end. The valve shall have stops to prevent rotating the valve past the completely open or completely closed positions. The apparatus shall conform to the requirements shown in Figure 1 (Note 1).

NOTE 1—The apparatus described here represents a design that has proven satisfactory. Other apparatus of similar proportions will perform equally well so long as the basic principles of the sand-volume determination are observed. This apparatus, when full, can be used with test holes having a volume of approximately 0.1 cu ft. The base plate shown in the drawing is optional; its use may make leveling more difficult but permits test holes of larger diameter and may reduce loss in transferring soil from test-hole to container as well as afford a more constant base for tests in soft soils. When the base plate is used it shall be considered a part of the funnel in the procedures of this test method.

2.2 *Sand*—Any clean, dry, free-flowing, uncemented sand having few, if any, particles passing the 0.075-mm or retained on the 2.00-mm sieves. In selecting a sand for use several bulk density determinations should be made using the same representative sample for each determination. To be acceptable the sand shall not have a variation in bulk density greater than 1 percent.

2.3 *Balances*—A balance conforming to the requirements of M 231, Class G20. Also, a balance conforming to the requirements of M 231, Class G2.

2.4 *Drying Equipment*—Stove or oven or other suitable equipment for drying moisture content samples.

2.5 *Miscellaneous Equipment*—Small pick, chisels, or spoons for digging test hole; 254 mm (10 in.) frying pan or any suitable container for drying moisture samples; buckets with lids, seamless tin cans with lids, canvas sacks or other suitable containers for retaining the density sample, moisture sample or density sand respectively; thermometer for determining the temperature of water; small paint-type brush, slide rule, notebook, etc.

3. PROCEDURE

3.1 Determine the volume of the jar and attachment up to and including the volume of the valve orifice as follows (Note 2):

3.1.1 Weigh the assembled apparatus and record.

3.1.2 Place the apparatus upright and open the valve.

3.1.3 Fill the apparatus with water until it appears over the valve.

3.1.4 Close valve and remove excess water.

3.1.5 Weigh the apparatus and water and determine the temperature of the water.

3.1.6 Repeat the procedure described in steps (1) to (5) at least twice. Convert the mass of water, in grams, to milliliters by correcting for the temperature as given in Section 4.1. The volume used shall be the average of three determinations with a maximum variation of 3 mL.

NOTE 2—The volume determined in this procedure is constant as long as the jar and attachment are in the same relative position. If the two are to be separated match marks should be made to permit reassembly to this position.

3.2 Determine the bulk density of the sand to be used in the field test as follows (Notes 3 and 4):

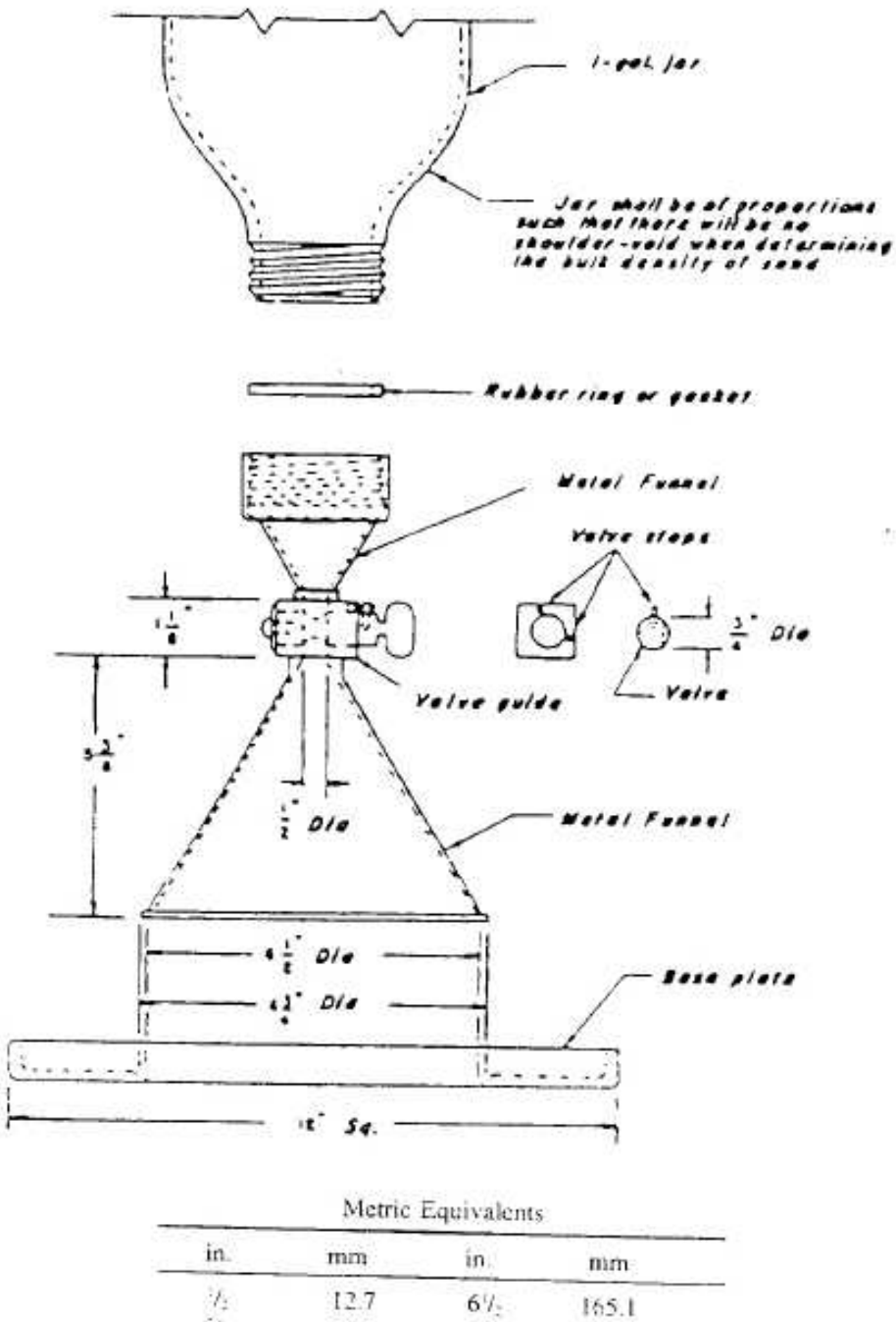
3.2.1 Place the empty apparatus upright on a firm level surface, close the valve and fill the funnel with sand.

3.2.2 Open the valve and, keeping funnel at least half full of sand, fill the apparatus. Close the valve sharply and empty excess sand.

3.2.3 Weigh apparatus with the sand and determine the net mass of sand by subtracting the mass of the apparatus.

NOTE 3—Vibration of the sand during any mass-volume determination may increase the bulk density of the sand and decrease the accuracy of the determination. Appreciable time intervals between the bulk density determination of the sand and its use in the field may result in change in the bulk density caused by a change in the moisture content or effective gradation.

NOTE 4—It is possible to determine the bulk density of the sand in other containers of known volume that dimensionally approximate the largest test hole that will be dug. The general procedure used is that given in



Metric Equivalents

in.	mm	in.	mm
½	12.7	6½	165.1
¾	19.1	6¾	171.5
1½	28.6	12	304.8
5½	136.5		

FIGURE 1 Density Apparatus

Section 3.4 for determining the volume of the test hole. If this procedure is to be followed it shall be determined that the resulting bulk density equals that given by the jar determination.

3.3 Determine the mass of sand required to fill the funnel as follows (Notes 5 and 6):

3.3.1 Put sand in the apparatus and secure mass of apparatus and sand.

3.3.2 Seat the inverted apparatus on a clean, level, plane surface.

3.3.3 Open the valve and keep open until after the sand stops running.

3.3.4 Close the valve sharply, weigh the apparatus with remaining sand and determine the loss of sand. This loss represents the mass of sand required to fill the funnel.

3.3.5 Replace the sand removed in the funnel determination and close the valve.

NOTE 5—This determination may be omitted if the procedure given in Note 7 is followed. When the base plate is used it shall be considered a part of the funnel.

NOTE 6—Where test holes of maximum volume are desired it is possible, after the bulk density determination, to settle the sand by vibration and increase the weight of sand in the apparatus. If this procedure is followed, the total weight of sand available shall be determined by re-weighing.

3.4 Determine the density of the soil in place as follows:

3.4.1 Prepare the surface of the location to be tested so that it is a level plane.

3.4.2 Seat the inverted apparatus on the prepared plane surface and mark the outline of the funnel (Note 7).

NOTE 7—In soils such that leveling is not successful a preliminary test shall be run at this point measuring the volume bounded by the funnel and ground surface. This step requires balances at the test site or emptying and refilling the apparatus. After this measurement is completed, carefully brush the sand from the prepared surface.

NOTE 8—It may be desired to express the in-place density as a percentage of some other density, for example, the laboratory maximum density determined in accordance with the Method of Test for Moisture-Density Relations of Soils (T 99). This relation can be determined by dividing the in-place density by the maximum density and multiplying by 100.

3.4.4 Seat the apparatus in the previously marked position, open the valve and after the sand has stopped flowing, close the valve (Note 3).

3.4.5 Weigh the apparatus with remaining sand and determine the mass of sand used in the test.

3.4.6 Weigh the material that was removed from the test hole.

3.4.7 Mix the material thoroughly and secure and weigh a representative sample for moisture determination.

3.4.8 Dry and weigh the soil sample for moisture content determination in accordance with T 265 or in accordance with rapid methods such as T 217, ASTM D 4959, or ASTM D 4643. The results obtained using these or other rapid test methods must be corrected to the values obtained in accordance with T 265.

3.5 The minimum test hole volumes suggested in determining the in-place density of soil mixtures are given in Table 1. This table shows the suggested minimum mass of the moisture content sample in relation to the maximum particle size in soil mixtures.

TABLE 1 Minimum Test Hole Volumes and Minimum Moisture Content Samples
Based on Maximum Size of Particle

Maximum Particle Size		Minimum Test Hole Volume, cu ft	Minimum Moisture Content Sample, g
mm	Alternate		
4.75	No. 4 Sieve	0.025	100
12.5	½ in.	0.050	250
25.0	1 in.	0.075	500
50.0	2 in.	0.100	1000

4. CALCULATIONS

4.1 Calculate the volume of the density apparatus as follows:

$$V_1 = GT$$

where:

V_1 = volume of the density apparatus, in cubic centimeters,
G = grams of water required to fill the apparatus, and
T = water temperature-volume correction shown in column 3 of Table 2.

4.1.1 Calculate the volume of the density apparatus to the nearest 0.0001 ft^3.

4.2 Calculate the bulk density of the sand as follows:

$$W_1 = \frac{62.427\ W_2}{V_1}$$

where:

W_1 = bulk density of the sand in pounds per cubic foot,
W_2 = grams of sand required to fill the apparatus (Section 3.2.3), and
V_1 = volume of apparatus, in cubic centimeters (Section 4.1).

4.2.1 Calculate the bulk density of the sand to the nearest 0.1 lb/ft^3.

4.3 Calculate the moisture content and the dry mass of material removed from the test hole as follows:

$$w = \frac{W_3 - W_4 \times 100}{W_4}$$

$$W_5 = \frac{0.2205\ W_3}{w + 100}$$

where:

w = percentage of moisture, in material from test hole,
W_3 = moist mass of moisture sample, in grams,
W_4 = dry mass of moisture sample, in grams
W_5 = moist mass of the material from the test hole, in grams, and
W_6 = dry mass of material from the test hole, in pounds.

4.3.1 Calculate the moisture content to the nearest 0.1 percent.

4.3.2 Calculate the dry mass of material removed from the test hole to the nearest 0.01 lb.

4.4 Calculate the in-place dry density of the material tested as follows:

$$V = \frac{W_2 - W_5}{453.6\ W_1}$$

$$W = \frac{W_6}{V}$$

where:

V = volume of test hole, in cubic feet,
W_2 = grams of sand used (Section 3.4.5),
W_5 = grams of sand in funnel (Section 3.3.3), and
W = dry density of the tested material, in pounds per cubic foot.

4.4.1 Calculate the in-place dry density of the material tested to the nearest 0.1 $lb/ft.^3$

TABLE 2 Volume of Water per Gram Based on Temperature

Temperature		Volume of water, cm^3 per g
deg Cent	deg Fahr	
12	53.6	1.00048
14	57.2	1.00073
16	60.8	1.00103
18	64.4	1.00138
20	68.0	1.00177
22	71.6	1.00221
24	75.2	1.00268
26	78.8	1.00320
28	82.4	1.00375
30	86.0	1.00435
32	89.6	1.00497