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INTERNATIONAL

**Designation: ~~D5030 – 04~~ D5030/D5030M – 13**

# Standard Test ~~Method~~Methods for Density of Soil and Rock in Place by the Water Replacement Method in a Test Pit[1]

This standard is issued under the fixed designation ~~D5030;~~D5030/D5030M; 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.

## 1. ~~Scope~~ Scope*

1.1 ~~This~~These test ~~method covers~~methods cover the determination of the in-place density ~~and unit weight~~ of soil and rock using water to fill a lined test pit to determine the volume of the test pit. The use of the word "rock" in ~~this~~these test ~~method~~methods is used to imply that the material being tested will typically contain particles larger than 3 in. ~~(75 mm).~~[75 mm].

1.2 ~~This~~These test ~~method is~~methods are best suited for test pits with a volume between approximately 3 and 100 ft$^3$ ~~(0.08~~[0.08 and 2.83 m$^3$~~).~~]. In general, the materials tested would have maximum particle sizes over 5 in. ~~(125 mm). This test method~~[125 mm]. These test methods may be used for larger sized excavations if desirable.

1.2.1 This procedure is usually performed using circular metal templates with inside diameters of 3 ft ~~(0.9 m)~~[0.9 m] or more. Other shapes or materials may be used providing they meet the requirements of ~~this~~these test ~~method~~methods and the guidelines given in Annex A1 for the minimum volume of the test pit.

1.2.2 Test Method D4914 may be used as an alternative method. Its use, however, is usually only practical for volume determination of test pits between approximately 1 and 6 ft$^3$ ~~(0.03~~[0.03 and 0.17 m$^3$~~).~~].

1.2.3 Test Method D1556 or Test Method D2167 is usually used to determine the volume of test holes smaller than 1 ft$^3$ ~~(0.03~~[0.03 m$^3$~~).~~].

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1.3 The two procedures are described as follows:

1.3.1 *Procedure A*—In-Place Density and ~~Unit Weight~~ Density of Total Material (Section ~~10~~12).

1.3.2 *Procedure B*—In-Place Density and ~~Unit Weight~~ Density of Control Fraction (Section ~~11~~13).

1.4 *Selection of Procedure:*

1.4.1 Procedure A is used when the in-place ~~unit weight~~ density of total material is to be determined. Procedure A can also be used to determine percent compaction or percent relative density when the maximum particle size present in the in-place material being tested does not exceed the maximum particle size allowed in the laboratory compaction test (Test Methods D698, D1557, D4253, D4254, D4564, and D7382). For Test Methods D698 and D1557 only, the ~~unit weight~~ density determined in the laboratory compaction test may be corrected for larger particle sizes in accordance with, and subject to the limitations of, Practice D4718.

1.4.2 Procedure B is used when percent compaction or percent relative density is to be determined and the in-place material contains particles larger than the maximum particle size allowed in the laboratory compaction test or when Practice D4718 is not applicable for the laboratory compaction test. Then the material is considered to consist of two fractions, or portions. The material from the in-place ~~unit weight~~ density test is physically divided into a control fraction and an oversize fraction based on a designated sieve size. The ~~unit weight~~ density of the control fraction is calculated and compared with the ~~unit weight(s)~~ density(ies) established by the laboratory compaction test(s).

~~1.4.2.1 Because of possible lower densities created when there is particle interference (see Practice D4718), the percent compaction of the control fraction should not be assumed to represent the percent compaction of the total material in the field.~~

1.4.3 Normally, the control fraction is the minus No. 4 [4.75-mm] sieve size material for cohesive or nonfree-draining materials and the minus 3-in. [75-mm] sieve size material for cohesionless, free-draining materials. While other sizes are used for the control fraction ~~(⅜, ¾-in.), this test method has~~-in. [9.5, 19-mm], these test methods have been prepared using only the No. 4 [4.75-mm] and the 3-in. [75-mm] sieve sizes for clarity.

1.5 Any material can be tested, provided the material being tested has sufficient cohesion or particle attraction to maintain stable sides during excavation of the test pit and through completion of this test. It should also be firm enough not to deform or slough due to the minor pressures exerted in digging the hole and filling with water.

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[1] ~~This~~These test ~~method is~~methods are under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.08 on Special and Construction Control Tests.

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***A Summary of Changes section appears at the end of this standard**

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~~1.5.1 A very careful assessment must be made as to whether or not the volume determined is representative of the in-place condition when this test method is used for clean, relatively uniform-sized particles 3 in. (75 mm) and larger. The disturbance during excavation, due to lack of cohesion, and the void spaces between particles spanned by the liner may affect the measurement of the volume of the test pit.~~

1.6 ~~This~~These test ~~method is~~methods are generally limited to material in an unsaturated condition and is not recommended for materials that are soft or friable (crumble easily) or in a moisture condition such that water seeps into the excavated hole. The accuracy of the test may be affected for materials that deform easily or that may undergo volume change in the excavated hole from standing or walking near the hole during the test.

1.7 *Units*—The values stated in either inch-pound units or SI units [presented in brackets] are to be regarded separately as ~~the~~ standard. The values ~~given in parentheses are for information only.~~stated in each system may not be exact equivalents; therefore each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.7.1 The gravitational system of inch-pound units is used when dealing with inch-pound units. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass is slugs. The slug unit is not given, unless dynamic (F = ma) calculations are involved.

1.7.2 In the engineering profession, it is customary practice to use, interchangeably, units representing both mass and force, unless dynamic calculations (F = Ma) are involved. This implicitly combines two separate systems of units, that is, the absolute system and the gravimetric system. It is scientifically undesirable to combine the use of two separate systems within a single standard. ~~This~~These test ~~method has~~methods have been written using inch-pound units (gravimetric system) where the pound (lbf) represents a unit of force (weight); however, conversions are given in the SI system. The use of balances or scales recording pounds of mass (lbm), or the recording of density in lbm/ft$^3$ should not be regarded as nonconformance with this standard.

1.8 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026.

1.8.1 The procedures used to specify how data are collected, recorded or calculated in this standard are regarded as the industry standard. In addition they are representative of the significant digits that generally should be retained. The procedures used do not consider material variation, purpose for obtaining the data, special purpose studies, or any considerations for the user's objectives; it is common practice to increase or reduce significant digits of reported data to be commensurate with these considerations. It is beyond the scope of this standard to consider significant digits used in analytical methods for engineering design.

1.9 *This standard does not purport to address all of the safety concerns, 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.* For a specific hazard statement, see Section ~~7~~9.

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

C127 Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
C138/C138M Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
C566 Test Method for Total Evaporable Moisture Content of Aggregate by Drying
D653 Terminology Relating to Soil, Rock, and Contained Fluids
D698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft$^3$ (600 kN-m/m$^3$))
D1556 Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
D1557 Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft$^3$ (2,700 kN-m/m$^3$))
D2167 Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method
D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
D4253 Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
D4254 Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density
D4564 Test Method for Density and Unit Weight of Soil in Place by the Sleeve Method
D4718 Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles
D4753 Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing
D4914 Test Methods for Density and Unit Weight of Soil and Rock in Place by the Sand Replacement Method in a Test Pit
~~E1~~D6026 ~~Specification for ASTM Liquid-in-Glass Thermometers~~Practice for Using Significant Digits in Geotechnical Data

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

D7382 Test Methods for Determination of Maximum Dry Unit Weight and Water Content Range for Effective Compaction of Granular Soils Using a Vibrating Hammer
E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves
F2362 Specification for Temperature Monitoring Equipment

## 3. Terminology

3.1 *Definitions*—Except as follows in 3.2, all definitions are in accordance with Terminology D653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *control fraction*—the portion of a soil sample consisting of particles smaller than a designated sieve size.

3.2.1.1 *Discussion*—

This fraction is used to compare in-place ~~unit weights with unit weights~~ densities with densities obtained from standard laboratory tests. The control sieve size depends on the laboratory test used.

3.2.2 *oversize particles*—the portion of a soil sample consisting of the particles larger than a designated sieve size.

## 4. Summary of Test Method

4.1 The ground surface at the test location is prepared and a template (metal ring) is placed and fixed into position. A liner is laid in the template and the volume of the space between a selected level within the template and the ground surface is determined by filling the space with water. The mass or the volume of the water required to fill the template to the selected level is determined and the water and liner removed. Material from within the boundaries of the template is excavated, forming a pit. A liner is placed in the test pit and template, water is poured into the pit and template up to the selected level; the mass or volume of the water within the pit and template and, subsequently, the volume of the hole are determined. The wet density of the in-place material is calculated from the mass of material removed and the measured volume of the test pit. The ~~moisture~~water content is determined and the dry ~~unit weight~~ density of the in-place material is calculated.

4.2 The ~~unit weight~~ density of a fraction of the material can be determined by subtracting the mass and volume of any oversize particles from the initial values and recalculating the ~~unit weight.~~density.

## 5. Significance and Use

5.1 ~~This~~These test ~~method is~~methods are used to determine the in-place ~~unit weight~~ density of compacted materials in construction of earth embankments, road fills, and structure backfill. For construction control, ~~it~~ the test methods can be used as the basis for acceptance of material compacted to a specified ~~unit weight~~ density or to a percentage of a maximum ~~unit weight~~ density determined by a standard laboratory test method such as determined from Test Methods D698 or D1557, subject to the limitations discussed in 1.4.

5.2 ~~This~~These test ~~method~~methods can be used to determine in-place ~~unit weight~~ density of natural soil deposits, aggregates, soil mixtures, or other similar material.

NOTE 1—The quality of the result produced by these test methods are dependent on the competence of the personnel performing them and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of these test methods are cautioned that compliance with Practice D3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some of those factors.

## 6. Interferences

6.1 Because of possible lower densities created when there is particle interference (see Practice D4718), the percent compaction of the control fraction should not be assumed to represent the percent compaction of the total material in the field.

6.2 A very careful assessment must be made as to whether or not the volume determined is representative of the in-place condition when this test method is used for clean, relatively uniform-sized particles 3 in. [75 mm] and larger. The disturbance during excavation, due to lack of cohesion, and the void spaces between particles spanned by the liner may affect the measurement of the volume of the test pit.

## 7. Apparatus

7.1 It is necessary to calculate density to at least three significant digits. Practice D6026 requires that all measurements be made to four significant digits. Report any readability limitations in the apparatus used in Section 16.

7.2 *Balance or Scale,* having a capacity and readability appropriate to the mass and procedural techniques for the specific test pit dimensions within the range of 3 to 100 ft$^3$ ~~(0.08~~[0.08 to 2.83 m$^3$~~)~~] volume and meeting the requirements of Specification D4753.

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7.3 *Balance or Scale*—a balance (or scale) to determine ~~moisture~~water content of minus No. 4 material having a minimum capacity of about ~~1000 g~~ 2 lbm [1000 g] and meeting the requirements of Specification D4753 for a balance of ~~0.1 g~~ 0.001 lb [0.1 g] readability.

7.4 *Drying Oven,* thermostatically controlled, preferably of the forced-draft type, and capable of maintaining a uniform temperature of 110 ± 5°C throughout the drying chamber.

7.5 *Sieves,* No. 4 sieve ~~(4.75-mm)~~[4.75-mm] and 3-in. ~~(75-mm),~~[75-mm], conforming to the requirements of Specification E11.

7.6 *Thermometer,* ~~0 to 50°C range, 0.5° graduations, conforming~~use of electrical thermocouples or thermoresistive devices (Specification F2362~~to the requirements of Specification~~) are required with readability ~~E1.~~to four significant digits.

7.7 *Metal Template*—a circular template to serve as a pattern for the excavation. Template dimensions, shapes, and material may vary according to the size of the test pit to be excavated. The template must be rigid enough not to deflect or bend.

NOTE 2—The template shown in Fig. 1 represents a design that has been found suitable for this purpose.

7.7.1 Since it may be difficult to place the template exactly level, particularly with 6-ft ~~(1.8-m)~~[1.8-m] and larger diameter rings, the height of the template should accommodate a slope of approximately 5 %. Since the water level has to be below the top of the template, it is not necessary that the template be level. The larger rings should be high enough to prevent any loss of water due to wave action caused by wind.

7.8 *Liners,* approximately 4 to 6 mil [100 to 150 µm] thick. Two pieces, each large enough to line the test pit, with about 3 ft ~~(1 m)~~[1 m] extending beyond the outside of the template. Any type of material, plastic sheeting, etc. can be used as long as it is flexible enough to conform to the ground surface.

7.9 *Water-Measuring Device,* including a storage container, delivery hoses or piping, and a water meter, scale, or other suitable measurement device. Water may be measured by mass or by volume. The equipment must be capable of controlling the delivery of the water so that any inaccuracies in filling and measuring do not exceed ± 1 % of the total mass or volume delivered.

7.10 *Water-Level Reference Indicator*—A water-level reference must be established so that the water level in the template is the same for the two determinations. A hook gage may be the simplest and most practical, although any device such as a rod with a pointed end that can be fastened to the template, a carpenter's level and scale, a carpenter's scale on a beam across the template, or other similar arrangement or device may be used. Whichever method is employed, the device must be able to be removed and replaced so that the reference water level is measured at the exact same location. Some type of protection around the device may be necessary if the water surface inside the template is not smooth.

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7.11 *Siphon Hose, Pump, Buckets, Hoses,* or other suitable equipment to move water to and from the template or pit, or both, and any storage container or reservoir.

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7.12 *Miscellaneous Equipment,* sandbags used to prevent movement of the template during the test; shovels, picks, chisels, bars, knives, and spoons for digging test pit; buckets or seamless cans with lids, drums, barrels, or other suitable containers for retaining the test specimen without ~~moisture~~water change; cloth for collecting excess soil; assorted pans and porcelain dishes suitable for drying moisture content specimens; boards, planks, ~~etc.,~~ to serve as a work platform when testing soils that may flow or deform;

**FIG. 1 A 6-ft ~~(1.8-m)~~[1.8-m] Diameter Metal Ring for Determining In-Place ~~Unit Weight~~Density**

hoists, slings, chains, and other suitable equipment that may be required to handle heavy loads; surveyor's level and rod or other suitable equipment for checking the slope on the template in place; duct tape or mortar, or both, used to prevent tearing of the plastic sheeting by sharp rock fragments.

## 8. Reagents and Water

8.1 Use clean potable water.

## 9. Safety Hazards

9.1 ~~This~~These test ~~method involves~~methods involve handling heavy loads.

## 10. Technical Hazards

10.1 Materials that may flow or deform during the test must be identified and appropriate precautions taken.

10.2 Errors may arise in the computed ~~unit weight~~ density of material due to the influence of excessive moisture in the material. These errors may be significant in materials with high permeability such as sands and gravels where the bottom of the test hole is close to or below the water table. The buoyant forces of free water beneath or behind the liner may adversely affect the volume determination.

10.3 The test area and equipment must be suitably protected during periods of inclement weather such as rain, snowfall, or high wind. If the in-place ~~moisture~~water content value is required, it may be necessary to protect the area from direct sunlight.

10.4 Numerous containers may be required during performance of ~~this~~these test ~~method.~~methods. All containers must be properly labeled to avoid a possible ~~mixup.~~mix-up.

10.5 The total mass of the water, or soil sample, or both, may exceed the capacity of the scale used, requiring cumulative determinations of mass. Care must be taken to ~~ensure~~ make sure that the total mass is properly determined.

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## 11. Calibration and Standardization

11.1 If the volume of water used is determined with a water-measuring device, the device must be calibrated to meet the requirements of ~~6.8~~7.9.

## 12. Procedure A—In-Place Density ~~and Unit Weight~~ of Total Material

12.1 Procedure A is used to determine a total ~~unit weight~~ density (see 1.4).

12.2 Determine the recommended sample volume and select the appropriate template for the anticipated soil gradation in accordance with information in Annex A1. Assemble the remainder of the required equipment.

12.3 Determine the mass of each combination of empty container, lid, and container liner (if used) that will contain the excavated material. Number the containers and mark as to use. Write the mass on the container or prepare a separate list.

12.4 Prepare the quantity of water to be used. The volume of the excavated test pit is determined by filling the test pit with water and either the mass or volume of the water measured. Measuring the mass of water used is usually only practical for 3 to 4-ft ~~(1~~[1 to ~~1.3-m)~~1.3-m] diameter rings. If the mass of water is measured, follow ~~10.4.1~~12.4.1. If the volume of water is measured, follow ~~10.4.2~~12.4.2.

12.4.1 If the mass of water used is measured, containers of water must be prepared with the mass of water determined before and after the test. For test pits with volumes of 3 to 6 $ft^3$, ~~(0.08~~[0.08 to 0.17 $m^3$~~),~~], use containers such as ~~5-gal~~hand-held buckets so the mass can be determined on a balance or scale of the type normally found in a laboratory. Larger test pit volumes can be measured using water contained in tanks or ~~55-gal~~large drums if equipment, such as a hoist and a suitable scale, is available to determine the mass.

12.4.1.1 Two sets of water and containers are necessary. Determining the volume of the test pit requires two separate determinations of the mass of water to: (*a*) measure the mass of water used to fill the space between the soil surface (before the test pit is excavated) and a water-level reference in the template; and (*b*) measure the mass of water used to fill the test pit up to the same water-level reference. The difference between the two masses gives the mass of water in the test pit.

12.4.1.2 Estimate the mass of water (and the number of containers) required to fill the template. The estimated mass may be calculated by multiplying the template volume by the density of water. Number the containers to be used and mark as to use, for example "template correction." Fill the containers with water, and determine and record the mass of the containers and water.

12.4.1.3 From the anticipated volume of the test pit, estimate the mass of water required to fill the test pit. The estimated mass of water to be used for the test pit may be calculated by multiplying the anticipated volume of the test pit by the density of water and then adding to it the mass of water calculated in ~~10.4.1.2~~12.4.1.2. Increase this amount by about 25 % to ~~ensure~~ make sure that a sufficient supply of water is available at the site. Determine the number of containers required, number them, and mark as to use, for example, "test pit." Fill the containers with water, and determine and record the mass of the containers and water. Proceed to ~~10.5~~12.5.

12.4.2 If the volume of water used is measured, use a water-measuring device to measure the ~~gallons (litres)~~ volume of water used from a water truck, a large water reservoir, or large containers of ~~water such as 55-gal drums.~~ water. The water-measuring device must meet the requirements of ~~6.8~~7.9.

12.4.2.1 Two separate determinations of volume are necessary to: (*a*) measure the volume of water to fill the space between the soil surface (before the test pit is excavated) and a water-level reference in the template; and (*b*) measure the volume of water used to fill the test pit up to the same water-level reference in the template. The difference between the two volumes gives the volume of water in the test pit.

12.4.2.2 The approximate volume of water required equals the anticipated volume of the test pit plus twice the calculated volume of the template. If appropriate, ~~multiply~~convert the required volume in cubic feet ~~by 7.48~~ [metres] to determine the volume in ~~gallons.~~ gallons [litres]. Increase this amount by about ~~25 %~~25 % to ~~ensure~~ make sure that a sufficient supply of water is available at the site. If containers are used, determine the number required and fill the containers with water; otherwise, fill the water truck or water reservoir with sufficient water.

12.5 Select a representative area for the test, avoiding locations where removal of large particles would undermine the template.

12.6 *Preparation of the Surface Area to be Tested:*

12.6.1 Remove all loose material from an area large enough on which to place the template. Prepare the exposed surface so that it is a firm, reasonably level plane.

12.6.2 Personnel should not step on or around the area selected for testing. Provide a working platform when testing materials which may flow or deform.

12.7 *Placing and Seating the Template on the Prepared Surface:*

12.7.1 Firmly seat the template to avoid movement of the template while the test is performed. The use of nails, weights, or other means may be necessary to maintain the position. Check the elevation at several locations on the template. Since the water-level reference is kept below the top of the template, it is not necessary that the template be exactly level, but the slope of the template should not exceed 5 %.

12.7.2 Remove any material loosened while placing and seating the template, taking care to avoid leaving any void space under the template. If necessary, voids under the template may be filled using plastic soil, molding clay, mortar, or other suitable material, provided that this material is not subsequently excavated as part of the material removed from the test pit.

12.7.3 Inspect the surface within the template. If necessary, cover any sharp edges with duct tape or other suitable material to prevent tearing or puncturing of the plastic lining.

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12.8 Determine the volume of the space between the soil surface and the water-level reference.

12.8.1 Irregularities of the soil surface within the template must be taken into account. To do this, determine the volume of water required to fill the space between the soil surface and the water-level reference.

12.8.2 Place a liner 4 to 6 mil [100 to 150 µm] thick over the template, and shape it by hand to conform to the irregular soil surface and the template. The liner should extend approximately 3 ft ~~(1 m)~~[1 m] outside the template. The liner should not be stretched too taut or contain excessive folds or wrinkles (see Fig. 2).

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12.8.3 Assemble the equipment for the water-level reference indicator. Normally, the water-level reference is set after the water in the template reaches a practical level.

**FIG. 2 Plastic Liner Placed in Preparation for the Initial Volume Determination**

12.8.4 If the volume of water is being measured, set the water-measuring device indicator to zero or record the initial reading of the indicator. Pour the water from the containers or discharge the water from the water reservoir into the template until the water level reaches a practical level. The slope of the template and any possible wave action must be considered to prevent losing any water. Set the water-level reference indicator (see Fig. 3). If the volume of water is being measured, record the final reading of the water-measuring device. If the mass of water is being measured, save the remaining water for a subsequent determination of mass.

12.8.4.1 Inspect for water leakage by looking for bubbles, observing the water level over an appropriate ~~time, etc.~~<u>time.</u>

12.8.5 Make appropriate markings so that the water-level indicator can be placed in the identical position and at the same elevation following excavation of the test pit. Disassemble the water-level reference indicator.

12.8.6 Remove the water in the template, and remove the liner.

12.9 *Excavating the Test Pit:*

12.9.1 Using ~~handtools~~ <u>hand tools</u> (shovel, chisel, knife, ~~bar, etc.),~~ <u>bar),</u> excavate the center portion of the test pit. Use of heavy equipment, such as a backhoe or a mechanical or hydraulic hoist, may be required to remove large particles.

12.9.1.1 Do not permit the movement of heavy equipment in the area of the test if deformation of the material within the test pit may occur.

12.9.2 Place all material removed from the test pit in the container(s). Take care to avoid losing any material.

NOTE 3—For the smaller size templates where the containers for the material may be outside the template, a cloth or plastic sheet may be placed under the containers to facilitate locating and collecting any loose material.

12.9.3 Keep container(s) covered when not in use to avoid loss of moisture. A sealable plastic bag may be used inside the container to hold the material.

12.9.4 Carefully trim the sides of the excavation so the dimensions of the test pit at the soil-template contact are as close as ~~possible~~<u>practical</u> to the dimensions of the template hole. Avoid disturbing the template or the material beneath or outside the template.

12.9.5 Continue the excavation to the required depth, carefully removing any material that has been compacted or loosened in the process.

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12.9.5.1 If during excavation of material from within the test pit, a particle (or particles) is found that is about 1½ times, or more, larger than the maximum particle size used to establish the dimensions and minimum volume of the test pit (see Annex A1), set the particle(s) aside and mark appropriately. The mass and volume of the particle(s) must be determined and subtracted from the mass and volume of the material removed from the test pit. Consider the larger particle(s) as "oversize," and follow the procedure outlined in Section ~~11~~<u>13</u> except that the "total" ~~unit weight,~~ <u>density,</u> which would include the larger particle(s), need not be calculated. The "control fraction" values determined then become the values for the total material from the test pit.

12.9.5.2 If enough of these particles are found so that their mass is determined to be about 5 % or more of the mass of the excavated soil, repeat the test with a larger test pit in accordance with the guidelines in Annex A1.

12.9.6 The sides of the pit should be as close to vertical as ~~possible~~<u>practical</u> but will, out of necessity, slope inward (see Fig. 4). Materials that do not exhibit much cohesion will result in a more conically shaped test pit.

12.9.7 The profile of the finished pit must be such that the water will completely fill the excavation. The sides of the test pit should be as smooth as possible and free of pockets or overhangs.

**FIG. 3 Measuring the Water-Level Reference with a Carpenter's Square**

FIG. 4 Test Pit ~~During~~ Excavation

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12.9.8 The bottom of the test pit must be cleaned of all loosened material.

12.9.9 Inspect the surface of the material within the template. Cover any sharp edges with duct tape or other suitable material to prevent tearing or puncture of the plastic lining. Mortar, or other suitable material, may be used to fill recesses to eliminate sharp edges, overhangs, or pockets that cannot be smoothed or eliminated. The volume of the material used must be able to be determined and provisions to do this made accordingly.

12.9.9.1 If mortar is used, measure the mass of mortar and calculate the volume in cubic feet in accordance with Test Method C138/C138M.

12.10 *Determine the Volume of the Test Pit:*

12.10.1 Calculate and record all volume measurements to four significant digits. Equations for calculations are shown in Section 14.

12.10.2 Place the liner into the test pit. The liner, approximately 4 to 6 mil [100 to 150 µm] thick, should be large enough to extend approximately 3 ft ~~(1 m)~~[1 m] outside the template boundaries after having been carefully placed and shaped within the pit. Make allowances for slack. The liner should not be stretched too taut nor contain excessive folds or wrinkles. Inspect the liner for punctures before use.

12.10.3 If the volume of water is being measured, set the water-measuring device indicator to zero or record the initial reading of the indicator. Pour the water from the containers or discharge the water from the water reservoir into the test pit until the water reaches the water-level reference indicator. When the filling is complete, record the final reading of the water-measuring device indicator. If the mass of water is being measured, set aside the remaining water for a subsequent determination of mass. If necessary, calculate the gallons ~~(litres)~~[litres] of water used.

12.10.3.1 Inspect for water leakage by looking for ~~bubbles,~~ bubbles and observing the water level over an appropriate ~~time, etc.~~time.

12.10.4 If the mass of the water is being measured, determine and record the temperature of the water in the test pit.

12.10.5 Remove the water from the test pit, and remove the liner. Inspect the liner for any holes that may have allowed water to escape during the test. Loss of water will require another determination of the volume.

12.11 *Calculating the Volume of the Test Pit:*

12.11.1 Calculate and record all volume measurements to four significant digits. Equations for calculations are shown in Section 14.

12.11.2 If the mass of water is being measured, determine the mass as follows:

12.11.2.1 Determine and record the mass of the container(s) and remaining water after filling the template (the space between the soil surface and the water-level reference).

12.11.2.2 Calculate and record the total mass of water used to fill the template to the water-level reference.

12.11.2.3 Determine and record the mass of the container(s) and remaining water after filling the test pit and template to the water-level reference.

12.11.2.4 Calculate and record the total mass of water used to fill the test pit and template to the water-level reference.

12.11.2.5 Calculate and record the mass of water used to fill the test pit.

12.11.2.6 Using a density of water of 62.3 lbm/ft$^3$ (this assumes a temperature between 18 and 24°C), calculate and record the volume of water used to fill the test pit. If mortar or other material was not used, this value is the volume of the test pit. If mortar was used, add the calculated volume of mortar to the volume of water used to determine the volume of the test pit.

12.11.3 If the volume of the water is being measured, determine the volume as follows:

12.11.3.1 Calculate and record the volume of water used to fill the template (the space between the soil surface and the water-level reference).

12.11.3.2 Calculate and record the volume of water used to fill the test pit and template.

12.11.3.3 Calculate and record the volume of water used to fill the test pit.

12.11.3.4 Calculate and record the cubic feet of water used to fill the test pit. If mortar was not used, this value is the volume of the test pit. If mortar was used, add the calculated volume of mortar (see ~~10.9.9.1~~12.9.9.1) to the volume of water used to determine the volume of the test pit.

12.12 *Determine the Dry ~~Unit Weight:~~ Density:*

12.12.1 Calculate and record volumes and masses and wet density to four significant digits. Calculate and record water content and dry density to three significant digits. Equations for calculations are shown in Section 14.

12.12.2 Determine the total mass of the excavated material and containers.

12.12.3 Calculate and record the total mass of the containers used to hold the excavated material. Record the container numbers.

12.12.4 Calculate and record the mass of excavated material.

12.12.5 Calculate the wet density of the excavated material.

12.12.6 If percent compaction or percent relative density of the control fraction is required, separate the material using the appropriate size sieve and follow the procedures in Procedure B.

12.12.7 If Procedure B is not used, obtain a ~~moisture~~water content specimen representative of the excavated material; determine the ~~moisture~~water content in accordance with Test Method D2216 or Test Method C566 and record.

NOTE 4—For rapid ~~moisture~~water content determination of soils containing less than 15 % fines (minus No. 200 sieve), a suitable source of heat such as an electric or gas hotplate may be used. If a source of heat other than the controlled temperature oven is used, stir the test specimen to accelerate drying and avoid localized overheating. The material may be considered dry when further heating causes, or would cause, less than 0.1 % additional loss of mass.

12.12.8 Calculate and record the dry density ~~and dry unit weight of the material.~~of the material to three significant digits.

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## 13. Procedure B—In-Place Density ~~and Unit Weight~~ of Control Fraction

13.1 This procedure is used when percent compaction or percent relative density of the control fraction is required (see 1.4).

13.2 Obtain the in-place wet density of the total material by following the procedure for Procedure A, as stated in ~~10.2-~~12.2-~~10.12.4~~12.12.5.

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13.3 Record all masses and volumes and wet density below to four significant digits. Calculate and record water content and dry density to three significant digits. Equations for calculations are shown in Section 15.

13.4 To obtain the wet density of the control fraction, determine the mass and volume of the oversize particles and subtract from the total mass and total volume to get the mass and volume of the control fraction. Calculate the density of the control fraction from the mass and volume of the control fraction.

13.4.1 Normally, the wet density of the control fraction is determined and the dry density is calculated using the ~~moisture~~water content of the control fraction.

13.4.2 In addition, the ~~moisture~~water content of the oversize particles, the ~~moisture~~water content of the total material, and the percentage of oversize particles may be determined.

13.5 After obtaining the wet mass of total material removed from the test pit, separate the material into the control fraction and the oversize particles using the designated sieve. Do this rapidly to minimize loss of moisture. If the test is for construction control, place the control fraction in an airtight container for further tests.

13.6 Wash the oversize particles and reduce the free water on the surface of the particles by blotting, draining, or using a similar method.

13.7 Determine the wet mass of the oversize particles plus the container of predetermined mass and record.

13.8 Calculate the wet mass of the oversize particles and record.

13.9 Calculate the wet mass of the control fraction and record.

13.10 Calculate and record the volume of the oversize particles by using a bulk specific gravity value of the oversize particles. If previous tests for bulk specific gravity of the oversize particles from a particular source have been performed and the value is relatively constant, a specific gravity may be assumed. Otherwise, obtain a representative sample and determine the bulk specific gravity in accordance with Test Method C127 except that oven drying and the 24-h soaking period are not used. The bulk specific gravity used must correspond to the moisture condition of the oversize particles when their mass is determined. As used in ~~this~~these test ~~method,~~methods, the bulk specific gravity must have been determined on the oversize particles in the moisture condition as stated in ~~11.5~~-13.6-~~11.7~~13.8. If an oven dry or saturated surface dry (SSD) bulk specific gravity is used, then determine the mass of the oversize particles for this procedure on oven dry or SSD material, respectively.

13.11 Calculate the volume of the control fraction and record.

13.12 Calculate the wet density of the control fraction.

13.13 Determine the ~~moisture~~water content of the control fraction in accordance with Test Method C566 or Method D2216 (see Note ~~2~~3) and record.

13.14 Calculate the dry density ~~and dry unit weight~~ of the control fraction and record.

13.15 If desired, determine and record the ~~moisture~~water content of the oversize particles in accordance with Test Method C566 or Method D2216 (see Note ~~2~~3). If previous tests for ~~moisture~~water content of the oversize particles from a particular source have been performed and the value is relatively constant, a ~~moisture~~water content may be assumed.

13.16 If desired, determine the percentage of oversize particles:
13.16.1 Calculate the dry mass of the control fraction and record.
13.16.2 Calculate the dry mass of the oversize particles and record.
13.16.3 Calculate the dry mass of the total sample and record.
13.16.4 Calculate the percentage of oversize particles and record.

13.17 If desired, calculate the ~~moisture~~water content of the total material and record.

13.18 If desired, calculate the dry density ~~and dry unit weight~~ of the total material and record.

## 14. Calculation—Procedure A

14.1 Calculate the mass of the water used to fill the test pit and template as follows:

$$m_5 = m_1 - m_3 \tag{1}$$

where:

~~$m_5$ = mass of water used for template and test pit volume, lbm (kg),~~
~~$m_1$ = mass of water and containers for template and test pit (before test), lbm (kg), and~~
~~$m_3$ = mass of water and containers for template and test pit volume (after test), lbm (kg).~~

$m_5$ = mass of water used for template and test pit volume, lbm [kg],
$m_1$ = mass of water and containers for template and test pit (before test), lbm [kg], and
$m_3$ = mass of water and containers for template and test pit volume (after test), lbm [kg].

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14.2 Calculate the mass of the water used to fill the template as follows:

$$m_6 = m_2 - m_4 \tag{2}$$

where:

~~$m_6$ = mass of water for template volume, lbm (kg),~~
~~$m_2$ = mass of water and containers for template volume (before test), lbm (kg), and~~
~~$m_4$ = mass of water and containers for template volume (after test), lbm (kg).~~

$m_6$ = mass of water for template volume, lbm [kg],
$m_2$ = mass of water and containers for template volume (before test), lbm [kg], and
$m_4$ = mass of water and containers for template volume (after test), lbm [kg].

14.3 Calculate the mass of the water used to fill the test pit as follows:

$$m_7 = m_5 - m_6 \tag{3}$$

where:

~~$m_7$ = mass of water in test pit, lbm (kg),~~
~~$m_5$ = mass of water used for template and test pit volume, lbm (kg), and~~
~~$m_6$ = mass of water for template volume, lbm (kg).~~

$m_7$ = mass of water in test pit, lbm [kg],
$m_5$ = mass of water used for template and test pit volume, lbm [kg], and
$m_6$ = mass of water for template volume, lbm [kg].

14.4 Calculate the volume of water used to fill the test pit as follows:
Measured mass of water:

$$V_4 = m_7/\rho_w \qquad \text{(inch-pound)} \tag{4}$$