Designation: D7263 – 09

Standard Test Methods for Laboratory Determination of Density (Unit Weight) of Soil Specimens[1]

This standard is issued under the fixed designation D7263; 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

1.1 These test methods describe two ways of determining the total/moist and dry densities (unit weights) of intact, disturbed, remolded, and reconstituted (compacted) soil specimens. Density (unit weight) as used in this standard means the same as "bulk density" of soil as defined by the Soil Science Society of America. Intact specimens may be obtained from thin-walled sampling tubes, block samples, or clods. Specimens that are remolded by dynamic or static compaction procedures may also be measured by these methods. These methods apply to soils that will retain their shape during the measurement process and may also apply to other materials such as soil-cement, soil-lime, soil-bentonite or solidified soil-bentonite-cement slurries. It is common for the density (unit weight) of specimens after removal from sampling tubes and compaction molds to be less than the value based on tube or mold volumes, or of in-situ conditions. This is due to the specimen swelling after removal of lateral pressures.

1.1.1 Method A covers the procedure for measuring the volume of wax coated specimens by determining the quantity of water displaced.

1.1.1.1 This method only applies to specimens in which the wax will not penetrate the outer surface of the specimen.

1.1.2 Method B covers the procedure by means of the direct measurement of the dimensions and mass of a specimen, usually one of cylindrical shape. Intact and reconstituted/remolded specimens may be tested by this method in conjunction with strength, permeability (air/water) and compressibility determinations.

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

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

1.3.1 The method used to specify how data are collected, calculated, or recorded in this standard is not directly related to the accuracy with which the data can be applied in design or other uses, or both. How one applies the results obtained using this standard is beyond its scope.

1.4 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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))

D854 Test Methods for Specific Gravity of Soil Solids by Water Pycnometer

D1557 Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3))

D1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes

D2166 Test Method for Unconfined Compressive Strength of Cohesive Soil

D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

D2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

D2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)

D3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils

D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as

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[1] These test methods are under the jurisdiction of ASTM Committee D18 on Soil and Rock and are the direct responsibility of Subcommittee D18.03 on Texture, Plasticity and Density Characteristics of Soils.

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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.

Used in Engineering Design and Construction
D4220 Practices for Preserving and Transporting Soil Samples
D4318 Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
D4753 Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing
D6026 Practice for Using Significant Digits in Geotechnical Data
E2251 Specification for Liquid-in-Glass ASTM Thermometers with Low-Hazard Precision Liquids

2.2 *Other Reference:*
Soil Science Society of America Glossary of Soil Science Terms[3]

3. Terminology

3.1 Refer to Terminology D653 for standard definitions of terms.

4. Significance and Use

4.1 Dry density, as defined as "density of soil or rock" in Terminology D653 and "bulk density" by soil scientists, can be used to convert the water fraction of soil from a mass basis to a volume basis and vise-versa. When particle density, that is, specific gravity (Test Methods D854) is also known, dry density can be used to calculate porosity and void ratio (see Appendix X1). Dry density measurements are also useful for determining degree of soil compaction. Since moisture content is variable, moist soil density provides little useful information except to estimate the weight of soil per unit volume, for example, pounds per cubic yard, at the time of sampling. Since soil volume shrinks with drying of swelling soils, bulk density will vary with moisture content. Hence, the water content of the soil should be determined at the time of sampling.

4.2 Densities (unit weights) of remolded/reconstituted specimens are commonly used to evaluate the degree of compaction of earthen fills, embankments, etc. Dry density values are usually used in conjunction with compaction curve values (Test Methods D698 and D1557).

4.3 Density (unit weight) is one of the key components in determining the mass composition/phase relations of soil, see Appendix X1.

NOTE 1—The quality of the result produced by this standard is dependent on the competence of the personnel performing it 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 this standard are cautioned that compliance with Practice D3740 does not in itself assure reliable results. Reliable results depend on several factors; Practice D3740 provides a means of evaluating some of these factors.

5. Apparatus

5.1 For Method A the following apparatus are required:

5.1.1 *Balance*—All balances must meet the requirements of Specification D4753 and this section. A Class GP1 balance of 0.01 g readability is required for specimens having a mass up to 200 grams and a Class GP2 balance of 0.1 g readability is required for specimens having a mass over 200 grams. For method A, the balance must be capable of measuring the mass of the specimen suspended in water. This is usually accomplished by a weighing hook built into the balance for that purpose, or a yoke assemblage is placed upon the pan which suspends a thin, non-absorbent string or wire, that is, a nylon line, etc., below the balance into the water reservoir.

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

5.1.3 *Wax*—Non-shrinking, paraffin and/or microcrystalline wax that has a known and constant density, ρ_ρ, to four significant figures and that does not change after repeated melting and cooling cycles.

NOTE 2—The waxes generally used are commercially available and have density values in the range of 0.87 to 0.91 g/cm^3 or Mg/m^3.

5.1.4 *Wax-Melting Container*—Used to melt the wax, but should not allow the wax to overheat. A container heated by hot water, preferably thermostatically controlled, is satisfactory. The wax should be heated to only slightly above the melting point to avoid flashing of the wax vapors and to permit quickly forming a uniform surface coating of wax. **Warning—**Vapors given off by molten wax ignite spontaneously above 205°C (400°F) and should not be allowed to come in contact with the heating element or open flame.

5.1.5 *Wire Basket*—A wire basket of 3.35 mm or finer mesh of approximately equal width and height of sufficient size to contain the specimen. The basket shall be constructed to prevent trapping air when it is submerged. The basket is suspended from the balance by a fine thread or string. A hairnet may also be used in lieu of the basket for smaller soil specimens.

5.1.6 *Container*—A container or tank of sufficient size to contain the submerged basket and specimen.

5.1.7 *Specimen Container*—A corrosion-resistant container of sufficient size to contain the specimen for water content determination.

5.1.8 *Thermometer*—Capable of measuring the temperature range within which the test is being performed graduated in a 0.1 degree C division scale and meeting the requirements of Specification E2251.

5.1.9 *Container Handling Apparatus*—Gloves or suitable holder for moving and handling hot containers.

5.1.10 *Miscellaneous*—Paintbrush, trimming tools, specimen containers, and data sheets provided as required.

5.2 For Method B the following apparatus are needed:

5.2.1 *Balance*—See 5.1.1.

5.2.2 *Drying Oven*—See 5.1.2.

5.2.3 *Specimen-Size Measurement Devices*—Devices used to determine the height and width or diameter of the specimen shall measure the respective dimensions to four significant digits and shall be constructed so that their use will not indent or penetrate into the specimen.

NOTE 3—Circumferential measuring tapes are recommended over calipers for measuring the diameter of cylindrical specimens.

[3] Available online: www.soils.org/sssagloss/index.php.

5.2.4 *Apparatus for Preparing Reconstituted or Remolded Specimens (Optional)*—Such apparatus is only required if these types of specimens are being tested.

5.2.5 *Miscellaneous Apparatus*—Specimen trimming and carving tools including a wire saw, steel straightedge, miter box and vertical trimming lathe, specimen containers, and data sheets shall be provided as required.

6. Samples and Test Specimens

6.1 *Samples*—Intact samples shall be preserved and transported in accordance with Practice D4220 Groups C and D soil. Compacted or remolded specimens shall be preserved in accordance with Practice D4220 Group B soil. Maintain the samples that are stored prior to testing in non-corrodible airtight containers at a temperature between approximately 3° and 30°C and in an area that prevents direct contact with sunlight.

6.2 *Specimens*—Specimens for testing shall be sufficiently cohesive and firm to maintain shape during the measuring procedure if Method A is used, see 1.1.1.1. Specimens shall have a minimum dimension of 30 mm (1.3 in.) and the largest particle contained within the test specimen shall be smaller than one-tenth of the specimen's smallest dimension. For specimens having a dimension of 72 mm (2.8 in.) or larger, the largest particle size shall be smaller than one-sixth of the specimen's smallest dimension. If, after completion of a test on an intact specimen, visual observations indicate that larger particles than permitted are present, indicate this information in the remarks section of the report of test data.

7. Procedure

7.1 Record all identifying information for the specimen, such as project, boring number, depth, sample type (that is, tube, trimmed, etc.), visual soil classification (Practice D2488), or other pertinent data.

7.2 *Method A—Water Displacement:*

7.2.1 Determine, if not previously established, the density of the wax to be used to four significant digits (see 5.1.3).

7.2.2 Prepare specimens in an environment that minimizes any changes in water content. For some soils, changes in water content are minimized by trimming specimens in a controlled environment, such as a controlled high-humidity room/enclosure.

7.2.3 If required, cut a specimen meeting the size requirements given in 6.2 from the sample to be tested. If required, trim the specimen to a fairly regular shape. Re-entrant angles should be avoided, and any cavities formed by large particles being pulled out should be patched carefully with material from the trimmings. Handle specimens carefully to minimize disturbance, change in shape, or change in water content. Typically, for most samples, changes in water content are minimized by trimming specimens, in a controlled environment, such as a controlled high-humidity room/enclosure.

7.2.4 Determine and record the moist mass of the soil specimen (M_t) to four significant figures in g or kg.

7.2.5 Cover the specimen with a thin coat of melted wax, either with a paintbrush or by dipping the specimen in a container of melted wax. Apply a second coat of wax after the first coat has hardened. The wax should be sufficiently warm to flow when brushed on the specimen, yet it should not be so hot that it dries the soil.

NOTE 4—If overheated wax comes in contact with the soil specimen, it may cause the moisture to vaporize and form air bubbles under the wax. Bubbles may be trimmed out and filled with wax.

7.2.6 Determine and record the mass of the wax-coated specimen in air (M_C) to four significant figures in g or kg.

7.2.7 Determine and record the submerged mass of the wax-coated specimen (M_{sub}) to four significant digits in g or kg. This is done by placing the specimen in a wire basket hooked onto a balance and immersing the basket and specimen in a container of water. In order to directly measure the submerged mass of the wet soil and wax, the balance must have been previously balanced (tared to zero) with the wire basket completely submerged in the container of water. Make sure that the specimen and basket is fully submerged, and that the basket is not touching the sides or bottom of the container.

7.2.8 Record the temperature of the water to 0.1 degrees C.

NOTE 5—Maintain water bath temperature and submerged basket depth the same as when calibrated or zeroed.

7.2.9 Remove the wax from the specimen. It can be peeled off after a break is made in the wax surface.

7.2.10 Determine the water content to the nearest 0.1 percent in accordance with Method D2216.

NOTE 6—The water content may be determined from an adjacent piece of soil or from trimmings if appropriate, for example, if the wax becomes difficult to remove from the specimen. Note in the report if water content is not from the specimen itself.

7.3 *Method B—Direct Measurement:*

7.3.1 *Intact Specimens*—Prepare intact specimens from large block samples or from samples secured in accordance with Practice D1587 or other acceptable tube sampling procedures, such as Practice D3550. Specimens can be obtained from intact block samples using a sharp cutting ring. Handle samples/specimens carefully to minimize disturbance, changes in cross section, or change in water content, see 6.1. Specimens are usually cubical or cylindrical in shape.

NOTE 7—Core sampling might be difficult or impossible in gravelly or hard dry soils. Wet soils tend to be more plastic and subject to compression.

7.3.1.1 Specimens obtained by tube sampling may be tested without extrusion except for cutting the end surfaces plane and perpendicular to the longitudinal axis of the sampling tube. The height and inner dimensions of the tube may be taken to represent specimen dimensions.

NOTE 8—Some soils may expand into the sampling tube with a resultant change in volume from the original in-situ condition.

7.3.1.2 Trim specimens in an environment that minimizes any change in water content, see 7.2.2. Where removal of gravel or crumbling resulting from trimming causes voids on the surface of the specimen, carefully fill the voids with remolded soil obtained from the trimmings. When the sample condition permits, a vertical trimming lathe may be used to reduce cylindrical specimens to a uniform diameter.

7.3.1.3 After obtaining uniform dimensions, place the specimen in a miter box or trimming collar (especially for friable soils) and cut the specimen to a uniform height with a wire saw or other suitable device, such as a sharpened steel straightedge. Perform one or more water content determinations on material obtained during the trimming of the specimen in accordance with Test Method D2216 for the estimated water content(s). Final water content shall be performed on the whole specimen or representative slice (if other testing such as plasticity limits, Test Methods D4318, are required) at the end of the test. Determine and record the mass (g) and dimensions (mm) of the specimen to four significant digits using the applicable apparatus described in 5.2. A minimum of three height measurements (approximately 120° apart if three, 90° apart if four, etc.) and at least three diameter measurements at the quarter points of the height shall be made to determine each the average height and diameter of cylindrical specimens. A minimum of three measurements each of length, width and height shall be made to determine the volume of cubical specimens.

NOTE 9—Test Method D2166, section 6.2, describes a procedure for preparing intact test specimens for strength testing.

7.3.2 *Remolded/Reconstituted (Compacted) Specimens*—Specimens shall be prepared as prescribed by the individual assigning the test or as prescribed by the applicable related test procedure. After a specimen is formed, trim (if necessary) the ends perpendicular to the longitudinal axis, remove the mold, and determine the mass and dimensions of the test specimens in accordance with 7.3.1.3. The height and inner dimensions of the mold may be taken to represent specimen dimensions.

NOTE 10—It is common for the density (unit weight) of the specimen after removal from the mold to be less than the value based on the volume of the mold. This occurs as a result of the specimen swelling after removal of the lateral confinement due to the mold.

8. Calculations

8.1 *Water Content, w*—Calculate in accordance with Test Method D2216 to four significant digits.

8.2 Calculate the moist density to four significant figures as follows:

8.2.1 *Method A—Water Displacement:*

$$\rho_m = M_t / [((M_c - M_{sub})/\rho_w) - ((M_c - M_t)/\rho_\rho)] \quad (1)$$

where:

M_t = mass of moist/total soil specimen, g,
M_c = mass of wax-coated specimen, g,
M_{sub} = mass of submerged paraffin-coated specimen, g,
ρ_ρ = density of paraffin, g/cm^3 or Mg/m^3,
ρ_w = density of water at test temperature, g/cm^3 or Mg/m^3, (see Test Methods D854, Table 1), and
ρ_m = density of total (moist) soil specimen, g/cm^3 or Mg/m^3.

8.2.2 *Method B—Direct Measurement:*

$$\rho_m = (M_t / V) \quad (2)$$

where:

V = volume of moist soil specimen, cm^3.

8.2.2.1 *Cylindrical Shape:*

$$V = (\pi\, d^2\, h)/4000 \quad (3)$$

where:

d = average specimen diameter, mm, and
h = average specimen height, mm.

8.2.2.2 *Cubical Shape:*

$$V = (l\, w\, h)/4000 \quad (4)$$

where:

l = average length, mm,
w = average width, mm, and
h = average height, mm.

8.3 Calculate the dry density for either method A or B as follows:

$$\rho_d = \rho_m / (1 + w/100) \quad (5)$$

where:

ρ_d = dry density of soil, g/cm^3 or Mg/m^3, and
w = water content of soil specimen (in percent), to nearest four significant digits.

8.4 Calculate the moist/total and dry unit weights to four significant figures for either method A or B as follows:

$$\gamma_m = 62.428\, \rho_m \text{ in lbf/ft}^3 \quad \text{and} \quad \gamma_d = 62.428\, \rho_d \text{ in lbf/ft}^3 \quad (6)$$

$$\gamma_m = 9.80665\, \rho_m \text{ in kN/m}^3 \quad \text{and} \quad \gamma_d = 9.80665\, \rho_d \text{ in kN/m}^3$$

where:

γ_m = moist/total unit weight of specimen, and
γ_d = dry unit weight of soil specimen.

9. Report: Test Data Sheet/Form

9.1 The report (data sheet) shall contain the following (see Appendix X2 and Appendix X3):

9.1.1 Identification of the sample (material) being tested, such as project, boring number, sample number, test number, container number, etc.,

9.1.2 Sample depth in meters (feet) below ground surface or elevation in meters (feet) (if applicable),

9.1.3 Classification of soil by Practice D2487, if determined, or visual classification of soil (group name and symbol) as determined by Practice D2488,

9.1.4 Moist/total and dry density (unit weight), to four significant digits,

9.1.5 Water content (in percent), to four significant digits,

9.1.6 Method used (A or B), and

9.1.7 Whether the specimen was intact, disturbed, remolded, or reconstituted (compacted).

10. Precision and Bias

10.1 *Precision*—The precision of the procedure in this test method for measuring the density (unit weight) of cohesive soil specimens is being determined. In addition, Subcommittee D18.03 is seeking pertinent data from users of the test method.

10.2 *Bias*—Since there is not an accepted reference material suitable for measuring the bias for this procedure, a statement on bias cannot be made.

11. Keywords

11.1 density; porosity; saturation; specimen; unit weight; void ratio

APPENDIXES

(Nonmandatory Information)

X1. RELATIONSHIPS AMONG SOIL PHASES; POROSITY, VOID RATIO, & SATURATION USING METRIC UNITS

X1.1 Let:

n = porosity, %,
e = void ratio,
S = saturation, %,
V = volume of soil specimen, cm^3,
V_v = volume of voids in soil specimen, cm^3,
V_s = volume of solids in soil specimen, cm^3,
w = water content of soil specimen, %,
G_s = specific gravity of soil solids in soil specimen as determined by Test Methods D854,
ρ_d = dry density of soil specimen, Mg/m^3, and
M_d = dry mass of soil in soil specimen, g.

X1.2 Then:

$$n = \frac{V_v}{V} \times 100 = \frac{V - V_s}{V} \times 100 = \frac{V - \frac{M_d}{G_s}}{V} \times 100 = \frac{e}{1+e} \times 100 \quad (X1.1)$$

$$e = \frac{V_v}{V_s} = \frac{V - V_s}{V_s} = \frac{V - \frac{M_d}{G_s}}{\frac{M_d}{G_s}} = \frac{n}{100 - n} = \frac{G_s w}{S} \quad (X1.2)$$

$$S = \frac{w G_s \rho_d}{G_s - \rho_d} = \frac{G_s w}{e} \quad (X1.3)$$

X2. EXAMPLE DATA SHEET
DISPLACEMENT METHOD—A

UNIT WEIGHTS, VOID RATIO, POROSITY, AND DEGREE OF SATURATION
(DISPLACEMENT METHOD—A)

NAME ______________________ DATE ____________ JOB NO. ______________

LOCATION ____

BORING NO. ______________ SAMPLE NO. ______________ DEPTH/ELEV. ______________

DESCRIPTION OF SAMPLE ____

WATER CONTENT						
SAMPLE OR SPECIMEN NO.						
TARE NO.						
MASS IN GRAMS	TARE PLUS WET SOIL					
	TARE PLUS DRY SOIL					
	WATER	M_w				
	TARE					
	DRY SOIL	M_d				
WATER CONTENT		w	%	%	%	%
WEIGHT-VOLUME RELATIONS						
SAMPLE OR SPECIMEN NO.						
TEST TEMPERATURE OF WATER, T, °C						
MASS IN GRAMS	SOIL AND WAX IN AIR					
	WET SOIL	M_t				
	WAX					
	WET SOIL AND WAX IN WATER					
	DRY SOIL[A]	M_d				
SPECIFIC GRAVITY OF SOIL		G_s				
VOLUME IN CC	WET SOIL AND WAX[B]					
	WAX					
	WET SOIL	V				
	DRY SOIL M_d/G_s	V_s				
LBS PER CU FT	WET UNIT WEIGHT $(M_t/V)\times 62.4$	γ_m				
	DRY UNIT WEIGHT $(M_d/V)\times 62.4$	γ_d				
VOID RATIO $(V-V_s)/V_s$		e				
POROSITY,% $[(V-V_s)/V]\times 100$		n	%	%	%	%
DEGREE OF SATURATION $[V_w/(V-V_s)]\times 100$		S	%	%	%	%

VOLUME OF WAX = WEIGHT OF WAX / SPECIFIC GRAVITY OF WAX = ______________
VOLUME OF WATER = $V_w = M_w$ / SPECIFIC GRAVITY OF WATER[C]

[A] IF NOT MEASURED DIRECTLY, MAY BE COMPUTED AS FOLLOWS: $M_d = M_t/(1+0.01w)$

[B] VOLUME OF WET SOIL AND WAX $\frac{(\text{WT OF WET SOIL \& WAX IN AIR}) - (\text{WT OF WET SOIL \& WAX IN WATER})}{\text{DENSITY OF WATER AT TEST TEMPERATURE}}$

[C] SPECIFIC GRAVITY OF WATER IN METRIC SYSTEM = 1 (APPROX)

REMARKS ______________________ COMPUTED BY ______________ CHECKED BY ______________

X3. EXAMPLE DATA SHEET
VOLUMETRIC METHOD—B

UNIT WEIGHTS, VOID RATIO, POROSITY, AND DEGREE OF SATURATION
(VOLUMETRIC METHOD—B)

NAME ______________ DATE ______________ JOB NO. ______________

LOCATION ______________

BORING NO. ______________ SAMPLE NO. ______________ DEPTH/ELEV. ______________

DESCRIPTION OF SAMPLE ______________

WATER CONTENT							
SAMPLE OR SPECIMEN NO.							
TARE NO.							
MASS IN GRAMS	TARE PLUS WET SOIL						
	TARE PLUS DRY SOIL						
	WATER	M_w					
	TARE						
	DRY SOIL	M_d					
WATER CONTENT		w	%	%	%	%	

WEIGHT-VOLUME RELATIONS						
SAMPLE OR SPECIMEN NO.						
CYLINDER NO.						
CENTIMETERS	HEIGHT OF CYLINDER	H				
	INSIDE DIAMETER OF CYLINDER	D				
MASS IN GRAMS	WET SOIL AND TARE					
	TARE					
	WET SOIL	M_t				
	DRY SOIL[A]	M_d				
SPECIFIC GRAVITY OF SOIL		G_s				
VOLUME IN CC	WET SOIL (VOLUME OF CYLINDER)					
	DRY SOIL M_d/G_s	V_s				
LBS PER CU FT	WET UNIT WEIGHT $(M_t/V)\times 62.4$	γ_m				
	DRY UNIT WEIGHT $(M_d/V)\times 62.4$	γ_d				
VOID RATIO $(V-V_s)/V_s$		e				
POROSITY,% $[(V-V_s)/V]\times 100$		n	%	%	%	%
DEGREE OF SATURATION $[V_w/(V-V_s)]\times 100$		S	%	%	%	%

VOLUME OF CYLINDER, $V = (\pi D^2 H) / 4$
VOLUME OF WATER = $V_w = M_w$ / SPECIFIC GRAVITY OF WATER[B]

[A] IF NOT MEASURED ON ENTIRE SPECIMEN, MAY BE COMPUTED AS FOLLOWS: $M_d = M_t/(1+0.01w)$

[B] SPECIFIC GRAVITY OF WATER IN METRIC SYSTEM = 1 (APPROX)

REMARKS ______________ COMPUTED BY ______________ CHECKED BY ______________