Designation: D4718/D4718M – 15

Standard Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles[1]

This standard is issued under the fixed designation D4718/D4718M; 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 U.S. Department of Defense.

1. Scope*

1.1 This practice presents a procedure for calculating the unit weights and water contents of soils containing oversize particles when the data are known for the soil fraction with the oversize particles removed.

1.2 This practice also can be used to calculate the unit weights and water contents of soil fractions when the data are known for the total soil sample containing oversize particles.

1.3 This practice is based on tests performed on soils and soil-rock mixtures in which the portion considered oversize is that fraction of the material retained on the 4.75-mm [No. 4] sieve. Based on these tests, this practice is applicable to soils and soil-rock mixtures in which up to 40 % of the material is retained on the 4.75-mm [No. 4] sieve. The practice also is considered valid when the oversize fraction is that portion retained on some other sieve, but the limiting percentage of oversize particles for which the correction is valid may be lower. However, the practice is considered valid for materials having up to 30 % oversize particles when the oversize fraction is that portion retained on the 19-mm [¾-in.] sieve.

1.4 The factor controlling the maximum permissible percentage of oversize particles is whether interference between the oversize particles affects the unit weight of the finer fraction. For some gradations, this interference may begin to occur at lower percentages of oversize particles, so the limiting percentage must be lower for these materials to avoid inaccuracies in the computed correction. The person or agency using this practice shall determine whether a lower percentage is to be used.

1.5 This practice may be applied to soils with any percentage of oversize particles subject to the limitations given in 1.3 and 1.4. However, the correction may not be of practical significance for soils with only small percentages of oversize particles. The person or agency specifying this practice shall specify a minimum percentage of oversize particles below which the practice need not be applied. If a minimum percentage is not specified, 5 % shall be used.

1.6 This practice may not be applicable to soil-rock mixtures which degrade under field compaction.

1.7 *Units*—The values stated in either SI Units or inch-pound units are to be regarded separately as standard. The values 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 nonconformance with the standard.

1.7.1 It is common practice in the engineering profession to concurrently use pounds to represent both a unit of mass (lbm) and a force (lbf). This implicitly combines two separate systems of units; that is, the absolute system and the gravitational system. It is scientifically undesirable to combine the use of two separate sets of inch-pound units within a single standard. This standard has been written using the gravitational system of units when dealing with the inch-pound system. In this system, the pound (lbf) represents a unit of force (weight). However, the use of balances or scales recording pounds of mass (lbm) or the recording of density in lbm/ft^3 shall not be regarded as a non conformance with this standard.

NOTE 1—Sieve size is identified by its standard designation in Specification E11. The alternative designation given in brackets is for information only and does not represent a different standard sieve size.

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 and 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 data, special purpose studies, or any considerations for the user's objectives; and it is common practice to increase or reduce significant digits of reported data to commensurate with these considerations. It is beyond the scope of these test

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rockand is the direct responsibility of Subcommittee D18.03 on Texture, Plasticity and Density Characteristics of Soils.

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

methods to consider significant digits used in analysis methods for engineering design.

1.9 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

NOTE 2—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 ensure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some of those factors.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C127 Test Method for Relative Density (Specific Gravity) and Absorption of Coarse Aggregate

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

D6026 Practice for Using Significant Digits in Geotechnical Data

D6938 Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

D7382 Test Methods for Determination of Maximum Dry Unit Weight and Water Content Range for Effective Compaction of Granular Soils Using a Vibrating Hammer

D7698 Test Method for In-Place Estimation of Density and Water Content of Soil and Aggregate by Correlation with Complex Impedance Method

D7830 Test Method for In-Place Density (Unit Weight) and Water Content of Soil Using an Electromagnetic Soil Density Gauge

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

3. Terminology

3.1 For definitions of common technical terms used in this standard, refer to Terminology D653.

3.2 *Definitions:*

3.2.1 *oversize particles, n*—particles that are larger than those allowed and normally removed for the normal performance of a standard test method.

4. Significance and Use

4.1 Compaction tests on soils performed in accordance with Test Methods D698, D1557, D4253, and D7382 place limitations on the maximum size of particles that may be used in the test. If a soil contains cobbles or gravel, or both, test options may be selected which result in particles retained on a specific sieve being discarded (for example the 4.75-mm [No. 4], the 19-mm [¾-in.] or other appropriate size) and the test performed on the finer fraction. The unit weight-water content relations determined by the tests reflect the characteristics of the actual material tested, and not the characteristics of the total soil material from which the test specimen was obtained.

4.2 It is common engineering practice to use laboratory compaction tests for the design, specification, and construction control of soils used in earth construction. If a soil used in construction contains large particles, and only the finer fraction is used for laboratory tests, some method of correcting the laboratory test results to reflect the characteristics of the total soil is needed. This practice provides a mathematical equation for correcting the unit weight and water content of the finer fraction of a soil, tested to determine the unit weight and water content of the total soil.

4.3 Similarly, as utilized in Test Methods D1556, D2167, D6938, D7698, and D7830, this practice provides a means for correcting the unit weight and water content of field compacted samples of the total soil, so that values can be compared with those for a laboratory compacted finer fraction.

NOTE 3—When this practice is used for construction control, the using agency should specify whether the maximum unit weight value used for reference is the unit weight including oversize fraction or the unit weight of the finer fraction. Calculated values of percent compaction based on this correction practice will vary depending on which unit weight value is used for reference.

5. Procedure

5.1 *Correction of Unit Weight and Water Content for Total Sample:*

5.1.1 Prepare the sample from which compaction test specimens are to be taken in accordance with provisions of the specific test methods. Determine the mass of the moist finer fraction of the sample and the mass of the moist oversize (plus 4.75-mm [No. 4] or plus 19-mm [¾-in.], or other appropriate size) fraction of the total sample. Determine the water content

[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.

of each of the two fractions based upon dry mass, in accordance with Test Methods D2216. With some test methods, the correction for water content may not apply. Calculate the mass of the dry finer fraction and the dry oversize fraction as follows:

$$M_D = M_M/(1+(w/100)) \quad (1)$$

where:

M_D = mass of the dry material (finer or oversize fraction), g,
M_M = mass of the moist material (finer or oversize fraction), g, and
w = water content of the respective finer or oversize fractions expressed in percent.

5.1.2 Calculate the percentage of the finer fraction and of the oversize fraction of the sample by dry mass as follows:

$$P_F = 100\,M_{DF}/(M_{DF}+M_{DC}) \quad (2)$$

and

$$P_C = 100\,M_{DC}/(M_{DF}+M_{DC}) \quad (3)$$

where:

P_F = percent of finer fraction by mass,
P_C = percent of oversize fraction by mass,
M_{DF} = mass of dry finer fraction, and
M_{DC} = mass of dry oversize fraction.

5.1.3 Determine the relative density (specific gravity) (oven dried) (G_M) of the oversize fraction in accordance with Test Method C127.

5.1.4 Calculate the corrected water content and corrected dry unit weight of the total material (combined finer and oversize fractions), as follows:

$$w_T = (w_F P_F + w_C P_C) \quad (4)$$

where:

w_T = corrected water content of combined finer and oversize fractions expressed in percent,
w_F = water content of finer fraction expressed as a decimal,
w_C = water content of oversize fraction expressed as a decimal,

and

$$\gamma_{DT} = 100\,\gamma_{DF} G_M \gamma_\omega/(\gamma_{DF} P_C + G_M \gamma_\omega P_F) \quad (5)$$

where:

γ_{DT} = corrected dry unit weight of the total material (combined finer and oversize fractions),
G_M = relative density (specific gravity) (oven dried) as determined by Test Method C127,
γ_{DF} = dry unit weight of the finer fraction, and
γ_ω = unit weight of water (62.42 lbf/ft^3 or 9.802 kN/m^3) (see Note 4).

NOTE 4—The unit weight of water may vary slightly depending on the geographical location and water temperature.

5.2 *Correction of Unit Weight and Water Content for Finer Fraction of a Soil Sample:*

5.2.1 When it is desired to compare the unit weight and water content of a field-compacted soil containing oversize particles with the results of laboratory compaction tests on the finer fraction, the following procedure may be used:

5.2.1.1 A sample of the total material is obtained in the field at the desired test location in conjunction with a unit dry weight (γ_{DT}) and water content (w) determination by acceptable field methods of density and unit weight determination. Since this practice is usually used for materials containing coarse gravel and cobble size particles, special care should be taken to ensure that the volume of material sampled is adequate to accurately represent the material in the field at the test location.

5.2.1.2 Remove the oversize particles of plus 4.75-mm [No. 4], 19-mm [¾-in.], or any other appropriate size from the field sample and determine the percentage of oversize particles in the total sample. If, in the laboratory testing of the materials, the relative density (specific gravity) (oven dried) by Test Method C127, and the water content by Test Methods D2216 of the oversize particles have been determined, these values may be used in the calculations. Otherwise, it will be necessary to determine the relative density (specific gravity) (oven dried) by Test Method C127.

5.2.1.3 Calculate the water content of the finer fraction of the field sample as follows:

$$w_F = (100\,w_T - w_C P_C)/P_F \quad (6)$$

where:

w_F = water content of finer fraction expressed in percent,
w_T = corrected water content of combined finer and oversize fractions expressed in percent, and
w_C = water content of oversize fraction expressed in percent.

5.2.1.4 Calculate the dry unit weight of the finer fraction of the field sample as follows:

$$\gamma_{DF} = \gamma_{DT} G_M \gamma_\omega P_F/(100\,G_M\,\gamma_w - \gamma_{DT}\,P_C) \quad (7)$$

6. Report: Test Data Sheet(s)/Form(s)

6.1 The methodology used to specify how data are recorded on the test data sheet(s)/form(s), as given below, is covered in 1.8.

6.2 Record as a minimum the following general information (data):

6.2.1 Project information, such as project number, project name, project location.

6.2.2 The identification or source of the sample, such as boring number, depth, supplier.

6.2.3 For laboratory compacted samples, the method used to compact the sample.

6.2.4 The method used to obtain the field sample (if appropriate).

6.2.5 The sieve size used to separate the oversize particles.

6.2.6 The person performing the work.

6.3 Record as a minimum the following test specimen data:

6.3.1 The percentage by dry mass of oversize particles.

6.3.2 The measured value of relative density (specific gravity) (oven dried), obtained by Test Method C127 or assumed value.

6.3.3 For laboratory compacted samples, the dry unit weight and water content of the finer fraction, and the corrected value for the total sample.

6.3.4 For samples collected in the field, the dry unit weight and water content of the total sample, and the corrected values for the finer fraction.

7. Keywords

7.1 compaction; oversize particles; relative density (specific gravity) (oven dried); unit weight; water content

APPENDIX

(Nonmandatory Information)

X1. RATIONALE

X1.1 The calculations to correct the unit weight and water content of soil samples containing oversize particles are based on the premise that the percentage of such particles is small enough that they do not interfere with the compaction of the finer fraction during the compaction process. Thus, the finer fraction of the soil will achieve the same unit weight and water content with the oversize particles absent as with them present. The equation used for the calculation of unit weight is based on the work of Ziegler.[3]

X1.2 Tests conducted by the Bureau of Reclamation [4,5] and the Waterways Experiment Station[6] indicate that the limiting oversize particle (plus 4.75-mm [No. 4] sieve) content may be as high as 40 %. It is necessary in evaluating such studies to ensure that the gradation of the finer fraction does not change as the oversize particle content changes. The upper limit of oversize particles in this practice has been set at 40 % of the plus 4.75-mm [No. 4] material and 30 % of the plus 19-mm [¾-in.] material.

X1.3 It is assumed that in a moist, compacted sample of soil containing oversize particles, those oversize particles absorb moisture from the surrounding medium. The maximum water content that the oversize particles can achieve approaches as a limit the percent absorption of the oversize fraction, as measured by Test Method C127. The water content of the oversize fraction also may be measured directly by Test Methods D2216.

[3] Ziegler, E. J., "Effect of Materials Retained on the No. 4 Sieve on the Compaction Test of Soil," *Proceedings* , Highway Research Board, Vol. 28, 1948, pp 409–414.

[4] Merriam, J., "Research on Compaction Control Testing for Gravelly Soils," *Earth Research Program Report EM662*, U.S. Bureau of Reclamation, Denver, CO, August 1963.

[5] Holtz, W. G., and Lowitz, C. A., "Compaction Characteristics of Gravelly Soils," *U.S. Bureau of Reclamation Earth Laboratory Report No. 509*, Denver, CO, September 1957.

[6] Donaghe, R. T., and Townsend, F. C., "Compaction Characteristics of Earth-Rock Mixtures," Report 2 "Blended Material," Misc. Paper S-73-25, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MI, August 1975.

SUMMARY OF CHANGES

In accordance with Committee D18 policy, this section identifies the location of changes to this standard since the last edition (1987(Reapproved 2007)) that may impact the use of this standard. (December 15, 2015)

(1) Added 1.7 in reference to units.
(2) Added 1.8 in reference to significant digits.
(3) Added in Note 2, a caveat for quality of the test results with laboratories meeting D3740 requirements.
(4) Removed from the Reference Document section standards related to density determination.
(5) Added references to laboratory and field test methods that utilize D4718 to D6026 in Reference Document section.
(6) Added a Terminology section.
(7) Replaced all references to "bulk specific gravity" with "relative density (specific gravity) (oven dried)."
(8) Added Note 3 referencing variability of the density of water.
(9) Updated the Report Section to conform to D18.91.