Designation: D4718 – 87 (Reapproved 2007)

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; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This 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 The 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 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 No. 4 sieve. The practice also is considered valid when the oversize fraction is that portion retained on some other sieve, such as the ¾-in. 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 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 *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. Nat 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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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

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

D2922 Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)[3]

D3017 Test Method for Water Content of Soil and Rock in

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is 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.

[3] Withdrawn. The last approved version of this historical standard is referenced on www.astm.org.

Place by Nuclear Methods (Shallow Depth)

D4253 Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

3. Significance and Use

3.1 Compaction tests on soils performed in accordance with Test Methods D698, D1557, and D4253 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 No. 4 (4.75-mm) or the ¾-in. (19-mm) 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.

3.2 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 tested finer fraction of a soil, to determine the unit weight and water content of the total soil.

3.3 Similarly, 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 1—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.

4. Procedure

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

4.1.1 Prepare the sample from which compaction test specimens are to be taken in accordance with provisions of Test Methods D698, D1557, or D4253. Determine the mass of the moist fine fraction of the sample and the mass of the moist oversize (plus No. 4 or plus ¾-in., or other appropriate size) fraction of the total sample. If Test Methods D4253 is used, the correction for water content does not apply. Determine the water content of each of the two fractions in accordance with Method D2216. Calculate the mass of the dry finer fraction and the dry oversize fraction as follows:

$$M_D = M_M/(1 + w) \tag{1}$$

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 as a decimal.

4.1.2 Calculate the percentage of the finer fraction and of the oversize fraction of the sample by dry weight as follows:

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

and

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

where:

P_F = percent of finer fraction by weight,

P_C = percent of oversize fraction by weight,

M_{DF} = mass of dry finer fraction, and

M_{DC} = mass of dry oversize fraction.

4.1.3 Determine the bulk specific gravity (G_M) of the oversize fraction as set forth in Test Method C127.

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

$$C_w = (w_F P_F + w_C P_C) \tag{4}$$

where:

C_w = corrected water content of combined and oversize fractions,

w_F = water content of finer fraction expressed as a decimal,

w_C = water content of oversize fraction expressed as a decimal,

and

$$C\delta_D = 100\, \delta_F G_M \delta_w/(\delta_F P_C + G_M \delta_w P_F) \tag{5}$$

where:

$C\delta_D$ = corrected unit dry weight of the total material (combined finer and oversize fractions),

G_M = bulk specific gravity,

δ_F = dry unit weight of the finer fraction, and

δ_w = unit weight of water (62.42 lbf/ft^3 or 9.802 kN/m^3).

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

4.2.1 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:

4.2.1.1 A sample of the total material is obtained in the field at the desired test location in conjunction with a unit dry weight (δ_D) and water content (w) determination by methods such as Test Methods D1556, D2167, or D2922 and D3017 combined. Since this practice is usually used for materials containing coarse gravel and cobble size particles, special care should be taken to assure that the volume of material sampled is adequate to accurately represent the material in the field at the test location.

4.2.1.2 Remove the oversize particles (plus No. 4 or ¾-in., or 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 bulk specific gravity

and the water content of the oversize particles have been determined, these values may be used in the calculations. Otherwise, it will be necessary to determine the bulk specific gravity by Test Method C127.

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

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

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

$$\delta_F = \delta_D G_M \delta_w P_F/(100\, G_M \delta_w - \delta_D P_C) \quad (7)$$

5. Report

5.1 The report shall contain the following:

5.1.1 The identification of the sample.

5.1.2 The method used in compacting the sample.

5.1.3 The method used to obtain the field sample (as appropriate).

5.1.4 The sieve size used to separate the oversize particles.

5.1.5 The percentage by weight of oversize particles.

5.1.6 The value of bulk specific gravity, G_M, used in the calculations.

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

5.1.8 For samples obtained in the field, the dry unit weight and water content of the total sample, and the corrected value for the finer fraction.

6. Keywords

6.1 oversize particles; 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.[4]

X1.2 Tests conducted by the Bureau of Reclamation[5, 6] and the Waterways Experiment Station[7] indicate that the limiting oversize particle (plus 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 No. 4 material and 30 % of the plus 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 Method D2216.

[4] 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.

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

[6] 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.

[7] 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.