

**METHOD OF SAMPLING AND TESTING**  
**MT 231-04**  
**PROCEDURE FOR CORRECTION FOR COARSE PARTICLES**  
**IN THE SOIL COMPACTION TEST**  
*(Modified AASHTO T 224)*

**1 Scope:**

- 1.1** This method describes a procedure for adjusting the densities of soil and soil aggregate mixtures to compensate for differing percentages of coarse particles retained on either the 4.75-mm (No. 4) or 19.0-mm (3/4 in.) sieve. This is necessary to adjust either the field wet density to a dry density of the material passing these sieves or the reverse, by adjusting the lab density to the field density when doing compaction control testing. Comparisons are made by comparing the field densities with the maximum dry density as determined by MT-210 (AASHTO T 99) or MT- 230 (AASHTO T 180).
- 1.2** Two methods are available for correction, either, lab to field or field to lab density. The method specified in Section 4.1 adjusts the compacted lab density to the field density. The method specified in Section 4.2 adjusts the field wet density to dry density of the fine fraction and compares its results with the compacted lab density.
- 1.3** This test method applies to soil mixtures that have 40 percent or less retained on the 4.75-mm (No. 4) sieve, when Method A or B of MT 210 (AASHTO T 99) or MT 230 (AASHTO T 180) is used, or mixtures that have 30 percent or less retained on the 19.0-mm (3/4 in.) sieve, when Method C or D of MT 210 (AASHTO T 99) or MT 230 (AASHTO T 180) is used. The material retained on these sieves shall be defined as oversize particles (coarse particles).
- 1.4** This method applies to soils with any percentage of oversize particles as specified in Section 1.3. However, the correction may not be of practical significance for soils with only a small percentage of oversize particles. The person or agency specifying this method shall specify a minimum percentage of oversize particles below which the method need not be applied. If a minimum percentage is not specified, this method shall be applied to samples with more than 5 percent by weight of oversize particles.
- 1.5** The following applies to all specified limits in this standard: For the purpose of determining conformance with these specifications, an observed value or a calculated value shall be rounded off to the nearest 10kg/m<sup>3</sup> (1 pcf), according to R 11, Recommended Practice for Indicating Which Places of Figures Are to Be considered Significant in Specified Limiting Values.
- 1.6** The values in SI units are to be considered as the standard.

**2 Reference Documents:****2.1 AASHTO Standards:**

- R 11 Recommended Practice for Indicating Which Places of Figures Are to Be Considered Significant in Specified Limiting Values
- T 85 Specific Gravity and Absorption of Coarse Aggregate
- T 99 The Moisture-Density Relations of Soils Using a 2.5-kg (5.5 -lb) Rammer and a 305-mm (12-in.) Drop
- T 180, Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in) Drop
- T 217 Determination of Moisture in Soils by Means of a Calcium Carbide Gas Pressure Moisture Tester
- T 255 Total Moisture Content of Aggregate by Drying
- T 272 Family of Curves-One Point Method

### 3 Outline of Method:

- 3.1 When method A or B of MT-210 or MT-230 is employed, the total field wet density is compared with the dry density of the soil particles passing the 4.75-mm (No. 4) sieve.
- 3.2 When method C or D of MT-210 or MT-230 is employed, the total field wet density is compared with the dry density of the soil particles passing the 19.0-mm (3/4 in) sieve.
- 3.3 Significant figures are as follows:
- 3.3.1 Adjusted wet density of the fine material passing the 4.75-mm (No. 4) sieve, Methods A and B; or 19.0-mm (3/4 in.) sieve, Methods C and D: ( $D_f$ ) 1 kg/m<sup>3</sup> (0.1pcf).
- 3.3.2 Bulk specific gravity of the coarse material retained on the 4.75-mm (No. 4) sieve, Methods A and B; or 19-mm (3/4 in.) sieve, Methods C and D; ( $G_m$ ) 0.01.
- 3.3.3 Percent by mass, of coarse and fine particles, of material retained and passing the 4.75-mm (No. 4) sieve, Methods A and B; or 19.0-mm (3/4 in.) sieve, Methods C and D; ( $P_c$ ) and ( $P_f$ ) 0.1 percent.
- 3.3.4 In-place (field) wet density of the total sample ( $D$ ) 1 kg/m<sup>3</sup> (0.1 pcf).

### 4 Adjustment Equation:

#### 4.1 *Compacted Laboratory Dry Density Corrected to Field Dry Density*

- 4.1.1 This section corrects the laboratory density obtained by either MT-210 or MT-230 for the moisture content and density of the material retained on the 4.74-mm (No. 4) sieve, Methods A and B; or the material retained on the 19.0-mm (3/4 in.) sieve, Methods C and D. The maximum laboratory dry density, adjusted for oversized particles and total moisture content are compared with the field dry density and field moisture content. This method is limited to field samples containing 40 percent or less of material retained on the 4.75-mm (No. 4) sieve, Methods A and B, or 30 percent or less of material retained on the 19.0-mm (3/4 in.) sieve, Methods C and D.
- 4.1.2 Determine the moisture content of the fine particles and oversize particles of the material used during compaction. The moisture contents can be determined by T 265, T 217, or T 255. The moisture content of the oversize material retained on the sieve can be assumed to be two (2) percent for most construction applications. If the moisture content of the oversized material is generally known, substitute the moisture content in the calculations. If drying equipment is available, determine the actual moisture contents. Calculate the moisture contents according to the calculations specified in T 265.
- 4.1.3 Calculate the dry mass of the coarse and fine particles as follows:

$$M_D = M_M / (1 + MC)$$

where:

$M_D$  = mass of dry material (fine or oversize particles).

$M_M$  = mass of moist material (fine or oversize particles).

MC = moisture content of respective fine or oversized particles, expressed as a decimal.

**4.1.4 Adjustment Equation: (continued)**

Calculate the percentage of the fine particles and oversized particles by dry weight of the total sample as follows:

$$P_f = 100 M_{DF}/(M_{DF} + M_{DC})$$

and

$$P_C = 100 M_{DC}/(M_{DF} + M_{DC})$$

where:

$P_f$  = percent of fine particles, of sieve used, by weight.

$P_C$  = percent of oversized particles, of sieve used, by weight.

$M_{DF}$  = mass of dry particles and

$M_{DC}$  = mass of oversize particles.

**4.1.5** Calculate the corrected moisture content and corrected dry density of the total sample (combined fine and oversize particles) as follows:

$$MC_T = (MC_f P_f + MC_C P_C)/100$$

where:

$MC_T$  = corrected moisture content of the combined fine and oversized particles, expressed as a decimal.

$MC_f$  = moisture content of the fine particles, expressed as a decimal.

$MC_C$  = moisture content of oversize particles, expressed as a decimal.

and

$$D_d = 100 D_f k / (D_f P_C + k P_f)$$

where:

$D_d$  = corrected total dry density (combined fine and oversize particles)  $\text{kg/m}^3$  (pcf).

$D_f$  = dry density of the fine particles  $\text{kg/m}^3$  (pcf).

$P_C$  = percent of oversize particles, of sieve used, by weight.

$P_f$  = percent of fine particles, of sieve used, by weight.

$K = 1,000 \cdot \text{Bulk Specific Gravity } (G_m) \text{ (oven dry basis) of coarse particles } (\text{kg/m}^3),$   
 Or  $62.4 \cdot \text{Bulk Specific Gravity } (G_m) \text{ (oven dry basis) of coarse particles } (\text{pcf}).$

*Note 1 – If the specific gravity has been determined, this value may be used in the calculations. Determine the Bulk Specific Gravity according to T 85. For most construction activities the specific gravity can be assumed to be 2.60.*

**4 Adjustment Equation: (continued)****4.2 Field Wet Density Corrected to Compacted Laboratory Density**

**4.2.1** The in-place total (field) wet density is corrected to a dry density of the sample passing the 4.75-mm (No. 4) sieve or the sample passing the 19.0-mm (3/4 in.) sieve. The adjusted dry density is compared with the maximum dry density obtained by methods T 99 or T 180.

**4.2.2** Determine the moisture content of the total sample and for the material retained on the sieve used during compaction. Moisture content can be determined by either T 265, T 217 or T 255. If using the nuclear moisture/density gauge, read the moisture content directly from the gauge for the total moisture content. The moisture content of the oversize material retained on the sieve can be assumed to be two (2) percent for most construction applications. If the moisture content of the oversize material is generally known, substitute the moisture content in the calculations. IF drying equipment is available, determine the actual moisture contents. Calculate the moisture contents according to the calculations specified in T 265.

**4.2.3** Calculate the moisture content of the fine particles of the field sample as follows:

$$MC_f = (100MC_T - MC_C P_C) / P_f$$

where:

$MC_f$  = moisture content of the fine particles, expressed as a decimal.

$MC_T$  = moisture content of total field sample, expressed as a decimal.

$MC_C$  = moisture content of the oversize particles, expressed as a decimal.

$P_C$  = percent of oversize particles, of sieve used, by weight.

$P_f$  = percent of fine particles, of sieve used, by weight.

**4.2.4** Calculate the dry field density of the sample as follows:

$$D_d = D / (1 + MC_T)$$

where:

$D_d$  = dry field density of total sample, kg/m<sup>3</sup> (pcf).

$D$  = total field wet density, kg/m<sup>3</sup> (pcf).

$MC_T$  = moisture content of total field sample, expressed as a decimal.

**4.2.5** Calculate the dry field density of the fine particles of the field sample as follows:

$$D_f = D_d P_f / (100 - ((D_d P_C) / k))$$

where:

$D_f$  = adjusted dry density of the fine particles, kg/m<sup>3</sup> (pcf).

$D_d$  = total field dry density, kg/m<sup>3</sup> (pcf).

**4 Adjustment Equation: (continued)**

$P_f$  = percent of fine particles, of sieve used, by weight.

$P_C$  = percent of oversize particles, of sieve used, by weight.

$k = 1,000 \cdot \text{Bulk Specific Gravity } (G_M) \text{ (oven dry basis) of coarse particles (kg/m}^3\text{),}$   
or  $62.4 \cdot \text{Bulk Specific Gravity } (G_M) \text{ (oven dry basis) of coarse particles (pcf), (Note 1).}$

**5 Precision:**

- 5.1** Since this correction for coarse particles involves no testing but instead utilizes the results of other tests and mathematically combines the results, determination of the precision and accuracy is not applicable.

**APPENDIX:****A1 NOTES:**

- A1.1** These methods, described for coarse particle correction, are applicable to one type of soil and soil-aggregate material only. If the characteristic of the material changes, then a moisture/density relationship (T 99 or T 180) test is performed to determine a new maximum density.
- A1.2** T 272 describes the methods for determining different maximum densities of soil and soil-aggregate materials which reveal certain similarities and trends characteristic of the material type and source.
- A1.3** *UTILIZATION OF A FAMILY OF CURVES* – When using the One Point Method (T 272), Note 3 does not apply. The percentage of oversize particles, when performing the density of soil and soil-aggregate in-place, must be determined to adjust the T 99 or T 180 maximum density to compensate for this percentage.