Colorado Procedure 23-13

Standard Method of Test for

Determining Maximum Dry Density and Optimum Moisture Content of Soil-Rock Mixtures

1.   SCOPE

1.1   This method of test is intended for determining the maximum dry density and optimum moisture content of soil-rock mixtures

2.   REFERENCED DOCUMENTS

2.1   *AASHTO Procedures:*

- T 85   Specific Gravity and Absorption of Coarse Aggregate
- T 99   Moisture-Density Relations of Soils Using a 2.5-kg Rammer and a 305-mm Drop
- T 180   Moisture-Density Relations of Soils Using a 4.54-kg Rammer and a 457-mm Drop
- T 265   Laboratory Determination of Moisture Content of Soils

2.2   *Colorado Procedures:*
- CP 80   In-Place Density and Moisture Content of Soil and Soil-Aggregate by the Nuclear Method

- CP-L 3104   Determining the Durability of Shales for Use as Embankments

3.   APPARATUS

3.1   *Balance* - Capacity of 2,500g or more and accurate to 0.1g.

3.2   *Drying Equipment* - Stove or oven.

3.3   No. 4 and ¾ inch Sieve.

4.   PROCEDURE

Moisture / Density Curve Development

4.1   Obtain a representative sample of the soil-rock mixture. The sample should be of sufficient size to yield 3-5 pounds of minus 3 in. plus No. 4 material.

4.2   Process the sample over a No. 4 sieve, saving both the minus No. 4 and plus No. 4 material.

4.3   Determine the maximum dry density and the optimum moisture content of the minus No. 4 material per AASHTO T 99 or T 180, Method A.

4.4 Determine the bulk specific gravity and absorption of the plus No. 4 material per AASHTO T 85.

In-Place Rock Correction

4.5 Determine the rock corrected maximum dry density and optimum moisture content of the in-place soil-rock mixture at a test site as follows:

4.5.1 Obtain a minimum 5lb sample of material from the density test as described in CP 80.

Method A - Oven Dry

4.6 Dry the entire specimen and determine the dry weight of the entire specimen per AASHTO T 265.

4.6.1 Separate the material by using a No. 4 sieve and weigh the plus No. 4 fraction retained. Calculate the percentage retained as follows:

$$\text{Percent plus No. 4 (rock)} = \frac{\text{Dry wt. of plus No. 4}}{\text{Dry wt. of total specimen}} \times 100\%$$

Method B – Using Gauge MC

4.7 Wet sieve the entire sample over the No. 4 sieve.

4.7.1 Weigh the retained on the No. 4 sieve and material passing the No. 4 sieve.

4.7.2 Calculate the dry weight of the material retained on the No. 4 sieve by dividing its weight by 1 + (absorption/100).

4.7.3 Calculate the dry weight of the material passing the No. 4 sieve by dividing its weight by 1 + (M/D gauge MC reading/100).

4.7.4 Calculate the percentage retained:

$$\text{Percent plus No. 4} = \frac{\text{Dry wt. of plus No. 4}}{\text{Dry wt. of plus No. 4} + \text{Dry wt. of minus No. 4}} \times 100\%$$

Note 1: Method B may be used if the gauge's MC is within +/- 1% of the AASHTO T 265 MC when checked in CP 80.

5. CALCULATIONS

5.1 Determine the corrected optimum moisture content (OMC$_C$) of the soil-rock mixture by the following formula:

$$OMC_C = \frac{(M_f \times P_f) + (M_c \times P_c)}{100}$$

5.2 Determine the maximum dry density of the soil-rock mixture.

5.2.1 When AASHTO T 99 is used to determine the maximum dry density of the minus No. 4 material, use the following equation to determine the corrected maximum dry density (MDD$_C$) of the soil-rock mixture:

$$MDD_C = \frac{(P_f \times D_f) + (P_c \times 0.90 \times D_c)}{100}$$

5.2.2 When AASHTO T 180 is used to determine the maximum dry density of the minus No. 4 material, use the following equation to determine the corrected maximum dry density (MDD$_C$) of the soil-rock mixture:

$$MDD_C = \frac{(P_f \times D_f) + (P_c \times 0.95 \times D_c)}{100}$$

Where:

P_f = Percent fine particles by weight (minus No. 4);
P_c = Percent coarse particles by weight (plus No. 4);
D_f = Maximum dry density of fine particles (minus No. 4), pcf;
D_c = 62.4 x bulk specific gravity of coarse particles (plus No. 4), pcf;
P_c = Percent coarse particles by weight (plus No. 4);
M_f = Optimum moisture content of the minus No. 4 material as determined by AASHTO T 99 or T180;
M_c = Absorption of the plus No. 4 material as determined by AASHTO T85.

6. LIMITATION FOR USE OF CP 23

6.1 CP 23 shall not be used when the plus No. 4 fraction of the sample consists of cinders, crushed concrete, recycled asphalt pavement, or other light porous rock since an accurate specific gravity determination is difficult to make on this type of material. For these materials AASHTO T 99 or T 180, Method D shall be used.

6.2   The plus No. 4 fraction of the sample shall be determined to be Rock-like (Durable) or Soil-like (Non-durable) either visually, by experienced field personnel, or in the Central Laboratory, according to CP-L 3104. If the plus No. 4 fraction is classified as Non-durable, then CP 23 will not apply and the total sample shall be treated as minus No. 4 material for moisture/density determination.

Note 2: Non-durable plus No. 4 material will usually be found in soils with a classification of A-6 or A-7.

6.3   When the soil-rock mixture contains more than 30% plus No.4 material but 30% or less of the material is retained on the ¾ inch sieve AASHTO T 99 or T 180 method D may be used as approved by the Engineer.

6.3.1   When Method D is used, procedures 4.1 thru 5.1 shall be used. The ¾ inch sieve shall be substituted for the No. 4 sieve. The material passing the ¾ inch sieve will be used for determining the un-corrected maximum dry density and optimum moisture content. The material retained on the ¾ inch sieve will be used for T85.

6.4   When the soil-rock mixture contains more than 50% plus No.4 material and more than 30% plus ¾ inch material, CP 23 cannot be used.

7.   RECORD

7.1   CDOT Form 24, Moisture - Density Relation.

7.2   CDOT Form 584, Moisture - Density Relation Graph.

7.3   CDOT Form 427, Nuclear Moisture / Density Soils Test.