11 Soils Field Procedures Using the Sand Cone Method

Apparatus

Cone Correction and Bulk Density Factors

Procedure

CHAPTER ELEVEN:
SOILS FIELD PROCEDURES USING THE SAND CONE METHOD

Field density determination of soil compaction is done in accordance with **AASHTO T 191** (Sand Cone) or **AASHTO T 310** (Nuclear Gauge). This chapter discusses the procedures for using **AASHTO T 191.**

AASHTO T 191 contains three very distinct and important sections. These are:

1) Section 3: Apparatus

2) Section 4: Cone Correction and Bulk Density Factors

3) Section 5: Procedure

The following references are required to be reviewed for this chapter:

Standard Specifications

1) Section **203.24(b)**

AASHTO

1) **T 191** - Density of Soil In-Place by the Sand-Cone Method

2) **T 224** - Correction for Coarse Particles in the Soil Compaction Test

3) **T 255** - Total Evaporable Moisture Content of Aggregate by Drying

ITM

1) **506** - Field Determination of Moisture Content of Soils

APPARATUS

The apparatus (Figure 11-1) required for the Sand Cone Method consists of a one-gallon jar, a detachable metal appliance, and a base plate. The metal appliance is attached to the jar to allow the sand to flow from the jar during calibrations or density testing. The density apparatus and base plate are detailed in **AASHTO T 191** Section 3.

A calibration container is also required for this test. The calibration container is used to determine the sand density. The requirements for this container are also detailed in **AASHTO T 191** Section 3. The volume of the container is determined annually at the District Testing lab in accordance with **AASHTO T 19**. The volume of the container is marked on the side of the container to an accuracy of 0.0001 ft^3.

Figure 11-1. Base Plate, Apparatus, and Calibration Container

CONE CORRECTION AND BULK DENSITY FACTORS

Prior to determining the bulk density of the sand and conducting density tests, the Technician determines the weight of sand required to fill the large cone of the density apparatus and the accompanying base plate. This weight is determined to the nearest 0.01 pounds and is referred to as the Cone Correction. The density apparatus and the base plate are required to remain together and not be interchanged with other devices without recalculating the Cone Correction. The Cone Correction is calculated daily on Form IT 625 (for soil) and on Form TD 320 (granular material).

The procedure for determination of the Cone Correction is detailed in **AASHTO T 191** and is summarized as follows:

1) Fill the apparatus with the calibration sand and record the weight to the nearest 0.01 lb

2) Place the base plate on a clean, level surface

3) Invert the apparatus onto the base plate and open the valve to allow the cone and the base plate to fill with sand

4) When the sand stops flowing into the cone, shut the valve and weigh the apparatus to the nearest 0.01 lb

5) The difference between the full weight of the apparatus and the final weight after filling the cone is referred to as the Cone Correction.

Determination of the bulk density of the calibration sand is a procedure done daily by the Technician prior to conducting in-place density tests. The bulk density of the calibration sand is referred to as the sand calibration factor. The gradation of the calibration sand required for this test is required to be in accordance with Section **203.24 (b),** which is an exception to **AASHTO T 191**. Sand complying with this requirement is furnished by District Testing and is obtained with the density equipment. The determination of the calibration sand density is done in accordance with **AASHTO T 191** and recorded on Form IT 625, Daily Summary of Soil In-Place Density Tests or on Form TD 320, Daily Summary of In-Place Density Tests (+3/4 material). The determination of the bulk density of the calibration sand is done daily and when a new bag of sand is used.

A calibration container with a known volume is required to determine the bulk density of the calibration sand. By knowing the volume of the calibration container and the weight of calibration sand required to fill the container, the bulk density of the calibration sand in pounds per cubic foot may be calculated.

The process of determining the bulk density of the sand is detailed in **AASHTO T191** Section 4 and is summarized as follows:

1) Fill the apparatus with the calibration sand and record the weight to the nearest 0.01 lb

2) Place the base plate on the calibration container

3) Invert the apparatus on the base plate and open the valve to allow the calibration container and the large cone to fill with sand

4) Shut the valve on the apparatus and weigh the apparatus to the nearest 0.01 lb

The initial weight of the apparatus minus the final weight and minus the Cone Correction is the weight of the calibration sand required to fill the container. Divide the weight of the sand in the container by the volume of the container to determine the bulk density of the sand. The bulk density of the sand is calculated to the nearest 0.1 lb/ft^3.

Sections **203.18** through **203.23** detail the methods of embankment construction with density control and without density control. The Frequency Manual lists the frequency of tests on embankment construction. Embankment layers so granular that density testing is impractical may be controlled visually and documented as such on Form IT 625 or Form TD 320. Documentation of visually accepted lifts of embankment maintains a record of the method of acceptance of the lift for coordination with the frequency manual requirements.

PROCEDURE

With the calculations of the Bulk Density of the calibration sand and the Cone Correction Factor completed, the Technician has all of the information necessary to begin in-place density tests. Using Form IT 625, the procedure for an in-place sand cone density tests on soil is as follows:

1) Fill the apparatus with calibration sand and record the weight on Line 5 of form IT 625

2) Weigh and record the weight of an empty pan on Line 2 and Line C of form IT 625

3) Locate a representative area to conduct the density test

4) Remove any loose and uncompacted soil from the test site and level the area for the base plate to be seated

5) Dig a hole into the soil through the hole in the base plate for the full depth of the layer being tested

6) Place the soil in a pan, weigh immediately, and record the weight on Form IT 625 Line 1 (Wet Wt. of Material from Hole & Pan) and Line A (Weight of Pan & Wet Material)

7) Reset the base plate over the test hole and invert the apparatus onto the base plate and open the valve to allow sand to flow into the test hole. When the sand flow stops, shut off the valve and remove and weigh the apparatus. Do not tap or vibrate the apparatus during this process. The weight obtained is entered on Form IT 625 Line 6 (Final Wt. Apparatus and Sand).

Form IT 625 may now be completed for Lines 7 through 9.

Determination of moisture for Line MC_T is obtained in accordance with **AASHTO T 217**, **ITM 506,** or **AASHTO T 255** depending upon the type of soil. If the soil is cohesive, **AASHTO T 217** or **ITM 506** may be used; however, **ITM 506** is the preferred method for obtaining the moisture for cohesive soil. If the soil is a sand then **AASHTO T 255** is required. Form IT 625 is used for calculation of the percent moisture of the soil using **ITM 506** or **AASHTO T 255**. This calculation is required before line 4 of the IT 625 may be calculated. The moisture sample for **ITM 506** or **AASHTO T 255** is the entire amount of the material removed from the test hole. The last step after the soil is dried is to sieve the moisture sample over the No. 4 sieve. Any particles retained on that sieve are weighed and the result recorded on Line 16 of the IT 625.

Lines 1-9 of the IT 625 should now be complete.

Line 12 of the IT 625 is the dry density of the material tested. The dry density is determined by dividing the dry weight of the soil removed from the hole (Line 4 of the IT 625) by the calculated volume of the hole (Line 9 of the IT 625) unless plus No. 4 sieve particles exist in the soil. When the soil contains plus No 4 particles, the density is adjusted to account for the material as required by Section **203.24(b)2**. This density correction is made in accordance with **AASHTO T 224**, Correction for Coarse Particles in the Soil Compaction Test. The required calculations are detailed on Form IT 625 Lines 16-23. Lines 16-23 are only done when Line 16 contains a number other than zero, i.e. the soil contained plus No. 4 sieve particles. The dry density value is determined to the nearest 0.1 pounds per cubic foot and is the actual in-place density of the soil.

The Specifications indicate whether the dry density requirement is 95 % or 100 % of the proctor value. On Form IT 625 line 13, the target density is listed from the laboratory test or from the one-point proctor test for the specific soil being tested. On line 11, the optimum moisture content is listed from the same report. The Specifications require passing results for both the density and moisture content of the soil.

Care should always be taken when selecting a target density and optimum moisture content from laboratory results from samples submitted to the District. Typically, representative samples of the soil are retained at the job-site in small jars and compared to field test site soil. This comparison is made by color, texture, and plasticity to determine which soil samples more closely represent the layer being tested and thus which target density should be used. The one-point proctor is the preferred method to determine the maximum dry density and optimum moisture content.

Form IT 625 may now be completed.

The density of coarse, granular material is also required to be determined. Density for embankment layers constructed with coarse granular material requires the use of Form TD 320. Some granular fill material, coarse aggregate size No.53, coarse aggregate size No.73, and some structural backfill (1 in. and larger B-Borrow) require the use of this form.

The density process for coarse, granular material is the same as described previously for sand except with the following:

1) The percent moisture is required to be obtained using **AASHTO T255**. As before, the entire sample removed from the test hole is dried.

2) The sample removed from the test hole is required to be weighed, dried, and then sieved through a 3/4 in. sieve. The weight of the dry plus 3/4 in. material is also obtained and recorded as dry weight of + 3/4 in. material on Form TD 320, Line 16. This dry weight of + 3/4 in. material is used to correct the field density of the material being tested based on an assumed moisture content of 2 percent and an assumed specific gravity of 2.60 for the + 3/4 material. The laboratory proctor for aggregate material is obtained on the minus 3/4 in. material only, and using the above procedure corrects the field in-place density so the field test results also represent only the minus 3/4 in. material.

3) The target density and optimum moisture content are required to be obtained from the District Soils laboratory.

Form TD 320 contains the procedures for cone correction, bulk density of the sand, percent moisture, and plus 3/4 in. correction required to complete the calculations for the in-place density of the granular material

Section **203.23** allows for the moisture content of granular materials to be several percentage points below the optimum moisture content. This means that dry density is required to be obtained; however, the moisture content obtained in accordance with **AASHTO T 255** is not required to be within +1 and -2 percent of optimum for the lift to pass the specified dry density. Several percentage points below optimum has been interpreted to be no less than 50 % of the optimum moisture content as indicated on the laboratory tested sample.

The sand from the test hole is not salvaged and reused. The salvaged sand may contain soil from the hole and the mixture of salvaged calibration sand and soil from the test site may change the sand bulk density and affect the volume calculations and the Cone Correction.