ATT-20/22, MOISTURE-DENSITY RELATION, One Point

1.0 SCOPE

This method describes a rapid procedure for estimating the maximum dry density and optimum moisture content of subgrade material by performing a one (or more) point moisture-density relation test on the material from the road density.

Depending on the soil type, there may be times where it may be necessary to perform the more detailed 5 point proctor test, using either ATT-19, or ATT-23.

2.0 EQUIPMENT

Microwave Oven – equipped with variable power levels and a turntable.

Electronic Balance - for measuring the mass of wet and dried aggregate samples.
Capable of reading to 0.1 grams.
The balance must be operated as per manufacturer's recommendations.
Balances must be inspected, cleaned, and calibrated annually.

Lab Drying Oven – thermostatically controlled heating chamber capable of maintaining a uniform temperature of 110 ± 5°C.

See ATT-19, MOISTURE-DENSITY RELATION, +5,000 µm Material
See ATT-23, MOISTURE-DENSITY RELATION, - 5,000 µm Material

3.0 PROCEDURE

This test method is used on subgrade construction and subgrade preparation projects. However, only one (1) road density test can be correlated to the dry density and microwave moisture content obtained by this method. The soil from a field density test is used to establish the moisture-density relation. The test results are used to determine the percent compaction.

3.1 Application

3.1.1 + 5,000 µm Material

Use a 152 mm diameter mold if the following conditions exist:

a) The soil is contaminated with aggregate and has more than 7% retained on the 5,000 µm sieve and less than 30% retained on the 20,000 µm sieve, or

b) The subgrade is contaminated with asphalt bound material, or

c) The subgrade is treated with lime and has more than 7% rock retained on the 5,000 µm sieve and less than 30% retained on the 20,000 µm sieve.

3.1.2 - 5,000 µm Material

Use a 102 mm diameter mold if the following conditions exist:

a) The subgrade soil has less than (<) 7% retained on the 5,000 µm sieve.

b) The subgrade soil is lime treated and has less than (<) 7% rock retained on the 5,000 µm sieve.

3.2 Sample Preparation

1. Perform an in-place density test on the compacted subgrade soil as directed in ATT-8 (Balloon Method) Sections 3.1 and 3.2 or ATT-9 (Sand Method), Sections 3.1 to 3.3.

2. Obtain an additional 5 kg of representative soil for the 152 mm diameter mold, or 2 kg of soil for the 102 mm diameter mold from the area adjacent to the road density test

3. For 152 mm diameter mold sample, add the -20,000 μm material from the density test to the -20,000 μm soil and pass the entire friable portion through the 5,000 μm sieve.

4. For the 102 mm diameter mold, add the density material to the sample and pass the entire friable portion through the 5,000 μm sieve. Discard the retained rock.

5. Estimate the soil's moisture condition by taking a handful of representative -5,000 μm soil mixture and performing the plastic limit test as directed in ATT-29.

6. Bring the entire sample to the estimated optimum moisture content by either air drying or adding water to the sample until the fines portion of the soil is barely holding together when rolled to a worm of 3 mm in diameter.

7. For clay soils, allow the water to distribute evenly throughout the sample, for at least one hour. For clean gravels (GW, GP), clean sands (SW, SP) and lime treated soils, proceed to Section 3.3 as soon as water is added.

3.3 Moisture-Density Relation Test

1. For the ***152 mm diameter mold***, compact the sample in ***three layers*** of approximately equal height. Each layer shall receive ***56 blows/lift*** using the ***standard tamper (2.5 kg weight*** and 304.8 mm drop), as directed in ATT-19, Section 3.3 steps 4 to 9.

2. For the ***102 mm diameter mold***, compact the sample in ***three layers*** of approximately equal height. Each layer shall receive ***25 blows/lift*** using the ***standard tamper***, as directed in ATT-23, Section 3.3, steps 1 to 20.

3. Use the microwave oven to determine the moisture content as outlined in ATT-15, Moisture-Content, Part IV, Microwave Method.

4. Calculate the dry density of the sample as outlined in Section 3.4 of ATT-23.

3.4 Percent Compaction

1. Calculate the road density as follows:

a) Determine the wet density of the density material as directed in ATT-8, Section 3.4.1, Minus 5,000 μm Material or Section 3.4.2, Contaminated Subgrade or Granular Base (Plus 5000 μm).

b) Use the microwave oven to determine the moisture content of the density material as directed in ATT-15, Part IV.

c) Calculate the in-place dry density using the formula:

$$\textit{Dry Density (kg/m}^3\textit{)} = \frac{\textit{Wet Density}}{\textit{100\% + Moisture Content (\%)}} \textit{ x 100}$$

2. Compare the road dry density to the one-point dry density to obtain the percent compaction as follows:

$$\textit{Percent Compaction (\%)} = \frac{\textit{Road Dry Density (kg/m}^3\textit{)}}{\textit{Maximum Dry Density (kg/m}^3\textit{)}} \textit{ x 100}$$

3.5 Forming Extra Points

The one-point dry density obtained by this method will always be lower than the maximum dry density obtained in the 5 point test. This results in a higher percent compaction. Extra points should be formed until the technologist is proficient estimating the optimum moisture content.

The following section describes the procedure for forming extra points to establish an optimum moisture content and maximum dry density.

3.5.1 + 5,000 μm Material (using 152 mm Mold)

1. Break up the specimen from the previous one-point test and sieve the material through the 5,000 μm sieve.

2. Add all this material to the processed material not used in the compacted specimen.

3. Thoroughly mix the material and place it in a tared mixing pan.

4. Determine the weight of dry soil using the moisture content previously determined and the following formula:

$$\textit{Wt of Dry Soil (grams)} = \frac{\textit{Wt. of Wet Soil (grams)}}{\textit{100\% + Moisture Content (\%)}} \textit{ x 100}$$

5. Add water, or dry the soil, until the sample is approximately 1.5% wetter, or 1.5% drier. For example:

$$\textit{Wt of Water to Add or Dry (grams)} = \frac{\textit{Wt. of Dry Soil x 1.5\%}}{\textit{100\%}} \textit{ x 100}$$

6. Compact and process sample as directed in Section 3.3, steps 1 and 3.

7. Repeat steps 1 to 6 above until the estimated optimum moisture content of the soil is reached.

3.5.2 - 5,000 μm Material (using 102 mm Mold)

1. Repeat steps 1 to 4 of Section 3.5.1 (Plus 5,000 μm Material).

2. Add water to or dry the soil until it is approximately 2% wetter or drier. The weight of water to be added to or removed from the sample is calculated using the formula:

$$\textit{Wt of Water to Add or Dry (grams)} = \frac{\textit{Wt. of Dry Soil x 2.0\%}}{\textit{100\%}} \textit{ x 100}$$

3. Compact and process sample as directed in Section 3.3 steps 2 and 3.

4. Repeat steps 1 to 3 above until the estimated optimum moisture content of the soil is reached.

4.0 HINTS AND PRECAUTIONS

1. When performing density tests on asphalt bound materials, the moisture content will include the amount of cutback in the mix and the weight of the aggregate will be increased by the weight of asphalt residue.

2. Microwave moisture contents may be performed on fine grained soils contaminated with asphaltic material.

3. For most soils, the plastic limit can be used to judge the optimum moisture condition of a soil.

4. As mixtures of soil-lime are conditioned, the density is decreased and the optimum moisture content is increased. Therefore, it is necessary to process soil-lime mixtures as quickly as possible after performing a field density test. Allow no more than one hour after performing a field density test before processing.