GDT 59

A. Scope

For a complete list of GDTs, see the Table of Contents.

Use this test method to determine the in-place density of roadway materials using a nuclear moisture and density gauge.

Note: This method should not be used to apply pay factors less than 1.00 for Asphaltic Concrete.

In this procedure a reference to a Primary Gauge refers to a gauge that has been calibrated to calibration cores, or 12" ring.

B. Apparatus

The apparatus consists of the following:

1. Surface Moisture and Density Gauge
2. Standard Block
3. Drill Rod and handle
4. Base Plate
5. Manufacturer's Instruction Manual
6. Shipping or Storage Case with required Labeling

C. Gauge Operation

1. To operate the nuclear gauge, follow the procedures shown in the Manufacturer's Instruction Manual accompanying each gauge.
2. Establish both density and moisture standard counts at least at the beginning of each day of testing. Take the moisture standard count more frequently if the humidity changes considerably between test sites.
3. Allow the gauge to warm up for 5 minutes before reading the counts.
4. Take the standard counts at least 10 ft (3 m) from any large object such as a wall, vehicle or heavy equipment and at least 33 ft (10 m) from any other radioactive source.
5. Test with the deepest mode the conditions and material thickness will allow.
6. It is critical to the accuracy of the test that the gauge rest flat on the surface of the material being tested. Excessive voids cracks or small depressions should be filled with sand, cement or native fines taking care to fill only the voids. Remove excess fines to ensure the gauge rest on the material being tested and not the added fines.
7. Do not utilize the in-place moisture from the gauge when the material is excessively wet or dry. A "flame dry" moisture shall be utilized for determining In-Place moisture in these cases. In all cases, take extreme care when testing material which is excessively wet or dry.

Note: Excessively wet material is when the material is spongy, boggy, or near saturation as shown by the zero air voids line in the Family of Curves in GDT 67. Excessively dry material is when the material is dusty, cracked, crusty, or when the moisture content falls below the bottom of the slope lines in GDT 67.

D. Gauge Calibration

1. The direct transmission and backscatter moisture charts may be used as they appear, but you will need to adjust both direct transmission and backscatter moisture for aggregate base and sand bituminous, and backscatter density on asphalt concrete. The procedures for making these adjustments are outlined in the following paragraphs.

2. Backscatter Density for Asphaltic Concrete (Use 4-inch inner diameter cores when calibrating to asphaltic concrete to minimize destructive testing)
3. Make a field adjustment based on a correlation test with cores. You may use the adjustment for subsequent testing and on later projects with the same conditions only for GAB.
4. Asphaltic concrete less than 1-1/4 in (32 mm) thick: Field-calibrate to each type per project of underlying material, such as asphaltic concrete, surface treatment, soil-cement, etc. Establish another adjustment for any change in the source of aggregate or type of mix being placed.

   Note*** For thickness less than 1-1/4 in (32 mm) consider GDT-39 as the preferred method for determining density.
5. Asphaltic Concrete greater than 1-1/4 in (32 mm) thick: Field-calibrate to each mix type for that project. Asphalt calibrations should be done for each mix type on a project and calibrations should not be carried over from another project. Gauges should be calibrated to cores or a Primary Gauge (A gauge calibrated to cores) and never from a gauge calibrated gauge. Gauge calibrations should be done at least 100ft apart. Asphalt and all other materials requiring calibration are only good for 1 year.
6. Direct Transmission Density and Backscatter Moisture
   a. Make field adjustments for direct transmission density and backscatter moisture for aggregate bases, subbases, and drainage material for each source. GAB and all other materials requiring calibration are only good for 1 year. Gauge calibrations should be done from 12” rings or from a Primary Gauge (A gauge calibrated to 12” rings) never from a gauge calibrated gauge. Gauge calibrations should be done at least 100ft apart.
   b. Verify the theoretical density and Optimum Moisture for aggregate bases, subbases, and drainage material by performing at least one AASHTO T 180 Method D comparison each year for each active quarry.

Gauges tested yearly by the process where the gauge is checked or adjusted – by comparison with a standard – the accuracy of a measuring instrument. When this is done all material calibrations are null and void, and must be recalibrated to each source.

7. Site Preparation for Subgrade, Embankment, and Backfill
   a. Remove material to a depth greater than the deepest penetration of the compaction equipment when sheep-foot rollers are utilized. The area should be at least 2 ft² (0.2 m²) and plane enough so the gauge bottom touches the material.
   b. Pat native fines into minor depressions or surface voids with the base plate.
   c. Subtract gauge wet density from the gauge moisture pcf to obtain the dry density.
   d. Divide the gauge dry density by the maximum dry density from the appropriate page of the GDT-67 curves for compaction.

E. Procedures

1. Correlation Tests

   Adjust field densities and moistures by comparing the nuclear gauge test and the conventional test—total density, wet density, or moisture in pounds per cubic foot (kilograms per cubic meter), whichever applies. a. Direct Transmission and Backscatter Density
   1) Perform a minimum of three nuclear density and three conventional density tests to determine density offset.

Note: Five tests are required for asphaltic concrete mixes for calibration. Four cores can be used only if one of the five causes the calibration to be unacceptable. No less than four cores may be used. All cores used for calibration must have passing air void content results.

   2) Locate the conventional test site directly beneath the center of the gauge for cores and 2 inches behind the drill rod hole for GDT-20 or GDT-21.

2. Correction (Offset) of the Nuclear Gauge to Conventional Density Tests

1) Ensure materials are within the acceptable specifications and tolerances
   a) For asphalt concrete, perform correlation testing provided; the mixture meets the allowable mixture control tolerances of Specification 828; the mixture meets compaction and air void requirements of Specification 400.
   b) For aggregate base, ensure the materials are meeting gradation and density requirements of the appropriate Specifications. Do not perform correlation testing on unstable materials.
2) Determine the average of the nuclear gauge densities.
3) Obtain the average conventional densities.

Note: To convert the specific gravity of cores to pcf, multiply the specific gravity by 62.4 pcf.

4) Use the average conventional densities and average nuclear gauge densities in pcf to determine the needed density result.
5) Subtract the average gauge densities in step E.1.b.2 by the average conventional densities in step E.1.b.3 to get the needed offset. If the average conventional density is higher than the average gauge density the offset will be positive (+). If the average conventional density is lower than the average gauge density the offset will be negative (-).
6) Add or subtract the offset factor from each density for that material.
7) Use the offset factor to calculate each nuclear gauge density.
8) Compare nuclear and conventional results. If the averages differ by more than 0.5 pcf, check your values and recalculate. If recalculation fails, recalibrate.

3. Moisture Correlation of the Nuclear Gauge

Determine the moisture content in aggregate bases and subbases.

Note: Moisture correlation is not typically required for subgrade, backfill and embankment materials.

a. Moisture Correlation Procedure for Aggregate Bases and Subbases

1) Perform a minimum of three nuclear gauge moisture/density tests and three flame dry moisture tests to determine gauge offset.
2) The flame dry samples are to be taken from the material directly below the gauge and wet weights obtained immediately to ensure accuracy of moisture content.
3) Test for direct transmission density at each location to determine the moisture offset in pcf as follows.

   Where:

   A = In-place wet density by direct transmission

   B = Percent moisture by drying a sample of material from the appropriate depth

   C = Corrected in-place dry density

   D = In-place moisture (pcf) by flame dry

   E = Original gauge moisture (pcf)

   a) Correct in-place dry density by flame dry moisture (for each of three sites)

   $$C = \left[\frac{A}{100+B}\right] X\ 100$$

   b) Calculate in-place moisture (pcf) by flame dry (for each of three sites)

   $$D = A - C$$

c) Determine moisture offset

Moisture Offset= (Average Original Gauge Moisture (pcf)) - (Average In-place Moisture (pcf)by Flame Dry)

d) Subtract the average in-place moisture (pcf) by flame dry (D) from the average original gauge moisture (pcf) to get the needed offset. If the average flame dry is higher than the average gauge moisture the offset will be positive (+). If the average flame dry is lower than the average gauge moisture the offset will be negative (-).

4. Density Analysis
   a. Backscatter (density of asphaltic concrete and moisture content of embankment and bases) 1) Place the gauge securely and flat on the test site. 2) Check density for 1 minute.
   b. Direct Transmission (wet density of bases and soils)
      1) Bases, and subbases, place the base plate on the test site.
      2) Drive the drill pin through the guide hole at least 2 in (50 mm) deeper than the depth to be tested.
      3) When required pat native fines into minor depressions or surface voids with the base plate.
      4) Move the plate and lower the source rod into the hole to the desired test depths (2, 4, 6, 8 10, 12 in [50, 100, 150, 200, 250, 300 mm]).

E. Calculations

1. Asphaltic Concrete:

$$\%\,Voids = \left[1 - \frac{In\text{-}place\ Density}{Theoretical\ Density}\right] X\ 100$$

2. Bases, Subbases, Subgrade, Backfill, and Embankment
   a. Dry density, wet density, and moisture are in pounds per cubic foot (kilograms per cubic meter). Use the following formula to calculate Dry Density directly from Gauge readings.

$$Dry\ Density = Wet\ Density - Moisture\ (pcf)$$

Use the following formula to correct the In-Place dry density based on the flame dry moisture content.

$$Corrected\ Dry\ Density = \left[\frac{Wet\ Density}{100 - \%\ Moisture}\right] X\ 100$$

$$\%\,Moisture = \left[\frac{Moisture\ (pcf)}{Dry\ Density}\right] X\ 100$$

$$\%\,Compaction = \left[\frac{In - place\ Dry\ Density}{Max\ Dry\ Density}\right] X\ 100$$

b. Moisture Determination by Drying

You may test the soil and aggregate moisture by drying approximately 1.1 lb (500 g) of wet soil or 4.4 lbs (2000 g) of material containing coarse aggregate. Calculate moisture content to the nearest 0.1percent as follows:

$$\%\ Moisture = \left[\frac{A - B}{B}\right] X\ 100\ where$$

A = Weight of wet sample

B = Weight of dry sample

Note: When you use the Family of Curves in GDT 67 to determine the maximum dry density, use the one-point proctor moisture as the in-place moisture, provided you have not added water to the material.

3. Precision

a. The results of two backscatter moisture, backscatter density, or direct transmission density tests without moving the gauge should be within ± 0.5 pcf.

b. Results of comparison tests between two nuclear gauges, using identical gauge orientations on the same test site, should be within ± 1.5 pcf for density of asphaltic concrete or wet density of other material.

F. Report

Report compaction and moisture to the nearest 0.1 percent on the appropriate form for the construction method and materials involved.