ALDOT-222-82
IN-PLACE DENSITY AND MOISTURE MEASUREMENTS AND ESTABLISHING MOISTURE CORRELATIONS FOR NUCLEAR MOISTURE/DENSITY GAUGES

1. Scope

1.1. This method of test provides a non-destructive measurement of in-place density and moisture content of soils and/or aggregate bases and thick layers of bituminous mixtures of 225 lbs/yd^2 (120 kg/m^2) or greater.

Note 1: Operators shall have a current operator's card issued by the Bureau of Materials and Tests after completion of the Radiation Safety Course. Operators are also required to be certified as Roadway Technician's by the Bureau of Materials and Tests.

2. Applicable Documents

2.1. Radiological Safety Manual; Manufacturers Operating Manual Supplied with gauge; Nuclear Gauge Training Manual available from the Bureau of Materials and Tests; AASHTO T-265 Laboratory Determination of Moisture Content of Soils; M&T-14 Revised Technical Specifications for Nuclear Moisture/Density Gauges; ALDOT-341 Standard Procedures for Comparing Independent Assurance Samples and Tests (IAS&T); Acceptance Test Results; AASHTO T-166 Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens; and, ALDOT-210 Selecting Samples by the Random Numbers Method.

3. Nuclear Gauging Device

3.1. This device must meet M&T 14 Revised, available at the Bureau of Materials and Tests.

Note 2: Before acceptance, gauge will be checked on Alabama Department of Transportation calibration standards and gauge accuracy will be required to be within ± 1.5% (1.5 lbs) (0.6818 kg) of calibration standards.

4. Apparatus

4.1. Cans - Four cans with a capacity of 500 g minimum with lids to prevent loss of moisture.

5. Procedure for Standardizing Check of Equipment

5.1. Check the gauge against a reference standard at least twice a day or more frequently if climatic, transporting, background or other conditions necessitate.

5.2. When using a CPN MC-1 or a Troxler 3401-B, a warm-up period for the gauge is required (use the manufacturer's recommendations for warm-up). After warm-up, take five one-minute counts on reference standard and average (to be used as a Standard Count).

5.3. The average for the five one-minute counts should be within the permissible variations set forth in Table 1. If any one individual count is outside of the statistical limits, a repeat of the entire count run is required.

6. Table 1

Acceptable Range of Count Variations Used for Standardizing and Calibrating Moisture Density Nuclear Gauges

Average Standard Counts (ASC)	Permissible Variations ± (1.96 ASC)
70,000	± 520
45,000	± 415
36,000	± 375
16,000	± 250
7,000	± 165
4,000	± 125
3,000	± 107
2,000	± 88

7. Procedure For In-Place Density And Moisture Tests

7.1. Clear away all loose surface material or dried crust and obtain a plane sufficient in area to accommodate the gauge and extending 6 in. (150 mm) beyond the gauge housing. (A probe hole is required for a direct transmission type gauge.)

7.2. Where sheepsfoot and similar type tamping rollers have been used, remove the loose surface material to a depth at least equal to the deepest penetration of the roller foot.

7.3. Modes of transmission shall be as follows:

7.3.1. Direct - May be used on all materials exceeding 2 in. (50 mm) in thickness and will be required for embankment, roadbed and fine grained base layers.

7.3.2. Backscatter - For most bituminous mixtures, and high coarse aggregate content base layers.

7.3.3. Backscatter/Air Gap - For very open graded high coarse aggregate content base layers and bituminous mixtures.

Note 3: Careful seating of the gauge is necessary. The surface under the gauge must be plane. When direct transmission mode is used, the access hole for the probe must be perpendicular to the base plane. Minor depressions, not exceeding 0.13 in. (3 mm) may be filled with native fines removed from the layer being tested. (Ottowa sand or any fine sand may be substituted for native fines.)

7.4. Take one one-minute reading, recording both moisture and density counts.

7.5. Rotate gauge at least 90° over the same centerpoint and obtain one additional one-minute time reading and record the moisture and density counts.

7.6. When operating gauge within 24 in. (600 mm) of the edge of the road-bed or asphalt mat, use the following procedure. For initial reading, place gauge parallel to the edge of the layer being tested. Then, rotate gauge at 60° intervals (over same centerpoint) to obtain the next three (3) readings. The last reading should be taken opposite the first reading, leaving the gauge parallel to the edge of the layer being tested.

Note 4: Measurement counts should be repeated if any count varies more than ± five (5) times the square root of the average.

Note 5: Nuclear gauge systems having radiation source materials in individual housings must be separated at least 3 m when counts are being taken.

8. Calculations

8.1. Wet density

$$R = \frac{n}{asc}$$

Where
R = wet density count ratio
n = average count for the one minute time readings for density probe
asc = average standard count for density probe

8.1.1. Wet density (D) in lbs/ft^3(kg/m^3). Locate R on calibration chart and record corresponding wet density (D) to nearest 0.25 lb (0.113 kg).

Note 6: Manufacturers supply a computer print-out for density and moisture measurements. These measurements are to the nearest 0.5 lb (0.227 kg) for density and 0.25 lb (0.113 kg) for moisture. To record to nearest 0.2 lb (0.0909 kg), interpolation is required for the density printout.

8.2. Moisture Content

$$R_1 = \frac{n_1}{asc_1}$$

Where
R_1 = moisture count ratio
n_1 = average count for the one minute time readings for moisture probe
asc_1 = average standard count for moisture probe

8.2.1. Moisture content (M) in lbs/ft^3 (kg/m^3). Locate R on calibration chart and record corresponding moisture content (M) to nearest 0.2 lb (0.113 kg).

8.3. Dry density in lbs/ft^3 (kg/m^3)

$D_1 = D - M$

Where
D_1 = dry density in lb/ft^3 (kg/m^3)

8.4. Percent moisture

$$P = \frac{M}{D_1} \text{ X } 100$$

Where
P = percent moisture (soil dry basis)
M=moisture content in lb/ft^3 (kg/m^3)
D_1=dry density in lb/ft^3 (kg/m^3)

8.5. Percent comparative compaction

$$P = \frac{D_1}{D_2} \text{ X } 100$$

Where
P = percent of comparative compaction
D_1 = dry density in lbs/ft^3 (kg/m^3)
D_2 = control weight of material expressed in lbs/ft^3 (kg/m^3).

9. Correlation of Moisture and Density Curves

9.1. Correlation moisture curves, when deemed necessary, will be under the direction of the Materials and Tests Engineer. Moisture curves will be correlated to values determined by AASHTO T-265.

9.2. For a moisture correlation, run four separate density tests. Record wet density in lbs/ft^3 (kg/m^3) and moisture content in lbs/ft^3 (kg/m^3) from the nuclear gauge for each separate test. Obtain a moisture sample with a minimum weight of 500 g from each test site and place in cans for transportation to division lab. Run moisture samples per AASHTO T265 to obtain oven dried moisture content of the samples. Using the nuclear gauge wet density and moisture content in lbs/ft^3 (kg/m^3), along with the results (percent moisture) of the laboratory oven dried moisture tests, Division Materials personnel will determine an individual moisture correlation for each of the four separate density tests, and will then average the individual values to obtain an overall moisture correlation. Sound engineering judgment should be utilized in the averaging process. If one of the individual moisture correlation values is significantly different from the other values, it should not be included in the averaging process to determine the overall moisture correlation. After the moisture correlation has been determined, Division Materials personnel will report the value in writing, with a copy sent to

the Central Office Materials Engineer. Data/Calculations used in determining the moisture correlation are to be placed in the project file at the Division office.

Note 7: Division Materials personnel will issue a temporary moisture correlation, if needed, based on gauge wet density and moisture content along with results from field dried moisture samples until oven dried results are available.

10. Procedure

10.1. Density of asphalt base and pavement layers determined by nuclear gauge readings will be correlated to density of core specimens obtained from the layer as determined by AASHTO T-166. Four core specimens from the layer being tested will be required for density curve correlations. The density correlation will be determined by establishing the difference between the average gauge density readings and the average bituminous core densities. If the average gauge wet density lbs/ft^3 (kg/m^3) is higher than the aver-age bituminous core density lbs/ft^3 (kg/m^3) the correlation will be negative. If the average gauge wet density lbs/ft^3 (kg/m^3) is lower than the average bituminous core density lbs/ft^3 (kg/m^3) the correlation will be positive.

Example: Average gauge wet density 130.0 lbs/ft^3 (2028.4 kg/m^3) average bituminous core density 137.5 lbs/ft^3 (2145.5 kg/m^3) equals a plus 7.5 lbs/ft^3 (117.1 kg/m^3) correlation.

Note 8: The density correlation shall be added to or subtracted from the nuclear gauge wet density reading.

11. Comparing IAS&T Samples and Tests and Acceptance Test Results

11.1. Compare in accordance with ALDOT-341 and pay special attention to Table #1.