Standard Test Method for Density of Bituminous Paving Mixtures in Place by the Electromagnetic Surface Contact Methods[1]

This standard is issued under the fixed designation D7113/D7113M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the procedures for determining the in-place density and relative compaction of bituminous concrete pavement paving mixtures by an electromagnetic surface contact device by measuring changes in the electromagnetic field resulting from the compaction process.

1.2 The equipment referenced in this method is a surface contact device, which must accommodate surface moisture and temperature variation in the range typically encountered in paving applications. This can be accomplished by design parameters that reduce the device's sensitivity to surface moisture and temperature variation or by measurements and algorithms to account for surface moisture and temperature variance in the rolling pattern.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials

D1188 Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Coated Samples (Withdrawn 0)[3]

D2726 Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures

D3665 Practice for Random Sampling of Construction Materials

D3666 Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials

D5361 Practice for Sampling Compacted Bituminous Mixtures for Laboratory Testing

D6752 Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Automatic Vacuum Sealing Method

3. Significance and Use

3.1 The test method described is useful as a rapid, nondestructive technique for determining the in-place density or relative compaction of compacted bituminous mixtures.

3.2 The test method can be used to establish the proper rolling effort and pattern to achieve the required density.

3.3 The non-destructive nature of the test allows repetitive measurements to be made at a single test location between roller passes or at multiple locations across the mat to monitor changes in density.

3.4 The density results obtained by this test method are relative. Device calibration (correlation with other test methods] is required to convert the results obtained using this method to actual density. Section 6 of this test method describes a method that has proven to be acceptable for correlation.

NOTE 1—The personnel and equipment used in performing this test can be evaluated in accordance with Specification D3666.

NOTE 2—Research and evaluation of devices used in this test method has been conducted. Reference is made to "Evaluation of Non-Nuclear Gauges to Measure Density of Hot-Mixed Asphalt Pavements," a pooled fund study, Pedro Romero, Ph.D., P.E., July 2002.

[1] This test method is under the jurisdiction of ASTM Committee D04 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.21 on Specific Gravity and Density of Asphalt Mixtures.

Current edition approved May 1, 2016. Published May 2016. Originally approved in 2005. Last previous edition approved in 2010 as D7113 – 10. DOI: 10.1520/D7113_D7113M-10R16.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

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4. Interferences

4.1 Electromagnetic force fields such as high-tension power lines, or large metal objects in close proximity may interfere with the device reading.

4.2 The chemical composition of the material being tested may significantly affect the measurement and adjustments may be necessary. The device can be calibrated to the specific mix design being used in the field.

4.3 The test method exhibits spatial bias in that the device is most sensitive to the density of the material in closest proximity to the sensor.

4.4 The surface texture of the material being tested may cause lower than actual density determination.

4.5 Oversize aggregate particles in the sensor path may cause variations in density determination.

4.6 The actual sample volume varies with the apparatus and the density of the material. In general, the higher the density the smaller the volume (see Note 3).

NOTE 3—The volume of field compacted material represented by a test can effectively be increased by repeating the test at adjacent locations and averaging the results.

5. Apparatus

5.1 *Electronic Sensing Device*—An electronic counting device, capable of being seated on the surface of the material under test, and which meets the outline below:

5.1.1 The device shall be housed in an enclosure of heavy-duty construction and designed for taking in-situ density measurements of bituminous paving mixtures.

5.1.2 The device shall function in the mat temperature and moisture levels experienced during the placement of hot bituminous paving mixtures.

5.1.3 The device shall include the internal circuitry suitable for displaying individual measurements to allow operators to record the readings.

5.1.4 The device shall include a continuous reading mode of operation.

5.1.5 The device shall employ suitable electronic circuitry to provide power and signal conditioning to the sensor to provide the data acquisition and readout function, and allow calibration of the unit over the expected range of application conditions and materials.

NOTE 4—The device manufacturer may choose to supply a Reference Standard, a block of material used for checking device operation and to establish conditions before actual pavement measurements are made.

6. Calibration

6.1 Calibrate the device for each mixture prior to performing tests on that particular mixture.

6.2 Record the calibration method used and the specific values obtained for future use of the device on the same type of material.

6.3 The calibration must be conducted on the mat within the mat temperature range that will be encountered during subsequent testing.

6.4 The core calibration allows the device to be offset to a specific density measured using Test Method D1188, Test Method D2726, or Test Method D6752.

6.4.1 Identify three to ten test locations within a 3 m [10 ft] length in the direction of the paving train on the mat.

6.4.2 At each location take a minimum of four measurements following the device manufacturer's recommendation for seating the device on the pavement and the procedures of operation noted in 7.7.

6.4.3 Record each individual measurement and the average for each location.

6.4.4 Cut a 150 mm [6 in.] core from the pavement location in accordance with Practice D5361 and proceed with the appropriate test method for determining the bulk specific gravity of the compacted specimen.

6.4.5 Average all device readings. Average all core measurements. Compare these values to determine a device offset.

6.4.6 Offset the device reading to reflect the value derived in step 6.4.5.

7. Procedure of Operation

7.1 The device should be turned on sufficiently in advance of taking any readings to allow the device to stabilize.

7.2 Standardize the device using the manufacturer's procedures as described in the device operation manual.

7.3 Select a test location in accordance with the project specifications, or, if not otherwise specified, in accordance with Practice D3665.

7.4 Ensure that no sources of electromagnetic interference such as high-tension power lines or large metal objects are near the immediate vicinity of the device.

7.5 For best results, avoid surfaces with large temperature extremes.

7.6 The following procedure may be used to determine the required number of roller passes:

7.6.1 Measure and record readings on the un-compacted mixture exiting the screed.

7.6.2 After each roller pass, measure and record the compaction readings.

7.6.3 When the measurements no longer increase or fall back with additional roller passes, record this reading and the number of passes.

7.6.4 Repeat steps 7.6.1 and 7.6.2 after each roller type where compaction is to be monitored.

7.7 The following procedure may be used for taking measurements on one or more pavement locations:

7.7.1 Select a smooth surface with no excess water (roller water is acceptable). Brush the surface clear of any sand or stones, which would prevent contact between the surface and the measuring device. The optimum condition for general testing would be a smooth surface, with total contact between the bottom surface of the device and the surface being tested. Optimum calibration conditions are the same as above including recommendations from the device manufacturer with respect to pavement moisture.

7.7.2 Ensure the device is calibrated for the site conditions and bituminous mix being placed in accordance with Section 6 of this test method.

7.7.3 Seat the device on the test surface allowing for the maximum device-to-material surface contact. If necessary, rotate the device to gain the maximum contact and eliminate any rocking or high points in the contact area.

7.7.4 For multiple testing and averaging for a specific location, follow the device manufacturer's recommendation for placing the device on the mat.

7.7.5 If profiling the pavement surface, measure and record each reading. Compare the individual readings to observable irregularities in the mat that may establish or identify segregation, uniformity or texture issues.

7.7.6 After initiating a test, the operator must move away from the device for a minimum distance of 30 cm [1 ft].

NOTE 5—Do not place the device on a hot surface unless you are conducting measurements. Prolonged high temperatures may adversely affect the device's electronics. The device should be allowed to cool between measurements.

8. Report

8.1 Immediately after taking the density reading(s), record the following data:

8.1.1 Job site identification and the test site location data, such as station number, offset from centerline, and so forth, in accordance with locally-established conventions.

8.1.2 Device calibration data as specified in Section 6.

8.1.3 Individual density readings at each measured point within a test location to the nearest 0.001 g/cc, together with the calculated average density value for the location.

8.1.4 Corresponding density data (if taken) from alternative methods for each test location to the nearest 0.001 g/cc. Such data may be from nuclear gage or core sample methods.

8.1.5 Notation of any qualitative observations of testing or material conditions that may affect the accuracy or interpretation of the test results.

8.1.6 Temperature of the bituminous mat at the time of the reading, to the nearest 0.5° C, if taken.

8.1.7 Dated signature by the test operator.

9. Precision and Bias[4]

9.1 *Precision:*

9.1.1 Precision is based on a field experiment in 2008 that used six gauges from five manufacturers. Materials included Superpave 9.5, 12.5, 19.0, and 37.5 HMA used on a construction project sponsored by the New York DOT. Density varied from 123.9 to 156.0 pounds per cubic foot with mean of 137.6 and standard deviation 3.089. Each test with a single gauge was conducted by the same operator, therefore, single-operator precision for this statement is also considered to be single-gauge precision if conducted by the same operator.

9.1.2 *Single Operator Precision*—The single-operator standard deviation has been found to be 20.50 kgm^3 [1.28 pounds per cubic foot].[5] Therefore, results of two properly conducted tests by the same operator on the same material should not differ by more than 57.67 kgm^3 [3.6 pounds per cubic foot].[5]

9.1.3 *Multilaboratory Precision*—The multilaboratory standard deviation has been found to be 23.55 kgm^3 [1.47 pounds per cubic foot].[5] Therefore, results of two properly conducted tests from two different laboratories on the same material should not differ by more than 65.68 kgm^3 [4.1 pounds per cubic foot].[5]

9.2 *Bias:*

9.2.1 There is no consensus on the most accurate method to determine the values of density against which this test can be compared. Accordingly, a statement of method bias cannot be made.

NOTE 6—With regards to the Bias statement above, any user may elect to conduct a comparison of these gauges related to the laboratory measured value from core samples. Gauge measurements should be taken directly on the location of the pavement where cores will be cut.

10. Keywords

10.1 bituminous-concrete density; density; in-place density; non-nuclear test method, electronic density device

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D04-1033.

[5] These numbers represent, respectively, the (1s) and (d2s) limits as described in Practice C670, for Preparing Precision Statements for Test Methods for Construction Materials.

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