Designation: D8541 – 23

Standard Test Method for Determination of Relative Rotation to Evaluate the Workability of Asphalt Mixture Using Wireless Particle-Size Sensors[1]

This standard is issued under the fixed designation D8541; 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 determination of relative rotation to evaluate the workability of asphalt mixture during compaction using a wireless particle-size sensor. It is applicable to asphalt mixture being compacted using the Superpave Gyratory Compactor (SGC).

1.2 This test method is appropriate for use to determine the relative rotation of laboratory-produced and plant-produced asphalt mixtures, regardless of the type or gradation of the aggregates, and whether reclaimed asphalt pavement (RAP), warm mix asphalt (WMA) additives, or any type of modifiers are used in the asphalt mixture.

1.3 *Units*—The values stated in SI units are to be regarded as the standard. No other units of measurement are included in this standard.

1.4 The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered requirements of the standard.

1.5 Since a complete precision and bias statement for this standard has not been developed, the test method is to be used for research and informational purposes only. Therefore, this standard should not be used for acceptance or rejection of a material for purchasing purposes.

1.6 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D979/D979M Practice for Sampling Asphalt Mixtures

D3549/D3549M Test Method for Thickness or Height of Compacted Asphalt Mixture Specimens

D3665 Practice for Random Sampling of Construction Materials

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

D6925 Test Method for Preparation and Determination of the Relative Density of Asphalt Mix Specimens by Means of the Superpave Gyratory Compactor

2.2 *AASHTO Standards:*[3]

R 30 Standard Practice for Mixture Conditioning of Hot Mix Asphalt (HMA)

R 83 Standard Practice for Preparation of Cylindrical Performance Test Specimens Using the Superpave Gyratory Compactor (SGC)

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *average residual rotation, ARR, n*—the average value of the residual rotation between two asphalt mixtures from the initial number of gyrations (N_{inital}) to the design number of gyrations (N_{design}).

3.1.2 *global coordinate, n*—the Cartesian coordinate system that is fixed in space and unaffected by the position and orientation of the object.

3.1.3 *local coordinate, n*—the coordinate system that is attached to the sensor and changes with the movement and rotation of the wireless sensor.

[1] This test method is under the jurisdiction of ASTM Committee D04 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.26 on Fundamental/Mechanistic Tests.

Current edition approved Dec. 1, 2023. Published January 2024. DOI: 10.1520/D8541-23.

[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] Available from American Association of State Highway and Transportation Officials (AASHTO), 555 12th St., NW, Suite 1000, Washington, DC 20004, http://www.transportation.org.

3.1.4 *quaternion, n*—an expression to describe the orientation or rotation of an object in 3D space using an ordered set of four numbers.

3.1.4.1 *Discussion*—If an object's orientation is expressed as $a + bi + cj + dk$, where a, b, c, d are real numbers and i, j, k are symbols of three spatial axes with unit vectors, the set of the four ordered numbers, a, b, c, and d is a quaternion.

3.1.5 *relative rotation, RR, n*—the difference between the maximum and minimum value of the Euler angle in a single compaction cycle, recorded by a wireless particle-size sensor.

3.1.6 *relative rotation capacity, RRC, n*—the area under the relative rotation curve from the N_{inital} to the N_{design}.

3.1.7 *residual rotation, n*—the difference in the relative rotation between the test mix and the control mix at the same gyration compaction.

3.1.8 *rotation matrix, n*—the matrix derived from the quaternion that can be used to transform the data between the local and the global coordinate systems.

3.1.9 *workability, n*—a term used to describe the relative ease of compaction of an asphalt mixture using the Superpave Gyratory Compactor (SGC).

3.1.9.1 *Discussion*—The workability describes the specific free rotation capability of the asphalt mixture particle under compaction loading in the SGC.

4. Summary of Test Method

4.1 This test procedure is used to determine the relative rotation to evaluate the workability of asphalt mixture during Superpave gyratory compaction (SGC) using a wireless particle-size sensor.

5. Significance and Use

5.1 Workability is one of the main factors that influence the compaction quality and ultimately the performance of asphalt pavement. This method uses the relative rotation measured by the wireless particle-size sensor to evaluate the workability of the asphalt mixture.

5.2 This test method is used to generate information concerning the workability of an asphalt mixture. Workability characteristics, in turn, can give users insight as to how the mixture will handle and compact in the field.

5.3 This method is used to evaluate workability of the mix in a situation where it is being used for research or mix design. It is not intended to be a quality control (QC) evaluation.

5.4 This test method can be used to evaluate conventional and modified asphalt mixtures to achieve the best workability at an appropriate compaction temperature. The test method can be used to determine the compaction temperature and optimal dosage rate of additives or modifiers to achieve the best workability for the modified asphalt mixtures, such as polymer modified, crumb rubber modified, waste plastic modified, etc.

5.5 This test method is appropriate for laboratory-produced mixtures and plant-produced mixtures, regardless of the type or grade of the binder, the type or gradation of the aggregates, and whether RAP, WMA additives, or other modifiers are used in the asphalt mixture.

NOTE 1—The quality of the results produced by this standard is dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of Specification D3666 are generally considered capable of competent and objective testing, sampling, inspection, etc. Users of this standard are cautioned that compliance with Specification D3666 alone does not completely ensure reliable results. Reliable results depend on many factors; following the suggestions of Specification D3666 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.

6. Apparatus

6.1 *Superpave Gyratory Compactor and Specimen Mold*—An electromechanical, electro-hydraulic, or electro-pneumatic compactor comprised of the required system components as determined by Test Method D6925 shall be utilized. The relevant parameter of the gyratory compactor and specimen mold should refer to Test Method D6925.

6.2 *Oven*—A forced-draft oven, thermostatically controlled, capable of maintaining any desired temperature setting. The oven shall be available for heating aggregates, asphalt, and equipment.

6.3 *Wireless Particle-Size Sensor*—The wireless particle-size sensor shall survive in a high-temperature environment for at least 10 min. The sensor shall collect the Euler angle or quaternion of the particulate material during the entire compaction process. The wireless particle-size sensor shall be able to connect to digital devices, such as computers, for data transmission. The size of the sensor should not be larger than one fifth of the diameter of the specimen mold. The sampling frequency of the quaternion shall be greater than 5 Hz (10 Hz and higher is recommended).

7. Test Specimens

7.1 *Preparation of Lab Mix Lab Compacted (LMLC) Test Specimens*—Samples of lab-mixed asphalt mix shall be obtained according to Test Method D6925 or other specified sampling method.

7.2 *Preparation of Plant Mix Lab Compacted (PMLC) Test Specimens*—Samples of plant-mixed asphalt mix shall be obtained according to Practices D3665 and D979/D979M or other specified sampling method.

7.3 *Conditioning of the Mixture*—Weigh the mixture to the required mass. Place the mixture in a pan and spread it to an even thickness ranging between 25 mm and 50 mm. Place the mixture and pan in the oven at the required temperature for 2 h ± 5 min short-term aging before compaction in accordance with AASHTO R 30.

7.3.1 *Specimen Size*—The specimens shall be compacted to 150 mm in diameter in accordance with Test Method D6925.

NOTE 2—Sample heights of 80 mm up to 180 mm can be used; however, this will impact the resulting kinematic parameters for relative rotation analysis.

NOTE 3—The specimen mass should follow the mix design after subtracting the mass of the sensor when the height of 115 mm is used.

7.4 *Preparation of Wireless Particle-Size Sensor*—The wireless particle-size sensor shall be able to operationally connect to digital devices before compaction.