METHOD OF SAMPLING AND TESTING
MT 332-14
GYRATORY COMPACTION OF BITUMINOUS MIXTURES
(*Montana Method)*

1   Scope

1.1   This test method describes the procedure for verification of asphalt content and mixture properties of bituminous mixtures by the compaction of cylindrical specimens of Plant Mix Surfacing (PMS) using the Superpave gyratory compactor. The density of bituminous mixtures is determined directly for N_{des}.

1.2   Establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1.3   This test method describes the procedure for placing a sample into a 150 mm diameter mold for an apparatus that compacts bituminous mixture using a combination of pressure and gyration. The apparatus measures the specimen height very precisely as compaction occurs after each gyration. The required compaction effort is defined from tables found in the specifications. This procedure shows how closely the bituminous mixture being produced is to the production requirements.

2   Referenced Documents

AASHTO

T 312   Preparing and Determining the Density of the Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
M 231   Weighing Devices Used in the Testing of Materials
T 344   Evaluation of Superpave Gyratory Compactor (SGC) Internal Angle Using Simulated Loading

MT Materials Manual
MT 314 Bulk Specific Gravity of Compacted Bituminous Mixtures
MT 319 Determining the Asphalt Binder Concrete of Plant Mix Surfacing (PMS) by the Ignition Method
MT 320 Mechanical Analysis of Aggregate Recovered from Ignition Oven Burn
MT 321 Determining Theoretical Maximum Specific Gravity of Bituminous Paving Mixtures – "Rice Gravity"

3   Significance and Use

3.1   Use this standard to prepare specimens for determining the mechanical and volumetric properties of PMS. The specimens simulate the density, aggregate orientation, and structural characteristics obtained in the actual roadway when proper construction procedures are used in the placement of the PMS.

4   Apparatus

Ensure equipment used meets the following requirements:

4.1   *Superpave Gyratory Compactor* - An electrohydraulic or electromechanical compactor with a ram and ram heads as described in Section 5.3 that are restrained from revolving during compaction. The axis of the ram is perpendicular to the platen of the compactor. The ram applies and maintains a pressure of 600 ± 18 kPa perpendicular to the cylindrical axis of the specimen during compaction. The compactor tilts specimen molds at an average internal angle of 1.16 ± 0.02 degrees, in accordance with AASHTO T 344. The equipment gyrates specimen molds at a rate of 30.0 ± 0.5 gyrations per minute throughout compaction.

4.1.1   *Specimen Height Measurement and Recording Device* - When specimen density is to be monitored during compaction, the Superpave Gyratory Compactor is equipped with means to continuously measure and record the height of the specimen to the nearest 0.1 mm during compaction; once per gyration.

4.1.2   The system may include a connected printer capable of printing test information, such as specimen height per gyration. In addition to a printer, the system may include a computer and suitable software for data acquisition and reporting.

4.2   *Specimen Molds* - Specimen molds have steel walls that are at least 7.5 mm thick hardened to a minimum Rockwell hardness of C48. The inside of the molds are smooth (Note 1). Ensure molds have an inside diameter of 149.90 to 150.20 mm and are at least 250 mm high at room temperature.

4.3   *Ram Heads and End Plates* - Ram heads and end plates are fabricated from steel with a minimum Rockwell hardness of C48. The ram heads stay perpendicular to its axis. The platen side of each end plate is flat and parallel to its face. Ensure all ram and end plate faces (the sides presented to the specimen) are flat to meet smoothness requirements in 4.2 (Note 1) and have a diameter of 149.50 to 149.75 mm.

Note 1 – Smooth is measured in accordance with ANSI B46.1 with rms value of 1.60 μm or less.

4.4   *Thermometers* - Armored, glass, digital probe or dial-type thermometers with metal stems for determining temperature of aggregates, binder and PMS between 10ºC to 232ºC.

4.5   *Balance* - a balance meeting the requirements of AASHTO M 231, Class G5, for determining the mass of aggregates, binder and PMS.

4.6   *Oven* - An oven, thermostatically controlled to ±3ºC, for heating aggregates, binder, PMS and equipment as required. Ensure the oven is capable of maintaining the compaction temperature range.

4.7   *Miscellaneous* - Flat bottom metal pans of at least 500 square inches that are square or rectangular for heating plant mix. Ensure pans will accommodate quartering. Scoop to remove mixture quarters for testing. Large spatula for turning and mixing sample prior to quartering. Insulated gloves, a lab apron or coat and other safety equipment as necessary. Lubricating materials recommended by compactor manufacturer and assorted cloth and paper rags for wiping molds and other surfaces. A Gyro Loader (a trough) is optional for adding samples to the mold.

5   Standardization

5.1   Items requiring periodic verification of calibration include the ram pressure, the angle of gyration, the gyration frequency, the LVDT (or other means used to continuously record the specimen height) and oven temperature. Verification of the mold and platen dimensions and the inside finish of the mold are also required. When the computer and software options are used, periodically verify the data processing system output using a procedure designed for such purposes. Verification of calibration, system standardization and quality checks may be performed by the manufacturer, other agencies providing such services, or in-house personnel. **Ensure verification is current in accordance with manufacturer's recommendations.**

5.2   The angle of gyration refers to the internal angle (tilt of the mold with respect to end plate surface within the gyratory mold). Verify the calibration of the internal angle of gyration in accordance with AASHTO T 344.

6   Materials

6.1   Obtain a sufficient quantity of PMS in accordance with MT 303 and MT 601.

7 Preparation of Apparatus

7.1 Turn on the main power for the compactor for the manufacturer's required warm-up period.

7.2 Verify machine settings are correct for angle, pressure and number of gyrations.

Note 2 – The required number of gyrations are shown in the contract.

7.3 Lubricate any bearing surfaces as needed per the manufacturer's instructions.

7.4 When specimen height is to be monitored, the following additional item of preparation is required. Immediately prior to the time when the PMS is ready for placement in the mold, turn on the device for measuring and recording the height of the specimen, and verify the readout is in the proper units (mm), and the recording device is ready. Prepare the computer, if used, to record the height data, and enter the header information for the specimen.

8 Asphalt Specimen Fabrication

8.1 Adjust the target specimen mass to result in a final compacted specimen having dimensions of 150 mm in diameter and 115 ± 5 mm in height at the designed number of gyrations based on volumetric properties. PMS that is brought to the test location and is still within the compaction temperature range may be batched for immediate testing. Bring loose PMS below the compaction temperature range to the compaction temperature range by careful uniform heating in an oven immediately prior to molding. Heating proceeds more quickly if the sample is placed in a clean (buttered) flat bottomed pan. Loose PMS that is within the compaction temperature range should not be reheated.

Note 3 – Ensure specimens are fabricated to maintain a consistent height throughout production to provide satisfactory test results.

9 Compaction Procedure

9.1 Place a compaction mold and end plates in an oven at the required compaction temperature to pre-heat the mold and end plates to compaction temperature prior to the estimated beginning of the compaction cycle. When the bituminous mixture is within the compaction temperature range, remove the heated mold and end plate from the oven and place a paper disc in the bottom of the mold.

Note 4 – Compact test specimens at a consistent temperature based on the compaction temperature range in the mix design.

9.2 Center the mold under the loading ram. Rotate the mold clockwise to the stop, and lock the head down.

9.3 Pour the pre-weighed quantity of bituminous mixture into the mold in one lift. Use a gyro loader to facilitate this operation. If you do not have a gyro loader, another method that works is to pour the sample from a paper bag. The bag acts as a container and a funnel when filling the mold. Care should be taken to avoid segregation. Introduce the sample into the mold in a continuous motion to avoid segregation. Level the mix with the stroke of a spatula (if necessary) and place another paper disk on top of the leveled material. Insert the top end plate with the bevel up.

9.4 Start the load compaction cycle. The machine will lower the ram until the pressure on the specimen reaches 600 kPa ± 18 kPa, apply a 1.16 ± 0.02º average internal angle to the mold assembly and begin the gyratory compaction. Allow the compaction to proceed until the desired number of gyrations is reached and the ram retracts. Record the specimen height at N_{des}. A printed record may be produced as the compactor operates. Extrude the specimen from the mold. Remove the mold from the compactor.

Note 5 – Normally, extrude the specimens from the mold immediately. For lean, rich or tender mixtures, cool 5 to 10 minutes before extruding the specimen to avoid specimen collapsing.

9.5   Immediately remove the paper discs from the top and bottom of the hot specimen. Write the specimen number on the specimen and the gyration worksheet. Cool the specimens by a fan or air conditioner. Handle specimens carefully. Hot specimens are very tender and fragile.

Note 6 – Before reusing the mold, clean thoroughly, place in an oven, and reheat to compaction target temperature. The use of multiple molds will speed up the compaction process.

10   Density Procedure

10.1   Determine the maximum specific gravity (G_{mm}) of the loose mix in accordance with MT 321 using a companion sample. Condition the companion sample to the same extent as the compaction sample.

10.2   Determine and record the mass of the extruded specimen to the nearest 0.1 gram and determine the bulk specific gravity (G_{mb}) of the extruded specimen in accordance with MT 314. This is the bulk gravity of the specimen at N_{des}. Measure the bulk density of the compacted bituminous mixture after the specimen has cooled sufficiently (to near room temperature) in accordance with MT 314.

11   Calculations

% Air Voids (V_a)

$$V_a = 100 \times \left(\frac{G_{mm} - G_{mb}}{G_{mm}} \right)$$

Where:
$G_{mm} = Maximum\ specific\ gravity\ of\ paving\ mixture\ (Rice)$
$G_{mb}\ \ = Bulk\ specific\ gravity\ of\ compacted\ mixture$

Record and round to the nearest 0.1%

Voids in the Mineral Aggregate (VMA)

$$VMA = 100 - \left(\frac{G_{mb}(100 - P_s)}{G_{sb}} \right)$$

Where:
$G_{mb} = Bulk\ specific\ gravity\ of\ compacted\ mixture$
$P_s\ \ \ = Aggregate\ content,\ percent\ by\ total\ mass\ of\ mixture$
$G_{sb}\ \ = Bulk\ specific\ gravity\ of\ aggregate$

Record and round to the nearest 0.1%

Voids Filled with Asphalt (VFA)

$$VFA = 100 \times \left(\frac{VMA - V_a}{VMA} \right)$$

Record and round to the nearest 0.1%

Dust/Asphalt Ratio

$$DA = \left(\frac{P_{200} - 1}{P_b}\right)$$

Where:
DA = Dust to Asphalt Ratio,
P_{200} = Aggregate content passing the 0.075mm sieve, the percent by mass of aggregate (MT 320)
P_b = Asphalt Content, percent by total mass of mixture (MT 319)

Record and round to the nearest 0.1%

Note 7 – The Dust/Asphalt ratio is used during mix design and field production.

Dust Proportion

$$DP = \left(\frac{P_{200} - 1}{P_{be}}\right)$$

Where:
DP= Dust Proportion,
P_{200} = Aggregate content passing the 0.075mm sieve, the percent by mass of aggregate (MT 320)
P_{be} = Effective asphalt content, percent by total mass of mixture

Note 8 – The Dust Proportion is used during mix design.

Effective Asphalt Content

$$P_{be} = -\left(P_s \times G_b\right) \times \left(\frac{G_{se} - G_{sb}}{G_{se} \times G_{sb}}\right) + P_b$$

Where:
P_{be} = Effective asphalt content, percent by total mass of mixture
P_s = Aggregate content, percent by total mass of mixture
G_b = Specific gravity of asphalt
G_{se} = Effective specific gravity of aggregate
G_{sb} = Bulk specific gravity of aggregate
P_b = Asphalt Content, percent by total mass of mixture

Record and round to the nearest 0.1%.

12   Report

12.1   Record pertinent information in the QA Suite Plant Mix section.

13   Forms

13.1   **Gyratory Data Entry Form**