1820 STANDARD METHOD FOR PREPARING AND DETERMINING THE DENSITY OF HMA SPECIMENS BY MEANS OF THE GYRATORY COMPACTOR

AASHTO T 312 (MN/DOT Modified)

1820.1 SCOPE

This standard covers the compaction of cylindrical specimens of hot mix asphalt using the gyratory compactor. This procedure is used to prepare specimens for the determination of mechanical and volumetric properties of the mix. The specimens simulate the density, aggregate orientation and structural characteristics of an actual bituminous mixture behind a roller.

This test method may be used to monitor the density of test specimens during compaction. It may also be used for field control of the production process.

NOTE 1: This procedure differs from AASHTO in the following areas. For Mix design, the temperature for short term conditioning is at 290 °F for 2 hours. Volumetrics are determined by compacting the mixture out to N_{design} only. Determining the Gmb at N_{max} and $N_{initial}$.are not necessary for Mn/DOT volumetric requirements.

1820.2 APPARATUS

A. Superpave Gyratory Compactor - Shall conform to AASHTO T 312

1. The ram shall apply and maintain a pressure of 600 ± 18kPa to the specimen during compaction.

2. The compactor shall tilt the specimen molds at an average internal angle of 20.2 ± 0.35 mrad (1.16˚± 0.02°)

NOTE 2: The **i**nternal angle shall be determined in accordance to AASHTO TP71

3. Compactor shall gyrate molds at a rate of 30.0 ±0.5 gyrations per minute.

B. Specimen Molds - Shall conform to AASHTO T 312.

1. New Molds – Initial inside diameter of molds shall be 149.90 – 150.00 mm and are at least 250mm high.

   Used Molds - Inside diameter of molds shall be 149.90 – 150.20 mm

Used molds shall be checked for excessive wear by measuring the inside dia. in the “compaction” area of the mold. This area is typically 1 to 5 inches an end of the mold (top or bottom) as determined by the wear area. Measurements are to be made at room temperature.

2. The walls shall be a minimum of 7.5mm thick.

C. Ram Heads and Plates - Shall conform to AASHTO T 312. Diameter of ram heads and plates shall be 149.50 – 149.75mm.

D. Computer or Printer - For data collection and recording. When specimen density needs to be monitored during compaction, there shall be a way to continuously measure and record the height of the specimen. The specimen shall be recorded to the nearest 0.1mm during compaction once per gyration.

E. Mechanical Mixer and Bowl.

F. Paper Disks: 150mm for compaction.

G. Oven - For heating aggregates, molds, and oil and capable of maintaining a temperature that does not vary more than 5°C (9 °F.).

H. Pans and Containers - For heating aggregate and mixtures.

I. Thermometers - For aggregates, asphalt, and asphalt mixtures

J. Balance - A balance conforming to the requirements of AASHTO M 231 (Class G2) with a minimum capacity of 10,000g, a readability and sensitivity of 0.1g and an accuracy of 0.1g or 0.1%.

K. Assorted Scoops, Trowels, Spoons, and Spatulas.

1820.3 BATCHING – PREPARATION OF AGGREGATES AND ASPHALT

Mix Design: Refer to the section 1804 for examples of batching and proportioning trial mixes. Aggregate batch size shall be a minimum of 15,000 grams for gyratory mixtures (enough for two specimens and 2 rice tests). Weigh the appropriate fractions from the design aggregate blend and combine into the desired batch weight.

Production (QCQA) Testing: Refer to section 1809 for sample preparation.

1820.4 TEMPERATURES

A. Refer to the manufacturer’s recommendation to determine the mixing and compaction temperatures for the required PG Binder.

B. Virgin aggregates are heated to 143 ± 5.6 °C (290 ± 10 °F). However, for mixtures using modified binders that require higher or lower mixing temperatures than 290 °F, heat the aggregates to the manufacturer's recommended mixing temperature. Virgin aggregates may be heated overnight.

C. RAP materials are heated to 143 ± 5.6 °C (290 ± 10 °F). (Minimum heating time is 2 hours; maximum heating time is 4 hours.)

D. Asphalt Binder is heated to the upper end of the manufacturer's recommended mixing temperature. Do not allow the binder to remain at that temperature for more than 4 hours.

NOTE 3: Asphalt binder may be heated only once; i.e., if mixing schedule is disturbed and not completed as scheduled a new sample of the binder must be used.

E. Mixing bowls and containers should be heated to the same temperature as the aggregates.

F. Molds and base plates are heated to the desired compaction temperatures. The molds should be at the desired temperature for at least 60 minutes prior to compaction.

G. Temperature for short term curing is 143 ± 5.6 °C (290 ± 10 °F) unless modified binders require a higher compaction temperature other than 290 °F. Refer to Section 1820.5G

1820.5 MIXING

A. Place the pre-heated bowl on the mixer and add the hot aggregates and R.A.P. (if it's a recycled mix) then dry-mix thoroughly.

NOTE 4: Prior to mixing an initial or "butter" mix is required to condition the mixing equipment. Remove and discard the butter mix from the bowl and paddle by scraping and leaving a uniform residual asphalt coating.

B. If using a digital balance that will read negative weights, place the can with the hot binder on the balance and tare to zero. Pour the predetermined amount of binder into the bowl while mixing, checking the weight after each pour until the target amount (± 0.5 gram) is achieved.

C. For other types of balances, first tare to zero then weigh the can and binder. Subtract the target amount of binder from the actual weight of the filled can. Record the difference and commence pouring, checking the weight after each pour, until that difference (± 0.5g) is achieved.

D. Record any difference outside of the tolerance and correct the report to show the actual amount and percentage of A.C. added.

E. Continue mixing until particles are thoroughly coated usually about two minutes with the mechanical mixer; however, some mixes with R.A.P. may take longer.

F. Place the loose mixture in a large shallow flat pan. Scrape the sides and bottom of the bowl as well as the paddles to remove any material clinging to them and spread the mixture to an even thickness.

NOTE 5: This material will have a high asphalt content and must be carefully and thoroughly blended by hand back into the rest of the mixture.

NOTE 6: A light coating of silicone lubricant may be sprayed on the pan to retard mixture adherence.

G. Prior to running any tests or compacting any specimens all the mixture must be short-term cured. This mixture conditioning for "volumetric mix design" simulates the pre-compaction phase of the construction process. It allows for binder absorption into the aggregates. For the majority of mixtures this "Mix Design" short-term cure shall take place in an oven at 143 ± 5.6 °C (290 ± 10 °F) for 2 hours

For modified binders the following shall apply. If a modified binder is used and its recommended compaction temperature is higher than 290 °F, the higher recommended temperature shall be used. However, if the recommended compaction is lower than 290 °F, a 290 °F curing temperature shall be used.

NOTE 7: This is for lab-mixed material only. Do not cure bituminous mixture samples that have been produced in a hot-mix plant. For these "Voids Update" samples see section 1809.

NOTE 8: For additional short-term and long-term conditioning for "Mixture Mechanical Property Testing" see the latest version of AASHTO R30.

H. Hand mix the mixture after one hour to maintain uniform conditioning.

1820.6 PREPARATION OF THE GYRATORY COMPACTOR

A. Turn on the compactor for the manufacturer's required warm-up period.

B. Verify the machine settings for the correct internal compaction angle (1.16 ±0.02˚), compaction pressure (600 kPa±18), speed of gyrations (30.0 ±0.5) and the desired number of gyrations (N_{design}).

NOTE 9: The number of gyrations can be found in the "Mixture Requirement" table located in the latest version of MN/DOT 2360 specifications.

C. Lubricate any bearing surfaces as needed.

D. Verify that the specimen's height data is being recorded and the readout is in proper units (mm).

E. Assure that the data acquisition device (computer or RS232 serial port) is functioning.

1820.7 PREPARATION OF SPECIMENS

A. After the short-term aging process remove the mix from the oven. Thoroughly hand-mix the mixture in the pan with a flat-bottom scoop and trowel and then quarter the material.

If Production Plant Mix is to be used, the mix shall be heated to it's compaction temperature prior to molding and compaction. Refer to section 1809.

B. From one quarter take a representative 2000-2050 gram sample for a maximum specific gravity (G_{mm}) or "Rice Test" and spread it out in a pan. (Test according to Section 1807).

NOTE 10: For Trial Mix Designs and Trial Mix Verification samples two Rice tests are required.

C. From the remaining quarters weigh out enough material for at least two individual 115 ± 5mm (4.53 ± 0.197") Gyratory specimens. (Approximately 4800-4900 grams will provide this intended specimen height; however, the amount will vary depending upon the aggregates and level of gyrations). It may be necessary to make a trial specimen to achieve this height requirement.

NOTE 11: The goal is to be as representative as possible when obtaining individual portions.

D. Place each batch in a preheated metal container. If the mixture is at the desired compaction temperature, proceed immediately with the compaction as outlined in Section 1820.8. If not insert a thermometer into the mix and place the container into an oven until the compaction temperature has been achieved. If the desired compaction temperature is lower, place the container with the mix on a counter top until the compaction temperature is achieved.

NOTE 12: Allow a maximum of 30 minutes to attain this temperature.

E. The remaining material may be used for other tests or retained for re-checks.

1820.8 GYRATORY COMPACTION

A. When compaction temperature is achieved, remove the preheated mold and base plate (and upper plate if required) from the oven. Remember to place a paper disk in the bottom of the mold before introducing the mix.

NOTE 13: Before reusing the same mold and in between the compaction of multiple specimens, reheating the mold for a minimum of 5 minutes is required.

B. Pour the mixture into the mold in one lift. Care should be taken to avoid segregation of the mix in the mold.

C. Level the mix and place another paper disk on top (and upper plate if required).

D. Load the mold with the mix into the compactor and center the mold under the loading ram.

E. Lower the ram until the pressure on the specimen reaches 600 kPa ±18 kPa. The ram will stop when the pressure reaches 600kPa.

F. Apply a 1.16 ± 0.02° internal angle to the mold assembly and begin the Gyratory compaction.

G. Allow the compaction to proceed until the desired number of gyrations (N) is reached. Record or print the final height data of the specimen to the nearest 0.1mm.

NOTE 14: The specimen height is continually monitored during compaction and the height measurement is recorded after each revolution.

H. The compactor will stop after reaching the N setting and the angle of gyration will be released from the mold assembly, and the loading-ram will be raised. Generally this is automatically done.

NOTE 15: No additional gyrations with the angle removed are required unless specifically called for.

I. Remove the mold from the compactor. Specimens can be extruded from the mold immediately for most mixtures. However for tender mixes or those that are compacted to a low number of gyrations, a cooling period of 5 to 10 minutes in front of a fan may be necessary before extruding the specimen from the mold. This will facilitate specimen removal without unnecessary distortion.

J. Extrude the specimen from the mold and remove the paper disks from the top and bottom while the specimen is still warm.

NOTE 16: The extruded specimen may not be a right-angle cylinder. For volumetric testing this is not critical.

K. Identify the specimen by number using a china marker or crayon.

L. Cool the specimen to room temperature (25 ± 5 °C [77 ± 9 °F]). The use of a fan will facilitate the cooling process.

1820.9 DETERMINE THE BULK SPECIFIC GRAVITY (G_{mb})

Refer to Section 1806 for specifics on the equipment used.

A. Specimens should be cooled to room temperature at 25 ± 5 °C (77 ± 9 °F).

B. Weigh each of the specimens in air to the nearest 0.1 g and record the dry weight as (**A**).

C. Immerse the specimens in water at 25 ± 1 °C (77 ± 1.8 °F) for 3 to 5 minutes. Placing one specimen at a time on the weighing platform below the scale and tipping the specimen to release any air bubbles without lifting the specimen from the water. Weigh to the nearest 0.1g and record the immersed weight as (**C**).

D. Immediately after obtaining the immersed weight remove the specimen from the water and then immediately surface-dry the specimen by rolling it in and blotting it on a damp towel. Weigh in air to the nearest 0.1g and record the saturated surface-dry weight (SSD) as (**B**). This entire step of obtaining a SSD and weighing shall be completed within 15 seconds of removal from the water bath.

The measured G_{mb} is calculated as follows A ÷ (B **-** C). Record to the nearest 0.001.

1820.10 BACK CALCULATIONS

A. To determine the corrected Gmb at any other gyration (Nx), a back calculation is utilized. To calculate the corrected Gmb use the Gmb of the final compacted specimen and the associated height of the specimen at the desired gyration. The corrected Gmb is calculated as follows :

Calculations:

$$G_{mb\ (corrected)} @ N_x = \frac{Gmb \times hm}{hx}$$

Where:

Gmb = bulk specific gravity of the compacted specimen
Nx = desired gyrations
hm = final height of the extruded specimen (mm)
hx = height of specimen at the desired gyration (mm)