ATT-77/2022 THEORETICAL MAXIMUM SPECIFIC GRAVITY OF BITUMINOUS PAVING MIXTURES

1.0 SCOPE

This method describes the procedures and Test Methods used for the determination of the theoretical maximum specific gravity (G_{mm}) of uncompacted asphalt paving mixtures at 25°C.

Specific gravity as determined by this method, is the ratio of the mass of a given volume of material at 25°C to the mass of an equal volume of water at the same temperature. Specific Gravity is unit-less.

The G_{mm} represents the maximum theoretical mass of a unit volume of an asphalt paving mixture with no air voids present in the mixture.

2.0 APPLICABLE DOCUMENTS

ASTM D2041 Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures.

3.0 EQUIPMENT

Vacuum Bowl – Metal, glass, or plastic bowl between 2,000 and 10,000 ml as required by the minimum sample size requirements in Table 1. The bowl should be capable of withstanding the applied vacuum pressure without deforming.

Vacuum Bowl Lid – A transparent lid fitted with a rubber gasket, with a suitable vacuum connection. This transparent lid allows for observation of the release of air bubbles during vacuum.

Bowl Lid – A glass, metal, or plastic cover with a vented opening.

Vacuum pump or Water Aspirator – capable of evacuating air from the vacuum bowl to a residual pressure of 30 mm of Hg (4.0 kPa) or less.

Manometer or Vacuum Gauge – Capable of measuring the vacuum being applied at the source of the vacuum.

Dryer/Desiccant (Water Trap) – to be installed between the vacuum vessel and vacuum source to reduce the amount of water vapour entering the vacuum pump.

Residual pressure manometer or vacuum gauge – Traceable to NIST and capable of confirming the vacuum being applied to the vacuum bowl, and capable of measuring residual pressure down to 30 mm of Hg (4.0 kPa) or less.

Bleeder Valve – attached to the vacuum train to facilitate both the adjustment of the vacuum being applied to the vacuum vessel and the slow release of vacuum pressure.

Mechanical Agitation Device – capable of applying a gentle but consistent agitation of the sample. This device shall be equipped with a means of firmly anchoring the container so that it does not move on the surface of the device.

Water Bath – capable of maintaining a constant temperature of 25 ± 1°C. The water bath must be of sufficient size to accommodate immersion of the suspended container with its deaerated sample.

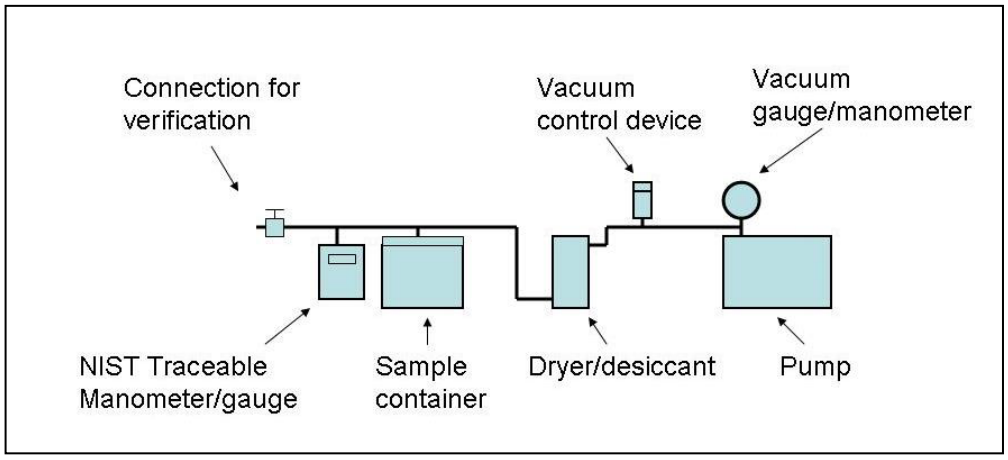
Timer or Stopwatch – used to check the vacuum and agitation time requirement of 15 ± 2 min. Also used to check the time for stabilizing the bowl and sample temperature in the water bath for the required 10 ± 1 min.

Thermometers – Standardized liquid-in-glass, or electronic digital total immersion type, accurate to 0.5°C.

Electronic Balance – capable of reading to 0.1 g and having an accuracy of at least 0.01% of the sample mass. The balance may be equipped with a suitable suspension apparatus and holder to permit weighing the sample and container in a temperature controlled water bath. The balance must be operated and calibrated as per manufacturer's recommendations.

Lab Oven – capable of maintaining a temperature of 110 ± 5°C.

Example of the MTD Setup:



4.0 PROCEDURE

4.1 Calibration of Containers

Two procedures are covered here – Bowl & Flask

4.1.1 Bowls

If the bowl is used for weighing under the scale, calibrate the container by accurately determining the mass of the container immersed in potable water at 25 ± 1°C, for 10 ± 1 min. ***Designate this mass as "B".***

If the bowl is used for weighing in air, on top of the balance, place the volumetric lid on the bowl in a water bath for 10 ± 1 min. Remove the water filled bowl with the lid in place, and dry the outside of the bowl & lid, prior to determining the combined mass of the bowl, lid, and water.
Repeat three times and average the results.
Designate this mass as "D".
Measure and record the temperature of the water in the bath also.

4.1.2 Flasks

Calibrate the volumetric flask by accurately determining the mass of the flask filled with water at the temperature of 25 ± 1°C. Accurate, and consistent filling of the flask shall be ensured by the use of a glass cover plate, or similar smooth flat transparent plate.
Designate this mass as "D".
Measure and record the temperature of the water in the bath also.

4.2 Test Sample Preparation

1. As per ATT-37, SAMPLING, Mixes, 3.2.5 Sampling Mix behind Paver, the field samples should be obtained from the mat behind the paver, stored in an insulated container, and then returned to the mobile lab for testing. Once the sample arrives at the lab, it is poured into large mixing pan, then thoroughly blended so that a representative sample can be obtained.

2. The appropriate MTD minimum sample size, as shown in Table 1 below, is then weighed out into a tare pan, and allowed to cool to room temperature.

3. During the cooling process, separate the particles by hand, taking care to avoid fracturing any aggregate, so that the particles of the fine aggregate portion are not larger than ¼" (6.25mm).

4. If the field sample has cooled too much, and is not sufficiently soft to be separated manually, it can be placed inside a lab oven at 110°C only until it is pliable enough to be separated by hand.

5. After separating the whole test sample, wait till the sample has cooled to room temperature, before proceeding with the testing.

TABLE 1 Test Sample Size for G_{mm}	
Nominal Maximum Aggregate Size mm	**Minimum Mass g**
40	4000
16 - 25	2500
12.5 or smaller	1500

4.3 Procedure – General

Two different procedures, the bowl and flask method, are covered here.
The first 9 steps are for both bowl & flask.

1. Determine and record the mass of the dry bowl or flask, including the cover, to the nearest 0.1 gram.

2. Place the sample into the bowl or flask.

3. Determine and record the mass of the dry bowl or flask, cover, and loose mix MTD sample to the nearest 0.1 gram.

4. Determine and record the actual mass of the sample by subtracting the mass determined in step 1 from the mass determined in Step 3.
   Designate this mass as "A".

5. Add sufficient water, at approximately 25°C, into the bowl or flask, to completely submerge the sample by about 25mm (1 inch).

6. Place the lid on the bowl, or flask, and attach the vacuum line. To ensure a proper seal between the flask and the lid, wet the O-ring.

7. Remove all entrapped air by subjecting the contents to a partial vacuum of 27.5 ± 2.5mm Hg for 15 ± 2 minutes.

8. Agitate the container and contents, either continuously by mechanical device, or manually by vigorous shaking at 2 minute intervals. This agitation also facilitates the removal of any entrapped air.

9. At the end of the vacuum period, turn off the vacuum pump, then gradually release the vacuum pressure using the bleeder valve, remove the bowl from the agitation device, then remove the lid.

10. ***Weighing in Water (Bowl)*** – Slowly suspend the bowl (without lid), under a balance equipped with a suitable suspension apparatus and holder (to permit weighing the sample and container in a temperature controlled water bath), for 10 ± 1 minutes, ***then determine and record this mass as "B".***
Measure and record the temperature of the water in the bowl.

11. ***Weighing in Air (Bowl)*** – Slowly submerge the bowl and sample in the 25 ± 1°C water bath, where it shall remain for 10 ± 1 minute. The lid shall also be placed in the water bath at the same time. While underwater, slide the lid onto the bowl without removing from the water so as to avoid entrapping any air, then firmly press the lid down onto the bowl. Remove the bowl with the lid in place from the water bath. Carefully dry the bowl and lid.
Determine and record the mass of the bowl, sample, and lid.
Measure and record the temperature of the water in the bowl.

    Repeat this procedure a second time by removing the lid and placing both the lid and the bowl back into the water bath. While underwater, slide the lid back onto the bowl without removing from the water so as to avoid entrapping any air, then firmly press the lid back down onto the bowl. It is not necessary to wait the 10 minutes before taking the second reading. Remove the bowl with the lid in place from the water bath. Carefully dry the bowl and lid. ***Determine and record the mass of the bowl, sample, and lid.***

    If the mass varies by more than 1.0 gram, repeat the procedure until any two mass readings are within 1.0 gram.

    Designate the average mass of these two readings as the mass of the bowl, lid, water and sample.

12. ***Weighing in Air (Flask)*** – Slowly fill the flask with water taking care not to introduce air into the sample. Place the flask into the water bath for 10 ± 1 minute to stabilize the temperature without submerging the top of the flask. Measure and record the temperature of the water in the flask. Remove the thermometer and completely fill the flask. Slide the cover plate over the top of the flask, taking care not to entrap air beneath the cover plate. The cover plate shall be the same one used during the calibration of the flask. Wipe any moisture from the exterior of the container and cover plate. Determine the mass of the flask, plate, and its cover plate.
Determine the mass of the flask, plate, and its contents completely filled with water. Designate this mass as E.

    Measure and record the temperature of the water in the flask *after the test is completed.*

5.0 CALCULATIONS

Calculate the G_{mm} to three decimal places:

A. Weighing in Water

BOWL PROCEDURE:

$$G_{mm} = A / (A - (C - B))$$

Where: A = mass of dry sample in air (g)

B = submerged mass of bowl under water (g), at 25°C, as determined during the Calibration Procedure.

C = submerged mass of bowl & sample under water (g), at 25°C.

B. Weighing in Air

BOWL or FLASK PROCEDURE:

$$G_{mm} = A / (A + D - E)$$

Where: A = mass of dry sample in air (g)

D = Mass of flask (or bowl), filled with water at 25°C, in grams, as determined during the Calibration Procedure.

E = Mass of flask (or bowl) and test sample, filled with water, at the test temperature, in grams.

6.0 WATER TEMPERATURE

Ensure the water temperature is maintained at 25°C ± 1°C.

Measure and record the temperature of the water on the test data sheet immediately after each test.

Temperature Corrections are not applied in order to simplify the calculations.

NOTE: Temperatures outside the allowable tolerance will affect the volumes and measured Specific Gravity.