Specification Year: January 2015
The terms Gmm or Maximum Specific Gravity or Rice gravity are often used interchangeably
The maximum specific gravity test is one of the most important tests run on the mix. It is the basis for all volumetric calculations including air voids and density. It accounts for the specific gravity of the aggregate gradation and is influenced by the source of the aggregate, and also accounts for the asphalt binder in the mix. It is crucial that proper procedures are used since the test is the basis for many other values used in the determining the quality of the mix.
Listed on the next two slides is the equipment needed to conduct this test. The test method is FM 1-T 209.
FM 1-T 209

Equipment

- Orbital shaker
  - Orbit of 3/4 inch
  - Able to shake 2 containers at a time
- Stop watch (timer)
- Valves

More equipment.
Shown here is a typical setup in a production lab. Other setups are used and vary in piping and the location of the pump/manometer. But, it is important that all the required elements are present in any setup.
A close-up picture of the orbital shaker, vacuum lines, desiccators, and vacuum pump. One of the keys for longevity of the vacuum pump is a series of moisture traps that include the use of a desiccant (moisture absorbing material). Allowing moisture to get into the pump will cause it to fail, and good quality pumps are expensive.
The remainder of the equipment needed to run this test is shown.
Shown here is a typical setup showing the testing equipment needed to conduct the maximum specific gravity test. This method is also commonly referred to as the Rice test, named after the inventor, Jim Rice.
The first step in conducting this test is to calibrate the flask. A capable and accurate scale meeting these requirements is needed. A scale like this will be common in the asphalt testing lab.
The next step is to determine the volume of the inside of the flask. Weigh the empty dry flask and cover plate to get a dry weight. Fill the flask completely with water and use a cover plate. Make sure the water temperature has stabilized to 77 + 2°F. Slide on the cover plate.

Getting the cover plate on properly (no entrapped air in the flask) takes a little practice, but can be mastered in a short time. Once the flask is full of water and the outside of the flask wiped dry, it is weighed again. Subtracting the empty flask weight from the flask plus water weight leaves the water weight. The water weight in grams is equal to the volume of the flask in cubic centimeters, as 1 gm = 1 cc, at a standard temperature of 77°F. This step should be done ahead of time prior to the mix samples arriving, so there is no delay.

Calibrate once a month, or if dry weight change is > 0.4g.

- Fill flask with water at 77° ± 2°F.
- Use cover plate to get accurate filling.
- Do not trap air.
- Weigh flask and water.
The next step is to obtain the mix samples, as shown in an earlier module. Secure a sample size of 2,000-2,200 grams. The test consists of running two complete samples weighing 1,000 to 1,100 grams each. These samples are conditioned in the oven for one hour to simulate haul time.

*From the Specifications.*

**Sampling and Testing Requirements:** … Prior to testing volumetric samples, condition the test-sized sample for one hour ± five minutes at the target roadway compaction temperature in a shallow, flat pan, such that the mixture temperature at the end of the one hour conditioning period is within ± 20° F of the roadway compaction temperature.

Once the conditioning period is completed, the Rice samples are cooled and tested, as shown in the following slides.

Obtain by FM 1-T 168. Total sample size = 2,000 to 2,200 grams. Divided into two 1,000 to 1,100 gram samples. Condition samples. Cool and separate particles.
The video shown here walks through the steps to run a Gmm test including the flask calibration. The time in compressed to show the main steps. This is a very important test as it serves as the foundation for the air voids and density calculations. Following the procedure without inducing shortcuts is critical.
As the mix cools, the agglomerations or chunks of asphalt need to be separated by hand. Simply rubbing the mix between your hands is normally sufficient. The goal is to separate any chunks of fine sand and asphalt binder to less than ¼ inch in size. We do not want trapped air bubbles left in the mix at this stage. It will affect the test results. If the mix cools off too rapidly, it may need to be warmed enough to separate the chunks.

Separate particles to less than ¼ inch. Warm if necessary.
Once the mix is sufficiently separated, add the sample to the flask (make sure you get the entire sample from the pan) and weigh. Again, we are going to run two flasks and then compare and average the results. Each flask will contain ½ of the Rice sample.

Add cooled sample to flask and weigh.
Shake the container gently to make sure the mix has not recombined or chunked up again. No trapped air pockets.

Shake container until mix moves freely.

Do not pound on the flask! This can cause it to break. A broken flask means start over. And it can cause a serious injury.
Add wetting agent to the water to help remove air. 1,000 ml H₂O + 1 ml aerosol.

The next step is to partially fill the flask, covering the sample completely. A wetting agent, such as aerosol, is used at the rate of 1 ml per 1,000 ml of water. The water and aerosol is mixed (see picture) and poured into the flask.

Add wetting agent to water to help remove air. 1,000 ml H₂O + 1 ml aerosol.
The next step is to partially fill the flask, covering the sample completely.
Most laboratories are using digital manometers. Shown is the mercury-filled type. If broken and the mercury spills, proper clean up and disposal procedures are required.

The stopper is placed into each flask and they are loaded in the orbital shaker. The pump is turned on and the manometer is adjusted to read a residual pressure of 30 mm of mercury ± 2 mm within 2 minutes. Shown here is a residual manometer. You calculate the total pressure by adding up each “leg” of column of mercury. There are also digital manometers available. Many labs are trying to eliminate the use of mercury.

Put stopper in and adjust vacuum to 30 ± 2 mm Hg. Achieve within 2 minutes.
Next, the sample is agitated while the vacuum pump removes the air. The orbital shaker is turned on and adjusted to $270 \pm 10$ rpm. The duration of this part of the test is $15 \pm 2$ minutes. Set a timer.

Shake continuously with orbital shaker ($270 \pm 10$ rpm) for $15 \pm 2$ minutes.
Slowly bleed pressure off. Remove stopper. Start a timer for 10 ± 1 minutes.

Once the 15 minutes of orbital shaking have elapsed, turn off the pump and slowly bleed the pressure off the flasks. Set the timer for 10 minutes and the next series of steps need to be completed in that time.

Slowly bleed pressure off. Remove stopper. Start a timer for 10 ± 1 minutes.
Immediately fill the flasks slowly with water to within ½ inch of the top of the flask. Pouring slowly ensures no air is forced into the sample. The goal is to get the flasks filled and the water temperature stabilized to 77ºF + 2ºF as quickly as possible.

Slowly fill with water. Remove entrapped air.
Determine the temperature. Adjust as necessary to 77° ± 2° F.

If the water temperature is outside that range, remove some water and adjust with either warmer or cooler water.

Determine the temperature. Adjust as necessary to 77° ± 2° F.
Fill flask with water and cap with glass plate. Use caution not to trap air.

Between the 9th and 11th minute after releasing the vacuum, fill the remainder of the flask with water and ease on the cover plate using caution to not trap any air. This takes a little practice to master.

Fill flask with water and cap with glass plate. Use caution not to trap air.
Keeping some pressure on the cover plate. Wipe down the flask, including the cover plate.

Carefully dry the outside of the flask and around the cover plate.
Weigh the filled flask. The requirement is to complete this entire process in 10 minutes + 1 minute.

Weigh the flask with contents and the plate. Complete between 9-11 minutes.
Dryback Procedure

The dryback procedure, which is used to determine the saturated surface dry (SSD) weight, will not be performed during production. The Gmm correction factor will be determined at the mix design stage. The correction factor will be included on the mix design and used during production.

\[
\text{Gmm, SSD} = \frac{A}{B+D-E}
\]

\[
\text{Gmm, dry} = \frac{A}{A+D-E}
\]

For reference:
When the dryback procedure is used, the maximum specific gravity (Gmm, SSD) is calculated as follows:
Gmm, SSD =A/(B+D-E)

When the dryback procedure is not used (in situations where a correction factor will be used), the formula is modified as follows:
Gmm, dry =A/(A+D-E)

The correction factor is determined from two Gmm tests (four flasks) using the dryback procedure. This value is referred to as Gmm, SSD. Additionally, for the same two tests, the maximum specific gravity, Gmm, dry, is calculated. For each of the two tests, the Gmm, dry is subtracted from the Gmm, SSD. These two differences are then averaged to obtain the correction factor.

During production, the correction factor is then added to the Gmm, dry values to obtain corrected Gmm, SSD values. The correction factor is either a negative value or equal to zero.

\[
\text{Gmm, SSD #1} - \text{Gmm, dry #1} = \text{Difference #1}
\]
\[
\text{Gmm, SSD #2} - \text{Gmm, dry #2} = \text{Difference #2}
\]
\[
\text{Difference #1} + \text{Difference #2} = \text{Sum of Differences}
\]
\[
\text{Sum of Differences} \div 2 = \text{Correction Factor}
\]
\[
\text{Gmm, dry} + \text{Correction Factor} = \text{Corrected Gmm, SSD}
\]
Drain the water through a 75 μm (200 mesh) sieve.

Following the weighing, start the dryback process. Drain the water through a 200 mesh sieve so that no particles are lost.

Drain the water through a 75 mm (200 mesh) sieve.
Empty as much mix as possible into a clean pan.

Rinse the flask over the sieve.

Once the water is removed, dump the mix into a flat rimmed pan. Rinse the flask out over the sieve. We need to get ALL the mix out of the flask.

Empty as much mix as possible into a clean pan. Rinse the flask over the sieve.
Rinse out flask onto sieve. Once the flask is completely empty, rinse the mix particles caught on the sieve into the pan. There should be no mix left in the sieve.

Rinse any mix material left in the sieve into the pan.
Tilt the pan slightly and let the excess water drain to one end. Blot out water being careful not to remove any of the mix sample.

Remove as much water as possible without losing any sample.
As shown in the picture, spread the mix out in the pan into one thin layer and place in front of a fan. The mixture should be stirred at frequent intervals to facilitate uniform drying.

Spread and dry the sample in front of a fan.
Set a timer and weigh the pan at 15 minute intervals. The saturated surface dried (SSD) condition is reached when the weight loss is less than 0.5 grams in 15 minutes. Stir the mix intermittently. Once SSD condition has been reached, obtain the final weight and proceed to the calculations that follow.

Weigh every 15 minutes. SSD is when the weight loss is less than 0.5 grams. Stir intermittently.
Calculations:

Maximum Specific Gravity = \( \frac{A}{(B + D - E)} \)

- \( A \) = Weight of dry sample
- \( B \) = Final weight surface-dry mass
- \( D \) = Weight of flask filled with water at 77°F
- \( E \) = Weight of flask filled with water and sample at 77°F

The Gmm, SSD formula shown here is used when the dry back procedure is performed.
Here is an example of the Gmm, SSD formula. The weights are in grams.
FM 1-T 209 Calculations

Calculations:

Maximum Specific Gravity = \( \frac{A}{(A + D - E)} \)

\( G_{m,\text{dry}} \)

A = Weight of dry sample
D = Weight of flask filled with water at 77°F
E = Weight of flask filled with water and sample at 77°F

During production, the \( G_{m,\text{dry}} \) values are calculated using the above formula. A correction factor is calculated during the mix design process. This correction factor is added to the \( G_{m,\text{dry}} \) values to obtain the corrected \( G_{m,\text{SSD}} \) values. The correction factor is either a negative value or equal to zero.

Next is an example of the \( G_{m,\text{dry}} \) formula. The weights are in grams.
Here is an example of the $G_{mm, \; dry}$ formula. The weights are in grams. The correction factor for this particular mix is -0.015.

\[
G_{mm, \; dry} = \frac{1,000.1}{(1,000.1 + 4,000.3 - 4,610.4)} = 2.564
\]

\[
Corrected \; G_{mm, \; SSD} = 2.564 + (-0.015) = 2.549
\]

Report to 3 decimal places
The precision of the test method is shown here.

FM 1-T 209
Precision

Acceptance range of 2 results

Single operator: 0.013
Multi-lab: 0.016
FM 1-T 209
Calculations
If difference between the two flasks is \( < 0.013 \)

- Tests are good
  - Average the two results and report
- If not:
  - Results are suspect
  - Repeat testing with different samples

There also needs to be a comparison made between the two Gmm tests conducted. The test results must be within 0.013 of each other to be considered a valid test.
Calculations

Flask 1 max. gravity = 2.505
Flask 2 max. gravity = 2.497
Difference is 0.008

Are results OK?

If OK, report average = (2.497 + 2.505) / 2
= 2.501

This comparison is shown on based on the example problem. The difference between the two tests is 0.008, which is less than the 0.013 allowed. The test results are considered OK. (They compare). Finally, the two test results are averaged together. This is the final Gmm of the sample.
An example of multi-lab precision is shown above. The difference of 0.012 (actual) is less than 0.016 (allowed) so the test results compare. This is used when the VT Gmm test results are compared to the QC Gmm test results.

*Also see the Table for Between-Laboratory Precision Values in Specification 334.*
What do we use the numbers for?

Now that we have the Gmm results, what do we do with them? Again, these are the basis of the air void and density tests. We use the bulk specific gravity (Gmb) of the pills or the cores to calculate these. Shown in the next slide.
Plant Air Voids

- Determines the properties of laboratory compacted specimens

\[
\text{% Air Voids} = \left( \frac{G_{mm} - G_{mb}}{G_{mm}} \right) \times 100
\]

The formula shown here is used to calculate the % air voids. This is covered in more detail in the Asphalt Plant Level 2.
Roadway Density: % of Maximum Gravity

- Very important; establishes baseline
- Gravity of mix in “voidless” state (Gmm)
- Core gravity is compared to Gmm

\[
\frac{G_{mb}}{G_{mm}} \times 100
\]

The formula shown here is used to calculate the roadway density. The Gmb in this case would be the average of the cores from the sublot compared to the Gmm from that same sublot. This is covered more in the Asphalt Paving Level 2.
QUESTIONS ?