THEORETICAL MAXIMUM SPECIFIC GRAVITY (G_{mm}) AND DENSITY OF HOT MIX ASPHALT (HMA) PAVING MIXTURES
FOP FOR AASHTO T 209

Scope

This procedure covers the determination of the maximum specific gravity (G_{mm}) of uncompacted hot mix asphalt (HMA) paving mixtures in accordance with AASHTO T 209-12. Two methods using different containers – bowl and pycnometer / volumetric flask– are covered.

Specimens prepared in the laboratory shall be cured according to agency standards.

Apparatus

- Balance or scale: 10,000 g capacity, readable to 0.1 g
- Container: A glass, metal, or plastic bowl, pycnometer or volumetric flask between 2000 and 10,000 mL as required by the minimum sample size requirements in Table 1 sample and capable of withstanding a partial vacuum
- Pycnometer / volumetric flask cover: A glass plate or a metal or plastic cover with a vented opening
- Vacuum lid: A transparent lid with a suitable vacuum connection, with a vacuum opening to be covered with a fine wire mesh
- Vacuum pump or water aspirator: Capable of evacuating air from the container to a residual pressure of 4.0 kPa (30 mm Hg)
- Residual pressure manometer or vacuum gauge: Traceable to NIST and capable of measuring residual pressure down to 4.0 kPa (30 mm Hg) or less
- Manometer or vacuum gauge: Capable of measuring the vacuum being applied at the source of the vacuum
- Water bath: A constant-temperature water bath (optional)
- Thermometers: Standardized liquid-in-glass, or electronic digital total immersion type, accurate to 0.5°C (1°F)
- Bleeder valve to adjust vacuum
- Automatic vacuum control unit (optional)
- Timer

Standardization of Pycnometer or Volumetric Flask

Use a pycnometer / volumetric flask that is standardized to accurately determine the mass of water, at 25 ±0.5°C (77 ±1°F), in the pycnometer / volumetric flask. The pycnometer / volumetric flask shall be standardized periodically in conformance with procedures established by the agency.

Test Sample Preparation

1. Obtain samples in accordance with the FOP for AASHTO T 168 and reduce according to the FOP for AASHTO R 47.

2. Test sample size shall conform to the requirements of Table 1. Samples larger than the capacity of the container may be tested in two or more increments. Results will be combined and averaged. If the increments have a specific gravity difference greater than 0.014 the test must be re-run.

Table 1
Test Sample Size for G_{mm}

Nominal Maximum* Aggregate Size mm (in.)	Minimum Mass g
37.5 or greater (1½)	4000
19 to 25 (3/4 to 1)	2500
12.5 or smaller (1/2)	1500

*Nominal maximum size: One sieve larger than the first sieve to retain more than 10 percent of the material using an agency specified set of sieves based on cumulative percent retained.

Procedure – General

Two procedures – bowl and pycnometer / volumetric flask – are covered. The first 11 steps are the same for both.

1. Separate the particles of the sample, taking care not to fracture the mineral particles, so that the particles of the fine aggregate portion are not larger than 6.3 mm (1/4 in.). If the mixture is not sufficiently soft to be separated manually, place it in a large flat pan and warm in an oven only until it is pliable enough for separation.

2. Cool the sample to room temperature.

3. Determine and record the mass of the dry container to the nearest 0.1 g.

4. Place the sample in the container.

5. Determine and record the mass of the dry container and sample to the nearest 0.1 g.

6. Determine and record the mass of the sample by subtracting the mass determined in Step 3 from the mass determined in Step 5. Designate this mass as "A."

7. Add sufficient water at approximately 25° C (77° F) to cover the sample by about 25 mm (1 in.).

Note 1: The release of entrapped air may be facilitated by the addition of a wetting agent. Check with the agency to see if this is permitted and, if it is, for a recommended agent.

8. Place the lid on the container and attach the vacuum line. To ensure a proper seal between the container and the lid, wet the O-ring or use a petroleum gel.

9. Remove entrapped air by subjecting the contents to a partial vacuum of 3.7 ±0.3 kPa (27.5 ±2.5 mm Hg) residual pressure for 15 ±2 minutes.

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

11. Release the vacuum. Increase the pressure to atmospheric pressure in 10 to 15 seconds if the vacuum release is not automated. Turn off the vacuum pump and remove the lid. When performing the pycnometer / volumetric flask method, complete steps 12B through 16B within 10±1 minute.

Procedure – Bowl

12A. Fill the water bath to overflow level with water at 25 ±1°C (77 ±2°F) and allow the water to stabilize.

13A. Zero or tare the balance with the immersion apparatus attached, ensuring that the device is not touching the sides or the bottom of the water bath.

14A. Suspend and immerse the bowl and contents in water at 25 ±1°C (77 ±2°F) for 10 ±1 minutes. The holder shall be immersed sufficiently to cover both it and the bowl.

15A. Determine and record the submerged weight of the bowl and contents to the nearest 0.1 g.

16A. Refill the water bath to overflow level.

17A. Empty and re-submerge the bowl following Step 12A to determine the submerged weight of the bowl to the nearest 0.1 g.

18A. Determine and record the submerged weight of the sample to the nearest 0.1 g by subtracting the submerged weight of the bowl from the submerged weight determined in Step 15A. Designate this submerged weight as “C.”

Procedure – Pycnometer or Volumetric Flask

12B. Immediately fill the pycnometer / volumetric flask with water without reintroducing air.

13B. Stabilize the temperature of the pycnometer / volumetric flask and contents so that the final temperature is within 25 ±1°C (77 ±2°F).

14B. Finish filling the pycnometer / volumetric flask with water that is 25 ±1°C (77 ±2°F), place the cover or a glass plate on the pycnometer / volumetric flask, and eliminate all air.

Note 2: When using a metal pycnometer and cover, place the cover on the pycnometer and push down slowly, forcing excess water out of the hole in the center of the cover. Use care when filling the pycnometer to avoid reintroducing air into the water.

15B. Towel dry the outside of the pycnometer / volumetric flask and cover.

16B. Determine and record the mass of the pycnometer / volumetric flask, cover, de-aired water, and sample to the nearest 0.1 g. within 10 ±1 minutes of completion of Step 11. Designate this mass as "E."

Procedure – Mixtures Containing Uncoated Porous Aggregate

If the pores of the aggregates are not thoroughly sealed by a bituminous film, they may become saturated with water during the vacuuming procedure, resulting in an error in maximum density. To determine if this has occurred, complete the general procedure and then:

1. Carefully drain water from sample through a towel held over the top of the container to prevent loss of material.

2. Spread sample in a flat shallow pan and place before an electric fan to remove surface moisture.

3. Determine the mass of the sample when the surface moisture appears to be gone.

4. Continue drying and determine the mass of the sample at 15-minute intervals until less than a 0.5 g loss is found between determinations.

5. Record the mass as the saturated surface dry mass to the nearest 0.1 g. Designate this mass as "ASSD."

6. Calculate, as indicated below, G_{mm} using "A" and "ASSD," and compare the two values.

Calculation

Calculate the G_{mm} to three decimal places as follows:

Bowl Procedure

$$G_{mm} = \frac{A}{A - C} \qquad or \qquad G_{mm} = \frac{A}{A_{SSD} - C}$$

(for mixes containing uncoated aggregate materials)

where:

A = mass of dry sample in air, g

A_{SSD} = Mass of saturated surface dry sample in air, g

C = submerged weight of sample in water, g

Example:

A = 1432.7 g

A_{SSD} = 1434.2 g

C = 848.6 g

$$G_{mm} = \frac{1432.7\ g}{1432.7\ g - 848.6\ g} = 2.453 \qquad or \qquad G_{mm} = \frac{1432.7\ g}{1434.2\ g - 848.6\ g} = 2.447$$

Pycnometer / Volumetric Flask Procedure

$$G_{mm} = \frac{A}{A + D - E} \qquad or \qquad G_{mm} = \frac{A}{A_{SSD} + D - E}$$

(for mixtures containing uncoated materials)

where:

A = Mass of dry sample in air, g

A_{SSD} = Mass of saturated surface-dry sample in air, g

D = Mass of pycnometer / volumetric flask filled with water at 25°C (77°F), g, determined during the Standardization of Pycnometer / Volumetric Flask procedure

E = Mass of pycnometer / volumetric flask filled with water and the test sample at test temperature, g

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Example (in which two increments of a large sample are averaged):

Increment 1	Increment 2
A = 2200.3 g	A = 1960.2 g
D = 7502.5 g	D = 7525.5 g
E = 8812.0 g	E = 8690.8 g
Temperature = 26.2°C	Temperature = 25.0°C

$$G_{mm_1} = \frac{2200.3\ g}{2200.3\ g + 7502.5\ g - 8812.0\ g} = 2.470$$

$$G_{mm_2} = \frac{1960.2\ g}{1960.2\ g + 7525.5\ g - 8690.8\ g} \times 1.00000 = 2.466$$

Allowable variation is: 0.014

2.470 - 2.466 = 0.004, which is < 0.014, so they can be averaged.

Average:

2.470 + 2.466 = 4.936 4.936 ÷ 2 = **2.468**

Theoretical Maximum Density

To calculate the theoretical maximum density at 25°C (77°F) use one of the following formulas. The density of water at 25°C (77°F) is 997.1 in Metric units or 62.245 in English units.

Theoretical maximum density $kg/m^3 = G_{mm} \times 997.1\ kg/\ m^3$

$2.468 \times 997.1\ kg/\ m^3 = 2461\ kg/\ m^3$

or

Theoretical maximum density $lb/ft^3 = G_{mm} \times 62.245\ lb/ft^3$

$2.468 \times 62.245\ lb/ft^3 = 153.6\ lb/ft^3$

Report

- Results on forms approved by the agency
- Sample ID
- G_{mm} to three decimal places
- Theoretical maximum density to1 kg/m^3 ($0.1\ lb/ft^3$)

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PERFORMANCE EXAM CHECKLIST

THEORETICAL MAXIMUM SPECIFIC GRAVITY AND DENSITY OF HOT MIX ASPHALT (HMA) PAVING MIXTURES FOP FOR AASHTO T 209

Participant Name _____ Exam Date _____

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	**Trial 1**	**Trial 2**
1. Sample reduced to correct size?	_____	_____
2. Particles carefully separated insuring that aggregate is not fractured?	_____	_____
3. After separation, fine aggregate particles not larger than 6.3 mm (1/4 in.)?	_____	_____
4. Sample at room temperature?	_____	_____
5. Mass of container determined to 0.1 g?	_____	_____
6. Mass of sample and container determined to 0.1 g?	_____	_____
7. Mass of sample calculated and conforms to required size?	_____	_____
8. Water at approximately 25°C (77°F) added to cover sample?	_____	_____
9. Entrapped air removed using partial vacuum for 15 ±2 min?	_____	_____
10. Container and contents agitated continuously by mechanical device or manually by vigorous shaking at intervals of about 2 minutes?	_____	_____
11. Vacuum released to atmospheric pressure in 10 to 15 seconds if not auto controlled?	_____	_____
12. Vacuum pump turned off?	_____	_____
13. Bowl determination:		
a. Water bath filled to the overflow level?	_____	_____
b. Bowl and contents suspended in water at 25 ±1°C (77 ±2°F) for 10 ±1 minutes?	_____	_____
c. Submerged weight of bowl and contents determined to 0.1 g?	_____	_____
d. Submerged weight of empty bowl determined to 0.1 g?	_____	_____
e. Net submerged weight of contents calculated?	_____	_____

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Procedure Element	**Trial 1**	**Trial 2**
14. Pycnometer / Volumetric Flask determination:		
a. Pycnometer / volumetric flask filled with water without reintroducing air into the sample?	_____	_____
b. Contents stabilized at 25 ±1°C (77 ±2°F)	_____	_____
c. Pycnometer / volumetric flask completely filled with water that is 25 ±1°C (77 ±2°F)?	_____	_____
d. Mass of filled pycnometer / volumetric flask and cover determined to 0.1 g, 10 ±1 minutes after removal of entrapped air completed?	_____	_____
e. Mass of pycnometer / volumetric flask, cover, and water obtained from the Standardization of Pycnometer or Volumetric Flask procedure?	_____	_____
15. G_{mm} calculated correctly and reported to 0.001?	_____	_____
16. Density calculated correctly and reported to 1 kg/m^3 (0.1 lb/ft^3)?	_____	_____

Comments: First attempt: Pass_____Fail_____ Second attempt: Pass_____Fail_____

Examiner Signature _____WAQTC #:_____