

BULK SPECIFIC GRAVITY (G_{mb}) OF COMPACTED ASPHALT MIXTURES USING SATURATED SURFACE-DRY SPECIMENS FOP FOR AASHTO T 166

Scope

This procedure covers the determination of bulk specific gravity (G_{mb}) of compacted asphalt mixtures using three methods – A, B, and C – in accordance with AASHTO T 166-21. This FOP is for use on specimens not having open or interconnecting voids or absorbing more than 2.00 percent water by volume, or both. When specimens have open or interconnecting voids or absorbing more than 2.00 percent water by volume, or both, AASHTO T 275 or AASHTO T 331 should be performed.

Overview

- Method A: Suspension
- Method B: Volumeter
- Method C: Rapid test for A or B

Test Specimens

Test specimens may be either laboratory-molded or sampled from asphalt mixture pavement. For specimens it is recommended that the diameter be equal to four times the maximum size of the aggregate and the thickness be at least one and one half times the maximum size.

Terminology

Constant Mass: The state at which a mass does not change more than a given percent, after additional drying for a defined time interval, at a required temperature.

Apparatus – Method A (Suspension)

- Balance or scale: 5 kg capacity, readable to 0.1 g, and fitted with a suitable suspension apparatus and holder to permit weighing the specimen while suspended in water, conforming to AASHTO M 231.
- Suspension apparatus: Wire of the smallest practical size and constructed to permit the container to be fully immersed.
- Water bath: For immersing the specimen in water while suspended under the balance or scale and equipped with an overflow outlet for maintaining a constant water level.
- Towel: Damp cloth towel used for surface drying specimens.
- Oven: Capable of maintaining a temperature of $110 \pm 5^{\circ}\text{C}$ ($230 \pm 9^{\circ}\text{F}$) for drying the specimens to a constant mass.

- Pan: Pan or other suitable container of known mass, large enough to hold a sample for drying in oven.
- Thermometer: Having a range of 19 to 27°C (66 to 80°F), graduated in 0.1°C (0.2°F) subdivisions.
- Vacuum device: refer to the FOP for AASHTO R 79 (optional)

Procedure – Method A (Suspension)

Recently molded laboratory samples that have not been exposed to moisture do not need drying.

1. Dry the specimen to constant mass, if required.
 - a. Oven method
 - i. Initially dry overnight at $52 \pm 3^\circ\text{C}$ ($125 \pm 5^\circ\text{F}$).
 - ii. Determine and record the mass of the specimen. Designate this mass as M_p .
 - iii. Return the specimen to the oven for at least 2 hours.
 - iv. Determine and record the mass of the specimen. Designate this mass as M_n .
 - v. Determine percent change by subtracting the new mass determination, M_n , from the previous mass determination, M_p , divide by the previous mass determination M_p , and multiply by 100.
 - vi. Continue drying until there is no more than 0.05 percent change in specimen mass after 2-hour drying intervals (constant mass).
 - vii. Constant mass has been achieved; sample is defined as dry.
 - b. Vacuum dry method according to the FOP for AASHTO R 79.
2. Cool the specimen in air to $25 \pm 5^\circ\text{C}$ ($77 \pm 9^\circ\text{F}$), and determine and record the dry mass to the nearest 0.1 g. Designate this mass as A.
3. Fill the water bath to overflow level with water at $25 \pm 1^\circ\text{C}$ ($77 \pm 2^\circ\text{F}$) and allow the water to stabilize.
4. 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.
5. Immerse the specimen shaking to remove the air bubbles. Place the specimen on its side in the suspension apparatus. Leave it immersed for 4 ± 1 minutes.
6. Determine and record the submerged weight to the nearest 0.1 g. Designate this submerged weight as C.
7. Remove the sample from the water and quickly surface dry with a damp cloth towel within 5 seconds.

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8. Zero or tare the balance.
9. Immediately determine and record the mass of the saturated surface-dry (SSD) specimen to nearest 0.1 g. Designate this mass as B. Any water that seeps from the specimen during the mass determination is considered part of the saturated specimen. Do not exceed 15 seconds performing Steps 7 through 9.

Calculations – Method A (Suspension)

Constant Mass:

Calculate constant mass using the following formula:

$$\%Change = \frac{M_p - M_n}{M_p} \times 100$$

Where:

M_p = previous mass measurement, g

M_n = new mass measurement, g

Bulk specific gravity (G_{mb}) and percent water absorbed:

$$G_{mb} = \frac{A}{B - C}$$

$$\text{Percent Water Absorbed (by volume)} = \frac{B - A}{B - C} \times 100$$

Where:

A = Mass of dry specimen in air, g

B = Mass of SSD specimen in air, g

C = Weight of specimen in water at $25 \pm 1^\circ\text{C}$ ($77 \pm 2^\circ\text{F}$), g

Example:

$$G_{mb} = \frac{4833.6 \text{ g}}{4842.4 \text{ g} - 2881.3 \text{ g}} = 2.465$$

$$\% \text{ Water Absorbed (by volume)} = \frac{4842.4 \text{ g} - 4833.6 \text{ g}}{4842.4 \text{ g} - 2881.3 \text{ g}} \times 100 = 0.45\%$$

Given:

A	=	4833.6 g
B	=	4842.4 g
C	=	2881.3 g

Apparatus – Method B (Volumeter)

- Balance or scale: 5 kg capacity, readable to 0.1 g and conforming to AASHTO M 231.
- Water bath: Thermostatically controlled to $25 \pm 0.5^\circ\text{C}$ ($77 \pm 0.9^\circ\text{F}$).
- Thermometer: Range of 19 to 27°C (66 to 80°F) and graduated in 0.1°C (0.2°F) subdivisions.
- Volumeter: Calibrated to 1200 mL or appropriate capacity for test sample and having a tapered lid with a capillary bore.
- Oven: Capable of maintaining a temperature of $110 \pm 5^\circ\text{C}$ ($230 \pm 9^\circ\text{F}$) for drying the specimens to a constant mass.
- Pan: Pan or other suitable container of known mass, large enough to hold a sample for drying in oven.
- Towel: Damp cloth towel used for surface drying specimens.
- Vacuum device: refer to the FOP for AASHTO R 79 (optional)

Procedure – Method B (Volumeter)

Recently molded laboratory samples that have not been exposed to moisture do not need drying.

1. Dry the specimen to constant mass, if required.
 - a. Oven method:
 - i. Initially dry overnight at $52 \pm 3^{\circ}\text{C}$ ($125 \pm 5^{\circ}\text{F}$).
 - ii. Determine and record the mass of the specimen. Designate this mass as M_p .
 - iii. Return the specimen to the oven for at least 2 hours.
 - iv. Determine and record the mass of the specimen. Designate this mass as M_n .
 - v. Determine percent change by subtracting the new mass determination, M_n , from the previous mass determination, M_p , divide by the previous mass determination, M_p , and multiply by 100.
 - vi. Continue drying until there is no more than 0.05 percent change in specimen mass after 2-hour drying intervals (constant mass).
 - vii. Constant mass has been achieved; sample is defined as dry.

Note 1: To expedite the procedure, steps 1 and 2 may be performed last. To further expedite the process, see Method C.

- b. Vacuum dry method according to the FOP for AASHTO R 79.
2. Cool the specimen in air to $25 \pm 5^{\circ}\text{C}$ ($77 \pm 9^{\circ}\text{F}$), and determine and record the dry mass to the nearest 0.1 g. Designate this mass as A.
3. Immerse the specimen in the temperature-controlled water bath for at least 10 minutes.
4. Fill the volumeter with distilled water at $25 \pm 1^{\circ}\text{C}$ ($77 \pm 2^{\circ}\text{F}$) making sure some water escapes through the capillary bore of the tapered lid.
5. Wipe the volumeter dry. Determine the mass of the volumeter to the nearest 0.1 g. Designate this mass as D.
6. At the end of the ten-minute period, remove the specimen from the water bath and quickly surface dry with a damp cloth towel within 5 seconds.
7. Immediately determine and record the mass of the SSD specimen to the nearest 0.1 g. Designate this mass as B. Any water that seeps from the specimen during the mass determination is considered part of the saturated specimen.
8. Place the specimen in the volumeter and let stand 60 seconds.
9. Bring the temperature of the water to $25 \pm 1^{\circ}\text{C}$ ($77 \pm 2^{\circ}\text{F}$) and cover the volumeter, making sure some water escapes through the capillary bore of the tapered lid.
10. Wipe the volumeter dry.
11. Determine and record the mass of the volumeter and specimen to the nearest 0.1 g. Designate this mass as E.

Note 2: Method B is not acceptable for use with specimens that have more than 6 percent air voids.

Calculations – Method B (Volumeter)**Constant Mass:**

Calculate constant mass using the following formula:

$$\%Change = \frac{M_p - M_n}{M_p} \times 100$$

Where:

M_p = previous mass measurement, g

M_n = new mass measurement, g

Bulk specific gravity (G_{mb}) and percent water absorbed:

$$G_{mb} = \frac{A}{B + D - E}$$

$$\text{Percent Water Absorbed (by volume)} = \frac{B - A}{B + D - E} \times 100$$

Where:

G_{mb} = Bulk specific gravity

A = Mass of dry specimen in air, g

B = Mass of SSD specimen in air, g

D = Mass of volumeter filled with water at $25 \pm 1^\circ\text{C}$ ($77 \pm 2^\circ\text{F}$), g

E = Mass of volumeter filled with specimen and water, g

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Example:

$$G_{mb} = \frac{4833.6 \text{ g}}{4842.4 \text{ g} + 2924.4 \text{ g} - 5806.0 \text{ g}} = 2.465$$

$$\% \text{ Water Absorbed (by volume)} = \frac{4842.4 \text{ g} - 4833.6 \text{ g}}{4842.4 \text{ g} + 2924.4 \text{ g} - 5806.0 \text{ g}} \times 100 = 0.45\%$$

Given:

A	=	4833.6 g
B	=	4842.4 g
D	=	2924.4 g
E	=	5806.0 g

Method C (Rapid Test for Method A or B)

See Methods A or B.

Note 3: This procedure can be used for specimens that are not required to be saved and contain substantial amounts of moisture. Cores can be tested the same day as obtained by this method.

Procedure – Method C (Rapid Test for Method A or B)

1. Start on Step 3 of Method A or B, and complete that procedure, then determine dry mass, A, as follows.
2. Determine and record mass of a large, flat-bottom container.
3. Place the specimen in the container.
4. Place in an oven at a minimum of 105°C (221°F). Do not exceed the Job Mix Formula mixing temperature.
5. Dry until the specimen can be easily separated into fine aggregate particles that are not larger than 6.3 mm (¼ in.).
6. Determine and record the mass of the specimen. Designate this mass as M_p .
7. Return the specimen to the oven for at least 2 hours.
8. Determine and record the mass of the specimen. Designate this mass as M_n .
9. Determine percent change by subtracting the new mass determination, M_n , from the previous mass determination, M_p , divide by the previous mass determination, M_p , and multiply by 100.

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10. Continue drying until there is no more than 0.05 percent change in specimen mass after 2-hour drying intervals (constant mass).
11. Constant mass has been achieved; sample is defined as dry.
12. Cool in air to $25 \pm 5^{\circ}\text{C}$ ($77 \pm 9^{\circ}\text{F}$).
13. Determine and record the mass of the container and dry specimen to the nearest 0.1 g.
14. Determine and record the mass of the dry specimen to the nearest 0.1 g by subtracting the mass of the container from the mass determined in Step 13. Designate this mass as A.

Calculations – Method C (Rapid Test for Method A or B)

Complete the calculations as outlined in Methods A or B, as appropriate.

Report

- On forms approved by the agency
- Sample ID
- G_{mb} to the nearest 0.001
- Absorption to the nearest 0.01 percent
- Method performed.

PERFORMANCE EXAM CHECKLIST

BULK SPECIFIC GRAVITY OF COMPACTED ASPHALT MIXTURES USING SATURATED SURFACE-DRY SPECIMENS FOP FOR AASHTO T 166

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
Method A:		
1. Mass of dry sample determined.		
a. Sample dried to constant mass if required?	_____	_____
b. Cooled in air to 25 ±5°C (77 ±9°F)?	_____	_____
c. Dry mass determined to 0.1g?	_____	_____
2. Water at the overflow?	_____	_____
3. Balance zeroed?	_____	_____
4. Immersed weight determined.		
a. Water at 25 ±1°C (77 ±2°F)?	_____	_____
b. Immersed, shaken, on side, for 4 ±1 min.?	_____	_____
c. Immersed weight determined to 0.1g?	_____	_____
5. Sample rapidly surface dried with damp towel and saturated surface dry (SSD) mass determined to 0.1 g (entire operation performed within 15 seconds)?	_____	_____
6. G_{mb} calculated to the nearest 0.001?	_____	_____
7. Absorption calculated to the nearest 0.01 percent	_____	_____

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Procedure Element**Trial 1 Trial 2****Method B:**

- | | | |
|----------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|
| 1. Specimen dried, cooled, and mass determined as in Method A? | _____ | _____ |
| 2. Saturated surface-dry (SSD) mass determined to 0.1g. | | |
| a. Immersed at least 10 minutes at 25 ±1°C (77 ±2°F)? | _____ | _____ |
| b. Sample rapidly dried with damp towel? | _____ | _____ |
| c. Specimen mass determined to 0.1 g? | _____ | _____ |
| d. Any water that seeps from specimen included in mass? | _____ | _____ |
| 3. Mass of volumeter filled with distilled water at 25 ±1°C (77 ±2°F) determined? | _____ | _____ |
| 4. SSD specimen placed into volumeter and let stand for 1 minute? | _____ | _____ |
| 5. Temperature of water brought to 25 ±1°C (77 ±2°F) and volumeter covered, allowing some water to escape through the capillary bore of the tapered lid? | _____ | _____ |
| 6. Volumeter wiped dry, and mass of volumeter and contents determined? | _____ | _____ |
| 7. G_{mb} calculated to the nearest 0.001? | _____ | _____ |
| 8. Absorption calculated to the nearest 0.01 percent? | _____ | _____ |

Method C/A:

- | | | |
|-----------------------------------------------------------------------------------------------------|-------|-------|
| 1. Immersed weight determined. | | |
| a. Water at 25 ±1°C (77 ±2°F)? | _____ | _____ |
| b. Immersed, shaken, on side, for 4 ±1 minutes? | _____ | _____ |
| c. Immersed weight determined to 0.1 g? | _____ | _____ |
| 2. Sample rapidly surface dried with damp cloth (within 5 seconds)? | _____ | _____ |
| 3. Saturated surface dry mass determined to 0.1 g? | _____ | _____ |
| 4. Dry mass determined by: | | |
| a. Heating in oven at a minimum of 105°C (221°F)? | _____ | _____ |
| b. Breaking down to 6.3 mm (¼ in.) particles? | _____ | _____ |
| c. Drying in oven to constant mass (change less than 0.05 percent in 2 hours of additional drying)? | _____ | _____ |
| d. Cooled in air to 25 ±5°C (77 ±9°F) and mass determined to 0.1 g? | _____ | _____ |
| 5. G_{mb} calculated to the nearest 0.001? | _____ | _____ |
| 6. Absorption calculated to the nearest 0.01? | _____ | _____ |

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Procedure Element

Trial 1 Trial 2

Method C/B:

- 1. Saturated surface-dry (SSD) mass determined to 0.1g.
 - a. Immersed at least 10 minutes at 25 ±1°C (77 ±2°F)?
 - b. Sample rapidly dried with damp towel (within 5 seconds)?
 - c. Specimen mass determined to 0.1g?
 - d. Any water that seeps from specimen included in mass?
- 2. Mass of volumeter filled with distilled water at 25 ±1°C (77 ±2°F) determined to 0.1 g?
- 3. SSD specimen placed into volumeter and let stand for 1 minute?
- 4. Temperature of water brought to 25 ±1°C (77 ±2°F) and volumeter covered, allowing some water to escape through the capillary pore of the tapered lid?
- 5. Volumeter wiped dry, and mass of volumeter and contents determined to 0.1 g?
- 6. Dry mass determined by:
 - a. Warming in oven at a minimum of 105°C (221°F)?
 - b. Breaking down to 6.3 mm (¼ in.) particles?
 - c. Drying in oven to constant mass (change less than 0.05 percent in 2 hours of additional drying)?
 - d. Cooled in air to 25 ±5°C (77 ±9°F) and mass determined to 0.1 g?
- 7. G_{mb} calculated to the nearest 0.001?
- 8. Absorption calculated to the nearest 0.01 percent?

Comments: First attempt: Pass Fail Second attempt: Pass Fail

Examiner Signature _____ WAQTC #: _____

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