

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 166-24. 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.
- Potable water: Water that is suitable for drinking.
- 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. Use potable water to fill the water bath. The water in the bath does not need to maintain a potable condition but must remain clear at all times.

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- Towel: Damp cloth towel used for surface drying specimens.
- Oven: Capable of maintaining a temperature of $52 \pm 3^{\circ}\text{C}$ ($126 \pm 5^{\circ}\text{F}$) 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 15 to 45°C (59 to 113°F) and, 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 specimens 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 $52 \pm 3^{\circ}\text{C}$ ($126 \pm 5^{\circ}\text{F}$).
 - 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 , dividing by the previous mass determination M_p , and multiplying 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; specimen 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 the 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 suspension apparatus attached, ensuring that the suspension apparatus is completely submerged and 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.

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

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FOP AASHTO T 166 (24)

6. Determine and record the submerged weight to the nearest 0.1 g. Designate this submerged weight as C.
7. Remove the specimen from the water and quickly surface dry with a damp cloth towel within 5 sec.
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 sec. 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:

G_{mb} = Bulk specific gravity

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.
- Potable water: Water that is suitable for drinking.
- Water bath: For immersing the specimen in water, capable of maintaining a uniform temperature at $25 \pm 1^\circ\text{C}$ ($77 \pm 2^\circ\text{F}$). Use potable water to fill the water bath. The water in the bath does not need to maintain a potable condition but must remain clear at all times.
- Thermometer: Range of 15 to 45°C (59 to 113°F) and graduated in 0.1°C (0.2°F) subdivisions.
- Distilled water: Clear, distilled water for filling the volumeter.
- Volumeter: Calibrated to 1200 mL or appropriate capacity for specimen and having a tapered lid with a capillary bore.
- Oven: Capable of maintaining a temperature of $52 \pm 3^\circ\text{C}$ ($126 \pm 5^\circ\text{F}$) for drying the specimens to a constant mass.
- Pan: Pan or other suitable container of known mass, large enough to hold a specimen 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)

Method B is not acceptable for use with specimens that have more than 6 percent air voids. Recently molded laboratory specimens 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 $52 \pm 3^{\circ}\text{C}$ ($126 \pm 5^{\circ}\text{F}$).
 - 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 , dividing by the previous mass determination, M_p , and multiplying 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; specimen is defined as dry.
 - b. Vacuum dry method according to the FOP for AASHTO R 79.

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

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 at $25 \pm 1^{\circ}\text{C}$ ($77 \pm 2^{\circ}\text{F}$) for at least 10 minutes.
4. At the end of the ten-minute period, 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 and water to the nearest 0.1 g. Designate this mass as D.
6. Remove the specimen from the water bath and quickly surface dry with a damp cloth towel within 5 sec.
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 sec.
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, water, and specimen to the nearest 0.1 g. Designate this mass as E.

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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FOP AASHTO T 166 (24)

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

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

- 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.

See Methods A or B.

Note 2: 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 $110 \pm 5 \text{ C}$ ($230 \pm 9 \text{ F}$).
5. Dry until the specimen can be easily separated into fine aggregate particles that are not larger than 6.3 mm ($\frac{1}{4}$ 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 .

ASPHALT

WAQTC

FOP AASHTO T 166 (24)

9. Determine percent change by subtracting the new mass determination, M_n , from the previous mass determination, M_p , dividing by the previous mass determination, M_p , and multiplying by 100.
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; specimen 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 and apparatus completely submerged?	_____	_____
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 (within 5 sec.) with a damp towel and saturated surface dry (SSD) mass determined to 0.1 g (entire operation performed within 15 sec.)?	_____	_____
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 (within 5 sec.) 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 sec.)? | _____ | _____ |
| 3. Saturated surface dry mass determined to 0.1 g? | _____ | _____ |
| 4. Dry mass determined by: | | |
| a. Heating in oven at 110 ± 5 C (230 ± 9 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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WAQTC

FOP AASHTO T 166 (23)

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 sec.)? _____
 - 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. Heating in oven at 110 ± 5 C (230 ± 9 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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