BULK DENSITY AND VOID CONTENT OF ASPHALT

1 SCOPE

This method describes the procedure for the determination of the bulk density, air voids, voids in mineral aggregate (VMA) and voids filled with bitumen (VFB) of asphalt by water displacement and direct measurement. The method is applicable to laboratory prepared specimens or core specimens.

2 SAFETY

This method does not attempt to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this method to establish appropriate occupational health and safety practices that meet statutory regulations.

3 REFERENCED DOCUMENTS

Australian Standards

AS/NZS 2891.2.2 Methods of sampling and testing asphalt - Sample preparation - Compaction of asphalt test specimens using a gyratory compactor

Main Roads Western Australia

WA 701.1	Sampling and Storage of Asphalt
WA 705.1	Preparation of Asphalt for Testing
WA 714.1	Density of Bituminous Materials and Oils
WA 730.1	Bitumen Content and Particle Size Distribution of Asphalt and Stabilised Soils - Centrifuge Method
WA 731.1	Stability and Flow of Asphalt - Marshall Method
WA 732.2	Maximum Density of Asphalt - Rice Method

4 APPARATUS

a) **Balance** readable to at least 0.01 g and capable of below balance mass determinations and having a Limit of Performance (F) of not more than 0.05 g.

b) **Suspension device** such as a wire basket or frame shaped to hold the specimen and suspended from the balance for mass determinations whilst the specimen is immersed in the water bath.

c) **Water bath** with an overflow device for maintaining a constant water level and maintained at a temperature of 25 ± 1 °C.

d) **Paraffin wax** with an approximate melting point of 54 °C to 60 °C and suitably heated to maintain the wax at a temperature slightly above its melting point.

e) **External vernier callipers** readable and accurate to at least 0.02 mm and with a jaw depth of at least half the diameter of the core, i.e. at least 50 mm jaw depth for a Marshall specimen or 100 mm diameter core and with a maximum uncertainty of measurement of less than or equal to ± 0.1 mm.

f) **Thermometer** readable to 0.1 °C and with a measurement of uncertainty of less than or equal to 0.3 °C.

5 PROCEDURE

Unless stated otherwise the term “specimen” refers to either a laboratory prepared specimen or a field core specimen.

(a) Obtain a field core specimen in accordance with WA 701.1 or a laboratory prepared specimen in accordance with WA 731.1 or AS/NZS 2891.2.2.

(b) Prepare a field core specimen in accordance with WA 705.1.

5.1 Water Displacement Method

This method is not applicable to bulk density determinations on open graded asphalt, or dense, non-porous field core specimens.

5.1.1 Uncoated

This method is applicable only to a dense, non-porous laboratory prepared specimen.

(a) Determine the mass (m_1) of the specimen to the nearest 0.01 g.

(b) Determine the mass (m_2) of the suspension device whilst immersed in water to the nearest 0.01 g.

NOTE: It is permissible to “tare to zero” the suspension device whilst immersed in water.

(c) Place the specimen in the suspension device and immerse in the water bath.

NOTES:

i. The specimen shall be stabilised at a temperature of 25 °C ± 5 °C prior to immersion in the water bath. This may be done by placing the specimen in a current of air at a temperature of 25 °C ± 5 °C.

ii. If a stream of air bubbles escapes from the specimen then the test is invalid and must be abandoned.

(d) Determine the mass (m_3) of the specimen and suspension device immersed in water to the nearest 0.01 g.

NOTE: If the mass steadily increases water is penetrating the voids and the test is invalid and must be abandoned.

5.1.2 Paraffin Wax Coated

This method is applicable only to dense, non-porous bulk density determination on an asphalt field core specimen, including stone mastic asphalt.

(a) Determine the density of the paraffin wax (ρ_{wax}) at 25 °C in accordance with WA 714.1.

NOTE: When the same batch of paraffin wax is being used to coat subsequent specimens then the density determination need not be repeated.

(b) Determine the mass (m_1) of the specimen to the nearest 0.01 g.

(c) Coat the specimen with paraffin wax by dipping and rotating as necessary to ensure complete coating with a sufficiently thick layer of paraffin wax to seal the surface voids.

NOTE: The surface of the wax coated specimen may be brushed with additional hot wax in order to fill any pin-point holes.

(d) Determine the mass (m_4) of the wax coated specimen to the nearest 0.01 g.

(e) Determine the mass (m_2) of the suspension device whilst immersed in water to the nearest 0.01 g.

NOTE: Refer to Note 5.1.1(b).

(f) Place the specimen in the suspension device and immerse in the water bath.

NOTE: Refer to Notes 5.1.1(c).

(g) Determine the mass (m_5) of the wax coated specimen and suspension device immersed in water to the nearest 0.01 g.

NOTE: Refer to Note 5.1.1(d).

5.2 Direct Measurement Method

This method is applicable only to open graded, porous bulk density determination on an asphalt core or laboratory prepared specimen.

(a) Measure the height of the specimen to at least 0.02 mm. The height shall be measured five times at approximately equal spaced distances around the specimen. Calculate the average specimen height (h) to the nearest 0.01 mm.

(b) Measure the diameter of the specimen to at least 0.02 mm. The diameter shall be measured six times, two times (at approximately right angles) near the top, middle and bottom of the specimen. Calculate the average specimen diameter (d) to the nearest 0.01 mm.

(c) Determine the mass (m_1) of the specimen to the nearest 0.01 g.

6 CALCULATONS

6.1 Water Displacement Method

6.1.1 Uncoated

(a) Calculate the volume of the specimen using the formula:

$$V_{sample} = \frac{m_1 - (m_3 - m_2)}{\rho_w}$$

Where:

V_{sample} = volume of specimen in cm^3

m_1 = mass of specimen in grams

m_2 = mass of suspension device immersed in water in grams

m_3 = mass of specimen and suspension device immersed in water in grams

ρ_w = density of water at 25^{o}C in g/cm^3 (sufficiently correct to use 0.997).

(b) Calculate the bulk density of the specimen using the formula:

$$\rho_{bulk} = \frac{m_1}{V_{sample}}$$

Where:

ρ_{bulk} = bulk density of specimen in t/m^3

m_1 = mass of specimen in grams

V_{sample} = volume of specimen in cm^3

6.1.2 Parraffin Wax Coated

(a) Calculate the voume of the paraffin wax on the specimen using the formula:

$$V_{wax} = \frac{m_4 - m_1}{\rho_{wax}}$$

Where:

V_{wax} = volume of parraffin wax on specimen in cm^3

m_1 = mass of specimen in grams

m_4 = mass of parraffin wax coated specimen in grams

ρ_{wax} = density of parraffin wax at 25 ºC in kg/L

(b) Calculate the volume of the paraffin wax coated specimen using the formula:

$$V_{sample} = \frac{m_4 - (m_5 - m_2)}{\rho_w}$$

Where:

V_{sample} = volume of parraffin wax coated specimen in cm^3

m_2 = mass of suspension device immersed in water in grams

m_4 = mass of parraffin wax coated specimen in grams

m_5 = mass of parraffin wax coated specimen and suspension device immersed in water in grams

ρ_w = density of water at 25ºC in g/cm^3 (sufficiently correct to use 0.997)

(c) Calculate the bulk density of the specimen using the formula:

$$\rho_{bulk} = \frac{m_1}{V_{sample} - V_{wax}}$$

Where:

ρ_{bulk} = bulk density of specimen in t/m^3

m_1 = mass of specimen in grams

V_{sample} = volume of paraffin wax coated specimen in cm^3

V_{wax} = volume of paraffin wax on specimen in cm^3

6.2 Direct Measurement

(a) Calculate the volume of the specimen using the formula:

$$V_{sample} = \frac{\pi d^2 \times h}{4000}$$

Where:

V_{sample} = volume of specimen in cm^3

π = pi (3.1416)

d = average diameter of specimen in mm

h = average height of specimen in mm

(b) Calculate the bulk density of the specimen using the formula:

$$\rho_{bulk} = \frac{m_1}{V_{sample}}$$

Where:

ρ_{bulk} = bulk density of specimen in t/m^3

m_1 = mass of specimen in grams

V_{sample} = volume of specimen in cm^3

6.3 Air Void Content, VMA and VFB

(a) Calculate the percentage air voids using the formula:

$$\%AIR\ VOIDS = \frac{\rho_{max} - \rho_{bulk}}{\rho_{max}} \times 100$$

Where:

ρ_{max} = maximum density of the asphalt determined by WA 732.2 in t/m^3

ρ_{bulk} = bulk of density of specimen in t/m^3

(b) Calculate the VMA using the formula:

$$VMA = \%\ AIR\ VOIDS + \%\ BITUMEN\ BY\ VOLUME$$

$$VMA = \%\ AIR\ VOIDS + \frac{\rho_{bulk} \times BIT\%}{\rho_{BIT}}$$

Where:

VMA = percentage voids in mineral aggregate

ρ_{bulk} = bulk density of specimen in t/m^3

$BIT\%$ = percentage bitumen as determined by WA 730.1.

ρ_{BIT} = density of bitumen at 25 °C in t/m^3

(c) Calculate the VFB using the formula:

$$VFB = \frac{\%\ Bitumen\ By\ Volume}{VMA} \times 100$$

$$VFB = \frac{\rho_{bulk} \times BIT\%}{\rho_{BIT} \times VMA} \times 100$$

Where:

VFB = percentage voids filled with bitumen

ρ_{bulk} = density of the specimen in t/m^3

$BIT\%$ = percentage bitumen as determined by WA 730.1

ρ_{BIT} = density of bitumen at 25°C in t/m^3

VMA = percentage voids in mineral aggregate

7 REPORTING

7.1 Laboratory prepared specimens

a) Report the average of all specimen's bulk densities to the nearest 0.001 t/m3 and the average of all percentage air voids to the nearest 0.1%.
a) Report the average of all specimen's percentage voids in mineral aggregate and average of all percentage voids filled with bitumen to the nearest 0.1 %.

7.2 Field core specimens

b) Report bulk density, to the nearest 0.001 t/m^3, and air voids, to the nearest 0.1%, for each specimen.
c) Report the average of all specimen's bulk densities to the nearest 0.001 t/m^3 and the average of all percentage air voids to the nearest 0.1%.

8 ISSUING AUTHORITY

Document Owner
Bituminous Products Consultant

9 REVISION STATUS RECORD

Date	Section	Revision Description / Reference
16-03-22	5, 5.1, ,5.1.1 5.1.2, 5.2,	Clarification of applicability of Method
21-03-22	7	Clarification on Reporting
05-10-18	3, 5(a)	Corrected AS 2891.2.2 to AS/NZS
05-10-18	6.3(c)	Added × 100 to second VFB Equation