Transport Roads & Maritime Services

NSW GOVERNMENT

Test method T649

Propensity for moisture damage in asphalt (Cores)

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Revision Summary

Ed/Rev Number	Clause Number	Description of Revision	Authorisation	Date
Ed 1/ Rev 0		New Issue.	D Dash	July 1999
Ed 2/Rev 0	ALL	New Issue. Revised title. General revision of test to be consistent with T640. Minor change to temperature tolerances. Method modified for selecting groups.	P Walter	June 2010
Ed 3 Rev 0	All	Reformatted RMS template	J. Friedrich	November 2012

Note that Roads and Maritime Services is hereafter referred to as 'RMS'.

The most recent revision to Test method T649 (other than minor editorial changes) are indicated by a vertical line in the margin as shown here.

Test method T649

Propensity for moisture damage in asphalt (Cores)

1. Scope

This test method sets out the procedure for measuring the change of resilient modulus, Indirect Tensile Strength and swell of asphalt core samples as a result of saturation and freeze/thaw conditioning.

NOTE: The Test Method has been adapted from the Modified Lottman Test, ASTM D 4867-92 Standard Test Method for Effect of Moisture on Asphalt Concrete Paving Mixtures and AASHTO T 283-85 Resistance of Compacted Bituminous Mixture to Moisture Induced Damage.

2. General

(a) The results are used to assess the propensity for moisture damage of dense graded asphalt from core samples. Testing can be used for conformance of freshly placed asphalt or investigation of aged asphalt pavements

(b) Testing of the asphalt core must be completed within 7 days of coring

(c) One asphalt core sample is used unless otherwise specified. Additional samples may be required to determine the maximum density

(d) Where there is more than one core to be tested, allow a suitable time interval between specimens after Step 5.3 to ensure that time constraints in the test are achieved

NOTE: As a guide an interval of 15 min can be tried.

(e) The following documents are referred to in this Test Method:

(i) T605 Maximum Density of Bituminous Plant Mix

NOTE: This test is suitable where historical records are used for maximum density.

(ii) T631 Coring of Road Construction Materials

(iii) AS 2193 Calibration & classification of force-measuring systems

(iv) AS 2891 Methods of sampling and testing asphalt:

- AS 2891.7.3 Determination of maximum density of asphalt - Methylated spirits displacement method
- AS 2891.8 Voids and density relationships for compacted asphalt mixes
- AS 2891.9.2 Determination of bulk density of compacted asphalt - Presaturation method
- AS 2891.9.3 Determination of bulk density of compacted asphalt-Mensuration method
- AS 2891.13.1 Determination of the resilient modulus of asphalt

3. Apparatus

(a) Apparatus as appropriate for AS 2891 that includes:

(i) Suspension device, water container and suspension bridge as specified in AS 2891.9.2

(ii) Apparatus as specified in AS 2891.13.1 (e.g. loading jig, strips)

(b) Testing machine driven at a constant speed to give a rate of platen travel of 51 ± 3 mm/min and able to measure force to at least 22 kN with a readability, accuracy and repeatability of Class B as specified in AS 2193

(c) Vacuum pump, rotary oil type, with gauge or manometer capable of providing a minimum vacuum of approximately 650 mm Hg readable to 25 mm

NOTE: Precision and calibration of the vacuum is not required because the result is voids filled with water so that the vacuum may be increased until this is achieved.

(d) Vacuum desiccator fitted with a tap and a shelf of perforated porcelain or stainless steel mesh, large enough to completely immerse samples with a cover of 25 mm. It is used as a vacuum chamber only so that the desiccant is not required

(e) Balance of not less than 5 kg capacity readable to 1 g and with a limit of performance of ± 0.5g

(f) A thermostatically controlled air environment capable of maintaining temperatures of 25° ± 1°C

NOTE: The conditioning chamber in the UMATTA machine is suitable.

(g) Thermostatically controlled water bath(s) equipped with a snug-fitting lid and fitted with a water circulating device and having a depth of at least 150 mm and capable of:

(i) Maintaining temperatures of 25° ± 1°C

(ii) Maintaining temperatures of 60° ± 2°C

(h) Thermostatically controlled freezer capable of maintaining temperatures at -18° ± 3°C

(i) Temperature measuring device, covering the range of 0° to 100°C graduated to 1°C or less with a limit of performance of ± 0.5°C

(j) Fan blower

(k) Timing device readable to ± 0.5 second

(l) Vernier callipers readable to 0.1 mm

(m) Graduated measuring cylinder of suitable capacity

(n) Marking crayon

(o) Plastic cling wrap, thick leak-proof plastic bags and tape to seal single specimens

(p) Magnifying glass/lamp with at least 3x magnification

4. Sampling and Preparation

4.1 Sampling

(a) Take an asphalt core in accordance with T631 to provide a suitable size specimen (refer to Table 1). Avoid surface contamination (e.g. traffic marking). Where the core will yield multiple specimens, mark the core to distinguish the relative location of each specimen

(b) Additional samples may be required to determine maximum density in Step 5.1

Table 1 - Specimen Dimensions

Max Particle Size of Asphalt	Diameter of Specimen	Height of Specimen
≤ 20 mm	100 ± 2 mm	50 +20/-15 mm
> 20 and ≤ 40 mm	150 ± 2 mm	75 ± 15 mm

NOTE: Consistent with Table 2 of AS 2891.13.1.

4.2 Preparation of Core Sub-samples in the Laboratory

Cut the core to size by sawing or other suitable means to the dimensions specified in Table 1. Ensure that the ends are parallel and no more than 2 mm out of square from the vertical axis. Where more than one layer of asphalt is present in the core, divide the core into separate specimens to represent each layer.

5. Procedure

5.1 Maximum density

(a) Determine the maximum density (ρ_{max}) of asphalt for the lot as the average of the results on the day of production that were tested in accordance with AS 2891.7.3 or T605. If the production results are not available, determine the maximum density (ρ_{max}) of the relevant layer in accordance with AS 2891.7.3 representative of the same lot using one of the following samples:

(i) Loose asphalt

(ii) The additional asphalt core(s) taken for this purpose

NOTE: More than 1 core may be required to provide sufficient material.

5.2 Conditioning Specimen

NOTE: The specimen is initially dried to a constant mass to determine the physical characteristics of the specimen and dry resilient modulus. The specimen is partially saturated and then freeze/thaw conditioned before testing resilient modulus and Indirect Tensile Strength.

(a) Dry the specimen to Constant Mass at a temperature range of 20° to 26°C

NOTE: Drying can be assisted by fan.

(i) Determine the mass of the specimen

(ii) After at least 1 h from the last mass determination, repeat Step 5.2(a)(i) until the change in mass between successive measurements is less than 0.5 g

(b) Determine the dry mass (M_d) of the specimen to 0.1 g

NOTE: This is the mass when constant mass was achieved.

(c) Determine the diameter (D_d), height (h_d) and volume (V_{md}) of the dry specimen by mensuration in accordance with AS 2891.9.3

(d) Position the test specimen in the jig with the arrow indicating direction of traffic pointing upwards and determine the dry Resilient Modulus (RM_d) in accordance with AS 2891.13.1

(e) Determine the bulk density (ρ_{bulk}) and volume by presaturation (V_d) in accordance with AS 2891.9.2

NOTE: At no stage shake the specimens to remove free water.

(f) Calculate the percent Air Voids (AV) to the nearest 0.1% (refer to Step 6.1(a))

(g) Calculate the volume of air (V_a) in mL (refer to Step 6.1(b))

5.3 Partial Saturation Process

(a) Place the specimen on its side on the shelf in the vacuum desiccator. Ensure that the specimen is covered by at least 25 mm of water at 50° ± 5°C

(b) Allow the specimen to soak for at least 5 min

(c) Gradually apply a vacuum of 625 ± 25 mm Hg for at least 5 min. Gently agitate the desiccator periodically to release any entrapped air or to release air clinging to the surface of the specimen

NOTE: The application of a vacuum over the minimum time period is to limit shock to the specimen.

(d) After the required time, stop the vacuum pump and gently agitate the desiccator to release any air which is clinging to the surface of the specimen. Gradually allow the pressure in the desiccator to return to atmospheric pressure. Remove the partially saturated specimen from the desiccator

(e) Wipe the partially saturated specimen with a damp cloth to bring the specimen to a saturated surface dry condition. Do not shake the specimen

(f) Determine the mass of the partially saturated specimen (M_{ps}) to 0.1 g

(g) Calculate the Degree of Saturation (S_p) as a percent (refer to Calculation 6.1(c)) and proceed based on the value as follows:

(i) If S_p < 55%, repeat the process on the same specimen from Step 5.3(a) with extra vacuum periods, increased in temperature up to 60°C or increased vacuum, until S_p is in the range 55% to 80%

NOTE: Extra vacuum periods of 5 min up to a total of 30 min are suggested.

(ii) If S_p is in the range 55% to 80% of the required saturation, proceed to Step 5.4

(iii) If S_p > 80% proceed to Step 5.4 but note in the report that the Degree of Saturation (S_p) was excessive

NOTE: The specimen may be weakened and give an unreliable result.

5.4 Freeze/Thaw Conditioning

(a) For the specimen:

(i) Once a satisfactory degree of saturation is achieved, immediately wrap the specimen in several layers of plastic cling wrap. Place the wrapped specimen in a separate plastic bag containing about 10 mL of water and seal the bag

(ii) Place the sealed specimen upright on a shelf in the freezer and ensure that specimens are not in contact with other specimens. Maintain a temperature of -18° ± 3°C for at least 18 h

(b) After the specified time, remove the specimen from the freezer, remove the plastic bag and wrapping and place in a water bath maintained at 60° ± 2°C for 24 ± 1 h. Ensure the water level in the bath covers the specimen by at least 25 mm

NOTE: Ensure that specimens are not in contact in the water baths.

(c) After the specified time, remove the specimen from the water bath and place in the second water bath maintained at 25° ± 1°C for 2 h ± 5 min. Ensure the water level in the bath covers the specimen by at least 25 mm

5.5 Testing Specimens

(a) After the specified period of Freeze/Thaw conditioning, remove the specimen from the water bath and within 15 min complete the test in a temperature controlled environment maintained at 25° ± 1°C

NOTE: Where there is more than one specimen, the order for testing should follow the same order as that for conditioning.

(b) Determine the diameter (D_f), height (h_f) and the volume (V_{mf}) of the specimen by mensuration in accordance with AS 2891.9.3

(c) Position the test specimen in the jig with the arrow indicating direction of traffic pointing upwards and determine the dry Resilient Modulus (RM_f) in accordance with AS 2891.13.1

(d) Determine the Indirect Tensile Strength as follows:

(i) Place the specimen centrally on its side into the loading jig

(ii) Apply load to the specimen at the specified constant rate

(iii) Record the maximum applied force (P) to the nearest 0.1 kN

(iv) Continue loading at the specified constant rate until the specimen fractures

(e) Carefully separate the fractured parts of the specimen and set aside to dry for at least 12 h at ambient temperature

(f) Calculate the swell (V_S) of the specimen after Freeze/Thaw conditioning (refer to Step 6.2)

(g) When the sample has dried, carry out a visual inspection of the fractured faces of the specimen under a magnifying lamp. Record whether there is binder coated on the aggregate, cracked or broken aggregate and any other observations using Table 2

NOTE: A photograph of the face most representative of the sample assists interpretation of results.

Table 2–Visual Rating of Fracture faces of a Specimen

Aggregate Size	Property	Visual Rating
Coarse	Coating of binder to aggregate	Nil/Minimal/Moderate/ Complete*
	Binder condition	Flat/semi-gloss/gloss*
	Cracked or broken aggregate	Minimal/ Moderate/ Extensive*
Fine	Coating of binder to aggregate	Minimal/ Moderate/ Complete*
	Binder condition	Flat/semi-gloss/gloss*
	Cracked or broken aggregate	Nil/Minimal/Moderate/ Extensive*

*NOTE: * Select the most appropriate rating from the list.*

6. Calculations

6.1 Degree of Saturation

(a) Calculate the percent Air Voids (AV) as follows:

$$AV = \left(\frac{\rho_{\max} - \rho_{bulk}}{\rho_{\max}} \right) \times 100\%$$

Where:

AV = Percent air voids (%)

ρ_{max} = Maximum density (t/m³) (from AS 2891.7.3)

ρ_{bulk} = Bulk density (t/m³) (from AS 2891.9.2)

(b) Calculate the Volume of Air (V_a) as follows:

$$V_a = \frac{AV \times V_d}{100}$$

Where:

V_a = Volume of air in the specimen (mL)

AV = Percent air voids (%) (from AS 2891.8)

V_d = Volume of the dry specimen by presaturation (cm³ or mL) (from AS 2891.9.2)

(c) Calculate the Degree of Saturation (S_p) as follows:

$$S_p = \left(\frac{M_{ps} - M_d}{V_a} \right) \times 100\%$$

Where:

S_p = Degree of Saturation of a vacuum saturated specimen (%)

M_{ps} = Mass of the partially saturated specimen (g)

M_d = Dry mass of the specimen (g)

V_a = Volume of air in the specimen (mL)

NOTE: Density of water is assumed to be 1.00g/mL and does not appear in the formula but makes S_p dimensionless.

6.2 Swell after Freeze/Thaw Conditioning

(a) Calculate the dry volume (V_{md}) by mensuration as follows:

$$V_{md} = \frac{\pi\, h_d\, D_d^{\,2}}{4} \times 10^{-3}$$

Where:

V_{md} = Volume of the dry specimen by mensuration (mL)

h_d = Height of the specimen (mm)

D_d = Diameter of the specimen (mm)

(b) Calculate the volume (V_{mf}) after Freeze/Thaw conditioning by mensuration as follows:

$$V_{mf} = \frac{\pi\, h_f\, D_f^{\,2}}{4} \times 10^{-3}$$

Where:

V_{mf} = Volume of the Freeze/Thaw conditioned specimen by mensuration (mL)

h_f = Height of the specimen after conditioning (mm)

D_f = Diameter of the specimen after conditioning (mm)

(c) Calculate the swell (V_S) after Freeze/Thaw conditioning as follows:

$$V_S = \left(\frac{V_{mf} - V_{md}}{V_{md}} \right) \times 100\%$$

Where:

V_S = Swell of Freeze/Thaw conditioned specimen (%)

V_{mf} = Volume of the Freeze/Thaw conditioned specimen by mensuration (mL)

V_{md} = Volume of the dry specimen by mensuration (mL)

6.3 Indirect Tensile Strength

(a) Calculate the Indirect Tensile Strength (T) of all specimens tested. Where a specimen disintegrates during freeze/thaw conditioning, record the Indirect Tensile Strength (T) as NIL

$$T = \left(\frac{2\, P}{\pi\, h_f\, D_f} \right) \times 10^{6}$$

Where:

T = Indirect Tensile Strength (kPa)

P = Maximum applied force indicated by the testing machine (kN)

h_f = Height of the specimen (mm)

D_f = Diameter of the specimen (mm)

6.4 Retained Resilient Modulus Ratio

(a) Calculate the Retained Resilient Modulus Ratio (*RMR*) rounded up to the nearest whole number as follows:

NOTE: The RMR is undetermined if one Resilient Modulus cannot be determined.

$$RMR = \left(\frac{RM_f}{RM_d} \right) \times 100\%$$

Where:

RMR = Retained Resilient Modulus Ratio rounded to the nearest whole %.

RM_f = Freeze/Thaw Resilient Modulus (MPa)

RM_d = Dry Resilient Modulus (MPa)

7. Reporting

Include the following data and results in the report:

(a) The date cored and date tested

(b) Location of core

(c) Mix identification including nominal aggregate size

(d) Layer represented by the test

(e) The Air Voids content (AV) to the nearest 0.1%

(f) Dry Resilient modulus (RM_d) rounded to the nearest 1 MPa

(g) The Degree of Saturation (S_p) to the nearest whole %

(h) After Freeze/Thaw conditioning:

  (i) The Swell (V_S) to the nearest 0.1%

  (ii) The Indirect Tensile Strength (T) to the nearest 10 kPa

  (iii) Freeze/Thaw Resilient modulus (RM_f) rounded to the nearest 1 MPa

(i) The Retained Resilient Modulus Ratio (*RMR*) to the nearest whole %. Provide comment if the *RMR* is undetermined or if a specimen disintegrated during conditioning

(j) Visual assessments according to Step 5.5(g)

(k) Reference to this Test Method