COMMENTARY TO AG:PT/T232 - STRIPPING POTENTIAL OF ASPHALT – TENSILE STRENGTH RATIO

PREFACE

This asphalt test method was prepared by the Asphalt Research Review Group on behalf of Austroads. Representatives of Austroads, ARRB Group and the Australian Asphalt Pavement Association have been involved in the development and review of this test method.

FOREWORD

Procedures in this test method have been adapted from ASTM D 4867-92 and AASHTO T 283-85.

SCOPE

This method sets out the procedures for preparation of specimens and measurement of the change of indirect tensile strength resulting from the effects of saturation and accelerated moisture conditioning. The additional effect of freeze/thaw on conditioning of samples is optional. The results can be used to assess the propensity for stripping of dense graded bituminous mixes.

Further Development

None.

STRIPPING POTENTIAL OF ASPHALT – TENSILE STRENGTH RATIO

1 REFERENCED DOCUMENTS

The following documents are referred to in this method:

AS /NZS

2891.1	Sampling of asphalt.
2891.2.1	Mixing, splitting and conditioning of asphalt in the laboratory
2891.2.2	Sample Preparation - Compaction of asphalt test specimens using a gyratory compactor
2891.7.1	Determination of maximum density of asphalt - Water displacement method.
2891.8	Voids and density relationships for compacted asphalt mixes
2891.9.2	Determination of bulk density of compacted asphalt - Presaturation method.
2891.9.3	Determination of bulk density of compacted asphalt - Mensuration method.
2891.13.1	Determination of the resilient modulus for asphalt

AASHTO

T 283-85	Resistance of Compacted Bituminous Mixture to Moisture Induced Damage

ASTM

D 4867-92	Standard Test Method for Effect of Moisture on Asphalt Concrete Paving Mixtures

2 APPARATUS

The following apparatus is required:

a. Gyratory compactor as specified in AS 2891.2.2 with 100 mm and 150 mm diameter moulds and other associated equipment.

b. Vacuum pump with gauge capable of providing a vacuum of at least 650 mm Hg.

c. Vacuum desiccator fitted with a tap.

d. Balance of not less than 5 kg capacity readable to 1g and with a limit of performance of ± 0.5 g.

e. Temperature controlled environment capable of maintaining temperature at 25ºC with thermostatic control to within 1ºC of the desired temperature.

f. Water bath having a depth of at least 150 mm capable of maintaining temperatures up to 60ºC with thermostatic control to within 1ºC of the desired temperature.

g. Water bath having a depth of at least 150 mm capable of maintaining temperatures up to 25ºC with thermostatic control to within 1ºC of the desired temperature.

h. Freezer capable of maintaining temperature at -18ºC with thermostatic control to within 3ºC of the desired temperature. (Optional freeze/thaw conditioning only)

i. Testing machine driven at a constant speed to give a rate of travel of platen of 51 mm/minute within 3 mm/minute. A suitable type of testing machine and data logging equipment which may be used is described in AS 2891.5 Part 4.

j. Loading jig and strips as specified in AS 2891.13.1.

k. Thermometer, or other suitable temperature measuring device, covering the range of 0 to 100ºC graduated to 1ºC or less with an uncertainty not greater than 0.5ºC.

l. Vernier callipers.

m. 10 mL graduated in measuring cylinder.

n. Mixing apparatus such as steel trays, steel trowel, spatula and scoop.

o. Insulated gloves and tongs for handling hot apparatus.

p. Marking crayon.

q. Damp cloths to wipe the wet specimens.

r. Plastic cling wrap, thick leak-proof plastic bags and masking tape suitable to enclose a single specimen.

3 PREPARATION OF SPECIMENS

a. Determine the maximum density (ρ_{max}) of the asphalt mix in accordance with AS 2891.7.1.

b. The standard test specimen shall be a briquette of diameter 100 mm ± 2 mm by 65 mm ± 1 mm high. For aggregate of nominal size larger than 20 mm and less than 40 mm the specimen diameter shall be 150 mm ± 2 mm by 85 mm ± 1 mm high.

c. Six specimens are required for each set of test conditions. Three specimens are to be tested dry and three after accelerated moisture conditioning. Two additional specimens may be required to establish the partial saturation procedure. If the partial saturation procedure is already known from previous experience using the same nominated mix, the partial saturation procedure may not be required to be determined again.

d. Specimens prepared from samples of asphalt mix produced outside the laboratory shall be sampled and prepared in accordance with AS 2891.1.

e. Specimens prepared from samples of asphalt mix produced in the laboratory shall have the mix prepared in accordance with AS 2891.2.1.

f. Compact the specimens in accordance with AS 2891.2.2 using a gyratory compactor set to achieve the desired specimen height. Specimens are to be compacted to a given density with a similar air voids content targeted at 8 ± 1%. This can be achieved by using the gyratory compactor in a controlled (fixed) volume mode after experimentally determining the compaction procedure for each mix before compacting the specimens for each set.

4 EVALUATION OF SPECIMENS

a. Weigh and record the dry mass (md) of each of the compacted specimens and then determine the bulk density (ρd) of each of them in accordance with AS 2891.9.2 except that the period of soaking of each specimen shall be 3 to 5 minutes instead of a minimum of 2 hours. The sample shall not be shaken (i.e.) only patted dry without shock or disturbance that may dislodge water.

b. Calculate the volume of the specimen (Vd) in cubic centimetres (refer to step 7.1).

c. Calculate the percentage of air voids for each of the compacted specimens in accordance with AS 2891.8 to the nearest 0.1% and then the volume of air (Va) in cubic centimetres (refer to step 7.2).

d. Select six specimens so that the difference between the maximum and minimum air voids content is less than 1%. Divide the set of six specimens into two subsets of three specimens, one to be tested dry and the other to be tested following moisture conditioning. Sort the specimens so that the averages of the air voids content of the two subsets do not differ in more than 0.5%. Mark each specimen for identification. Store at room temperature the subset to be tested dry until such time as the moisture conditioned specimens are ready to be tested. (This allows time for air drying back to the dry mass after the bulk density determination).

e. Use one of the two additional specimens to establish the procedure to achieve partial saturation of the specimens of the moisture conditioned subset.

5 PRECONDITIONING OF SPECIMENS

5.1 Partial Saturation Procedure for Moisture Conditioned Subset

a. Place one of the two additional specimens on its side into the vacuum desiccator and support the specimen above the desiccator bottom. Have sufficient water in desiccator at 50 ± 5ºC so that the specimen is covered by at least 25 mm of water.

b. Apply a vacuum at 600 ± 25 mm Hg for 10 minutes. Gently agitate the desiccator periodically to release any entrapped air or to release air clinging to the surface of the specimen. Stop the vacuum pump and gently agitate the desiccator to release any air which is clinging to the surface of the specimen. Allow the pressure in the desiccator to return to atmospheric. Remove the partially saturated specimen from the desiccator.

c. Wipe the partially saturated specimen with a damp cloth to bring the specimen to a saturated surface dry condition. Avoid shaking the specimen.

d. Weigh the partially saturated specimen and record the mass (m_{ps}) in grams.

e. Calculate the degree of saturation (Sp) in percent (refer to step 7.3).

f. If the degree of saturation is between 55% and 80%, record the steps which were taken to achieve partial saturation and proceed to step 6.1(i).

g. If the degree of saturation is less than 55%, repeat the procedure beginning from step 5.1(a) with a minimum vacuum up to 30 minutes. If the degree of saturation is still not achieved then use an increased vacuum or water temperature up to 60ºC or both. The duration of vacuum may vary from 5 to 30 minutes. Continue this procedure until the degree of saturation is between 55% and 80%. Record the steps which were taken to achieve the saturation and proceed to step 5.1(i).

h. If the degree of saturation is greater than 80%, the specimen is presumed to have been damaged and must be discarded. Repeat the partial saturation procedure using the second additional specimen.

i. Complete partial saturation for three specimens.

j. If optional freeze/thaw conditioning is to be carried out, proceed to step 5.2. If optional freeze/thaw conditioning is not required, proceed direct to step 5.3.

5.2 Freeze/Thaw of Moisture Conditioned Subset (Optional)

a. Immediately following achievement of a satisfactory degree of saturation in step 5.1, wrap each of the specimens in several layers of plastic cling wrap. Place each wrapped specimen into a separate plastic bag containing 10 mL of water and seal the bag using masking tape.

b. Place the plastic bags containing the specimens into the freezer maintained at -18 ± 3ºC for 18 hours ± 1 hour. Ensure that the wrapped specimens are not in contact with each other while in the freezer.

5.3 Moisture Conditioning

a. Condition the specimens that have been partially saturated in accordance with step 5.1, or frozen in accordance with step 5.2, for 24 hours ± 1 hour in a water bath maintained at 60 ± 1ºC. As soon as possible after placement of frozen specimens in the water bath, remove the plastic bag and wrapping.

b. After conditioning at 60ºC, remove the specimens from the water bath and place into a water bath held at a temperature of 25 ± 1ºC for a further 2 hours ± 5 minutes. A suitable time interval must be allowed between placing each specimen into the water bath and testing so that the period of time for conditioning at 25ºC before testing does not exceed 2 hours 5 minutes for each specimen (a time interval of 15 minutes may be used as a guide).

c. Ensure that the specimens are not in contact with each other while in the water baths. Proceed to step 6.2

5.4 Conditioning of Dry Subset Specimens

Condition the three specimens of the dry subset in a temperature controlled environment maintained at 25 ± 1ºC for 2 hours ± 5 minutes prior to being tested. A suitable time interval must be allowed between the start of conditioning of each specimen and testing so that the period of time for conditioning before testing does not exceed 2 hours ± 5 minutes for each specimen (a time interval of 10 minutes may be used as a guide). Proceed to step 6.1.

6 PROCEDURE

6.1 Dry Subset Specimens

a. Measure and record the diameter (D) and height (H) of the specimen in millimetres in accordance with Part 6 of AS 2891.9.3.

b. Place the specimen centrally on its side into the loading jig. Commence loading the specimen without shock at the specified constant rate and record the maximum applied force to the nearest 0.1 kN.

c. Continue loading at the specified constant rate until the specimen fractures. Break the specimen open to inspect the fractured surfaces for stripping. Record observations such as adhesion of binder to aggregate, cracked or broken aggregate and any other observations.

d. Repeat the procedure in steps (a), (b) and (c) for the remaining two specimens of the dry subset. Removal of each specimen from the temperature controlled environment is to follow the same order as that for placement of each into the temperature controlled environment.

6.2 Moisture Conditioned Subset Specimens

a. Remove the first specimen of the moisture conditioned subset from the water bath after the period of conditioning at 25ºC. Determine the diameter and height of the specimen in accordance with Part 6 of AS 2891.9.3 for input into step 7.5 and calculate the volume (V_{mc}) (refer to step 7.4).

b. Calculate the swell (V_S) of each specimen in percent to the nearest 0.1% (refer to step 7.4).

c. Place the first specimen centrally on its side into the loading jig. Commence loading the specimen without shock at a constant rate and record the maximum applied force to the nearest 0.1 kN.

d. Continue loading until the specimen fractures. Break the specimen open to inspect the fractured surfaces for stripping. Record observations such as adhesion of binder to aggregate, cracked or broken aggregate and any other observations. The degree of stripping shall be assessed separately for coarse and fine aggregates as shown in Table 1 below.

Table 1
Visual Assessment on Degree of Stripping (Mark where applicable)

Type of Aggregate	Nil	Minimal	Moderate	Severe	Comments
Coarse					
Fine					

e. Repeat the procedure in steps (a), (b) and (c) for the remaining two specimens. Removal of each specimen from the water bath is to follow the same order as that for placement of each into the water bath.

7 CALCULATIONS

7.1 Volume of Specimen (Refer to AS 2891.9.2)

$$V_d\ (cm^3) = \frac{m_3 - m_2}{F}$$

Where

V_d = Volume of the dry specimen in cubic centimetres

m_3 = Mass in air of the saturated sample in grams

m_2 = Mass in water of the saturated sample in grams

F = Density of water at the test temperature in tonnes per cubic metre (See Table 2)

Table 2
Variation of water density with temperature

Temperature (ºC)	Density (t/m3)	Temperature (ºC)	Density (t/m3)
20	0.998	25	0.997
21	0.998	26	0.997
22	0.998	27	0.997
23	0.998	28	0.996
24	0.997	29	0.996

7.2 Volume of Air in Compacted Specimen

$$V_a\ (cm^3) = \frac{AV\,x\,V_d}{100}$$

where

AV = Percent Air voids

7.3 Degree of Saturation

The degree of saturation of a vacuum saturated specimen is calculated as follows:

$$SP\ (\%) = \left(\frac{m_{ps} - m_d}{V_a}\right) \times 100$$

where

m_{ps} = Mass of the partially saturated specimen in grams

m_d = Dry mass of the specimen in grams

7.4 Swell

The swell of an accelerated moisture conditioned specimen is calculated as follows:

$$VS\ (\%) = \left(\frac{V_{mc} - V_d}{V_d}\right) \times 100$$

where

V_{mc} = Volume of the accelerated moisture conditioned specimen, in cubic centimetres

$= m_{ps} - m_d$

7.5 Tensile Strength

Calculate the tensile strength of all specimens tested to the nearest whole number as follows:

$$T\ (kPa) = \left[\frac{2 \times P}{\pi \times H \times D}\right] \times 10^6$$

where

T = tensile strength in kPa

P = maximum applied force indicated by the testing machine in kN

H = specimen height in millimetres

D = specimen diameter in millimetres

7.6 Tensile Strength Ratio

Calculate the Tensile Strength Ratio (TSR) rounded up to the nearest whole number as follows:

$$TSR\ (\%) = \left[\frac{S_2}{S_1}\right] \times 100$$

where

S_1 = average tensile strength of dry subset

S_2 = average tensile strength of moisture conditioned subset

NOTE: If for any reason it is not possible to calculate the tensile strength of all six specimens, the tensile strength ratio is to be reported as undetermined.

8 INFORMATION TO BE REPORTED

The following information is to be reported for all specimens:

a. Air voids content for each specimen and average air voids content in each subset.

b. Degree of saturation of each specimen in the moisture conditioned subset and average degree of saturation.

c. Swell after conditioning of each specimen in the moisture conditioned subset and average swell.

d. Tensile strength of each specimen, average tensile strength of the dry subset and average tensile strength of the moisture conditioned subset.

e. Tensile Strength Ratio. If undetermined provide relevant details.

f. Visual assessment on degree of stripping (as per above table) including any observations.

g. Reference to this method, i.e. AG:PT/T232.

AMENDMENT RECORD

Amendment No.	Clauses amended	Action	Date
1	Commentary Page	New	June 2005
	Footer and header	Format	
	Applied revised test method number	Format	
	Applied new styles	Format	
2	Altered maximum density from methylated spirits to water based method, 1, 3.(a)	Substitution	Nov 2005
3	3(e) deleted 'Part 4'	Substitution	June 2006
	5.2(g) changed 'step 6.1' to 'step 5.1'		
	5.3(a) changed 'step 6.1' to 'step 5.1'		
	5.3(a) changed 'step 6.2' to 'step 5.2'		
	5.3(c) changed 'step 7.2' to 'step 6.2'		
	8.4 removed repeated definition of Vd		
	8.5 Tensile strength corrected error in formula		
4	Renumber section headings in section 7 and 8 and references to the sections	Substitution	Jan 2007
	Replace reference to mensuration density and volumes with reference to saturated surface dry density and volumes		

Key

Format	Change in format
Substitution	Old clause removed and replaced with new clause
New	Insertion of new clause
Removed	Old clauses removed