Materials Testing Manual

Part 12: Pavements
Test Method Q704: Skid resistance - portable pendulum

1 Source
This method applies the principles of AS 1141.42: Pendulum friction test. It differs from this standard by:

a) performing testing in the field and correcting values for measured surface temperature

b) using the 75 mm wide slider for all testing

c) correcting the skid resistance value to a test temperature of 30°C.

2 Scope
This method describes the procedure for the determination of the resistance of a road surface to skidding. The apparatus measures the frictional resistance between a rubber slider mounted on the end of a pendulum arm and the road surface.

3 Apparatus
Where appropriate, the working tolerances of particular apparatus are contained in Tables 1 and 2.

The following apparatus is required:

3.1 Pendulum friction tester, comprising a tester and auxiliary scale constructed in accordance with details available from the Australian Road Research Board, Melbourne. All bearings and working parts of the instrument are enclosed as far as possible and all materials used suitably treated to prevent corrosion under wet conditions. Use and store the pendulum friction tester in a dust-free environment that is not subject to a large temperature variation. Calibrate the tester to ensure compliance with the following requirements at intervals not exceeding two years or when results obtained from the friction tester control specimens vary from the established values by more than three units. The tester will consist of the following:

a) Spring-loaded rubber slider mounted on the end of a pendulum so that the sliding edge is 515 mm from the axis of suspension. The sliding edge will be square, clean cut and free from contamination. The rubber slider is 76.0 mm long, 25.4 mm wide and 6.4 mm thick. The slider is rigidly backed and, together with the rigid backing plate having a total mass of 35 g.

b) Slider material is Slider 55 (IRHD 55) and complying with the resilience requirements of Table 2. Avoid handling of the surface of a rubber slider and, when not in use, store sliders in the dark at a temperature between 10°C and 25°C. Discard a slider when:

i. more than 12 months old from the date stamped on the slider, or

ii. it does not comply with the requirements of Table 2.

c) The mass of the pendulum including the slider is 1.50 kg with the centre of gravity lying on the axis of the pendulum at a distance of 410 mm from the centre of suspension. Mount the slider on an axis set at an angle of 25 degrees to the horizontal when the pendulum is at the lowest point of its swing, so that only the rear edge of the slider contacts the test surface. The slider can turn about its axis without obstruction to follow unevenness of the surface. Spring load the slider against the test surface. The calibration procedure will set the nominal static force on the slider.

d) Means for levelling the instrument.
e) Means for raising and lowering the axis of suspension of the pendulum so that the slider can:
   i. swing clear of the surface of the specimen, and
   ii. be set to slide over a fixed length of the surface.

f) Means for holding and releasing the pendulum so that it falls freely from a horizontal position.

g) Pointer balanced about the axis of suspension, indicating the position of the pendulum throughout its forward swing and moving over the circular scale attached to the instrument. The mass of the pointer, excluding felt friction washers, is not more than 85 g. The friction in the pointer mechanism is adjustable so that, with the pendulum swinging freely from a horizontal position, will bring the outward tip of the pointer to rest on the forward swing of the pendulum at a point 10 mm below the horizontal, the point corresponding to the zero position on the attached circular scale.

3.2 Bannister brush.

3.3 Spray bottle and water container.

3.4 Temperature measurement device covering the range of 0°C to 60°C and graduated to 1°C and an uncertainty of no more than 0.5°C. A thermocouple or infra-red thermometer has been found to be suitable.

4 Materials

The following materials are required:

4.1 Potable water.

4.2 Suitable insulation material for temperature measurements (for example, polystyrene block or fine sand).

5 Procedure

The procedure shall be as follows:

5.1 Determine the test location (Note 8.1).

5.2 Set the instrument in line with the traffic flow so that the pendulum will swing in the same direction as the traffic flow.

5.3 Clear the road surface of loose materials by brushing briskly with a bannister brush.

5.4 Place the temperature measurement device on the road surface adjacent to the test site under the insulating material.

5.5 Set the base level, by means of the levelling device and the three levelling screws on the base frame. Secure a rubber slider on its pivot ensuring the correct positioning of the two washers and spring.

5.6 Raise the axis of suspension of the pendulum so that the arm swings freely. Adjust the friction rings in the pointer mechanism so that, when the pendulum arm and pointer are released from the right-hand horizontal position, the pointer will zero repeatedly (Note 8.2).

5.7 Adjust the height of the axis of suspension of the pendulum by means of the rack and pinion so that the whole trailing edge of the slider is in contact with the test surface for the set length while traversing the test surface. This length is set by aligning the trailing edge of the slider
against the marks on the scale supplied with the friction tester. When the apparatus has been
set correctly, the sliding length should be between 125 and 127 mm on the scale. The outer
marks are 127 mm apart and the inner one each indicates the 2 mm tolerance allowed.

5.8 Using the spray bottle, thoroughly wet the rubber slider and road surface with water.

5.9 Return the pendulum to its horizontal position and move the pointer against its stop. Release
the pendulum and pointer from the horizontal position, allowing them to swing over the test
surface. As the pendulum and slider falls back from its peak after traversing the test surface,
catch it before the slider again makes contact and note the reading indicated by the pointer
(Note 8.3).

5.10 Lift the slider using the lifting lever keeping it clear of the road surface and return the
pendulum and pointer to the horizontal position and lock in the release position.

5.11 Repeat Steps 5.7 to 5.10 four times and record the mean of the five readings provided they do
not differ by more than three units. If the range exceeds three units, repeat Steps 5.7 to 5.10
until three successive readings are the same and record this value.

5.12 Raise the head of the pendulum so that the pendulum arm swings clear of the surface and
check the free swing for zero error. If the free swing does not zero, then adjust the pendulum
as detailed in Step 5.6 and repeat the testing at the location as detailed in Steps 5.7 to 5.12. If
the check of the free swing for zero error fails again, remove the pendulum from service and
partially or fully recalibrate the pendulum.

5.13 Record the test surface temperature.

6 Calculations

Calculations shall be as follows:

6.1 Calculate the mean wet skid resistance value at 30°C as follows:

$$SRV_{30} = \frac{SRV_t}{1-0.00525(t-30)}$$

where

- $SRV_{30}$ = mean wet skid resistance value corrected to 30°C
- $SRV_t$ = mean skid resistance value at the test temperature
- $t$ = test surface temperature (°C)

7 Reporting

The following shall be reported:

7.1 The mean wet skid resistance value (SRV30) corrected to 30°C to the nearest whole number
(Note 8.4).

7.2 The description of surface being tested.

8 Notes on method

8.1 The location of the test site may be variable according to the investigation being conducted.
However, for routine testing, readings are usually taken along a wheel path.
8.2 Adjustment of the friction rings is necessary as the testing is carried out under varying conditions of temperature and wind velocity.

8.3 If the slider is allowed to hit the test surface on the return swing it can be damaged and effect the zero adjustment.

8.4 The skid resistance of a dry surface may also be measured using the same method except that water is not applied to either the rubber slider or road surface. However, the appropriate correction for temperature is not known.

Table 1 - Dimensions and tolerances for pendulum friction tester

<table>
<thead>
<tr>
<th>Apparatus</th>
<th>Dimension</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance of sliding edge from axis of suspension (mm)</td>
<td>515</td>
<td>± 2</td>
</tr>
<tr>
<td>Length of rubber slider (mm)</td>
<td>75.0</td>
<td>± 1.0</td>
</tr>
<tr>
<td>Width of rubber slider (mm)</td>
<td>24.0</td>
<td>± 1.0</td>
</tr>
<tr>
<td>Thickness of rubber slider (mm)</td>
<td>6.0</td>
<td>± 0.5</td>
</tr>
<tr>
<td>Mass of rubber slider and backing plate (g)</td>
<td>35</td>
<td>± 2</td>
</tr>
<tr>
<td>Mass of slider and pendulum (kg)</td>
<td>1.50</td>
<td>± 0.03</td>
</tr>
<tr>
<td>Distance from centre of gravity of pendulum to the centre of suspension (mm)</td>
<td>410</td>
<td>± 5</td>
</tr>
<tr>
<td>Angle of slider to horizontal at lowest point of swing (°)</td>
<td>25</td>
<td>± 1</td>
</tr>
<tr>
<td>Mass of pointer (g)</td>
<td>85</td>
<td>maximum</td>
</tr>
</tbody>
</table>

Table 2 - Properties of rubber slider

<table>
<thead>
<tr>
<th>Property</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Resilience (%)*</td>
<td>44 to 49</td>
</tr>
<tr>
<td>Hardness (IRHD)+</td>
<td>55 ± 5</td>
</tr>
</tbody>
</table>

* Lupke rebound test in accordance with BS ISO 4662.
+ Hardness in accordance with BS ISO 48.
Test Method Q705B: Surface texture depth - silicone putty

1 Source

This method was developed in house using information obtained from the following technical references:


2 Scope

This method covers the measurement of the surface texture depth of a pavement surface using the silicone putty technique. This method is based on a procedure developed by the Texas Transportation Institute (1970 & 1977) and is particularly suited to measurement of texture depths of less than 0.5 mm.

The method involves placement of a known volume of silicone putty on the pavement surface and pressing the putty into the surface texture using a recessed plate. The average diameter of the flattened putty is recorded. The recess is circular with a depth of 1.587 mm (1/16 inch). The diameter of the recess is such that the volume of putty will completely fill it if the surface has zero texture. A decrease in diameter of the deformed putty, relative to the recess diameter, is related to an increase in texture depth. The texture depth determined by this method is the average height of the volume of putty that has filled the texture as related to the circular area covered. The primary reference test for volumetric texture depth determination is still Q705 (2010). This is a supplementary test method for use on low textured surfaces and other situations where the traditional sand patch test is unsuited. For texture depths greater than 0.5 mm, this method has been found to correlate well with the traditional sand patch test TMR (2011).

3 Apparatus

The following apparatus is required:

3.1 Test plate either 160 or 200 mm square by 25 mm thick of flat acrylic plastic, with a centrally machined 101.6 or 143.42 mm (respectively) diameter by 1.578 mm deep recess on one side (Note 8.1).
3.2 25 kg surcharge weight.
3.3 Soft hand brush.
3.4 500 mL spray bottle for application of putty release agent.
3.5 150 mm or greater steel ruler, graduated in mm, for measuring flattened putty diameter.
3.6 Metal knife, spatula of paint scraper (for separation of the plate from the pavement surface at the end of the test).
3.7 Suitable containers for storage of premeasured putty quantities for the test (for example, small takeaway plastic containers).

4 Materials

The following materials are required:

4.1 Dental grade, skin safe fast curing two component Flexible Silicone Impression Putty with a specific gravity of 1.44. The quantities required for a test are 12.82 or 25.64 mL depending on the size of the plate used. Pre-measure the two parts off site and store in the small containers for transport to the test site.

4.2 Dilute solution of domestic detergent (for example, dishwashing liquid) for use as a mould release agent.

5 Procedure

The procedure shall be as follows:

5.1 Select a test location as detailed in Test Method Q050.

5.2 Clean the test surface by sweeping using the soft hand brush.

5.3 Spray the test surface with the dilute solution of detergent.

5.4 Select the plate size and corresponding putty volume for the test. Select the small plate and 12.82 mL putty volume for fine textured surfaces while the large plate and 25.64 mL putty volume is preferred for coarse textured surfaces.

5.5 Combine the two parts of the pre measured silicone putty together, mix by kneading and form into an approximate sphere.

5.6 Place the sphere of putty on the pavement surface.

5.7 Centre the recess of the test plate over the putty and press the plate down in firm contact with the pavement surface. Use of the 25 kg weight on the test plate for 1 minute is sufficient to achieve this contact.

5.8 After 1 - 2 minutes, remove the weight and the test plate from the pavement surface. The flattened silicone putty should remain on the pavement surface.

5.9 Measure the diameter of the flattened putty at 4 approximately equally spaced locations to the nearest 1 mm and record the results.

5.10 After 5 minutes, the flattened silicone putty should have cured sufficiently to remove intact from the pavement surface.

6 Calculations

Calculations shall be as follows:

6.1 Calculate the average flattened putty diameter to the nearest 1 mm.

6.2 Calculate the surface texture depth as follows:

\[
STD = \frac{4V.1000}{\pi D^2}\times 1.587
\]

where

- \(STD\) = surface texture depth (mm)
- \(V\) = proportion of the aggregate component in the mix design (%)
\[ D = \text{average diameter of flattened putty (mm)} \]

7 **Reporting**

Report the surface texture depth to the nearest 0.1 mm.

8 **Notes on method**

8.1 Before the apparatus is used for field measurements, the standard calibration procedure should be followed in the laboratory, using a flat sheet of glass as a surface with zero texture depth. If the putty is measured out correctly, it should completely fill the test plate recess.
Test Method Q707A: Permeability of road surfacing and granular materials –
even flow field permeameter

1 Source
This method was developed in-house using techniques evolved through internal departmental
research investigations (Waters T.J., “Permeability of Road Surfacing and Granular Materials

2 Scope
This method describes the procedure for the determination of the permeability of pavement materials
using the Evenflow Field Permeameter. It is applicable to bituminous materials (for example sprayed
seal, asphalt) and granular materials (where the surface is reasonably flat and well compacted) having
permeability values within the range 0.04 to 1500μ m/s. The guidelines included for categorising
permeability values were developed specifically for asphalt, although they do have application to other
materials.

3 Apparatus
The following apparatus is required:

3.1 Field permeameter, consisting of an inverted clear plastic conical funnel attached to a rigid
plastic base plate as follows (Figure 1):

a) Base plate (Figure 2) with a diameter of about 200 mm and a thickness of about 20 mm.
   Containing a centrally located circular hole of diameter 100 ± 1 mm. Form a circular
groove around the hole in the top surface of the base plate to locate the top edge of the
inverted funnel centrally over the hole. The top surface of the base plate extending
beyond the bottom surface by about 10 mm to enhance removal of the base plate from
the pavement at the completion of the test.

b) Funnel will have a top internal diameter of about 150 mm and a height of about 230 mm.
The stem of the funnel having an external diameter of about 14 mm and an internal
diameter of about 12 mm, and

c) With the inverted funnel inserted into the groove on the base plate, apply silicone sealant
externally over the join between the funnel and the base plate to secure the funnel. Mark
the funnel at heights of 100 mm, 150 mm and 200 mm above the bottom of the base
plate.

3.2 Small funnel, with a top internal diameter of about 65 mm and a ribbed stem to provide an air
gap when fitted into the permeameter funnel. Reduce the length of the stem as required so
that, when positioned in the permeameter funnel, the bottom of its stem is approximately
10 mm above the 200 mm mark on the stem of the permeameter funnel.

3.3 Annular template, of diameter 190 mm and containing a centrally located hole of 110 mm
diameter (bituminous materials only).

3.4 Annular restraining weight, of mass about 4 kg and of suitable dimensions to allow positioning
over the permeameter funnel to rest on the base plate.

3.5 Stop watch or other suitable timing device readable to 0.1 s.

3.6 Measuring cylinder, plastic measuring cylinder of 100 mL capacity.

3.7 Beakers, plastic beakers of appropriate capacity (for example, 100 mL, 600 mL and 1000 mL).
3.8 Water container, having a capacity of at least 10 litres.
3.9 Spatula, to aid application of the silicone sealant to the pavement or base of the permeameter.
3.10 Marking crayon.
3.11 Assorted implements, for cleaning of the pavement before and after testing (for example wire brush, broom, paint scraper).

4 Materials
   The following materials are required:
4.1 Silicone sealant, neutral cure (Note 8.1).
4.2 Potable water.

5 Procedure
   The procedure shall be as follows:
5.1 Remove any loose material from the pavement.
5.2 Attach the permeameter to the pavement using the appropriate method as follows:
5.2.1 Granular Material (Note 8.2)
   a) Apply silicone sealant to the base of the permeameter to a thickness of about 2 mm.
   b) Press the permeameter firmly onto the pavement.
5.2.2 Sprayed Seal/Asphalt Material
   a) Place the annular template on the pavement and use the crayon to mark two concentric circles of diameter 100 mm and 200 mm (Note 8.3).
   b) Apply silicone sealant to the pavement between the two concentric circles and spread it out evenly to a final thickness of about 2 mm using a spatula (Note 8.4).
   c) Align the base plate with the 200 mm diameter circle and press the permeameter firmly onto the pavement.
5.3 Position the restraining weight onto the base plate.
5.4 Place the small funnel into the stem of the permeameter funnel.
5.5 Using a beaker of appropriate capacity, pour water into the small funnel to fill the permeameter funnel to the 100 mm mark.
5.6 Check for leaks at the base of the permeameter. If any leakage is observed, caulk the area with additional silicone sealant (Note 8.5).
5.7 Continue adding water to the permeameter to maintain the water level above the 100 mm mark for 5 minutes or until 600 mL of water has passed through the pavement.
5.8 Immediately add additional water as required to raise the water level to just above the 200 mm mark. Discontinue the addition of water and record the time taken for the water level to drop from the 200 mm mark to the 150 mm mark to the nearest 0.1 seconds.
5.9 If the time recorded in Step 5.8 exceeds 2 seconds, use the falling head method. Otherwise, use the constant head method. The relevant method will be as follows:

5.9.1 Falling head method
Repeat Step 5.8 twice.

5.9.2 Constant head method
a) Allow the water level in the permeameter funnel to fall to the 100 mm mark, start the timer and then progressively pour 100 mL of water from the measuring cylinder into the funnel at a rate that maintains the water level in the permeameter funnel at the 100 mm mark.
b) Record the time in seconds to transfer 100 mL of water to the permeameter funnel to the nearest 0.1 seconds.
c) Add additional water as required to raise the water level in the permeameter above the 100 mL mark.
d) Repeat Steps 5.9.2 a) to c).
e) Repeat Steps 5.9.2 a) to b).

5.10 Remove the silicone sealant from the base of the permeameter and the bulk of the silicone sealant from the pavement.

6 Calculations
Calculations shall be as follows:

6.1 Falling head method
6.1.1 Calculate the average of the three time measurements \( (t) \).

6.1.2 Calculate the volume of the stem of the permeameter funnel between the 150 mm and 200 mm marks as follows (Note 8.6):

\[
V = \frac{\pi D^2}{80}
\]

where \( V \) = volume of stem between 150 mm and 200 mm marks (mL)
\( D \) = internal diameter of stem at 175 mm mark (mm)

6.1.3 Calculate the permeability as follows:

\[
k = \frac{25.5V}{t}
\]

where \( k \) = permeability (\( \mu \)m/s)
\( V \) = volume of stem between 150 mm and 200 mm marks (mL)
\( t \) = average time (s)

6.2 Constant head method
6.2.1 Calculate the average of the three time measurements \( (t) \).
6.2.2 Calculate the permeability as follows:

\[ k = \frac{3819 \nu}{t} \]

where

\( k \) = permeability (µm/s)
\( t \) = average time (s)

7 Reporting
The following shall be reported:

7.1 Test location including a longitudinal (chainage) and a lateral (offset) reference.

7.2 Test site description including pavement type and surface condition.

7.3 Permeability to three significant figures (µm/s).

7.4 Permeability category and description (Table 1).

8 Notes on method

8.1 Before handling the silicone sealant, the operator should consult the relevant SDS.

8.2 For granular materials, trial runs may be necessary to ensure that there is sufficient silicone sealant to effectively seal the permeameter without contaminating the exposed surface with an excess of sealant. It is desirable to keep the diameter of the exposed surface as close as possible to 100 mm.

8.3 The dimensions of the annular template allow for a 5 mm gap between the line marked by the crayon and the edge of the template. If necessary, the marking technique should be adjusted to ensure that the internal diameter of the smaller circle is 100 mm.

8.4 The sealant should be applied in a manner which spreads the sealant to, but not inside, the 100 mm diameter circle when the permeameter is pressed into position on the pavement.

8.5 It is normal for water to escape through the pavement surface at the outside edge of the base plate and this does not constitute leakage.

8.6 Alternatively, the stem end of the permeameter funnel can be stoppered, the permeameter inverted and water added to the 200 mm mark. The volume of water between the 200 mm and 150 mm marks can then be measured directly to the nearest 0.1 mL using a burette.

Table 1 – Permeability category and description

<table>
<thead>
<tr>
<th>Permeability (µm/s)</th>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01 - 0.10</td>
<td>A1</td>
<td>Very low permeability</td>
</tr>
<tr>
<td>0.11 - 1.00</td>
<td>A2</td>
<td>Low permeability</td>
</tr>
<tr>
<td>1.01 – 10.0</td>
<td>B</td>
<td>Moderately permeable</td>
</tr>
<tr>
<td>10.1 - 100</td>
<td>C</td>
<td>Permeable</td>
</tr>
<tr>
<td>101 - 1000</td>
<td>D</td>
<td>Moderately free draining</td>
</tr>
<tr>
<td>1001 - 10000</td>
<td>E</td>
<td>Free draining</td>
</tr>
</tbody>
</table>
Figure 1 – Evenflow field permeameter
Figure 2 – Plastic base plate
Test Method Q707B: Permeability of road surfacing and granular materials – rapid flow field permeameter

1 Source
This method was developed in-house using techniques evolved through internal departmental research investigations (Waters, T.J., “Permeability of Road Surface Materials Using the Rapidflow Field Permeameter”, Report TT305, 1999).

2 Scope
This method describes the procedure for the determination of the permeability of pavement materials using the Rapid Flow Field Permeameter. It is applicable to bituminous materials (for example sprayed seal, asphalt) and granular materials (where the surface is reasonably flat and well compacted) having permeability values within the range 10 to 5000 mm/s.

3 Apparatus
The following apparatus is required:

3.1 Field permeameter (Figure 1), consisting of a cylinder of clear rigid plastic (for example Perspex) attached to a rigid plastic base plate as follows:
   a) Base plate (Figure 2) with a diameter of about 200 mm and a thickness of about 20 mm. Containing a centrally located circular hole of diameter 100 ± 1 mm. Form a circular groove around the hole in the top surface of the base plate to locate the top edge of the inverted funnel centrally over the hole. The top surface of the base plate extending beyond the bottom surface by about 10 mm to enhance removal of the base plate from the pavement at the completion of the test.
   b) Cylinder with a height of about 215 mm, an internal diameter of about 145 mm and an outside diameter of about 152 mm, and
   c) With the bottom of the cylinder inserted in the groove on the base plate, apply silicone sealant externally over the join between the cylinder and the base plate. Mark the cylinder with etched lines at heights of 165 mm and 185 mm above the bottom of the base plate. The top of the cylinder should be about 225 mm above the bottom of the base plate (the base plate accounts for approximately 10 mm).

3.2 Annular template, of diameter 190 mm and containing a centrally located hole of 110 mm diameter (bituminous materials only).

3.3 Stop watch or other suitable timing device readable to 0.1 seconds.

3.4 Containers, of 10 L and 1 L capacity and fitted with a pouring lip.

3.5 Water container, having a capacity of at least 20 L.

3.6 Spatula, to aid application of the silicone sealant to the pavement or base of the permeameter.

3.7 Marking crayon.

3.8 Assorted implements, for cleaning of the pavement before and after testing (for example wire brush, broom, paint scraper).
4 Materials
The following materials are required:

4.1 Silicone sealant, neutral cure (Note 8.1).
4.2 Potable water.

5 Procedure
The procedure shall be as follows:

5.1 Remove any loose material from the pavement.

5.2 Attach the permeameter to the pavement using the appropriate method as follows:

5.2.1 Granular Material (Note 8.2)
   a) Apply silicone sealant to the base of the permeameter to a thickness of about 2 mm.
   b) Press the permeameter firmly onto the pavement.

5.2.2 Sprayed Seal/Asphalt Material
   a) Place the annular template on the pavement and use the crayon to mark two concentric circles of diameter 100 mm and 200 mm (Note 8.3).
   b) Apply silicone sealant to the pavement between the two concentric circles and spread it out evenly to a final thickness of about 2 mm using a spatula (Note 8.4).
   c) Align the base plate with the 200 mm diameter circle and press the permeameter firmly onto the pavement.

5.3 Using the containers as appropriate, pour water into the cylinder to fill it to the 165 mm mark.

5.4 Check for leaks at the base of the permeameter. If any leakage is observed, caulk the area with additional silicone sealant (Note 8.5).

5.5 Continue adding water to the permeameter to maintain the water level at the 165 mm mark for 5 minutes or until 600 mL of water has passed through the pavement.

5.6 Immediately add additional water as required to raise the water level to the 185 mm mark. Discontinue the addition of water and record the time taken for the water level to drop from the 185 mm mark to the 165 mm mark to the nearest 0.1 seconds.

5.7 Repeat Step 5.6 twice.

5.8 Remove the silicone sealant from the base of the permeameter and the bulk of the silicone sealant from the pavement.

6 Calculations
Calculations shall be as follows:

6.1 Calculate the average of the three time measurements (t).

6.2 Calculate the volume of the cylinder between 165 mm and 185 mm marks as follows:

\[ V = \frac{\pi D^2}{200} \]

where \( V \) = volume of cylinder between 165 mm and 185 mm marks (mL)
6.2.1 Calculate the permeability as follows:

\[
D = \text{internal diameter of the cylinder (mm)}
\]

\[
k = \frac{25.5V}{t}
\]

where \( k \) = permeability (\( \mu \text{m/s} \))

\( V \) = volume of cylinder between 165 mm and 185 mm marks (mL)

\( t \) = average time (s)

7 Reporting

The following shall be reported:

Test location including a longitudinal (chainage) and a lateral (offset) reference.

7.1 Test site description including pavement type and surface condition.

7.2 Permeability to three significant figures (\( \mu \text{m/s} \)).

7.3 Permeability category and description (Table 1).

8 Notes on method

8.1 Before handling the silicone sealant, the operator should consult the relevant SDS.

8.2 For granular materials, trial runs may be necessary to ensure that there is sufficient silicone sealant to effectively seal the permeameter without contaminating the exposed surface with an excess of sealant. It is desirable to keep the diameter of the exposed surface as close as possible to 100 mm.

8.3 The dimensions of the annular template allow for a 5 mm gap between the line marked by the crayon and the edge of the template. If necessary, the marking technique should be adjusted to ensure that the internal diameter of the smaller circle is 100 mm.

8.4 The sealant should be applied in a manner which spreads the sealant to, but not inside, the 100 mm diameter circle when the permeameter is pressed into position on the pavement.

8.5 It is normal for water to escape through the pavement surface at the outside edge of the base plate and this does not constitute leakage.

Table 1 – Permeability category and description

<table>
<thead>
<tr>
<th>Permeability (( \mu \text{m/s} ))</th>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.01 – 10.0</td>
<td>B</td>
<td>Moderately permeable</td>
</tr>
<tr>
<td>10.1 - 100</td>
<td>C</td>
<td>Permeable</td>
</tr>
<tr>
<td>101 - 1000</td>
<td>D</td>
<td>Moderately free draining</td>
</tr>
<tr>
<td>1001 - 10000</td>
<td>E</td>
<td>Free draining</td>
</tr>
</tbody>
</table>
Figure 1 – Rapid flow field permeameter
Figure 2 – Plastic base plate
Test Method Q708B: Road roughness – surface evenness - two laser profilometer

1 Source
This method was developed in-house using information obtained from the following technical references:


2 Scope
This test method defines the procedure for measuring the road roughness or surface evenness of road pavements, for construction compliance testing. The roughness is determined from direct measurement of the longitudinal profile in each wheel path using a vehicle-mounted inertial laser based non-contact device (that is, a two laser Profilometer).

The roughness measurement is expressed in terms of International Roughness Index (IRI). This index is obtained by quarter-car simulation at a set speed of 80 km/h using standardised suspension characteristics over a longitudinal profile.

The single roughness measurement produced by this method is the lane IRI, using the average of the two individual wheel path IRI values obtained separately for each wheel path of a lane. Conversion of lane IRI to equivalent NAASRA Roughness Meter counts is included. Generally, a test lot is defined as having minimum length of 100 m and a maximum length of 500 m.

3 Definitions
For the purpose of this method, the following definitions shall apply:

3.1 Longitudinal profile - the shape of a pavement surface measured as vertical distances from a datum horizontal plane along the direction of traffic flow.

3.2 Inertial profilometer - vehicle mounted laser-based non-contact device used for measuring the longitudinal profile of a road pavement within a given range of wavelengths of surface irregularities.

3.3 International Roughness Index (IRI) - mathematical model of the dynamic response of a real motor vehicle travelling along a single wheel path (or wheel track) of longitudinal road profile, referred to as the quarter-car (or World Bank) model. The IRI is expressed in terms of accumulated displacement of the simulated suspension in metres per measured kilometre (m/km). IRI can be reported in different ways, as follows:

- Single Track IRI
  The IRI based on a quarter-car model run at 80 km/h over a single wheel path of longitudinal profile (ASTM E1926-08).
- Lane IRI
  This is a composite IRI value representing the roughness of a road lane section determined by the Single Track IRI track averaging (quarter-car method). Using the Single Track IRI averaging (quarter-car) method, Lane IRI is determined by averaging two individual Single
Track IRI values obtained separately in each wheelpath of a lane (at 0.75 m on either side of the centre of the lane mid-track).

3.4 Wheel path – the path 0.75 m on either side of the centre of the lane.

3.5 NAASRA Roughness Meter - standard mechanical device used extensively in Australia and New Zealand since the 1970s for measuring road roughness by recording the upward movement of the rear axle of a standard station wagon relative to the vehicle’s body as the vehicle travels at a standard speed along the road being tested. A cumulative upward vertical movement of 15.2 mm corresponds to 1 NAASRA Roughness Count. For reporting purposes, this test method allows for the determination of NAASRA Roughness Counts.

4 Apparatus

The following apparatus is required:

4.1 A two laser profilometer comprising the following equipment is required:

a) Vehicular platform, capable of transporting the profilometer testing equipment and operators at highway speeds.

b) Two accelerometers to establish the inertial reference that enables reference to be maintained at the level of resolution and accuracy required for the laser displacement measurement transducers. Typically, for this application a minimum sample rate of 100 Hz and a range of ±2 g is sufficient.

c) Two laser displacement transducers that measure the distance between the accelerometers and the road surface. The laser displacement transducers shall be set to ensure mid-range operation during normal testing. Lasers suitable for this application typically have a stand-off height of 300 mm, a measuring range of 200 mm and a sample rate of 8-16 kHz.

d) The lasers and accelerometers are mounted 750 mm left and right of the longitudinal centreline of the vehicle.

e) Distance measuring rotational encoder capable of measuring the distance travelled to an accuracy of ± 0.1% over a distance of 1.0 km and having a resolution of 5 mm per pulse to enable data acquisition to be triggered at a minimum interval of 250 mm.

f) Data logger, capable of capturing the output from the lasers and accelerometers at equal intervals of 250 mm (minimum), and

g) Computer, to calculate the profile from the laser and accelerometer data and analyse the profile data using the quarter-car model to obtain the IRI.

4.2 Manufacturer’s user manual for operating the test equipment.

4.3 Flat base plates, gauge blocks and any other equipment required by the manufacturer user manual for the calibration of the laser displacement transducers.

5 Calibration and validation

Equipment calibration and validation shall be performed as follows:

5.1 Equipment calibration

5.1.1 Distance encoder

a) Calibrate the distance encoder by driving the host vehicle over a known distance (1 km to an accuracy of ± 1 m) and recording the number of pulses produced by the encoder.
b) Store the calibration factor and associated information (such as, the date and time of calibration). Use this for all subsequent testing until a new distance calibration is performed.

c) Calibrate the distance encoder whenever fitting a new distance encoder to the vehicle or when changing the wheels or tyres. Re-calibrate periodically to compensate for tyre wear.

5.1.2 Accelerometers

Undertake calibration and checking of the accelerometers in accordance with the procedures and requirements stated in the manufacturer’s user manual.

5.1.3 Laser Displacement Transducers

a) Perform the calibration of the laser displacement transducers immediately following any change to the transducers or a change to any part of the host vehicle that may interfere with the existing calibration.

b) Perform the calibration of the laser displacement transducers using the gauge blocks and flat plates in accordance with the procedures and requirements stated in the manufacturer’s user manual.

5.2 System validation

Validate the system as follows every 12 months:

5.2.1 Perform the distance measurement validation as detailed in Austroads Test Method AG:AM/T005.

5.2.2 Perform the roughness measurement validation as detailed in Austroads Test Method AG:AM/T003 except the validation loop is the Roads and Maritime Services loop near Newcastle in New South Wales.

5.3 Pre-test checks

5.3.1 If the laser displacement transducers are of a demountable design, calibrate the transducers as detailed in Step 5.1.3 each time the lasers are refitted to the vehicle.

5.3.2 Perform the manufacturer’s operation validation test (bounce test) before the start of each day’s testing as detailed in the manufacturer’s user manual (Note 9.1).

5.3.3 If the recorded roughness during the bounce phase of the test exceeds 0.15 lane IRI m/km or 3 NAASRA counts/km, the validation test has failed and the equipment requires recalibration, repair or replacement as appropriate.

6 Procedure

The procedure shall be as follows (Note 9.2):

6.1 Select the test section such that it includes sufficient length of pavement to allow for acceleration and deceleration of the vehicle. This is particularly important where the pavement test surface does not join the existing pavement smoothly or includes incomplete structures. In such situations, allow a length of 100 m at the start and finish of the section as ‘lead in’ and ‘lead out’ areas that are not included in the test section. Relate all start and finish points to either job chainages or other fixed references such as bridges, intersections, and so on.

6.2 Determine the test interval for testing (Note 9.3).

6.3 Ensure that the test section is dry and sufficiently clean and note any abnormal surface conditions that could affect the roughness results (Note 9.4).
6.4 Select the vehicle speed for testing (Note 9.5).

6.5 Check the vehicle tyre pressures against the vehicle manufacturer’s recommendation and adjust if necessary, to maintain the calibration of the distance encoder.

6.6 Follow the instructions in the manufacturer's user manual to measure the surface profile along each wheel path in the test lane, at a relatively constant speed, with the vehicle travelling along the centre of the lane being tested (Note 9.6), ensuring the following:

6.6.1 The test vehicle is travelling within the operating speed range prior to the defined start point of the survey.

6.6.2 Make no attempt to avoid pavement defects unless they are likely to damage the vehicle and/or jeopardise safety.

6.6.3 Avoid sudden braking and acceleration of the vehicle.

6.6.4 Conduct no testing if the surface is wet as this can affect the accuracy of the laser readings.

6.6.5 Conduct no testing in extremely dusty conditions as this can affect the accuracy of the laser readings.

6.7 Conduct one test run per traffic lane.

6.8 Record any events during testing that may affect roughness measurements or provide location references including the following (Note 9.7):

   a) Change of seal/construction joint
   b) Pothole/patch/pavement defect
   c) Bridge or culvert
   d) Intersection
   e) Railway crossing or grids
   f) Access pit covers
   g) Reference points.

7 Calculations

Calculations shall be as follows:

7.1 From the measured profile of each wheel path, calculate the IRI for each wheel path (\( IRI_L, IRI_R \)) using the quarter-car model (m/km).

7.2 Calculate the lane IRI as follows:

\[
IRI = \frac{IRI_L + IRI_R}{2}
\]

where

\( IRI \) = Lane IRI (m/km)

\( IRI_L \) = Left wheel path IRI (m/km)

\( IRI_R \) = Right wheel path IRI (m/km)

7.3 If required, calculate the NAASRA roughness (counts/km) as follows:
\[ N = (26.49 \text{ IRI})^{-1.27} \]

where

\[ N = \text{NAASRA roughness (counts/km)} \]
\[ \text{IRI} = \text{Lane IRI (m/km)} \]

8 Reporting

The following shall be reported:

8.1 Report the following general information for each test run:

a) Survey title/file name
b) Date and time of test
c) Test vehicle/equipment identification
d) Calibration relationship used
e) Operator and driver
f) Road number or job number
g) Test direction
h) Start and end references.

8.2 Report the following values for each test lot:

a) End distance
b) GNSS coordinates of Latitude, Longitude and Elevation.
c) Left/outer/passenger wheel path IRI to the nearest 0.01 m/km
d) Right/inner/driver wheel path IRI to the nearest 0.01 m/km
e) Lane IRI to the nearest 0.01 m/km
f) NAASRA roughness to the nearest 1 count/km
g) Test speed (km/h)
h) Any event recorded during testing.

9 Notes on method

9.1 This test simulates a bouncing vehicle travelling along a completely flat surface. The measured profile should be zero as the movement of the laser transducers is expected to be cancelled out by the accelerometers. However, due to electronic noise and other factors, a negligible roughness value is usually recorded.

9.2 A driver and operator are required to perform this test.

9.3 The maximum test interval is the test lot size. However, adoption of a shorter test interval such as 20 m still enables roughness data to be aggregated up to the required test lot while providing an indication of the roughness distribution within the test lot.

9.4 Sweep unsealed pavement layers prior to testing.

9.5 Profile based roughness testing is not speed dependent within the recommended operating speed range which is generally 25 to 120 km/h. As a safety precaution, most systems automatically cut power to the lasers if the vehicle speed drops below around 10 km/h.
testing under traffic, adopt a test speed of no less than 15 km/h under the posted or signed speed limit. When testing on construction sites, the test speed is not critical; however, it is preferable but not essential that the selected test speed, within the equipment's operating range, be maintained throughout the test run.

9.6 In the absence of defined traffic lanes, conduct testing in areas as directed by the site engineer or supervisor.

9.7 The number of events that can be recorded is a function of the test equipment system.
Test Method Q708C: Road roughness – surface evenness - static level and staff

1 Source
This method was developed in-house using information obtained from the following technical references:


2 Scope
This test method defines a procedure for measuring the road roughness or surface evenness of road pavements, for construction compliance testing. The roughness is determined from direct measurement of the longitudinal profile in each wheel path using a static level and staff.

Although labour intensive, this method is suitable for testing short sections of pavements which cannot be tested with vehicle based test methods.

The roughness measurement is expressed in terms of International Roughness Index (IRI). This index is obtained by quarter-car simulation at a set speed of 80 km/h using standardised suspension characteristics over a longitudinal profile.

The single roughness measurement produced by this method is the lane IRI, using the average of the two individual wheel path IRI values obtained separately for each wheel path of a lane. Conversion of lane IRI to equivalent NAASRA Roughness Meter counts is included. Generally, a test lot is defined as having minimum length of 100 m and a maximum length of 500 m.

3 Definitions
For the purpose of this method, the following definitions shall apply:

3.1 Longitudinal profile - is the shape of a pavement surface measured as vertical distances from a datum horizontal plane along the direction of traffic flow.

3.2 Level and staff profiles - An automatic surveyor’s level and staff can produce profiles to Class 2 standard. Class 2 Profile Standard requires a maximum sample interval, between elevation points, of 500 mm and a precision of the elevation measures of 1.0 mm. The precision of Class 2 is adequate for the calibration of vehicle based response type roughness meter systems such as the NAASRA Roughness Meter.

3.3 International Roughness Index (IRI) - is a mathematical model of the dynamic response of a real motor vehicle travelling along a single wheel path (or wheel track) of longitudinal road profile, referred to as the quarter-car (or World Bank) model. The IRI is expressed in terms of accumulated displacement of the simulated suspension in metres per measured kilometre (m/km). IRI can be reported in different ways, as follows:

- Single Track IRI
  The IRI based on a quarter-car model run at 80 km/h over a single wheel path of longitudinal profile (ASTM E1926-08).
• Lane IRI
  This is a composite IRI value representing the roughness of a road lane section determined by the Single Track IRI track averaging (quarter-car method). Using the Single Track IRI averaging (quarter-car) method, Lane IRI is determined by averaging two individual Single Track IRI values obtained separately in each wheel path of a lane (at 0.75 m on either side of the centre of the lane mid-track).

3.4 Wheel path – the path 0.75 m on either side of the centre of the lane.

3.5 NAASRA Roughness Meter - standard mechanical device used extensively in Australia and New Zealand since the 1970s for measuring road roughness by recording the upward movement of the rear axle of a standard station wagon relative to the vehicle’s body as the vehicle travels at a standard speed along the road being tested. A cumulative upward vertical movement of 15.2 mm corresponds to 1 NAASRA Roughness Count. For reporting purposes, this test method allows for the determination of NAASRA Roughness Counts.

4 Apparatus
  The following apparatus is required:

  4.1 Tape, surveyor’s tape to locate and mark the positions along the wheel paths of the lane where the elevation measures are to be taken, having an accuracy within 0.2% of its total length.

  4.2 Level, automatic surveyor’s level to provide the height readings from the staff (Note 8.1).

  4.3 Staff, standard metric staff, which enables 10 mm values to be read directly and the 1 mm values to be visually estimated. A bubble level attached to the staff is required to keep the staff vertical to maintain the precision of the height measurements (Note 8.1).

  4.4 Computer, to process the height measurements, generate the longitudinal profiles and analyse the profile data using the quarter-car model to obtain the IRI.

  4.5 Means for securing the tape (for example, weights or adhesive tape).

  4.6 Means for marking the wheel paths (for example, chalk or paint).

5 Procedure
  The procedure shall be as follows (Note 8.2):

  5.1 Clearly mark the transverse location of the wheel paths with chalk or paint at a maximum of 15 m intervals from the start and ensure that the start and end points for each tape set-up are also marked.

  5.2 Place the tape on a wheel path with the zero position on the tape at the start of the wheel path to be tested. Secure the tape with weights or adhesive tape.

  5.3 Place the level at a location that allows focusing on the staff at the start of the tape and over as much of the length of the tape as possible. Location of the level in line with the wheel path will minimise viewing adjustment.

  5.4 At 500 mm intervals along the tape, measure and record the distance between the road surface and an arbitrary height associated with the level.

  5.5 Move the tape such that the new zero point coincides with the old end point and secure the tape with weights or adhesive tape.
5.6 Before moving the level, identify the last measurement in the field notes. Mark the location of the measurement on the road if necessary. This point on the road is the pivot point for the change in instrument height that occurs with the new set-up.

5.7 Repeat Steps 5.3 to 5.6 until reaching the end of the test section.

5.8 Repeat Steps 5.2 to 5.7 for the other wheel path to be tested.

6 Calculations

Calculations shall be as follows:

6.1 Using a computer, enter the level measurements for each wheel path and calculate the longitudinal profile for each wheel path using a start chainage of 0 m and an arbitrary start elevation.

6.2 Plot the first 10 to 20 m of each longitudinal profile and use this to estimate an elevation at a location 11 m before the profile start, such that a line joining this point to the profile provides a smooth lead-in to the profile. Use the lead-in slope for initialising the IRI computation. The 11 m represents 0.5 seconds of travel at 80 km/h of the quarter-car model.

6.3 Add this point (chainage - 11.0 m with its estimated elevation) to the start of the profile data.

6.4 From the measured profile of each wheel path, calculate the IRI for each wheel path (IRI_L, IRI_R) using the quarter-car model (m/km) (Note 8.3).

6.5 Calculate the lane IRI as follows (Note 8.3):

\[ IRI = \frac{IRI_L + IRI_R}{2} \]

where

- IRI = Lane IRI (m/km)
- IRI_L = Left wheel path IRI (m/km)
- IRI_R = Right wheel path IRI (m/km)

6.6 If required, calculate the NAASRA roughness (counts/km) as follows:

\[ N = (26.49 \ IRI) - 1.27 \]

where

- N = NAASRA roughness (counts/km)
- IRI = Lane IRI (m/km)

7 Reporting

The following shall be reported:

7.1 Report the following general information for each test run:

a) Survey title/file name
b) Date and time of test
c) Operators
d) Road number or job number
e) Test direction and lane description
f) Start and end references.

7.2 Report the following values for each test lot:
   a) Test lot end distance
   b) Left/outer/passenger wheel path IRI to the nearest 0.01 m/km
   c) Right/inner/driver wheel path IRI to the nearest 0.01 m/km
   d) Lane IRI to the nearest 0.01 m/km
   e) NAASRA roughness to the nearest 1 count/km, if required.

8 Notes on method

8.1 This will provide the required Class 2 precision.

8.2 Three operators are recommended for this procedure. One operator positions the staff, the second reads the heights on the level and the third operator records the results.

8.3 For all IRI computations, use an interval of 20 m. These results can then be aggregated to produce a Road Roughness – Surface Evenness value for each test lot.
Test Method Q708D: Road roughness – surface evenness - ARRB walking profiler

1 Source

This method was developed in-house using information obtained from the following technical references:


2 Scope

This test method defines a procedure for measuring the road roughness or surface evenness of road pavements, for construction compliance testing. The roughness is determined from direct measurement of the longitudinal profile in each wheel path using the ARRB Walking Profiler.

Although slow in operation, this method is suitable for testing short sections of pavements that cannot be tested with vehicle based test methods.

The roughness measurement is expressed in terms of International Roughness Index (IRI). This index is obtained by quarter-car simulation at a set speed of 80 km/h using standardised suspension characteristics over a longitudinal profile.

The single roughness measurement produced by this method is the lane IRI, using the average of the two individual wheel path IRI values obtained separately for each wheel path of a lane. Conversion of lane IRI to equivalent NAASRA Roughness Meter counts is included. Generally, a test lot is defined as having minimum length of 100 m and a maximum length of 500 m.

3 Definitions

For the purpose of this method, the following definitions shall apply:

3.1 Longitudinal profile - is the shape of a pavement surface measured as vertical distances from a datum horizontal plane along the direction of traffic flow.

3.2 Walking profiler - precision mechanical device with a moveable platform (241.3 mm in length), fitted with a horizontally mounted accelerometer that can record the longitudinal profile, to Class 1 standard, along a wheel path at a speed of 800 metres/hour. Class 1 Profile Standard specifies a maximum sample interval between elevation points of 250 mm and a precision of the elevation measures of 0.5 mm.

3.3 International Roughness Index (IRI) - is a mathematical model of the dynamic response of a real motor vehicle travelling along a single wheel path (or wheel track) of longitudinal road profile, referred to as the quarter-car (or World Bank) model. The IRI is expressed in terms of accumulated displacement of the simulated suspension in metres per measured kilometre (m/km). IRI can be reported in different ways, as follows:

- Single Track IRI
The IRI based on a quarter-car model run at 80 km/h over a single wheel path of longitudinal profile (ASTM E1926-08).

- Lane IRI
  This is a composite IRI value representing the roughness of a road lane section determined by the Single Track IRI track averaging (quarter-car method). Using the Single Track IRI averaging (quarter-car) method, Lane IRI is determined by averaging two individual Single Track IRI values obtained separately in each wheelpath of a lane (at 0.75 m on either side of the centre of the lane mid-track).

3.4 Wheel path – the path 0.75 m on either side of the centre of the lane.

3.5 NAASRA Roughness Meter - standard mechanical device used extensively in Australia and New Zealand since the 1970s for measuring road roughness by recording the upward movement of the rear axle of a standard station wagon relative to the vehicle’s body as the vehicle travels at a standard speed along the road being tested. A cumulative upward vertical movement of 15.2 mm corresponds to 1 NAASRA Roughness Count. For reporting purposes, this test method allows for the determination of NAASRA Roughness Counts.

4 **Apparatus**

The following apparatus is required:

4.1 ARRB Walking Profiler, calibrated in accordance with the procedure specified in the manufacturer’s user manual.

4.2 Tape measure, to locate and mark the positions along the wheel paths of the lane to provide guidance for the walking profiler operator.

4.3 Paint, crayon or similar for marking alignment reference points along the wheel paths to be tested.

4.4 Broom, to sweep the test wheel paths, if required.

4.5 Thermometer for measuring the ambient operational air temperature of the walking profiler. A thermometer with a range of -5° to 100°C (minimum) and resolution of 1°C.

4.6 Computer, to analyse the individual wheel path and averaged wheel path longitudinal profile data using the quarter-car model to obtain the IRI.

4.7 Manufacturer’s data acquisition user manual.

5 **Procedure**

The procedure shall be as follows (Note 8.1):

5.1 Clearly mark the transverse location of the wheel paths at 3 to 5 m intervals from the start, along the length to be tested, to facilitate accurate tracking of the walking profiler.

5.2 Ensure that the wheel paths are free from any loose materials, by sweeping if necessary.

5.3 Place the walking profiler at the start point of the first wheel path to be tested and record the ambient air temperature within the profiler cowling. If operating without a cowling, record the ambient air temperature within the workings of the profiler.

5.4 Over the first 20 m of the wheel path to be tested, carry out the Field Offset Trim in accordance with the manufacturer’s data acquisition user manual.
5.5 Conduct the survey of the first test wheel path in accordance with the manufacturer’s data acquisition user manual selecting metric units in the set-up.

5.6 Record the profiler’s ambient air temperature as described in Step 5.3.

5.7 If the temperature at the end of the survey is within ± 10ºC of the start point temperature, accept the survey and move the profiler to the start of the next wheel path to be tested. Otherwise, repeat Steps 5.3 to 5.7.

5.8 Repeat Steps 5.3 to 5.7 for the second wheel path to be tested.

6 Calculations

Calculations shall be as follows:

6.1 Using a computer, load the profile data files for each wheel path from the walking profiler into a spreadsheet.

6.2 Plot the first 10 to 20 m of each longitudinal profile and use this to estimate an elevation at a location 11 m before the profile start, such that a line joining this point to the profile provides a smooth lead-in to the profile. Use this lead-in slope for initialising the IRI computation. The 11 m represents 0.5 seconds of travel at 80 km/h of the quarter-car model.

6.3 Add this point (chainage -11.0 m with its estimated elevation) to the start of the profile data to produce a new profile data file for each wheel path suitable for input into the IRI computation program.

6.4 From the measured profile of each wheel path, calculate the IRI for each wheel path (IRI_L, IRI_R) using the quarter-car model (m/km) (Note 8.2).

6.5 Calculate the lane IRI as follows (Note 8.2):

\[
IRI = \frac{IRI_L + IRI_R}{2}
\]

where

- IRI = Lane IRI (m/km)
- IRI_L = Left wheel path IRI (m/km)
- IRI_R = Right wheel path IRI (m/km)

6.6 If required, calculate the NAASRA roughness (counts/km) as follows:

\[
N = (26.49 \times IRI) - 1.27
\]

where

- N = NAASRA roughness (counts/km)
- IRI = Lane IRI (m/km)

7 Reporting

The following shall be reported:

7.1 Report the following general information for each test run:

a) Survey title/file name
b) Date and time of test
c) Operator
d) Road number or job number
e) Test direction and lane description
f) Start and end references.

7.2 Report the following values for each test lot:
   a) Test lot end distance
   b) Left/outer/passenger wheel path IRI to the nearest 0.01 m/km
   c) Right/inner/driver wheel path IRI to the nearest 0.01 m/km
   d) Lane IRI to the nearest 0.01 m/km
   e) NAASRA roughness to the nearest 1 count/km, if required.

8 Notes on method
8.1 Only one operator is required to perform this test.
8.2 For all IRI computations, use an interval of 20 m. These results can then be aggregated to produce a Road Roughness – Surface Evenness value for each test lot.
Test Method Q711A: Field spread rate of cover aggregate - canvas mat

1 Source
This method was developed in-house using techniques evolved through internal departmental investigations.

2 Scope
This method describes the procedure for the determination of the spread rate of cover aggregate delivered from a mechanical spreading device to determine spreader performance in a trial run prior to use on sprayed sealing works or just beyond the conclusion of a spray run.

3 Apparatus
The following apparatus is required:

3.1 Balance of suitable capacity, having a resolution of at least 100 g and with a limit of performance within the range of ± 500 g. A spring balance with a capacity of 30 kg and an attached hook has been found to be suitable.

3.2 Square mats, made from heavy duty fabric such as canvas with a reinforced lip around the perimeter and lifting points at each corner. The reinforced lip should be approximately 35 mm in height and stand perpendicular to the mat. The mat area enclosed within the lip should be as close as practicable to one square metre (that is 1 m x 1 m) (Figure 1).

3.3 Tape measure, with a resolution of 1 mm.

3.4 Small pegs to hold the mats in place during testing.

3.5 Brush and scoop.

4 Procedure
The procedure shall be as follows:

4.1 Determine the length and breadth of each mat used (l1, b1).

4.2 Determine the mass of each mat used (m1).

4.3 Arrange the one or more of the mats on a level surface in an arrangement so that the spread rate across the spreading width of the aggregate spreader can be determined (Note 7.1). If required, secure the mat(s) to the surface using pegs.

4.4 With the spreading device travelling at the desired operating speed and other mechanical spreading equipment (for example gates, rollers) adjusted to the desired settings, drive the spreader over the arrangement of mats. Record all equipment settings.

4.5 After the spreader has passed over the mat(s), remove excess aggregate spread over and outside the reinforced lip of the mat. A scoop may be required to move the aggregate from the outside of the mat.

4.6 Determine the mass of each mat and aggregate (m2).

4.7 Where the spread rate is required as an area spread per volume (m²/m³), perform an uncompacted bulk density test as detailed in Test Method AS 1141.4 on either a sample of retained aggregate collected from the mat(s) or on a representative sample of aggregate collected prior to spreading.
5 Calculations

Calculations shall be as follows:

5.1 Calculate the area of each mat as follows:

\[ A_i = \frac{l_i b_i}{10^6} \]

where
\( A_i \) = area of mat (m\(^2\))
\( l_i \) = length of mat (mm)
\( b_i \) = breadth of mat (mm)

5.2 Calculate the spread rate for each mat as follows:

\[ R_{ii} = \frac{m_{2i} - m_{ii}}{1000 A_i} \]

where
\( R_{ii} \) = spread rate for mat (kg/m\(^2\))
\( m_{2i} \) = mass of mat and aggregate (g)
\( m_{ii} \) = mass of mat (g)
\( A_i \) = area of mat (m\(^2\))

5.3 If required, calculate the mean spread rate when more than one mat is used as follows:

\[ R_1 = \frac{\sum R_{ii}}{n} \]

where
\( R_1 \) = mean spread rate (kg/m\(^2\))
\( R_{ii} \) = spread rate for mat (kg/m\(^2\))
\( n \) = number of mats used

5.4 If required, calculate the spread rate on an area spread per volume basis for each mat as follows:

\[ R_{2i} = \frac{1000 \rho}{R_{ii}} \]

where
\( R_{2i} \) = spread rate for mat (m\(^2\)/m\(^3\))
\( \rho \) = uncompacted bulk density of aggregate (t/m\(^3\)) obtained from Test Method AS 1141.4
\( R_{ii} \) = spread rate for mat (kg/m\(^2\))

5.5 If required, calculate the mean spread rate when more than one mat is used as follows:

\[ R_2 = \frac{\sum R_{2i}}{n} \]
where \( R_2 \) = mean spread rate (m\(^2\)/m\(^3\))
\( R_{2i} \) = spread rate for mat (m\(^2\)/m\(^3\))
\( n \) = number of mats used

6 Reporting

The following shall be reported:

6.1 Individual spread rate(s) to the nearest 0.1 kg/m\(^2\).
6.2 Mean spread rate to the nearest 0.1 kg/m\(^2\).
6.3 Individual spread rate(s) to the nearest 1 m\(^2\)/m\(^3\), if required.
6.4 Mean spread rate to the nearest 1 m\(^2\)/m\(^3\), if required.

7 Notes on method

7.1 Where several mats are used, they can be placed diagonally across the path of the spreader, avoiding overlap of the mats, while allowing the full width to be sampled.

*Figure 1 – Example of canvas mat*
Test Method Q712: Surface evenness of road surface – three metre straightedge

1 Source

This method was developed in-house with reference to AS 1003: Engineers straightedges and Roads and Maritime Services Test Method T183: Surface deviation using a straightedge.

2 Scope

This method describes the procedure for obtaining a measure of the evenness of a pavement surface as determined by the deviation from a three metre straightedge. It is applicable only to the measurement of depressions in the pavement surface and to those straightedges that can be positioned in direct contact with the pavement surface.

3 Apparatus

The following apparatus is required:

3.1 Straightedge, a 3 m rigid length of metal of either rectangular or I-section shape. The flat working face of the straightedge having deviations along its entire length less than ± 0.5 mm from true, and less than ± 1.0 mm from true when resting on supports at both ends. The straightedge will be constructed so that it can rest unsupported on the pavement with its working face in contact with the pavement.

3.2 Depth gauge, a suitable device for measuring the gap between the straightedge and the pavement to the nearest 1 mm. One such device is a metal wedge that is slid beneath the straightedge and calibrated in so the gap width can be read directly from the wedge as determined by the distance penetrated by the wedge at its first contact with the straightedge.

3.3 Tape measure, steel rule and wheel meter as required.

4 Procedure

The procedure shall be as follows:

4.1 Select the test location and remove any loose material from the surface of the pavement.

4.2 Place the straightedge at the required orientation (normally longitudinal or transverse to the centre-line) so that the working face of the straightedge is in contact with the pavement surface (Note 6.1).

4.3 Reposition the straightedge, if necessary, to ensure that:

a) the straightedge sits firmly on the pavement surface without rocking (Note 6.2)

b) the straightedge is at right angles to any linear feature that is under the straightedge (for example, joint, edge, tie-in), and

c) for other than joint testing, the length of the straightedge that is cantilevered is minimised (Note 6.3).

4.4 Where the test location is on a crown or superelevation of the road or there is any feature that may affect the measurement, record these details.

4.5 Visually estimate the point at which the greatest deviation appears to occur between the straightedge and the pavement surface (Note 6.4).
4.6 Using the depth gauge, determine the deviation at this point and record the value to the nearest 1 mm.

4.7 Repeat Steps 4.5 to 4.6 for other points along the straightedge, as necessary until the maximum deviation is recorded.

5 **Reporting**

The following shall be reported:

5.1 Surface type and layer.

5.2 Test location (for example, chainage, direction, lane, offset/wheel path and so on).

5.3 Orientation of straightedge relative to centreline.

5.4 Maximum deviation to the nearest 1 mm.

5.5 Where the cantilever is greater than 750 mm, the length of the cantilever to the nearest 5 mm.

5.6 Test location features (for example, convex shape, linear feature, crown, superelevation and so on).

6 **Notes on method**

6.1 Where a joint is to be tested, position one end of the straightedge directly over the joint with the remainder of the straightedge supported on the surface to be tested.

6.2 Where a convex surface prevents the positioning of the straightedge firmly on the pavement without rocking, terminate the test. Record “Convex shape” for the test location.

6.3 Where the cantilever is greater than 750 mm, measure the length of cantilever to the nearest 5 mm.

6.4 Maximum deviation may be under the supported or cantilevered portion of the straightedge.
Test Method Q713: Skid resistance – mobile, variable slip technique

1 Source
This test shall be performed in accordance with ASTM E1859–06, Standard test method for Friction Coefficient Measurements Between Tire and Pavement Using a Variable Slip Technique, but with the following changes, as detailed below. These changes are due to:

a) amendment specific to the ViaFriction Skid Tester
b) local terminology and operational procedures.

The changes to the ASTM Standard Test Method were developed in-house based on information obtained from the following technical references:


2 Scope
This method covers the direct measurement of the braking force coefficient of friction at a slip speed of 60 km/h (F60) and the speed dependency (Sp) of that measure (that is, the two components of International Friction Index (IFI)) using the ViaTech – ViaFriction skid tester operating in variable slip mode. Also measured during the test is Peak Friction, the slip speed at which it occurred (Vcrit.) and the coefficient of friction at a slip speed of 30 km/h (F30 – commonly referred to as European Friction Index (EFI)).

3 Definitions
The terminology use is as detailed in ASTM E1859-06, except as shown below:

- 3.2.1 peak friction number, n is referred to as Peak Friction
- 3.2.1.1 SNF peak(S) – S is the slip speed at which peak friction occurs and is referred to as Vcrit.
- 3.2.1.1 SNF peak = Peak Friction x 100
- 3.2.2.1 SNF Characteristic is the slip friction at a specified slip speed. At the 60 km/h adopted slip speed, this friction value is denoted as F60 where SNF(60)/100 = F60.
- 3.2.3 “slip – to skid Friction number” is the friction value at wheel lockup and is only a meaningful measure when testing at constant speed. This value is not reported.
3.2.5 slope indicator is equivalent to Speed Number and is designated as Sp. F60 and Sp are the two components of International Friction Index (IFI).

3.2.6 tire longitudinal stiffness indicator is not recorded or reported.

4 Apparatus

The apparatus required is as detailed in ASTM E1859-06, except as shown below:

- 5.4.1.1 The ViaFriction skid tester operates under a 71 kg (156.1 lbs) load not the ASTM specified 1.423 kN (320 lbf) load.
- 5.4.1.2 Initial calibration is supplied by the manufacturer against a reference device used in the PIARC International Trial. Annual stability of calibration is undertaken using a relative calibration approach over a number of established test sites.
- 5.4.5 The distance encoders on the ViaFriction skid tester have a resolution of 100 and 25 mm on the test wheel and test vehicle respectively. With a brake cycle of 0.5 seconds, at a test speed of 60 to 80 km/h, the 100 mm distance resolution on the test wheel provides approximately 100 data points in the braking cycle that provides a slip speed resolution of <1 km/h.

5 Test procedure

The procedure shall be as follows:

- 5.1 Testing is not speed dependent and conducted under traffic conditions, at test speeds between 40 and 90 km/h. When testing on construction sites or runways (that is, not under traffic), a test speed of 60 to 80 km/h is preferred.
- 5.2 Select a water film depth of 0.5 mm for road testing and a 1.0 mm water film depth for runway testing.
- 5.3 Unless specified, carry out testing in the left hand wheel path of the test lane.
- 5.4 Although the testing operation is continuous, at the adopted brake profile (ramp setting) of 500 ms, the braking system takes 0.5 seconds to do a test and 4 to 5 seconds to dissipate its energy and reset for the next test. At a test speed of 80 km/h the combined braking and reset cycles take around 5 seconds and cover a travelled distance of 100 to 120 m. Therefore, the minimum test intervals are 100 and 150 m for speed zones ≤ 60 km/h and > 60 km/h respectively.
- 5.5 Record the water temperature and ambient temperature during testing in addition to the ViaFriction test unit’s automatic acquisition of surface temperature.

6 Calculations

Calculate as follows:

- 6.1 The ViaFriction system reports for each test interval, the test speed, peak friction, Vcrit, F30, F60, Friction Slip Slope, surface temperature and GPS coordinates. The Friction Slip Slope can be converted to Sp using the following relationship:
\[ S_p = \frac{-1}{FSS} \]

where

- \( S_p \) = slope indicator
- \( FSS \) = Friction Slip Slope

6.2 The recorded F60 skid resistance value shall be temperature corrected as follows:

6.2.1 The Transport and Main Roads adopted reference surface temperature for skid resistance measurement correction is 30°C. It is proposed that this be raised to 35°C for areas west of the Charleville, Alpha, Hughenden, Georgetown and Weipa line to reflect the higher operating surface temperature conditions in that area (TMR (2010)).

6.2.2 For correction of F60 skid resistance results to a 30°C reference temperature, the following relationship shall be used:

\[ F60_{30} = F60_{(t)} + 0.0015(t) - 0.045 \]

where

- \( F60_{30} \) = corrected F60 value for a 30°C reference temperature
- \( F60_{(t)} \) = recorded F60 value at \( t \)°C
- \( (t) \) = surface temperature at time of test (°C)

6.2.3 For correction to 35°C reference temperature, the following relationship shall be used:

\[ F60_{35} = F60_{(t)} + 0.0015(t) - 0.0525 \]

where

- \( F60_{35} \) = corrected F60 value for a 35°C reference temperature
- \( F60_{(t)} \) = recorded F60 value at \( t \)°C
- \( (t) \) = surface temperature at time of test (°C)

7 Reporting

For each test interval the following shall be reported:

7.1 Location of the test (road, chainage, lane, wheel path, GPS coordinates).

7.2 Date and time of test.

7.3 International Friction Index comprising the two components, that is, the temperature corrected F60 friction coefficient to the nearest 0.01 and the speed dependency (Sp) factor to the nearest 1 km/h (Note 8.1).

7.4 Other measured friction coefficients and parameters (optional).

7.5 Ambient and water temperatures (optional) (Note 8.2).

8 Notes on method

8.1 The speed dependency (Sp) factor is the slope of the friction/slip speed curve at 60 km/h. As the coefficient of friction is dimensionless, Sp is expressed in km/h.

8.2 These are only recorded for future use with possibly more refined temperature correction procedures.
Test Method Q714: Skid resistance - mobile, continuous reading, fixed slip technique

Perform this test in accordance with ASTM E2340/E2340M Standard Test Method for Measuring the Skid Resistance of Pavements and Other Trafficked Surfaces Using a Continuous Reading, Fixed-Slip Technique and ASTM E1960 Standard Practice for Calculating International Friction Index of a Pavement Surface, but with the following changes, as detailed below. These changes are due to:

a) amendment specific to the ViaFriction Skid Tester.

b) local terminology and operational procedures.

1 Scope

This method covers the measurement of the braking force coefficient of friction at a slip speed of 60 km/h (that is, F60, the friction component of International Friction Index (IFI)) using the ViaTech – ViaFriction skid tester operating in continuous fixed slip mode.

The changes were developed in house based on information obtained from the following technical references:


For test speeds greater than 60 km/h, the slip ratio is selected to enable direct measurement of the braking force coefficient of friction at a slip speed of 60 km/h (F60). For slower test speeds, the maximum effective slip ratio of 90% is selected and the measured coefficient of friction is corrected to F60 using the Penn State relationship (J.J. Henry & M. Marasteanu (1992)), as adopted by PIARC (1995) and described in ASTM (E1960 – 07).

The Penn State relationship uses the speed dependency factor (Sp), the second component of International Friction Index. Sp can be measured directly with a supplementary test using the Via Friction in variable slip mode (Q713) or calculated from surface texture measurements (Q705 (2010)) and the PIARC (1995) relationship for device A8 (Sand Patch Test using glass beads).
2 Test procedure

2.1 Carry out testing at the test speeds and their associated slip ratio in Table 1. Note: 100% slip is a locked wheel.

2.2 Select a water film depth of 0.5 mm for road testing and a 1.0 mm water film depth for runway testing.

2.3 Unless specified, carry out testing in the left hand wheel path of the test lane.

2.4 Although testing is continuous, process data in 10 m (maximum) test lots. Report either, individually, or averaged into reporting lots of 100 m minimum length.

2.5 Record surface temperature, water temperature and ambient temperature.

3 Data processing

3.1 Transformation sequence

3.1.1 Convert the measured friction to a slip speed of 60 km/h – Speed Correction.

3.1.2 Convert the speed corrected friction measure to F60 – the friction component of IFI.

3.1.3 Temperature correction of F60.

3.2 Speed correction

3.2.1 The first step is to convert the measured friction level to what would have been measured at a slip speed of 60 km/h using the Penn State relationship:

\[
\text{FR60} = \text{FRS} \cdot e^{(S-60)/S_p}
\]

where

- \( \text{FR60} \) = adjusted value of friction to a slip speed of 60 km/h
- \( \text{FRS} \) = friction measured at slip speed \( S \)
- \( S \) = slip speed at which the friction value was measured (km/h)
- \( S_p \) = speed dependency factor

3.2.2 The speed dependency factor (Sp) is determined either by direct measurement in variable slip mode (Q713 (2011)) or from Sand Patch texture depth (MTD) as detailed in PIARC (1995) as follows:

\[
S_p = -11.6 + (113.6 \cdot \text{MTD})
\]

where

- \( S_p \) = speed dependency factor
- \( \text{MTD} \) = sand patch texture depth (mm)
3.3 **Harmonisation**

3.3.1 The next step is to convert the adjusted friction measure (FR60) to the harmonised International Friction Index (IFI) friction measure F60 as detailed in PIARC (1995) as follows:

\[ F60 = A + (B \times FR60) \]

where
- \( F60 \) = Harmonised International Friction Index (IFI)
- \( A \) = constant for reference test device used in PIARC harmonisation trial
- \( B \) = constant for reference test device used in PIARC harmonisation trial
- \( FR60 \) = adjusted value of friction to a slip speed of 60 km/h

3.3.2 The ViaFriction test unit is internally calibrated, against OSCAR, a reference device used in the PIARC harmonisation trial. This relationship as detailed in ViaTech (2009) is:

\[ OSCAR = -0.0366 + (0.9934 \times \text{ViaFriction}) \]

3.3.3 The relationship for OSCAR as detailed in Norsemeter (1996) is:

\[ F60 = -0.000074 + (1.000022 \times FR60) \]

3.3.4 In practical terms, as the A & B constants nearly equal zero and 1, the OSCAR and units calibrated against it, measure F60 directly when testing at a 60 km/h slip speed. Therefore, this step is not required for ViaFriction test results.

3.4 **Temperature correction**

3.4.1 The TMR adopted reference temperature for skid resistance measurement correction is 30\(^\circ\)C. It is proposed that this be raised to 35\(^\circ\)C for areas west of the Charleville, Alpha, Hughenden, Georgetown and Weipa line to reflect the higher operating surface temperature conditions in that area (TMR (2010)).

3.4.2 For correction of F60 skid resistance results to a 30\(^\circ\)C reference temperature, the following relationship shall be used:

\[ F60_{30} = F60_{(t)} + 0.0015(t) - 0.045 \]

where
- \( F60_{30} \) = corrected F60 value for a 30\(^\circ\)C reference temperature
- \( F60_{(t)} \) = recorded F60 value at \( t\)\(^\circ\)C
- \( t \) = surface temperature at time of test (\(^\circ\)C)

3.4.3 For correction to 35\(^\circ\)C reference temperature, the following relationship shall be used:

\[ F60_{35} = F60_{(t)} + 0.0015(t) - 0.0525 \]

where
- \( F60_{35} \) = corrected F60 value for a 35\(^\circ\)C reference temperature
- \( F60_{(t)} \) = recorded F60 value at \( t\)\(^\circ\)C
- \( t \) = surface temperature at time of test (\(^\circ\)C)
3.5 **Application of speed and temperature correction**

Speed correction shall be applied first at the processing 10 m test lot stage when the calculated slip speed varies by more than ± 3% of the targeted slip speed. Temperature correction shall be applied last at the reporting test lot stage using the average surface temperature recorded for the test lot.

4 **Calibration**

The ViaFriction has been dynamically calibrated by the manufacturer (ViaTech) against OSCAR, a reference device used in the PIARC (1995) trial. The data produced by ViaFriction, when testing at a slip speed of 60 km/h, is a direct measure of F60, the friction component of International Friction Index. In Australia, we do not undertake static calibration tests but rely in the equipments in-build diagnostics and regular dynamic reference calibration checks over our Nudgee Beach Road test site and the Department's Mt. Cotton test track in Brisbane. For major projects, dynamic reference calibration checks are carried out before and after each skid resistance survey.

**Table 1 – Nominal test speeds and slip ratios**

<table>
<thead>
<tr>
<th>Posted speed (km/h)</th>
<th>Test speed (km/h)</th>
<th>Slip ratio (%)</th>
<th>Friction measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>110</td>
<td>90</td>
<td>67</td>
<td>FR60</td>
</tr>
<tr>
<td>100</td>
<td>80</td>
<td>75</td>
<td>FR60</td>
</tr>
<tr>
<td>90</td>
<td>80</td>
<td>75</td>
<td>FR60</td>
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<tr>
<td>80</td>
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</tr>
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<td>70</td>
<td>86</td>
<td>FR60</td>
</tr>
<tr>
<td>60</td>
<td>60</td>
<td>90*</td>
<td>FR54**</td>
</tr>
<tr>
<td>50</td>
<td>50</td>
<td>90*</td>
<td>FR45**</td>
</tr>
<tr>
<td>40</td>
<td>40***</td>
<td>90*</td>
<td>FR36**</td>
</tr>
</tbody>
</table>

* Maximum effective slip ratio  
** Needs to be corrected to FR60 using a measured or calculated Sp  
*** Minimum test speed.
Test Method Q719: Field spread rate of solid stabilisation agents - fabric mat

1  Source
This method was developed in-house using techniques evolved through internal departmental investigations.

2  Scope
This method describes the procedure for the determination of the spread rate of solid stabilising agents delivered from a mechanical spreading device to determine spreader performance in terms of spread rate and uniformity of distribution.

3  Apparatus
The following apparatus is required:

3.1 Balance of suitable capacity, having a resolution of at least 100 g and with a limit of performance within the range of ± 500 g. A spring balance with a capacity of 30 kg and an attached hook has been found to be suitable.

3.2 Square mats, made from heavy duty fabric such as canvas or polyester with a reinforced lip around the perimeter and lifting points at each corner. The mat should be as close as practicable to one square metre (that is 1 m x 1 m).

3.3 Tape measure, with a resolution of 1 mm.

3.4 Small masses or pegs to hold the mats in place during testing.

3.5 Brush and scoop.

4  Procedure
The procedure shall be as follows:

4.1 Determine the length and breadth of each mat used (l₁, b₁).

4.2 Determine the mass of each mat used (m₁).

4.3 Arrange one or more of the mats on a level surface so that the spread rate across the spreading width of the spreader can be determined (Note 7.1). Secure the mat(s) to the surface using masses or pegs.

4.4 After the spreader has passed over the mat(s), carefully brush the stabilising agent from the periphery of each mat towards the centre of the mat. A scoop may be required to move the stabilising agent from the periphery of the mat.

4.5 Determine the mass of each mat and stabilising agent used (m₂).

4.6 Return the stabilising agent to the surface and spread over the area previously covered by the mat(s).
5 Calculations
Calculations shall be as follows:

5.1 Calculate the area of each mat as follows:

\[ A_i = \frac{l_i b_i}{10^6} \]

where

- \( A_i \) = area of mat (m²)
- \( l_i \) = length of mat (mm)
- \( b_i \) = breadth of mat (mm)

5.2 Calculate the spread rate for each mat as follows:

\[ R_i = \frac{m_{2i} - m_{1i}}{1000 A_i} \]

where

- \( R_i \) = spread rate for mat (kg/m²)
- \( m_{2i} \) = mass of mat and stabilising agent (g)
- \( m_{1i} \) = mass of mat (g)
- \( A_i \) = area of mat (m²)

5.3 Calculate the mean spread rate when more than one mat is used as follows:

\[ R = \frac{\sum R_i}{n} \]

where

- \( R \) = mean spread rate (kg/m²)
- \( R_i \) = spread rate for mat (kg/m²)
- \( n \) = number of mats used

6 Reporting
The following shall be reported:

6.1 Individual spread rate(s) to the nearest 0.1 kg/m².

6.2 Mean spread rate to the nearest 0.1 kg/m².

7 Notes on method

7.1 Where several mats are used, they can be placed diagonally across the path of the spreader, avoiding overlap of the mats, while allowing the full width to be sampled.
Test Method Q720: Loose aggregate on sprayed seals

1 Source
This method is based on the RMS Test Method T277: Measurement of loose aggregate on sprayed seals.

2 Scope
This method describes the procedure for determining the quantity of loose aggregate particles on the surface of a sprayed seal constructed with aggregates of 10 mm nominal size or larger.

3 Apparatus
The following apparatus is required:

3.1 Square template, of rigid construction and with internal dimensions as close as practicable to 1 m by 1 m. The template should be designed to allow ready removal of aggregate from the template area.

3.2 Brush, a stiff-bristled brush suitable for removing loose aggregate particles.

3.3 Container, suitable for collecting aggregate particles removed from the template area.

3.4 Tape measure, with a resolution of 1 mm.

3.5 Sieve, 6.70 mm complying with ISO 3310.

4 Procedure
The procedure shall be as follows:

4.1 Determine the length and breadth of the template (l, b).

4.2 Place the template on the sprayed seal surface.

4.3 Using the brush, remove any loose aggregate particles from within the template area and collect them in the container, taking care not to dislodge any aggregate particles which are embedded in the seal binder.

4.4 Screen the collected loose aggregate particles over a 6.70 mm sieve.

4.5 Count the number of aggregate particles retained on the 6.70 mm sieve (n).

5 Calculations
Calculations shall be as follows:

5.1 Calculate the area of the template as follows:

\[ A = \frac{lb}{10^6} \]

where

\[ A = \text{area of template (m}^2\text{)} \]
\[ l = \text{length of template (mm)} \]
\[ b = \text{breadth of template (mm)} \]
5.2 Calculate loose aggregate as follows:

\[ L = \frac{n}{A} \]

where 

- \( L \) = loose aggregate (particles/m\(^2\))
- \( A \) = area of mat (m\(^2\))
- \( n \) = number of loose aggregate particles

6 Reporting

The following shall be reported:

6.1 Loose aggregate to the nearest 1 particles/m\(^2\).

6.2 The stage or time at which the testing was performed, for example, “after rolling and before sweeping”.