AUSTROADS TEST METHOD AG:AM/T014

VALIDATION OF A LASER PROFILOMETER FOR MEASURING PAVEMENT SURFACE TEXTURE (REFERENCE DEVICE METHOD)

1 SCOPE

This test method defines the procedure for performing validation checks of the measurements of pavement surface macro-texture determined using a vehicle-mounted laser-based non-contact device (i.e. a laser profilometer), compared to the measurements from a static or manual reference device.

It is preferable that the surface texture measurements made by the laser profilometer are validated against an objective measuring device which is not influenced by human error. However, if access to such a device is not possible comparisons can be made against manual sand patch measurements.

This test method is one of two alternative validation methods required by Austroads Test Method AG:AM/T013 – *Pavement surface texture measurement with a laser profilometer*. The other validation method is Austroads Test Method AG:AM/T015.

This test method does not address all occupational health and safety issues associated with its use. It is the responsibility of the user to operate in accordance with appropriate legislation.

2 REFERENCED DOCUMENTS

ASTM E 1845 (2009). Standard practice for calculating pavement macrotexture mean profile depth. ASTM International.

Austroads Test Method AG:AM/T005. *Distance measurement validation of road condition monitoring vehicles*. March 2011.

Austroads Test Method AG:AM/T013. *Pavement surface texture measurement with a laser profilometer*. March 2011.

Austroads Test Method AG:AM/T015. *Validation of a laser profilometer for measuring pavement surface texture (loop method)*. March 2011.

Austroads Test Method AG:AM/T016. *Pavement surface texture repeatability and bias error checks for a laser profilometer*. March 2011.

Austroads Test Method AG:PT/T250. Modified surface texture depth (pestle method). June 2008.

International Organization for Standardization (ISO) 2005, *Quality management systems – fundamentals and vocabulary*, ISO 9000:2005.

International Organization for Standardization (ISO) 13473-1 (2004). Characterization of pavement texture by use of surface profiles – Part 1: Determination of mean profile depth.

3 DEFINITIONS

(a) Validation

ISO (1994) defines 'validation' as:

> confirmation, through the provision of objective evidence that requirements for a specific intended use or application have been fulfilled.

4 EQUIPMENT

The following equipment is required:

(a) a calibrated laser profilometer as detailed in Austroads Test Method AG:AM/T013

(b) a suitable calibrated reference device.
Examples are the WDM Texture Meter 2 which, for ease of use, is preferred to a device such as the Stationary Laser Profiler.

(c) equipment necessary for performing volumetric texture measurements in accordance with the selected manual test method.

5 PROCEDURE

5.1 Validation of Distance Measurement

Test Method AG:AM/T005 must be followed, and its check limits passed, in order to validate the distance measuring equipment used in the profilometer.

5.2 Validation of Surface Texture Measurement

It is preferable that the surface texture measurements made by the laser profilometer are validated against an objective reference measuring device which is not influenced by human error. The *reference device method* must be followed when undertaking such a validation. However, if access to such a reference device is not possible, comparisons can be made against manual sand patch measurements. In such cases the *volumetric method* must be followed.

5.2.1 Reference Device Method

(a) Select five test sections of road pavement, each 200 m long, with the following characteristics:

- At least one 200 m test section must have an average equivalent sand patch texture depth of between 0.5 and 1.0 mm (based on texture reported at 100 m (or less, if required)), i.e. the average of the two 100 m (or less, if required) segments must fall within these limits.
- Similarly, the remaining four sections must have an average equivalent sand patch texture depth of between 1.0 and 1.5 mm, 1.5 and 2.0 mm, 2.0 and 2.5 mm and 2.5 and 3.0 mm.
- At least one of the ten individual 100 m (or less, if required) segments must have an equivalent sand patch texture depth ≤ 0.8 mm and another ≥ 3.2 mm.
- Sections shall be selected so as to ensure that their surface characteristics (materials, texture, etc.) are representative of the road network(s) to be surveyed.

- Sections should be selected with sufficient lead-in to bring the inertial profilometer vehicle up to the highest test speed (nominally 100 km/h) at approach and sufficient length beyond the test site for safe operations.

(b) Measure the surface texture in the left wheelpath and between wheelpaths using the nominated reference device. When using a device such as the WDM Texture Meter, this step should be repeated to obtain two sets of readings in each of the measurement paths, and the average surface texture determined for each path.

(c) Following Test Method AG:AM/T013, use the laser profilometer to measure the surface texture in the left wheelpath and between wheelpaths of each section at several test speeds. A minimum of three test speeds should be selected; one near the bottom, mid-range and top of the profilometer's specified operating speed range.

(d) Repeat (c) four times to obtain a minimum of five sets of readings for each of the test speeds selected.

(e) Additionally, Test Method AG:AM/T016 must be followed, and its check limits passed, in order to validate the repeatability and bias error of test measurements for the equipment, operator, and driver.

5.2.2 Volumetric Method

(a) Follow the procedure outlined in Section 5.2.1 with the following exceptions:

- test sections to be 20 m in length and results reported at 10 m
- measure the surface texture in the left wheelpath and between wheelpaths in accordance with the selected volumetric sand patch test method (refer Test Method AG:PT/T250) rather than using a reference device – one sand patch test shall be performed every 0.5 m and the results averaged to give a single value for every 10 m.

6 CALCULATIONS

6.1 Reference Device Method

(a) Determine the surface texture for each 100 m (or less, if required) segment of each 200 m test section for all of the test runs from both the laser profilometer and the reference measurements (WDM Texture Meter 2, Stationary Laser Profiler). If repeat runs were made with the reference device calculate the mean value for each 100 m (or less, if required) segment.

(b) For each of the three speeds, group the surface texture data measured by the inertial profilometer into a single set of data, totalling 50 records (one speed x five test sections x two chainages per section x five repeat survey runs per section) for each measurement path. Using a least squares regression, a line of best fit between the two sets of corresponding results should be identified for each speed in the form:

$$t_{Base} = A \cdot t_{Profilometer} + B$$

where

t_{Base} = texture calculated from the base reference measurements (i.e. either WDM Texture Meter 2, or Stationary Laser Profiler)

$t_{Profilometer}$ = texture calculated from the operational laser profilometer

A = regression equation slope

B = regression equation intercept

The coefficient of determination, r^2, for each regression must also be determined.

(c) Group all of the surface texture data measured by the laser profilometer into a single set of data, totalling 150 records (three speeds x five test sections x two chainages per section x five repeat survey runs per section) for each measurement path. Using a least squares regression, a line of best fit between the two sets of corresponding results should be identified in the form:

$$t_{Base} = A \cdot t_{Profilometer} + B$$

where

t_{Base} = texture calculated from the base reference measurements (i.e. either WDM Texture Meter 2, or Stationary Laser Profiler)

$t_{Profilometer}$ = texture calculated from the operational laser profilometer

A = regression equation slope

B = regression equation intercept

The coefficient of determination, r^2, for each regression must also be determined.

6.2 Volumetric Method

Follow the procedure outlined in Section 6.1 above using the results reported at 10 m, rather than 100 m (or less, if required) intervals, from the laser profilometer and the volumetric sand patch testing.

6.3 Effect of Speed

(a) Determine the mean surface texture for each 100 m (or less, if required) segment of each 200 m test section for all speeds by averaging all five repeat survey runs.

(b) Compare the corresponding mean surface texture values for each 100 m (or less, if required) segment for all speeds and report the maximum variation between any two readings.

(c) Calculate the average variation across all test sites.

7 REPORTING

7.1 Validation of Distance Measurement

Report the items required by Test Method AG:AM/T005.

7.2 Validation of Surface Texture Measurement

7.2.1 General Details

Report the following:

(a) the location of each section tested

(b) date and time of validation checks

(c) identification of laser profilometer and base (reference) instruments used.

7.2.2 Reference Device Method

Report the additional details:

(a) for each section and survey speed, the calculated surface texture values for the left wheelpath and between wheelpaths using both the laser profilometer and the reference method

(b) for each of the three test speeds, the slope A, intercept B, and coefficient of determination, r^2, calculated in 6(b)

(c) for all of the results combined, the slope A, intercept B, and coefficient of determination, r^2, calculated in 6(c)

(d) a statement as to whether the profilometer passes or fails validation of surface texture measurement. The profilometer is considered to have passed the surface texture measurement validation if all the values reported in Section 7.2.2 (b) and (c) fall within the following ranges:

Individual speeds (Section 6.1 (b)):	$0.95 \le A \le 1.05$	$-0.25 \le B \le 0.25$ mm	$r^2 \ge 0.950$
Combined results (Section 6.1 (c)):	$0.97 \le A \le 1.03$	$-0.20 \le B \le 0.20$ mm	$r^2 \ge 0.975$.

7.2.3 Volumetric Method

Report the additional details:

(a) for each section and survey speed, the calculated surface texture values for the left wheelpath and between wheelpaths using both the laser profilometer and the volumetric method

(b) for each of the three test speeds, the slope A, intercept B, and coefficient of determination, r^2, calculated in Section 6.1 (b)

(c) for all of the results combined, the slope A, intercept B, and coefficient of determination, r^2, calculated in Section 6.1 (c)

(d) a statement as to whether the profilometer passes or fails validation of surface texture measurement. The profilometer is considered to have passed the surface texture

measurement validation if all the values reported in Section 7.2.3 (b) and (c) fall within the following ranges:

Individual speeds (Section 6.1 (b)):	$0.90 \le A \le 1.10$	$-0.25 \le B \le 0.25$ mm	$r^2 \ge 0.85$
Combined results (Section 6.1 (c)):	$0.925 \le A \le 1.075$	$-0.20 \le B \le 0.20$ mm	$r^2 \ge 0.90$.

7.2.4 Effect of Speed

Report the following additional details:

(a) for each section and survey speed, the mean surface texture values for the left wheelpath and between wheelpaths from the laser profilometer

(b) the average difference as determined in Section 6.3 (c)

(c) a statement as to whether the surface texture measurements made by the profilometer vary with speed. The profilometer is considered to be unaffected by speed if the average value reported in Section 7.2.4 (b) is less than ±0.2 mm for MPD and ±0.15 mm for SMTD.

7.2.5 Validation Notes

(a) A potential issue arises when the reference device does not produce the same output as the laser profilometer e.g. the reference device reports MPD and the laser profilometer SMTD. In such instances it may not be possible to specify an acceptable range for the resultant slope and intercept unless a previous comparison has been made and the relationship between the two measures is known. However, an assessment of the linearity of the relationship can still be determined through the coefficient of determination.

(b) When comparing outputs against volumetric measurements allowance should be made for the subjective nature of the testing by specifying a lower r^2 and a wider range for both the slope and intercept.

8 FAILED VALIDATION

In the event that the profilometer fails the validation process, causes for the failure must be investigated, defects rectified and this test method repeated.

AMENDMENT RECORD

Amendment No.	Sections amended	Action [1]	Date
1 (Initial release)	All (Richard Wix & Michael Moffatt, ARRB)	New	26 March 2007
2 (Revised release)	All (Richard Wix & Young Choi, ARRB, project AT1484)	Substitution	2 March 2011

[1] Key:

Format	change in format
Substitution	old section removed and replaced with new section
New	insertion of new section
Removed	old section removed