# COMMENTARY TO AG:PT/T231 - DEFORMATION RESISTANCE OF ASPHALT MIXTURES BY THE WHEEL TRACKING TEST

## PREFACE

This test method was prepared by the Austroads Asphalt Research Group (formerly the National Asphalt Research Co-ordination Project Group) on behalf of the Austroads Pavement Reference Group. Representatives of Austroads, ARRB Transport Research and the Australian Asphalt Pavement Association have been involved in the development and review of this test method.

## FOREWORD

Asphalt.

## SCOPE

This document describes the procedures to be followed to test a sample of asphalt using a wheel tracking test device. The procedures can be carried out on prismatic specimens that have been manufactured in the laboratory, cut from an existing pavement or on cylindrical samples that have a diameter exceeding 200mm.

## Further Development

There are no further plans for the development of this test method.

# DEFORMATION RESISTANCE OF ASPHALT MIXTURES BY THE WHEEL TRACKING TEST

## 1 REFERENCED DOCUMENTS

The following documents are referred to in this method:

**AUSTROADS**

AST 005 Sample preparation – Compaction of asphalt slabs suitable for characterisation.

**AS /NZS**

AS 2891.7.1 Determination of maximum density of asphalt – Water displacement method.

AS2891.8 Voids and density relationships for compacted asphalt mixes.

AS2891.9.2 Determination of bulk density of compacted asphalt – Presaturation method.

## 2 DEFINITIONS

For the purpose of this standard, the following definitions apply:

a. Tracking depth - The reduction in the thickness of a test specimen caused by repeated passes of a loaded wheel.

b. Load Pass - A single pass of the loaded wheel over the test sample.

c. Tangential Slope - A straight line drawn tangential to the tracking depth versus loading passes curve in the region from 4000 to 10000 loading passes.

d. Tracking Rate (TR) - The rate at which the tracking depth increases with load passes under repeated passes of a loaded wheel (in mm/kPasses).

e. Single Test Result - The value obtained by applying the test method fully, once, to a test portion.

f. Specimen thickness - The thickness (in mm) of a specimen in which a rut can form and does not included any regulation course placed under the bottom of the specimen to eliminate bottom irregularities.

## 3 APPARATUS

The following apparatus is required:

a. Wheel tracking device consisting of a loaded wheel that bears on a specimen held on a moving table. The table oscillates beneath the loaded wheel and a displacement measuring device is provided that measures the vertical depth of the rut as it develops. Vertical play in the loaded wheel mechanism shall be less than 0.25 mm.

(i) Consist of a steel wheel with a non-treaded rubber bearing rim with an outside diameter of between 200 to 205 mm with a width of 50 ± 1 mm when new.

The rubber tread shall be smooth (during use the rubber will become pitted but no pits shall exceed 5 mm in diameter) with a thickness of between 10 to 13 mm with a hardness number of 80 ± 10 IRHD units.

(ii) A load shall be applied to the specimen, accurate to within 20 N of the target value. The applied load shall be measured at the level of the top surface of a specimen normal to the plane of the moving table.

(iii) The specimen table shall provide fixings to firmly hold a 300 x 300 mm prismatic specimen or a cylindrical specimen of at least 200 mm in diameter, centrally in a horizontal plane below the load wheel. There should be sufficient adjustment to cater for samples from 35 mm to 110 mm in thickness. The table shall perform a simple harmonic motion beneath the loaded wheel with travel distance of 230 ± 5 mm. The table shall move at frequency of 42 ± 0.5 load passes per minute.

b. Tracking depth measuring device consisting of a displacement measuring device shall have a total travel of not less than 20 mm with an accuracy of ± 0.1 mm.

c. A dummy specimen with a mass of at least 25% of that of the test specimen shall be instrumented so as to provide a measure of core temperature. The dummy specimen shall be maintained in the same temperature controlled environment.

d. Temperature control to ensure that the dummy and test specimens are maintained at the target temperature ± 1°C throughout the testing process.

e. Marking medium to identify specimens.

f. Regulation course material capable of being poured which sets so that the test specimen is firmly affixed in the test mould/frame. Commonly used materials include Plaster of Paris and Plaster of Paris mixed with fine mineral particles (fine sand or dust).

g. Ensure a smooth flat bottom surface parallel to the upper surface. The same regulation course material shall also be used to provide restraint to the four sides.

h. Mixing utensils consisting of a container and a stirring rod is required to prepare the regulation course material.

i. Steel ruler to measure the dimensions of specimens to the nearest millimetre.

# 4 TEST SPECIMENS

### *4.1 Specimen Dimensions*

Specimens for wheel tracking consist of a single layer of asphalt mixture (unless otherwise reported) with no discontinuities. In plan, the specimens shall be 300 mm by 300 mm or 200 mm in diameter. Specimens prepared in the laboratory for reference purposes shall have a thickness of 50 or 75 mm ± 5 mm. Specimens cut from a pavement shall have a minimum thickness of 35 mm and a maximum thickness of 110 mm.

### *4.2 Manufacture*

Laboratory prepared asphalt mixtures shall be prepared according to AS 2891.2.1 and compacted in accordance with AST 005, (slab compaction in a rolling wheel compaction facility).

Test specimens shall be cut from the central portion of the each slab produced and the remainder discarded. It is preferable to compact wheel tracking specimens to the required size to negate the need to discard material.

Specimens from an existing pavement shall have a regulation course applied (see clause 4f and 4g) to the lower face to alleviate rocking and to the four sides to eliminate gaps between the sample and the support frame. (Note: This can be applied before air drying the specimens.) Laboratory prepared specimens can be tested in the compaction moulds. If laboratory prepared specimens are not tested within the moulds in which they were compacted then a regulation course shall be applied to the lower surface and to the gap between the sides of the specimen and the support frame.

Prior to testing or the application of the regulation course, the bulk density of the specimens shall be determined in accordance with AS 2891.9.2. Specimens shall be air dried to a constant mass before testing.

### *4.3 Storage of prepared specimens*

Prepared specimens must be stored in a cool (less than 30°C) environment. All laboratory manufactured specimens shall be tested when they are between 4 and 30 days old. Specimens shall be stored on flat non-deforming surfaces (25 mm tempered plywood, or 8 mm steel plate is adequate) and these are used to transport them from storage to the testing device.

Prior to testing, test specimens shall be examined for sampling and handling defects and rejected if cracks are visible to the naked eye or if the geometry of the specimen is compromised through spalling of corners and edges. The rolling or traffic direction is to be clearly indicated on the upper surface.

### *4.4 Specimen Conditioning prior to testing*

All test specimens shall be conditioned so as to achieve the target test temperature and the conditioning period should not exceed a maximum of 24 hours at the test temperature.

# 5 STANDARD REFERENCE TEST CONDITIONS

The test method permits wheel tracking of samples using a range of conditions but for the purpose of recording a universal standard wheel tracking depth for asphalts, the following values shall be used (see Note 1):

| | |
|---|---|
| Test temperature (°C) | 60 ± 1°C |
| Sample Thickness (mm) | 50 ± 5 mm (for mixes with a nominal size of 14 mm or less) |
| | 75 ± 5 mm (for mixes with a nominal size of 20 mm) |
| Air Void Content (%) | 5 ± 1.0 % |
| Vertical Load (N) | 700 ± 20 N |

# 6 PROCEDURE

a. Place a test specimen on the moving table and align traffic or rolling direction to the direction of the loading wheel travel.

b. Firmly secure the test specimen to the moving table.

c. The test specimen, or a dummy specimen (see Note 2) shall be maintained at the target temperature ± 1°C throughout the testing process. .

d. Set the displacement measuring device such that there is sufficient downwards travel to complete the test.

e. Record the temperature of the dummy specimen and take an initial reading of the tracking depth.

f. Commence wheel tracking for a minimum of 10,000 load passes (about 3.6 hours) or until the tracking depth exceeds 15 mm.

g. Record the temperature of the dummy specimen and the tracking depth in the centre of the wheel travel, at ± 7.5 mm from the centre of the wheel travel, at ± 22.5 mm from the centre of the wheel travel and at ± 37.5 mm from the centre of the wheel travel to within 2.5 mm. Readings shall be taken, as a minimum, at the following intervals: 0, 10, 20, 30, 40,50, 60, 70, 80, 90, 100, 150, 200, 250, 300, 400, 500, 1,000, 2,000 3,000, 4,000, 5,000, 6,000, 7,000, 8,000, 9,000 and 10,000. Tracking depth measurements can be taken at more frequent intervals, preferably without interrupting the test.

# 7 CALCULATIONS

### *7.1 Individual Replicates*

For each replicate specimen calculate: (see Note 3)

#### *7.1.2 Final Tracking Depth*

This is defined as the depth of the rut caused by the loaded wheel at the end of the test and shall be recorded to the nearest 0.1 mm. The final Tracking Depth is calculated by taking the mean of the seven Tracking Depth measurements at pass 10,000 located at:

- Centre of the wheel travel,
- ± 7.5 mm from the centre of the wheel travel,
- ± 22.5 mm from the centre of the wheel travel and
- ± 37.5 mm from the centre of the wheel travel.

The measurement locations shall be within 2.5 mm of the positions noted above.

#### *7.1.2 Tests that reach maximum tracking depth*

Tests that attain a 15 mm Tracking Depth before 10,000 Passes have elapsed shall record the number of loading passes required to achieve a Tracking Depth of 15 mm.

### *7.2 Replicate group*

For each replicate group calculate: (see Note 3)

a. the mean Tracking Depth of the replicate group; or

b. the mean number of Passes to a tracking depth of 15 mm.

# 8 INFORMATION TO BE REPORTED

The report should include the following information for each test portion:

a. Specimen identification and description of irregularities.

b. Specimen thickness.

c. Specimen age, for the case of laboratory manufactured specimens or date of extraction, for those specimens from an existing pavement.

d. Applied load.

e. Test date.

f. Temperature of the dummy specimens at the start and end of each test.

g. Bulk density and air void content of each test specimen.

h. Maximum number of loading passes for each replicate.

i. Maximum tracking depth for each replicate at the completion of the test.

j. The mean tracking depth of all replicates or the mean number of Passes to a tracking depth of 15 mm.

k. Comments pertaining to the validity of each test (see Note 4).

l. Plot of tracking depth versus loading passes for each replicate (optional).

# 9 PRECISION

Not determined

***NOTES:***

1. If test conditions are other than those described as the standard reference test conditions, these should be detailed along with the results.

2. The test specimen can be prepared to accommodate the temperature measuring devices. This ensures that the temperature recorded during the test is the temperature of the test specimen. However, it is also permitted to use a dummy specimen which has been prepared to accommodate the temperature measuring devices. Where a dummy specimen is used to monitor the test temperature (which is the more common practice) then the relationship between the temperature of the dummy specimen and the temperature of the test specimen needs to be established.

   The dummy specimen should have a mass of at least 25% of that of the test specimen and be composed of a material similar to that of the test specimen. The mass and composition requirement ensures that the dummy specimen has similar temperature sensitivity as the test specimen.

   The temperature measuring devices shall be placed so as to provide a measure of core and surface temperature. The core temperature device should be placed at about mid depth and displaced from the sample edge by at least half the sample thickness. The core temperature can be attached to the surface of the sample or placed in a shallow groove. In both cases the surface temperature measuring devices shall be shielded from contact with the air. A common practice is to cover the surface temperature measurement device with a thin strip of polystyrene. When the test sample is used to record test temperature, the temperature measurement devices shall not be placed so as to interfere with the test outcome.

   Allow sufficient time for the test specimen and/or dummy specimen to reach temperature equilibrium. It is advisable for the temperature to stabilise rather than allow testing to commence immediately the temperature falls within the tolerance range.

3. The number of replicates will normally be referenced in a specification but it is advisable to consider, as a minimum, duplicate specimens.

4. A note on the validity of a test is included in the report sheet to report if the specimens were blemished in any way and particularly relates to specimens obtained from an existing pavement

5. Whilst the CEN draft standard on wheel tracking is not referenced in this method, those using this standard may find it a useful citation.

   Two other optional parameters can be obtained from the wheel tracking data and these are:

   **Steady State Tracking Rate** This is found by determining the tangential slope of the tracking depth versus the loading passes and is determined to the nearest 0.01 mm/Pass. This is found by linear regression analysis or by using equation (N.1).

   Most statistical texts will be able to provide information on performing linear regression analysis to determine the slope of the tracking depth versus loading passes curve. Most computer spreadsheets have a facility to calculate the slope of a curve.

   The tangential slope is determined over the range 4,000 passes to 10,000 passes and is multiplied by 1,000 to give the steady state tracking rate (TR) in mm/kPasses as is shown by equation (N.1):

   Tangential slope = (tracking depth at 10,000 passes - tracking depth at 4,000 Passes) / 6000 ..(N.1)

   Steady state tracking rate = Tangential slope * 1,000 mm/kPasses ..(N.2)

   If additional tracking depth data has been gathered in the interval from 4,000 to 10,000 load Passes this can be used to obtain a more accurate tracking rate by undertaking a linear regression of the loading passes against tracking depth.

   a. **Central Steady State Tracking Rate** is calculated using the central tracking depth measurement recorded during a load pass. The tracking depth at the central point at 4,000 load passes and at 10,000 load passes is used to calculate the central steady state tracking rate using equation (N.1). If additional tracking depth data for the central point has been gathered in the interval from 4,000 to 10,000 load passes this can be used to obtain a more accurate tracking rate by undertaking a linear regression of the loading passes against tracking depth.

   b. **Average Steady State Tracking Rate** is calculated using the seven tracking depth measurements recorded during a single load pass. The mean tracking depth is calculated at 4,000 load passes and at 10,000 load passes is used to calculate the average steady state tracking rate. If additional data (seven tracking depth measurements per pass) have been gathered in the interval from 4,000 to 10,000 load passes this can be averaged per pass and the mean used to obtain a more accurate tracking rate by undertaking a linear regression of the loading passes against tracking depth.

   CEN Tracking Rate is based on central tracking depth measurement data gathered at five minute intervals during the first 45 minutes of the test and is based upon a tracking rate that is calculated using formulae dependant upon the duration of the test. To calculate the tracking rate for tests that last for 45 minutes or more, use equation (N.3); for tests that last between 25 and 44 minutes, use equation (N.4); for tests that last between 15 and 24 minutes, use equation (N.5); and for tests that last

less than 14 minutes, use equation (N.6). The CEN tracking rate is calculated using equation (N.7).

$$T_R = 3.6\ (r_{45} - r_{30}) + 1.2\ (r_{40} - r_{35}) \quad ..(N.3)$$

$$T_R = 6\ (r_{35} - r_{25}) \quad ..(N.4)$$

$$T_R = 12\ (r_{20} - r_{15}) \quad ..(N.5)$$

$$T_R = 900/\ t_{15}) \quad ..(N.6)$$

where

$r_i$ is the tracking depth measured at time I

$t_{15}$ is the time for the tracking depth to reach 15 mm (in minutes)

$$\text{CEN Tracking Rate} = T_R * 10.4 * w/L \quad ..(N.7)$$

where

w is the width of the wheel (in millimetres)

L is the vertical load (in Newtons)

The Central and Average Steady State Tracking rate is calculated on that portion of the data that exhibits a linear relationship between tracking depth and loading passes. A linear relationship is defined for this standard as the portion of the data where the square of the correlation coefficient ($R^2$ ) is greater than or equal to 0.95.

$$R^2 = \frac{\sum\left(X - \bar{X}\right)\left(Y - \bar{Y}\right)}{n\left(\sigma_x \sigma_y\right)^{0.5}} \quad ..(N.8)$$

where

X = the individual number of recorded passes of the data portion under consideration

$\bar{X}$ = the average number of passes of the data portion under consideration

Y = the individual tracking depth measurements of the data portion under consideration

$\bar{Y}$ = the average measured tracking depth of the data portion under consideration

n = the number of measurements in the data portion under consideration

$\sigma_x$ = the standard deviation of the individual number of recorded passes in the data portion under consideration

$\sigma_y$= the standard deviation of the individual tracking depth measurements in the data portion under consideration

NOTE: Calculation of equation (N.8) can be tedious and it is advisable to seek assistance from a computer software package that can undertake regression analysis.

# AMENDMENT RECORD

| Amendment No. | Clauses amended | Action | Date |
|---|---|---|---|
| 1 | Commentary Page | New | June 2005 |
| | Footer and header | Format | |
| | Applied revised test method number | Format | |
| | Applied new styles | Format | |
| | | | |
| | 4.4 Temperature conditioning | Substitution | Jan 2006 |
| | 6 (c) Temperature monitoring | Substitution | |
| | Note 2 Temperature monitoring | Substitution | |

Key

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