

COMMENTARY TO AG:PT/T450 - DETERMINATION OF THE INTERNATIONAL ROUGHNESS INDEX (IRI) USING ARRB WALKING PROFILER

PREFACE

This pavement test method was prepared by a Working Group of Austroads.

FOREWORD

This test method defines the procedure for measuring the International Roughness Index (IRI) of pavement surfaces using the ARRB TR Walking Profiler.

SCOPE

The ARRB TR Walking Profiler is pushed over the pavement surface by an operator at a slow walking pace.

It is assumed that the reader is familiar with the Walking Profiler Instruction Manual published by ARRB Transport Research and/or has a copy available for reference profiler.

Further Development

None.

DETERMINATION OF THE INTERNATIONAL ROUGHNESS INDEX (IRI) USING ARRB WALKING PROFILER

1 REFERENCED DOCUMENTS

The following documents are referred to in this method:

ARRB

Walking Profiler Instruction Manual, Model APR1, February 1996 (Published: ARRB Transport Research Ltd., Vermont South, Victoria 3133).

2 DEFINITIONS

The following definitions are used throughout this document:

- a. The IRI (International Roughness Index): The IRI is the roughness index determined by applying a mathematical model (referred to as a quarter-car model) which has the dynamic response of a simulated response-type road roughness measuring vehicle along a single wheel-path of measured road profile. The IRI is expressed in terms of accumulated vertical displacement of the simulated suspension in metres per measured kilometre (m/km). IRI can be reported in different ways, as follows:
 - i. Single Track IRI: The IRI based on a quarter car model run over a single track of longitudinal profile
 - ii. Lane IRI: This is a composite IRI value representing the roughness of a road lane section. It is determined by averaging two individual, Single Track IRI values obtained separately in each wheel-path of a lane (at 0.75 metres either side of the lane mid-track).
- b. NAASRA Roughness: The NAASRA Roughness (see Note 1) is determined by applying a mathematical model (referred to as a half-car model and having the dynamic response of a standard vehicle) to two longitudinal profiles measured simultaneously. NAASRA Roughness is expressed in counts per kilometre (c/km).
- c. A Surface Profile of a line on a surface is the representation of the vertical locations of points on the line against their horizontal distances along the line from a specified starting point.
- d. Grade is the rate of longitudinal rise or fall of the surface with respect to the horizontal distance, expressed as a ratio or a percentage. The longitudinal grade of the pavement surface to be measured shall not exceed 1 in 6.
- e. Road Roughness is a measure of the riding quality of pavement in response to longitudinal profile.
- f. Absolute Offset is the machine-specific average output value between forward and reverse offset.
- g. Absolute Slope is the machine specific average value between forward and reverse slope.

3 APPARATUS

- a. A manually operated walking profiler fitted with a lap-top computer and measuring beam which enables the collection and presentation of pavement surface profile and roughness information. The profiler shall be calibrated in accordance with the procedure specified in the manufacturer's Instruction Manual reproduced as Appendix A of this test method.
- b. Calibrated Smart Level or other similar device which can measure pavement grade or slope to an accuracy of ± 1 % of grade.
- c. Paint, crayon or similar for marking reference points along the intended survey path.

Note: The use of a chalked string line facilitates the marking of the survey path.

- d. Ruler or tape measure, graduated in millimetres, for establishing reference marks along the intended survey path. The ruler or tape measure used shall be accurate to at least ± 5 mm.
- e. Broom for sweeping the survey surface.
- f. Thermometer, suitable for the measurement of temperatures within the range 0 – 100°C, readable to at least 1°C and having an accuracy of ± 1 °C.

Note: A digital thermometer with a sensor remote from the display is recommended. This will enable the probe to be secured under the cowling while the display is mounted near the lap-top computer.

4. PROCEDURE

4.1 *Pre-operation set-up*

- a. Ensure the profiler battery and the lap-top computer internal battery are fully charged and all leads are correctly connected and secured on the walking profiler and computer.
- b. Clean the foot pads of the measuring beam by lightly brushing.
- c. Ensure that the tyres, on the profiler wheels, and other components are free from the build up of deposits of road-making materials (eg. bitumen, cements etc.) by cleaning with a mild solvent or brushing.
- d. Ensure that the power to the machine is switched on at least 20 minutes prior to any use of the walking profiler.

4.2 *Operating conditions*

Do not operate the walking profiler in ambient temperatures outside the temperature range of 0 to 45°C or on road surface temperatures exceeding 75°C.

4.3 *Field offset trim*

- a. Switch on the power to the walking profiler and wait at least 20 minutes before performing the field offset trim procedure.

- b. Perform the field offset trim immediately prior to use of the walking profiler for the IRI survey. If, during performance of the IRI survey, the air temperature within the cowling changes by more than $\pm 10^{\circ}\text{C}$ from the temperature recorded when the most recent field offset trim was performed, then another field offset trim shall be performed.
- c. Record the temperature within the profiler cowling, then perform the field offset trim in accordance with the Manufacturer's Instruction Manual (the procedure is reproduced as Appendix B to this Test Method). If necessary repeat the procedure until a successful run is obtained.

4.4 IRI surveys

4.4.1 Single track IRI survey

- a. Define the length of the test section to be surveyed, which should have a length exceeding 100 metres. Select the wheel-path or other tracking line upon which the single track survey is to be performed.

Note: The IRI result is applicable for runs greater than or equal to 100 m in length.

- b. Check that the longitudinal grade of the test section does not exceed 1 in 6. If the grade is greater abandon the test.
- c. Mark the starting point of the line of survey with a cross as indicated in the Instruction Manual and mark the transverse position survey line every 3 to 5 metres along its length to facilitate accurate tracking of the machine. Ensure the line to be surveyed is free from all loose material.

Note: For inexperienced operators the tracking line may best be marked by use of a chalked string line.

- d. (d) Record the time and the temperature, within the profiler cowling. Conduct the survey in the direction of lane traffic flow in accordance with the Manufacturer's Instruction Manual and within the operational speed range.

Note: Care should be taken to minimise the deviations from the survey line, with even greater care required as the transverse cross-slope of the site increases. If, during the survey, the centre line of the machine beam is permitted to deviate from this line by greater than ± 100 mm, repeat the run.

- e. Display and then record the Single Track IRI value calculated by the lap top computer for the surveyed section.

4.4.2 Lane IRI Survey

- a. (a) Define the length of the test section to be surveyed, which should have a length exceeding 100 metres. Unless otherwise stipulated, the tracking lines shall be located 0.75 metres either side of the centre of the lane to be surveyed.

Note: The IRI is accurate for runs greater than or equal to 100 m in length.

- b. Check that the longitudinal grade of the test section does not exceed 1 in 6. If the grade is greater abandon the test.
- c. Mark the starting points for each line of survey as in the instructions in the manufacturer's Instruction Manual, such that both starting points are coincident at the same road chainage location. Ensure that each line of survey is free from all loose material.

- d. Record the time and the temperature within the profiler cowling, then conduct the first survey in the direction of lane traffic flow in accordance with the manufacturer's Instruction Manual and within the operational speed range.
- e. Display and record the single track IRI value (IRI1) calculated by the lap top computer for the first completed line of survey.
- f. Record the time and the temperature, within the profiler cowling, then conduct the second survey in the direction of lane traffic flow in accordance with the Manufacturer's Instruction Manual and within the operational speed range.
- g. Record the IRI value (IRI2) calculated for the second line of survey.

5 CALCULATIONS

When a Lane IRI Survey has been carried out by the completion of two single lane surveys, one in the inner wheel-path and the other in the outer wheel-path, calculate the Lane IRI using the following equation:

$$\text{Lane IRI} = \frac{1}{2} (\text{IRI1} + \text{IRI2})$$

Where

IRI1 The result of the first Single Lane IRI as computed by the on-board lap-top computer

IRI2 The result of the second Single Lane IRI as computed by the on-board lap-top computer.

6 REPORTING

Report the following:

- a. The start and end chainage of the test section for which either Single Track IRI or Lane IRI was determined.
- b. The Single Track IRI and the transverse location of each completed line of survey which exceeds 100 metres in length .
- c. Where appropriate the Lane IRI for the test section.

If required, the following may also be reported for each 100 metre long sub-section of the test section:

- i. The start and end chainage of each sub-section,
- ii. The Single Track IRI and the transverse location of each completed line of survey within each sub-section,
- iii. The Lane IRI for each sub-section.

Note: When the length of the test section is not exactly divisible by 100 metres then one subsection of length between 100 to 200 meters shall be included.

Note: The average of the Lane IRI values from sequential sub-sections will equal the overall test section Lane IRI only if the length of all the sub-sections is identical.

NOTES

1. Note: An approximate value of NAASRA Roughness can be calculated from measured IRI as follows:

$$\text{NAASRA Roughness} = -1.3 + 26.5 * (\text{IRI}) \text{ c/km.}$$

APPENDIX A CALIBRATION PROCEDURE

A1 CALIBRATION FREQUENCY

The following calibration procedure shall be performed at least once every six months or if a satisfactory field offset trim cannot be achieved. This procedure is specific to calibration of the ARRB TR Walking Profiler.

A2 APPARATUS

- a. 1. Stainless steel calibration surface plate with minimum dimensions of at least 320 mm long, 75 mm wide and 25 mm high. The top surface of the plate shall be machined plane with an out of-flatness not exceeding 0.1 mm. The bottom of the plate shall be fitted with three adjustable legs to enable adjustment, for level, of the top surface.
- b. Stainless steel step block conforming to the following dimensions:
 - i. Width 74.0 ± 1.0 mm,
 - ii. Length 74.0 ± 1.0 mm,
 - iii. Height 25.0 ± 0.1 mmwith the two large faces parallel to within 0.1 mm.
- c. Bulls eye spirit level.
- d. A small paint brush for cleaning the calibration plate and block

A3 CALIBRATION PROCEDURE

Laboratory Offset and Slope Calibration

- a. Stabilise the temperature of the measuring beam and profiler by placing the walking profiler, with the beam attached, in a clean, temperature controlled environment for at least twelve hours prior to commencement of the calibration. The cowl should be left in position during the conditioning period to prevent accidental damage to or dirt contamination of the mechanism and measuring foot.
- b. Remove the cowl and ensure there is sufficient room beside the walking profiler to carry out the calibration procedure.
- c. Set the Test/Survey selector switch, on the walking profiler, to the TEST position.
- d. Place the calibration surface plate on the ground beside the walking profiler, immediately adjacent too and with the long side parallel to the measuring foot. Place the bulls eye level on top of the surface plate and establish a level surface by adjusting the legs.
- e. Undo the two (2) M4 hexagon head screws which secure the accelerometer cable clamp. Check that the 6 foot pads, on the measuring beam, are clean.

- f. Clean the top of the surface plate by lightly brushing with the paint brush. Disengage the rear pick up arm cones and remove the measuring beam from the walking profiler. Place the measuring beam on top of the surface plate in the forward position i.e. as it was removed from the walking profiler. Do not lift the measuring beam by the accelerometer or the resilient mounting plate. Ensure the accelerometer cable is not pulling or twisting on the accelerometer at any time throughout the calibration process.
- g. Gently lift the measuring beam ends, one at a time and gently tap each end on the surface plate as necessary to position it correctly. Check to ensure there is no overhang of the measuring beam, at either end on the surface plate.
- h. Activate the calibration menu and then follow the prompts from the computer. Continue the calibration, through forward offset to reverse offset, forward slope and reverse slope as directed by the computer prompts. The calibration is complete when the absolute offset lies between -300 mV and $+300$ mV, and the absolute slope lies between -2900 m V and -3100 mV.
- i. Replace the measuring beam in the walking profiler and reposition the accelerometer cable clamp. Ensure the cable is free to move without pulling tight or snagging any other leads when the walking profiler is in use and confirm the correct operation of the entire machine before field use by performing an offset calibration check.

APPENDIX B FIELD OFFSET TRIM PROCEDURE

B1 INTRODUCTION

The field offset trim procedure is undertaken to initialise the walking profiler for the ambient conditions, particularly temperature, under which an IRI survey will be conducted. A field offset trim should be carried out each time the walking profiler is used, to make full allowance for local variables.

Prior to any use of the walking profiler, including the field offset trim procedure, the power to the machine must have been switched on for at least twenty (20) minutes.

The field offset trim procedure should be carried out on a 20 metre portion of the section to be surveyed, that portion being as level and smooth as possible and free of any loose material.

The field offset trim procedure is carried out under the direction of the on-board computer system discussed in the Manufacturer's Instruction Manual. It is assumed that the reader is familiar with that Manual and/or has a copy available for reference.

B2 APPARATUS

As listed in Section 4 of the Test Method.

B3 *Field offset trim procedure*

- a. Set up the walking profiler in the intended working situation, switch on the power and wait at least 20 minutes before performing the field offset trim procedure.
- b. Select a section approximately 20 metres long, and as level and smooth as possible, of the pavement to be measured, and sweep it clear of all loose debris.
- c. Using a chalked string line or similar, mark a straight line along the selected section of pavement, to be the path of the field offset trim run.
- d. At one end of the chosen path, rule a chalk line about 0.7 metres long in the direction of the intended walking profiler run, then approximately bisect this line at right angles with another chalk line, again about 0.7 metres long. This cross will mark both the beginning and the end of the field offset trim run.
- e. Press the <F10> key on the on-board computer to activate the main menu, select Calibration using the horizontal arrow key, and press <Enter> to display the vertical selection panel.
- f. Use the vertical arrow keys to select Field Offset Trim, then press <Enter>.
- g. Ensure that the machine is in the staged condition as defined in the Manufacturer's Instruction Manual. Manoeuvre the walking profiler on its back wheels to position it over the chalked cross such that the arrow markings on the machine align with the lines on the pavement (see Figure 2 of Quick Guide to Conducting a Precision Survey in the Manufacturer's Instruction Manual).
- h. Press <Enter> to start data logging for the field offset trim run.

- i. Squeeze the staging release bar to the push handle, then push the machine forward in a straight line for at least 20 metres and stop in the staged condition by letting go of the staging release bar and gently pushing until the mechanism locks.
- j. Press <H> (for half-way) to mark the end of the outward phase.
- k. Mark the pavement with chalk directly below each of the arrow markings on the machine, then remove the machine and join opposite chalk marks on the pavement with two ruled lines, one in the direction of the walking profiler run, the other at right angles (see Figure 4 of Quick Guide to Conducting a Precision Survey in the Manufacturer's Instruction Manual). The intersection of these two lines marks the position of the front foot of the walking profiler at the last placement of the measuring beam, and is the precise end of the survey.
- l. Turn the machine to face it back toward the starting point of the run and position it over the cross drawn on the pavement in (k), using the procedure described in (g).
- m. Press <Enter> to continue the field offset trim run, then push the machine back along the same line, finishing the run by staging it precisely over the starting cross. ***If the finishing position is more than 5 mm horizontally from precisely over the starting cross, the procedure must be repeated from point (e).***
- n. Press <F> (for finish) to indicate the end of the field offset trim run. The software then automatically calculates the new offset correction and incorporates it into the processing system. The new value will be displayed and a message will indicate that the process was successful and prompt the operator to press <Enter> to return to the main menu.
- o. Check that there are no particles adhering to the footpads after completing the field offset trim procedure. ***If there are any present, the offset correction may be in error and the procedure should be repeated.***

AMENDMENT RECORD

Amendment No.	Clauses amended	Action	Date
1	First draft	New	March 2001
2	Commentary Page	New	June 2006
	Footer and header	Format	
	Applied revised test method number	Format	
	Applied new styles	Format	
3	Amended title on page 2	Substitution	May 2007

Key

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