Test method T191

Determination of deflection and curvature by deflectograph

OCTOBER 2012

Revision Summary

Ed/Rev Number	Clause Number	Description of Revision	Authorisation	Date
		Reformatted and Revision Summary Added	D.Dash	May 1999
		Date on Test Method Revised to Agree with Date on Revision	D.Dash	Feb 2001
Ed 2/ Rev 0	All	Reformatted RMS template	J Friedrich	October 2012

Note that Roads and Maritime Services is hereafter referred to as 'RMS'.

The most recent revision to Test method T191 (other than minor editorial changes) are indicated by a vertical line in the margin as shown here.

Test method T191

Determination of deflection and curvature by deflectograph

1. Scope

(a) This test method defines the procedure for measuring the deflections of a pavement under a standard axle load using Deflectograph equipment.

(b) Testing is carried out on flexible pavements only. The pavements to be tested should be in a stable condition, ie without large potholes; excessive rutting and patching, and should not include speed humps.

(c) The structural capacity of a pavement is evaluated by measuring the deflections of a pavement subjected to load of 8.2 tonnes applied on a single axle through dual rear wheels. The testing is carried out to provide a 4m measurement cycle, simultaneously in both wheel paths at a continuous speed of about 3 km/h.

(d) Deflectograph testing requires adequate traffic control. The traffic control required for this test should be set up as per the RMS *<M>Traffic Control at Work <M>Sites* manual.

(e) The values measured represent the deflections of a pavement as obtained with the equipment and procedures stated herein and do not necessarily agree or correlate directly with those obtained by other pavement deflection measuring methods.

2. Definition

Term	Definition
Term	
Deflection	(a) the measured vertical elastic deformation of a pavement surface beneath the dual wheels of a standard axle load and is an indication of the rate at which permanent deformation will occur under traffic.
Deflection Bowl	(b) is a representation of the shape of the deformation of the pavement surface caused by a load being applied to it.
Maximum Deflection	(c) the measured maximum vertical movement of the pavement generally recorded slightly behind the centre line of the rear wheels.
Curvature	(d) is an indication of the shape of the Deflection Bowl which is determined by calculating the difference between the maximum deflection and the measured deflection at a point 200 mm away. The curvature of the deflected pavement gives an indication of the fatigue performance of the pavement.

3. Apparatus

3.1. Vehicle Specification

3.1.1 A truck or similar vehicle having:

(a) A single rear axle with dual wheels fitted with (1200 x 20) radial non-lugged tyres, and spaced to allow the test arms to move freely between them

(b) A ballast of a constant and evenly distributed load of 8200 ± 150kg on the rear axle measured at the specified tyre pressure

(c) The capability to travel at a speed of about 3km/hr for extended periods

(d) The capability of mounting a guide frame, a winching system for the test frame and a test frame assembly with measuring arms each connected to a Linear Variable Differential Transformer (LVDT)

(e) Hazard warning devices and a high intensity flashing arrow mounted on a panel at the rear of the vehicle having a daytime sighting distance in excess of 300m

3.1.2 Other Equipment:

(a) A device such as a Shaft Encoder or Rotopulser to allow the precise measurement of the distance travelled during testing to an accuracy of ± 1 metre/km, and capable of generating a measurable electronic pulse at least every 50 mm of travel

(b) A guide frame attached to the steering system of the truck that will allow the tips of the measuring arms of the test frame to pass freely between the dual wheels without touching the sides of the tyre

(c) A winching system to cycle the test frame which does not transmit vibrations to the frame during the measurement phase. The winch should be capable of drawing the beam frame forward on the truck at a speed twice of the truck itself

(d) A test frame assembly of such dimensions and geometry that will allow it to be pulled along the pavement for substantial distances, and also allow the tips of each measuring arm to pass through the corresponding set of rear dual wheels without touching the sides of the tyres. The test arms are connected to a measuring device such as a Linear Variable Differential Transformer (LVDT) of infinite resolution. The complete unit shall have an accuracy of measuring ± 40 microns at the test arm tip

(e) Suitable instrumentation, signal conditioning and a Data Acquisition System (DAS) capable of capturing and recording deflection values for each deflection bowl at approximately 4m intervals. The components of the system <u>should</u> conform to the manufacturer's specifications and be suitable for continuous use under highway conditions

(f) Means of checking the maintenance of tyre pressures to 770 kPa ± 35 kPa. (05 to 110 PSI)

(g) A thermometer with a range of -5°C to +100°C capable of determining ambient and Pavement temperatures at a depth of 30mm below the surface with an accuracy of ± 0.1°C. A sufficient quantity of Glycerol should be kept on board to be used as a medium to take the pavement temperatures

(h) A cordless impact drill capable of drilling a 6mm dia 30 mm deep hole in the pavement and an accurate digital voltmeter with a range of ± 20V

(i) Feature sheets and a road location database, if available and a supply of floppy disks to transfer data

(j) Personal and vehicular hazard warning and safety devices, as required by the governing law and including OH&S requirements

4. Procedure

(a) Ascertain the exact start and end points of the survey and also the number of lanes and direction to be tested. If in doubt, check with the client and or the Supervisor

(b) Measure and record both air (shaded) and pavement (at a depth of 30mm below the road surface) temperatures *every hour*. Additional recording of temperature shall be carried out if a new road or section is tested within the hour. The air and pavement temperatures should be recorded on the feature sheets against the appropriate chainage at the time of measurement which is to be read off the computer screen. Drill a 6mm dia hole to a depth of 30mm, fill the hole with Glycerol, insert the thermometer and record the temperature after allowing it to stabilise

(c) Follow the instructions in the Deflectograph user manual, Sections 5 & 6, and enter the header information

(d) Make a visual check of all test components and check the rear tyre pressure at the start of the day and adjust to 770 $\pm$ 35 kPa (105 to 110 PSI) if necessary

(e) Mark by paint, on the road surface or the adjacent kerb, the starting point of the test. Position the truck on the road in such a manner that the measuring tip of the test beam is aligned to the paint mark when the winch has been manually moved forward

(f) Lower the test frame assembly and the fifth wheel (Rotopulser / Odometer) on the pavement

(g) Start moving the truck forward from a stationary state and actuate the data acquisition system at the same time

(h) Steer the truck so that the tips of the test arms are in the centre of the traversed wheel paths. If it is not possible to track both paths simultaneously, the left hand arm should be given preference, and a note made to that effect. The steering wheel of the truck should be turned the absolute minimum necessary to steer the vehicle during the measuring phase

(i) Testing should be terminated by stopping the data acquisition system at the end of a measuring cycle. Mark with paint, on the road surface or the adjacent kerb, the end point of the test

(j) Make two copies of the test file on separate floppy discs. Label one in black or blue as "WORKING COPY", and one in red as "BACKUP COPY". Store these in an area protected from physical or magnetic damage. As soon as possible after returning from the field, both copies should be archived

(k) Disengage the test frame assembly by raising it and fixing it securely to the undercarriage of the truck. The fifth wheel should also be lifted and secured before driving off

5. Data Collection and Reporting

(a) Data is collected for both wheel paths simultaneously, at about 4m intervals and stored

(b) Each data acquisition cycle consists of taking a set of readings every 50 mm, being 22 in all. The system software stores and displays the deflection readings as separate bowls for both the left and right hand wheel paths

(c) Transfer the “WORKING COPY” files to the office computer and run the data through the quality check software, rejecting faulty data (see User Manual for details)

(d) Convert the data to the required format, copy the data to a separate disk and dispatch it together with the report to the end user

6. Driving

6.1 Speed

(a) During testing, the vehicle should maintain a maximum speed of between 3 km/h to 3.5 km/h. As there is no minimum speed limit, extreme care should be taken by slowing down, while testing over potholes and other surface irregularities like bridge joints

(b) The truck shall be driven such that the test beam arms traverse in the observed worn wheel paths of the pavement

6.2 Test Lane

(a) The lane to be tested is normally the one which is used by the majority of the traffic. However, in many circumstances it is required that all the lanes in both directions be tested. This should be confirmed before commencing the survey

(b) The selected lane should be followed throughout the survey where possible. On the change from single to dual carriageway and vice - versa, the kerb lane shall be followed to its end. If required to do so, the section of the dual carriageway shall be tested separately. Examples of correct lane changes are shown in Figures 1 to 4. A note shall be made for all events that occur during testing such as lane changes

(c) Overtaking should be avoided where possible and is only permitted in specific circumstances such as a parked or broken-down vehicle in the test lane. When such a manoeuvre becomes necessary, it shall be carried out with proper traffic control. A note should be made of all such events

6.3 Road Surface Conditions

(a) Tracking of the vehicle shall not be changed unless irregularities such as excessive potholes and patching or speed humps are likely to damage the test assembly or the vehicle

(b) Testing shall be terminated if continuation is likely to cause damage of the test assembly or vehicle

(c) Testing shall not be carried out in rain or when there is excessive water on the pavement

7. Calibration

7.1 Frequency of Calibration

(a) Calibration should be carried out at least every month. After the completion of calibration, the data file is downloaded to a floppy disk designated “CALIBRATION FILE” and an entry shall be made into a calibration log maintained in the office

(b) Perform on-road verification at known calibration sites having known deflection values

(c) Calibration shall also be carried out under the following circumstances:

(i) When components likely to influence the measurements are replaced, repaired or adjusted

(ii) Where damage could reasonably be anticipated to have occurred, such as when the beam tips are run over

(iii) When there is an alteration to the signal conditioner

(iv) When the voltage span of the transducer moves out of the span of ± 9.5 volts

7.2 Apparatus for Calibration

The following equipment is required:-

(a) A digital voltmeter with a range from 0 to 20 Volts

(b) Jacks, blocks or adjustable car stands to raise and hold the test frame off the ground

(c) A certified distance measuring device with a digital output and having a total travel of at least 250mm and with an accuracy exceeding 10 microns

(d) A laptop computer with suitable software

7.3 Calibration Procedure

7.3.1 Signal Conditioning

(a) Using the span screw on the signal conditioner, adjust the voltage span of the maximum swing of the arms to 16 volts

(b) Using the zero screw adjust the voltage back to 8 volts. If this has been carried out successfully, the respective voltages at the bottom and at the top of the travel of the test arm should be -8 ± 0.1 volts and + 8 ± 0.1 volts respectively

7.3.2 Test Frame Assembly

(a) Disconnect the trailing cable and select a flat level surface such as a concrete slab large enough to accommodate the test frame and provide a vibration free environment

(b) Remove the test frame assembly from under the truck and mount it onto the jacks or blocks to enable it to be raised off the ground. This is to allow for the full travel of the legs plus the height of the measuring device. Make sure that the Test Frame is level and the arm tips are in the same plane

(c) Place the tip of the arm on the measuring device and raise or lower the arm until it just touches the respective travel stops, and zero the display instrument

(d) Record the distance travelled in mm by the arm and calculate the starting point by deducting 150mm from the distance travelled and halving it. Lower the arms until it just touches the lower travel stop and re-zero the instrument. Now raise the arm by the distance calculated and re-zero the display again. This is the starting point and the first reading should be read on the computer

(e) Raise and lower the arm, as appropriate, by turning the wheel, in 5mm increments to 150mm and record the corresponding readings. If the calibration is successful, the data will be graphed as a straight line and should give an R<M>2 value better than 0.999. Save the calibration file and repeat the procedure for the other arm

7.3.3 Odometer

(a) Drive the truck to the Odometer Calibration Site. Lower the Odometer wheel and position the front wheel of the truck at the start point as marked on the pavement

(b) Start the Odometer Calibration programme on the computer and move the truck forward at the test speed

(c) Drive to the end of the 1 km site and stop the front wheel of the truck at the end point

(d) Stop the calibration, store the file, raise the Odometer wheel and secure it. Calibration of the odometer shall be repeated if the variance from the preceding calibration exceeds 0.1%

8. Traffic Control and Safety

(a) All Deflectograph work shall be performed with adequate traffic control and the type of traffic control needed depends on the specific work site. Compliance of traffic control procedures shall take precedence over operational expediency at all times

(b) Reference shall be made to the RMS *Traffic Control at Worksites* manual which is based on the Australian Standard 1742.3 - 1985, *Manual of Uniform Traffic Control Devices, Part 3, Traffic Control Devices for Roads*. However, judgement is required in ensuring the safe passage of traffic at all times

(c) The test vehicle as well as all attachments to it, shall comply with all applicable State and Commonwealth laws. All necessary precautions shall be taken beyond those imposed by laws and regulations to ensure maximum safety of operating personnel and other traffic

(d) In any circumstance either the driver or operator may nominate to cease operation (or not to commence) where safety to themselves or to other road users is of concern

(e) If testing of the site in the normal manner is considered to present danger to the testing staff or the public, the local RMS Office or the police should be consulted. If in the opinion of either, the prevailing conditions are unsafe for testing, the survey shall not proceed

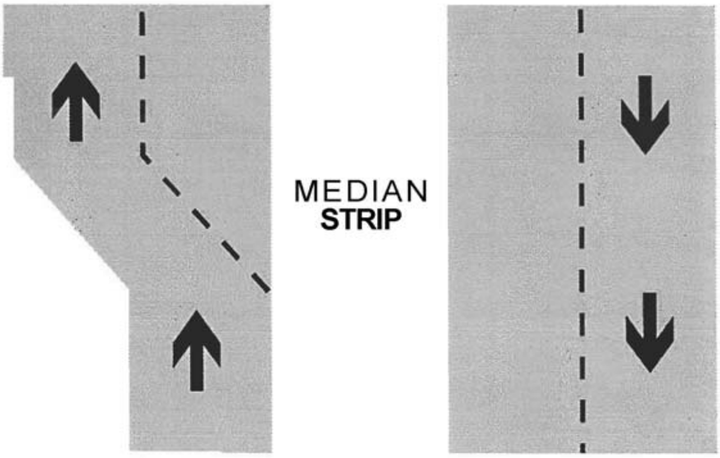

Fig 1. Slow Lane Hill Climb

NOTE: Follow the road markings into the slow lane until the lane ends and flag as a change of lane on re-entry to single carriageway.

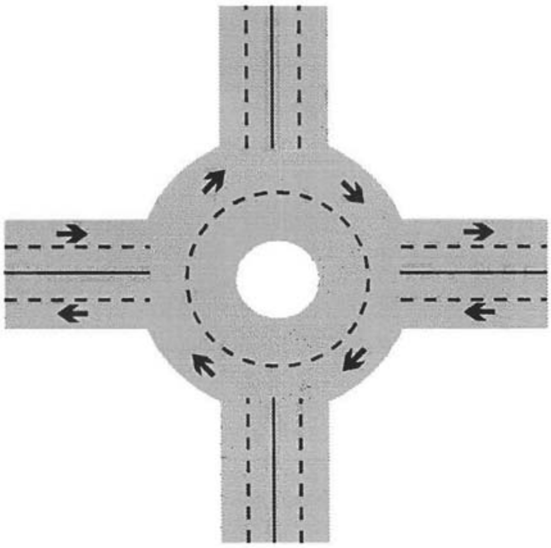

Fig. 2 Roundabout - Test Path Straight ahead

(lanes to be tested and direction of test)

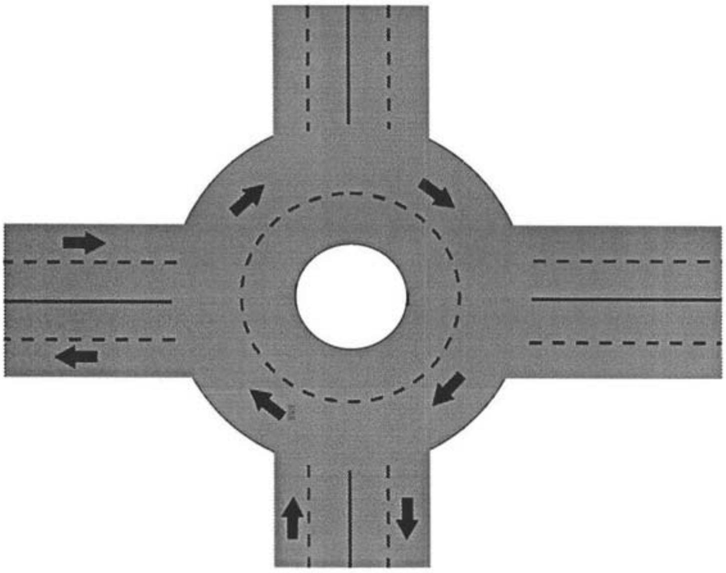

Fig 3. Roundabout - Test Path,
both left and right hand turn
(lanes to be tested and direction of test)

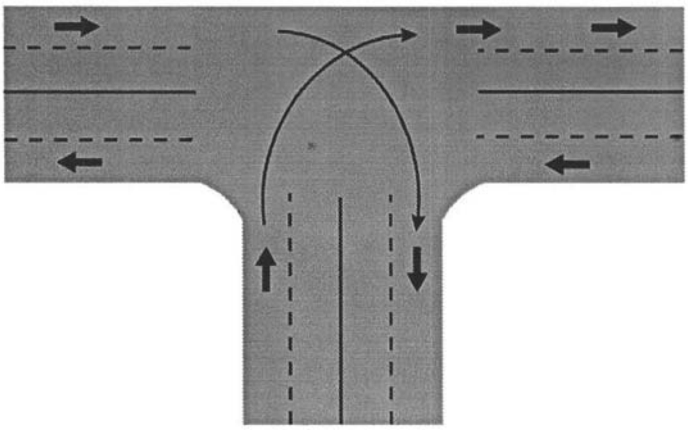

Fig 4. Multi-lane T-Junction into One Way Street
(lanes to be tested and direction of test)