PAVEMENT DEFLECTION AND CURVATURE: 
BENKELMAN BEAM TEST

SCOPE

This method describes the procedure for the determination of rebound deflection and curvature function of a flexible pavement under a standard wheel load, using the Benkelman Beam. The method also describes the procedure for the calibration of the Benkelman Beam and the Rotopulse transducer which determines the spacing at which the data is logged.

REFERENCED DOCUMENTS


APPARATUS

1. Two calibrated modified Benkelman Beams (Figure 1) with a Data Acquisition System and accessories. Benkelman Beams shall be calibrated in accordance with Appendix A of this method.

Note: The following accessories are added to the usual Benkelman Beam:

Data Acquisition System: QTDAS capable of logging test data at every 50mm travel of the test truck.

DAS: A suitable analogue to digital transducer signal converter and amplifier.

Rotopulse: A signal interrupt control unit which enables the Data Acquisition System to send signals to the data logging computer at every 50mm travel of the test truck. Rotopulse shall be calibrated in accordance with Appendix A of this method.

IBM Compatible Computer with Data Logging Software BWL4 and Processing Software BAN3: The computer acts as the data logging, storage and processing device and also as the control unit.

Connecting Cables:

Communication cable connects the Data Acquisition System to the parallel port of the Computer.

Beam cables supplies power to the DCDT and deliver voltage response of the DCDT's to the Data Acquisition System.

Rotopulse Cable provides power to the infra red transmitting device inside the Rotopulse and delivers signals to the Data Acquisition System to log a reading.

Data Acquisition System Power Supply Cable

DC Power Supply: A 14 Volt DC power supply. This should preferably be a separate battery (other than test vehicle's system) to minimise noise on transducer signals.

Dial Gauges: Calibrated dial gauges eg., Mercer Type 251, with the measuring range of 10mm, readable to 0.01mm.
2. Single axle, dual tyre truck with:
   - the rear axle ballasted to give a load of 8.2 ± 0.1 tonne, and distributed evenly over both sets of dual tyres;
   - 10 x 200 size tyres rated 12 ply or higher, in matched pairs and in good condition (if any wear, all four rear tyres should have the same degree of wear), and inflated to 550 ± 10 kPa. The tyre inflation pressure must be checked on site at the start of each day’s testing;
   - tyres should be spaced 330 ± 10 mm apart, measured centre to centre, and should give a clear spacing of 120 ± 10 mm between treads. This spacing should be the same for both sets of the dual tyres.

3. Calibrated trip meter, readable to 1m.


5. Digital thermometer with a range of approximately 0°C to 100°C, readable to the nearest 1°C.


PROCEDURE

1. Setting up the Data Acquisition System

1.1 Set up the Data Acquisition System and check to ensure that it is in working order prior to departure for field testing. Refer to the DDAS Manual.

2. Selection of Test Site

2.1 Choose test sites at regular intervals along the length of the road to be tested.

2.2 Carry out the test in both the outer and inner wheel paths of the lane under test.

3. Testing

3.1 Set up the Data Acquisition System in Range 3 at the test site by following the procedures described in the DDAS Manual. Switch on the Data Acquisition System no less than 20 minutes prior to initiating the first deflection reading.

Note: Range 3 shall be selected in the Data Acquisition System (DAS) for deflections of less than or equal to 2.0mm. When the deflection exceeds 2.0mm, then Range 2 shall be selected in the DAS. The Benkelman Beam shall be calibrated for both Range 2 and 3 prior to testing commencing.
3.2 Set up the Benkelman Beams ready for testing.

3.2.1 Activate the vibrator on the beam and set the dial gauge to approximately 500.

3.2.2 From the BWL4 menu on the computer screen select “Zero DCDTs”. Loosen the DCDT clamp and move the DCDT up or down so that the count on the computer is approximately 800. Tighten the clamp holding DCDT. Check that the count is still about 800.

3.2.3 Choose the calibration factor selection menu in BWL4 and enter the calibration factor appropriate for the selected Range in the DAS.

3.2.4 Repeat (3.2.1) to (3.2.3) for the other beam.

3.3 Locate the truck at the test site.

3.4 Insert the end of the Benkelman Beam in the space between the dual tyres, such that the end of the beam rests approximately 1.2m in front of the centre of contact between the tyre and the pavement.

3.5 Align the beam parallel to the direction of travel of the truck such that with the forward movement of the truck, the wheels will not come in contact with the beam.

3.6 Adjust the rear leg of the Benkelman Beam so that the beam tip is in contact with the surface at the test location and that the plunger is in contact with the stem of the dial gauge. Release the arresting rod and allow the beam itself to move freely.

3.7 Activate the vibrator on beams. Set up the beams to give dial gauge reading of approximately 500. Record the initial dial gauge reading.

3.8 Activate the Data Acquisition System so that a reading of the DCDT displacement during the test is recorded automatically for every 50mm travel of the truck.

Note: The Data Acquisition System can be set to automatically read and record DCDT displacements at every Rotopulse interrupt which occurs at 50mm intervals.

3.9 Move the truck forward steadily and smoothly at least 6m at a walking speed. During the forward movement of truck, continuously monitor the dial gauge behaviour and record the maximum value reached.

3.10 Record the final dial gauge reading when the dial gauge needle comes to rest.

3.11 Examine the deflection bowl display and where a badly shaped bowl occurs, repeat the test.

Note: After 6m travel of the test truck, the Data Acquisition System will automatically stop logging and show a graphical trace of the deflection bowls. Badly shaped bowls can be distinguished by comparison with the adjacent deflection bowl at the same test site, and/or with the deflection bowl/s of the previous test site/s. It should generally be obvious to an experienced operator when a test bowl is invalid.
3.12 Clamp the arresting rod onto the beam to avoid damage to the dial gauge and the DCDTs before picking up the beam.

3.13 If required mark the deflection test site with a paint spot of approximately 50mm diameter, located about 300mm to the left or right of the test point.

3.14 Measure and record the pavement surface temperature to the nearest 1°C at the first site and at least every ten test sites.

REPORTING

1. Using BAN3 data processing software, report the rebound deflections and the curvature function to the nearest 0.001mm in BAN3 “Table of analysed results” output format.

2. Report the initial, maximum and final dial gauge readings and the rebound deflection in millimetres for each test site. The rebound deflection is twice the difference between the maximum and the final dial gauge readings.

3. Report the pavement surface temperature to the nearest 1°C.
APPENDIX A

FIELD CALIBRATION

1. Calibration of the Benkelman Beam

The data acquisition calibration factor of a Benkelman Beam is determined by applying known deflections to the beam tip and comparing each calibration jig dial gauge reading to the deflection calculated by the deflection test computer program BWL4.

1.1 Apparatus

1.1.1 Benkelman beam calibrating jig with calibrated dial gauge (Figure 2).

1.1.2 3 spacing blocks (the same height as the base of the calibration jig).

1.2 Procedure

1.2.1 Set the Benkelman Beam up on the three blocks so that one is under each of the feet, and the third is under the sliding leg.

1.2.2 Release the locking device and raise and lower the body of the beam gently through the full travel of the dial gauge of the beam. Replace the dial gauge if the gauge is found to be sticking.

1.2.3 Check the dial gauge on the calibration jig. Replace the dial gauge if the gauge is found to be sticking.

1.2.4 Position the calibration jig so that the beam tip is directly under the dial gauge measuring point (Figure 2).

1.2.5 Set up the Data Acquisition System in Range 3.

Note: The selection of Range 3 in the Data Acquisition System (DAS) will be suitable for deflections of less than or equal to 2.0 mm. The calibration shall also be conducted in Range 2 for deflections greater than 2.0 mm.

1.2.6 Connect the DCDT located on the Benkelman Beam to the correct input plug on the Data Acquisition System (DAS) and data logging and storage computer via cables.

1.2.7 Connect the Rotopulse and power leads to the DAS box.

1.2.8 Screw the knurled nut of the calibration jig up, to position the sprung platform giving a working range of at least 5mm.

1.2.9 Open the BWL4 program on the computer and choose the “ZERO DCDT’s” from the menu.
1.2.10 Turn on the vibrator on the Benkelman Beam. Loosen the DCDT clamp and move the DCDT up or down so that the count on the computer is approximately 800. Tighten the clamp holding DCDT. Adjust the dial gauge on both the calibration jig and Benkelman Beam to zero. Check that the DCDT reading on the computer screen is still approximately 800. Escape the window.

1.2.11 Choose the “CALIBRATION FACTORS” selection from the menu. Enter 1000 in the boxes for both channels and then escape the window.

Note: Enter 240 in the boxes for both channels when calibration is done for Range 2 in the DAS.

1.2.12 Choose the “DO BOWLS” from the menu and enter all fields as required. One person is required to watch the dial gauge on the beam and another to operate the calibration jig and read the dial gauge mounted on the calibration jig. Ensure that both dial gauges read zero.

1.2.13 Rotate the shaft of the Rotopulse slowly to simulate truck movement. Press the space bar on the computer. Turn the knurled nut on the calibration jig smoothly so that the sprung platform moves down 0.20mm as measured by the dial gauge on the calibration jig. Turn the knurled knot smoothly again in the opposite direction so that the sprung platform moves up to the initial position to give zero dial gauge reading. Record the jig dial gauge maximum reading, the beam dial gauge maximum reading and the result as displayed on the computer and compare. The dial gauge on the beam should read approximately half that of the calibration jig dial gauge reading.

1.2.14 Repeat (1.2.13) four times to determine the average values.

1.2.15 Repeat (1.2.13) and (1.2.14) at 0.20mm increments over the deflection range of 0 to 2mm.

Note: The calibration shall be carried out over the deflection range of 0 to 2mm when Range 3 in the DAS is selected. When Range 2 is selected then the calibration should be performed over the deflection range of 0 to at least 3mm.

1.2.16 Plot the resultant average calibration jig dial gauge readings against the corresponding computer generated deflection results and draw a straight line of best fit. The beam calibration figure is the slope of the regression equation of the line.

1.2.17 Repeat (1.2.5) and (1.2.11) to (1.2.16) for Range 2 in the Data Acquisition System.

1.2.18 Repeat (1.2.1) to (1.2.17) for the other beam(s).

2. Calibration of the Rotopulse for Benkelman Beam Testing

The following describes the procedure for the verification of accuracy in 50mm intervals of pulse generation by the Rotopulse in the data logging process.

2.1 Procedure
2.1.1 Measure a test section of 6m in length on a smooth surface and mark each end.

2.1.2 Connect Rotopulse (Figure 3) to the data logging and storage unit (computer) via the Data Acquisition System.

2.1.3 Locate the drive wheel of the Rotopulse at start of the measured section and choose the “DO BOWLS” window. Activate logging of data and roll the Rotopulse drive wheel over the measured distance.

2.1.4 Stop the movement of Rotopulse at the mark denoting 6m and confirm that the logging cycle on the “DO BOWLS” window ceases at that point.

2.1.5 Verify that 120 data points were logged. This confirms that a reading has been taken at 50mm intervals.
Figure 1. Benkelman Beam

Figure 2. Beam Calibration Jig with Dial Gauge.

Figure 3. Rotopulse.