Transport Roads & Maritime Services

Test method T2160

Determination of extent of road pavement cracking by RoadCrack™ equipment

OCTOBER 2012

Revision Summary

Ed/Rev Number	Clause Number	Description of Revision	Authorisation	Date
		New Issue – J.Carrasco/WHapukotuwa	Greg Hall	Feb 2005
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 T2160 (other than minor editorial changes) are indicated by a vertical line in the margin as shown here.

Test method T2160

Determination of extent of road pavement cracking by RoadCrack™ equipment

1. Scope

(a) This test method defines the procedure for detecting, measuring and classifying the extent and severity of cracking on a road pavement using the RoadCrack™ equipment developed through CSIRO/RMS collaborative research

(b) The testing can be carried out on rigid and flexible pavements (asphalt, sprayed seal or concrete pavements) but not on unsealed roads . Testing on wet surfaces in rainy or wet weather conditions will not give reliable results and must be avoided (refer section 5.5)

(c) The pavements to be tested should be dry, free of oil, dirt/gravel, ice and snow and should be in a stable condition without excessive pavement failures such as frequent large potholes

(d) The speed of testing can vary between 3km/h and 80km/h to suit the road conditions. The lower speeds are adopted in specific conditions such as roundabouts, steep gradients, etc as required

2. Definition

Term	Definition
RoadCrack™	(a) Is a truck mounted fully automated vision system, which is capable of scanning the road surface at highway speeds while analysing and storing the cracking data in 'real-time' using an onboard computer network. The system has crack detection modules (Line-scan sensors and lighting), which are housed under the chassis ahead of the rear wheels of the truck. The current system uses four modules each scanning a width of up to 750mm to cover the majority of the 2.5m legal vehicle width. The optical system and timing circuitry are integrated to record 1mm wide linear array image per 1mm longitudinal movement of the truck. A generator located on the rear tray of the truck supplies electricity to power the camera lighting modules, computers and air-conditioning units. The system detects cracks as fine as 1mm in width with the maximum reported width set at 8mm, and classifies them as either transverse, longitudinal or crocodile, whilst travelling at highway speeds of up to 80km/h irrespective of the pavement surface type - sprayed chip seal, asphalt or concrete (70km/h).
The RoadCrack ™ system	(a) Utilises line-scan technology (referred here as cameras) to produce a continuous digital image of the road pavement. Camera and lighting modules have been installed and positioned to detect "load associated" cracking of the pavement (wheelpaths) as well as centre of the lane or "non-Load associated" cracking. The signal from each sensor is assembled into "frames" by the truck's computers, and crack detecting algorithms are applied to each of these frames to detect, classify and determine the width of cracking in "real-time". 'Frame' is a basic unit of measuring the cracked surface by RoadCrack™. A frame is a 600mm x 500mm digital image

	formed by scanning 500mm of longitudinal movement of a single camera module. The extent of cracking is determined by the number of cracked frames in a given length of road in each predominant crack type. The severity of cracking is determined by the average crack width in each frame. The system has a limited capacity to retain digital images of the pavement as an optional feature; this facility is limited to 200m lengths.

3. Apparatus

(a) Vehicular platform

(b) Specially designed line scan sensors (cameras) and lighting assembly to capture road surface images at highway speeds

(c) Data acquisition software and hardware (computer network and operator interface) to facilitate data capture through 'real-time' analysis of images to interact with the operator

(d) Generator and associated electrical components to provide an uninterrupted power supply to lighting assembly, computers and air-conditioning

(e) Horizontal linear distance measuring device (shaft encoder), accurate to ± 0.1%

(f) Manufacturer's user manual

(g) Means of determining ambient and road surface temperatures with an accuracy ±1°C

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

4. Procedure

4.1 Pre-test procedure

(a) Follow pre-test procedures as per manufacturer's user manual

(b) Tyre pressure of all wheels is checked manually and maintained at the manufacturer's recommended values

(c) All testing apparatus and cables must be correctly mounted, connected and secure, as per the Manufacturer's User Manual

(d) Make sure all light assembly covers are lifted and carry out a lamp check. Replace any broken lamps

(e) Ensure all traffic warning devices are in place and operational

4.2 Recording of data

(a) Ascertain the exact start and end points of the survey. If there is any doubt, a check must be made with the client, or the Pavement Condition Unit Supervisor

(b) Record the surface temperature of the pavement in a non-shaded area

(c) Follow instructions in the user manual for operating and entering the header information on the operator's screen

(d) Start data acquisition at the nominated start point of the test site

(e) Check data is being recorded and corresponds with distance measured during testing through the operator's screen

(f) Follow the instructions as set out in the RoadCrack™ User Manual and enter the relevant control points and other features as required

5. Driving

5.1 Speed

(a) The test speed shall be maintained within the manufacturer's operational speed range for the equipment, legal speed limits and road and traffic condition encountered

(b) Testing must be terminated if conditions are such that difficulty is encountered maintaining the required test line and/or minimum test speed

5.2 Test lane

(a) RoadCrack™ must be driven in the observed usual wheel paths on the lane

(b) The selected lane must be followed throughout the survey. On the change from single to dual carriageway or dual climbing lanes, the kerb lane must be followed to its end. The change back to single carriageway is recorded as a lane change

(c) Note and/or flag sections where testing is not possible due to construction sites, parked cars, etc. Results for this section are to be omitted from the data report

5.3 Overtaking

(a) Overtaking must be avoided unless designated test lane is obstructed or unsafe, in such case, section must be noted and/or flagged

5.4 Road Surface Conditions

(a) No attempt must be made to avoid pavement defects such as potholes, excessive patching etc. unless it is likely to cause damage to the Lights or Cameras (test assembly) or the vehicle. Refer also to Safety - Section 7.

(b) Testing must be terminated if continuation is likely to cause damage to the Lights, Cameras (test assembly) or vehicle i.e.: unsealed roads

(c) If localised areas of contamination of the road surface are encountered (e.g. mud, debris etc) this must be noted and/or flagged and results for the section shall be omitted from the report

5.5 Rain

(a) Testing must not be commenced if road is wet, prior to start of testing

(b) Testing must be aborted if road becomes wet, after start of testing. Refer also to Safety – Section 7

5.6 Data Collection and Reporting

(a) Data is collected every 1mm of travel and routinely reported in 100 metre intervals

(b) Raw data must be retained in a secure long-term repository for a minimum of 5 years

(c) Where applicable, data must be collected with reference to the Road Authority's "ROADLOC" (road referencing) system. To avoid the accumulation of errors in distance recording, RMS requires that the distance measurement is re-zeroed at each of it's ROADLOC Control Points during Network Survey Operation

(d) In generic data collection surveys where no road referencing system exists ("Non-ROADLOC" sites), the testing must be carried out by noting surrounding permanent features such as Kilometre signposts, cross streets, rivers/creeks, bridge abutments etc. All such reference points must be noted during the test and edited at the end of the test run

(e) Survey results shall be available for reporting in database format

6. Calibration

6.1 Light alignment Procedure

(a) Park vehicle on a level surface

(b) Turn on the main power supply

(c) Turn on the computer. When the main menu appears on the operator's screen, select the Calibration option

(d) Carry out height measurements as per manufacturer's User Manual

(e) Align all test assemblies.

(f) Camera and Light alignment must be carried out once a month and,

(g) Alignment should also be carried out under the following circumstances:

(i) If components likely to influence calibration are replaced, repaired or adjusted

(ii) Where damage could reasonably be anticipated, such as after striking an object, animal, pothole etc, with the test gear

6.2 Component Calibration

6.2.1 Distance Transducer

(a) Care should be taken to check and maintain the component(s) of the vehicle and testing system that could potentially influence the distance measured in testing

(b) The Data Acquisition System must record the linear distance travelled by the vehicle during testing, by a distance transducer fitted to the host vehicle, to an accuracy of ± 0.1%.

(c) The distance transducer must be calibrated by driving the host vehicle over a known distance (one kilometre to an accuracy of ± 1.0 metre) and recording the number of pulses or ticks produced by the transducer. Knowing the number of pulses produced over a standard distance, a calibration factor is then calculated relating the number of pulses to the distance travelled.

(d) The calibration factor and associated information such as date and time of calibration is then stored and used for all subsequent testing until such time as a new distance calibration is performed

(e) Distance calibrations shall be performed immediately following any change to the distance transducer or a change to any part of the host vehicle that may interfere with the existing calibration constant

6.2.2 Validation

(a) Repeatability runs must be carried out before and after a network survey is undertaken and/or after any changes to the vehicle and/or its installed components. A sound and stable site that represents different types of surfaces as well as having reasonable amount of cracking is required for this purpose. See Appendix A for procedure

(b) At the beginning of each days testing, image quality is confirmed by capturing and examining a sample of pavement images for clarity and contrast. These images must be retained in a secure long-term repository for a minimum of 5 years

(c) All other aspects of the vehicle are maintained to the settings provided by the manufacturer and not generally subject to operator intervention

6.3 Maintenance measures and logs

(a) It should be assumed that any person called upon to initiate repairs, service or even installation will be unfamiliar with the maintenance of a RoadCrack™ vehicle; therefore the following control is required

(i) All repairs to the test equipment must be carried out by CSIRO, or under their supervision, as per the Technical Support Agreement, between the RMS and CSIRO

(ii) Only the particular fault, which has been identified, must be repaired and all other items MUST be left in their initial state (unless with the expressed permission of RMS maintenance technician)

(iii) Qualified personnel only must carry out repairs to the host vehicle

(iv) All faults and their repair or replacement must be reported to RMS supervisor, on appropriate forms and recorded in daily diary

(b) Records must detail:

(i) Modifications and adjustments that were required to achieve initial calibration (held by CSIRO)

(ii) Any damage and subsequent repairs to the test equipment (held by CSIRO)

(iii) Times and details of each calibration (held by CSIRO)

(iv) Truck Diary entries must be completed daily, operator reports once a week and incident forms as required

7. Safety

(a) The test vehicle and test equipment, **must comply** with all applicable State and Commonwealth safety standards. All necessary precautions must be taken beyond those imposed by laws and regulations to ensure maximum safety of operating personnel and other road users

(b) Testing **must not commence**, or **be continued**, if it is deemed to present a danger to the truck, operating personnel or other road users.

Appendix A: Procedure for RoadCrack Verification

A.1 PURPOSE

This procedure was developed by RMS NSW; it must be carried out before any major Network survey or after any repairs to the vehicle and its installed components. This procedure was designed to:

(a) Ensure the proper working of the RoadCrack system (including the host vehicle and installed instruments)

(b) Verify the repeatability of the data acquisition system.

(c) Assess the ability of the driver to track consistently.

Use of this procedure has been specifically confined to two well-documented sites, one in Sydney and the other in Albury.

A.2 Background

The 2 sites were chosen for being sound and stable sites that represent different types of surfaces as well as having reasonable amount of cracking. They were also chosen for their location.

Site 1: Pacific Highway, Hornsby
Start: Beryl Av R[0000010, 0770, 0.000]
End: Sydney-Newcastle Freeway R[0000010, 0820, 1,280]

Site 2: Riverina Highway, Albury
Start: Thurwoona St R[0000020, 1120, 0.000]
End: Pemberton St R[0000020, 1120, 2.566]

The Sydney site is the most commonly used due to its proximity to the RoadCrack's home base. It is used before any major Network surveys and after any repairs carried out in Sydney. The Albury site is used whenever any repairs are carried out in Melbourne by CSIRO.

This procedure involves a comparison of the longitudinal cracking (the most predominant cracking type) values for each run against the average of all five repeat runs.

A.3 Procedure

For a verification test, five repeat runs by the RoadCrack vehicle must be carried out. Whenever possible an external trigger (cone with appropriate reflective surface) shall be used to accurately establish the run's start point.

Data must be reported in 100m intervals. Using control points in RMS's location system (ROADLOC), the data is split into links. Only 100m sections are used in the analysis, any section shorter than 100m is then excluded.

A system validation at the Sydney site must be carried out at least once every 6 months.

A.4 Analysis

Each run is plotted and visual assessment of the amount of cracking, type(s) of cracking and general trend(s), is carried out by overlapping each plot on one another. Any differences between runs are clearly spotted.

Also, a regression analysis is carried out to test the R^2 correlation of the longitudinal cracking value of each 100 m section against the average of the 5 runs for the same 100 m section. For acceptance the R^2 correlation should be at least 0.90.

Any repairs to the vehicle's installed instruments or ride height will invalidate its previous verification. A further set of five runs will then be required and the results analysed to determine the repeatability of the RoadCrack system.