Road Visual Condition Assessment Manual

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ACKNOWLEDGEMENT

This manual is a combination of the Road Visual Condition Assessment Manual and the Technical Basis for Road Condition Index Formulation Manual compiled for WALGA by ARRB Group Ltd.

The Roman Data Collection Manual prepared for WALGA by Shawmac formed the basis of the Road Visual Condition Assessment Manual and ARRB and WALGA acknowledge this contribution.

The City of South Perth's Asset Manager, Mr Colin Ward, compiled the section covering path data collection which is reproduced within this Manual.

Cover: Keating Road, Toodyay

INTRODUCTION

As most road authorities have budget limits, accurate assessment of pavement and surface distress can provide a consistent and rational method for allocating limited resources.

Numerous studies indicate that properly maintained pavements that are kept in good condition (i.e. only requiring routine maintenance), have a total annual maintenance investment as low as 25% of a similar asset which has been allowed to deteriorate to a poor condition (i.e. requiring periodic maintenance or renewal) and then applying rehabilitation.

With regular routine maintenance (surface rejuvenation, patching, crack sealing, etc.) the surface is kept intact, reducing the likelihood of water penetration into the base layers of the pavement. If the pavement surface is allowed to deteriorate, the potential acceleration in the rate of deterioration in the base layers will result in more substantial and early treatments being required to rectify the pavement structure and hence increasing the whole of life cycle costs of the pavement.

Given that selection of treatments for timing and suitability is dependent on current information related to the road section's current performance, it is therefore important to have a database which is up to date and provides an accurate and current representation of the:

- inventory of assets
- condition of those assets
- usage (traffic demands or routes linking to essential services).

An up to date database will help guide asset managers to develop asset management plans that minimise whole of life cycle costs by maintaining the network to a targeted level of service. It will also allow asset valuations to be produced taking into consideration the asset condition, and not solely being dependent on construction data.

A road data collection strategy is therefore a critical component for any asset management plan. This manual provides the guidelines for the manual collection of visual surface condition data. The surface defects prescribed in this manual are intended to represent, at the network level, a snapshot of how the network is performing at a specific point in time. Its purpose is to assist in the selection of potential sites for maintenance and capital works programs. It is not intended to facilitate project level investigations or design.

The descriptions of each defect and collection methods shown in this manual have been adapted from the ROMAN Data Collection Manual. A number of defects have been removed as they are more suited for project level investigations or amalgamated into one classification. The combined changes improve the simplicity and efficiency in rating while removing some ambiguity.

The Western Australian Local Government Association (WALGA) identified a need to provide Local Governments with a set of simple algorithms to derive road condition indices (RCI) based on the visual data collection categories. The RCI was developed for WALGA by ARRB and the technical basis for the development of the RCI including calculation examples, is provided in Appendix C. The indices provide a common methodology and benchmark to measure and assess the network's performance.

CONTENTS

1. CONDITION ASSESSMENT

1.1 Purpose

Pavement condition assessment begins with collecting standardised and detailed information, which is then interpreted to determine the current condition of the pavement.

The visual condition assessment methods described in this manual are intended to provide Local Governments (LGs) with a method of assessing the current condition of their network based on the observed defects. It is intended to facilitate a network level assessment of how the network is performing at a specific point in time. This then provides an opportunity to measure network performance and effectiveness of asset management strategies.

The data collected described in this manual could also be used to inform development of a capital works programme, which is not meant to be the absolute list of works the authority would commit to, but moreover to be a guide for LGs to identify candidate sites for project level investigations. These detailed investigations would then confirm the suitability of the actual treatments required to address the observed distress. Hence, the assessment method for the different defects has been kept general and does not delve into the level of detail required for project level assessment.

1.2 Preparing for a condition assessment

Before the condition assessment begins it is imperative that LGs determine what the treatment lengths are for their particular network. A treatment length represents a segment of pavement that is homogenous in nature (such as same surfacing material, condition, underlying structure, etc.), of which a single treatment would be expected to be applied across the whole length. Therefore, it is important to ensure that treatment lengths are defined/created relative to their current condition and relevant attributes with due consideration for appropriate minimum and maximum defined lengths.

1.2.1 Treatment Lengths

Currently for the majority of road networks the default definition of a treatment lengths is a segment of road located between intersections (Figure 1.1). It is therefore recommended that all treatment lengths be reviewed and where appropriate, these are manipulated (RAMM uses a “Treatment Length Dynamic Segmentation” tool) to create treatment lengths of an appropriate size and parameters that result in a homogeneous section of road being defined.

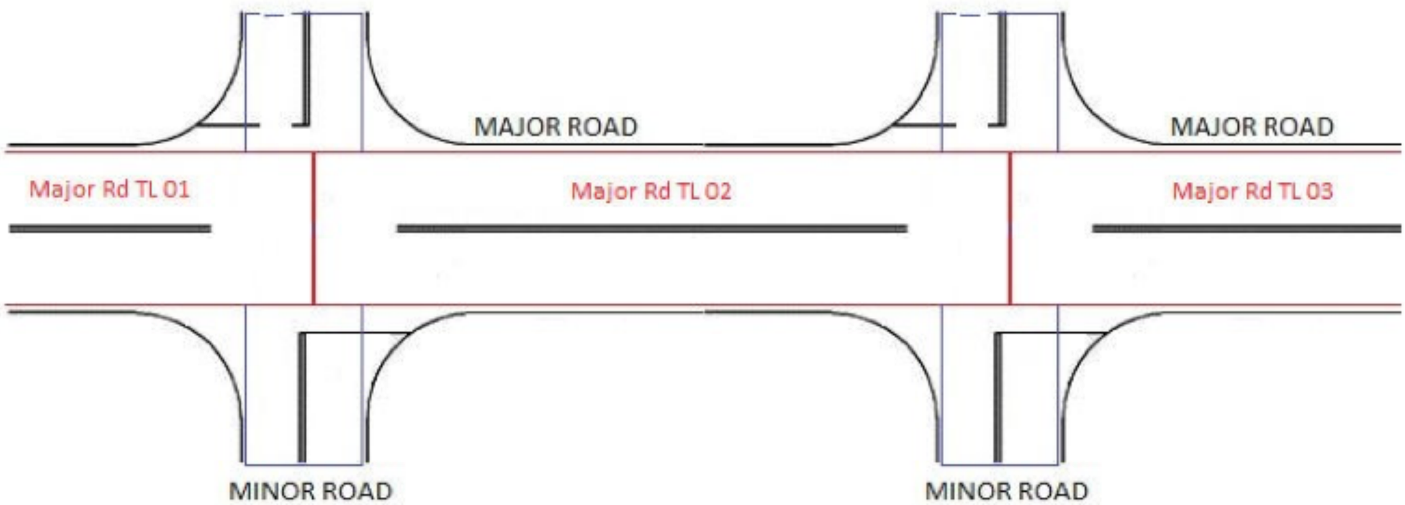


Figure 1.1: Typical treatment length definition

The defined treatment lengths are important because these sections of road are the homogenous lengths the assessor will investigate in the field when making decisions on defect percentages and parameters. The length of treatment lengths is important, where they are too short, the mobilisation cost to perform treatments could be high and inefficient. If they are too long, assessing the condition for the overall type and number of defects across the section length is difficult. This may lead to incorrect condition assignment which may lead to incorrect treatment selection.

The minimum and maximum length of the chosen treatment lengths are dependent on the road environment and can vary from LG to LG, but for urban networks this should ideally be no smaller than an intersection or cul-de-sac bowl and no longer than a typical reseal length or intersection to intersection depending on the LG requirements. For rural networks, typically if the condition of the road is generally homogeneous, then splitting the road up into contiguous lengths of 500m to no more than 1km is preferable.

1.2.2 Defining Treatment Lengths at Intersections

Treatment lengths are based on the road length or carriageway sections recorded in the database. These tend to run between the intersection of the centrelines, resulting in a slight duplication at intersections.

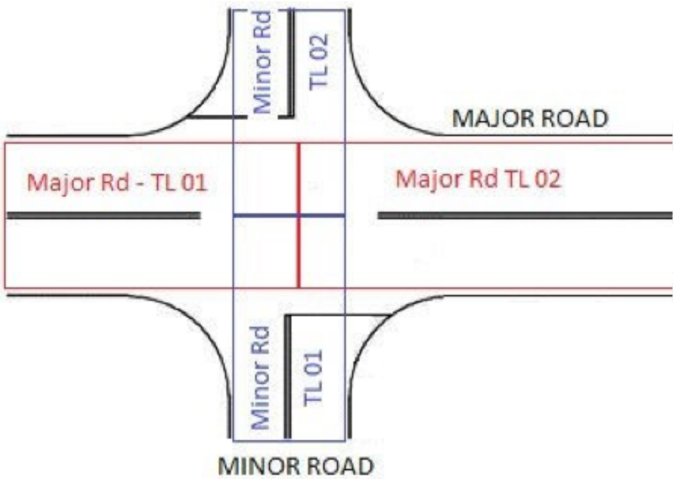


Figure 1.2: Typical duplication of surface area

If this duplication is considered a problem, the user can isolate the small duplicated length at every intersection and disable the treatment length. This will ensure the treatment areas are accurately calculated. It is anticipated that this practice would only have to be done once when treatment lengths are first established.

1.3 Condition assessment strategy

This manual provides guidelines and methodologies to consistently collect and assess the severity and extent of road surface defects.

A sound asset database with up to date inventory and condition data is required to enable asset managers to develop short and long term plans and programs to maintain the value of the assets for which they are responsible.

Prior to commencing data collection, an assessment strategy needs to be formulated to guide the collection process. By establishing a consistent approach to the collection and assessment of pavement condition, asset managers will have confidence to routinely apply available asset management tools to inform decision making, which will be founded on accurate and current data.

As part of a condition assessment strategy consideration should be given to budget and relevance of the data collection process. For instance, modern data collection techniques facilitates seamless collection of vast amounts of data, such as type, extent, and severity of surface defects, structural integrity, ride quality, and skid resistance. However, data not utilised as part of a regular asset management process to facilitate decision making could be considered redundant. This potentially misdirects limited funding from works programs that could be commissioned to effect improvements to the network condition directly. This manual provides the required visual surface condition assessment approach to assist in determining the condition of the pavement for defined treatment lengths for both sealed and unsealed pavements. Assessment of path asset condition is also included in this document.

The frequency of survey and network coverage should also be considered within the development of the assessment strategy. Pavements often deteriorate slowly, with some surfacing having useful lives of 10 years and in some cases possessing useful lives of 30 years, while pavements can have useful lives of over 60 years. Hence, for pavement assets it is not necessary to collect data as regularly as for surfacing assets. However, the collection interval should not be so elapsed so as to render the data redundant before the next data collection survey is undertaken.

It is therefore recommended that condition surveys are conducted as regularly as required by the agency. As a guide, a three year rolling cycle would be considered the average time lapse between successive surveys, with some agencies undertaking surveys more regularly (annually) and others less frequently (every 5 years). Defining a process for the regular inspection and assessment of the condition of pavement assets provides:

- a methodology to monitor deterioration rates to determine life cycle cost and models
- surface condition is generally relevant within 3 years
- works programming spanning 3 to 5 years is possible with the ability to review the effectiveness of these programs regularly throughout the collection cycle.

Finally the strategy should consider ongoing data collection and management, i.e. setting up a regular data collection process. The inherent value of condition assessments is associated with building up a quality data set that can be interrogated to determine past performance of the network. With old and/or inaccurate data there is significant potential to skew the ability of asset management tools to correctly assess network needs. To facilitate this, and in recognition of the challenges for some LGs to recruit and retain trained staff, consideration could be given establishment of in-house data management services or to adding ongoing data management services to the scope of the data collection contractors.

1.4 Quality assurance

Data quality assurance reviews are an important part of any LG condition assessment strategy. Creating a plan for how to review the data before it is collected or compiled allows a data collector to think systematically about the kinds of errors, conflicts, and other data problems they are likely to encounter in a given data set or when this is being loaded into the asset register of the authority. It is important to note that both the actual collected data and its associated metadata need to be considered in the documented quality control procedures to ensure a comprehensive dataset is readily available. A helpful approach to documenting the data checking process (Quality Assurance, QA) and data review (Quality Control, QC) is to list the actions required to evaluate the data, what decisions were reached to identify problem data, and what actions were taken to resolve the problems at each step in the data life cycle. A QA/QC plan should include:

- determining how to identify potentially erroneous data
- how to deal with erroneous data
- how problematic data will be marked (i.e. flagged).

1.5 Condition categories

Data collected can be categorised to provide the end user with the ability to carry out specific analysis which can assist with network or project level asset management tasks. Some of these categories are described below in the following sections.

1.5.1 Structural capacity

Structural capacity is the maximum number of equivalent standard axle repetitions a pavement can carry before reaching a defined condition representing the end of useful life.

Structural analysis is normally conducted at a project-level to determine the pavement load-carrying capacity and the capacity needed to accommodate projected traffic. This type of analysis should be focused on roads with high commercial traffic or those that are showing clear signs of structural distress.

Deflection testing using a falling weight deflectometer (FWD) or deflectograph (DFG) is the most common method used to determine structural capacity, as it is a form of non-destructive testing and therefore prevents further damage to the pavement. However, more detailed testing may be required for detailed design of rehabilitation treatments. This includes trenching or coring of pavement for samples and dynamic cone penetrometer (DCP) tests.

1.5.2 Roughness (ride quality)

Roughness, or ride quality, is a measure of distortion of the road surface along a linear plane or an estimate of the ability of the road to provide a comfortable ride to users. Laser profiling of the road surface is the most common method used to collect roughness. It is a quick, reliable and repeatable method of collection as it uses a computer algorithm to determine the roughness.

Roughness is often used as an indication of the pavements overall condition, allowing asset managers to identify those sections that may require treatment. However, high roughness does not necessarily indicate a weak or failed pavement. Detailed investigation is required on roads with high roughness to identify the cause of this distress and therefore the most appropriate treatment.

Roughness is considered very important for high speed roads (such as regional and primary distributors), but generally of less importance to local roads with the speeds less than 70 km/h (such as local distributors and access roads). Austroads (2011b) and Martin (2005) recommend the following investigation levels for roughness for roads with the following speed limits:

- highways with 100 km/h speed limit – 4.2 IRI or 110 counts/km
- main roads with speed limit of 80 km/h – 5.3 IRI or 140 counts/km
- local roads with speed limit of 50-60 km/h – 6.5 IRI or 170 counts/km, however, with local roads, traffic calming measures need to be taken into account such as speed humps and roundabouts when assessing the reported roughness.

Databases generally have provision for roughness data to be stored (including recording data for several years of history) and used in planning of maintenance and renewal strategies.

1.5.3 Surface friction (skid resistance)

Surface friction, or skid resistance, indicates the ability of the road surface to provide sufficient friction to avoid skid related safety problems.

It is generally considered a separate measure of surface condition and often can be used to determine the need for remedial maintenance by itself. It is not common to measure skid resistance on local roads and measurement is usually undertaken on a project basis.

There are numerous pieces of equipment that are currently used by road authorities to measure skid resistance. All of the equipment applies essentially the same principle, where a rubber slider or tyre is forced to slide across a wetted road surface under an applied load and the horizontal friction force is then measured. However, the different pieces of equipment produce different outputs and are used for different applications. For example for network level tests the most common equipment used is SCRIM, while portable apparatus such as British Pendulums are more suited for project level investigations.

1.5.4 Visual Surface Defects

Visual surface defects are the primary parameters that asset managers rely on to determine the overall performance of the network and to plan maintenance or renewal activities. This manual is designed to ensure a consistent methodology is applied to visual surface defect data collection and reporting across Western Australian local government road networks. The scope of the manual incorporates:

- Sealed pavements:
  - Local surface defects – indicates surfacing nearing end of its useful life and also creates hazards to road users
  - Pavement undulations – areas within a pavement with elevations lower or higher than the surrounding area resulting in long wave and/or irregular depressions often a result of poor compaction control.
  - Patching – excessive patching can cause loss of texture and indicates that the seal is nearing the end of its useful life
  - Potholes – potholes present a safety hazard and could indicate the onset of more severe pavement failures through increased water ingress
  - Rutting – can indicate a local material failure or a potential issue with the pavement's structural condition
  - Cracking – indicates a loss of waterproofing and other deficiencies
  - Surface deficiencies – ravelling, flushing and polishing are indicators of various deficiencies in the surface layer
  - Edge break – mainly relevant for rural roads presenting as a safety concern and increasing the rate of overall pavement deterioration
  - Kerb defects – affect drainage and are often repaired in conjunction with surfacing works
  - Unsealed shoulders – affects road safety and can increase rate of overall pavement deterioration
  - Table drains – affects the drainage of water runoff from the road surface.
- Unsealed pavements:
  - Unsealed surface condition – measures the overall surface condition of unsealed roads
  - Unsealed shape – indicates a measure of the cross fall of unsealed pavements, affects surface drainage and vehicle dynamics
  - Depth of base – loss of pavement depth reduces its strength and durability.
- Paths condition

The following sections provide a detailed description, the possible causes and the collection method for each of the distress modes shown above. The structure of the manual is in line with the previous ROMAN data collection manual, Austroads Guide to Asset Management Part 5 (Austroads 2011) series for pavement performance and Austroads Guide to Pavement Evaluation and Treatment Design (Austroads 2009).

2. LOCAL SURFACE DEFECTS EXTENT

Local Surface defects are characterised by localised failures, those that do not occur consistently over the length of the road but rather occur at discrete locations, which typically manifest as surface breakdown.

Defects typically consist of temporary or unsuccessful patches, localised shoving, localised rutting or cracking, localised corrugations and depressions or any other surface defects that can contribute to surface and pavement failure. Defects considered in this manual are outlined in the following sections.

2.1 Failed patches

2.1.1 Description

Failed patches are areas of the road surface where the original seal has been replaced; this can be due to repair or reinstatement following service alterations or a localised pavement failure. Patches may include expedient patches, where the surface has been repaired without 'dig out' or reconstruction of the patched area. Unsuccessful patches are those where there is a level difference across any dimension of the patch between the patch and the pre-existing adjacent surface. Unsuccessful patches also include those where the patch has cracked or fatigued again.

2.1.2 Possible causes

- Incorrect preparation of the pavement and seal prior to patching
- Structural deficiencies in the material used to construct the patch
- Poor construction control.

2.2 Localised rutting or cracking

2.2.1 Description

- Localised rutting or cracking are surface defects that cannot be categorised into the normal rutting or cracking defects.

2.2.2 Possible causes

- Local weak patch due to poor sub-soil drainage or leaking pipes
- Unsuccessful patch or successful patch with wear and tear
- Isolated area of inadequate pavement thickness or compaction
- Isolated area of poor subgrade
- Isolated load on substandard material.

2.3 Pavement Deformation

Localised pavement deformations are areas within a pavement with elevations lower or higher than the surrounding area that will contribute to short wave roughness. They should not be confused with structural pavement failures resulting from the trafficking of weak pavements and usually relate to differential settlement at culverts, bridge abutments, embankment slumping, tree root subsidence or uplift and soft spots in the subgrade. These deformations are not generally confined to the wheel paths.

2.3.1 Possible causes

- Settlement of service and widening trenches
- Settlement or uplift due to embankment instability
- Consolidation of isolated areas of soft or poorly compacted subgrade, these are common at bridge approaches
- Volume change of subgrade materials due to environmental influences, such as change in moisture contents of expansive soils
- Tree root uplift or subsidence due to moisture changes or root growth.

2.4 Localised shoving and corrugations

2.4.1 Description:

Localised shoving, corrugations or transverse shoving usually takes the form of fairly regular waviness closely and regularly spaced, with wavelengths less than two metres. This is seen as ridges and troughs of the waves in areas of braking, acceleration or cornering.

2.4.2 Possible causes

- Poor bond between pavement layers
- Reinstatements following excavations for services
- Braking or accelerating of turning and stopping vehicles
- Inadequate stability of asphalt layers
- Invading roots.

2.5 Method of measurement

The rating of surface defects is expressed as the percentage of the area of the surface defects in the total area of the treatment length.

Visual identification of the dimensions should be straight forward; however, use of a string line may be necessary for larger areas.

1) Determine the area of the treatment length by multiplying the treatment length's length by the average width. In a visual condition assessment the same treatment length is utilised for all criteria.
2) Determine the area affected by surface defects within the treatment length area.
3) Express the affected area as a percentage of the total treatment length area.
4) Assign a rating according to the table below.

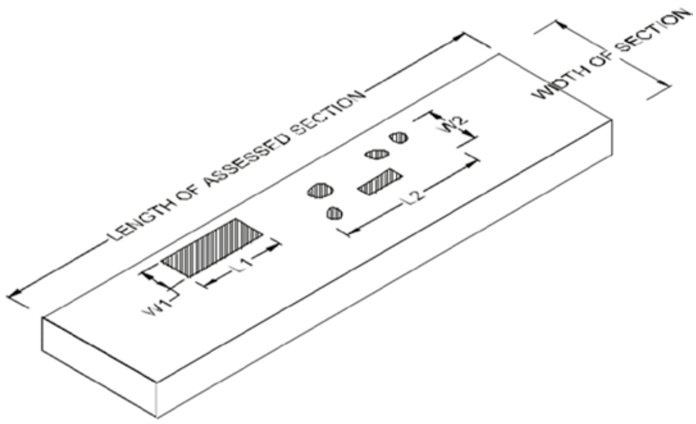


Figure 2.1: Measuring local surface defects extents

Table 2.1: Local surface defect measurements

	Rating
Not Applicable	0
No area affected	1
0% < area affected < 5%	2
5% < area affected < 10%	3
10% < area affected < 20%	4

20% < area affected	5

2.6 Examples of surface defects

Localised shoving

Localised shoving

Localised cracking

Poor trench repair

Unsuccessful patch

Poor patch repair

Failure at edge of seal and channel

Subsidence of pavers

Poor water channel construction

Tree root causing up-heave

3. PAVEMENT UNDULATIONS

Pavement undulations are areas within a pavement with elevations lower or higher than the surrounding area that will contribute to long wave and/or irregular depressions and uplift; they may be isolated or extensive and in some cases be present over the entire treatment length. They should not be confused with structural pavement failures resulting from the trafficking of weak pavements and usually relate to differential settlement within the subgrade. These deformations are not generally confined to the wheel paths.

Defects typically consist of long wave undulations providing a ride similar to a boat travelling on a wavy sea and irregular depressions and uplift resulting in sections of roughness. Defects considered in this manual are outlined in the following sections.

Table 3.1 is a guide to the degree of pavement undulations as they relate to ride quality, this also relates to the degree of hazard the undulations presents. Being a visual assessment, there is the likelihood of high speed roughness data not being collected on the network being rated.

Table 3.1: Description of the degree of undulation

Degree	Description
1	Undulation causes slight unevenness, ride is still comfortable at the posted speed.
3	Undulation is noticeably visible and has an effect on ride quality. Motorists may have to reduce speed.
5	Ride very poor and very uncomfortable. Road unsafe at the posted speed. Hazard signs and temporary speed limits required.

3.1 Long Wave Undulations

3.1.1 Description

Long wave undulations develop on roads built over swamp or peat and usually develop deep in the subgrade. During initial road construction, if the underlying organic material has not been sufficiently compressed to squeeze out the water surrounding the organic material deep in the subgrade, over time, the traffic reshapes the pavement and subgrade into long wave roughness.

3.1.2 Possible causes

- Incorrect preparation of the subgrade using wick drains and preload to compress and drain void spaces surrounding organic material
- Poor construction control during grading.

3.2 Irregular Depressions and Uplift

3.2.1 Description

Irregular depressions and uplift develop within the pavement layers or the upper subgrade and are characterised by depressions randomly located throughout the treatment length. If testing and treatment of subgrade soft spots is inadequate during construction these will develop into depressions over time. Another cause can be the slumping and uplift due to geological changes in the underlying land.

3.2.2 Possible causes

Areas of inadequate pavement thickness or compaction

- Areas of poor subgrade
- Poor construction control
- Movements in the surrounding land, slumping and uplift including subsiding banks
- Tree root uplift or subsidence due to moisture changes or root growth.

3.3 Method of measurement

The rating of pavement undulations is expressed as the percentage of the area affected by the undulations in the total area of the treatment length.

Where the defect is pavement undulations, the boundaries of the deformation is determined by assessing the point where the surface departs abruptly from the general surface in the form of a bump or large irregular grade change to the point where the surface returns to regular again in the same manner, this includes all the variations and undulations in between these points.

Visual identification of the dimensions should be straight forward; however, use of a string line may be necessary for larger areas.

1) Determine the area of the treatment length by multiplying the treatment length's length by the average width. In a visual condition assessment the same treatment length is utilised for all criteria.
2) Determine the area affected by surface defects within the treatment length area.
3) Express the affected area as a percentage of the total treatment length area.
4) Assign a rating according to the following table.

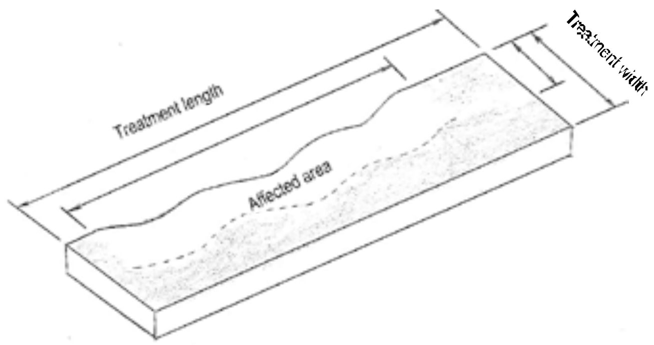


Figure 3.1: Measuring pavement undulation defect extents

Table 3.2: Pavement undulation defect measurements

	Rating
Not Applicable	0
No area affected	1
0% < area affected < 15%	2
15% < area affected < 30%	3
30% < area affected < 60%	4
60% < area affected	5

3.4 Examples of pavement undulations

Long Wave

Irregular Depressions

4. PATCHES EXTENT

4.1 Description

Patches are defined as areas where the original surfacing has been successfully replaced. The patched area provides a surface area similar to the surrounding area and a waterproof seal to prevent the ingress of water to the pavement layers. Patches can be expedient patches, which are identified as irregularly sided (typically small) patches usually less than a few square metres in area, or reconstruction patches that are typically straight sided and of regular shape.

4.2 Possible causes

- Correction of surface deficiencies or failures
- Correction of structural deficiencies or failures
- Reinstatements following excavations for services
- Poor construction control (inadequate compaction in base or surfacing).

4.3 Method of measurement

The rating of patching extent is expressed as the percentage of the area of the patching extent in the total area of the treatment length.

1) Determine the area of the treatment length by multiplying the treatment length's length by the average width. In a visual condition assessment the same treatment length is utilised for all criteria.
2) Determine the area affected by local surface defects within the treatment length area.
3) Express the affected area as a percentage of the total treatment length area.
4) Assign a rating according to the following table.

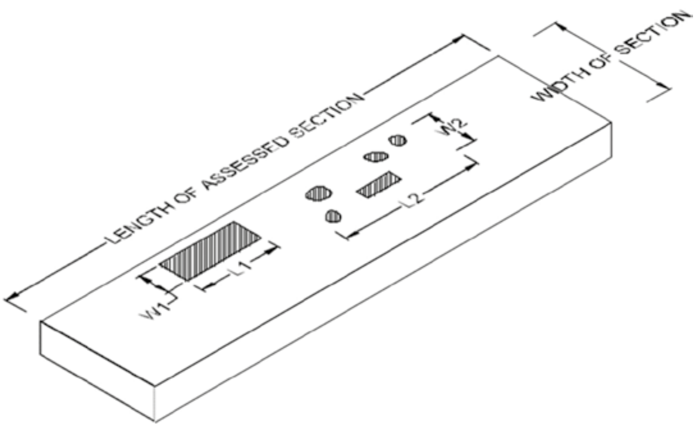


Figure 4.1: Measuring local surface defects extents

Table 4.1: Local surface defect measurements

	Rating
Not Applicable	0
No area affected	1
0% < area affected < 5%	2
5% < area affected < 10%	3
10% < area affected < 20%	4
20% < area affected	5

4.4 Examples of patches extent

No area affected

10% < area affected < 20%

0% < area affected < 5%

20% < area affected

5% < area affected < 10%

5. POTHOLES EXTENT

5.1 Description

A pothole is a hole in the road surfacing, frequently rounded in shape, resulting from the loss of surfacing material under traffic.

Potholes are often created through the interaction between water and traffic. Inadequate drainage alongside the road shoulder can result in water entering the underlying pavement structure during prolonged periods of rain. This weakens the pavement structure resulting in fatigue failure, or cracking, due to the movement of the pavement under vehicular loading. These cracks in the pavement surface thereby provide another entry for water and exacerbate the weakening of the pavement sub-layers.

In the case of roads with heavy traffic, water that has entered through the surface itself can generate potholes. The incompressible water residing within the confines of the voids inside base layers can develop extremely high pressures and velocity under heavy traffic, causing parts of the surfacing to blow out.

Potholes can also form on roads where ravelling or stripping of the surface has occurred. This results in the base layer being exposed, instigating the formation of a pothole. Other reasons for pothole formation include surface defects left untreated, for example excessive cracking, failed patches and rutting.

5.2 Possible causes

- Inadequate road drainage
- Structural deficiencies in the pavement material
- Poor construction control (inadequate compaction in subgrade or poor surface application)
- Inadequate pavement strength
- Inadequate maintenance.

5.3 Method of measurement

The rating of potholes extent is expressed as the percentage of the area of the potholes extent in the total area of the treatment length.

1) Determine the area of the treatment length by multiplying the treatment length's length by the average width. In a visual condition assessment the same treatment length is utilised for all criteria.
2) Determine the area affected by local surface defects within the treatment length area.
3) Express the affected area as a percentage of the total treatment length area.
4) Assign a rating according to the following table.

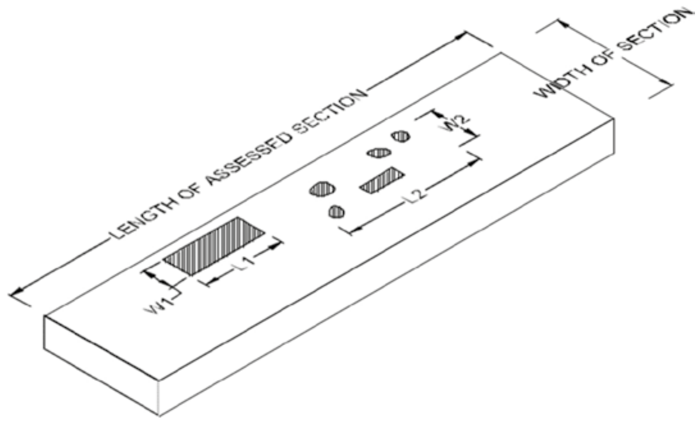


Figure 5.1: Measuring local surface defects extents

Table 5.1: Local surface defect measurements

	Rating
Not Applicable	0
No area affected	1
0% < area affected < 5%	2
5% < area affected < 10%	3
10% < area affected < 20%	4
20% < area affected	5

5.4 Examples of pothole extent

< 5% area affected

< 20% area affected

> 20% area affected

6. RUTTING

6.1 Description

Rutting takes the form of depressions along the wheel paths visible on the road surface. Usually the length of a rut is at least 4 times longer than the width of the rut. Sometimes rutting is also accompanied by a bulging of the road surface adjacent to the rut.

Rutting is common in pavements that are not thick enough to take the loads imposed by the traffic using them and is caused by the densification of one or more pavement layers. This may be due to insufficient subgrade cover or the pavement materials inability to support the traffic load.

6.2 Possible causes

- Inadequate pavement thickness for subgrade material in thin asphalt granular pavements
- Structural deficiencies in the pavement material
- Poor construction control (inadequate compaction in subgrade or poor surface application).

6.3 Method of measurement

To measure rutting it is necessary to record the following information:

- maximum depth under a straight edge placed across the rut
- length of the road surface affected by rutting.

Rutting is assessed by considering the same treatment lengths utilised throughout the visual condition assessment. The treatment length is to represent the typical rutting pattern for the section of road being considered and includes all carriageways.

Measurements are taken at regular intervals along the outer wheel path of each lane. Measurements are based on the depth of rut when measured from a 1.2 metre long straight edge.

Determination of the distress due to rutting is based on these measurements and is calculated as below.

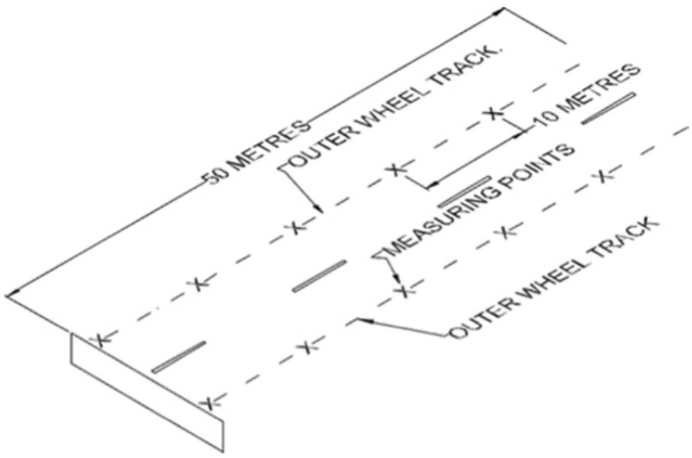


Figure 6.1: Measuring rutting extents

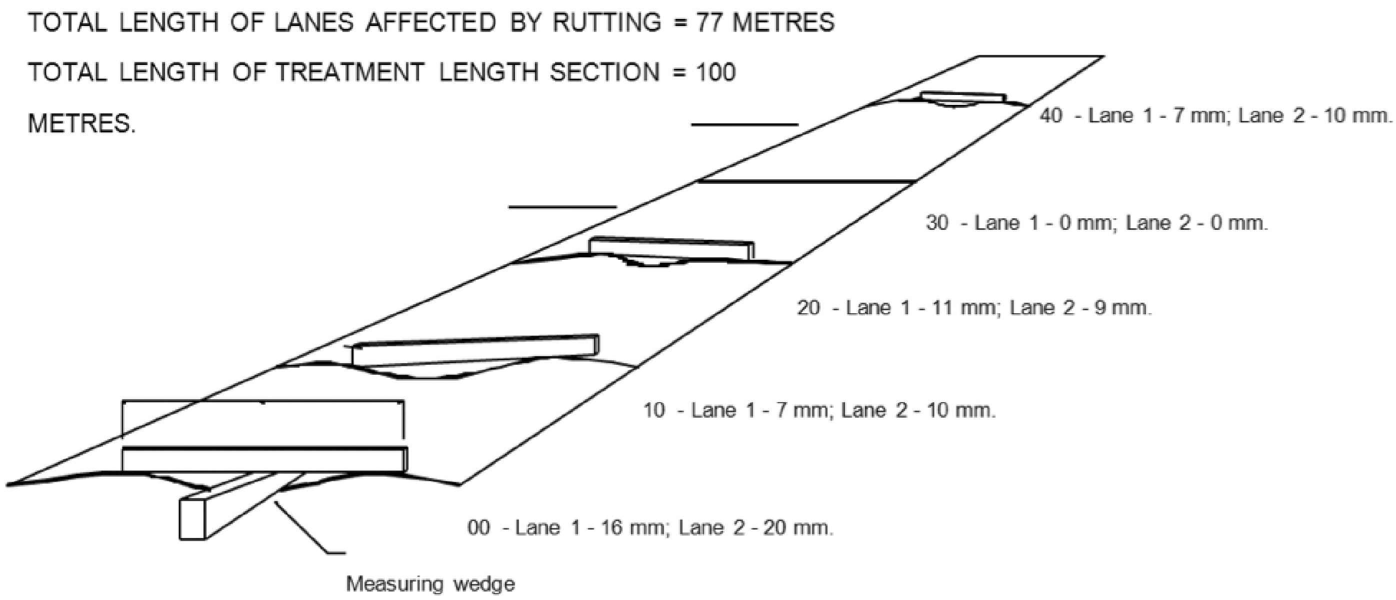


Figure 6.2: Example of determining severity and extent

6.3.1 Rutting severity

Severity is determined by measuring the depth of rutting along the same treatment length utilised in the visual assessment and assessing the average depth of ruts. To measure severity:

1) At regular intervals in each lane measure the rutting by placing a 1.2 metre long straight edge across the rut and measuring the depth of the rut. A graduated measuring wedge may assist in the accurate and speedy measurement of depth.
2) From the results, determine average rut depth as is shown in the example on the following page.

Table 6.1: Example of average rut depth calculation

Lane 1 distance	Rut depth (>5mm)	Lane 2 distance	Rut depth (>5 mm)
00	16	00	20
10	7	10	10
20	11	20	9
30	0	30	0
40	7	40	10
Sum of all lane rut depths		90	
Sum of all lane rut depths divided by 10 (=Average rut depth).		9 – Rate 2	

3) Determine the severity rating according to the scale below.

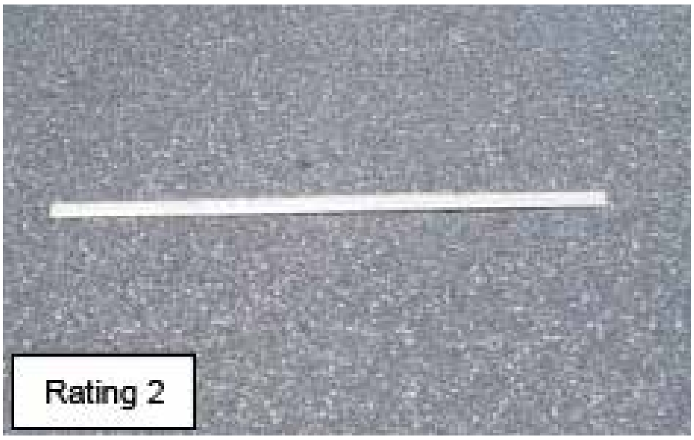
Table 6.2: Rutting severity measurements

	Rating
Not Applicable	0
No area affected (Average depth < 5mm)	1
Slight Rutting (Average depth 5-10 mm)	2
Moderate Rutting (Average depth 10-20 mm)	3
Heavy Rutting (Average depth 20-30 mm)	4
Extreme Rutting (Average depth > 30 mm)	5

6.4 Examples of rutting severity

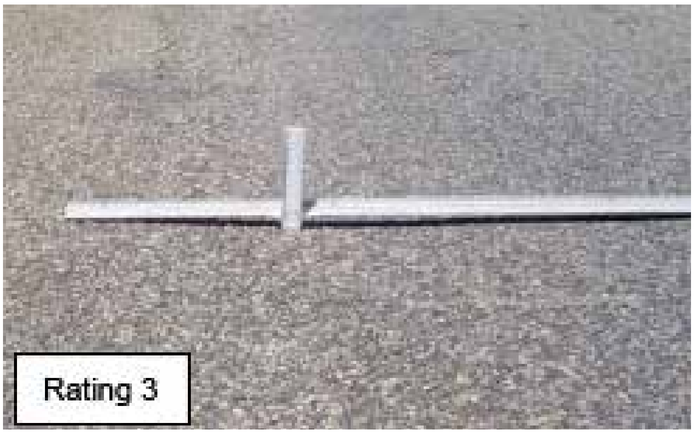
None of the are affected (depth > 30mm.)

Heavy rutting (average depth 20 - 30 mm.)



Slight rutting (average depth < 10 mm.)

Extreme rutting (average depth > 30 mm.)



Moderate rutting (average depth 10-20 mm.)

7. CRACKING

Cracking results from the partial or complete fracture of the surfacing and can happen in a wide variety of patterns.

Cracking can detrimentally affect roads in the following ways:

- Loss of waterproofing
- Loss of load spreading ability (where the surfacing is asphalt).

Loss of fines from the pavement base layers by 'pumping'. Factors that may contribute to cracking include:

- deformation
- age of the surfacing
- reflection of movements in the pavement
- shrinkage
- poor construction joints.

Crack patterns either alone or together with deformation are useful in assessing the likely causes of surface distress. Cracking generally takes the various forms shown in Figure 7.1.

7.1 Types of cracking and possible causes

Cracking is split into two types:

Structural – structural cracking are traffic load induced and indicates a failure in one of more layers in the pavement structure. For asphalt flexible pavements, structural cracks normally occur in the vicinity of the wheel paths, initially showing up as longitudinal cracking and often developing into crocodile cracks.

Non-structural – cracking that occurs without traffic loading, it is mainly due to environmental effects such as changes in moisture, expansive subgrades, and oxidation of the seal or reflection cracking through shrinkage cracks in stabilised pavement layers. There may be no immediate loss of structural strength or surface shape , although the longer term consequences of environmental cracking, if left untreated, can often lead to pavement failure.

All types of cracks whether they are structural or environmental should be treated with caution as a cracked surface diminishes water proofing for the layers below. Moisture ingress into the base and sub-base layers could result in the loss of fines through erosion or pumping, where traffic loading or movement in wet pavements can create a pumping action due to build-up of pore pressure from the moisture, pumping fine materials from the base layers up through the cracks. Loss of fines reduces the strength of pavement through a reduction in density of the material.

The following sections describe the different types of cracks, which category they belong to and possible causes.

7.1.1 Crocodile cracking (structural)

Easily identified by its resemblance to a crocodile's skin, this form of cracking is typically found running along the wheel-paths. Cell sizes are generally less than 150 millimetres across but may extend up to 300 millimetres. In early stages, crocodile cracks often start as longitudinal cracks within the wheel path, before developing into two parallel cracks prior to crocodile cracking. Possible causes of crocodile cracking may be:

- inadequate pavement thickness
- brittle base or wearing course
- fatigue cracking due to the wearing course becoming brittle
- insufficient stiffness (elastic modulus) of the base material
- asphalt fatigue.

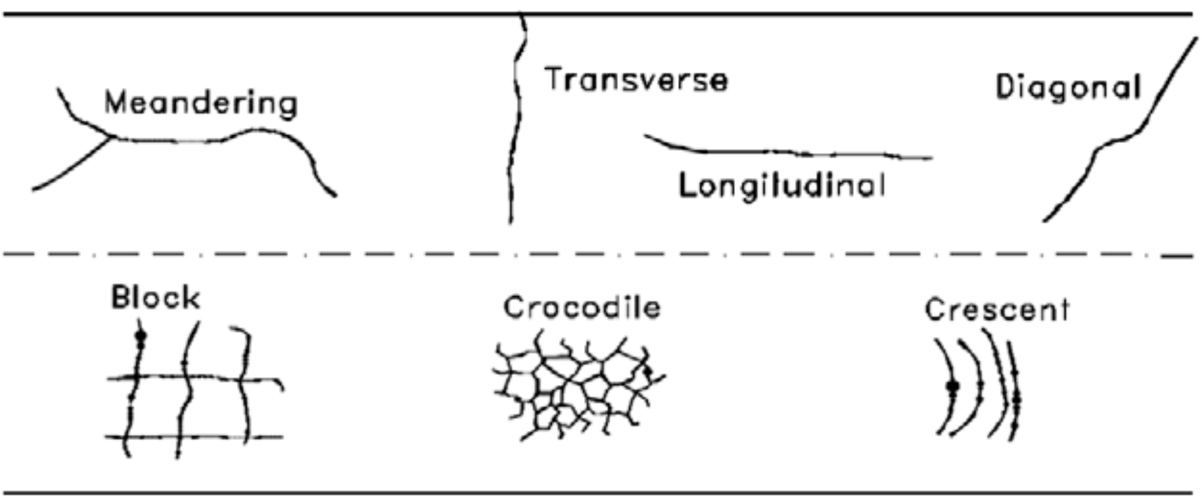


Figure 7.1: Crack types

7.1.2 Block cracks (non-structural)

Block cracks are a series of interconnected cracks forming an approximately rectangular pattern. Usually block cracking is distributed over the entirety of the road surface with cell sizes typically between 200 millimetres and 300 millimetres in length, though sides of up to 1000 millimetres in length is also possible. Block cracking is caused by:

- shrinkage and fatigue of underlying pavement materials.

7.1.3 Crescent cracks (non-structural)

Crescent cracks are identifiable by their half-moon or crescent shape and commonly associated with shoving. This type of cracking is usually found in asphalt surfaces. Possible causes are:

- poor bond between the wearing course and pavement
- thin wearing course
- high stresses due to braking, accelerating and cornering
- poor construction practices on the road surface during low temperatures.

7.1.4 Diagonal cracking (non-structural)

This is typified by an unconnected crack which generally takes a diagonal line across the surface. The most common causes of diagonal cracks are:

- reflection of an underlying crack or joint in the pavement
- differential settlements in the pavement caused by tree roots.
- shrinkage cracks in asphalt due to changes in daily temperatures.

7.1.5 Longitudinal cracking (non-structural)

Longitudinal cracks run along the surface either singly or as a series of parallel cracks. The most common causes of longitudinal cracks are:

- reflection of a shrinkage crack in an underlying pavement
- poor construction techniques and joint details
- change in volume of a plastic pavement materials or subgrade
- differential settlement often associated with pavement widening.

7.1.6 Meandering crack (non-structural)

Meandering cracks are unconnected irregular cracks varying in direction and usually occurring singly. Possible causes of meandering cracking are:

- reflection of a shrinkage crack in an underlying pavement
- weakening of the pavement edge by the entry of water (this can also cause longitudinal cracking
- differential settlement
- tree roots.

7.1.7 Transverse cracks (non-structural)

These are unconnected cracks running transversely across the road surface. Possible causes are:

- reflection of a shrinkage crack in the underlying pavement
- construction joint.

The following table summarises the possible causes of cracking.

Table 7.1: Possible causes of cracking

	Possible causes									
Crack type	Reflection of cracks in the base course	Poor construction	Shrinkage in base course	Fatigue in wearing course and/or base course	Poor bond between wearing course and base course	Weak or plastic base course	Effect of braking and acceleration	Thin base course or wearing course	Differential settlements	Tree Roots
Structural:										
Crocodile cracks				✓		✓		✓		
Environmental:										
Block cracks	✓		✓	✓						
Crescent cracks					✓	✓	✓	✓		
Diagonal cracks	✓								✓	
Longitudinal cracks	✓	✓				✓			✓	
Transverse cracks	✓	✓							✓	
Meandering cracks		✓				✓			✓	✓

7.2 Method of measurement

Cracking is assessed over the same treatment length utilised in the visual assessment and includes all carriageways. Cracking is an isolated data type and does not include cracking around unsuccessful patches and potholes.

7.2.1 Severity of cracking

Severity is rated according to the average width of the cracks typically occurring in the assessment area and is applicable to both structural and non-structural cracking. To assess severity:

1) Measure the average crack width.
2) Record the severity rating according to the following scale.

Table 7.2: Crack severity measurements

	Rating
Not Applicable	0
No area affected	1
Slight - average crack width < 2mm wide	2
Moderate - average crack width 2mm - 4mm	3
Heavy - average crack width 4mm - 6mm	4
Extreme - average crack width >6mm	5

7.2.2 Crack extent

The crack extent is divided into two areas, namely structural and non-structural and both are determined by measuring the area of surfacing affected by cracking and expressing this as a percentage of the total area within the treatment length area.

The extent of cracking is determined as follows:

1) Determine area of treatment area by multiplying the treatment length by the average width. Note where a specific area is not easily identified (e.g. the lateral and longitudinal cracks below) the width is assumed to be 0.25 m either side of the crack. For example a 1 m longitudinal crack would have an area of 0.5 m2 (1 * (0.25+0.25)).
2) Measure the two different types of cracking (structural and non-structural) areas affected by multiplying the length by the width as shown in the diagram below.
3) Add all areas affected by cracking together and divide this by the treatment length area and separate them into the structural and non-structural types.

Express the area affected as a percentage and determine the extent rating the table below:

Table 7.3: Crack extent measurements

	Rating
Not Applicable	0
No area affected	1
0% < area affected < 5%	2
5% < area affected < 10%	3
10% < area affected < 20%	4
20% < area affected	5

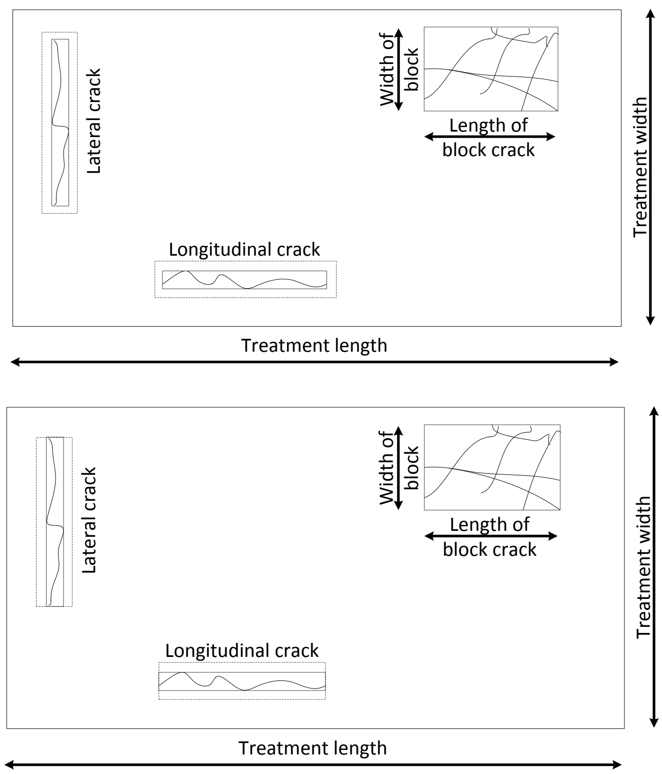


Figure 7.2: Measuring crack extent

7.2.3 Measuring sealed cracks severity and extent

If crack sealing is encountered during the rating process, it is recommended one of the following approaches is used:

- Crack sealing as part of preparatory works – if crack sealing forms part of a temporary preparatory works prior to a planned resurfacing treatment then a severity rating of 5 should be assigned and the extent of cracking is calculated as normal based on ratings from Table 7.3.
- Crack sealing as routine maintenance – If crack sealing is used as part of routine maintenance works to keep the pavement layers waterproofed with no immediate plans for resurfacing treatment then a severity rating of 1 would apply and the extent of cracking is calculated as normal based on ratings from Table 7.3.

7.3 Examples of crack extent

No area affected

0% < area affected < 5%

5% < area affected < 10%

10% < area affected < 20%

20% < area affected

8. SURFACE DEFICIENCIES (ASPHALT AND CHIP SEALS) EXTENT

Surface deficiencies are measured for both chip seal and asphalt surfaces. Surface deficiencies are usually identified by either loss of texture or loss of a portion of a seal layer.

8.1 Types of deficiencies

With chip seals, texture deficiencies usually involve loss of surface aggregate or flushing.

Asphalt surface deficiencies can include ravelling, flushing, polishing or delamination of the surface layer.

Surface deficiencies are typified by the following.

8.1.1 Delamination

Delamination consists of the loss of a large and discrete area of the wearing course or surfacing layer.

Delamination is usually caused by:

- inadequate bond between base and surfacing
- seepage of water which breaks the bond between base and surfacing
- weak, loose layer immediately underlying the seal.

8.1.2 Flushing

Flushing is the immersion, either partially or completely of aggregate into the bituminous binder.

Possible causes are:

- excessive application of binder
- penetration of aggregate into base course
- poor sealing techniques
- poor selection of asphalt type
- poor mix design.

8.1.3 Polishing

Polishing appears as a smoothing or rounding of the upper surface of the aggregate making it feel smooth to the touch.

Possible causes include:

- use of stone that is not hard enough to resist polishing by tyres
- use of naturally smooth aggregate
- excessive traffic environments.

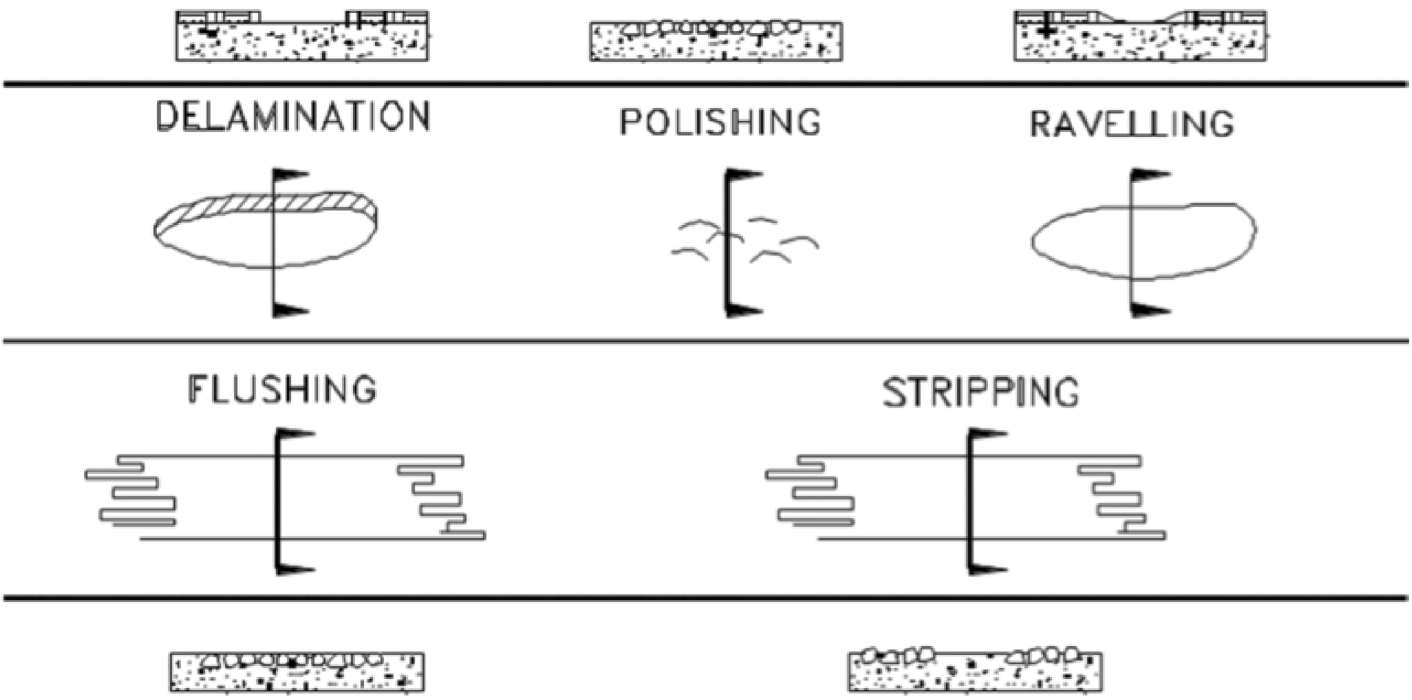


Figure 8.1: Measuring surface deficiencies

8.1.4 Ravelling

Ravelling occurs when the seal binder and aggregate is progressively eroded. In asphalt pavements this occurs from the surface down and hence it is referred to as ravelling. If it is not repaired the exposed pavement base layers can rapidly deteriorate.

Possible causes include:

- deterioration of binder and/or stone
- inferior asphalt mix design or manufacture
- inadequate compaction
- compaction below minimum temperature specifications
- excessive moisture exposure during construction.

8.1.5 Stripping

Stripping is the loss of bond between aggregates and binder causing the aggregates to become loose and able to be stripped off the seal. It is similar to ravelling however, for sprayed seals, the loss of bond occurs from the bottom up and hence it is referred to as stripping.

Possible causes are:

- low binder contents
- poor binder to stone adhesion
- incorrect blending of binder
- inadequate rolling
- excess moisture during construction
- sealing below minimum temperature specifications.

8.2 Method of measurement

To assess surface deficiencies it is usual to undertake an initial assessment from a slow moving vehicle over the full length of the treatment length being assessed. A representative area is then inspected more closely and the surface texture assessed for suitability.

The rating of surface deficiencies is expressed as the percentage of the area of the surface deficiencies in the total area of the treatment length.

1) Determine the area of the treatment length by multiplying the treatment length's length by the average width. In a visual condition assessment the same treatment length is utilised for all criteria.
2) Determine the area affected by local surface defects within the treatment length area.
3) Express the affected area as a percentage of the total treatment length area.
4) Assign a rating according to the following table.

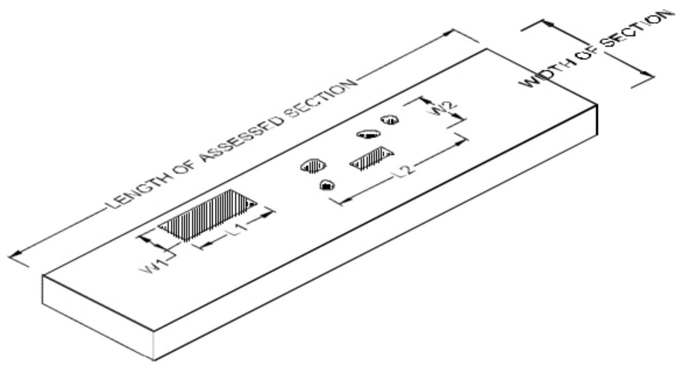


Figure 8.2: Measuring local surface defects extents

Table 8.1: Local surface defect measurements

	Rating
Not Applicable	0
No area affected	1
0% < area affected < 5%	2
5% < area affected < 10%	3
10% < area affected < 20%	4
20% < area affected	5

8.3 Examples of surface deficiency extent

No area affected

10% < area affected < 20%

0% < area affected < 5%

20% < area affected

5% < area affected < 10%

9. EDGE BREAK

9.1 Description

Edge break often occurs in association with edge drop off along the interface between a bituminous surface and an unsealed shoulder. The detrimental effects of edge breaks can include:

- reduction of shoulder and/or seal width
- loss of ride quality
- potential hazard to road users
- channelling of water with subsequent shoulder erosion
- water entry into base course.

9.2 Possible causes

- inadequate seal width or alignment that encourages drivers to travel on the seal edge
- inadequate edge support
- weak seal coat, loss of adhesion to base course
- lack of shoulder maintenance.

9.3 Method of measurement

When assessing edge break the average defect index of the full length of the treatment length being assessed is the basis for rating. In order to assess edge break, two aspects are considered.

1) Severity
2) Extent

9.3.1 Edge break severity

Severity is rated according to the average edge break width (mm) occurring in the assessment area, to assess severity:

1) Inspect the seal edge within the treatment length to determine edge break width. Edge break width is the distance between the seal edge and the width of break (Figure 9.1 and Figure 9.2).
2) Determine the average edge break width.
3) Record the severity rating according to the following scale.

Table 9.1: Edge break severity measurements

		Rating
Not Applicable		0
No edge break over 20 mm		1
Slight	average edge break between 20 mm and 75 mm.	2
Moderate	average edge break between 75 mm and 150 mm	3
High	average edge break between 150 mm and 250 mm	4
Extreme	average edge break greater than 250 mm	5

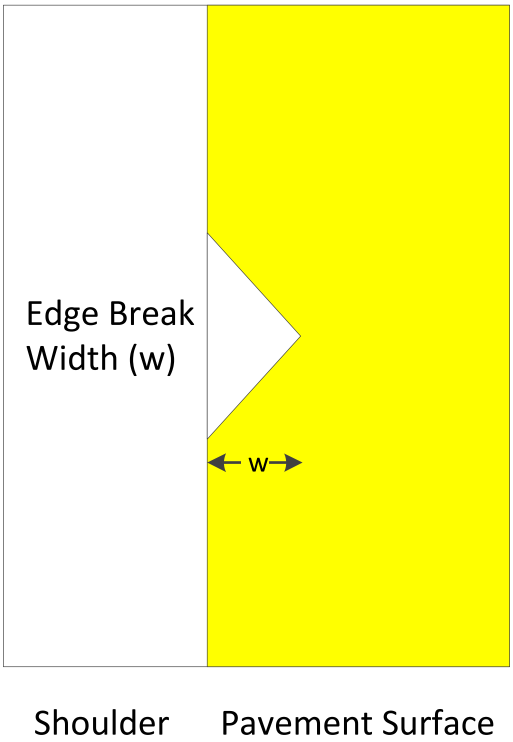


Figure 9.1: Illustration of edge break width measurement

Figure 9.2: Photos of onsite edge break width measurement

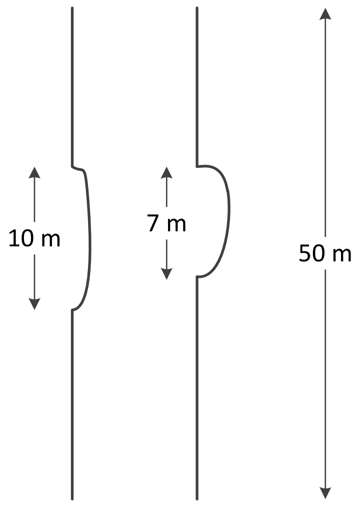
9.3.2 Edge break extent

Edge break extent is the measure of the length of the seal edge displaying edge break of greater than 20 mm on both sides of the seal, expressed as a percentage of the total length of the treatment length. Edge break is rated by:

1) Measure the length of the treatment length affected by edge breaks greater than 20 mm (on both sides of the seal).
2) Divide this length by the treatment length multiplied by 2 (as you are measuring both sides) and express as a percentage.
3) Determine the extent rating from the following scale.

Table 9.2: Edge break extent rating scale

	Rating
Not Applicable	0
No area affected	1
0% < length affected < 5%	2
5% < length affected < 10%	3
10% < length affected < 20%	4
20% < length affected	5



Length	50 m
Edge defects	17 m
Calculation	17/(50*2)*100
	17%
Rating	4

Figure 9.3: Measurement example

10. EDGE DROP OFF

10.1 Description

Edge drop off often occurs in association with edge break along the interface between a bituminous surface and an unsealed shoulder. Edge drop offs are characterised as the difference in the height of the sealed surface and the shoulder. Detrimental effects of edge drop offs can include:

- loss of ride quality
- potential safety hazard to road users
- sudden drop offs can cause truck roll overs or loss of control of vehicles.

10.2 Possible causes

- inadequate pavement width
- shoulder material with inadequate resistance to erosion and abrasion
- Resurfacing of pavement without resurfacing of shoulder creating a height differential.

10.3 Method of measurement

When assessing edge drop off, the average defect index of the full length of the treatment length being assessed is the basis for rating. In order to assess edge drop off, two aspects are considered.

1) Severity
2) Extent, which is a measure of the length of the edge displaying edge drop offs with height greater than 15 mm. expressed as a percentage of the total length of edge in the treatment length, i.e. both sides.

10.3.1 Edge drop off severity

Severity is rated according to the average edge drop off height (mm) occurring in the assessment area.
To assess severity:

1) Inspect the seal edge within the treatment length to determine edge drop off height. Edge drop off height is the distance between the surface of the seal and surface of the shoulder (Figure 10.1 and Figure 10.2).
2) Determine the average edge drop off height.
3) Record the severity rating according to the following scale.

Table 10.1: Edge drop off severity measurements

		Rating
Not Applicable		0
No edge break over 15 mm		1
Slight	average edge drop off, 15 mm – 30 mm	2
Moderate	average edge drop off, 30 mm – 50 mm	3
High	average edge drop off, 50 mm – 75 mm	4
Extreme	average edge drop off > 75 mm	5

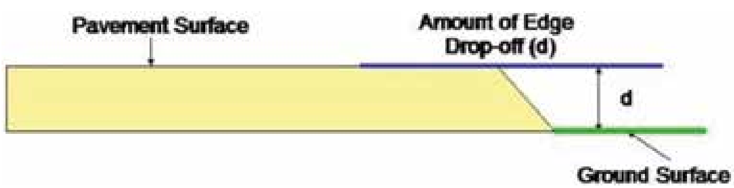


Figure 10.1: Illustration of edge drop-off height measurement

Figure 10.2: Photo of edge drop off height measurement

10.3.2 Edge drop off extent

Edge drop off extent is the measure of the length of the seal edge and shoulder interface displaying edge drop off of greater than 15 mm on both sides of the road, expressed as a percentage of the total length of the treatment length, i.e. both sides of the treatment length. Edge drop off is rated by:

1) Measure the length affected by edge drop off greater than 15 mm (on both sides of the road).
2) Divide this length by the treatment length multiplied by 2 (as you are measuring both sides) and express as a percentage.
3) Determine the extent rating from the following scale.

Table 10.2: Edge drop off extent rating scale

	Rating
Not Applicable	0
No area affected	1
0% < area affected < 5%	2
5% < area affected < 10%	3
10% < area affected < 20%	4
20% < area affected	5

11. KERB DEFECTS

11.1 Description

Kerbing is placed to provide an edge restraint for the pavement or more commonly to control stormwater flows longitudinally along the road. The detrimental effects of kerbing defects can include:

- drainage scour and damage where kerbing is too low to control flows
- damage to vehicles where kerbing is misaligned or protrudes into the carriageway
- potential hazard to road users, particularly cyclists where kerbing protrudes into the carriageway area.

11.2 Possible causes of kerb defects

Damaged kerbing may be attributable to:

- inadequate keying to the underlying pavement
- inadequate provision of expansion joints
- vehicles driving over the kerbing (particularly in new subdivisions where construction activities are high)
- damage by service authorities
- Inadequate kerb height can be attributable to:
  - repeated asphalt surfacing
  - incorrect kerb height constructed.

11.3 Method of measurement

11.3.1 Kerb defect severity

Kerb defect severity is rated on two criteria.

1) Severity of kerb defects.
2) Height of kerb.

Kerb defect severity is measured as whether a section of kerb achieves the purpose of the kerb which includes;

- protect the road edge
- assist drainage
- reduce maintenance of shoulders
- improve delineation of traffic flow
- protect pedestrians.

A kerb does not need to be new or without fault to achieve its design outcome. Kerb defects can include a number of defects such as being cracked and segmented lengths of kerbing possessing misaligned kerbing. A rating of 1 means that there are no or minimal kerb defects visible impacting the intended design or function while a 5 represents an unacceptable level of defects.

Table 11.1: Kerb defect severity measurements

	Rating
Not Applicable	0
Adequate, no or minimal impact on function	1
Slight impact on function	2
Moderate impact on function	3
High impact on function	4
Inadequate, unacceptable impact on function	5

11.3.2 Examples of kerb defect severity

Adequate

Inadequate

11.3.3 Kerb height

Kerb height is generally rated as adequate or inadequate depending on the height of the kerb above the road surface. In most circumstances an inadequate kerb height is defined as a kerb height of less than original design parameters. For example high rainfall areas may require kerb heights >100 mm while in areas with little rainfall the design height could be 50 mm.

In assessing kerb height for adequacy, consideration should be given to the effectiveness of the kerbing in controlling stormwater runoff. If stormwater control is effective with kerbing lower than the design parameter the rating may be adjusted to reflect this.

Table 11.2: Kerb height measurements

	Rating
Not Applicable	0
Adequate, no or minimal impact on function	1
Slight impact on function	2
Moderate impact on function	3
High impact on function	4
Inadequate, unacceptable impact on function	5

11.3.4 Measuring kerb height

Kerb height should be measured as the difference between the top of the kerb to the surface level. Dropped kerbs can be measured to the top of the ramped area with reference to the edge of the road.

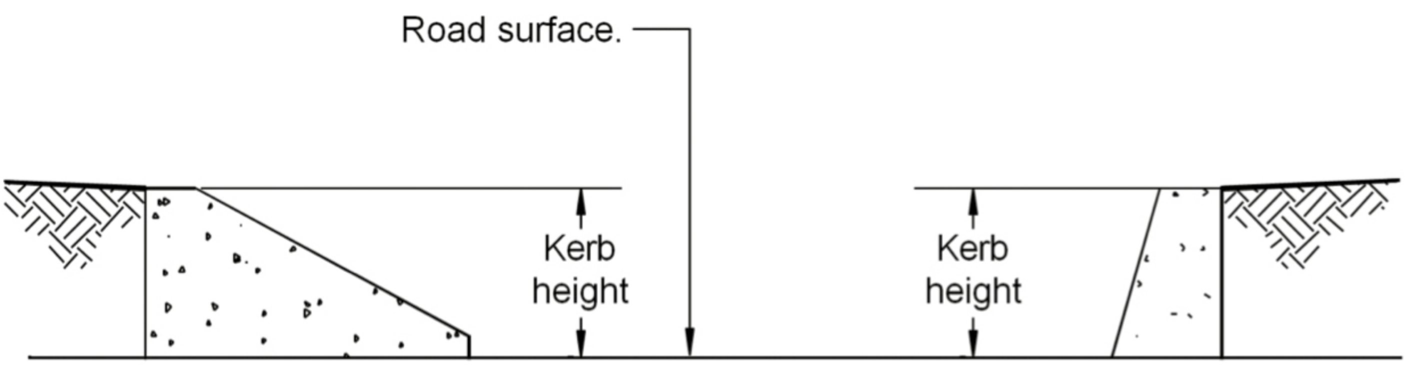


Figure 11.1: Measuring kerb height

11.3.5 Extent of kerb defects

The extent of kerb with unacceptable amount of defects or inadequate height is determined by measuring the total length of inadequate kerb on both sides of the treatment length and expressing this as a percentage of the total treatment length surveyed, i.e. both sides of the treatment length.

1) Measure the length of inadequate kerb within the treatment length (on both sides).
2) Divide this length by the treatment length multiplied by 2 (if you are measuring both sides) and express as a percentage.
3) Determine the extent rating from the following scale.

Table 11.3: Kerb condition extent measurements

	Rating
Not Applicable	0
No area affected	1
0% < area affected < 5%	2
5% < area affected < 10%	3
10% < area affected < 20%	4
20% < area affected	5

12. UNSEALED SHOULDERS

12.1 Description

Unsealed shoulders provide a hard standing area where vehicles can safely run off the sealed surface. Unsealed shoulders need to be maintained to ensure a safe and trafficable condition. Unsealed shoulder defects include:

- excessive cross fall
- rutting
- undulation
- soft or boggy shoulders.

Unsealed shoulders also provide drainage laterally from the sealed surface of a road to longitudinal table drains or to drainage structures. Unsatisfactory condition on unsealed shoulders is potentially hazardous to road users and may restrict drainage.

Typically unsealed shoulders are constructed between 1.2 and 1.5 metres wide, however they can be narrower depending on the location and classification of the road.

12.2 Possible causes

- lack of maintenance
- poor maintenance practices
- unsuitable material used to construct shoulder
- poor construction
- poor geometric design.

12.3 Method of measurement

When assessing unsealed shoulders it is important to ensure that assessment does not include areas outside of where the shoulder construction terminates. Typically the shoulder area is between and 1.5 metres on most major rural roads, but may be as little as 0.6 m on other roads. When assessing unsealed shoulder condition the following process is undertaken:

1) Identify the shoulder width and ensure that assessment does not extend outside this area.
2) Inspect the total length of the unsealed shoulder on both road edges over the length.
3) Determine the average condition of the shoulder and compare it to the rating guide below.
4) Apply appropriate rating score.

12.4 Characteristics and example of unsealed shoulder condition

Excellent

- The cross fall is adequate for drainage and is typically >1% of the sealed carriageway cross fall.
- The surface is well bound, compact and minimal loose gravel is present.
- No scouring is apparent.
- No vegetation is on the shoulder area.

Good

- Cross fall is adequate to allow unrestricted drainage across the shoulder.
- Minor scouring is evident
- No vegetation is on the shoulder area.

Average

- Slight restriction to drainage flow.
- Scouring present with depth between 25 & 40mm Unconsolidated soft patches <10 % of area.
- Loose stones (14 mm) present >30% of the area.

Very Poor

- Major restriction to drainage flow.
- Scouring present >80 mm deep.
- Unconsolidated soft patches >50 % of the area. Cross fall severely steep, flat towards road

Poor

- Moderate restriction to drainage flow across the shoulder.
- Scouring present, with depth 40 to 80 mm.
- Unconsolidated soft patches between 10 to 50% of area.
- Loose stones present between 30 and 50% of the area.
- Cross fall too steep or flat.

13. TABLE DRAINS

13.1 Description

Table drains provide longitudinal drainage along road edges and allow stormwater runoff from the sealed area and shoulders to be collected and disposed of.

Table drains may have a number of profiles depending on the situation in which they occur and may range from shallow "V" drains to deep and well-formed channels.

13.2 Possible causes of table drain inadequacy

- lack of maintenance
- excess runoff or high velocity runoff
- unsuitable material used to construct the table drain
- sedimentation
- partial restriction caused by vehicles crossing
- poor geometric design.

13.3 Method of measurement

When assessing table drains, the table drains on either side of the road are inspected along the length of the treatment length. The condition score for the treatment length is based on the average or typical condition for the table drain over the entire treatment length assessed. When assessing table drains:

1) Inspect the total length of the table drain on both road edges over the treatment length.
2) Determine the average condition of the table drain and compare it to the rating guide below.
3) Apply appropriate rating score.

Table 13.1: Table drain measurements

	Rating
Not Applicable	0
Excellent	1
Good	2
Average	3
Poor	4
Very poor	5

13.4 Examples of table drain condition

Adequate shape and depth. Negligible scour, siltation or vegetation.

May be some obstruction in the form of vegetation build up or scour or siltation. This is less than 30 mm.

Slight obstruction to either runoff entering the table drain or along the table drain invert through scour, siltation or vegetation build up typically in the range of 30 to 50 mm.

Moderate restriction to drainage flow across the shoulder. Scouring present with depth between 40 and 80 mm. Soft patches of unconsolidated material over between 10 and 50 % of the area.

Major restriction to drainage flow across the shoulder. Scouring present greater than 80 mm deep.

14. UNSEALED SURFACE EXTENT

Assessment of the condition of unsealed roads differs significantly from that of sealed roads. Unsealed roads are highly dynamic systems with the appearance and condition varying almost from day to day. Although sealed roads are also dynamic systems, the rate of change of typical performance characteristics is much slower and annual observation is generally sufficient to identify changes and provide timely inputs for maintenance intervention activities. This is considerably more difficult for unsealed roads, and for routine use, the visual assessment is most applicable for determining:

- regravelling requirements
- whether current grader blading frequencies are sufficient
- whether the gravel on the road is suitable for the traffic and environment
- what type of distress is typical of the road/gravel combination?

Unlike sealed roads, the performance of unsealed roads depends primarily on the functional characteristics. Localised structural failures are usually repaired during routine grader maintenance (occasionally spot regravelling is necessary) whereas structural failures of sealed roads require intensive repair to restore functional performance.

Assessment of unsealed roads typically considers unsealed shape and depth of base but can also incorporate defects such as pothole extent, rutting extent, corrugation extent and dust extent which can help provide a basis for determining which unsealed roads are of greatest need.

Unsealed surface defects are characterised by localised failures, which typically manifest as surface and pavement breakdown.

14.1 Potholes

14.1.1 Description

A pothole is a hole in the road surface, frequently rounded in shape, resulting from the loss of surface material under traffic.

14.1.2 Possible causes

- incorrect preparation of the unsealed pavement
- structural deficiencies in the material used to construct the pavement
- interaction between water and traffic
- poor construction control.

14.2 Localised rutting

14.2.1 Description

Rutting takes the form of depressions along the wheel paths. Usually the length of a rut is at least 4 times longer than the width of the rut. Sometimes rutting is also accompanied by a bulging of the road surface adjacent to the rut.

Rutting is common in pavements that are not thick enough to take the loads imposed by the traffic using them. This may be due to the pavement being incorrectly designed for the available subgrade or being designed for a stronger pavement material than was actually used or possibly because the actual traffic levels are higher than it was designed for.

14.2.2 Possible causes

- inadequate pavement thickness
- structural deficiencies in the pavement material
- poor construction control (inadequate compaction in subgrade or poor surface application)
- Trafficking of moisture sensitive pavements in wet conditions.

14.3 Localised corrugations

14.3.1 Description

Corrugations usually take the form of fairly regular waviness in road surfaces. The deformations are usually shallow and should not be confused with larger depressions or pavement failures resulting from weaknesses in the pavement or the subgrade.

14.3.2 Possible causes

- inadequate pavement thickness
- braking or accelerating of turning vehicles
- Low cohesion in the pavement material.

14.4 Dust extent

14.4.1 Description

For all unsealed roads, whether they are paved or unpaved, dust is rated according to the nuisance it poses to local residents. This includes the propensity of the unsealed road to generate dust clouds, settling characteristics after disturbance, i.e. rate of settling and density of dust and visual impairment

14.4.2 Possible causes

- poor bonding in top pavement layer
- inadequate pavement thickness
- braking or accelerating of turning vehicles.

14.5 Surface texture

Consideration of the unsealed road surface texture including;

- excessive loose or sharp stony surfaces
- ravelling extent
- surface smoothness or slipperiness.

14.6 Method of measurement

To measure unsealed surface condition, the area of the treatment length being assessed is determined and the area affected by unsealed surface defects is determined. Rating is based on the ratio of the area affected to the area of the treatment length being assessed expressed as a percentage. To rate unsealed surface condition:

1) Determine the treatment length area by multiplying the length by average width.
2) Determine the area affected within the treatment length area.
3) Express the affected area as a percentage of the total treatment length area.
4) Assign a rating according to the scale below.

Table 14.1: Unsealed surface measurements

	Rating
Not Applicable	0
No area affected	1
0% < area affected < 5%	2
5% < area affected < 10%	3
10% < area affected < 20%	4
20% < area affected	5

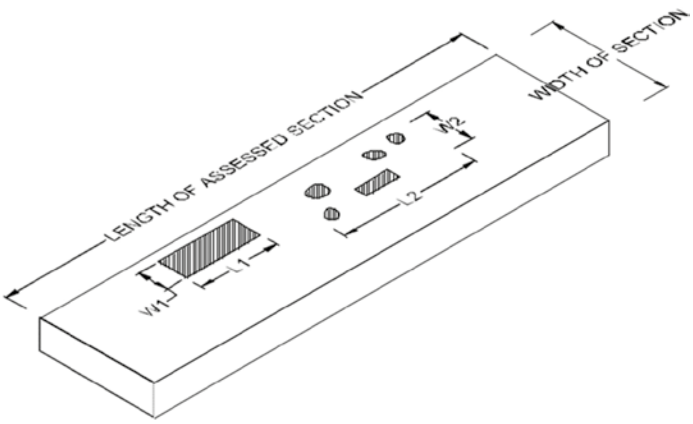


Figure 14.1: Measuring unsealed surface condition

Rating 1 – no dust nuisance

Rating 5 – dust nuisance

15. UNSEALED SHAPE

15.1 Road profile

The profile of a road has a major impact on the performance of that road. Roads with good profile tend to shed water rapidly avoiding the development of potholes and potentially impassable defects. Where the profile is flat, water tends to pond in localised depressions resulting in softening of the wearing course and the development of potholes and other defects. Failure to repair a flat road will usually result in the development of ruts under traffic. These may become preferential water paths resulting in erosion, accelerated gravel loss and significant deterioration in riding quality.

It should be noted that rutting in unsealed roads is generally the result of loosening and whip-off of material, and is only seldom the result of subgrade deformation/ settlement. Routine grading usually reduces rutting.

15.2 Cross section

There is a strong interrelationship between the road profile and the cross section in providing adequate drainage. Where the profile relates more directly to the capacity of the road to shed water without causing erosion, drainage from the road relates more closely to the impact of standing water on both the wearing course and underlying road structure. Effective operation of adequate cross fall and table drains is the predominant aspect to be considered when rating unsealed shape. Excessive cross fall on unsealed roads can create extreme hazards.

15.3 Method of measurement

When assessing unsealed shape, the predominant determinant is the cross section shape of the road within the treatment length being assessed. Notwithstanding this, the profile of the road within the treatment length should be considered in the final rating. The average condition of the road within the treatment length is assessed by inspection from a slow moving vehicle, with closer inspection out of the vehicle being undertaken as appropriate. When assessing unsealed shape the following process is undertaken:

1) Inspect the total length of the unsealed shape over the treatment length.
2) Determine the average condition of the unsealed shape by inspection and assessing the height of the crown above the adjacent table drains, or where table drains are not constructed, above the line of longitudinal water flow.
3) Compare it to the rating guide below and apply appropriate rating score.

Table 15.1: Unsealed shape measurements

	Rating
Not Applicable	0
Excellent	1
Good	2
Average	3
Poor	4
Very poor	5

15.4 Examples of unsealed shape condition

The cross fall is adequate for drainage with the crown ≥1 metre above the adjacent table drain or longitudinal watercourse. The surface is well bound, compact and minimal loose gravel is present.

Cross fall is adequate to allow unrestricted drainage across the shoulder. Crown is between 0.75 and 1 metre above adjacent table drain of longitudinal watercourse.

Variable cross fall resulting in slight restriction to drainage flow across the shoulder. Crown is between 0.5 and 0.75 metres above adjacent table drain of longitudinal watercourse.

Variable cross fall resulting in slight restriction to drainage flow across the shoulder. Crown is between 0.25 and 0.5 metres above adjacent table drain of longitudinal watercourse. Note in instances of excessive crossfall a rating of 5 should be applied.

Inadequate or excessive cross fall and poor material quality. Crown is between 0.05 and 0.25 metres above adjacent table drain of longitudinal watercourse.

16. DEPTH OF BASE

The depth of base is rated for all paved unsealed roads. For unpaved roads this criteria is not assessed.

Depth of base can be rated by:

- measuring the actual thickness of the base
- visually assessing the adequacy of the base.

16.1 Measuring the depth

To assess the adequacy of the base by measurement, it is necessary to sample the pavement along a rating treatment length to determine the thickness. A hole is dug between the wheel tracks and excavated until the interface between the pavement and the subgrade is identified.

Where the natural subgrade is similar to the imported or in-situ pavement material, the identification of the interface may be difficult. Difficulty may also be encountered if the pavement consists of a sub-base material and a base-course material. Care must be taken to ensure that the full depth of the pavement is identified.

Once the depth of the pavement has been determined, a condition score is assigned; with reference to the original design thickness and according to the following:

Table 16.1: Depth of base measurements

	Rating
Not Applicable	0
Very Thick	1
Thick	2
Moderate	3
Thin	4
Very Thin	5

16.2 Visual assessment of the depth

It is more common to assess the adequacy of the base by visual assessment. To do this a judgment must be made as to whether or not the existing base over a total segment length is of sufficient depth to be graded without difficulty.

Typically, if a base is too thin this is usually identifiable by the presence of the subgrade or rocks showing through the base. To visually assess the adequacy of the base:

1) Inspect the total length of the rating segment to ascertain whether there are indications of subgrade or rocks protruding through the base.
2) If there is evidence of subgrade protrusion assign a rating value of 5, if there is no evidence of subgrade protrusion assign a rating of 1.

16.3 Examples of depth of base

No evidence of protrusion

Evidence of scattered protrusion

Evidence of protrusion

17. PATHS (BY SHAWMAC)

17.1 Introduction

This part of the manual has been developed under contract by Tony Shaw of Shawmac, to provide guidance on the process to be used when rating the condition of footpaths.

Footpaths are given an overall condition score of between one and five. A rating of one indicates that there are no problems with the footpath, and a rating of five indicates that the footpath is in a very poor state of repair.

The assessment of footpath condition should be based on a number of factors, such as cracking and displacement, as outlined in the rating descriptions. The condition score given to each section of footpath should be based on the extent/severity relating to the worst defect. For example, a footpath that is badly cracked but with no displacement would be given the rating relating to the cracking, as that is the worst defect.

In many cases the condition of footpaths may change considerably over the length of only a few metres. It is not the intention to break the network into very small sections and generally sections should be no less than 20m in length. Where sections vary considerably over short lengths, data collectors should rate the whole section at the worse rate.

17.2 On-road footpaths

On-road footpaths are defined as paths that run parallel to a road in the road reserve. Footpath data collection should be undertaken in the same direction as road data collection is undertaken.

On-road footpath data should be collected such that a single footpath is determined as a section of footpath between intersections. If any of the footpath parameters being collected, such as condition or type, change along the length of the section between intersections then the footpath should be broken down into smaller similar sections of measured distance.

It is quite common in the Metropolitan area to find brick paved verges constructed beside concrete footpaths. In these cases only the footpath rating should be included on the footpath data collection sheet.

17.3 Bituminous seal and asphalt footpaths (Type Codes 1 & 2)

Condition Rating = 1

- No cracks present
- No deformation or sinking sections
- No problems with service structure levels
- No potholes / unsuccessful patches, no edge break
- No risk of public injury due to surface defects

Condition Rating = 2

- Slight surface cracking < 2 mm width present
- Slight deformation in surface
- Service structure levels less than 5 mm above / below surrounding path level
- No potholes / unsuccessful patches, very slight edge break
- Very low risk of public injury due to surface defects

Condition Rating = 3

- Cracking of 2 – 5 mm width present
- Some minor deformation or sinking in surface level of < 5 mm
- Service structure levels 5 – 10 mm above / below surrounding path level
- Small isolated potholes / unsuccessful patches, slight edge break
- Low risk of public injury due to surface defects

Condition Rating = 4

- Cracking of 5 – 10 mm width present
- Deformation or sinking of surface level of 5 – 10 mm
- Service structure levels 10 – 15 mm above / below surrounding path level
- Small potholes / unsuccessful patches, moderate edge break
- Medium risk of public injury due to surface defects

Condition Rating = 5

- Cracking of > 10 mm width present
- Deformation or sinking of surface level of > 10 mm
- Service structure levels greater than 15 mm above / below path level
- Large potholes / unsuccessful patches, high level of broken edges
- High risk of public injury due to surface defects

17.3.1 Examples of bituminous seal and asphalt footpaths condition

No evidence of protrusion

17.4 Slab footpaths (Type Code 3)

Condition Rating = 1

- No broken or cracked slabs
- Uniform joints between slabs, joints not spread
- Even finish with displacement of slabs <5 mm
- No problems with service structure levels
- Very low risk of public injury due to surface defects

Condition Rating = 2

- Slightly cracked slabs present
- Uniform joints between slabs, joints slightly spread (< 10 mm)
- Fairly even finish with displacement of slabs between 5 – 10 mm
- Service structure levels < 5 mm above / below surrounding path level
- Very low risk of public injury due to surface defects

Condition Rating = 3

- Cracked slabs present
- Non uniform joints between slabs with spreads of 10 – 20 mm,
- Fairly uneven surface with displacement of slabs of 10 – 15 mm
- Service structure levels 5 – 10 mm above / below surrounding path level
- Low risk of public injury due to surface defects

Condition Rating = 4

- Badly cracked slabs present
- Non uniform joints between slabs with spreading of 20 – 30 mm
- Uneven surface with displacement of slabs of 15 – 20 mm
- Service structure levels 10 – 15 mm above / below surrounding path level
- Medium risk of public injury due to surface defects

Condition Rating = 5

- Badly cracked or broken slabs present
- Non uniform joints between slabs with spreading of > 30 mm
- Very uneven surface with displacement of slabs > 20 mm
- Service structure levels > 15 mm above / below path level
- High risk of public injury due to surface defects

17.4.1 Examples of slab footpaths condition


Rating 1


Rating 2


Rating 3


Rating 4


Rating 5

17.5 In-situ concrete footpaths (Type Code 4)

Condition Rating = 1

- No cracking present
- No broken / sinking sections
- Uniform gaps between sections of < 10 mm
- No displacement between sections
- No problems with service structure levels
- No risk of public injury due to surface defects

Condition Rating = 2

- Slight cracking present < 2 mm wide
- No broken / sinking sections
- Uniform gaps between sections of 10 – 15 mm
- Displacement between sections of < 5 mm
- Service structure levels < 5 mm above / below surrounding path level
- Very low risk of public injury due to surface defects

Condition Rating = 3

- Cracking present
- No broken / sinking sections
- Non - uniform gaps between sections of 10 – 15 mm
- Displacement between sections of 5 – 10 mm
- Service structure levels 5 – 10 mm above / below surrounding path level
- Low risk of public injury due to surface defects

Condition Rating = 4

- Cracking present
- Broken / sinking sections
- Non - uniform gaps between sections of 15 – 20 mm
- Displacement between sections of 10 – 15 mm
- Service structure levels 10 – 15 mm above / below surrounding path level
- Medium risk of public injury due to surface defects

Condition Rating = 5

- High level of cracking present
- High level of broken / sinking sections present
- Non uniform gaps between sections of > 20 mm
- Displacement between sections of > 15 mm
- Service structure levels > 15 mm above / below path level
- High risk of public injury due to surface defects

17.5.1 Examples of in-situ concrete footpaths condition

17.6 Brick paved and interlocking concrete paved footpaths (Type Codes 5 and 6)

Condition Rating = 1

- No broken or cracked pavers
- Uniform gaps between pavers of < 2 mm, pavers stable
- No displacement of pavers
- No problems with service structure levels
- No risk of public injury due to surface defects

Condition Rating = 2

- No broken or cracked pavers
- Uniform gaps between pavers of < 5 mm, pavers stable
- Displacement between pavers of < 5 mm
- Service structure levels < 5 mm above / below surrounding path level
- Very low risk of public injury due to surface defects

Condition Rating = 3

- Paver edges chipped or cracked
- Uniform gaps between pavers of < 5 mm, pavers stable
- Displacement between pavers of 5 – 10 mm
- Service structure levels 5 – 10 mm above / below surrounding path level
- Low risk of public injury due to surface defects

Condition Rating = 4

- Pavers broken, edges chipped
- Non uniform gaps of 5 – 10 mm, pavers generally stable
- Displacement between pavers of 10 – 15 mm
- Service structure levels 10 – 15 mm above / below surrounding path level
- Medium risk of public injury due to surface defects

Condition Rating = 5

- Pavers broken and sections missing
- Non-uniform gaps of > 10 mm, pavers unstable
- Displacement between pavers of > 15 mm
- Service structure levels > 15 mm above / below path level
- High risk of public injury due to surface defects

17.6.1 Examples of brick paved and interlocking concrete paved footpaths condition

APPENDIX A
Road Visual Condition Assessment Rating Sheet

ROAD VISUAL CONDITION ASSESSMENT RATING SHEET

ROAD NUMBER | **ROAD NAME** | **DATE** | **SHEET** | **OF**

TREATMENT LENGTH (To be entered before conducting survey)		SEALED ROAD																				UNSEALED ROAD			NOTES
Start (m)	End (m)	Local Surface Defects Extent	Pavement Undulations Degree	Pavement Undulations Extent	Patches Extent	Pothole Extent	Rutting Severity	Structural Cracking Severity	Structural Cracking Extent	Non Structural Cracking Severity	Non Structural Cracking Extent	Surface Deficiencies Extent	Edge break Severity	Edge break Extent	Edge drop off Severity	Edge drop off Extent	Kerb Severity	Kerb Extent	Kerb Height	Unsealed Shoulders	Table Drains	Unsealed Surface Extent	Unsealed Shape	Depth of base	

APPENDIX B
Path Visual Condition Assessment Rating Sheet

PATH VISUAL CONDITION ASSESSMENT RATING SHEET

				DATE	
Description		**Path type** (tick one type)		**Rating** (1 – 5)	**Comment**
Path number		Bituminous seal & asphalt			
Path name		Slab			
Start (m)		In-situ concrete			
End (m)		Brick paved & interlocking concrete			
Path number		Bituminous seal & asphalt			
Path name		Slab			
Start (m)		In-situ concrete			
End (m)		Brick paved & interlocking concrete			
Path number		Bituminous seal & asphalt			
Path name		Slab			
Start (m)		In-situ concrete			
End (m)		Brick paved & interlocking concrete			
Path number		Bituminous seal & asphalt			
Path name		Slab			
Start (m)		In-situ concrete			
End (m)		Brick paved & interlocking concrete			
Path number		Bituminous seal & asphalt			
Path name		Slab			
Start (m)		In-situ concrete			
End (m)		Brick paved & interlocking concrete			
Path number		Bituminous seal & asphalt			
Path name		Slab			
Start (m)		In-situ concrete			
End (m)		Brick paved & interlocking concrete			
Path number		Bituminous seal & asphalt			
Path name		Slab			
Start (m)		In-situ concrete			
End (m)		Brick paved & interlocking concrete			

APPENDIX C
Technical Basis For Road Condition Index Formulation

Technical Basis For Road Condition Index Formulation

1. Introduction

Condition indices are developed and calculated to assist road network managers to improve their decision-making processes through:

- ensuring that all performance indicators are on the same scale
- relating and comparing all performance indicators to one another easily through a common presentation format
- providing a direct link between the senior management level decision making which subsequently is translated to the operational level for service delivery
- lending themselves to modelling and forecasting to facilitate long-term strategic financial planning and management.

The Western Australian Local Government Association (WALGA) identified a need to provide LGs with a set of simple algorithms to derive a sealed pavement condition index or road condition index (RCI). LGs would then have a common methodology and benchmark to measure and assess their network's performance.

ARRB was engaged to develop the RCI for use by WALGA and its members. The RCI developed by ARRB was designed to meet the following specifications:

- development of an RCI in line with the agreed WA pavement condition rating method as detailed in the *Road Visual Condition Assessment Manual* (the manual) (ARRB 2016)
- establishment of condition categories rated from 0 (not applicable and 1 being excellent) through to 5 (very poor)
- facility for the index to be applied to any data resolution, from the road section level to the finest data collection interval applied
- ensuring that the developed RCI from data summarised at road length level can be based on a length-weighted average value.

Based on the above specifications the RCI was constructed as follows:

- individual indices were developed for each condition category using a scale of 1 to 5
- individual indices were then categorised as being related to either structural, surface or drainage performance and therefore three composite indices were then developed to represent the overall performance of these high level reporting categories.

To ensure that the newly developed RCI methodology was appropriate and suitable for application across the Western Australian road network, the approach was validated against data contained in the ROMAN II treatment length summary table. Through this process, defect data was extracted in a summarised form at treatment length or road section level for application through the approach and the results were reviewed to ensure the calculations and process worked appropriately.

This report outlines the detailed steps that users would apply in the process of developing an RCI applicable for their road network.

2. Individual Defect Index Curve Formulation

The RCI was formulated using the following visual defect parameters from the manual, which includes:

- local surface defects extent
- pavement undulations, degree and extent
- patches extent
- potholes extent
- rutting severity
- structural cracking severity and extent
- non-structural cracking severity and extent
- surface deficiencies extent
- edge break severity and extent
- edge drop off severity and extent
- kerb defects severity, extent and height
- unsealed shoulders
- table drains.

For each parameter a defect index was developed using the current ARRB method based on a rating of 0–5 in line with local government road condition assessment rating systems, where:

- 0–1 – Very good condition for newly or recently constructed pavements
- 1–2 – Good condition and likely to require only routine maintenance
- 2–3 – Fair condition and likely to require light maintenance or resurfacing
- 3–4 – Poor condition and likely to require a surface correction or possibly a structural treatment
- 4–5 – Very poor condition possibly requiring a structural treatment or a reconstruction.

Defect values are assigned to each rating range and a curve developed by interpolating values (straight line) between the defined ranges. Different defect values are assigned according to road hierarchy to represent the different service levels that may be preset on any defined road network. Table 2.1 shows an example for the rut depth defect index range for three different road categories.

Table 2.1: Rut depth bins for three different road categories (in mm)

Defect index rating		Category 1	Category 2	Category 3
0–1	Very good	0–10	0–8	0–4
1–2	Good	>10-15	>8-12	>4–8
2–3	Fair	>15-20	>12-16	>8–12
3–4	Poor	>20-25	>16–20	>12–16
4–5	Very poor	>25	>20	>16

The coloured part of the table shows the index bands and their numerical representation, whilst the subsequent columns show the corresponding rut depth ranges for the three defined road categories.

For the WA road network, the road categories are based on the carriageway hierarchies defined in accordance with MRWA classifications which include:

- access roads
- local distributors
- distributor B
- distributor A
- regional distributor
- primary distributor.

Based on the different values assigned to each defect index rating and for each road category, Figure 2.1 shows a graphical representation of sample index curves for rutting.

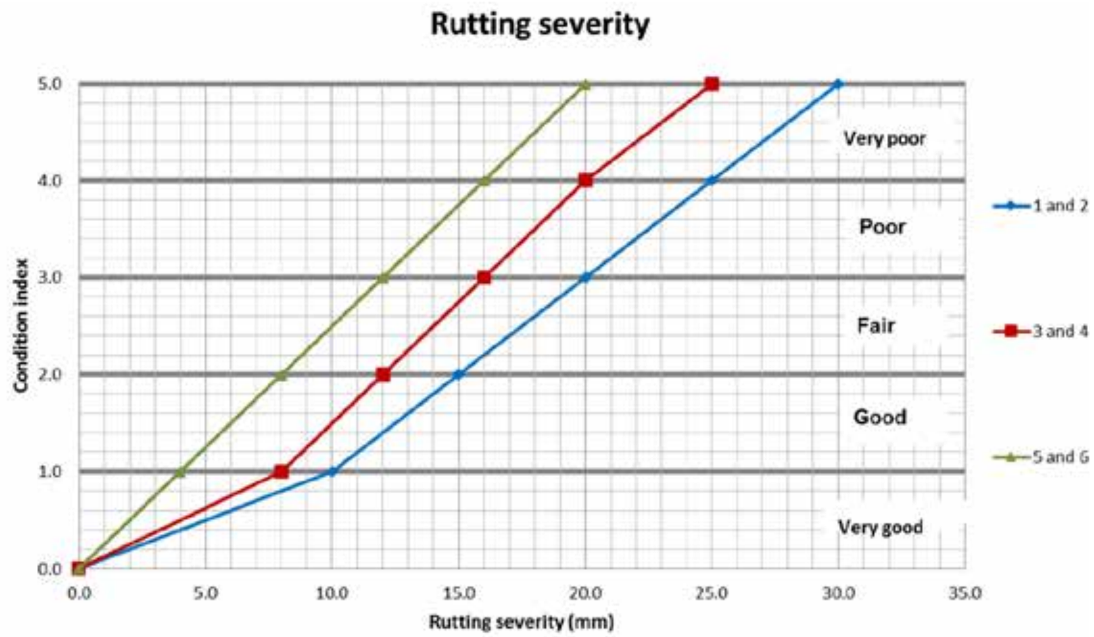


Figure 2.1: Transformation curves for the three road categories, based on Table 2.1

The rating ranges adopted in this report are applied as default values within ROMAN II. Alternative rating ranges could be adopted to suit particular operating conditions of an individual LG. Any such changes would however need to be supported by further studies.

3. Defect Index Curves

The following section details the defect values used to represent each index rating for each of the individual defect parameters across the different carriageway hierarchies. The values are based on those prescribed in the manual and *Guide to Asset Management Part-5* (Austroads 2009) with modifications to suit different carriageway hierarchies.

3.1 Local Surface Defects (Extent)

The extent of local surface defects and patches represents the percentage area of the seal exhibiting local surface defects or has been patched. Table 3.1 shows the extent values that represent the index ranges for local surface defects and patches. The corresponding index curves are shown in Figure 3.1.

The extent values prescribed in the manual were used for local access and distributor roads, while an increased standard has been recommended for the range of distributor roads.

Table 3.1: Extent values (%) for local surface defects index curves

Defect index rating		Access roads	Local distributor	Distributor B	Distributor A	Regional distributor	Primary distributor
		1	2	3	4	5	6
0–1	Very good	0–5	0–5	0–2	0–2	0–2	0–2
1–2	Good	>5–10	>5–10	>2–5	>2–5	>2–5	>2–5
2–3	Fair	>10–15	>10–15	>5–10	>5–10	>5–10	>5–10
3–4	Poor	>15–20	>15–20	>10–15	>10–15	>10–15	>10–15
4–5	Very poor	>20	>20	>15	>15	>15	>15

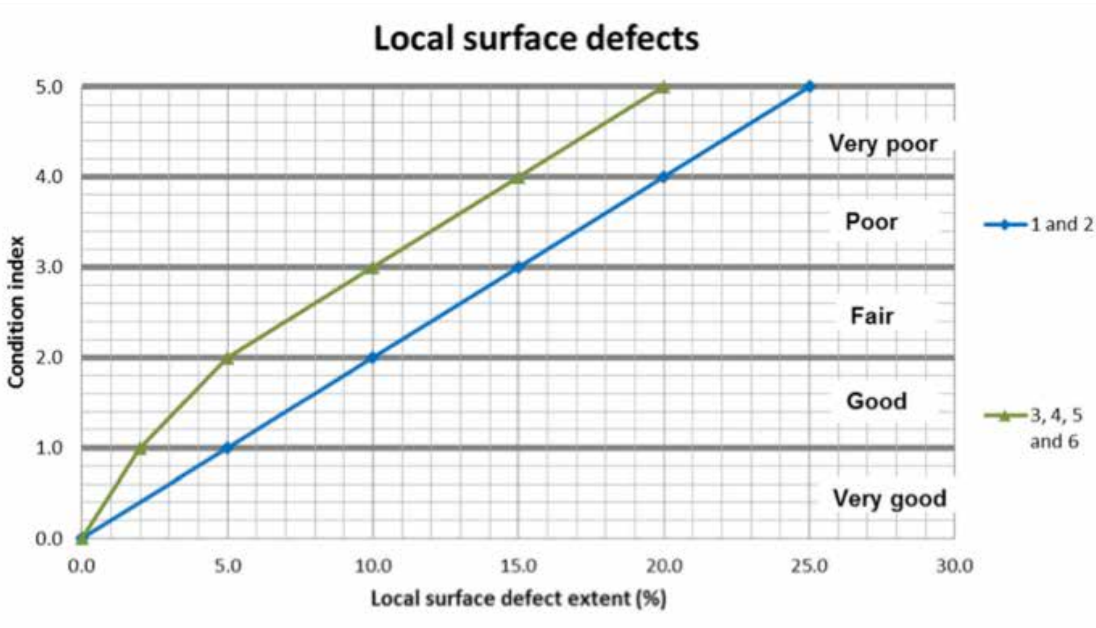


Figure 3.1: Local surface defects index curves for different road hierarchies

3.2 Pavement Undulations

The pavement undulations index is derived based on the extent (% area affected) and degree of pavement undulations within the treatment length. An individual index will be produced for extent of pavement undulations. The degree of undulations is to be stored as values 1, 3 or 5 hence no conversion is required to produce the index curve. The formulation of defect curves for the extent is described below.

3.2.1 Extent

The extent of pavement undulations represents the percentage area of the pavement elevations lower or higher than the surrounding area that will contribute to long wave and/or irregular depressions and uplift.

Table 3.2 shows the extent values that represent the index ranges for pavement undulations and Figure 3.2 shows the corresponding index curves.

The extent values prescribed in the manual have been applied to the local access roads. As pavement undulations are of greater concern on higher speed and heavier trafficked roads the values presented for distributor roads in the table below have been adjusted accordingly.

Table 3.2: Extent values (%) for pavement undulations index curves

Defect index rating		Access roads	Local distributor	Distributor B	Distributor A	Regional distributor	Primary distributor
		1	2	3	4	5	6
0–1	Very good	0-15	0-15	0-15	0-15	0-15	0-15
1–2	Good	>15-30	>15-30	>15-30	>15-30	>15-30	>15-30
2–3	Fair	>30-45	>30-45	>30-45	>30-45	>30-45	>30-45
3–4	Poor	>45-60	>45-60	>45-60	>45-60	>45-60	>45-60
4–5	Very poor	>60	>60	>60	>60	>60	>60

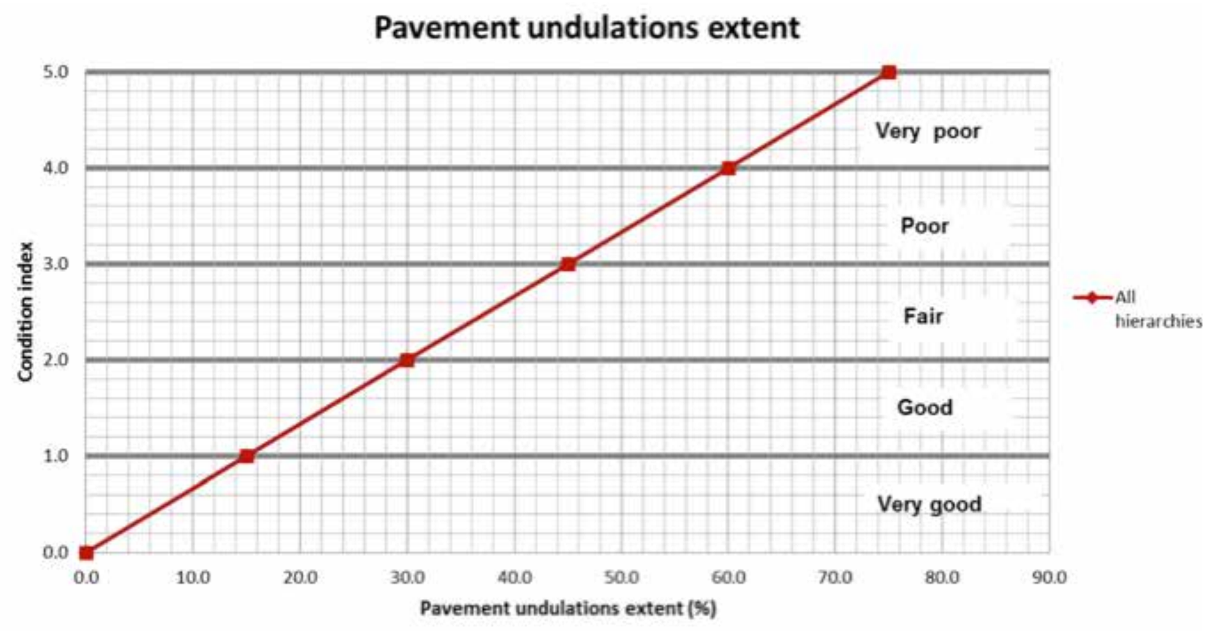


Figure 3.2: Pavement undulations extent index curves for different road hierarchies

3.2.2 Degree

The degree of undulations is measured and recoded as a value of 1, 3 or 5. No conversion is therefore applied as the measured rating is used directly to produce the index.

3.3 Patches (Extent)

The extent of patches values prescribed in the manual were used for local access and distributor roads, while an increased standard was used for distributor roads. The same defect values were chosen for both local surface defects and patches as patching is often used to repair local surface defects and both represent a failure in the surfacing.

Table 3.3: Extent values (%) for patches index curves

Defect index rating		Access roads	Local distributor	Distributor B	Distributor A	Regional distributor	Primary distributor
		1	2	3	4	5	6
0–1	Very good	0–5	0–5	0–2	0–2	0–2	0–2
1–2	Good	>5–10	>5–10	>2–5	>2–5	>2–5	>2–5
2–3	Fair	>10–15	>10–15	>5–10	>5–10	>5–10	>5–10
3–4	Poor	>15–20	>15–20	>10–15	>10–15	>10–15	>10–15
4–5	Very poor	>20	>20	>15	>15	>15	>15

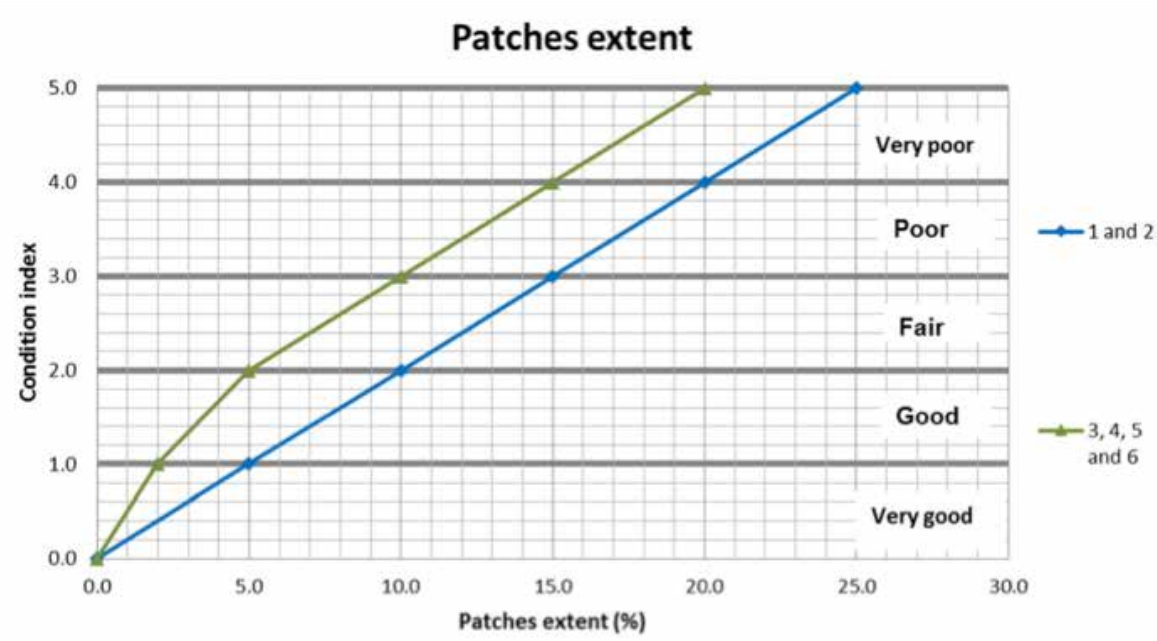


Figure 3.3: Patches index curves for different road hierarchies

3.4 Potholes (Extent)

The extent of potholes represents the percentage area of the pavement surface affected by potholing. It does not take into account the severity (depth of pothole). Table 3.4 shows the extent values that represent each of the index ranges for potholes and Figure 3.4 shows the corresponding index curves. The extent values from the manual were used and are applied across all carriageway hierarchies, as potholing requires immediate attention on all roads.

Table 3.4: Extent values (%) for potholes index curve

Defect index rating		Access roads	Local distributor	Distributor B	Distributor A	Regional distributor	Primary distributor
		1	2	3	4	5	6
0–1	Very good	0–2	0–2	0–2	0–2	0–2	0–2
1–2	Good	>2–5	>2–5	>2–5	>2–5	>2–5	>2–5
2–3	Fair	>5–10	>5–10	>5–10	>5–10	>5–10	>5–10
3–4	Poor	>10–15	>10–15	>10–15	>10–15	>10–15	>10–15
4–5	Very poor	>15	>15	>15	>15	>15	>15

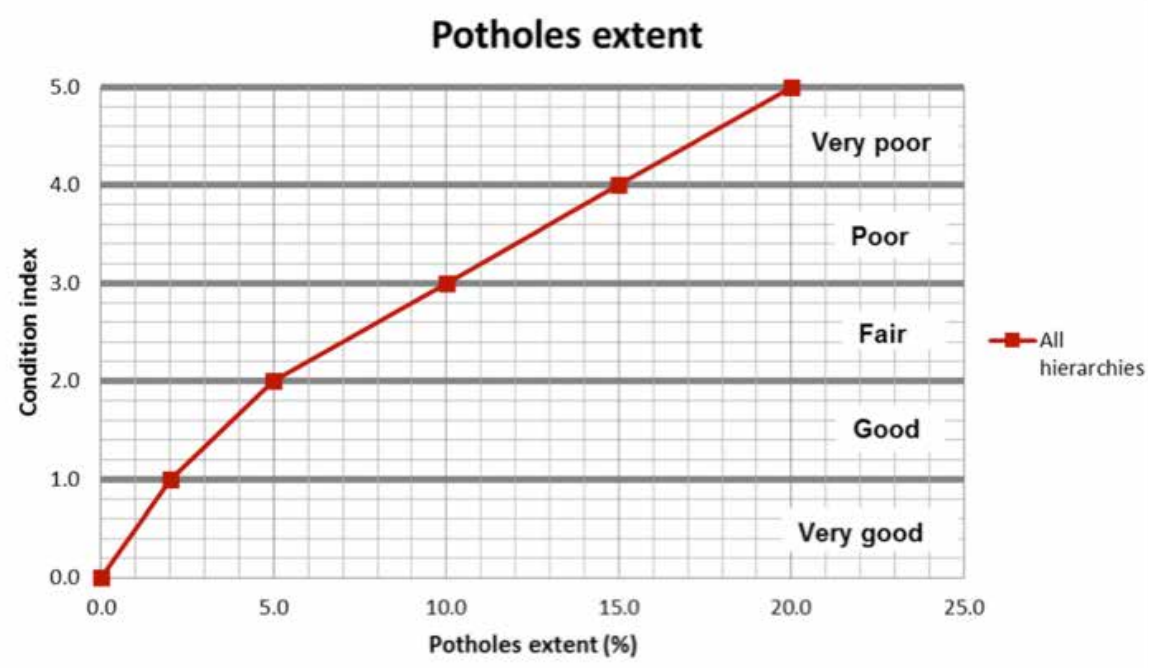


Figure 3.4: Extent of potholes index curve for different road hierarchies

3.5 Rutting (Average Severity)

The average severity of rutting represents the average rut depth (mm) of all rutting data along the length of the treatment length. Table 3.5 shows the severity values that represent the index ranges for rutting and Figure 3.5 shows the corresponding index curves.

The severity values prescribed in the manual were used for local access and distributor roads. Rutting is more of a concern on higher speed and heavier trafficked roads and also may be an indication of structural failure, hence the values were lowered for distributor roads. For rutting the drop in serviceability as represented by the defect index is slower at the beginning but once rutting has reached a defect index rating of 1 a linear approach is recommended.

Table 3.5: Average severity (mm) values for rutting index curves

Defect index rating		Access roads	Local distributor	Distributor B	Distributor A	Regional distributor	Primary distributor
		1	2	3	4	5	6
0–1	Very good	0–10	0–10	0–8	0–8	0–4	0–4
1–2	Good	>10–15	>10–15	>8–12	>8–12	>4–8	>4–8
2–3	Fair	>15–20	>15–20	>12–16	>12–16	>8–12	>8–12
3–4	Poor	>20–25	>20–25	>16–20	>16–20	>12–16	>12–16
4–5	Very poor	>25	>25	>20	>20	>16	>16

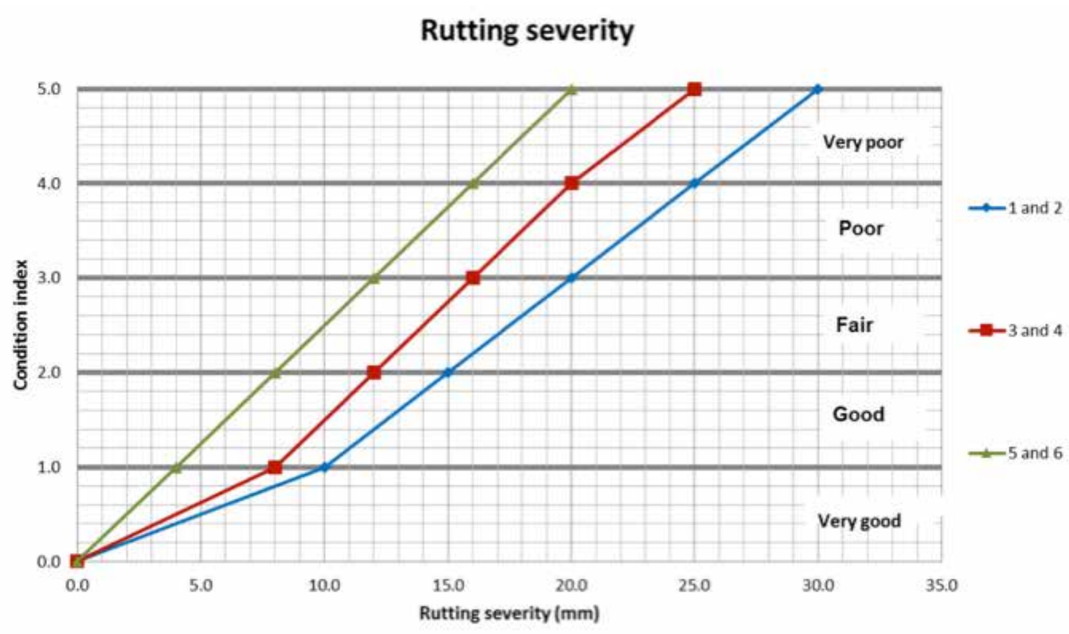


Figure 3.5: Rutting severity index curves for different road hierarchies

3.6 Cracking – Structural

A structural cracking index is based on the extent (% area affected) and severity (average width of cracking) of structural cracking within the treatment length. An individual index is produced for both the extent and severity of structural cracking. The formulation of the defect curves for the extent and severity of structural cracking are described below.

3.6.1 Extent

The extent of structural cracking represents the percentage area of the pavement surface that may be exhibiting structural cracks such as crocodile cracking. Table 3.6 shows the extent values that represent the index ranges for structural cracking and Figure 3.6 shows the corresponding index curves.

Table 3.6: Extent values (%) for structural cracking index curves

Defect index rating		Access roads	Local distributor	Distributor B	Distributor A	Regional distributor	Primary distributor
		1	2	3	4	5	6
0–1	Very good	0–10	0–10	0–8	0–8	0–6	0–6
1–2	Good	>10–15	>10–15	>8–12	>8–12	>6–9	>6–9
2–3	Fair	>15–20	>15–20	>12–15	>12–15	>9–12	>9–12
3–4	Poor	>20–25	>20–25	>15–20	>15–20	>12–15	>12–15
4–5	Very poor	>25	>25	>20	>20	>15	>15

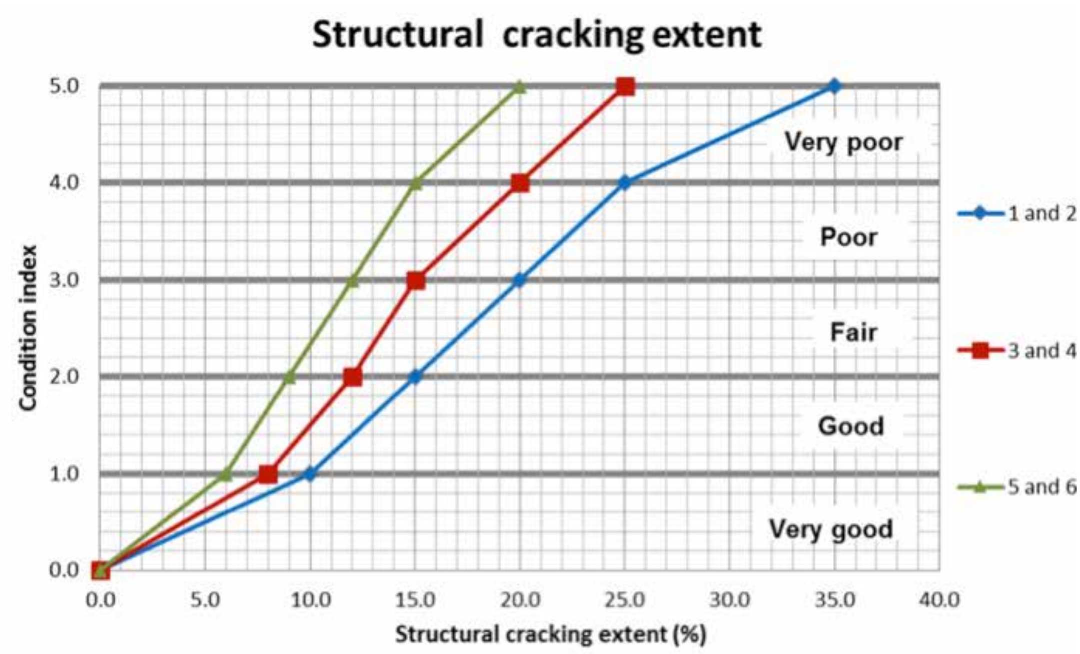


Figure 3.6: Structural cracking index curves for different road hierarchies

Within the manual, structural and non-structural cracking extent values are measured utilising the same criteria. Structural and non-structural cracking values have then adopted an S curve approach to represent the rate of decrease in serviceability once cracking propagates beyond a certain point and plateaus towards the end.

As structural cracking is more of an issue for roads that carry heavier traffic, the local access and distributor roads were allowed to have substantially more structural cracking than distributor roads.

3.6.2 Severity

The severity of structural cracking represents the average crack width (mm) of structural cracks within the treatment length. Table 3.7 shows the crack width values that represent the index ranges and Figure 3.7 shows the corresponding index curves.

Table 3.7: Severity values (mm) for structural cracking index curve

Defect index rating		Access roads	Local distributor	Distributor B	Distributor A	Regional distributor	Primary distributor
		1	2	3	4	5	6
0–1	Very good	0–1	0–1	0–1	0–1	0–1	0–1
1–2	Good	>1–2	>1–2	>1–2	>1–2	>1–2	>1–2
2–3	Fair	>2–4	>2–4	>2–4	>2–4	>2–4	>2–4
3–4	Poor	>4–6	>4–6	>4–6	>4–6	>4–6	>4–6
4–5	Very poor	>6	>6	>6	>6	>6	>6

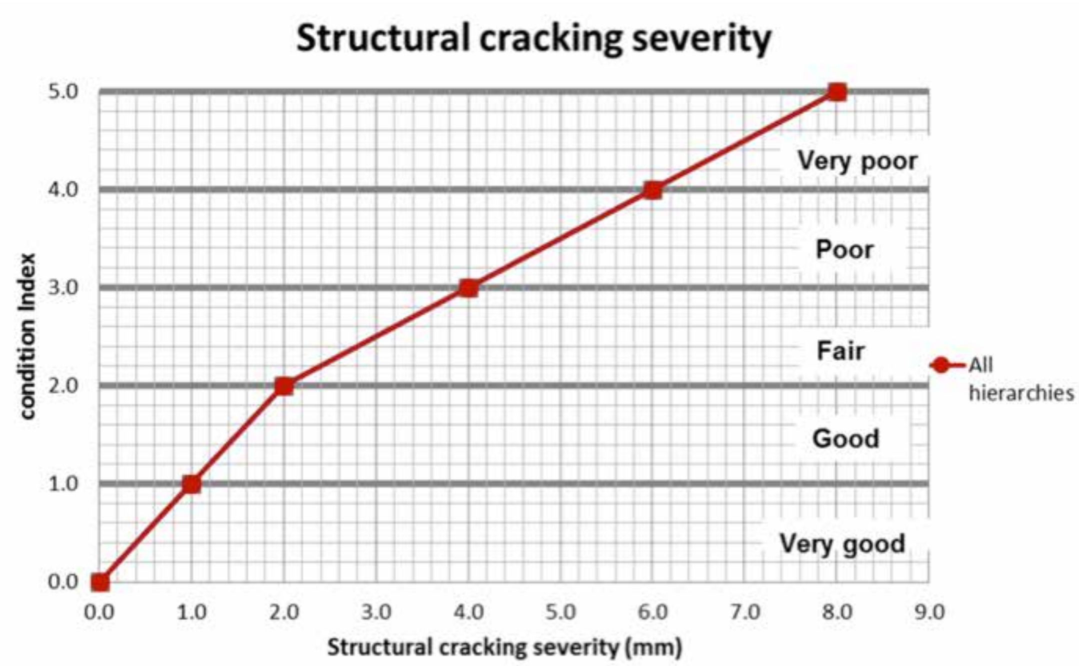


Figure 3.7: Severity of structural cracking index curve for different road hierarchies

The severity values chosen for all road classes were based on those prescribed in the manual. As outlined in Table 3.7 and Figure 3.7, the same thresholds have been applied as it is noted that the influence of crack width applies to all classes of roads in the same way, as the wider a crack, the greater the potential for water ingress into the pavement layers.

3.7 Cracking – Non-structural

The non-structural cracking index is based on the extent (% area affected) and severity (average width of cracking) of non-structural cracking within the treatment length. An individual index is produced for both extent and severity of non-structural cracking. The formulation of the defect curves for extent and severity are described below.

3.7.1 Extent

The extent of non-structural cracking represents the percentage area of the surface possessing non- structural cracks such as longitudinal, transverse and meandering cracks. Table 3.8 shows the extent values that represent the index ranges for non-structural cracking and Figure 3.8 shows the corresponding index curves.

Table 3.8: Extent values (%) for non-structural cracking index curves

Defect index rating		Access roads	Local distributor	Distributor B	Distributor A	Regional distributor	Primary distributor
		1	2	3	4	5	6
0–1	Very good	0–12	0–12	0–8	0–8	0–6	0–6
1–2	Good	>12–18	>12–18	>8–12	>8–12	>6–9	>6–9
2–3	Fair	>18–24	>18–24	>12–18	>12–18	>9–12	>9–12
3–4	Poor	>24–30	>24–30	>18–25	>18–25	>12–18	>12–18
4–5	Very poor	>30	>30	>25	>25	>18	>18

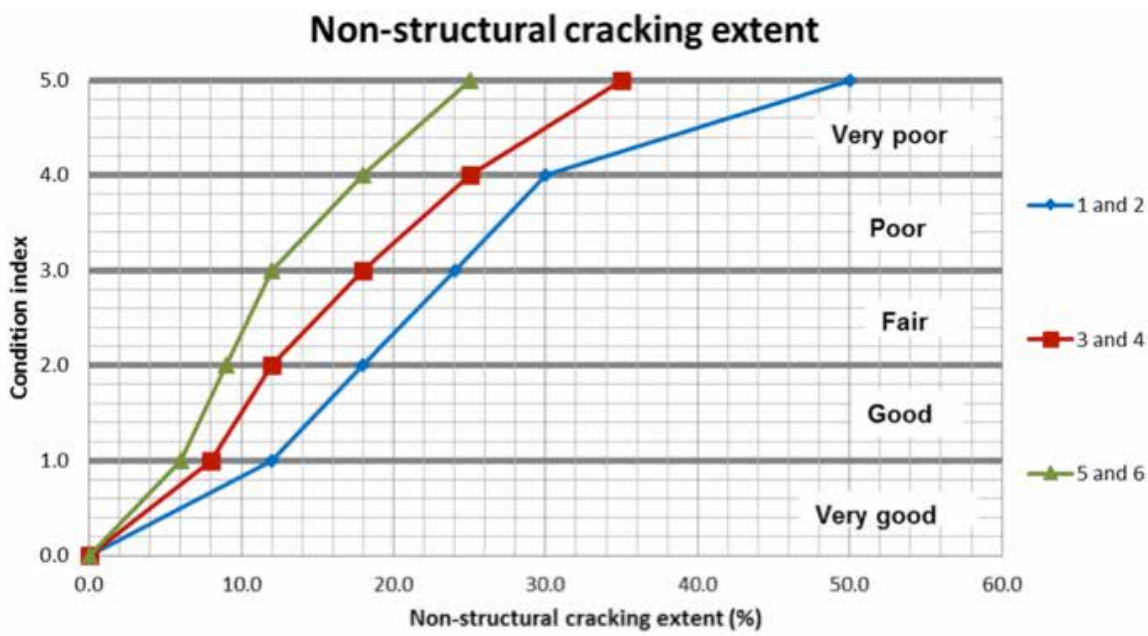


Figure 3.8: Extent of non-structural cracking index curves for different road hierarchies

The cracking extent values chosen for local access and distributor roads were based on those prescribed in the manual. A graduated level of service (acceptable level of non-structural cracking) was applied from distributor A and B to regional distributors and primary distributors, in line with those prescribed in Austroads (2009).

3.7.2 Severity

The severity of non-structural cracking represents the average crack width (mm) of non-structural cracks within the treatment length.

Table 3.9 shows the crack width values that represent the index ranges and Figure 3.8 shows the corresponding index curve.

Table 3.9: Severity values (mm) for non-structural cracking index curve

Defect index rating		Access roads	Local distributor	Distributor B	Distributor A	Regional distributor	Primary distributor
		1	2	3	4	5	6
0–1	Very good	0–1	0–1	0–1	0–1	0–1	0–1
1–2	Good	>1–2	>1–2	>1–2	>1–2	>1–2	>1–2
2–3	Fair	>2–4	>2–4	>2–4	>2–4	>2–4	>2–4
3–4	Poor	>4–6	>4–6	>4–6	>4–6	>4–6	>4–6
4–5	Very poor	>6	>6	>6	>6	>6	>6

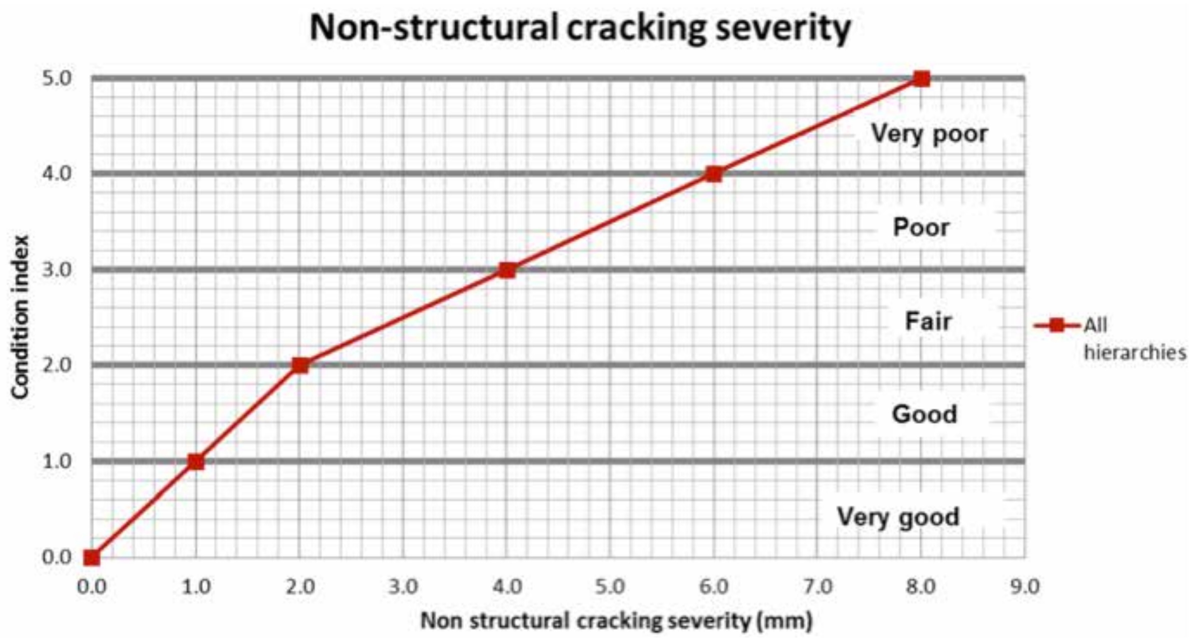


Figure 3.9: Severity of non-structural cracking index curve for different road hierarchies

The severity values chosen for all road classes were based on those prescribed in the manual as the influence of crack width applies to all road classes in the same way, in that the wider the crack, the more water ingress into the pavement layers.

3.8 Surface Deficiencies (Extent)

The extent of surface deficiencies represents the percentage area of the surface possessing surface deficiencies such as ravelling, flushing, stripping, etc. Table 3.10 shows the extent values that represent the index ranges for surface deficiencies and Figure 3.10 shows the corresponding index curves.

The extent values from the manual were used for local access and distributor roads. As surface deficiencies reduce skid resistance and macrotexture, which can have an impact on road safety, they have been lowered significantly for higher speed roads such as primary and regional distributors. The index curves also adopted the S shape approach to ensure project level investigations occur earlier once the index has reached a rating between 1 to 4 and plateaus from a rating of 4 to 5.

Table 3.10: Extent values (%) for surface deficiencies index curves

Defect index rating		Access roads	Local distributor	Distributor B	Distributor A	Regional distributor	Primary distributor
		1	2	3	4	5	6
0–1	Very good	0–12	0–12	0–8	0–8	0–6	0–6
1–2	Good	>12–18	>12–18	>8–12	>8–12	>6–9	>6–9
2–3	Fair	>18–24	>18–24	>12–18	>12–18	>9–12	>9–12
3–4	Poor	>24–30	>24–30	>18–25	>18–25	>12–18	>12–18
4–5	Very poor	>30	>30	>25	>25	>18	>18

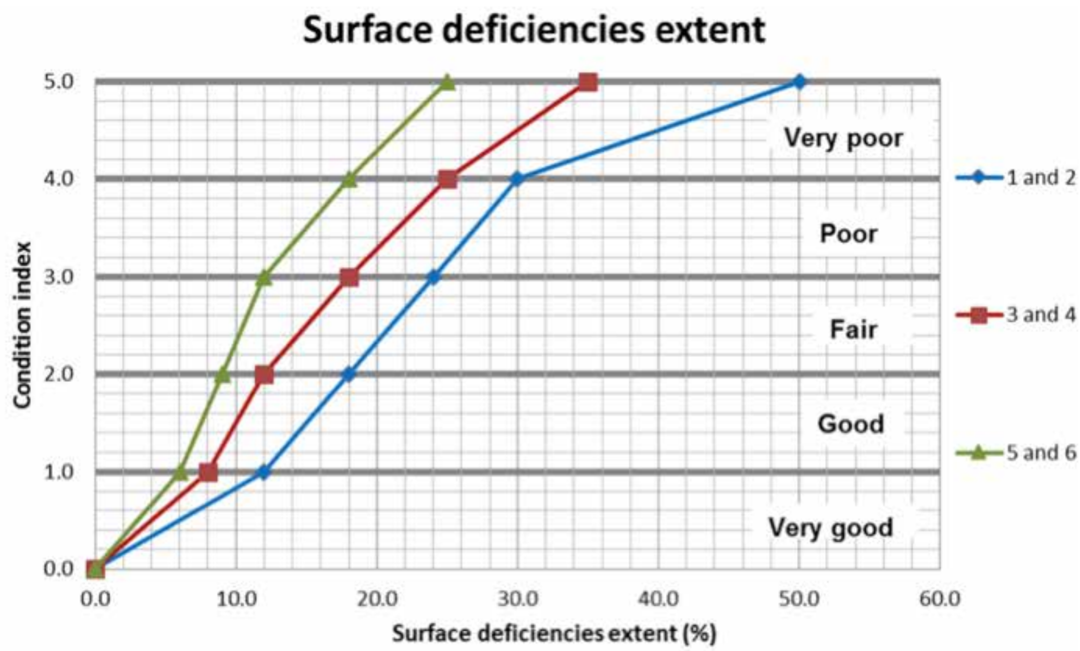


Figure 3.10: Extent surface deficiencies index curves for different road hierarchies

3.9 Edge Break

The edge break index is based on the extent (% length affected) and average severity (average width of edge break) within the treatment length. Individual indices are produced for both extent and severity of edge break. The formulation of defect curves for the extent and severity are described below.

3.9.1 Extent

The extent represents the length of the surface edge displaying edge break of greater than 20 mm on both sides of the pavement, expressed as a percentage of the total length of the treatment length. Table 3.11 shows the severity values that represent the index ranges for edge break extent and Figure 3.11 shows the corresponding index curves.

The values prescribed in the manual were used for local access and distributor A and B roads. As edge break is more of a concern on higher speed roads where seal width is important for road safety, the severity values were lowered to indicate a higher level of service for regional and primary distributors.

Table 3.11: Extent values (%) for edge break index curves

Defect index rating		Access roads	Local distributor	Distributor B	Distributor A	Regional distributor	Primary distributor
		1	2	3	4	5	6
0–1	Very good	0-5	0-5	0-5	0-5	0-5	0-5
1–2	Good	>5-10	>5-10	>5-10	>5-10	>5-10	>5-10
2–3	Fair	>10-15	>10-15	>10-15	>10-15	>10-15	>10-15
3–4	Poor	>15-20	>15-20	>15-20	>15-20	>15-20	>15-20
4–5	Very poor	>20	>20	>20	>20	>20	>20

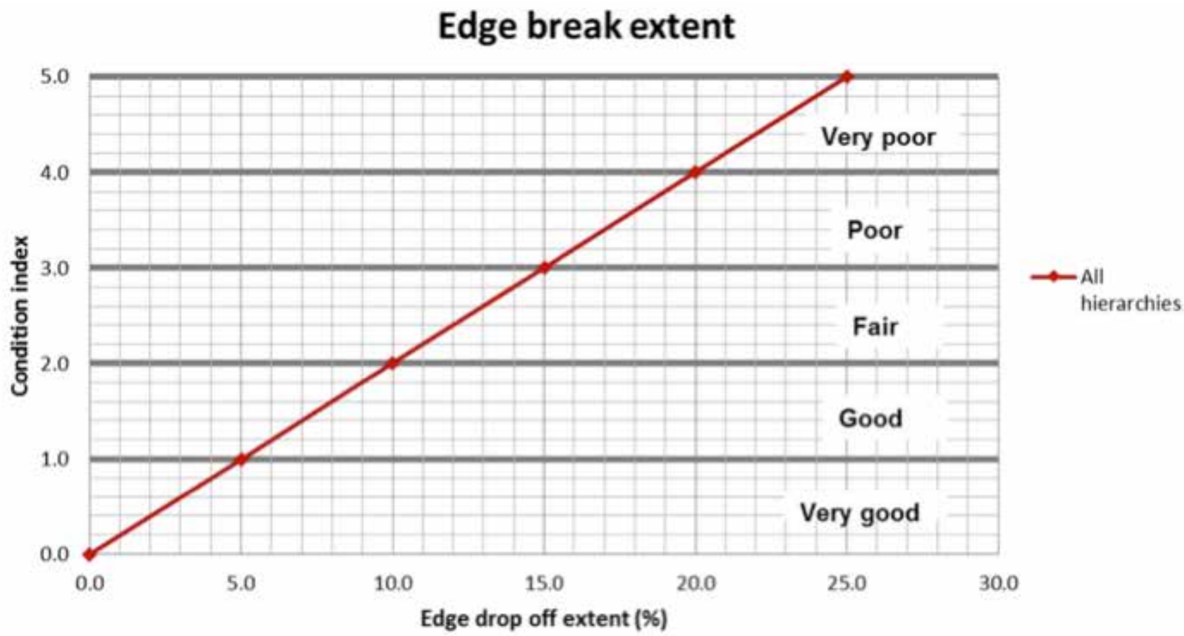


Figure 3.11: Edge break extent index curves for different road hierarchies

3.9.2 Severity

The average severity represents the average edge break width (mm) of all edge break observations along the length of the treatment length. Table 3.12 shows the severity values that represent the index ranges for edge break severity and Figure 3.12 shows the corresponding index curves.

The values prescribed in the manual were used for local access and distributor roads. As edge break is more of a concern on higher speed roads where seal width is important for road safety, the severity values were lowered to indicate a higher level of service for regional and primary distributors. For urban roads, edge break can affect the flow of water to the kerb and channel or pavement shoulders, thereby affecting the drainage of surface water.

Table 3.12: Severity values (mm) for edge break index curves

Defect index rating		Access roads	Local distributor	Distributor B	Distributor A	Regional distributor	Primary distributor
		1	2	3	4	5	6
0–1	Very good	0–25	0–25	0–25	0–25	0–15	0–15
1–2	Good	>25–75	>25–75	>25–75	>25–75	>15–50	>15–50
2–3	Fair	>75–150	>75–150	>75–150	>75–150	>50–100	>50–100
3–4	Poor	>150–250	>150–250	>150–250	>150–250	>100–200	>100–200
4–5	Very poor	>250	>250	>250	>250	>200	>200

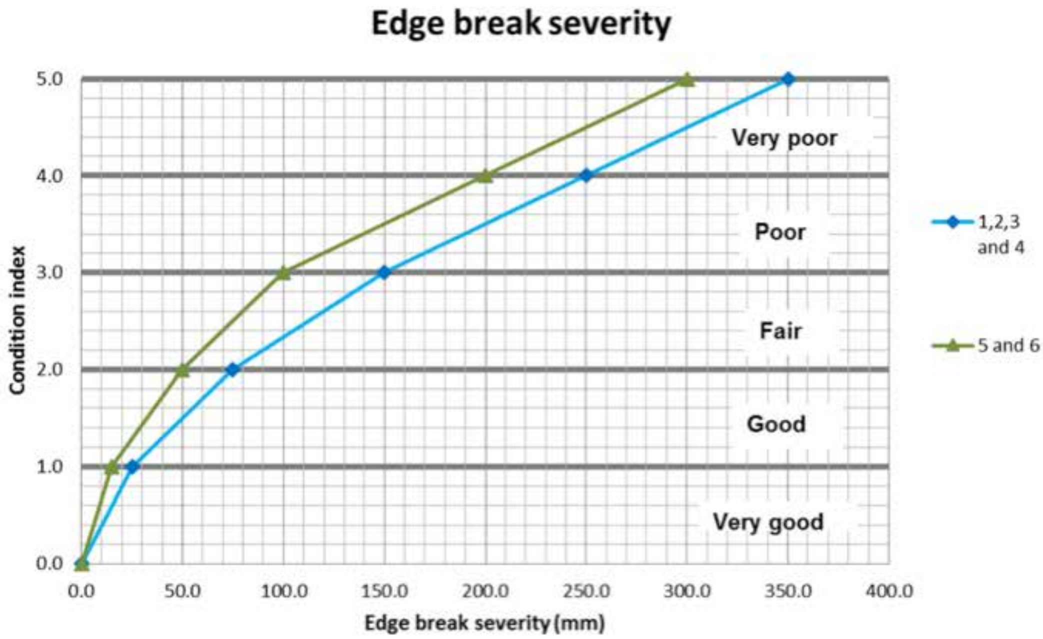


Figure 3.12: Edge break severity index curves for different road hierarchies

3.10 Edge Drop Off

The edge drop off index is based on the extent (% length affected) and average severity (average drop off of edge) within the treatment length. An individual index is produced for both extent and severity of edge drop off. The formulation of defect curves for extent and severity are described below.

3.10.1 Extent

The extent represents the length of the surface edge and shoulder interface displaying edge drop off of greater than 15 mm on both sides of the road.

Table 3.13 shows the extent values that represent the index ranges for edge drop off and Figure 3.13 shows the corresponding index curve.

The extent values prescribed in the manual were assigned to all road classes as edge drop off presents a safety issue.

Table 3.13: Extent values (%) for edge drop off index curve

Defect index rating		Access roads	Local distributor	Distributor B	Distributor A	Regional distributor	Primary distributor
		1	2	3	4	5	6
0–1	Very good	0-5	0-5	0-5	0-5	0-5	0-5
1–2	Good	>5-10	>5-10	>5-10	>5-10	>5-10	>5-10
2–3	Fair	>10-15	>10-15	>10-15	>10-15	>10-15	>10-15
3–4	Poor	>15-25	>15-25	>15-25	>15-25	>15-25	>15-25
4–5	Very poor	>25	>25	>25	>25	>25	>25

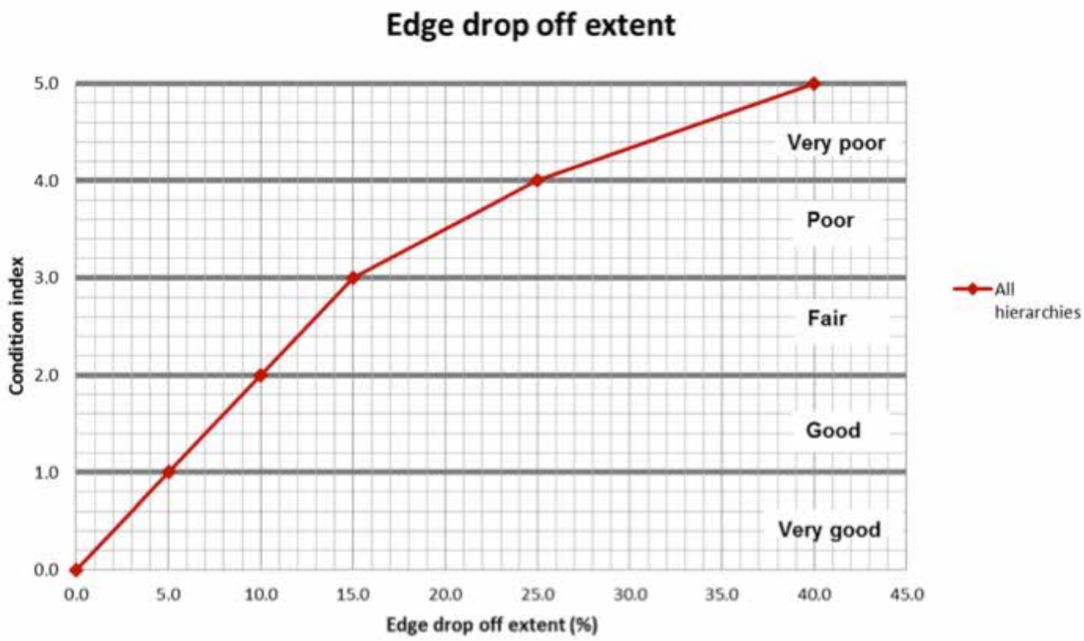


Figure 3.13: Edge drop off extent index curve for different road hierarchies

3.10.2 Severity

The average severity represents the average edge drop off height (mm) of all edge drop off observations along the treatment length. Table 3.14 shows the severity values that represent index ranges for edge drop off and Figure 3.14 shows the corresponding index curves.

The severity values chosen were based on two sources - *Road safety engineering risk assessment: Part II* (Austroads 2010) and *Safety impacts of pavement edge drop offs* (AAA Foundation 2006) done by AAA foundation and Federal Highway Administration (FHWA). The Austroads guide indicates that a drop off height of 75 mm increases crash risk while the AAA Foundation report recommends an intervention is required when drop off height reaches 2 inches (~50 mm). The same edge drop off height values were assigned to all road classes as it presents a safety issue.

Table 3.14: Severity values (mm) for edge drop off index curve

Defect index rating		Access roads	Local distributor	Distributor B	Distributor A	Regional distributor	Primary distributor
		1	2	3	4	5	6
0–1	Very good	0–15	0–15	0–15	0–15	0–15	0–15
1–2	Good	>15–30	>15–30	>15–30	>15–30	>15–30	>15–30
2–3	Fair	>30–50	>30–50	>30–50	>30–50	>30–50	>30–50
3–4	Poor	>50–75	>50–75	>50–75	>50–75	>50–75	>50–75
4–5	Very poor	>75	>75	>75	>75	>75	>75

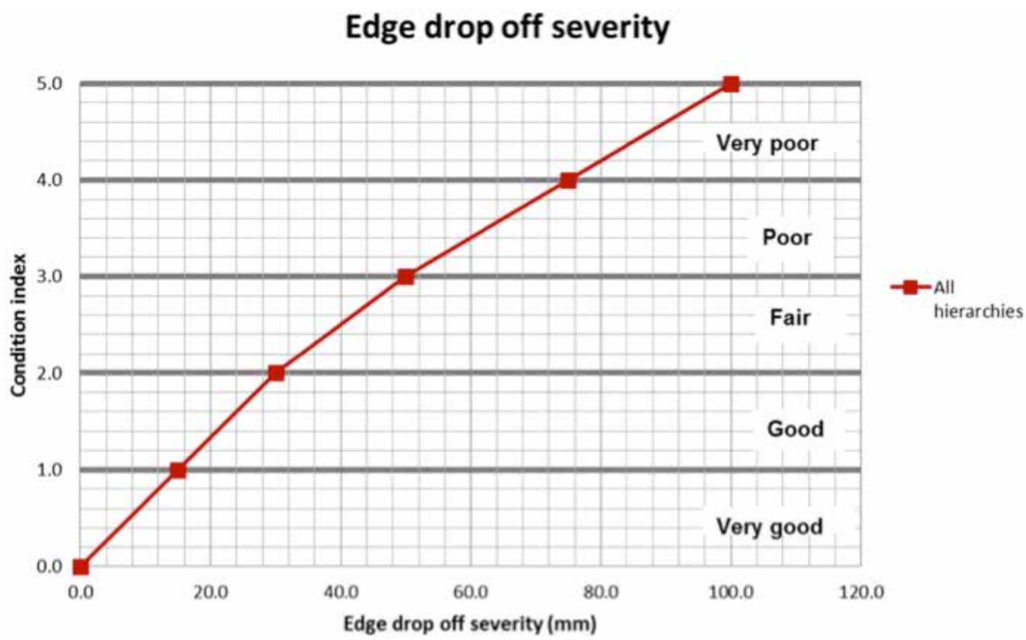


Figure 3.14: Edge drop off severity index curve for different road hierarchies

3.11 Kerb Defects

The kerb defects index is based on the extent (% of length with inadequate kerb), severity and height within the treatment length. An individual index is produced for the extent of kerb defects. Kerb severity and height are assessed on a 1 to 5 rating hence no conversion is required to produce the index curve. The formulation of defect curves for extent is described below.

3.11.1 Extent

The extent of kerb defects index represents the unacceptable amount of defects or inadequate height which is determined by measuring the total length of inadequate kerb on both sides of the treatment length and expressing this as a percentage of the total treatment length surveyed.

Table 3.15 shows the extent values that represent the index ranges for the kerb defect index and Figure 3.15 shows the corresponding index curve.

The extent values prescribed in the manual were assigned to all road classes as kerb defects present a safety issue and affect the water flow.

Table 3.15: Extent values (%) for kerb defects index curve

Defect index rating		Access roads	Local distributor	Distributor B	Distributor A	Regional distributor	Primary distributor
		1	2	3	4	5	6
0–1	Very good	0-5	0-5	0-5	0-5	0-5	0-5
1–2	Good	>5-10	>5-10	>5-10	>5-10	>5-10	>5-10
2–3	Fair	>10-15	>10-15	>10-15	>10-15	>10-15	>10-15
3–4	Poor	>15-25	>15-25	>15-25	>15-25	>15-25	>15-25
4–5	Very poor	>25	>25	>25	>25	>25	>25

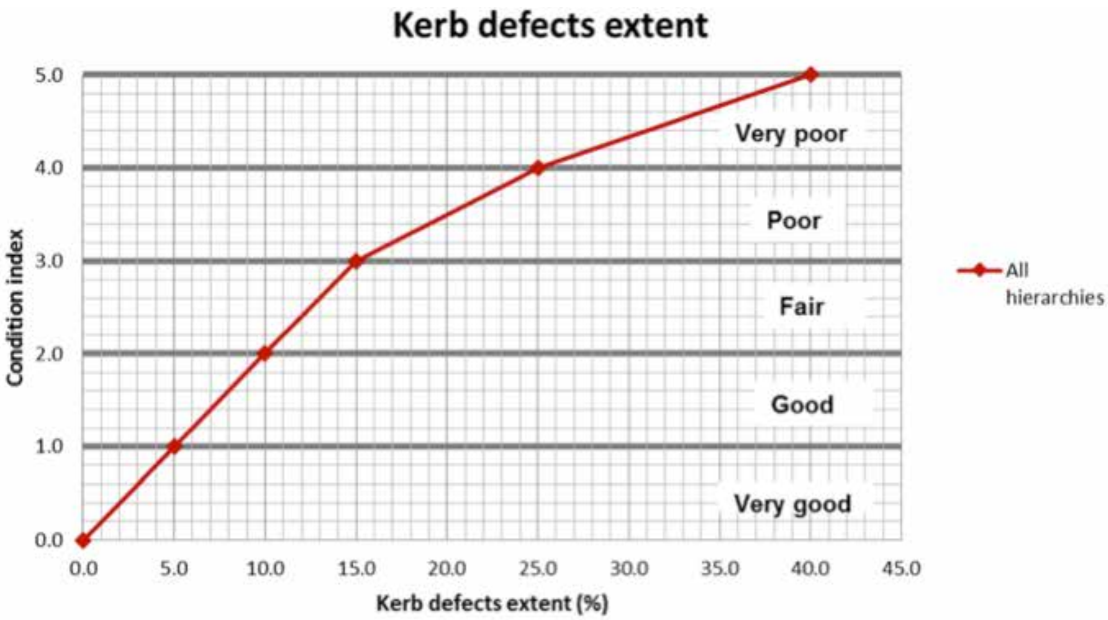


Figure 3.15: Kerb defects extent index curve for different road hierarchies

3.11.2 Severity

Kerb severity is recorded on a 1 to 5 rating. The rating is not related to the road hierarchy and so the rating is used directly to calculate the index.

3.11.3 Height

Similarly, kerb height is recorded on a 1 to 5 rating. The rating is not related to the road hierarchy and so the rating is used directly to calculate the index.

3.12 Unsealed Shoulders

Unsealed shoulder data is recorded as a rating of 1 to 5. It is not linked to road hierarchy and hence no conversion is required to produce an index curve. The ratings from the treatment length summary table are used directly as the index for unsealed shoulders condition.

3.13 Table Drains

Table drain data is recorded as a rating of 1 to 5. It is not linked to road hierarchy hence no conversion is required to produce an index curve. The ratings from the treatment length summary table are used directly as the index for table drains.

4. Linkage With Roman II Database

Table 4.1 shows the link between the specified defect parameters for formulating the RCI and RAMM data fields currently available.

Table 4.1: Defect parameters and corresponding RAMM fields

Defect parameter	RAMM field to be used
Localised surface defects (extent)	**local_surface_defects_avg_pct** (modified to now include unsuccessful patches, localised rutting or cracking, and localised shoving, corrugations and depressions)
Rut depth (severity)	**rutting_severity_avg_mm** or **hsd_rutting_avg** (if high speed data is available)
Pavement undulations (degree and extent)	Currently there is no field that stores pavement undulations. New fields will be used once created for degree and extent of pavement undulations
Patches (extent)	**patches_extent_avg_pct**
Cracking – structural (extent)	Currently linked to **crack_extent_avg_pct** and if crack type (**crack_type_ls**) is crocodile cracking. New field will be used once created for extent of structural cracking as a percentage of total treatment length area (includes crocodile)
Cracking – structural (severity)	Currently linked to **crack_severity_avg_pct** and if crack type (**crack_type_ls**) is crocodile cracking. New field will be used once created for severity of structural cracking in treatment length (includes crocodile)
Cracking – non-structural (extent)	Currently linked to **crack_extent_avg_pct** and if crack type (**crack_type_ls**) is not crocodile cracking. New field will be used once created for extent of non-structural cracking as a percentage of total treatment length area (includes longitudinal, diagonal, transverse and meandering cracking)
Cracking – non-structural (severity)	Currently linked to **crack_severity_avg_pct** and if crack type (**crack_type_ls**) is not crocodile cracking. New field will be used once created for severity of non- structural cracking in treatment length (includes longitudinal, diagonal, transverse and meandering cracking)
Potholes (extent)	Currently there is no field that stores potholes. New field will be used once created for extent of potholing as a percentage of total treatment length area
Surface deficiencies (extent)	Currently only **stripping_avg** and to some extent **asphalt_condition_avg** and **binder_stone_avg** stores data regarding surface deficiencies. New field will be used once created for extent of surface deficiencies as a percentage of total treatment length area (includes delamination, flushing, polishing, ravelling and stripping)
Edge break (average severity)	**edge_severity_avg**
Edge break (extent)	Currently there is no field that stores edge break extent. A new field will be used, once created for extent of edge break as a percentage of total treatment length area
Edge drop off (average severity)	Currently there is no field that stores edge drop off average severity. New field will be used once created for average severity of edge drop.
Edge drop off (extent)	Currently there is no field that stores edge drop off extent. New field will be used once created for extent of edge drop as a percentage of total treatment length area
Unsealed shoulders	Currently no field is available for unsealed shoulders within RAMM. New field will be used once created for unsealed shoulder condition based on a rating of 1–5 measuring the width and shape of the shoulder
Kerb defects (severity, extent and height)	Currently there is no field that stores severity, extent and height of kerb defects separately. New fields will be used once created for severity, extent and height of kerb defects
Table drain	The average of **left_drain_avg** and **right_drain_avg**

5. Overall Composite Index Formulation

5.1 Composite Indices

In order to provide an overall high-level report of the network, the individual indices were then categorised and three overarching composite indices developed. These indices – structural, surface and drainage condition – represent the network as a whole based on condition assessments conducted in the field.

5.1.1 Structural condition index

The structural condition index is used to indicate the structural condition of the pavement, and may be used as a network-level indicator to identify whether further investigation into the need for structural works is warranted. The structural condition index is comprised of:

- structural cracking, (severity and extent combined)
- rut depth
- pavement undulation (degree and extent combined).

5.1.2 Surface condition index

The surface condition index is used to determine the overall condition of the pavement surfacing. The surfacing condition index is comprised of the following defect indices:

- local surface defects
- patches
- potholes
- non-structural cracking (severity and extent combined)
- surface deficiencies.

5.1.3 Drainage condition index

The drainage condition index is intended to be used as an indication of adequate seal width and ability to drain surface water off the pavement to avoid water ingress. This is used for both rural and urban sealed networks. The drainage condition index is comprised of the following defect indices:

- edge break (severity and extent combined) – applicable for both urban and rural networks
- edge drop off (severity and extent combined) – only applicable for rural roads
- unsealed shoulders – only applicable for rural roads
- kerb defects (severity, height and extent combined) – only applicable for urban roads
- table drains – only applicable for rural roads.

5.2 Formulation of Composite Indices

The composite indices described above were formulated using the advanced maximum method, based on the findings published by COST (European Cooperation in Science and Technology) in 2008, regarding standardised pavement performance indicators across Europe. The formula used by the advanced maximum method is shown in Equation1:

$$CI = MIN\ [5,\ MAX\ [All\ indices] + p \times \frac{\sum All\ indices - MAX\ [All\ indices]}{Number\ of\ Indices - 1}$$

where:

CI = composite index incorporating multiple defect indices

p = influence factor, typically 0.1 - 0.3 used to determine the contribution to the CI from other parameters other than the worst parameter, a default value of 0.1 will be used

The advanced maximum method (Equation 1) emphasises the component in the worst condition, thus indicating the criticality of the worst condition. This method is particularly practical for assessing risk, as the critical property will be highlighted and emphasised, whereas a purely weighted average of all condition indices may conceal problems and present pavements in better condition than they really are.

The influence factor p enables control of the total influence of the other indices. A higher p factor increases the influence of the other indices than the maximum one. A default value of 0.1 was chosen for this application.

The purpose of the influence factor is outlined in the following example. If only the maximum value will be used for the combination procedure and no influence of the other weighted single performance indices is given, then a section with rutting in 'poor' condition and cracking in 'very good' condition will be similar to a section with both rutting and cracking in 'poor' condition. There will be no difference in the value of the composite index derived.

Using the advanced maximum method, the composite indices derived for structural, surface and drainage condition allows LGs to monitor the performance of their network in each of these areas based on the critical conditions.

APPENDIX A1 – RCI Calculation Examples

A.1 Introduction

The examples of structural condition indices below have been developed to assist practitioners in the understanding the RCI calculation process. For simplicity the examples are based on a small number of assumed data. Non-structural and drainage; individual and composite condition indices are calculating in a similar manner.

A.2 Calculations

For this example it was assumed that as part of a data collection exercise the following condition information was observed on the network, Table A.1. The observations are in accordance with the treatment length noted in RAMM. For this example the treatment lengths are simply noted as segments 1 through to segment 7.

Table A.1: Observed condition in field

Treatment length	Pavement undulations		Rutting	Structural cracking	
	Degree	Extent (%)	Severity (mm)	Severity (mm)	Extent (%)
1	Slight	0 to 15	5 to 10	2 to 4	5 to 10
2	Slight	15 to 30	5 to 10	2 to 4	5 to 10
3	Slight	0 to 15	20 to 30	2 to 4	5 to 10
4	Slight	0 to 15	5 to 10	2 to 4	10 to 20
5	Slight	0 to 15	5 to 10	2 to 4	10 to 20
6	Slight	0 to 15	10 to 20	2 to 4	5 to 10
7	Slight	0 to 15	10 to 20	2 to 4	5 to 10

Based on these observations, the condition is recorded (in the field) using Appendix A from the manual and as noted in Table A.2.

Table A.2: Field condition report

Treatment length	Pavement undulations		Rutting	Structural cracking	
	Degree	Extent (%)	Severity (mm)	Severity (mm)	Extent (%)
1	1	2	2	3	3
2	1	3	2	3	3
3	1	2	4	3	3
4	1	2	2	3	4
5	1	2	2	3	4
6	1	2	3	3	3
7	1	2	3	3	3

In calculating the indices, the advanced maximum method is applied. In the case of individual indices it is first necessary to determine the worst case condition for each of the data points. For example an extent rating of 2 for pavement undulations represents a range of 0 to 15% of the area affected. As a single value is required by the process, it is recommended that the upper bound of the range is adopted, and in this example the maximum (15%) would be adopted when determining the RCI. Table A.3 lists the maximum values used in this example.

Table A.3: Maximum condition rating, worst case

Treatment length	Pavement undulations		Rutting	Structural cracking	
	Degree	Extent (%)	Severity (mm)	Severity (mm)	Extent (%)
1	1	15	10	4	10
2	1	30	10	4	10
3	1	15	30	4	10
4	1	15	10	4	20
5	1	15	10	4	20
6	1	15	20	4	10
7	1	15	20	4	10

The worst case condition rating noted (Table A 3) is then coupled with the road hierarchy by treatment length as noted in Table A.4.

Table A.4: Road hierarchy added

TL	Road Hierarchy	Pavement undulations		Rutting	Structural cracking	
		Degree	Extent (%)	Severity (mm)	Severity (mm)	Extent (%)
1	Access	1	15	10	4	10
2	Access	1	30	10	4	10
3	Access	1	15	30	4	10
4	Access	1	15	10	4	20
5	Dist. A	1	15	10	4	20
6	Access	1	15	20	4	10
7	Dist. B	1	15	20	4	10

Utilising the RCI graphs it is then possible to determine the individual RCI indices. For example, treatment length 1 has a pavement undulations extent (maximum) of 15% and is classified as an access road. Therefore by utilising Figure A.1, the condition along the X axis is selected as 15% (Table A.4) then the corresponding index is determined by moving up the chart until the intersection of the blue line (access roads and local distributor) yields the RCI which in this example is 1. Table A.5 represents the RCI indices based on the road hierarchy and field observations.

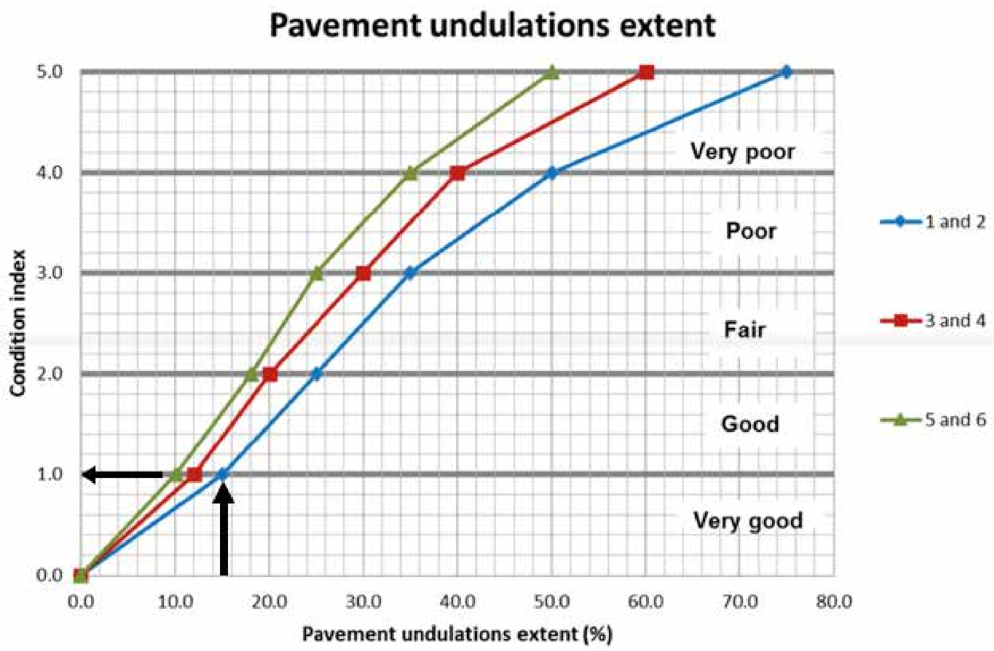


Figure A.1: Condition index for and access road with a pavement undulations extent of 15%

Table A.5: Calculated RCI

TL	Road Hierarchy	Pavement undulations		Rutting	Structural cracking	
		Degree	Extent (%)	Severity (mm)	Severity (mm)	Extent (%)
1	Access	1	1	1	3	1
2	Access	1	2.5	1	3	1
3	Access	1	1	5	3	1
4	Access	1	1	1	3	3
5	Dist. A	1	1.4	1.5	3	4
6	Access	1	1	3	3	1
7	Dist. B	1	1.4	4	3	1.5

To calculate the individual structural condition index by treatment length equation 1 is applied. For example, in the case of treatment length 1, the SCI is calculated as outlined in Table A.6.

Table A.6: SCI for treatment length 1

∑ All indices	7	
MAX [All indices]	3	
Number of indices	5	
Number of indices – 1	4	
$\frac{\sum \text{All indices} - \text{MAX [All indices]}}{\text{Number of indices} - 1}$	1	
$0.1 * \frac{\sum \text{All indices} - \text{MAX [All indices]}}{\text{Number of indices} - 1}$	0.1	A
MAX [All indices]	3	B
$\text{MAX [All indices]} + 0.1 * \frac{\sum \text{All indices} - \text{MAX [All indices]}}{\text{Number of indices} - 1}$	3.1	B+A
MIN [5 or B+A above]	3.1	
Structural condition index	3.1	

Utilising equation 1 Table A.7 summarises the structural condition indices by treatment length.

Table A.7: Structural condition indices by treatment length

Treatment length	Road Hierarchy	Structural condition index
1	Access	3.1
2	Access	3.1
3	Access	5.0
4	Access	3.2
5	Dist. A	4.2
6	Access	3.2
7	Dist. B	4.2

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