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Rural Flexible Roads Manual

Pavement Surface Condition Index

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Table of Contents

Acknowledgements	2
Table of Contents.....	3
Section 1: Introduction	4
Section 2: Pavement Distress – Flexible Pavements	5
Surface Defects.....	6
Ravelling	6
Bleeding.....	8
Pavement Deformation	10
Rutting	10
Surface Distortion.....	11
Cracks	13
Alligator Cracking	13
Edge Breakup/Cracking	15
Other Cracking.....	18
Surface Openings.....	20
Patching.....	20
Potholes.....	22
Road Disintegration	23
Section 3: Rating Pavement Condition.....	24
Table 1: The PSCI Rating System.....	25
Rating 10.....	26
Rating 9.....	27
Rating 8.....	29
Rating 7.....	30
Rating 6.....	33
Rating 5.....	35
Rating 4.....	37
Rating 3.....	39
Rating 2.....	41
Rating 1.....	42
Section 4: Practical Advice on Rating Roads.....	44
Inventory and Field Inspection	44
Averaging and Comparing Sections	44
Section 5: Conclusions and Next Steps	45
Table 2: Treatment Measures	46
Section 6: Bibliography	47

Section 1: Introduction

A major function of a local authority is to use public funds to provide a comfortable, safe and economical road surface. This requires balancing priorities and making difficult decisions in order to manage pavements. Many local pavement networks are often managed informally, based solely on the staff's judgment and experience. While this process is both important and functional, using a slightly more formalised technique can make it easier to manage pavements effectively.

Experience has shown that there are three especially useful steps in managing local roads:

1. Inventory all local roads.
2. Periodically evaluate the condition of all pavements.
3. Use the condition evaluations to set priorities for projects and select appropriate treatments.

A comprehensive pavement management system involves collecting data and assessing several road characteristics: roughness (ride), surface distress (condition), surface skid resistance and structure (pavement strength and deflection). Managers can combine this condition data with economic analysis to develop short-range and long-range plans for a variety of budget levels. However, many local agencies lack the resources for such a full-scale system.

Since surface condition is the most vital element in any pavement management system, local agencies can use the simplified Pavement Surface Condition Index (PSCI) rating system presented in this Rural Flexible Roads Manual to evaluate their roads. The Flexible Roads ratings combined with other inventory data (width, length, shoulder, pavement type, etc.) can be very helpful in planning future budgets and priorities.

The PSCI condition rating system in this manual has been designed with a number of objectives in mind. It should be simple to understand and implement by a wide range of survey personnel. No prior experience in pavement rating should be necessary to carry out the rating procedure. The PSCI rating system in Table 1 and Section 3 of this manual should be based only on visual pavement distresses. The impact of surface-related distresses, structural-related distresses and other defects on the overall rating system should be identified. The results of the rating system should be relatable to the maintenance treatment categories specified for use on Non-National roads by the Department of Transport, Tourism and Sport (DTTAS). Table 2 in Section 5: Conclusions and Next Steps of this manual summarises the overall relationships between these factors.

This Manual is designed to improve the data collection and quality of visual surveying of non-national roads within the local authorities of the Republic of Ireland. Substantial use was made of the template provided by the Pavement Surface Evaluation and Rating (PASER) manuals produced by the Transportation Information Center at the University of Wisconsin-Madison.

Section 2: Pavement Distress – Flexible Pavements

This manual uses visual inspection to evaluate pavement surface conditions. The key to a useful evaluation is identifying different types of pavement distress and linking them to a cause. Understanding the cause for current conditions is extremely important in selecting an appropriate maintenance or rehabilitation technique.

Deterioration has three general modes. These are

- Environmental deterioration due to weathering and aging
- Structural deterioration caused by repeated traffic loading
- Deterioration due to unsuitable materials (e.g. consolidation of subgrade, subsidence).

Pavement deterioration will result from contributions by one or more of the modes. It is important to try to determine the relative contributions in order to select the most effective rehabilitation techniques. The rate at which pavement deteriorates depends on its environment, traffic loading conditions, original construction quality and interim maintenance procedures. Poor quality materials or poor construction procedures can significantly reduce the life of a pavement. As a result, two pavements constructed at the same time may have significantly different lives, or certain portions of a pavement may deteriorate more rapidly than others. On the other hand, timely and effective maintenance can extend a pavement's life. Crack sealing and surface dressing can reduce the effect of moisture on weakening of flexible road pavements.

With all of these variables it is easy to see why pavements deteriorate at various rates and why we find them in various stages of disrepair. Recognising defects and understanding their causes helps us rate pavement condition and select cost-effective repairs. The pavement defects shown on the following pages provide a background for this process. Some defects are localised while others indicate that problems may develop throughout the pavement. It is important to distinguish between local and widespread defects. Assessing the conditions of actual roadways also involves looking for combinations of these individual defects.

There are four major categories of common road surface defects on rural flexible roads:

Surface Defects

Ravelling
Bleeding

Pavement Deformation

Rutting
Surface Distortion

Cracks

Alligator Cracking
Edge Cracking and Breakup
Other Cracking (longitudinal, transverse, reflection, slippage, etc.)

Surface Openings

Patching
Potholes
Road Disintegration

Periodic inspection is necessary to provide current and useful evaluation data. It is recommended that Flexible Road ratings be updated every two years, and an annual update is even better.

SURFACE DEFECTS

Ravelling

Ravelling is progressive loss of binder and aggregate chippings from the pavement surface. Ravelling can be caused by stripping of the bituminous film from the aggregate, binder hardening due to aging, poor compaction especially in cold weather construction, insufficient binder content or poor quality aggregate. In addition, ravelling can be caused by the action of tracked vehicles or oil spillage.



Moderate Ravelling. Small aggregate particles have worn away exposing tops of large aggregate.



Severe Ravelling. Most of the new surface has been lost, exposing the older surface beneath.

SURFACE DEFECTS

Ravelling



Moderate Ravelling evident in wheelpaths.



Loss of surface material at the edge of the road. This is ravelling, not edge breakup.

SURFACE DEFECTS

Bleeding

Bleeding or fatting up is a film of excess bituminous material on the pavement surface which creates a shiny reflective surface that usually becomes sticky in hot weather. In surface dressings, it is usually caused by excessive embedment of the chippings or too high a rate of spread of the binder. Repair by the application of a properly designed surface treatment to restore adequate skid resistance or thin overlay if additional strength is required.



Bleeding/Fatting-up of binder needs repair.



Bleeding. Dark, shiny areas extending along the wheelpaths.

SURFACE DEFECTS

Bleeding



Bleeding. Dark, shiny areas show where binder has worked to surface.

PAVEMENT DEFORMATION

Rutting

Rutting is a permanent longitudinal deformation in the wheel paths caused by traffic loading. It occurs due to the displacement of material, creating channels in the wheel paths. Some uplift may also occur along the sides of the rut. It is caused by traffic compaction or sideways movement of unstable material. Severe rutting (over 50mm) may be caused by base or subgrade consolidation. It is a form of structural failure caused by repeated traffic loading.



Severe Rutting over 50mm in depth evident in wheel path.



Severe Rutting caused by poor base or subgrade problems.

PAVEMENT DEFORMATION

Surface Distortion

All permanent surface deformation, with the exception of rutting, is identified as surface distortion. Rutting is a permanent longitudinal deformation in the wheel paths caused by traffic loading.

Surface distortion can be caused by poor construction, improper mix design or settlement of the subgrade. Distortion includes depressions or sags which are defined as small abrupt downward displacements producing flat irregular shaped basins. Other pavement distortions maybe caused by shoving, settling, frost heave etc. with longer wavelengths. Surface distortions are not caused by traffic loading. This distress can have a significant effect on driver and passenger comfort. Moderate surface distortion will reduce the driver comfort speed to less than 50 km/hr. Severe surface distortion will reduce the driver comfort speed to less than 30 km/hr.



Significant depression visible in concentrated area.



Depression in subsided area.

PAVEMENT DEFORMATION

Surface Distortion



Surface Distortion (note road marking on left edge).



Surface deformation and shape problems (note road marking on left edge for reference).

Alligator Cracking

Alligator cracking is a series of interconnected cracks forming small, many-sided, sharp-angled polygons ranging in size from about 25mm to 125mm resembling chicken wire or the skin of an alligator. It's caused by fatigue failure of the surface due to traffic loading and very often also due to inadequate base or subgrade support.

Alligator cracking may comprise;

- Fine, longitudinal hairline cracks running parallel to each other and with none or only a few interconnecting cracks. There is no spalling which is a breakdown of material along the sides of a crack.
- A pattern of parallel and interconnecting cracks that may be lightly spalled.
- A well-defined pattern of interconnected polygon shaped cracks which are spalled at the edges. Some pieces may appear to be loose or may appear to rock under traffic.

Repair by excavating localised areas and replacing base and surface. Large areas require overlay or reconstruction. Improvements in drainage may often be required.



Characteristic “Chicken wire” crack pattern shows smaller pavement pieces and patching.

Alligator Cracking



Open alligator cracking with settlement along lane edge most likely due to very weak subgrade.



Wide area of alligator cracking.

Edge Breakup/Cracking

Edge breakup can be caused by inadequate pavement width, inadequate lateral support to the pavement, moisture penetration, poor drainage or frost action. It is accelerated by repeated traffic loading. Edge breakup is identified as

- Any singular or multiple cracking within 300 mm of the pavement edge.
- Pavement edge showing considerable breakup with some portions of the edge having been removed.
- Breakup of the pavement edge including a mix of potholing, cracking and patching along the pavement edge.

Edge breakup differs from loss of surface (Ravelling) at the pavement edge as it is a structural distress caused by traffic loading. Edge breakup can be distinguished from Ravelling by the presence of cracking and loss of some or all the underlying pavement layers at the pavement edge.

Multiple longitudinal cracks in the pavement edge indicate a need for strengthening with an overlay or reconstruction.



Edge Breakup identified by cracking at the edge of the road pavement.

Edge Breakup/Cracking



Edge Breakup at the edge of the road pavement.



Edge breakup/cracking and material loss from weakened subbase and traffic loads.

Edge Breakup/Cracking



Multiple cracking within 300 mm of the pavement edge.



Potholes and loss of pavement material along the pavement edge.

Other Cracking

Longitudinal cracks are parallel to the pavement centreline. Transverse cracks extend across the pavement at approximately right angles to the pavement centreline and are often regularly spaced. Transverse cracking at regular, short intervals will often be seen on boggy ground.

These types of cracking can be caused by reflection cracking from cracking or joints in the underlying pavement layers or by movement of the underlying layers due to moisture penetration, temperature changes, binder hardening due to aging or traffic loading. The crack edges can further deteriorate by ravelling, eventually eroding the adjacent pavement.

Other cracking also includes Slippage cracking which are crescent or rounded cracks. They are caused by slippage between an overlay and the underlying pavement due to a low-strength surface mix or poor bond. Slippage is most likely to occur at areas where traffic is stopping and starting, turning or braking.



Regular pattern of transverse cracking – bleeding also evident in the wheelpaths.

Other Cracking



Slippage cracking with underlying stability problems.



Combined Transverse and Longitudinal cracking.

SURFACE OPENINGS

Patching

A patch is an area of pavement which has been replaced with new material to repair the original pavement. This indicates a pavement defect or utility cut excavation which has been repaired. Patches with cracking, settlement or distortions indicate underlying causes still remain. Patches may be in good condition and performing satisfactorily, moderately deteriorating or badly deteriorating with other defects in the patched area and in need of replacement.



Typical patching repair of utility excavation.



Large patching in reasonably good condition.

SURFACE OPENINGS

Patching



Extensive patching in very poor condition.



Very Poor/failed Patching with potholes and structural distress evident.

SURFACE OPENINGS

Potholes

Potholes are bowl-shaped depressions where part of the pavement has been removed, exposing the underlying layer(s). They are produced when cracking or some other defect allows moisture to penetrate the pavement surface, which is subjected to repeated traffic loading. This results in disintegration of the surface and the progressive removal of the underlying material. This is often combined with poor drainage. Repair by excavating or rebuilding localised potholes as well as localised surface dressing/overlay of repaired areas. Reconstruction required for extensive defects.



Large isolated pothole, extends through base. Note adjacent alligator cracks which commonly deteriorate into potholes.



Reoccurring potholes due to poor patching work.

SURFACE OPENINGS

Road Disintegration

Road disintegration is identified in two primary forms;

- Loss of road surface resulting in unbound surfacing materials (gravel or stone).
- Breakup of road into craters with less than 50% of the road width available to road traffic. The road is no longer passable at speeds above walking pace.



Road not passable by vehicles at speeds above walking pace. Damage to vehicle may occur.



Disintegration of road resulting in exposure of subbase materials.

Section 3: Rating Pavement Condition

Table 1 on the following page outlines the PSCI rating system for rating pavement condition. With an understanding of surface defects, structural distresses and other pavement defects, you can evaluate and rate flexible pavement surfaces. **Surface defects** comprise ravelling and bleeding; **Structural distresses** (i.e. load-related) include rutting, alligator cracking, edge cracking and breakup, potholes, poor/failed patching and road disintegration; while **Other pavement defects** include other cracking (longitudinal, transverse reflection and slippage cracking), good/fair patching and surface distortion.

The PSCI rating scale ranges from 10 for a pavement in excellent condition to 1 for a pavement in failed condition. Most pavements will deteriorate through the phases listed in the rating scale. The time it takes to go from excellent condition (10) to complete failure (1) depends largely on the quality of the original construction and the amount of heavy traffic loading.

Once significant deterioration begins, it is common to see the pavement decline rapidly. This is usually due to a combination of loading and the effects of additional moisture. As a pavement ages and additional cracking develops, more moisture can enter the pavement and accelerate the rate of deterioration.

Look at the photographs in this section to become familiar with the descriptions of the individual rating categories. To evaluate an individual pavement segment, first determine its general condition. Is it relatively new, toward the top end of the scale? Is it in very poor condition and at the bottom of the scale? Or somewhere in-between?

Finally, review the individual pavement distresses and using the primary rating indicators and secondary rating indicators given in Table 1, select the appropriate PSCI surface rating category for the pavement segment.

Individual pavements will not have all of the types of distress listed for any particular rating. They may have only one or two types.

Table 1: The PSCI Rating System

Overall PSCI Rating	Primary Rating Indicators*	Secondary Rating Indicators*
10	No Visible Defects.	Road surface in perfect condition.
9	Minor Surface Defects¹. Ravelling or Bleeding <u>≤10%</u> .	Road surface in very good condition.
8	Moderate Surface Defects¹. Ravelling or Bleeding <u>10% to 30%</u> .	Little or No Other defects.
7	Extensive Surface Defects¹. Ravelling or Bleeding <u>≥ 30%</u> .	Little or No Other defects. Old surface with aged appearance.
6	Moderate Other Pavement Defects². Other Cracking <u>≤ 20%</u> . Patching generally in Good condition. Surface Distortion requiring some reduction in speed.	Surface defects ¹ may be present. No structural distress ³ .
5	Significant Other Pavement Defects². Other Cracking <u>> 20%</u> . Patching in Fair condition. Surface Distortion requiring reduction in speed.	Surface defects ¹ may be present. Very localised structural distress³ (<u>< 5 m²</u> or a few isolated potholes).
4	Structural Distress³ Present. Rutting, Alligator Cracking or Poor Patching for <u>5% to 25%</u> . Short lengths of Edge Breakup/Cracking. Frequent Potholes.	Other defects may be present.
3	Significant Areas of Structural Distress³. Rutting, Alligator Cracking or Poor Patching for <u>25% to 50%</u> . Continuous lengths with Edge Breakup/Cracking. More frequent Potholes.	Other defects may be present.
2	Large Areas of Structural Distress³. Rutting, Alligator Cracking or Very Poor Patching for <u>≥ 50%</u> . Severe Rutting (<u>≥ 75mm</u>). Extensive Very Poor Patching. Many Potholes.	Very difficult to drive on.
1	Extensive Structural Distress³. Road Disintegration of surface. Pavement Failure. Many large and deep Potholes. Extensive Failed Patching.	Severe Deterioration. Virtually undriveable.

* Individual pavements will not have all the types of distress listed for any particular rating.
They may have only one or two types.

Note 1: Surface Defects = Ravelling or Bleeding.

Note 2: Other Pavement Defects = Other Cracking (longitudinal, transverse, reflection or slippage), Surface Distortion (Shape problems, depressions/sags, shoving, bumps, settlement or heave), Good/Fair Patching.

Note 3: Structural Distress = Load-related defects comprising Rutting, Alligator Cracking, Edge Breakup/Cracking, Poor/Failed Patching, Potholes or Road Disintegration.

Rating 10

Excellent – Routine Maintenance

Newly constructed or recently overlaid roads are in excellent condition and require routine maintenance.



Rating 10: Road with no visible pavement defects.



Rating 10: New overlay, local road, no defects.

Rating 9

Very Good – Routine Maintenance

Pavements in very good condition with very few visible defects. Newly surface dressed pavements.

Less than 10% of surface with surface defects (ravelling and bleeding). No other defects.



Rating 9: Road recently surfaced, good shape, little or no visible distresses.



Rating 9: Road recently surfaced with some minor loss of chippings.



Rating 9: Recent surface dressing with some minor bleeding.

Rating 8

Good – Restoration of Skid Resistance

This category includes roads which are showing surface defects (ravelling and bleeding) only. Roads with 10 to 30% of surface with surface defects. Little or No Other defects present: No structural distresses (rutting, alligator cracking, edge problems, potholes); No patching and No other cracking. Road shape is very good.



Rating 8: Ravelling, 10% to 30% of surface.



Rating 8: Significant Bleeding, 10% to 30% of surface, note shine off dry road.

Rating 7

Good - Restoration of Skid Resistance

Greater than 30% of surface with surface defects (ravelling or bleeding). Little or No Other defects: No structural distresses (rutting, alligator cracking, edge problems, potholes); No patching; No other cracking present, and road shape is good. This category also includes old roads with aged appearance that need a surface dressing to maintain or restore waterproofing of the pavement surface.



Rating 7: Extensive Ravelling (> 30%) over most of pavement surface.



Rating 7: Extensive Bleeding (> 30%) over most of pavement surface.



Rating 7: Bleeding on greater than 30% of pavement surface.



Rating 7: Old surface, Ravelling > 30% and aged appearance.



Rating 7: Old surface with some ravelling and aged appearance.

Rating 6

Fair – Surface Restoration

Small quantities (< 20%) of other cracking (longitudinal, transverse, reflection, or slippage) may be present. Patching present, generally in good condition. Pavement may be out of shape with some surface distortion present requiring some reduction in driver speed necessary to maintain driver and passenger comfort. Surface defects (ravelling and bleeding) may be present. No structural distresses present (rutting, alligator cracking, edge problems, poor/failed patching or potholes). Localised repair needed before surfacing.



Rating 6: Pavement surface distortion, transverse cracking at regular intervals.



Rating 6: Pavement surface distortion requiring reduction in driver speed, surface defects also present.



Rating 6: Transverse cracking, weak support.



Rating 6: Old surface, surface seal is clearly broken due to transverse cracking, moisture can penetrate the surface. Road in need of surface restoration to restore shape and waterproofing surface layer.

Rating 5

Fair – Surface Restoration

Frequent other cracking present (> 20% of surface). Patching present generally in fair condition. Pavement out of shape with significant surface distortions requiring driver to reduce speed. Some very localised structural distress (rutting, alligator cracking, edge problems, poor/failed patching or potholes) may be present in small quantities (< 5 sq.m of surface or a few isolated potholes). Surface defects (ravelling and bleeding) may be present. The road requires either large quantities of localised repair before surfacing or the road is clearly in need of reshaping with significant driver discomfort.



Rating 5: Loss of Shape, localised repair needed, patching in fair condition.



Rating 5: Surface distortion, transverse cracking, some localised structural distresses.



Rating 5: Extensive Longitudinal and Transverse Cracking, pumping of fines from under surface.

Rating 4

Poor – Structural Overlay

Road shows signs of needing strengthening by structural overlay. Structural distresses are present (rutting, edge problems, alligator cracking, poor/failed patching or potholes). Rutting, alligator cracking or poor patching present (5% to 25% of surface). Short lengths of edge breakup/cracking present. Frequent potholes present. Other defects (ravelling, bleeding, surface distortion or other cracking) may be present.



Rating 4: Rutting, potholes and patching in wheelpath. Structural distresses are clear.



Rating 4: Edge problems, rutting, out of shape and other defects present.



Rating 4: Alligator cracking, rutting, and potholes present.



Rating 4: Alligator cracking, rutting and pothole formation in wheelpath. Structural distresses are clear.

Rating 3

Poor – Structural Overlay

Significant quantities of structural distress present (rutting, edge problems, alligator cracking, poor/failed patching or potholes). Rutting, alligator cracking or poor patching present (25% to 50% of surface). Significant continuous lengths with edge breakup/cracking and loss of material at edges. More frequent potholes. Other defects may be present. Structural overlay required to strengthen road.



Rating 3: Significant alligator cracking over large areas, some potholes and edge problems.



Rating 3: Extensive alligator cracking and structural distress.



Rating 3: Significant alligator cracking and structural problems over large areas.



Rating 3: Edge problems/cracking, alligator cracking, rutting and potholes.

Rating 2

Very Poor – Road Reconstruction

Roads are severely deteriorated and need reconstruction. Very significant quantities of alligator cracking, rutting or very poor patching present (over 50% of surface). Severe rutting (over 75 mm deep). Extensive patching in very poor condition. Many potholes. Very difficult to drive on. Road needs full depth reconstruction with extensive base repair.



Rating 2: Severely deteriorated, extensive patching and structural problems , loss of surfacing in places.



Rating 2: Failed areas, extensive patching in very poor condition, loss of surfacing in places.

Rating 1

Failed – Road Reconstruction

Road layers have completely failed. Severe structural distress with extensive loss of pavement surface. Many large and deep potholes, patching in failed condition. Severe deterioration and virtually undrivable. Road needs full depth reconstruction with extensive base repair.



Rating 1: Entire width of road disintegrated with reconstruction required.



Rating 1: Road surface disintegrated, extensive road failure.



Rating 1: Significant loss of pavement surface, extensive road failure.



Rating 1: Significant loss of pavement surface, Large quantities of severe potholes.

Section 4: Practical Advice on Rating Roads

Inventory and Field Inspection

Most agencies routinely observe roadway conditions as a part of their normal work and travel. However, a road network inspection means looking at the entire roadway system as a whole and preparing a written summary of conditions. This inspection has many benefits over casual observations. It can be helpful to compare segments, and rating decisions are likely to be more consistent because the roadway system is considered as a whole within a relatively short time.

Having a written record and objective information also improves your credibility with the public. Finally a written inventory is very useful in documenting changing roadway conditions. Without records over several years it is impossible to know if road conditions are improving, holding their own, or declining.

Annual budgets and long range planning are best done when based on actual needs as documented with a written inventory.

Averaging and Comparing Sections

For evaluation, divide the local road system into individual segments which are similar in construction and condition. Obviously, no roadway segment is entirely consistent. Also, surfaces in one section will not have all of the types of distress listed for any particular rating. They may have only one or two types. Therefore, some averaging is necessary.

The condition of the full width of the road should be rated. The objective is to rate the condition that represents the majority of the roadway. Small or isolated conditions should not influence the rating. Occasionally surface conditions vary significantly within a short length along the road segment. For example, short sections of good condition may be followed by sections of poor surface conditions. In these cases, it is best to rate the segment according to the worst conditions. It is not necessary to keep track of all changes in road condition if the condition is varying over very short lengths. As a rough guide, a length of at least 200metres is required to justify recording a change in road condition rating category.

The overall purpose of condition rating is to be able to compare each segment relative to all the other segments in your roadway system. On completion you should be able to look at any two pavement segments and find that the better surface has a higher rating.

Within a given PSCI rating, say 6, not all pavements will be exactly the same. However, they should all be considered to be in better condition than those with lower PSCI ratings, say 5. Sometimes it is helpful in rating a difficult segment to compare it to other previously rated segments. For example, if it is better than one you rated 5 and worse than a typical 7, then a rating of 6 is appropriate. Having all pavement segments rated in the proper relative order is most important and useful.

Section 5: Conclusions and Next Steps

Using local road funds most efficiently requires good planning and accurate identification of appropriate rehabilitation projects. Assessing roadway conditions is an essential first step in this process. The Pavement Surface Condition Index (PSCI) rating system in this Rural Flexible Roads Manual has been developed to improve the data collection and quality of visual surveying of non-national roads, and to improve decision making and use of road maintenance funds more efficiently. It can be used directly by local authority officials and staff in the Republic of Ireland. It may be combined with additional pavement testing and data collection in a more comprehensive pavement management system in planning future budgets and priorities.

The PSCI rating system is based only on visual pavement defects. The impact of surface-related defects, structural-related defects and other defects is identified when applying the overall PSCI rating. The results of the rating system should be relatable to the maintenance treatment categories specified for use on Non-National roads by the Department of Transport, Tourism and Sport. Table 2 on the following page summarises the overall relationships between these factors.

Table 2: Treatment Measures

Overall PSCI Rating	Treatment Measures	Surface	Structure
10	Routine Maintenance	Excellent	
9		Very Good	
8	Resealing & Restoration of Skid Resistance	Fair	Good
7		Poor	
6	Surface Restoration — Carry out localised repairs and treat with surface treatment or thin overlay.	Fair	Fair
5		Poor	
4	Structural Overlay — Required to strengthen road. Localised patching and repairs required prior to overlay.	Poor Overall	
3			
2	Road Reconstruction — Needs full depth reconstruction with extensive base repair.	Very Poor Overall	
1		Failed Overall	

Section 6: Bibliography

1. PASER Asphalt Roads Manual, Wisconsin Transportation Information Center, University of Wisconsin-Madison (2002).
2. Non-National Road Pavement Condition Study, Distress Catalogue Descriptions and Rating Procedures (2004).