Mn/DOT Pavement Distress Identification Manual

July 2011

Office of Materials and Road Research
Pavement Management Unit

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BACKGROUND

This manual describes the pavement rating procedures used by the Minnesota Department of Transportation (Mn/DOT) as of 2001. The purpose of the manual is to provide insight into the various types of pavement distress measured by Mn/DOT, the pavement rating indices and how they are calculated.

Mn/DOT's highway system consists of 12,200 centerline miles of pavement. This system consists of bituminous, concrete and composite pavements ranging in condition, age and performance. Each year, the Pavement Management Unit collects condition data on approximately 60 percent of the entire system. This data is used to monitor the performance of the system, to help in the selection of projects and identify pavements that need future maintenance and/or rehabilitation.

Each year, the Pavement Management Unit prepares an annual report summarizing the status of the pavement system. Copies of the annual report are available from the Office of Materials and Road Research, Pavement Management Unit web site:
http://www.mnroad.dot.state.mn.us/pavement/pavmtmgmt/pavemgmt.asp

Mn/DOT Pavement Condition Indices

Mn/DOT's pavement condition data is reduced to three indices, the RQI, SR and PQI. These indices are used to rank pavement sections and for predicting future condition and needs. Each index is reported to the tenths place and is briefly described below.

RQI: Ride Quality Index

The RQI is Mn/DOT's ride or smoothness index. It uses a 0.0 – 5.0 rating scale, the higher the value, the smoother the road. Most new construction projects have an initial RQI slightly over 4.0. Pavements are normally designed for a terminal RQI value of 2.5. This does not mean the road is undrivable at this level but rather that it has deteriorated to a point where most people feel it is uncomfortable to drive and it is need of major rehabilitation.

SR: Surface Rating

The SR is Mn/DOT's crack and surface distress index. It uses a 0.0 – 4.0 rating scale, the higher the number the less cracking is present. A brand new road has a SR of 4.0. As the type, amount and severity of the various defects increase, the SR drops. The pavement distress that make up the SR are determined by two trained raters from the Pavement Management Unit using the criteria contained in this manual.

PQI: The Pavement Quality Index

The PQI is Mn/DOT's overall pavement condition index. It combines the RQI and SR to give an overall performance indicator. It is equal to the square root of the RQI multiplied by the SR and ranges from 0.0 to about 4.5.

PERFORMING PAVEMENT CONDITION SURVEYS

A separate pavement rating is done at specific locations along a roadway as described below:

- Whenever the number of lanes or surface type changes and other intermediate locations as determined by the districts. These locations are designated as D-records (Design Records) in the pavement management system.

- At each Reference Post between D-records except when the reference post is less than 0.3 miles from the D-record or where the district deems a special D-record is needed less than the 0.3 mile guideline. Ratings taken at the reference post locations are designated M-records (Mile Records) in the pavement management system.

For all roadways, crack surveys, for calculating SR, are taken over the first 500 feet beginning at each D-record and M-records in the increasing direction. In addition, a similar rating is done in the decreasing direction on multi-lane roadways.

BITUMINOUS PAVEMENT RATING PROCEDURE

For bituminous surfaced pavements, the following distress types are measured and recorded.

Distress Type	Severity Levels	How to Measurement
Transverse Cracking	Low. Medium, High	Count
Longitudinal Cracking	Low, Medium, High	Lineal Feet
Longitudinal Joint Deterioration	Low, Medium, High	Lineal Feet
Multiple (block) cracking	None	Lineal Feet
Alligator Cracking	None	Lineal Feet
Rutting	None	Lineal Feet
Raveling & Weathering	None	Lineal Feet
Patching	None	Lineal Feet

With the following exceptions, count only the most severe distress in any lineal foot:

- Medium and High severity transverse cracks, raveling/weathering, patching, longitudinal joint cracking and rutting shall be counted in combination with other deficiencies.

- Low severity transverse cracks shall not be counted in the same foot as multiple or alligator cracking.

TRANSVERSE CRACKING

Description

Cracks that are predominantly perpendicular to the pavement centerline.

Severity Levels

LOW
Any crack, at least 6-feet long, running transverse to the centerline of the roadway, including cracks that jog at a junction with a longitudinal crack, with no random cracking. If the crack has been “sawed and sealed” or routed and sealed and the sealant is in good condition it should also be rated as a low severity transverse crack.

MEDIUM
Any crack running transverse to the centerline of the roadway, with adjacent low severity random cracking, less than 12 inches apart. There may also be a small amount of patching or popouts. Cracks that have been repaired with hot mix or slurry materials and are in good condition are also rated as medium severity.

HIGH
Any crack running transverse to the centerline of the roadway with significant adjacent random cracking (12 inches or more apart), have large areas of spalling, missing material and/or potholes.

How to Measure

Record the number of transverse cracks at each severity level. Rate the entire crack at the highest severity level present for at least 10 percent of the total length of the crack.

Figure 1. Low Severity Transverse Crack (no random cracks)

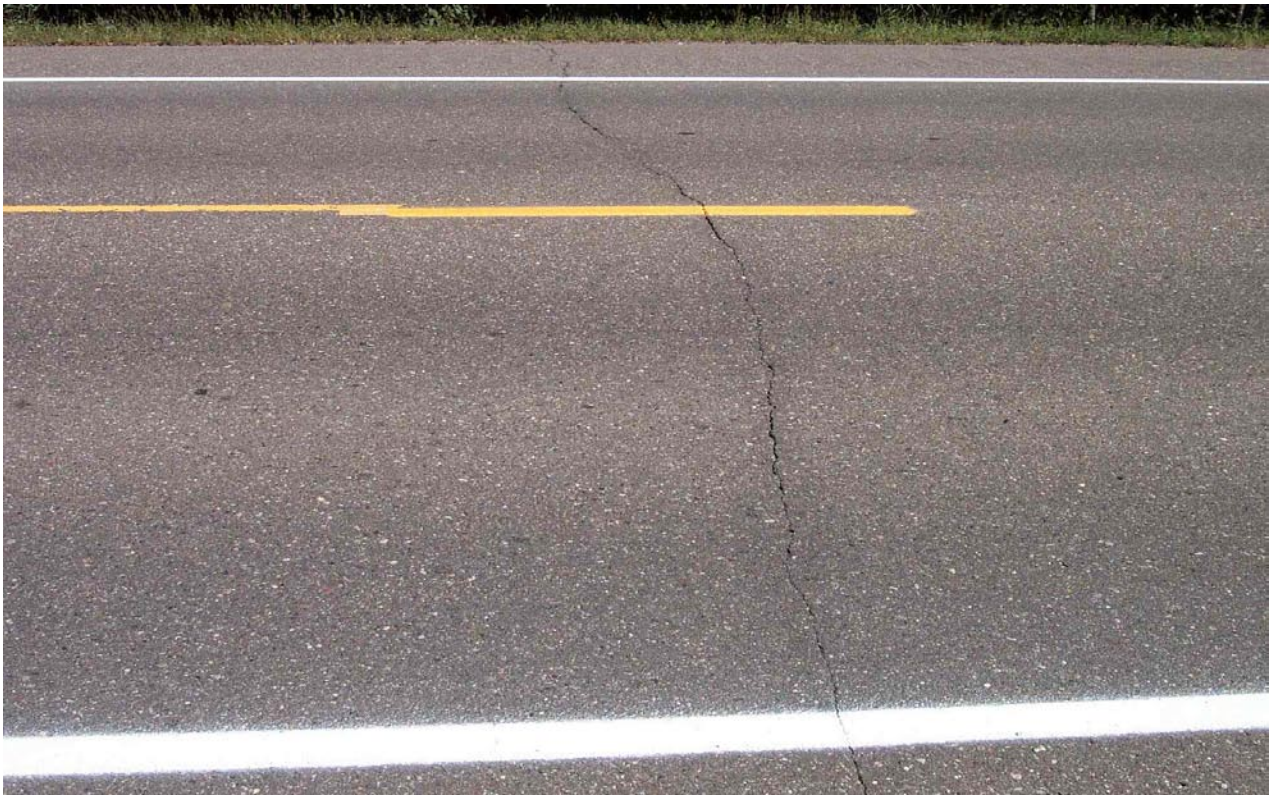

Figure 2. Low Severity Transverse Crack (no random cracks)

Figure 3. Low Severity Transverse - Saw and Seal

Figure 4. Medium Severity Transverse Crack (some spalling and random cracks)

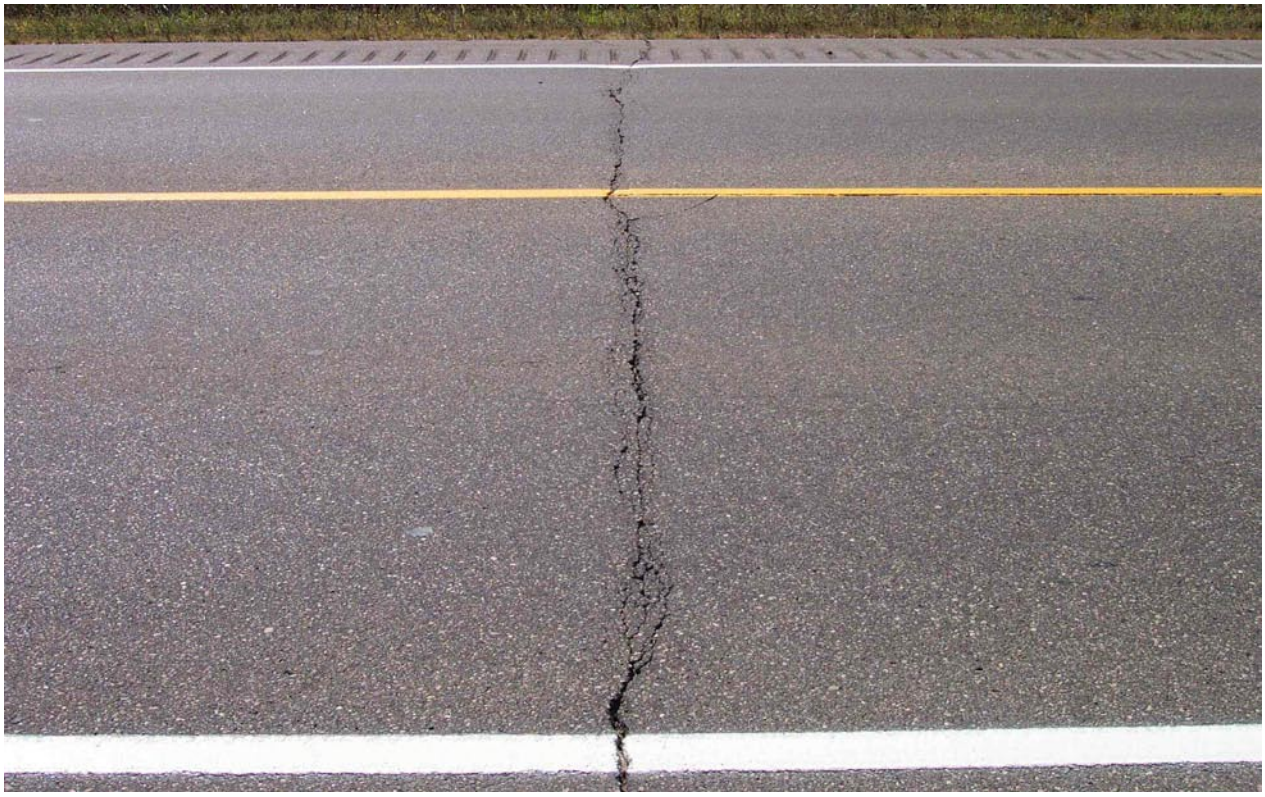

Figure 5. Medium Severity Transverse Crack (some spalling and random cracks)

Figure 6. High Severity Transverse Crack (random cracking over 12” wide)

Figure 7. High Severity Transverse Crack (spalling and missing pieces)

LONGITUDINAL CRACKING

Description

Cracks predominantly parallel to the pavement centerline.

Severity Levels

LOW
A single crack, at least 3-feet long, parallel to the centerline of the roadway, with no random cracking, including a crack that has been routed and sealed as long as the sealant is in good condition.

MEDIUM
Any crack running parallel to the centerline of the roadway with adjacent low severity random cracking, less than 12 inches wide. There may also be a small amount of patching or popouts. Cracks that have been repaired with hot mix or slurry materials and are in good condition are also rated as medium.

HIGH
Any crack running parallel to the centerline of the roadway with significant adjacent random cracking (12 inches or more apart), large areas of spalling, missing material and/or potholes.

How to Measure

Record the length, in feet, of longitudinal cracking at each severity level.

Figure 8. Low Severity Longitudinal Crack

Figure 9. Slight Longitudinal Cracking (no spalling or random cracks)

Figure 10. Medium Severity Longitudinal Crack (random cracks are less than 12” wide)

Figure 11. High Severity Longitudinal Crack (random cracks over 12” wide)

LONGITUDINAL JOINT CRACKING

Description

Cracks predominantly along the pavement centerline, lane division lines or the lane to shoulder division.

Severity Levels

LOW
A single crack, at least 3-feet long, parallel to the centerline of the roadway, including a crack that has been route and sealed as long as the sealant is in good condition.

MEDIUM
Any crack running parallel to the centerline of the roadway with adjacent low severity random cracking, less than 12 inches apart. There may also be a small amount of patching or popouts. Cracks that have been repaired with hot mix or slurry materials and are in good condition are also rated as medium.

HIGH
Any crack running parallel to the centerline of the roadway with significant adjacent random cracking (12 inches or more apart), have large areas of spalling, missing material and/or potholes.

How to Measure

Record the length, in feet, of longitudinal cracking at each severity level.

Figure 12. Low Severity Longitudinal Joint Deterioration (no spalling or random cracks)

Figure 13. Low Severity Longitudinal Joint Deterioration (no spalling or random cracks)

Figure 14. Medium Severity Longitudinal Joint Deterioration (random cracks)

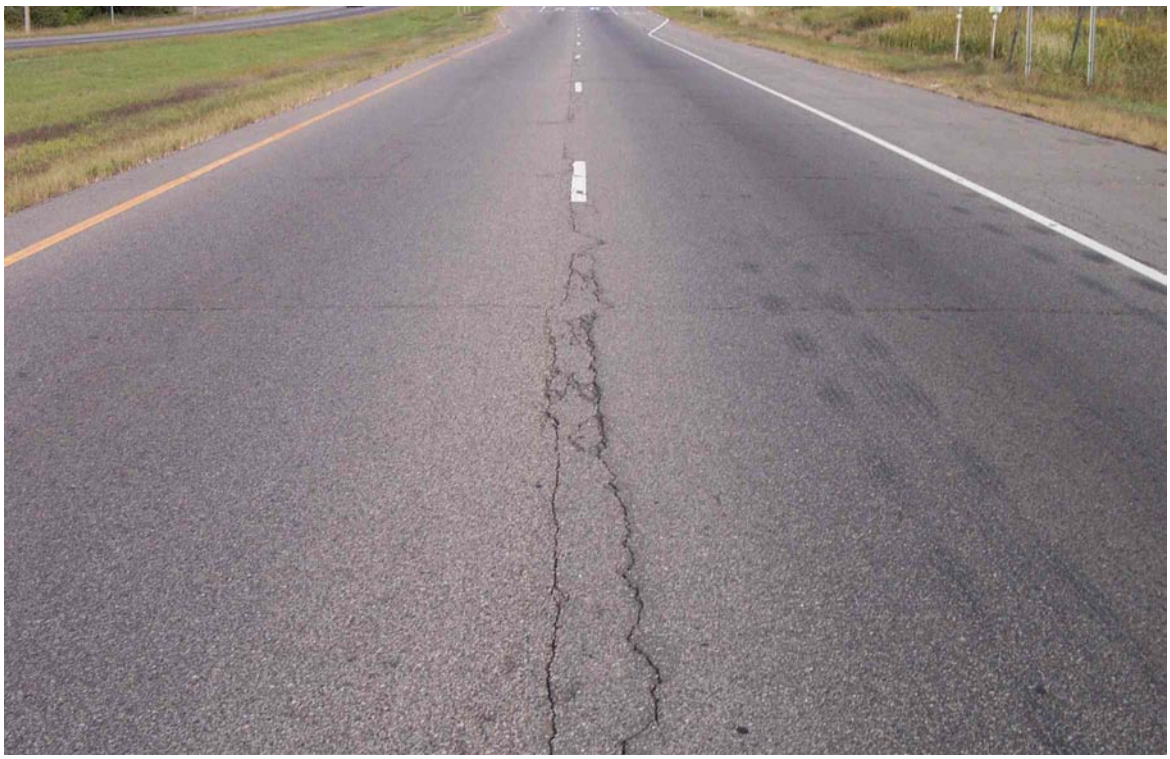

Figure 15. Medium Severity Longitudinal Joint Deterioration (random cracks)

Figure 16. High Severity Longitudinal Joint Deterioration (spalling)

MULTIPLE CRACKING

Description

A pattern of cracks dividing the pavement into approximately rectangular blocks. The size of the blocks ranges from 6 inches to approximately 3 feet across. This type of distress normally covers the entire pavement surface.

Severity Levels

There are no separate severity levels for Multiple Cracking. If it is present it is measured and recorded.

How to Measure

Record the lineal feet of pavement exhibiting multiple cracking.

Figure 17. Multiple Cracking

Figure 18. Multiple Cracking

Figure 19. Multiple Cracking

ALLIGATOR CRACKING

Description

A series of interconnected cracks forming many-sided, sharp-angled pieces, six inches or less in size typically located in the wheelpaths or where traffic loads are concentrated.

Severity Levels

There are no separate severity levels for Alligator Cracking. If it is present it is measured and recorded.

How to Measure

Record the number of lineal feet of pavement with this type of cracking.

Figure 20. Alligator Cracking

Figure 21. Alligator Cracking

RUTTING

Description

A longitudinal surface depression located in the wheel path. It may also have associated transverse displacement.

Severity Levels

There are no separate severity levels for rutting. Although the actual amount of rutting is measured and stored in the pavement management system, only rutting that exceeds 0.5 inches is used when calculating the SR.

How to Measure

Record the lineal feet of rutting that exceeds 0.5 inches.

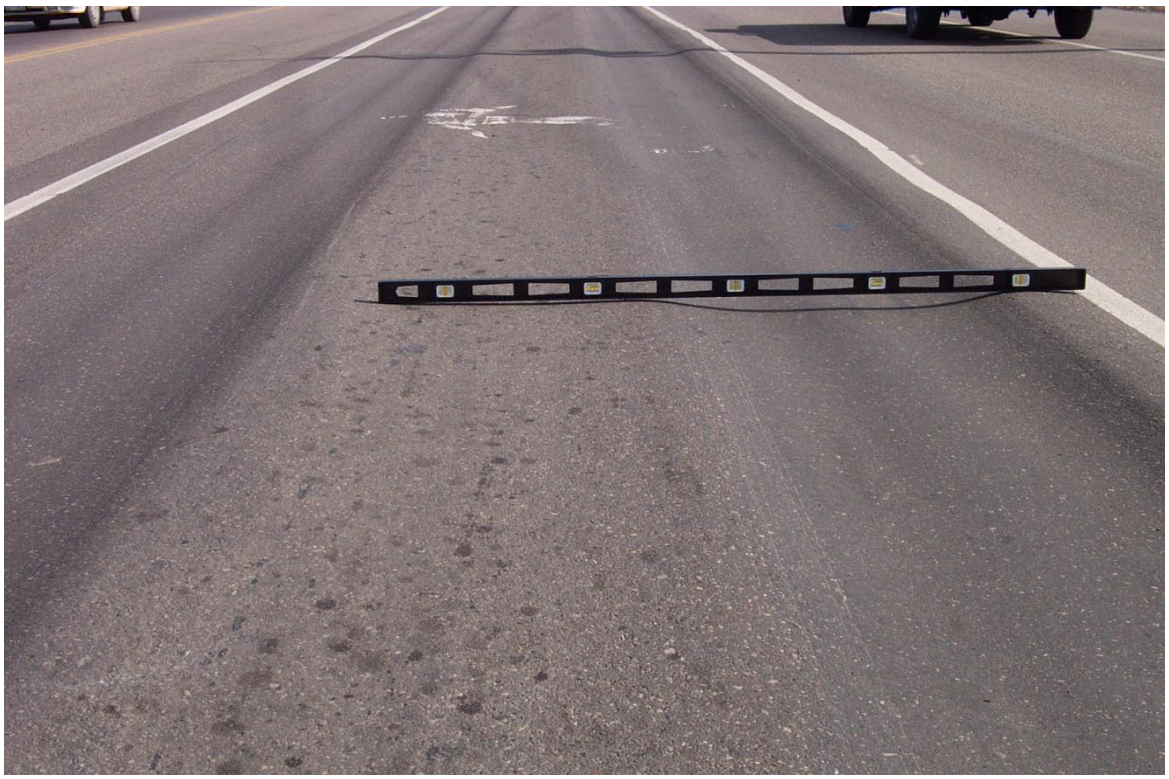

Figure 22. Rutting (0.50 inches or greater)

RAVELING & WEATHERING

Description

Wearing away of the pavement surface in hot mix asphalt concrete caused by the dislodging of aggregate particles and/or the loss of the asphalt binder. Raveling generally occurs in the wheel paths and weathering in the non-traffic areas.

Severity Levels

There are no separate severity levels for Raveling & Weathering. Raveling and weathering is present when the coarse aggregate in the wheel path protrudes 1/16 of an inch or more and/or if the coarse aggregate is starting to kick out.

How to Measure

Record the number of lineal feet of pavement exhibiting the conditions listed above.

Figure 23. Raveling Under a Bridge

PATCHING

Description

A portion of the pavement surface, 1 ft. or greater in width, and in either wheelpath. If the patch is full width of the lane being surveyed it must be less than 50 ft. in length. If not, it is considered to be an overlay.

Severity Levels

There are no separate severity levels for patching. If it is present it is measured and recorded if it is at least 1-foot wide.

How to Measure

Record the number of lineal feet that is patched. Patching is counted in combination with other deficiencies. However, when a longitudinal deficiency other than low or medium severity longitudinal cracking or longitudinal joint deterioration is observed in the patch, count the longitudinal defect only and not the patch.

Figure 24. Bituminous Patching

JOINTED CONCRETE PAVEMENT RATING PROCEDURE

For *jointed* concrete pavements, the following distress types are measured and recorded.

Distress Type	Severity Levels	How to Measurement
Slight Joint Spalling	None	Number of Joints
Severe Joint Spalling	None	Number of Joints
Faulted Joints	None	Number of Joints
Cracked Panels	None	Number of Panels
Broken Panels	None	Number of Panels
Faulted Panels	None	Number of Panels
Overlaid Panels	None	Number of Panels
Patched Panels	None	Number of Panels
D-Cracking	None	Number of Panels
Slight Longitudinal Joint Spalling	None	Number of Panels
Severe Longitudinal Joint Spalling	None	Number of Panels

Important details to remember:

- If the beginning of the section has been overlaid with hot mix asphalt, move ahead to the concrete portion and then begin rating. If, however, the overlaid section is too long (0.3 miles), a new D-record should be added.

- Count the total number of joints in the 500-foot rating section. Begin the survey sample at a joint and survey the last panel but do not survey the last joint.

- All deficiencies will be counted on a panel basis with the exception of spalled and faulted joints, which will be counted on a joint basis.

The following pages describe each of the jointed concrete pavement defects in detail, describe how to measure them and show examples of each.

TRANSVERSE & LONGITUDINAL JOINT SPALLING

Description

Cracking, breaking, chipping or fraying along the joints and edges of a slab. Joints that have bituminous patches are also considered as spalled. If the spalling occurs along the transverse joint or edge of the panel it is rated as Transverse Joint Spalling. If it occurs along the longitudinal joint or edge of a panel, it recorded as Longitudinal Joint Spalling. A panel can have both Transverse and Longitudinal Spalling.

Severity Levels

LOW
Spalling occurs a minimum of 2-inches from the edge of the joint for a minimum continuous length of 1-foot along the joint. Joints that have bituminous patches along the joint, for a minimum of 1-foot, are also considered spalled.

A joint is also considered as having Low Severity Spalling when parallelled by a series of fine, hairline cracks for nearly its entire length. Staining, not associated with D-cracking may also be present. *If low and high severity spalling exist along the same joint, record the highest severity level that exists.*

HIGH
Spalling occurs a minimum of 3-inches from the edge of the joint for a minimum continuous length of 3-foot and in the wheel path. Joints that have bituminous patches, for a minimum of 3 continuous feet in the wheel path are also considered as High Severity Spalling.

How to Measure

Record the number of joints that exhibit Joint Spalling.

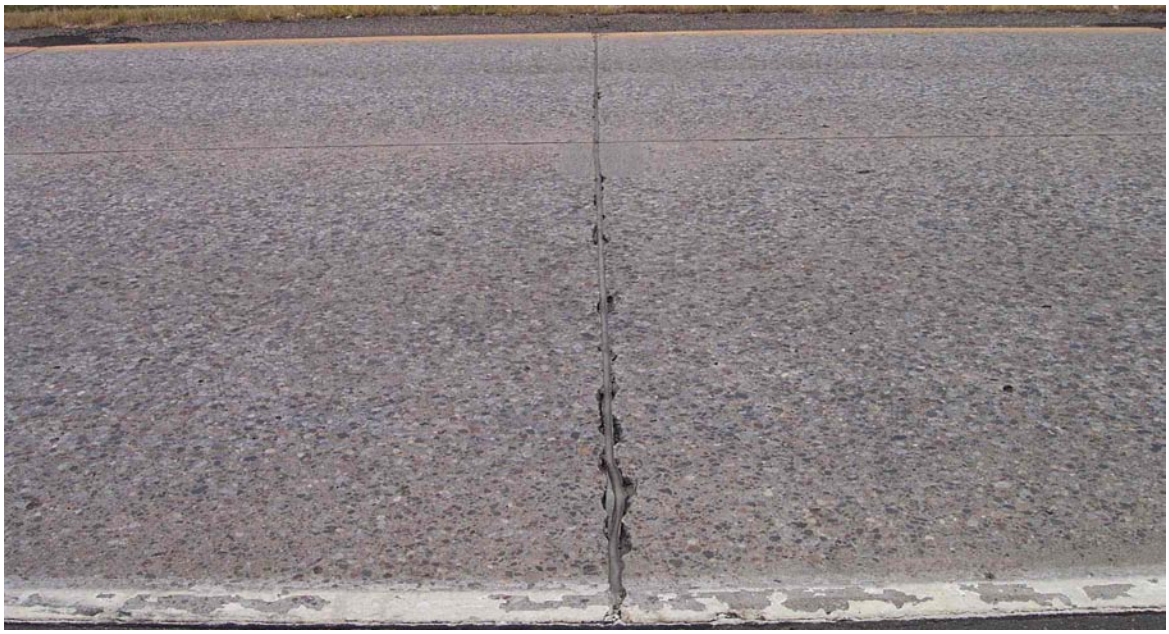

Figure 25. Low Severity Transverse Joint Spalling

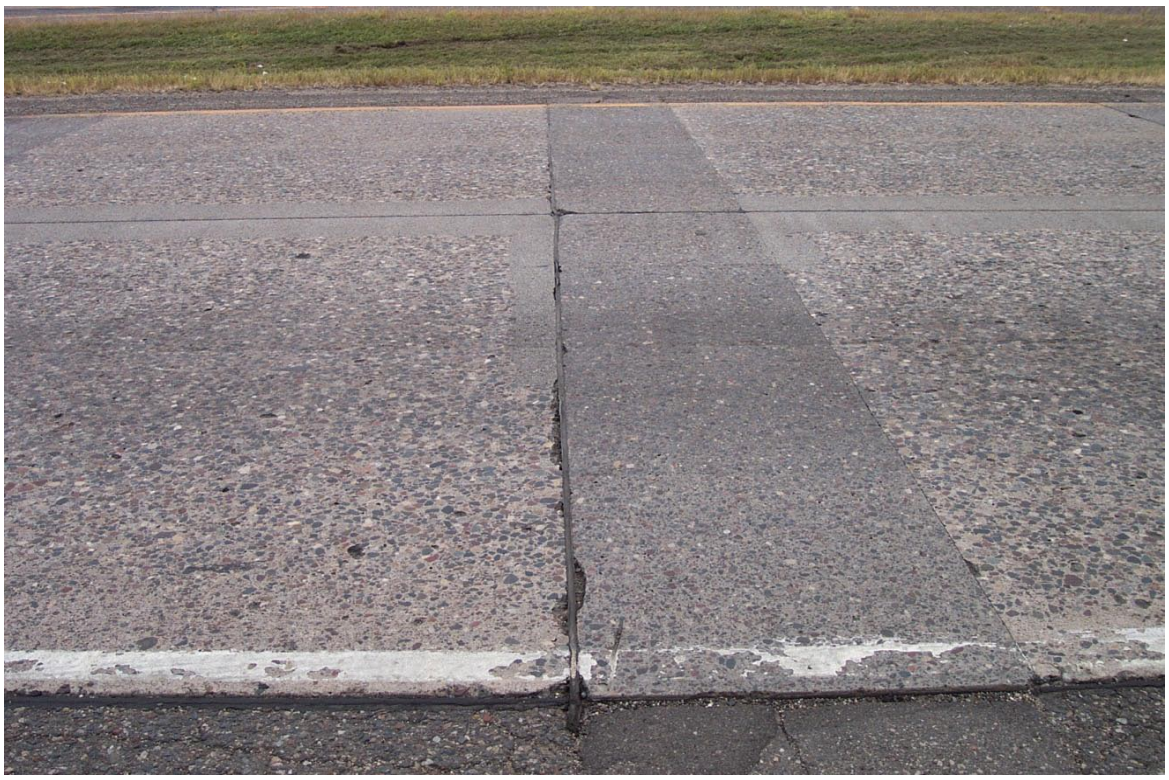

Figure 26. Low Severity Transverse Joint Spalling

Figure 27. Low Severity Longitudinal Joint Spalling

Figure 28. Low Severity Longitudinal Joint Spalling

Figure 29. High Severity Transverse Joint Spalling

Figure 30. High Severity Transverse Joint Spalling

Figure 31. High Severity Longitudinal Joint Spalling

FAULTED JOINT

Description

A difference in elevation of at least 0.25-inches across a transverse joint.

Severity Levels

There are no separate severity levels for faulting. If it is present and exceeds the 0.25-inch threshold, it is measured and recorded.

How to Measure

Record the number of transverse joints that exceed the 0.25-inch criteria at any point along its length.

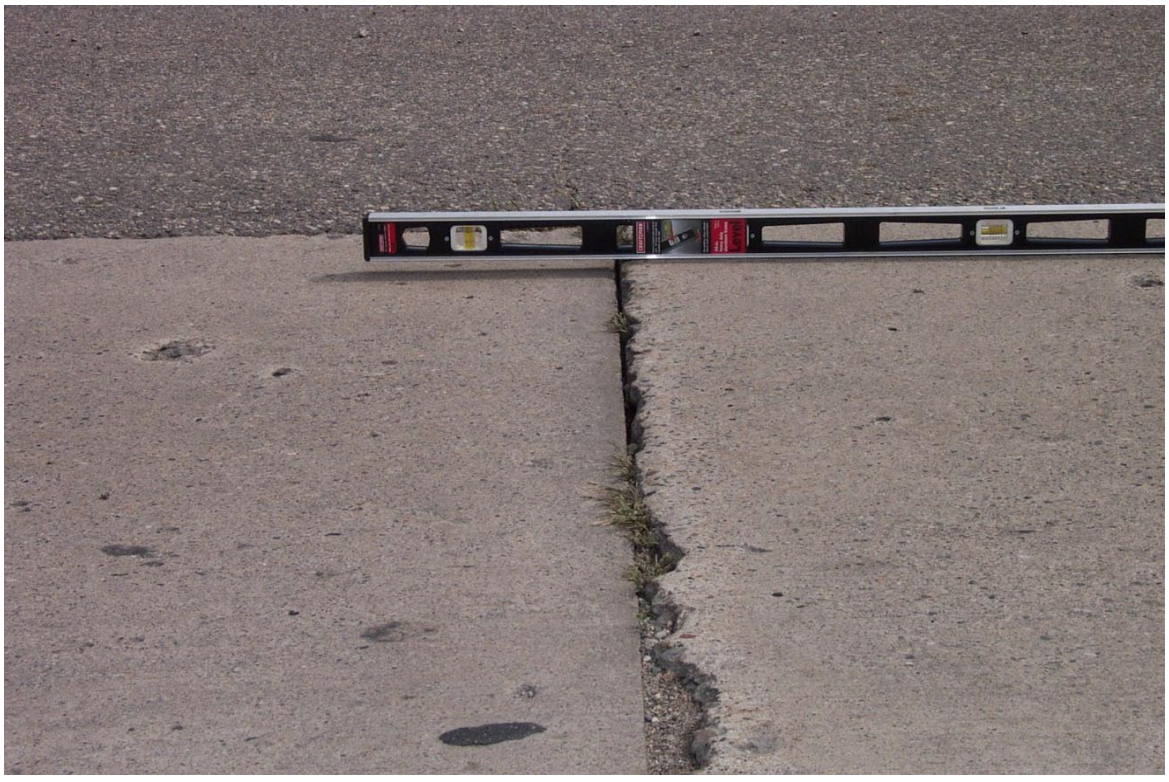

Figure 32. Faulted Joint

CRACKED PANELS

Description

A panel or slab with cracks resulting in the panel being divided into three or less pieces. The cracks must be at least 2-feet long for the slab to be counted as cracked.

Severity Levels

There are no separate severity levels for cracked panels. If the slab is cracked it is recorded. A slab can be both cracked and broken (see Broken Panels).

How to Measure

Record the number of slabs that are cracked.

Figure 33. Cracked Panel (slab is divided into two pieces)

BROKEN PANELS

Description

A panel or slab with cracks resulting in the panel being divided into four or more pieces. The cracks must be at least 2-feet long for the slab to be counted as broken.

Severity Levels

There are no separate severity levels for broken panels. If the slab is broken it is recorded. A slab must be cracked to be broken and both defects counted.

How to Measure

Record the number of slabs that are broken.

Figure 34. Cracked and Broken Panel

Figure 35. Cracked and Broken Panel

Figure 36. Cracked and Broken Panel

FAULTED PANELS

Description

A difference in elevation of at least 0.25-inches across a transverse crack within a slab.

Severity Levels

There are no separate severity levels for faulting. If it is present and exceeds the 0.25-inch threshold, it is measured and recorded.

How to Measure

Record the number of panels with faulted cracks that exceed the 0.25-inch criteria at any point along its length.

Figure 37. Faulted Panel

Figure 38. Faulted Panel

Figure 39. Faulted Panel

PATCHED PANELS

Description

A portion of the pavement surface, at least 5-sq.ft., that has been removed and replaced or had additional material applied and is in a deteriorated condition. A deteriorated condition is defined as any bituminous patch or a concrete patch showing deficiencies such as spalling or raveling at the edges or within the patch.

Severity Levels

There are no separate severity levels for patched panels. If the panel has been patched and the patch is in a deteriorated condition, as described above, it is recorded.

How to Measure

Record the number of panels or slabs that are patched.

Figure 40. Patched Panels

D-CRACKING (Durability Cracking)

Description

A series of closely spaced, crescent shaped, hairline cracks that appear in a concrete slab adjacent and roughly parallel to transverse cracks and joints, longitudinal joints and free edges of slabs. Dark coloring often exists around the cracking pattern and surrounding area.

Severity Levels

There are no separate severity levels for D-cracking. If it is present it is measured and recorded.

How to Measure

Record the number of slabs with D-cracking. D-cracking is counted together with spalled joints that occur in the same area.

Figure 41. D-Cracking

Figure 42. D-Cracking

Figure 43. D-Cracking

CONTINUOUSLY REINFORCED CONCRETE PAVEMENT (CRCP) RATING PROCEDURE

For continuously reinforced concrete pavements (CRCP), the following distress types are measured and recorded.

Distress Type	Severity Levels	How to Measurement
Patch Deterioration	None	Lineal Feet
Localized Distress	None	Number
D-Cracking	None	Number
Transverse Cracking	None	Number

Important details to remember:

- If the beginning of the section has been overlaid, move ahead to the concrete portion and then begin rating. If, however, the overlaid section is too long (0.3 miles), a new D-record should be added.

The following pages describe each of the jointed concrete pavement defects in detail, describe how to measure them and show examples of each.

PATCH DETERIORATION

Description

A patch, in excess of 5-sq.ft., but less than 50-feet long, or any size, if it is less than the width of the lane, in a deteriorated condition, exhibited by bituminous material, spalled edges, a spalled crack inside the patch or maintenance patching inside the patch.

Severity Levels

There are no separate severity levels for patch deterioration. If it is present it is measured and recorded.

How to Measure

Record the number of lineal feet of patch deterioration.

Figure 44. Patch Deterioration

LOCALIZED DISTRESS

Description

An area of a slab, usually one square foot or more, but less than five square feet, which is broken into pieces and/or spalled and/or patched. It is also be defined spalling along a crack, for at least one foot, associated with D-cracking.

Severity Levels

There are no separate severity levels for localized distress. If it is present, it is measured and recorded.

How to Measure

Record the number of localized distress areas.

Figure 45. Localized Distress

D-CRACKING (Durability Cracking)

Description

A series of closely spaced, crescent shaped, hairline cracks that appear in a concrete slab adjacent and roughly parallel to transverse cracks and joints, longitudinal joints and free edges of slabs. Dark coloring often exists around the cracking pattern and surrounding area.

Severity Levels

There are no separate severity levels for D-cracking. If it is present it is measured and recorded.

How to Measure

Record the number of slabs with D-cracking. D-cracking is counted together with spalled joints that occur in the same area.

Figure 46. D-Cracking

TRANSVERSE CRACKING

Description

Sealed or unsealed cracks, breaks or relief cuts, perpendicular to the roadway centerline, that are greater than 0.75 inches wide or exhibit faulting of 0.25 inches or greater anywhere along its length.

Severity Levels

There are no separate severity levels for transverse cracking. If it is present it is measured and recorded.

How to Measure

Record the number of transverse cracks.

Figure 47. Transverse Crack on CRCP

CALCULATING THE SURFACE RATING (SR)

Once the distress is categorized and measured, the SR can be calculated using the following procedure:

Step 1. Convert the amount of distress to a percentage

The amount of each distress type and severity level must be converted to percent as described below.

Bituminous Pavements

For bituminous pavements, the number of transverse cracks, at all severities, is converted to percent using the following:

- $\text{Percent Cracks (\%)} = \text{Number of Cracks} \times 2$ *(not to exceed 100%)*

For other distresses, simply divide the length of each defect by the length of the section being surveyed, 500-feet in most cases, to get percent.

Jointed Concrete Pavements

For jointed concrete pavement, the number of panels or slabs with each type and severity of defect is divided by the total number of slabs in the section being surveyed to get percent.

Continuously Reinforced Concrete Pavements (CRCP)

For continuously reinforced concrete pavements, the number of cracks and distressed areas is converted to percent according to the following:

- Patch Deterioration: Divide the lineal feet of this distress by the length of the section being surveyed (normally 500-feet).

- D-cracking and Localized Distress: (based on a 500-ft section)

# of Distress Areas	Percent
12+	100%
8 – 12	40 to 100%
4 – 8	8 to 40%
0 – 4	0 to 8%

- Transverse Cracks: (based on a 500-ft section)

# of Cracks	Percent
4	100%
3	75%
2	50%
1	25%

Step 2. Calculate the Individual Weighted Distress

Multiply the percent of each distress by the appropriate weighting factors listed in Tables 1-3.

Step 3. Calculate the Total Weighted Distress (TWD)

Sum up all of the Individual Weighting Distress to get the Total Weighted Distress.

Step 4. Convert the TWD to SR

The TWD is used as input to Equation 1 of Figure 48 to determine the SR.

Equation 1. Formula for Calculating the SR

$$SR = e^{(1.386-(0.045)(TWD))}$$

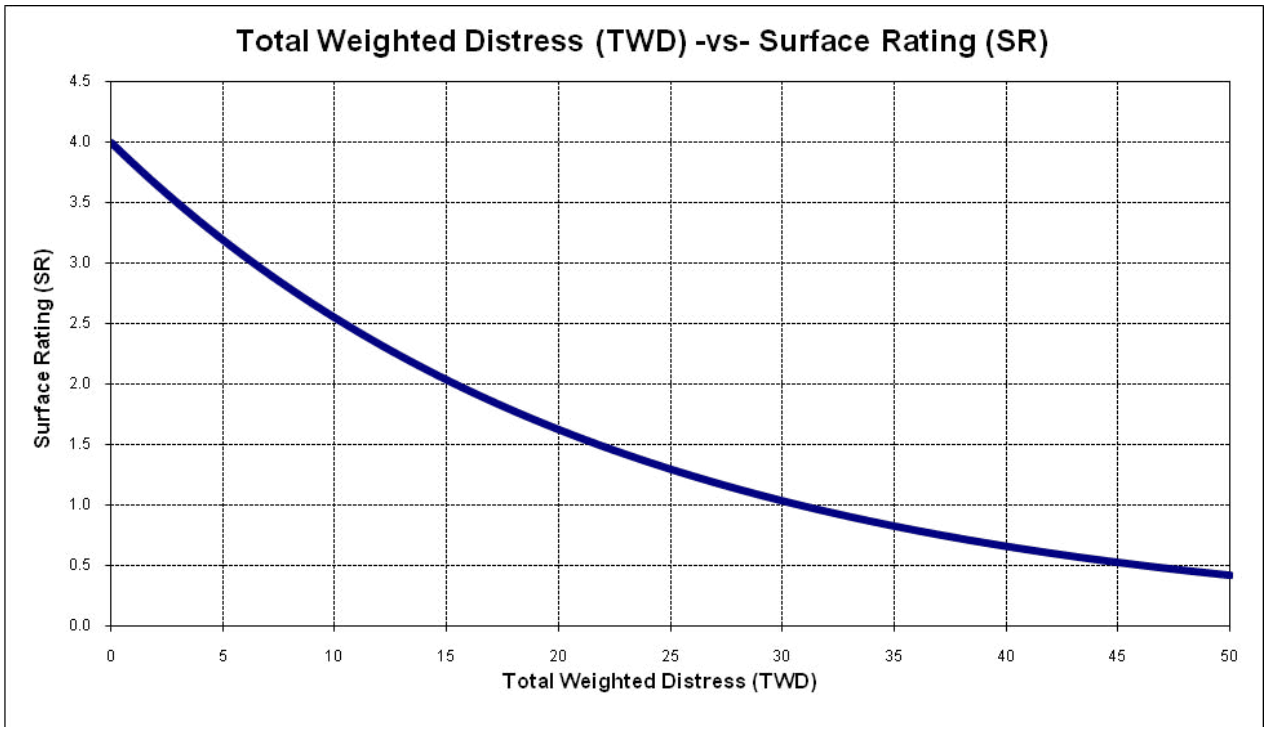

Figure 48. Chart for Calculating the Surface Rating (SR)

EXAMPLE

A 500-foot section of bituminous road was surveyed and found to have the has the following defects:

Distress Type	Severity	Amount
Transverse Cracking	Low	20 cracks
Transverse Cracking	Medium	5 cracks
Longitudinal Joint Deterioration	Medium	500 lineal feet
Multiple Cracking	N/A	50 lineal feet

Step 1. Convert the amount of distress to a percentage

Distress Type	Severity	Percent
Transverse Cracking	Low	20 cracks = 40%
Transverse Cracking	Medium	5 cracks = 10%
Longitudinal Joint Deterioration	Medium	500/500 = 100%
Multiple Cracking	N/A	50/500 = 10%

Step 2 and 3. Calculate the Individual Weighted Distress and Total Weighted Distress

Distress Type	Severity	Weighting Factor		Percent	Individual Weighted Distress
Transverse Cracking	Low	0.01	X	40	0.4
Transverse Cracking	Medium	0.10	X	10	1.0
Longitudinal Joint Deterioration	Medium	0.03	X	100	3.0
Multiple Cracking	N/A	0.15	X	10	1.5
Total Weighed Distress (TWD)					**5.9**

Step 4. Calculate SR

The TWD of 5.9 is then used with either Equation 1 or Figure 48 to determine the SR of 3.0.

$$SR = e^{(1.386-(0.045)(5.9))}$$

$$SR = e^{(1.386-0.2655)} = e^{(1.1205)} = 3.07 = 3.0$$

The SR is truncated to the nearest tenths place. So the SR in this example is 3.0

Table 1. Bituminous Pavement SR Weighting Factors

Distress Type	Severity	Weighting Factor
Transverse Cracking	Low	0.01
	Medium	0.10
	High	0.20
Longitudinal Cracking	Low	0.02
	Medium	0.03
	High	0.04
Longitudinal Joint Deterioration	Low	0.02
	Medium	0.03
	High	0.04
Multiple (block) cracking	-	0.15
Alligator Cracking	-	0.35
Rutting	-	0.15
Raveling & Weathering	-	0.02
Patching	-	0.04

Table 2. Concrete Pavement SR Weighting Factors

Distress Type	Severity	Weighting Factor
Transverse Joint Spalling	Low	0.10
	High	0.20
Longitudinal Joint Spalling	Low	0.10
	High	0.20
Cracked Panels	-	0.07
Broken Panels	-	0.07
Faulted Joints	-	0.10
Faulted Panels	-	0.07
100% Overlaid Panels		0.00
Patched Panels		0.14
D-Cracking		0.10

Table 3. Continuously Reinforced Concrete Pavement (CRCP) SR Weighting Factors

Distress Type	Severity	Weighting Factor
Patch Deterioration	-	0.30
Localized Distress	-	0.40
D-Cracking	-	0.05
Transverse Cracking	-	0.25

Moving Minnesota

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