APPENDIX B
DISTRESSES

INTRODUCTION

The purpose of this appendix is not to provide a detailed discussion of the various descriptions and causes of distresses that may occur in any given pavement structure. The purpose of this appendix is only to provide a brief presentation. Numerous other manuals and publications already exist that provide information that is much more detailed. The state DOT Agency's Pavement Designer group should review these manuals and publications. This will assist them in understanding the causes of distresses in pavements. This knowledge can then be used to effectively select a preferred pre-overlay treatment strategy for use on a specific project.

The information, figures, and pictures provided in this chapter, unless otherwise noted, were obtained from the FHWA's *Distress Identification Manual for the Long-Term Pavement Performance Program*. These descriptions are provided as a guide only and should not be viewed as the only guidance available for distress type-severity description or identification.

Since the publication of this *Distress Identification Manual*, additional distress-type-severity descriptions or identifications for frost heave, roughness, and alkali–silica reaction (ASR) have been added to this synthesis. Other distresses may exist, but will not be made a part of this synthesis.

HOT-MIX ASPHALT (HMA) PAVEMENT DISTRESSES

This section contains the general descriptions of the major types of distress that may be encountered in flexible pavements. A typical description of three severity levels associated with each distress is provided.

Fatigue Cracking

This distress occurs in areas subjected to repeated traffic loadings, usually in the wheel path. It can be a series of interconnected cracks in the early stages of development. It develops into many-sided, sharp-angled pieces, usually less than 1 foot on the longest side, characteristically with a chicken wire/alligator pattern, in the later stages.

FIGURE B1 Fatigue cracking.

Low—An area of cracks with no or only a few connecting cracks; cracks are not spalled or sealed; pumping is not evident.

Moderate—An area of interconnected cracks forming a complete pattern; cracks may be slightly spalled; cracks may be sealed; pumping is not evident.

High—An area of moderately or severely spalled interconnected cracks forming a complete pattern; pieces may move when subjected to traffic; cracks may be sealed; pumping may be evident.

Block Cracking

This distress is a pattern of cracks that divides the pavement into approximately rectangular pieces. The rectangular blocks range in size from approximately 1 ft^2 to 100 ft^2.

FIGURE B2 Block cracking.

Low—Cracks with a mean width ≤ ¼ in.; or sealed cracks with sealant material in good condition and with a width that cannot be determined.

Moderate—Cracks with a mean width > ¼ in. and ≤ 3/4 in.; or any crack with a mean width ≤ 3/4 in. and adjacent low severity random cracking.

High—Cracks with a mean width > 3/4 in.; or any crack with a mean width ≤3/4 in. and adjacent moderate to high severity random cracking.

Edge Cracking

This distress applies only to pavements with unpaved shoulders. Crescent-shaped cracks or fairly continuous cracks that intersect the pavement edge and are located within 2 ft of the pavement edge, adjacent to the shoulder. This includes longitudinal cracks outside of the wheel path and within 2 ft of the pavement edge.

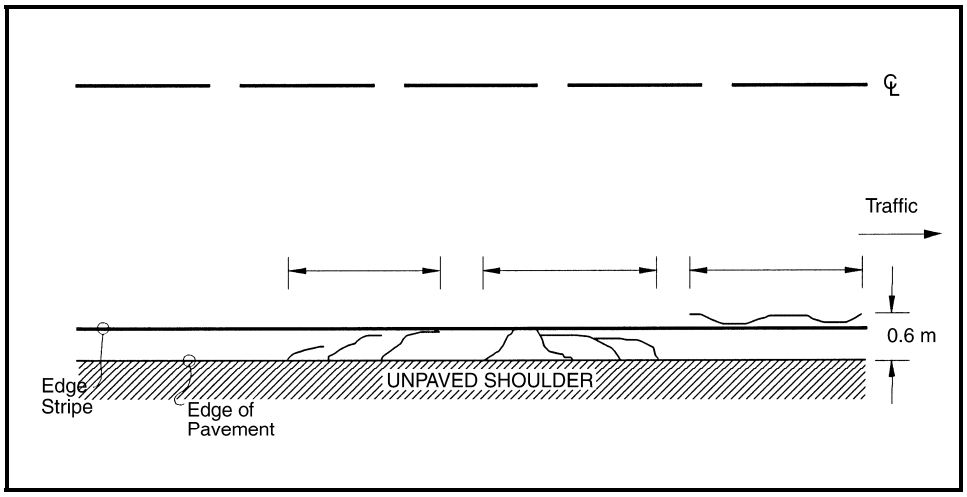

FIGURE B3 Edge cracking.

Low—Cracks with no breakup or loss of material.

Moderate—Cracks with some breakup and loss of material for up to 10% of the length of the affected portion of the pavement.

High—Cracks with considerable breakup and loss of material for more than 10% of the length of the affected portion of the pavement.

Longitudinal Cracking

This distress's cracks are predominantly parallel to the pavement centerline. The location within the lane (wheel path versus non-wheel path) is significant.

FIGURE B4 Longitudinal cracking.

Low—A crack with a mean width ≤ ¼ in.; or a sealed crack with sealant material in good condition and with a width that cannot be determined.

Moderate—Any crack with a mean width > ¼ in. and ≤ 3/4 in.; or any crack with a mean width ≤ 3/4 in. and adjacent low severity random cracking.

High—Any crack with a mean width > 3/4 in.; or any crack with a mean width ≤ 3/4 in. and adjacent moderate to high severity random cracking.

Reflection Cracking at Joints

This distress has cracks in an HMA overlay surface that occur over joints in portland cement concrete (PCC) pavements.

FIGURE B5 Reflection cracking at joints.

Low—An unsealed crack with a mean width ≤ ¼ in.; or a sealed crack with sealant material in good condition and with a width that cannot be determined.

Moderate—Any crack with a mean width > ¼ in. and ≤ 3/4 in.; or any crack with a mean width ≤ 3/4 in. and adjacent low severity random cracking.

High—Any crack with a mean width > 3/4 in.; or any crack with a mean width ≤3/4 in. and adjacent moderate to high severity random cracking.

Transverse Cracking

This distress has cracks that are predominantly perpendicular to the pavement centerline.

FIGURE B6 Transverse cracking (HMA surfaces).

Low—An unsealed crack with a mean width ≤ ¼ in.; or a sealed crack with sealant material in good condition and with a width that cannot be determined.

Moderate—Any crack with a mean width > ¼ in. and ≤ 3/4 in.; or any crack with a mean width ≤ 3/4 in. and adjacent low severity random cracking.

High—Any crack with a mean width > 3/4 in.; or any crack with a mean width ≤ 3/4 in. and adjacent moderate to high severity random cracking.

Patch/Patch Deterioration

This distress is a portion of the pavement surface, greater than 1 ft^2, that has been removed and replaced or where additional material has been applied to the pavement after original construction.

FIGURE B7 Patch/patch deterioration.

Low—Patch has, at most, low severity distress of any type including rutting <¼ in.; pumping is not evident.

Moderate—Patch has moderate severity distress of any type or rutting from ¼ in. to ½ in.; pumping is not evident.

High—Patch has high severity distress of any type including rutting >½ in., or the patch has additional different patch material within it; pumping may be evident.

Potholes

This distress has bowl-shaped holes of various sizes in the pavement surface. Minimum plan dimension is 6 in.

FIGURE B8 Potholes.

Low—Less than 1 in. deep.

Moderate—1 to 2 in. deep.

High—Greater than 2 in. deep.

Rutting

This distress is a longitudinal surface depression in the wheel path. It may have associated transverse displacement.

FIGURE B9 Rutting.

Note: The severity level is not applicable. Severity levels could be defined by categorizing the measurements taken. However, a record of the measurements taken is much more desirable because it is more accurate and repeatable than are severity levels.

Shoving

This distress is a longitudinal displacement of a localized area of the pavement surface. It is generally caused by braking or accelerating vehicles and is usually located on hills or curves, or at intersections. It also may have associated vertical displacements.

FIGURE B10 Shoving.

Note: The severity level is not applicable. However, severity levels can be defined by the relative effect of shoving on ride quality.

Bleeding (Discolorization)

Excess bituminous binder occurring on the pavement surface that is usually found in the wheel paths. Surface discolorization relative to the remainder of the pavement will exist.

FIGURE B11 Discolorization.

Note: The severity level is not applicable. The presence of bleeding indicates potential mixture-related performance problems. The extent is sufficient to monitor any progression.

Bleeding (Loss of Texture)

Excess bituminous binder occurring on the pavement surface that is usually found in the wheel paths. The surface will lose surface texture because of excess asphalt.

FIGURE B12 Loss of texture.

Note: The severity level is not applicable. The presence of bleeding indicates potential mixture-related performance problems. The extent is sufficient to monitor any progression.

Bleeding (Aggregate Obscured)

Excess bituminous binder occurring on the pavement surface that is usually found in the wheel paths. The aggregate is obscured by excess asphalt, possibly with a shiny, glass-like, reflective surface that may be tacky to the touch.

FIGURE B13 Aggregate obscured.

Note: The severity level is not applicable. The presence of bleeding indicates potential mixture-related performance problems. The extent is sufficient to monitor any progression.

Polished Aggregate

This distress has the surface binder worn away to expose coarse aggregate that has been worn smooth by the action of traffic.

FIGURE B14 Polished aggregate.

Note: The severity level is not applicable. However, the degree of polishing may be reflected in a reduction of surface friction.

Raveling (Loss of Fine Aggregate)

This distress has wearing away of the pavement surface caused by the dislodging of aggregate particles and loss of asphalt binder.

FIGURE B15 Loss of fine aggregate.

Note: The severity level is not applicable. The presence of raveling indicates potential mixture-related performance problems. The extent is sufficient to monitor any progression.

Raveling (Loss of Fine Aggregate and Some Coarse Aggregate)

This distress has wearing away of the pavement surface caused by the dislodging of aggregate particles and loss of asphalt binder.

FIGURE B16 Loss of fine and some coarse aggregate.

Note: The severity level is not applicable. The presence of raveling indicates potential mixture-related performance problems. The extent is sufficient to monitor any progression.

Raveling (Loss of Coarse Aggregate)

This distress has wearing away of the pavement surface caused by the dislodging of aggregate particles and loss of asphalt binder.

FIGURE B17 Loss of coarse aggregate.

Note: The severity level is not applicable. The presence of raveling indicates potential mixture-related performance problems. The extent is sufficient to monitor any progression.

Water Bleeding and Pumping

This distress has seeping or ejection of water beneath the pavement through cracks. In some cases, it is detectable by deposits of fine material left in the pavement surface that were eroded (pumped) from the support layers and have stained the surface.

FIGURE B18 Water bleeding and pumping.

Note: The severity level is not applicable. The severity levels are not used because the amount and degree of water bleeding and pumping changes with varying moisture conditions.

Roughness

This distress is a measured performance parameter over the design life of a pavement structure. It is based on the initial as-constructed profile of the pavement and upon the subsequent development of distresses over time. These distresses include rutting, fatigue cracking, and thermal cracking. Additionally, subgrade and climatic factors are also considered to account for the roughness caused by shrinking or swelling soils and frost heave conditions (NCHRP Project 1-40 MEPDG, Flexible Pavement Analysis Parameters). The current unit of measure within many State DOTs is based on the International Roughness Index (IRI).

Low—IRI < 95 in./mile

Medium—IRI ≥ 95 in./mile and ≤ 120 in./mile

High—IRI > 120 in./mile

Frost Heave

This distress may occur within or beneath a pavement and is caused by the accumulation of ice within the larger soil voids and, usually, a subsequent expansion to form continuous ice lenses, layers, veins, or other ice masses (AASHTO *Guide for Design of Pavement Structures* 1993).

FIGURE B19 Frost heave (Dimillo 1998)

Note: The severity level is not applicable. The severity levels are not used because the amount and degree of frost heave changes with varying moisture conditions.

JOINTED PLAIN CONCRETE PAVEMENT (JPCP) DISTRESSES

This section contains the general descriptions of the major types of distress that are encountered in JPCP. A typical description of three severity levels associated with each distress is provided.

Corner Breaks

This distress has a portion of the slab separated by a crack that intersects the adjacent transverse and longitudinal joints, describing approximately a 45-degree angle with the direction of traffic. The length of the sides is from 1 ft to one-half the width of the slab on each side of the corner.

FIGURE B20 Corner breaks.

Low—Crack is not spalled for more than 10% of the length of the crack; there is no measurable faulting; and the corner piece is not broken into two or more pieces and has no loss of material and no patching.

Moderate—Crack is spalled at low severity for more than 10% of its total length; or faulting of crack or joint is < ½ in.; and the corner piece is not broken into two or more pieces.

High—Crack is spalled at moderate to high severity for more than 10% of its total length; or faulting of the crack or joint is ≥ ½ in.; or the corner piece is broken into two or more pieces or contains patch material.

Durability Cracking (D-cracking)

This distress has a closely spaced, crescent-shaped, hairline-cracking pattern. It may occur adjacent to joints, cracks, or free edges, initiating in slab corners. It will have dark coloring of the cracking pattern and surrounding area.

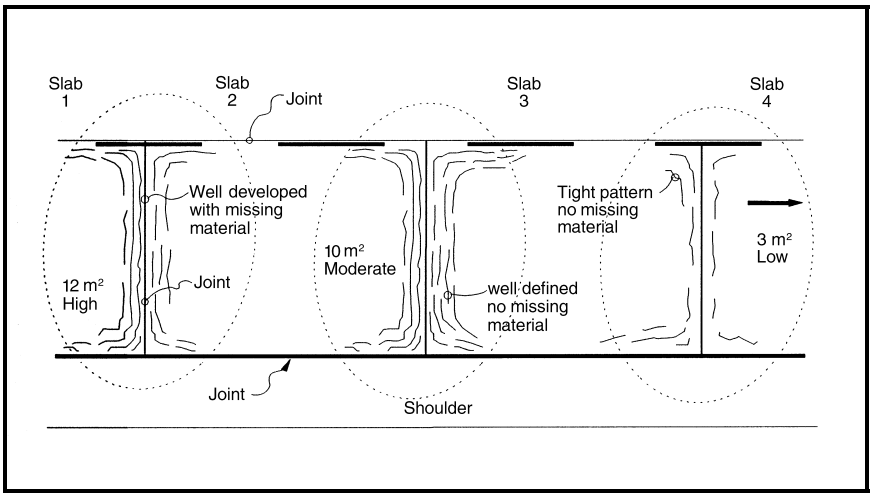

FIGURE B21 Durability cracking (D-cracking).

Low—D-cracks are tight, with no loose or missing pieces, and no patching is in the affected area.

Moderate—D-cracks are well-defined, and some small pieces are loose or have been displaced.

High—D-cracking has a well-developed pattern, with a significant amount of loose or missing material. Displaced pieces, up to 1 ft^2, may have been patched.

Longitudinal Cracking

This distress has cracks that are predominantly parallel to the pavement centerline.

FIGURE B22 Longitudinal cracking.

Low—Crack widths < 1/8 in., no spalling and no measurable faulting; or well-sealed and with a width that cannot be determined.

Moderate—Crack widths ≥ 1/8 in. and < ½ in.; or with spalling < 3 in.; or faulting up to ½ in.

High—Crack widths ≥ ½ in.; or with spalling ≥ 3 in.; or faulting ≥ ½ in.

Transverse Cracking

This distress has cracks that are predominantly perpendicular to the pavement centerline.

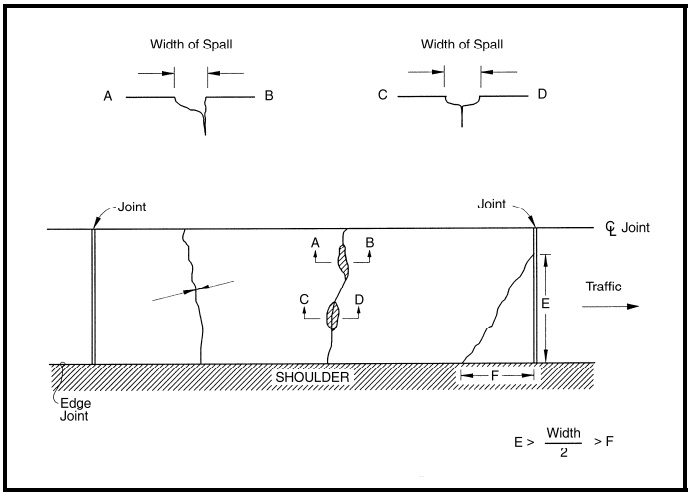

FIGURE B23 Transverse cracking.

Low—Crack widths < 1/8 in., no spalling and no measurable faulting; or well-sealed and with a width that cannot be determined.

Moderate—Crack widths ≥ 1/8 in. and < ¼ in.; or with spalling < 3 in.; or faulting up to ¼ in.

High—Crack widths ≥ ¼ in.; or with spalling ≥ 3 in.; or faulting ≥ ¼ in.

Transverse Joint Seal Damage

Where joint sealing is used, this distress has joint seal damage in any condition that enables incompressible materials or water to infiltrate the transverse joint from the surface. Typical types of joint seal damage are extrusion, hardening, adhesive failure (bonding), cohesive failure (splitting), or complete loss of sealant; intrusion of foreign material in the joint; or weed growth in the joint.

FIGURE B24 Transverse joint seal damage—Low severity.

Low—Joint seal damage over less than 10% of the joint.

Moderate—Joint seal damage over 10% to 50% of the joint.

High—Joint seal damage over more than 50% of the joint.

Longitudinal Joint Seal Damage

Where joint sealing is used, this distress has joint seal damage in any condition that enables incompressible materials or water to infiltrate the longitudinal joint from the surface. Typical types of joint seal damage are extrusion, hardening, adhesive failure (bonding), cohesive failure (splitting), or complete loss of sealant; intrusion of foreign material in the joint; or weed growth in the joint.

FIGURE B25 Longitudinal joint seal damage.

Note: The severity level is not applicable.

Spalling of Longitudinal Joints

This distress has cracking, breaking, chipping, or fraying of slab edges within 1 ft from the face of the longitudinal joint.

FIGURE B26 Spalling of longitudinal joints.

Low—Spalls < 3 in. wide, measured to the face of the joint, with loss of material or spalls with no loss of material and no patching.

Moderate—Spalls 3 in. to 6 in. wide, measured to the face of the joint, with loss of material.

High—Spalls > 6 in. wide, measured to the face of the joint, with loss of material, is broken into two or more pieces, or contains patch material.

Spalling of Transverse Joints

This distress has cracking, breaking, chipping, or fraying of slab edges within 1 ft from the face of the transverse joint.

FIGURE B27 Spalling of transverse joints.

Low—Spalls < 3 in. wide, measured to the face of the joint, with loss of material or spalls with no loss of material and no patching.

Moderate—Spalls 3 in. to 6 in. wide, measured to the face of the joint, with loss of material.

High—Spalls > 6 in. wide, measured to the face of the joint, with loss of material, is broken into two or more pieces, or contains patch material.

Map Cracking

This distress has a series of cracks that extend only into the upper surface of the slab. Larger cracks frequently are oriented in the longitudinal direction of the pavement and are interconnected by finer transverse or random cracks.

FIGURE B28 Map cracking.

Note: The severity level is not applicable.

Scaling

This distress is the deterioration of the upper concrete slab surface, normally 1/8 in. to ½ in., and may occur anywhere over the pavement.

FIGURE B29 Scaling.

Note: The severity level is not applicable.

Polished Aggregate

This distress has the surface binder worn away to expose coarse aggregate that has been worn smooth by the action of traffic.

FIGURE B30 Polished aggregate.

Note: The severity level is not applicable. However, the degree of polishing may be reflected in a reduction of surface friction.

Popouts

This distress has small pieces of pavement broken loose from the surface, normally ranging in diameter from 1 in. to 4 in., with a depth from ½ in. to 2 in.

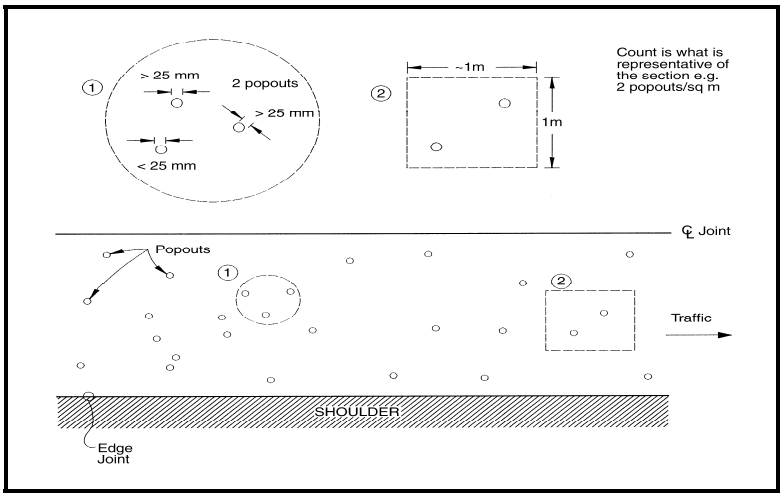

FIGURE B31 Popouts.

Note: The severity level is not applicable. However, severity levels can be defined in relation to the intensity of popouts.

Blowups

This distress has localized upward movement of the pavement surface at transverse joints or cracks, often accompanied by shattering of the concrete in that area.

FIGURE B32 Blowups.

Note: The severity level is not applicable. However, severity levels can be defined by the relative effect of a blowup on ride quality and safety.

Faulting of Transverse Joints and Cracks

This distress has a difference in elevation across a joint or crack.

FIGURE B33 Faulting of transverse crack.

Note: The severity level is not applicable. The severity level could be defined by categorizing the measurements taken. A complete record of the measurements taken is much more desirable, however, because it is more accurate and repeatable than are severity levels.

Patch/Patch Deterioration

This distress is a portion of the pavement surface, greater than 1 ft^2, that has been removed and replaced or where additional material has been applied to the pavement after original construction.

FIGURE B34 Patch/patch deterioration.

Low—Patch has low severity distress of any type; and no measurable faulting or settlement; pumping is not evident.

Moderate—Patch has moderate severity distress of any type; or faulting or settlement up to ¼ in.; pumping is not evident.

High—Patch has a high severity distress of any type; or faulting or settlement ≥ ¼ in.; pumping may be evident.

Water Bleeding and Pumping

This distress has seeping or ejection of water from beneath the pavement through cracks. In some cases, it is detectable by deposits of fine material left on the pavement surface that were eroded (pumped) from the support layers and have stained the surface.

FIGURE B35 Water bleeding and pumping.

Note: The severity level is not applicable. Severity levels are not used because the amount and degree of water bleeding and pumping changes with varying moisture conditions.

Roughness

This distress is a measured performance parameter over the design life of a pavement structure. It is based on the initial as-constructed profile of the pavement and upon the subsequent development of distresses over time. These distresses include cracking and faulting. Additionally, subgrade and climatic factors are also considered to account for the roughness caused by shrinking or swelling soils and frost heave conditions (NCHRP Project 1-40 MEPDG, Rigid Pavement Analysis Parameters). The current unit of measure within many state DOTs is based on the IRI.

Low—IRI < 95 in./mile

Medium—IRI ≥ 95 in./mile and < 120 in./mile

High—IRI > 120 in./mile

Frost Heave

This distress may occur within or beneath a pavement and is caused by the accumulation of ice within the larger soil voids and, usually, a subsequent expansion to form continuous ice lenses, layers, veins, or other ice masses (AASHTO *Guide for Design of Pavement Structures* 1993).

FIGURE B36 Frost heave.

Note: The severity level is not applicable. The severity levels are not used because the amount and degree of frost heave changes with varying moisture conditions.

Alkali–Silica Reaction (ASR)

This distress, though not discussed in the FHWA Distress Manual, is caused by the expansion and cracking of portland cement resulting from chemical reactions involving alkali ions from portland cement, hydroxyl ions, and certain siliceous aggregate constituents, that lead to the loss of strength, elasticity, and durability of concrete (Mehta 1986).

FIGURE B37 Alkali–silica reaction.

Note: The severity level is not applicable. The severity levels are not used because the amount and degree of ASR changes with varying permeability, ion and silica concentrations, and moisture conditions.

CONTINUOUSLY REINFORCED CONCRETE PAVEMENT (CRCP) DISTRESSES

This section contains the general descriptions of the major types of distress that may be encountered in CRCP. A typical description of three severity levels associated with each distress is provided.

Durability Cracking (D-cracking)

This distress has a closely spaced, crescent-shaped, hairline-cracking pattern. It may occur adjacent to joints, cracks, or free edges, initiating in slab corners. Dark coloring of the cracking pattern and surrounding area.

FIGURE B38 Durability cracking (D-cracking).

Low—D-cracks are tight with no loose or missing pieces and no patching is in the affected area.

Moderate—D-cracks are well-defined and some small pieces are loose or have been displaced.

High—D-cracking has a well-developed pattern with a significant amount of loose or missing material. Displaced pieces, up to 1 ft^2, may have been patched.

Longitudinal Cracking

This distress has cracks that are predominantly parallel to the pavement centerline.

FIGURE B39 Longitudinal cracking.

Low—Crack widths < 1/8 in., no spalling and no measurable faulting; or well-sealed and with a width that cannot be determined.

Moderate—Crack widths ≥ 1/8 in. and < ½ in.; or with spalling < 3 in.; or faulting up to ½ in.

High—Crack widths ≥ ½ in.; or with spalling ≥ 3 in.es; or faulting ≥ ½ in..

Transverse Cracking

This distress has cracks that are predominantly perpendicular to the pavement centerline. This cracking is expected in a properly functioning CRCP. All transverse cracks that intersect an imaginary longitudinal line at midlane, and propagate from the pavement edges, should be counted as individual cracks. Cracks that do not cross midlane should not be counted.

FIGURE B40 Transverse cracking.

Low—Cracks that are not spalled or with spalling along ≤ 10% of the crack length.

Moderate—Cracks with spalling along > 10% and ≤ 50% of the crack length.

High—Cracks with spalling > 50% of the crack length.

Map Cracking

This distress has a series of cracks that extend only into the upper surface of the slab. Larger cracks frequently are oriented in the longitudinal direction of the pavement and are interconnected by finer transverse or random cracks.

FIGURE B41 Map cracking.

Note: The severity level is not applicable.

Scaling

This distress is the deterioration of the upper concrete slab surface, normally 1/8 in. to ½ in., and may occur anywhere over the pavement.

FIGURE B42 Scaling.

Note: The severity level is not applicable.

Polished Aggregate

This distress has the surface binder worn away to expose coarse aggregate that has been worn smooth by the action of traffic.

FIGURE B43 Polished aggregate.

Note: The severity level is not applicable. However, the degree of polishing may be reflected in a reduction of surface friction.

Popouts

This distress has small pieces of pavement broken loose from the surface, normally ranging in diameter from 1 in. to 4 in., with a depth from ½ in. to 2 in..

FIGURE B44 Popouts.

Note: The severity level is not applicable. However, severity levels can be defined in relation to the intensity of popouts.

Blowups

This distress has localized upward movement of the pavement surface at transverse joints or cracks, often accompanied by shattering of the concrete in that area.

FIGURE B45 Blowups.

Note: The severity level is not applicable. However, severity levels can be defined by the relative effect of a blowup on ride quality and safety.

Transverse Construction Joint Deterioration

This distress has a series of closely spaced transverse cracks or a large number of interconnecting cracks occurring near the construction joint.

FIGURE B46 Transverse construction joint deterioration.

Low—No spalling or faulting within 2 ft of a construction joint.

Moderate—Spalling < 3 in. exists within 2 ft of a construction joint.

High—Spalling ≥ 3 in. and breakup exists within 2 ft of construction joint.

Patch/Patch Deterioration

This distress is a portion of the pavement surface, greater than 1 ft^2, that has been removed and replaced or where additional material has been applied to the pavement after original construction.

FIGURE B47 Patch/patch deterioration.

Low—Patch has low severity distress of any type; and no measurable faulting or settlement; pumping is not evident.

Moderate—Patch has moderate severity distress of any type; or faulting or settlement up to ¼ in.; pumping is not evident.

High—Patch has a high severity distress of any type; or faulting or settlement ≥ ¼ in.; pumping may be evident.

Punchouts

This distress has an area enclosed by two closely spaced (usually < 2 ft) transverse cracks, a short longitudinal crack, and the edge of the pavement or a longitudinal joint. Also, includes "Y" cracks that exhibit spalling, breakup, or faulting.

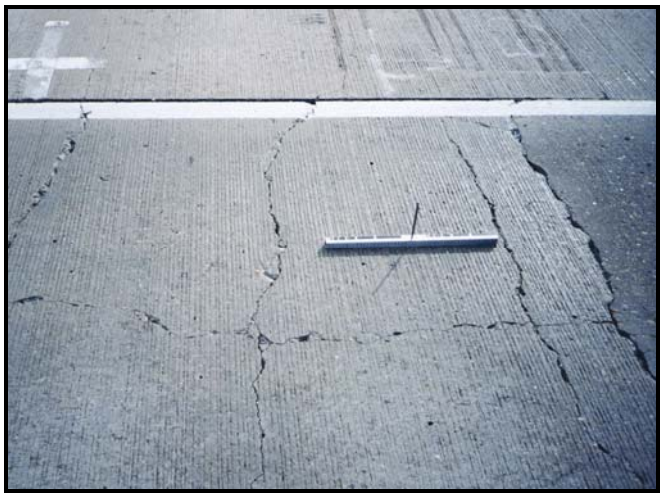

FIGURE B48 Punchouts.

Low—Longitudinal and transverse cracks are tight and may have spalled < 3 in. or faulting < ¼ in. with no loss of material and no patching. Does not include "Y" cracks.

Moderate—Spalling ≥ 3 in. and < 6 in. or faulting ≥ ¼ in. and < ½ in.

High—Spalling ≥ 6 in., or concrete within the punchout is pushed down by ½ in. or is loose and moves under traffic or is broken into two or more pieces or contains patch material.

Spalling of Longitudinal Joints

This distress has cracking, breaking, chipping, or fraying of slab edges within 1 ft of the longitudinal joint.

FIGURE B49 Spalling of longitudinal joints.

Low—Spalls < 3 in. wide, measured to the face of the joint, with loss of material or spalls with no loss of material, and no patching.

Moderate—Spalls 3 in. to 6 in. wide, measured to the face of the joint, with loss of material.

High—Spalls > 6 in. wide, measured to the face of the joint, with loss of material, is broken into two or more pieces, or contains patch material.

Water Bleeding and Pumping

This distress has seeping or ejection of water from beneath the pavement through cracks. In some cases, it is detectable by deposits of fine material left on the pavement surface that were eroded (pumped) from the support layers and have stained the surface.

FIGURE B50 Water bleeding and pumping.

Note: The severity level is not applicable. Severity levels are not used because the amount and degree of water bleeding and pumping changes with varying moisture conditions.

Roughness

This distress is a measured performance parameter over the design life of a pavement structure. It is based on the initial as-constructed profile of the pavement and upon the subsequent development of distresses over time. These distresses include cracking, faulting, or punchouts. Additionally, subgrade and climatic factors are also considered to account for the roughness caused by shrinking or swelling soils and frost heave conditions (NCHRP Project 1-40, MEPDG, Rigid Pavement Analysis Parameters). The current unit of measure within many state DOTs is based on the IRI.

Low—IRI < 95 in./mile

Medium—IRI ≥ 95 in./mile and < 120 in./mile

High—IRI > 120 in./mile

Frost Heave

This distress may occur within or beneath a pavement and is caused by the accumulation of ice within the larger soil voids and, usually, a subsequent expansion to form continuous ice lenses, layers, veins, or other ice masses (AASHTO *Guide for Design of Pavement Structures* 1993).

FIGURE B51 Frost heave.

Note: The severity level is not applicable. The severity levels are not used because the amount and degree of frost heave changes with varying moisture conditions.

Alkali–Silica Reaction (ASR)

This distress is caused by the expansion and cracking of portland cement resulting from chemical reactions involving alkali ions from portland cement, hydroxyl ions, and certain siliceous aggregate constituents, that lead to the loss of strength, elasticity, and durability of concrete (Mehta 1986).

FIGURE B52 Alkali–silica reaction.

Note: The severity level is not applicable. The severity levels are not used because the amount and degree of ASR changes with varying permeability, ion and silica concentrations, and moisture conditions.