APPENDIX B
DISTRESS IDENTIFICATION MANUAL

ASPHALT SURFACED PAVEMENTS

INTRODUCTION

The distress definitions were developed initially on the airfield distress identification manual by Shahin, Darter and Kohn\(^1\) and the "Standard Nomenclature and Definitions for Pavement Components and Deficiencies" (Special Report 113, Highway Research Board); and considerably further developed through extensive field surveys and discussions with state highway engineers. The photographs were obtained during many field trips and surveys conducted on highways located throughout the United States. This manual can be used as a standard guide for distress identification and measurement for highway asphalt surfaced pavements, including both typical flexible pavements and asphalt overlays of concrete pavements.

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Name of Distress: Alligator or Fatigue Cracking

Description: Alligator or fatigue cracking is a series of interconnecting cracks caused by fatigue failure of the asphalt concrete surface (or stabilized base) under repeated traffic loading. The cracking initiates at the bottom of the asphalt surface (or stabilized base) where tensile stress and strain is highest under a wheel load. The cracks propagate to the surface initially as one or more longitudinal parallel cracks. After repeated traffic loading the cracks connect, forming many-sided, sharp-angled pieces that develop a pattern resembling chicken wire or the skin of an alligator. The pieces are usually less than 1 ft. on the longest side. Alligator cracking occurs only in areas that are subjected to repeated traffic loadings. Therefore, it would not occur over an entire area unless the entire area was subjected to traffic loading. Alligator cracking does not occur in asphalt overlays over concrete slabs. Pattern-type cracking which occurs over an entire area that is not subjected to loading is rated as block cracking which is not a load-associated distress. Alligator cracking is considered a major structural distress.

Severity Levels: L* - Longitudinal disconnected hairline cracks running parallel to each other. The cracks are not spalled. Initially there may only be a single crack in the wheel path (defined as Class 1 cracking at AASHO Road Test).

M* - Further development of low severity alligator cracking into a pattern of pieces formed by cracks that may be lightly surface spalled. Cracks may be sealed (defined as Class 2 cracking at AASHO Road Test).

H* - Medium alligator cracking has progressed so that pieces are more severely spalled at the edges and loosened until the cells rock under traffic. Pumping may exist (defined as Class 3 cracking at AASHO Road Test).

How to Measure: Alligator cracking is measured in square feet or square meters of surface area. The major difficulty in measuring this type of distress is that many times two or three levels of severity exist within one distressed area. If these portions can be easily distinguished from each other, they should be measured and recorded separately. However, if the different levels of severity cannot be easily divided, the entire area should be rated at the highest severity level present.

*L - Low severity level
*M - Medium severity level
*H - High severity level
Low severity alligator cracks allow moisture to enter the pavement structure. Moisture can greatly accelerate alligator cracking severity by softening the underlying granular or fine grain soil layers which results in increased deflections and stresses/strains under load. Saturation of granular materials or soils greatly decreases their capability to support loads and also leads to pumping of fines. The area of an asphalt shoulder near the lane/shoulder joint is particularly susceptible to excessive moisture infiltration and is also subjected to some encroachment and shoulder parking loads. Thus excess moisture in combination with freeze/thaw action can greatly decrease the base/subbase support and lead to accelerated occurrence of alligator cracking. Once low severity alligator cracking begins, moisture can infiltrate into the cracks causing accelerated increase in severity (i.e. changing from low to medium to high severity).
Figure B.1. Low Severity Alligator Cracking (fine longitudinal cracks in wheel path)

Figure B.2. Low Severity Alligator Cracking (fine longitudinal cracks in wheel path)
Figure B.3. Low Severity Alligator Cracking (sealed longitudinal cracks in wheel path of outer truck lane)

Figure B.4. Medium Severity Alligator Cracking in Wheel Paths
Figure B.5. Medium Severity Alligator Cracking in Wheel Paths

Figure B.6. Medium Severity Alligator Cracking in Wheel Paths Near Longitudinal Joint in Shoulder Due To Encroaching Traffic and Loss of Support
Figure B.7. Medium Severity Alligator Cracking in Wheel Paths

Figure B.8. Medium Alligator Cracking at Free Edge of Lane
Figure B.9. Medium Alligator Cracking in Outer Wheel Path
(pumping also exists)

Figure B.10. High Severity Alligator Cracking (in portions of
picture where pieces are severely spalled)
Figure B.11. High Severity Alligator Cracking in Center of Photo Where Pieces Are Severely Spalled

Figure B.12. High Severity Alligator Cracking of Shoulder Where Large Amount of Trucks Park
<table>
<thead>
<tr>
<th>Name of Distress:</th>
<th>Bleeding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>Bleeding is a film of bituminous material on the pavement surface which creates a shiny, glass-like, reflecting surface that usually becomes quite sticky. Bleeding is caused by excessive amounts of asphalt cement in the mix and/or low air void contents. It occurs when asphalt fills the voids of the mix during hot weather and then expands out onto the surface of the pavement. Since the bleeding process is not reversible during cold weather, asphalt will accumulate on the surface.</td>
</tr>
<tr>
<td>Severity Levels:</td>
<td>No degrees of severity are defined. Bleeding should be noted when it is extensive enough to cause a reduction in skid resistance.</td>
</tr>
<tr>
<td>How to Measure:</td>
<td>Bleeding is measured in square feet or square meters of surface area.</td>
</tr>
</tbody>
</table>

Figure B.13. Bleeding in Wheel Paths
Water does not normally affect bleeding. However, on some projects during the early stages of stripping, asphalt cement floats to the surface and gives the appearance and symptoms of bleeding. The surface looks oversphalted, while under layers are under asphalted due to stripping.
Figure B.14. Bleeding in Wheel Paths
Name of Distress: Block Cracking

Description: Block cracks divide the asphalt surface into approximately rectangular pieces. The blocks range in size from approximately 1 ft$^2$ to 100 ft$^2$. Cracking into larger blocks are generally rated as longitudinal and transverse cracking. Block cracking is caused mainly by shrinkage of the asphalt concrete and daily temperature cycling (which results in daily stress/strain cycling). It is not load-associated, although load can increase the severity of individual cracks from low to medium to high. The occurrence of block cracking usually indicates that the asphalt has hardened significantly. Block cracking normally occurs over a large proportion of pavement area, but sometimes will occur only in nontraffic areas. This type of distress differs from alligator cracking in that alligator cracks form smaller, many-sided pieces with sharp angles. Also unlike block cracks, alligator cracks are caused by repeated traffic loadings, and are, therefore, located only in trafficked areas (i.e., wheel paths).

Severity Levels:

L - Blocks are defined by (1) nonsealed cracks that are nonsplained (sides of the crack are vertical) or only minor spalling with a 1/4 in. (6 mm) or less mean width; or (2) sealed cracks have a sealant in satisfactory condition to prevent moisture infiltration.

M - Blocks are defined by either (1) sealed or nonsealed cracks that are moderately spalled; (2) nonsealed cracks that are not spalled or have only minor spalling, but have a mean width greater than approximately 1/4 in. (6 mm) or (3) sealed cracks that are not spalled or have only minor spalling, but have sealant in unsatisfactory condition.

H - Blocks are well-defined by cracks that are severely spalled.

How to Measure: Block cracking is measured in square feet or square meters of surface area. It usually occurs at one severity level in a given pavement section; however, any areas of the pavement section having distinctly different levels of severity should be measured and recorded separately.
Acceleration of Block Cracking by Moisture:

Moisture does not affect the initiation of block cracking, but significant infiltration into the cracks can lead to accelerated increase in severity of the crack if heavy traffic uses the pavement. Excess water infiltration into the cracks can also lead to other distress such as frost heaving near the crack.
Figure B.15. Low Severity Block Cracking

Figure B.16. Low Severity Block Cracking Near Centerline
Figure B.17. Medium Severity Block Cracking

Figure B.18. Medium Severity Block Cracking
Figure B.19. High Severity Block Cracking

Figure B.20. High Severity Block Cracking
Name of Distress: Corrugation

Description: Corrugation is a form of plastic movement typified by ripples across the asphalt pavement surface. It occurs usually at points where traffic starts and stops. Corrugation usually occurs in asphalt layers that lack stability in warm weather, but may also be attributed to excessive moisture in a subgrade, contamination of the mix, or lack of aeration of liquid asphalt mixes.

Severity Levels:

- L: Corrugations cause some vibration of the vehicle which creates no discomfort.
- M: Corrugations cause significant vibration of the vehicle which creates some discomfort.
- H: Corrugations cause excessive vibration of the vehicle which creates substantial discomfort, and/or a safety hazard, and or vehicle damage, requiring a reduction in speed for safety.

How to Measure: Corrugation is measured in square feet or square meters of surface area. Severity levels are determined by riding in a mid to full sized sedan weighing approximately 3000-3800 lbs (13.3-16.9 kN) over the pavement inspection unit at the posted speed limit.

Figure B.21. Illustrative Diagram of Corrugation Profile
Acceleration of Corrugation Due to Moisture:

Moisture may accelerate ride quality distress by reducing the stiffness of asphalt mixes. Significant moisture may permeate into the asphalt mix, particularly cold mixes (cut backs and emulsions). The excess moisture causes the resilient modulus to decrease and this increases the potential for permanent deformation under repeated load. Excessive moisture in the subgrade will result in increased deflections in the surface. Repeated dynamic loads may result in small surface deformations, which cause increased roughness. Dynamic loading and depressions can create the corrugations which affect ride quality.
Figure B.21a. High Severity Corrugation

Figure B.21b. High Severity Corrugation
<table>
<thead>
<tr>
<th>Name of Distress:</th>
<th>Depression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>Depressions are localized pavement surface areas having elevations slightly lower than those of the surrounding pavement. In many instances, light depressions are not noticeable until after a rain, when ponding water creates &quot;birdbath&quot; areas; but the depressions can also be located without rain because of strains created by oil droppings from vehicles. Depressions can be caused by settlement of the foundation soil or can be &quot;built in&quot; during construction. Depressions cause roughness, and when filled with water of sufficient depth could cause hydroplaning of vehicles.</td>
</tr>
<tr>
<td>Severity Levels:</td>
<td>L - Depressions cause some bounce of the vehicle which creates no discomfort.</td>
</tr>
<tr>
<td></td>
<td>M - Depressions cause significant bounce of the vehicle which creates some discomfort.</td>
</tr>
<tr>
<td></td>
<td>H - Depressions cause excessive bounce of the vehicle which creates substantial discomfort, and/or a safety hazard, and/or vehicle damage, requiring a reduction in speed for safety.</td>
</tr>
<tr>
<td>How to Measure:</td>
<td>Depressions are measured in square feet or meters in each inspection unit. Each depression is rated according to its level of severity. Severity level is determined by riding in a mid to full sized sedan weighing approximately 3000-3800 lbs (13.3-16.9 kN) over the pavement inspection unit at the posted speed limit.</td>
</tr>
</tbody>
</table>
Depressions delay the runoff of water after a rain storm. The water is collected in the depressions, thus increasing the exposure time of the water to infiltrate through the pavement surface. Higher moisture contents within the pavement will accelerate various distresses such as pumping, rutting and alligator cracking.
Name of Distress: Joint Reflection Cracking from PCC Slab

Description: This distress occurs only on pavements having an asphalt concrete surface over a jointed portland cement concrete (PCC) slab and they occur at transverse and longitudinal joints (i.e., widening joints). This distress does not include reflection cracking away from a joint or from any other type of base (i.e., cement stabilized, lime stabilized) as these cracks are identified as "Longitudinal and Transverse Cracking." Joint reflection cracking is caused mainly by movement of the PCC slab beneath the asphalt concrete (AC) surface because of thermal and moisture changes; it is generally not load initiated. However, traffic loading may cause a breakdown of the AC near the initial crack, resulting in spalling. A knowledge of slab dimensions beneath the AC surface will help to identify these cracks.

Severity Levels:

L - Cracks have either minor spalling or no spalling and can be sealed or nonsealed. If nonsealed, the cracks have a mean width of 1/4 in. (6 mm) or less; sealed cracks are of any width, but their sealant material is in satisfactory condition to substantially prevent water infiltration. No significant bump occurs when a vehicle crosses the crack.

M - One of the following conditions exists: (1) cracks are moderately spalled and can be either sealed or nonsealed of any width; (2) sealed cracks are not spalled or have only minor spalling, but the sealant is in a condition so that water can freely infiltrate; (3) nonsealed cracks are not spalled or are only lightly spalled, but the mean crack width is greater than 1/4 in. (6 mm); (4) low severity random cracking exists near the crack or at the corners of intersecting cracks; or (5) the crack causes a significant bump to a vehicle.

H - (1) Cracks are severely spalled and/or there exists medium or high random cracking near the crack or at the corners of intersecting cracks, or (2) the crack causes a severe bump to a vehicle.

How to Measure: Joint reflection cracking is measured in linear feet or meters. The length and severity level of each crack should be identified and recorded. If the crack does not have the same severity level along its entire length, each general portion should be recorded separately. The vehicle used to determine bump severity is a mid to full sized sedan weighing approximately 3000-3800 lbs (13.3-16.9 kN) over the pavement inspection unit at the posted speed limit.
Acceleration of Joint Reflection Cracking Due to Moisture: The initiation of this cracking is not moisture related, but after the crack forms, water can infiltrate into the pavement if it is not properly sealed. Excessive free moisture in the crack may accelerate the change in severity of the crack due to softening of the asphalt concrete from stripping or loss of bond with aggregate, or freeze-thaw action.
Figure B.22. Low Severity Depression (identified by oil droppings on pavement surface)

Figure B.23. High Severity Depression in Shoulder (high severity alligator cracking also exists and would be recorded in addition to the depression)
Figure B.24. Low Severity Joint Reflection Cracking From Transverse Joint in PCC Slab

Figure B.25. Low Severity Joint Reflection Cracking from Transverse Joint in PCC Slab
Figure B.26. Medium Severity Joint Reflection Cracking from Longitudinal Widening Joint in PCC Slab

Figure B.27. Medium Severity Joint Reflection Cracking from Transverse Joint in PCC Slab
Figure B.28. High Severity Joint Reflection Cracking from Transverse Joint in PCC Slab

Figure B.29. High Severity Joint Reflection Cracking from Longitudinal Widening Joint in PCC Slab
Figure B.30. High Severity Joint Reflection Cracking from Transverse Joint in PCC Slab
Name of Distress: Lane/Shoulder Dropoff or Heave

Description: Lane/Shoulder dropoff or heave occurs wherever there is a difference in elevation between the traffic lane and shoulder. Typically the outside shoulder settles due to consolidation or a settlement of the underlying granular or subgrade material, or pumping of the underlying material. Heave of the shoulder may occur due to frost action or swelling soils. Dropoff of granular or soil shoulder is generally caused from blowing away of shoulder material from passing trucks.

Severity Level: Severity level is determined by computing the mean difference in elevation between the traffic lane and shoulder:

- **L** 1/4 - 1/2 in. (6 - 13 mm)
- **M** 1/2 - 1 in. (3 - 25 mm)
- **H** > 1 in. (> 25 mm)

How to Measure: Lane/shoulder dropoff or heave is measured every 100 ft. (30 m) in inches (or mm) along the joint. The mean difference in elevation is computed from the data and used to determine severity level.

Figure B.31. Medium Severity Lane/Shoulder Drop-off
Acceleration of Dropoff Due to Moisture: Moisture entering through the longitudinal joint between the shoulder and lane results in excess free moisture in the underlying material. The material then becomes soft and settles under load, and/or pumping may occur disintegrating the material and creating a voids. In both cases the shoulder will then settle downward producing the dropoff. Heave is caused by (1) frost heave from ice lenses, or (2) swelling subgrade soils. Both settlement and heave usually results in shoulder edge cracking and breakup in conjunction with traffic load encroachment.
Name of Distress: Lane/Shoulder Joint Separation

Description: Lane/Shoulder joint separation is the widening of the joint between the traffic lane and the shoulder generally due to movement in the shoulder. If the joint is tightly closed or well sealed so water cannot enter (or if there is no joint due to full width paving), then lane/shoulder joint separation is not considered a distress. If the shoulder is not paved (i.e., gravel or grass) then the severity should be rated as high. If a curbing exists, then it should be rated according to the width of the joint between the asphalt surface and curb.

Severity Level: Severity level is determined by the mean joint opening. No severity level is counted if the joint is well sealed to prevent moisture intrusion.

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>0.04 - .12 in.</td>
<td>(1 - 3 mm)</td>
</tr>
<tr>
<td>M</td>
<td>&gt; .12 - .40 in.</td>
<td>(&gt; 3 - 10 mm)</td>
</tr>
<tr>
<td>H</td>
<td>&gt; .40 in</td>
<td>(&gt; 10 mm) (also a nonpaved shoulder)</td>
</tr>
</tbody>
</table>

How to Measure: Lane/Shoulder joint separation is measured in inches (or millimeters) at about 50 ft. (15.2 m) intervals along the sample unit. The mean separation is used to determine severity level.

Figure B.32. Medium Severity Lane/Shoulder Joint Separation (note Separation near outside of edge paint strip)
Excess moisture beneath the shoulder may result in frost heave and/or settlement of the shoulder which would cause lane/shoulder joint opening. Once the joint is open additional moisture can enter which accelerates many distresses as described under lane/shoulder dropoff or heave.
Name of Distress: Longitudinal and Transverse Cracking (Non-PCC Slab Joint Reflective)

Description: Longitudinal cracks are parallel to the pavement’s centerline or laydown direction. They may be caused by (1) a poorly constructed paving lane joint, (2) shrinkage of the AC surface due to low temperatures or hardening of the asphalt, or (3) a reflective crack caused by cracks beneath the surface course, including cracks in PCC slabs (but not at PCC slab joints). Transverse cracks extend across the pavement centerline or direction of laydown. They may be caused by items 2 or 3 above. These types of cracks are not usually load associated.

Severity Levels:

L - Cracks have either minor spalling or no spalling, and cracks can be sealed or nonsealed. If sealed, cracks have a mean width of 1/4 in. (6 mm) or less; sealed cracks are of any width, but their sealant material is in satisfactory condition to substantially prevent water infiltration. No significant bump occurs when a vehicle crosses the crack.

M - One of the following conditions exists: (1) cracks are moderately spalled and can either be sealed or nonsealed of any width; (2) sealed cracks are not spalled or have only minor spalling, but the sealant is in a condition so that water can freely infiltrate; (3) nonsealed cracks are not spalled or have only minor spalling, but mean crack width is greater than 1/4 in. (6 mm); (4) low severity random cracking exists near the crack or at the corners of intersecting cracks; or (5) the crack causes a significant bump to a vehicle.

H - (1) Cracks are severely spalled; and/or medium or high random cracking exists near the crack or at the corners of intersecting cracks, or (2) the crack causes a severe bump to a vehicle.

How to Measure: Longitudinal and transverse cracks are measured in lineal feet or lineal meters. The length and severity of each crack should be identified and recorded. If the crack does not have the same severity level along its entire length, each general portion of the crack having a different severity level should be recorded separately. The vehicle used to determine bump severity is a mid to full sized sedan weighing approximately 3000-3800 lbs. (13.5-16.9 kN) over the pavement inspection unit at the posted speed limit.
Acceleration of Longitudinal and Transverse Cracking Due to Moisture:

The initiation of this cracking is generally not moisture related, but after the cracking occurs water can infiltrate into the pavement if it is not properly sealed. Excessive free moisture in the crack may accelerate a change in severity of the crack due to stripping or loss of bond with the aggregate, or freeze-thaw action causing spalling of the crack. Water that infiltrates into the base, subbase and subgrade will increase the degree of saturation. The loss of support causes increased stress near the crack which may lead to alligator cracking, settlement or rutting. Also, a saturated base will produce ice lenses during the winter causing heaving or "tenting" near the crack. After spring thaw the material will settle and again the stress concentration along the crack increases.
Figure B.33. Low Severity Transverse Cracking

Figure B.34. Low Severity Longitudinal and Transverse Cracking
Figure B.35. Low Severity Transverse Cracking Across Shoulder

Figure B.36. Medium Severity Transverse Cracking
Figure B.37. Medium Severity Transverse Cracking

Figure B.38. Medium Severity Transverse Cracking
Figure B.39. Medium Severity Transverse Cracking

Figure B.40. Medium Severity Transverse Cracking Across Shoulder
Figure B.41. High Severity Transverse Cracking

Figure B.42. High Severity Longitudinal Cracking
Figure B.43. High Severity Transverse Cracking

Figure B.44. High Severity Transverse Cracking (this crack is Caused initially by reflection from cement Stabilized base)
Name of Distress: Patch Deterioration

Description: A patch is an area where the original pavement has been removed and replaced with either similar or different material.

Severity Levels: L - Patch is in very good condition and is performing satisfactorily.

M - Patch is somewhat deteriorated, having low to medium levels of any types of distress.

H - Patch is badly deteriorated and soon needs replacement.

How to Measure: Each patch is measured in square feet or square meters of surface area. Even if a patch is in excellent condition it is still rated low severity.

Figure B.45. Low Severity Patch
Acceleration of Patch Distress Due to Moisture: Excess moisture accumulated beneath the patch or in the patch/pavement joint can cause high deflections and pumping near the edges and cracking or disintegration of the patch. Excess moisture can also accelerate the breakdown of the bond between the patch and pavement. Thus the severity of patch distress would increase more rapidly.
Figure B.46. Low Severity Patch

Figure B.47. Low Severity Patch Along Shoulder Joint
Figure B.48. Medium Severity Patch

Figure B.49. Medium Severity Patch
Figure B.50. High Severity Patch
<table>
<thead>
<tr>
<th>Name of Distress:</th>
<th>Polished Aggregate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td>Aggregate polishing is caused by repeated traffic applications. Polished aggregate is present when close examination of a pavement reveals that the portion of aggregate extending above the asphalt is either very small, or there are no rough or angular aggregate particles to provide good skid resistance.</td>
</tr>
<tr>
<td>Severity Levels:</td>
<td>No degrees of severity are defined. However, the degree of polishing should be significant in reducing skid resistance before it is included as a distress.</td>
</tr>
<tr>
<td>How to Measure:</td>
<td>Polished aggregate is measured in square ft. or square meters of surface area. The existence of polishing can be detected by both visually observing and running the fingers over the surface.</td>
</tr>
</tbody>
</table>

Figure B.51. Polished Aggregate (photo taken in wheel path of 23 year old high traffic volume turnpike)
Acceleration of Polished Aggregate Due to Moisture: None.
Name of Distress: Potholes

Description: A bowl shaped hole of various sizes in the pavement surface. The surface has broken into small pieces by alligator cracking or by localized disintegration of the mixture and the material is removed by traffic. Traffic loads force the underlying materials out of the hole, increasing the depth.

Severity Levels:

<table>
<thead>
<tr>
<th>Area (ft²)</th>
<th>&lt; 1</th>
<th>1 - 3</th>
<th>&gt; 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth - ins. (mm) (m²)</td>
<td>&lt; 1/3</td>
<td>1/3 - 1</td>
<td>&gt; 1</td>
</tr>
<tr>
<td>&lt; 1 (&lt; 25)</td>
<td>L</td>
<td>L</td>
<td>M</td>
</tr>
<tr>
<td>1-2 (25-50)</td>
<td>M</td>
<td>M</td>
<td>H</td>
</tr>
<tr>
<td>&gt; 2 (&gt; 50)</td>
<td>M</td>
<td>H</td>
<td>H</td>
</tr>
</tbody>
</table>

How to Measure: Potholes are counted in numbers of holes of each severity level in the inspection unit.

Figure B.52. Low Severity Pothole
Figure B.53. Low Severity Pothole

Figure B.54. Medium Severity Pothole
Figure B.55. Medium Severity Pothole

Figure B.56. High Severity Pothole
Figure B.57. High Severity Pothole
Acceleration of Pothole Distress: Potholes occur due to the breakdown or disintegration of the asphalt surface material from alligator cracking, linear cracking, or raveling and weathering, all of which are accelerated by free moisture.

Once a small hole exists, free moisture will accumulate and through freeze-thaw and/or pumping action additional material will be broken out of the hole and it will increase in severity.
Name of Distress: Pumping and Water Bleeding

Description: Pumping is the ejection of water and fine materials under pressure through cracks under moving loads. As the water is ejected it carries fine material resulting in progressive material deterioration and loss of support. Several cases of pumping of stabilized base materials have been observed for example. Surface staining or accumulation of material on the surface close to cracks is evidence of pumping. Water bleeding occurs where water seeps slowly out of cracks in the pavement surface.

Severity Levels:
- L - Water bleeding exists or water pumping can be observed when heavy loads pass over the pavement, however no fines (or only a very small amount) can be seen on the surface of the pavement.
- M - Some pumped material can be observed near cracks in the pavement surface.
- H - A significant amount of pumped material exists on the pavement surface near the cracks.

How to Count: If pumping or water bleeding exists anywhere in the sample unit it is counted as occurring.

Figure B.58. Medium Severity (stabilized base is pumping)
Acceleration of Pumping Due to Moisture: Pumping or water bleeding is caused by excess free water and significant pumping will lead to disintegration of the base/sub base resulting in the occurrence of several distresses.
Figure B.58a. Medium Severity Pumping

Figure B.58b. Medium Severity Pumping
Figure B.59. High Severity Pumping (stabilized base is pumping)

Figure B.60. High Severity Pumping (stabilized base is pumping)
**Name of Distress:** Raveling and Weathering

**Description:** Raveling and weathering are the wearing away of the pavement surface caused by the dislodging of aggregate particles (raveling) and loss of asphalt binder (weathering). They generally indicate that the asphalt binder has hardened significantly.

**Severity Levels:**

- L - Aggregate or binder has started to wear away, but has not progressed significantly.
- M - Aggregate and/or binder has worn away and the surface texture is moderately rough and pitted. Loose particles generally exist.
- H - Aggregate and/or binder has worn away and the surface texture is severely rough and pitted.

**How to Measure:** Raveling and weathering are measured in square ft. or square meters of surface area.

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Figure B.61. Low Severity Raveling and Weathering
Acceleration of Raveling and Weathering Due To Moisture: Prolonged soaking of the asphalt stabilized materials causes moisture to penetrate between the asphalt and aggregate surface that wets the surface of the aggregate. The moisture may penetrate the asphalt films by emulsion formation causing stripping and thus contributing to raveling and weathering.
Figure B.62. Medium Severity Raveling and Weathering

Figure B.63. Medium Severity Raveling and Weathering
Figure B.64. Medium Severity Raveling and Weathering

Figure B.65. Medium Severity Raveling and Weathering
Figure B.66. High Severity Raveling and Weathering

Figure B.67. High Severity Raveling and Weathering
Name of Distress: Rutting

Description: A rut is a surface depression in the wheel paths. Pavement uplift may occur along the sides of the rut; however, in many instances ruts are noticeable only after a rainfall, when the wheel paths are filled with water. Rutting stems from a permanent deformation in any of the pavement layers or subgrade, usually caused by consolidation or lateral movement of the materials due to traffic loads. Rutting may be caused by plastic movement in the mix in hot weather, or inadequate compaction during construction. Significant rutting can lead to major structural failure of the pavement and hydroplaning potential. Wear of the surface in the wheel paths from studded tires can also cause a type of "rutting."

Severity Levels:

<table>
<thead>
<tr>
<th>Severity</th>
<th>Mean Rut Depth Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>1/4 - 1/2 in. (6 - 13 mm)</td>
</tr>
<tr>
<td>M</td>
<td>&gt;1/2 - 1 in. (13 - 25 mm)</td>
</tr>
<tr>
<td>H</td>
<td>&gt;1 in. (&gt; 25 mm)</td>
</tr>
</tbody>
</table>

How to Measure: Rutting is measured in square feet or square meters of surface area, and its severity is determined by the mean depth of the rut. To determine the mean rut depth, a 4 ft. (1.2 m) straightedge should be laid across the rut and the maximum depth measured. The mean depth should be computed from measurements taken every 20 ft. (6 m) along the length of the rut.
Acceleration of Rutting Due to Moisture:

Moisture may accelerate rutting in several ways: 1) by softening the asphalt mix, 2) outward displacement of non-stabilized material in the pavement structure through pumping and 3) reduction of strength of the base/subbase/subgrade soil.

Moisture may cause the strength of the asphalt mix to decrease through stripping or loss of bond between asphalt and aggregate. This will increase the potential for permanent deformation in the mix. Moisture may cause outward displacement of non-stabilized material in two ways. At high degrees of saturation (i.e., 80% or greater), granular material tends to lose stability under repeated loading due to the development of excess pore water pressures. At high moisture contents under heavy dynamic loads, fine grain material will go into suspension and move under water pressure away from the loaded area. Both of these conditions result in decreasing the layer thickness in the wheel paths.

Excess moisture softens subgrade soils, which results in increased deflections and stresses/stains under load. The capability of the subgrade soil to support loads may be decreased to the point where permanent deformation may occur. Also, freeze-thaw cycles on near saturated soils causes great loss in strength and resiliency.
Figure B.68. Low Severity Rutting

Figure B.69. Medium Severity Rutting
Figure B.70. High Severity Rutting
Name of Distress: Slippage Cracking

Description: Slippage cracks are crescent or half-moon shaped cracks generally having two ends pointed into the direction of traffic. They are produced when braking or turning wheels cause the pavement surface to slide and deform. This usually occurs when there is a low strength surface mix or poor bond between the surface and next layer of pavement structure.

Severity Levels: No degrees of severity are defined. It is sufficient to indicate that a slippage crack exists.

How to Measure: Slippage cracking is measured in square meters or in square feet of surface area within the inspection unit.

Figure B.71. Slippage Cracking
Figure B.72. Slippage Cracking

Figure B.73. Slippage Cracking
Name of Distress: Swell

Description: Swell is characterized by an upward bulge in the pavement's surface. A swell may occur sharply over a small area or as a longer, gradual wave. Either type of swell can be accompanied by surface cracking. A swell is usually caused by frost action in the subgrade or by swelling soil, but a swell can also occur on the surface of an asphalt overlay (over PCC) as a result of a blowup in the PCC slab. They can often be identified by oil droppings on the surface.

Severity Levels:  
L - Swell causes some bounce of the vehicle which creates no discomfort.

M - Swell causes significant bounce of the vehicle which creates some discomfort.

H - Swell causes excessive bounce of the vehicle which creates substantial discomfort, and/or a safety hazard, and/or vehicle damage, requiring reduction in speed for safety.

How to Measure: Swells within the inspection unit are measured in square feet or meters. Severity level is determined by riding in a mid to full sized sedan weighing approximately 3000-3800 lbs (13.6-16.9 kN) over the pavement inspection unit at the posted speed limit.

Figure B.74. Medium Severity Swell Occurring at a Patch Due to Buckling of Concrete Slab Beneath Asphalt Surface
<p>| Acceleration of Slippage Cracking Due to Moisture: | Free moisture between the asphalt concrete surface and granular layer may weaken the bond between the layers. Once this bond is lost the potential for slippage cracking in areas of breaking or turning traffic increases dramatically. |</p>
<table>
<thead>
<tr>
<th>Acceleration of Swells</th>
<th>Swells can be accelerated by moisture in two ways:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swell Due to Frost</td>
<td>(1) frost heaves may occur in freeze climates,</td>
</tr>
<tr>
<td>Moisture:</td>
<td>(2) an expansive soil will swell when exposed to</td>
</tr>
<tr>
<td></td>
<td>moisture, and (3) heave over culverts, when colder</td>
</tr>
<tr>
<td></td>
<td>soils draw in moisture and create local heaves.</td>
</tr>
<tr>
<td></td>
<td>Frost heave is caused by the formation of ice crystals in a frost susceptible sub grade. The ice crystals grow until ice lenses from which produce frost heave.</td>
</tr>
<tr>
<td></td>
<td>A swelling soil increases in volume when content increases, and decreases its volume when water content is reduced. A swelling soil has a high plasticity index and can be determined by lab test or experience.</td>
</tr>
</tbody>
</table>
Figure B.75. High Severity Swell Due to Buckling of Concrete Slab Beneath Asphalt Surface