

# CONCRETE SURFACED ROADS & PARKING LOTS

## PAVER™ DISTRESS IDENTIFICATION MANUAL

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## FOREWORD

This document is a revision and technical update of the original *PAVER™ Concrete Distress Manual* by M.Y. Shahin and S.D. Kohn (USACERL, June 1989). This update was prepared for HQ IMCOM, Public Works Division. The Technical Monitor was Ali A. Achmar.

The work was conducted by the U.S. Army Corps Of Engineers, ERDC-CERL. The Principal Investigator was M.Y. Shahin.

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Shahin, M.Y., and S.D. Kohn, Pavement Maintenance Management for Roads and Parking Lots. TR-M-294/ADA110296 (USACERL, October 1981).

Technical Manual (TM) 5-623, Pavement Maintenance Management (Headquarters, Department of the Army, 1982).

## **OBJECTIVE AND SCOPE OF THIS MANUAL**

This manual contains distress definitions and measurement methods for jointed concrete surfaced roads and parking lots. This information is used to determine the Pavement Condition Index (PCI).

# IDENTIFYING AND COUNTING CONCRETE PAVEMENT DISTRESSES

This manual lists alphabetically 19 distress types for jointed concrete pavements. Distress definitions apply to both plain and reinforced jointed concrete pavements, with the exception of linear cracking distress, which is defined separately for plain and reinforced jointed concrete.

New PAVER™ users often ask about identification and counting methods for various distresses. Detailed answers to these questions are included for each distress under the heading “How To Count.” For the reader’s convenience, however, the most frequently asked questions are addressed below:

1. **How should faulting be counted?**  
Faulting is counted only at joints. Faulting associated with cracking is not counted separately since it is incorporated into the severity level definitions of cracks. Crack definitions are also used in defining corner breaks and divided slabs.
2. **How should joint seal damage be counted?** Joint seal damage is not counted on a slab-by-slab basis. Instead, a severity level is assigned based on the overall condition of the joint seal in the area.
3. **How are shrinkage cracks distinguished from linear cracks?** Cracks in reinforced concrete slabs that are less than  $\frac{1}{8}$  in. wide are counted as shrinkage cracks. Shrinkage cracks should not be counted to determine if a slab is broken into four or more pieces.
4. **When should low severity scaling be counted?** Low severity scaling (i.e., crazing) should be counted only if there is evidence that future scaling is likely to occur.

The reader should note that the items above are general issues and do not stand alone as inspection criteria. To measure each distress type properly, the inspector must be familiar with the individual distress criteria, which are described and illustrated on the pages that follow.

# RIDE QUALITY ASSESSMENT

Two types of distresses, Blowup/ Buckling and Railroad Crossings, require an assessment of ride quality in order to establish a distress severity level. To assess ride quality for these distresses, the inspector should use the following severity level definitions:

- L      Low: Vehicle vibrations (e.g., from corrugation) are noticeable, but no reduction in speed is necessary for comfort or safety; and/ or individual bumps or settlements cause the vehicle to bounce slightly, but create little discomfort.
- M      Medium: Vehicle vibrations are significant and some reduction in speed is necessary for safety and comfort; and/ or individual bumps or settlements cause the vehicle to bounce significantly, creating some discomfort.
- H      High: Vehicle vibrations are so excessive that speed must be reduced considerably for safety and comfort; and/ or individual bumps or settlements make the vehicle to bounce excessively, creating substantial discomfort, a safety hazard, or a strong possibility of causing vehicle damage.

The inspector should drive at the posted speed in a sedan that is representative of cars typically seen in local traffic. Pavement sections near stop signs should be rated at a deceleration speed appropriate for the intersection.

## BLOWUP/ BUCKLING (21)

### *Description*

Blowups or buckles occur in hot weather, usually at a transverse crack or joint that is not wide enough to permit slab expansion. The insufficient width is usually caused by infiltration of incompressible materials into the joint space. When expansion cannot relieve enough pressure, a localized upward movement of the slab edges (buckling) or shattering will occur in the vicinity of the joint. Blowups can also occur at utility cuts and drainage inlets.

### *Severity Levels*

- L** Buckling or shattering causes low severity ride quality.
- M** Buckling or shattering causes medium severity ride quality.
- H** Buckling or shattering causes high severity ride quality.

### *How To Count*

At a crack, a blowup is counted as being in one slab. However, if the blowup occurs at a joint and affects two slabs, the distress should be recorded as occurring in two slabs. When a blowup renders the pavement impassable, it should be repaired immediately.





LOW



MEDIUM



HIGH

## CORNER BREAK (22)

### *Description*

A corner break is a crack that intersects the joints at a distance less than or equal to half the slab length on both sides, measured from the corner of the slab. For example, a slab measuring 11½ by 20 ft (3½ by 6 m) that has a crack 5 ft (1½ m) on one side and 11½ ft (3½ m) on the other side, is not considered a corner break; it is a diagonal crack. However, a crack that intersects 4 ft (1.2 m) on one side and 8 ft (2½ m) on the other is considered a corner break. A corner break differs from a corner spall in that the crack extends vertically through the entire slab thickness, whereas a corner spall intersects the joint at an angle. Load repetition combined with loss of support and curling stresses usually cause corner breaks.

### *Severity Levels*

**L** Break is defined by a low severity\* crack. A low severity crack is  $\leq \frac{1}{2}$  in. (13 mm), cracks of any width with satisfactory filler; no faulting. The area between the break and the joints is not cracked or may be lightly cracked.

**M** Break is defined by a medium severity\* crack and/ or the area between the break and the joints has a medium crack. A medium severity crack is a non-filled crack  $> \frac{1}{2}$  in. and  $\leq 2$  in. (13 mm to 50 mm), a non-filled crack  $\leq 2$  in. (50 mm) with faulting  $\leq \frac{3}{8}$  in. (10 mm), or a filled crack with faulting  $\leq \frac{3}{8}$  in. (10 mm).

**H** Break is defined by a high severity\* crack and/ or the area between the break and the joints is highly cracked. A high severity crack is a non-filled crack  $> 2$  in. (50 mm) wide, or any filled or non-filled crack with faulting  $> \frac{3}{8}$  in. (10 mm).

### *How To Count*

Distressed slab is recorded as one slab if it:

1. Contains a single corner break.
2. Contains more than one break of a particular severity.
3. Contains two or more breaks of different severities. For two or more breaks, the highest level of severity should be recorded. For example, a slab containing both low and medium severity corner breaks should be counted as one slab with a medium corner break.

\*The above crack severity definitions are for non-reinforced slabs. For reinforced slabs see Linear Cracking.



LOW



MEDIUM



HIGH

22 CORNER BREAK

## DIVIDED SLAB (23)

### **Description**

Slab is divided by cracks into four or more pieces due to overloading and/ or inadequate support. If all pieces or cracks are contained within a corner break, the distress is categorized as a severe corner break.

### **Severity Levels**

Table 1 lists severity levels for divided slabs.

*Table 1: Levels Of Severity For Divided Slabs.*

Severity Of Majority Of Cracks	Number Of Pieces In Cracked Slab		
	4 to 5	6 to 8	More than 8
L	L	L	M
M	L	M	H
H	M	H	H

### **How To Count**

If the divided slab is medium or high severity, no other distress is counted for that slab.



LOW



MEDIUM



HIGH

23 DIVIDED SLAB

## DURABILITY (“D”) CRACKING (24)

### *Description*

“D” Cracking is caused by freeze-thaw expansion of the large aggregate which, over time, gradually breaks down the concrete. This distress usually appears as a pattern of cracks running parallel and close to a joint or linear crack. Since the concrete becomes saturated near joints and cracks, a dark-colored deposit can usually be found around fine “D” cracks. This type of distress may eventually lead to disintegration of the entire slab.

### *Severity Levels*

- L** “D” cracks cover less than 15 percent of slab area. Most of the cracks are tight, but a few pieces may be loose and/ or missing.
- M** One of the following conditions exist: (1) “D” cracks cover less than 15 percent of the area and most of the pieces are loose and/ or missing, or (2) “D” cracks cover more than 15 percent of the area and most of the cracks are tight, but a few pieces may be loose or missing.
- H** “D” cracks cover more than 15 percent of the area and most of the pieces have come out or could be removed easily.

### *How To Count*

When the distress is located and rated at one severity, it is counted as one slab. If more than one severity level exists, the slab is counted as having the higher severity distress. For example, if low and medium “D” cracking are on the same slab, the slab is counted as medium severity cracking only.



LOW



MEDIUM



HIGH

24 DURABILITY

## FAULTING (25)

### **Description**

Faulting is the difference in elevation across a joint. Some common causes of faulting are:

1. Settlement because of soft foundation.
2. Pumping or eroding of material from under the slab.
3. Curling of the slab edges due to temperature and moisture changes.

### **Severity Levels**

Severity levels are defined by the difference in elevation across the joint as indicated in Table 2.

Table 2: Levels Of Severity For Faulting.

Severity Level	Difference In Elevation
L	$> \frac{1}{8}$ and $\leq \frac{3}{8}$ in. ( $> 3$ and $\leq 10$ mm)
M	$> \frac{3}{8}$ and $\leq \frac{3}{4}$ in. ( $> 10$ and $\leq 19$ mm)
H	$> \frac{3}{4}$ in. ( $> 19$ mm)

### **How To Count**

Faulting across a joint is counted as one slab. Only affected slabs are counted. Faults across a crack are not counted as distress, but are considered when defining crack severity.





LOW



MEDIUM



HIGH

25 FAULTING

## JOINT SEAL DAMAGE (26)

### Description

Joint seal damage is any condition that enables soil or rocks to accumulate in the joints or allows significant water infiltration. Accumulation of incompressible materials prevents the slab from expanding and may result in buckling, shattering, or spalling. A pliable joint filler bonded to the edges of the slabs protects the joints from material accumulation and prevents water from seeping down and softening the foundation supporting the slab.

Typical types of joint seal damage are:

1. Stripping of joint sealant.
2. Extrusion of joint sealant.
3. Weed growth.
4. Hardening of the filler (oxidation).
5. Loss of bond to the slab edges.
6. Lack or absence of sealant in the joint.

### Severity Levels

**L**

Joint sealant is in generally good condition throughout section. Sealant is performing well, with only minor damage. Joint seal damage is at low severity if a few of the joints have sealer which has debonded from, but is still in contact with, the joint edge. This condition exists if a knife blade can be inserted between sealer and joint face without resistance.

**M**

Joint sealant is in generally fair condition over the entire section, with one or more of the above types of damage to a moderate degree. Sealant needs replacement within 2 years. Joint seal damage is at medium severity if a few of the joints have any of the following conditions: (a) joint sealer is in place, but water access is possible through visible openings no more than  $\frac{1}{8}$  in. (3 mm) wide. If a knife blade cannot be inserted easily between sealer and joint face, this condition does not exist; (b) pumping debris are evident at the joint; (c) joint sealer is oxidized and "lifeless" but pliable (like a rope), and generally fills the joint opening; or (d) vegetation in the joint is obvious, but does not obscure the joint opening.

**H**

Joint sealant is in generally poor condition over the entire section, with one or more of the above types of damage to a severe degree. Sealant needs immediate replacement. Joint seal damage is at high severity if 10% or more of the joint sealer exceeds limiting criteria listed above, or if 10% or more of sealer is missing.

### How To Count

Joint seal damage is not counted on a slab-by-slab basis, but is rated based on the overall condition of the sealant over the entire area.



LOW



MEDIUM



HIGH

## LANE/ SHOULDER DROP-OFF (27)

### *Description*

Lane/ shoulder drop-off is the difference between the settlement or erosion of the shoulder and the pavement travel-lane edge. The elevation difference can be a safety hazard; it can also cause increased water infiltration.

### *Severity Levels*

- L** The difference between the pavement edge and shoulder is  $> 1$  and  $\leq 2$  in. ( $> 25$  and  $\leq 50$  mm).
- M** The difference in elevation is  $> 2$  and  $\leq 4$  in. ( $> 50$  and  $\leq 100$  mm).
- H** The difference in elevation is  $> 4$  in. ( $> 100$  mm).

### *How To Count*

The mean lane/ shoulder drop-off is computed by averaging the maximum and minimum drop along the slab. Each slab exhibiting distress is measured separately and counted as one slab with the appropriate severity level.



LOW



MEDIUM



HIGH

27 LANE DROP-OFF

# LINEAR CRACKING (28) (LONGITUDINAL, TRANSVERSE, AND DIAGONAL CRACKS)

## Description

These cracks divide the slab into two or three pieces and are usually caused by a combination of repeated traffic loading, thermal gradient curling, and repeated moisture loading. Slabs divided into four or more pieces are counted as divided slabs. Hairline cracks only a few feet long and not extending across the entire slab are counted as shrinkage cracks.

## Severity Levels

### Non-reinforced Slabs

- L** Non-filled\* cracks  $\leq \frac{1}{2}$  in. (13 mm) or filled cracks of any width with the filler in satisfactory condition. No faulting exists.
- M** One of the following conditions exists: (1) non-filled crack with a width  $> \frac{1}{2}$  and  $\leq 2$  in. ( $> 13$  and  $\leq 50$  mm); (2) non-filled crack of any width  $\leq 2$  in. (50 mm) with faulting of  $\leq \frac{3}{8}$  in. (10 mm), or (3) filled crack of any width with faulting  $\leq \frac{3}{8}$  in. (10 mm).
- H** One of the following conditions exists: (1) non-filled crack with a width  $> 2$  in. (50 mm), or (2) filled or non-filled crack of any width with faulting  $> \frac{3}{8}$  in. (10 mm).

### Reinforced Slabs

- L** Non-filled cracks  $\geq \frac{1}{8}$  and  $< 1$  in. ( $\geq 3$  and  $< 25$  mm) wide; filled crack of any width with the filler in satisfactory condition. No faulting exists.
- M** One of the following conditions exists: (1) non-filled cracks with a width  $\geq 1$  and  $\leq 3$  in. ( $\geq 25$  and  $\leq 75$  mm) and no faulting; (2) non-filled crack of any width  $\leq 3$  in. (75 mm) with  $\leq \frac{3}{8}$  in. (10 mm) of faulting, or (3) filled crack of any width with  $\leq \frac{3}{8}$  in. (10 mm) faulting.
- H** One of the following conditions exists: (1) non-filled crack  $> 3$  in. (75 mm) wide, or (2) filled or non-filled crack of any width with faulting  $> \frac{3}{8}$  in. (10 mm).

## How To Count

After severity has been identified, the distress is recorded as one slab. If two medium severity cracks fall within one slab, the slab is counted as having one high severity crack. Slabs divided into four or more pieces are counted as divided slabs. In reinforced slabs, cracks  $< \frac{1}{8}$  in. (3 mm) wide are counted as shrinkage cracks. Slabs longer than  $29\frac{1}{2}$  ft (9 m) are divided into 'virtual slabs' of approximately equal length, with joints assumed to be in perfect condition.

\*Filled cracks with unsatisfactory filler are treated as non-filled cracks.



LOW



MEDIUM



HIGH

28 LINEAR CRACKING

## **PATCHING, LARGE (MORE THAN 5.5 FT<sup>2</sup> (0.5 M<sup>2</sup>)) AND UTILITY CUTS (29)**

### ***Description***

A patch is an area where the original pavement has been removed and replaced by filler material. A utility cut is a patch that has replaced the original pavement to allow the installation or maintenance of underground utilities. The severity levels of a utility cut are assessed according to the same criteria as large patching.

### ***Severity Levels***

- L** Patch is functioning well, with little or no deterioration.
- M** Patch is moderately deteriorated and/ or moderate spalling can be seen around the edges. Patch material can be dislodged with considerable effort.
- H** Patch is badly deteriorated. The extent of the deterioration warrants replacement.

### ***How To Count***

If a single slab has one or more patches with the same severity level, it is counted as one slab containing that distress. If a single slab has more than one severity level, it is counted as one slab with the higher severity level.





LOW



MEDIUM



HIGH

29 PATCHING, LARGE

## **PATCHING, SMALL (LESS THAN 5.5 FT<sup>2</sup> (0.5 M<sup>2</sup>)) (30)**

### ***Description***

A patch is an area where the original pavement has been removed and replaced by a filler material.

### ***Severity Levels***

- L** Patch is functioning well with little or no deterioration.
- M** Patch is moderately deteriorated. Patch material can be dislodged with considerable effort.
- H** Patch is badly deteriorated. The extent of deterioration warrants replacement.

### ***How To Count***

If a single slab has one or more patches with the same severity level, it is counted as one slab containing that distress. If a single slab has more than one severity level, it is counted as one slab with the higher severity level.



LOW



MEDIUM



HIGH

30 PATCHING, SMALL

## **POLISHED AGGREGATE (31)**

### ***Description***

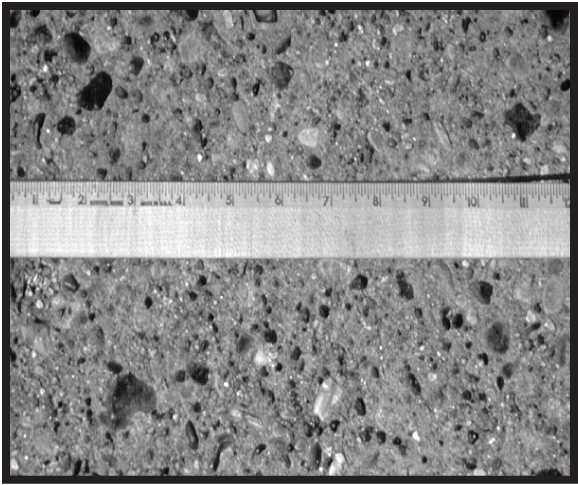
This distress is caused by repeated traffic applications. Polished aggregate is present when close examination of a pavement reveals that the portion of aggregate extending above the asphalt is either very small, or there are no rough or angular aggregate particles to provide good skid resistance.

### ***Severity Levels***

No degrees of severity are defined. However, the degree of polishing should be significant before it is included in the condition survey and rated as a defect.

### ***How To Count***

A slab with polished aggregate is counted as one slab.



31 POLISHED AGG.

## **POPOUTS (32)**

### ***Description***

A popout is a small piece of pavement that breaks loose from the surface due to freeze-thaw action, combined with expansive aggregates. Popouts usually range in diameter from approximately 1 to 4 in. (25 to 100 mm) and in depth from 1/2 to 2 in. (13 to 50 mm).

### ***Severity Levels***

No degrees of severity are defined for popouts. However, popouts must be extensive before they are counted as a distress. Average popout density must exceed approximately three popouts per m<sup>2</sup> over the entire slab area.

### ***How To Count***

The density of the distress must be measured. If there is any doubt that the average is greater than three popouts per square meter, at least three random 11 ft<sup>2</sup> (1 m<sup>2</sup>) areas should be checked. When the average is greater than this density, the slab should be counted.



32 POPOUTS

## **PUMPING (33)**

### ***Description***

Pumping is the ejection of material from the slab foundation through joints or cracks. This is caused by deflection of the slab with passing loads. As a load moves across the joint between the slabs, water is first forced under the leading slab, and then forced back under the trailing slab. This action erodes and eventually removes soil particles, resulting in progressive loss of pavement support. Pumping can be identified by surface stains and evidence of base or subgrade material on the pavement close to joints or cracks. Pumping near joints is caused by poor joint sealer and indicates loss of support; repeated loading will eventually produce cracks. Pumping can also occur along the slab edge, causing loss of support.

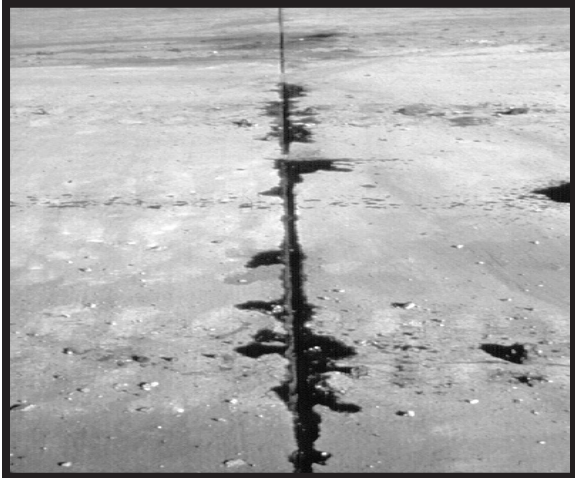
### ***Severity Levels***

No degrees of severity are defined. It is enough to indicate that pumping exists.

### ***How To Count***

One pumping joint between two slabs is counted as two slabs. However, if the remaining joints around the slab are also pumping, one slab is added per additional pumping joint.





33 PUMPING

## PUNCHOUT (34)

### **Description**

This distress is a localized area of the slab that is broken into pieces. The punchout can take many different shapes and forms, but it is usually defined by a crack and a joint. The distance between the joint and the crack or two closely spaced cracks is < 5 ft (1½ m) wide. This distress is caused by heavy repeated loads, inadequate slab thickness, loss of foundation support, and/ or a localized concrete construction deficiency (e.g., honeycombing).

### **Severity Levels**

Table 3 lists the severity levels for punchouts.

*Table 3: Levels Of Severity For Punchouts.*

Severity Of Majority Of Cracks	Number Of Pieces		
	2 to 3	4 to 5	> 5
L	L	L	M
M	L	M	H
H	M	H	H

### **How To Count**

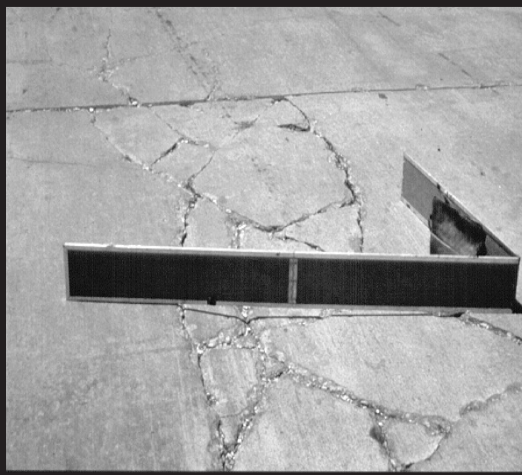
If a slab contains more than one punchout or a punchout and a crack, it is counted as shattered.



LOW



MEDIUM



HIGH

34 PUNCHOUT

## **RAILROAD CROSSING (35)**

### ***Description***

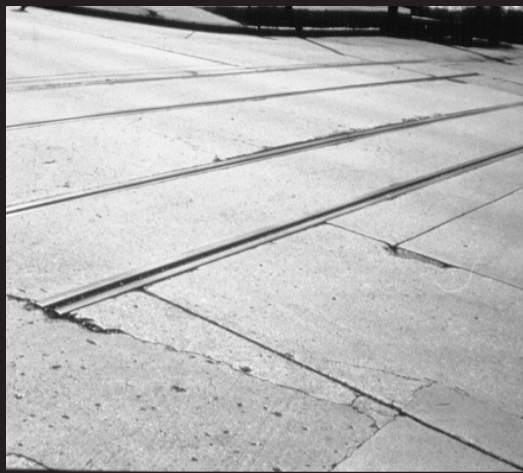
Railroad crossing distress is characterized by depressions or bumps around the tracks.

### ***Severity Levels***

- L** Railroad crossing causes low severity ride quality.
- M** Railroad crossing causes medium severity ride quality.
- H** Railroad crossing causes high severity ride quality.

### ***How To Count***

The number of slabs crossed by the railroad tracks are counted. Any large bump created by the tracks should be counted as part of the crossing.



LOW



MEDIUM



HIGH

## SCALING, MAP CRACKING, AND CRAZING (36)

### *Description*

Map cracking or crazing refers to a network of shallow, fine, or hairline cracks that extend only through the upper surface of the concrete. The cracks tend to intersect at angles of 120 degrees. Map cracking or crazing is usually caused by concrete over-finishing, and may lead to surface scaling, which is the breakdown of the slab surface to a depth of approximately  $\frac{1}{4}$  to  $\frac{1}{2}$  in. (6 to 13 mm). Scaling may also be caused by deicing salts, improper construction, freeze-thaw cycles, and poor aggregate. The type of scaling defined here is not caused by “D” cracking. If scaling is caused by “D” cracking, it should be counted under that distress only.

### *Severity Levels*

- L** Crazing or map cracking exists over most of the slab area; the surface is in good condition, with only minor scaling present.
- M** Slab is scaled, but less than 15 percent of the slab is affected.
- H** Slab is scaled over more than 15 percent of its area.

### *How To Count*

A scaled slab is counted as one slab. Low severity crazing should only be counted if the potential for scaling appears to be imminent, or a few small pieces come out.



LOW



MEDIUM



HIGH

## **SHRINKAGE CRACKS (37)**

### ***Description***

Shrinkage cracks are hairline cracks that are usually less than 2 m long and do not extend across the entire slab. They are formed during the setting and curing of the concrete and usually do not extend through the depth of the slab.

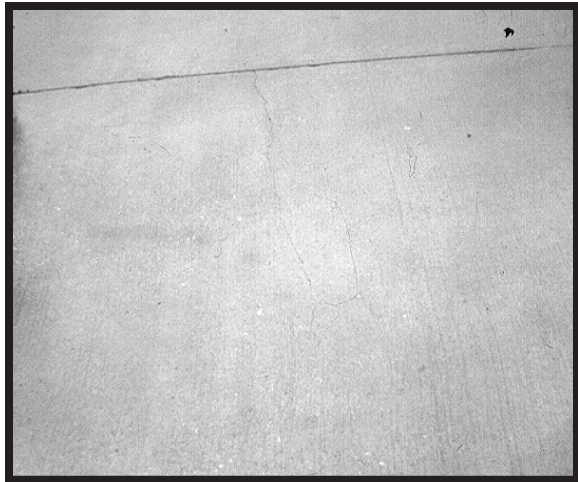
### ***Severity Levels***

No degrees of severity are defined. It is enough to indicate that shrinkage cracks are present.

### ***How To Count***

If any shrinkage cracks exist on a particular slab, the slab is counted as one slab with shrinkage cracks.





37 SHRINKAGE CRACKS

## SPALLING, CORNER (38)

### **Description**

Corner spalling is the breakdown of the slab within approximately 1½ ft (½ m) of the corner. A corner spall differs from a corner break in that the spall usually angles downward to intersect the joint, whereas a break extends vertically through the slab corner. Spalls less than 5 in. (130 mm) from the crack to the corner on both sides should not be counted.

### **Severity Levels**

Table 4 lists the levels of severity for corner spalling. Corner spalling with an area of less than 10 in<sup>2</sup> (64½ cm<sup>2</sup>) from the crack to the corner on both sides should not be counted.

*Table 4. Levels Of Severity For Corner Spalling.*

Depth Of Spall	Dimensions Of Sides Of Spall	
	5 x 5 in. to 12 x 12 in. (130 x 130 mm to 300 x 300 mm)	> 12 x 12 in. (300 x 300 mm)
< 1 in. (25 mm)	L	L
> 1 to 2 in. (25 mm to 50 mm)	L	M
> 2 in. (50 mm)	M	H

### **How To Count**

If one or more corner spalls with the same severity level are in a slab, the slab is counted as one slab with corner spalling. If more than one severity level occurs, it is counted as one slab with the higher severity level.



LOW



MEDIUM



HIGH

38 SPALLING, CORNER

## SPALLING, JOINT (39)

### Description

Joint spalling is the breakdown of the slab edges within 1½ ft (½ m) of the joint. A joint spall usually does not extend vertically through the slab, but intersects the joint at an angle. Spalling results from:

1. Excessive stresses at the joint caused by traffic loading or by infiltration of incompressible materials.
2. Weak concrete at the joint caused by overworking.
3. Water accumulation in the joint and freeze-thaw action.

### Severity Levels

Table 5 shows the severity levels of joint spalling. A frayed joint where the concrete has been worn away along the entire joint is rated as low severity.

*Table 5: Levels Of Severity For Joint Spalling*

Spall Pieces	Width Of Spall	Length Of Spall	
		≤ 2 ft (0.6 m)	> 2 ft (0.6 m)
Tight: Cannot be easily removed (maybe a few pieces missing)	≤ 4 in. (102 mm)	L	L
	> 4 in.	L	L
Loose: Can be removed and some pieces are missing; if most or all pieces are missing, spall is shallow, less than 25 mm (1 in.)	≤ 4 in	L	M
	> 4 in	L	M
Missing: Most or all pieces have been removed	≤ 4 in	L	M
	> 4 in	M	H

### How To Count

If spall is along the edge of one slab, it is counted as one slab with joint spalling. If spalling is on more than one edge of the same slab, the edge having the highest severity is counted and recorded as one slab. Joint spalling can also occur along the edges of two adjacent slabs. If this is the case, each slab is counted as having joint spalling.



LOW



MEDIUM



HIGH

39 SPALLING, JOINT



0 cm.

1

2

3

4

5

6

7

8

9

10

11

12

13

14

15

16

17

18



