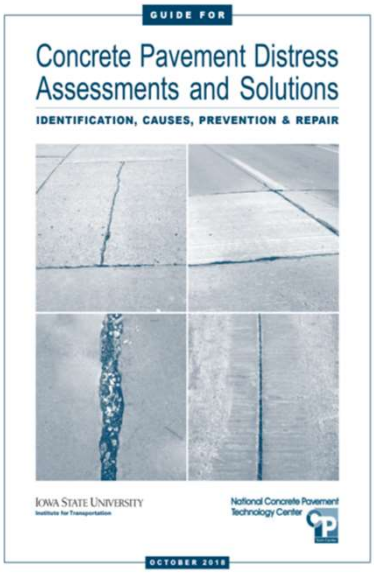
2019 MCA Winter Conference

February 20-21, 2019
Plymouth, Michigan

National Concrete Pavement Technology Center

Iowa State University
Institute for Transportation



Why Was This Guide Developed?

Help the agency staff with:

- Identifying the Distress
- Understanding the Causes
- Preventing Future Distress
- Rehabilitation Methodologies

Who is this Guide For?

- Pavement Inspectors/Design Engineers
- Project Concept Engineers
- Construction and Maintenance Staff
- Asset & Pavement Management Engineers
- Consulting Engineers

Guide Development

- Published: October 2018
- Pages: 470
- E-pubs Version
- 8 Authors
- 16 Technical Advisory Committee Members
- Principal Investigator: Dr. Peter Taylor, PE
- Project Manager: Dale S. Harrington, PE

Chapters

- Surface defects
- Surface Delamination
- Materials Related cracks
- Transverse and Diagonal Cracks
- Longitudinal Cracks
- Corners Cracks
- Spalling
- Faulting
- Joint Warping and Curling
- Blowups
- Settlement and Heaves
- Subgrades and base Support
- CRCP
- Overlays
- Laboratory and Field Testing

Division 1: Full-Depth Concrete Pavements

Division 1 Chapters

1. Intro to Full Depth Concrete Pavements
2. Surface Defects
3. Surface Delamination
4. Material-Related Cracks
5. Transverse and Diagonal Cracking
6. Longitudinal Cracking
7. Corner Cracking
8. Spalling-Transverse and Longitudinal Joints and Cracks

Division 1: Full-Depth Concrete Pavements

Division 1 Chapters

9. Faulting
10. Curling and Warping
11. Blowups
12. Subgrades and Base Support Conditions (settlement and heave distresses)
13. Continuously Reinforced Concrete Pavement (CRCP)

Division 2: Concrete Overlays

Division 2 Chapters

14. Introduction
15. Bonded Concrete Overlay on Asphalt (BCOA)
16. Bonded Concrete Overlay on Concrete (BCOC)
17. Unbonded Concrete Overlay on Asphalt (UBCOA)
18. Unbonded Concrete Overlay on Concrete (UBCOC)
19. Field Evaluation and Laboratory Testing Procedures **(Division 3)**

Chapter Content/Format

Typical Chapter Sections/Content

1. Description
2. Severity
3. Testing
4. Identification of Causes
5. Evaluation
6. Treatment and Repairs
7. References

Division 1. Full Depth Pavements

Chapter 2. Surface Defects

Division 1: Full Depth Pavements

Chapter 3. Surface Delaminations

Division 1: Full Depth Pavements

Chapter 4. Material-Related Cracks

Division 1: Full Depth Pavements

Chapter 5. Transverse and Diagonal Cracking

Division 1: Full Depth Pavements

Chapter 6. Longitudinal Cracking

Division 1: Full Depth Pavements

Chapter 7. Corner Cracking

Division 1: Full Depth Pavements

Chapter 8. Transverse and Longitudinal Joints and Cracks

Division. 1: Full Depth Pavements

Chapter 9. Faulting

Division 1: Full Depth Pavements

Chapter 10. Curling and Warping

Division 1: Full Depth Pavements

Chapter 11. Blowups

Division 1: Full Depth Pavements

Chapter 12. Subgrade and
Base Support Conditions

Division 1: Full Depth Pavements

Chapter 13. Continuously Reinforced Concrete Pavement (CRPC)

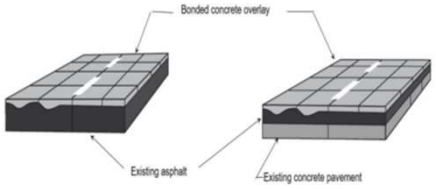
Division 2: Concrete Overlays

Chapter 14. Introduction to Division 2

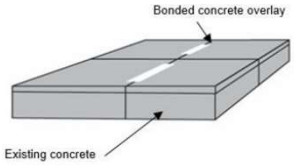
- Distresses
- Causes
- Prevention
- Treatment and Repairs

Concrete Overlay Chapters

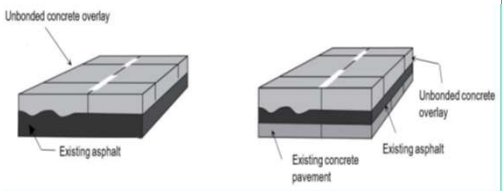
Chapter 15. Bonded Concrete Overlay on Asphalt



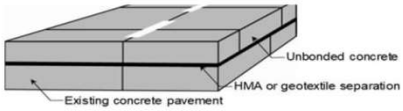
Chapter 16. Bonded Concrete Overlay on Concrete



Chapter 17. Unbonded Concrete Overlay on Asphalt (UBCOA)



Chapter 18. Unbonded Concrete Overlay on Concrete



Division 2: Concrete Overlays

Chapter 15. Concrete Overlay on Asphalt (BCOA)

Interior Structure/ Unbonded Cracks

Longitudinal lane-shoulder joint spall due to shoulder heave

Compression-transverse joints

Transverse joint faulting

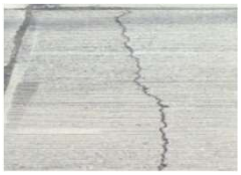
Panel migration/slippage

Longitudinal cracking in wheel path

Division 2: Concrete Overlays

Ch 16. Bonded Concrete Overlay on Concrete (BCOC)

Reflective crack over transverse crack



Multiple panel cracks near panel end due to debonding

Longitudinal crack-overlay fatigue after debonding

Late sawing/or not sawing over existing joint/crack

Wheel path cracking-debond & fatigue cracking of overlay

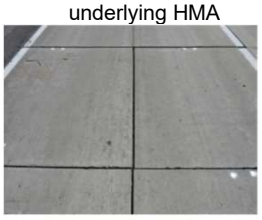
Reflective crack-not cutting a joint over existing crack

Division 2: Concrete Overlays

Ch 17. Unbonded Concrete Overlay on Asphalt (UBCOA)

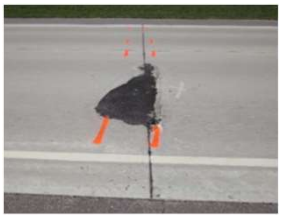
Longitudinal cracking in wheel path with tied & widened shoulders

Faulting & panel movement due to deformation of underlying HMA



Diagonal longitudinal crack over widened section

Cracking- misaligned dowels



Mid-panel cracking

Blowups

Division 2: Concrete Overlays

Ch 18. Unbonded Concrete Overlay on Concrete (UBCOC)

Longitudinal cracking in wheel path with tied shoulders

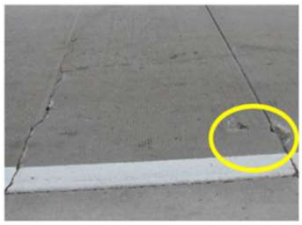
Transverse joint faulting

Longitudinal cracking in wheel path

Transverse reflective cracking

Mid-panel cracking

Cracking due to misaligned dowels



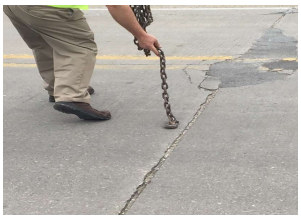
Division 3:

Chapter 19. Field Evaluation and Laboratory Testing Procedures

- Common Field and Laboratory Tests Associated With Identification of Pavement Distresses are Highlighted
- ASTM & AASHTO Tests are Referenced
- Each Individual Distress Chapter Discusses Appropriate Field and Laboratory Tests to Identify the Nature and Severity of the Specific Distress and Refers Back to Related Information in Ch 19.

Chapter 19. Common Field Tests for Concrete Pavements

Chain Drag or Hammer Sounding

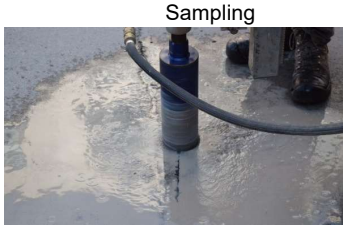


Falling Weight Deflectometer (FWD)

Automated Plate Load Test

Dynamic Cone Penetrometer (DCP)

Coring and Material Sampling



High Speed Ground Penetrating Radar (GPR)

Chapter 19. Common Laboratory Tests for Subgrade and/or Base Materials

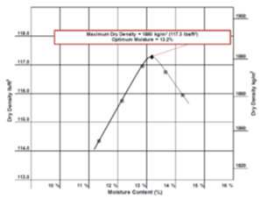
Sieve Analysis of Fine and Coarse Aggregates

Materials Finer Than No. 200 Sieve Aggregates by Washing

Particle Size Analysis of Soils – Hydrometer Test

Plastic Limit and Plasticity Index of Soils

Moisture-Density Relations of Soils



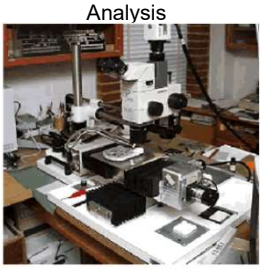
Resilient Modulus of Soils and Aggregate Minerals

Chapter 19. Common Laboratory Tests for Hardened Concrete Materials

Compressive Strength

Flexural Strength of Concrete

Hardened Air Petrographic Analysis



Petrographic Examination of Aggregates for Concrete

Permeability " rapid chloride" Surface Resistivity Test

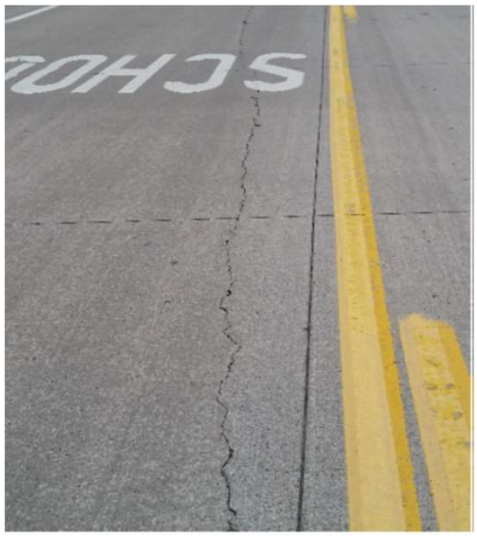
Resistance of Concrete to Rapid Freezing and Thawing

Full-Depth Concrete Pavements

Chapter 6. Longitudinal Cracking

(pp. 105-142)

Chapter 6. Longitudinal Cracking



Chapter 6. Longitudinal Cracking
2. Severity

Table 6.1 Severity levels of longitudinal cracking

Distress	Description and Severity Levels	Measurement
Longitudinal Cracking – Jointed Concrete Pavement (JCP)	Cracks that are predominantly parallel to the pavement centerline **Low**: Crack widths less than 0.125 in. (3 mm), no spalling, and no measurable faulting or well-sealed and with a width that cannot be determined **Medium**: Crack widths greater than 0.125 in. (3 mm) but less than 0.50 in. (13 mm); or with spalling less than 3 in. (75 mm); or faulting up to 0.50 in. (13 mm) **High**: Crack widths greater than 0.50 in. (13 mm) or with spalling greater than 3 in. (75 mm) or faulting greater than 0.50 in. (13 mm)	Record the length of longitudinal cracking at each severity level. Also record the length of longitudinal cracking with sealant in good condition at each severity level. Sealant is not considered to be in good condition unless at least 3 ft (1 m) of continuous sealant in good condition is present. In cases where a crack is less than 3 ft (1 m) long, the sealant must be present and in good condition over the entire length of the crack.

Chapter 6. Longitudinal Cracking
3. Testing

Field Tests
- Coring
- Straightedge or String Line Test
- FWD Testing
- Ground Penetrating Radar (GPR)

Laboratory Tests (temperature and shrinkage characteristics)
- Evaluation of Coefficient of Thermal Expansion
- Petrographic Analysis

Chapter 6. Longitudinal Cracking

4. Identification of Causes

Table 6.2 Summary of physical and material/chemical causes of longitudinal cracking

Distress	Category	Causes
Longitudinal Cracking	Physical	Nonuniform slab support (variable stiffness, swelling soils, frost heave, erosion, instability, etc.)
		Variations in slab-based friction or bond
		Slab restraint
		Excessive panel size relative to slab thickness, foundation stiffness, slab-based friction, and applied traffic loads, and/or environmental conditions
		As-designed panel width (e.g., wide ramps)
		Inadequate saw cut depth (effective width)
		Too much joint reinforcement (effective width)
		Late sawing of joints
		Designs that produce excessive lateral restraint
		Environmental conditions (e.g., ambient temperature and moisture conditions relative to those present during placement and curing) that influence curling, warping, and drying shrinkage
		Stress concentrations due to embedded features (e.g., utility access blockouts) and ties to adjacent structures (e.g., transitions to different longitudinal joint patterns, adjacent structures)
		Construction-related aspects (e.g., timing/depth of joint sawing, timing and effectiveness of curing)
		Construction and service traffic loadings (load magnitude, configuration, location, number of repetitions, and strength at time of loading, etc.)
Longitudinal Cracking	Material/ Chemical	Thermal characteristics of the concrete (mainly a function of aggregate type and content)
		Shrinkage characteristics of the concrete (mainly a function of paste content and w/cm ratio)
		Concrete mixture components and proportions that affect strength development

Chapter 6. Longitudinal Cracking
5. Evaluation (pp 111-136)

Cause/Prevention Examples:

- Excessive Slab Width
- Late Sawing/Inadequate Saw Cut Depth
- Non-uniform Support

Figure 6.2 Longitudinal cracking in pavement due to the lack of a longitudinal joint

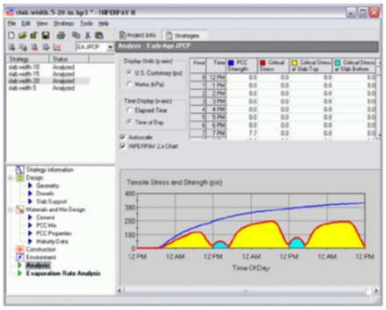
Chapter 6. Longitudinal Cracking
5. Evaluation (pp 111-136)

Cause/Prevention Examples:

- Late Sawing or Inadequate Saw Cut Depth
- Timing/Depth – Mix Parameters, Pavement/Base, Curing Conditions

Figure 6.7 Longitudinal cracking due to longitudinally bounded variation in pavement support

Figure 6.6 Example screenshot from HIPERPAV software



Chapter 6. Longitudinal Cracking
5. Evaluation (pp 111-136)

Cause/Prevention Examples:

- Non-uniform Support

Figure 6.7 Longitudinal cracking due to longitudinally bounded variation in pavement support

Chapter 6. Longitudinal Cracking
5. Evaluation (pp 111-136)

Cause/Prevention Examples:

- Non-uniform Support **Table 6.4**
  - ✓ Element
  - ✓ Aspect
  - ✓ Issue
  - ✓ Considerations

Table 6.4 Considerations for addressing longitudinal cracking caused by nonuniform slab support.

Foundation Element	Aspect	Issue	Considerations
Base and Subgrade	Compaction /Density	Poor or inadequate compaction can lead to post-construction settlement of the base, reducing the support provided to the slab.	Ensure that all unbound foundation layers are compacted to the specified target densities.
Base and Subgrade	Uniformity of Support	Areas of nonuniformity in the foundation layers can lead to cracking	Ensure base course is homogenous and not segregated when placed. Cross-haul and mix, undercut and replace or stabilize soft spots in subgrade. Consider subgrade stabilization for plastic soils.
Base	Base Erodibility	Pumping and erosion of base beneath slab leads to unsupported conditions	Use widened lanes (if slab thickness and support conditions permit) and/or tied concrete shoulders to reduce slab deflections that induce pumping. Use bound (stabilized or treated) base materials, especially for facilities that carry heavy truck traffic. If aggregate base layers are used, limit the fines passing the No. 200 [0.075mm] sieve to 10% or less (but consider fines requirements to achieve stability during construction operations). Seal longitudinal joints (especially the lane-shoulder joint and/or provide edge drains or daylighted aggregate base to quickly remove water from the base.
Subgrade*	Swelling Soils*	Subgrade volumetric changes due to variations in subgrade moisture contents	Remove and replace small areas of swelling soils. Compact at 1–3% above optimum moisture content (AASHTO T 99). Consider use of soils stabilization and membranes.
Subgrade*	Frost Heave*	Subgrade volumetric changes due to frost penetration and growing ice lenses in subgrade	Compact slightly wet of optimum moisture content (AASHTO T 99). Use non-frost-susceptible materials within the depth of frost penetration. Protect (cover) frost-susceptible soil with sufficient thickness of non-frost-susceptible material.

Chapter 6. Longitudinal Cracking
5. Evaluation/Summary of Causes and Prevention

Table 6.5 Overall summary of causes and prevention of longitudinal cracking

Distress in Concrete Pavement	Contributing Causes	Prevention: Design	Prevention: Materials	Prevention: Construction
Excessive Panel Width Cracking	Greater slab widths increase critical curling, warping, and shrinkage stresses in the slab that can lead to cracking Exacerbated by increased base stiffness and friction or bond	Employ suitable panel width for climate conditions, foundation support and friction, and slab thickness Avoid over-tying longitudinal joints to create a wider effective panel width	Avoid high-shrinkage mixtures (high water and paste contents, high CTE aggregates). Minimize mixture paste content Avoid using exceedingly stiff base Use interlayer between slab and stabilized base	Saw joints deeply enough to ensure joint activation
Late Sawing or inadequate Saw cut depth	Inadequate saw cut depth Late sawing		Maximize sawing window through good materials selection and mixture proportioning, good curing materials	Maximize sawing window with proper coverage and timely application of curing techniques and site control techniques (e.g., fogging, shading and wind breaks where needed and feasible) Saw joints within the "window of opportunity" Saw joints to the specified depth Monitor early-age strength development Employ HIPERPAV or other software to determine cracking risk for potential paving scenarios

Chapter 6. Longitudinal Cracking
6. Treatment and Repairs (pp 137-140)

Repairs:
Full-Depth Repair
Cross-titching and Slot Stitching
Crack Sealing or Filling
Diamond Grinding
Do Nothing

b. Cross-stitched longitudinal crack

b. Slot-stitched longitudinal crack

Distress Manual
CP Tech Center Link!

The Distress Guide is now available at the website:
https://cptechcenter.org/publications/

The Distress Guide is also available as an E-Pub document and can be found on the same website

The direct link to the uploaded document:

https://intrans.iastate.edu/app/uploads/2018/12/concrete_pvmt_distress_assessments_and_solutions_guide_w_cvr.pdf

THANK YOU!