Concrete
building for life.

Treatment and Repair of Concrete Pavement Distresses

2022 SWIFT Conference -
CAPTG Session
Montreal

Cement Association of Canada

September 13th, 2022

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- Performance Issues
- Preventive Maintenance vs Pavement Preservation
- Pavement Evaluation to Determine Distresses and Causes of Defects
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- Joint Sealants and Crack Repair Materials
- Resources

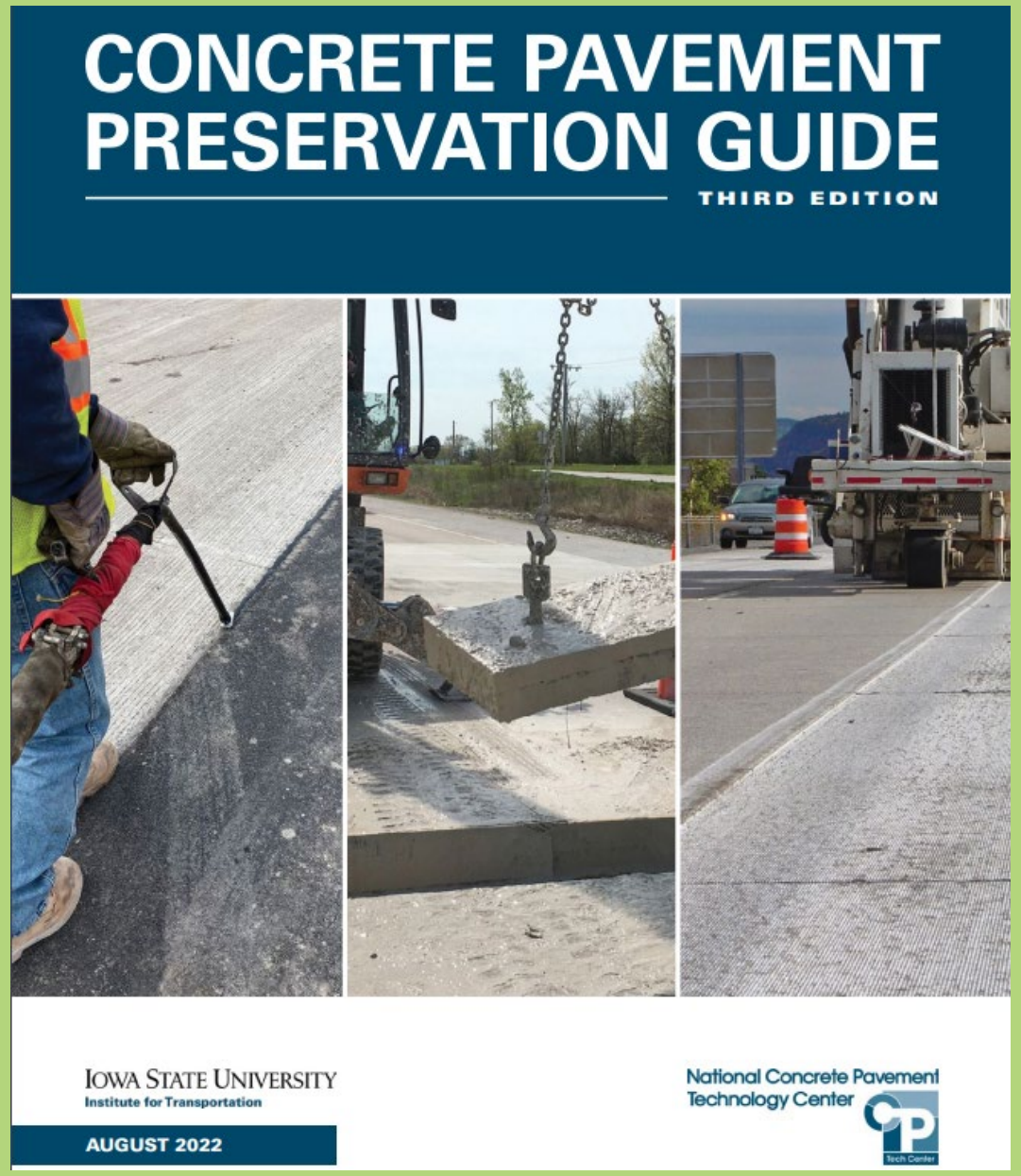
Performance Issues

- Airfield Functional Condition
  - FOD potential
  - Friction/Hydroplaning
  - Profile
- Airfield Distress
  - cracking **(crack and joint sealing, repair)**
  - corner breaks, shattered panels **(full-depth repair)**
  - spalling **(partial-depth repair)**
  - roughness / polishing **(diamond grinding)**
  - Faulting **(dowel bar retrofitting)**

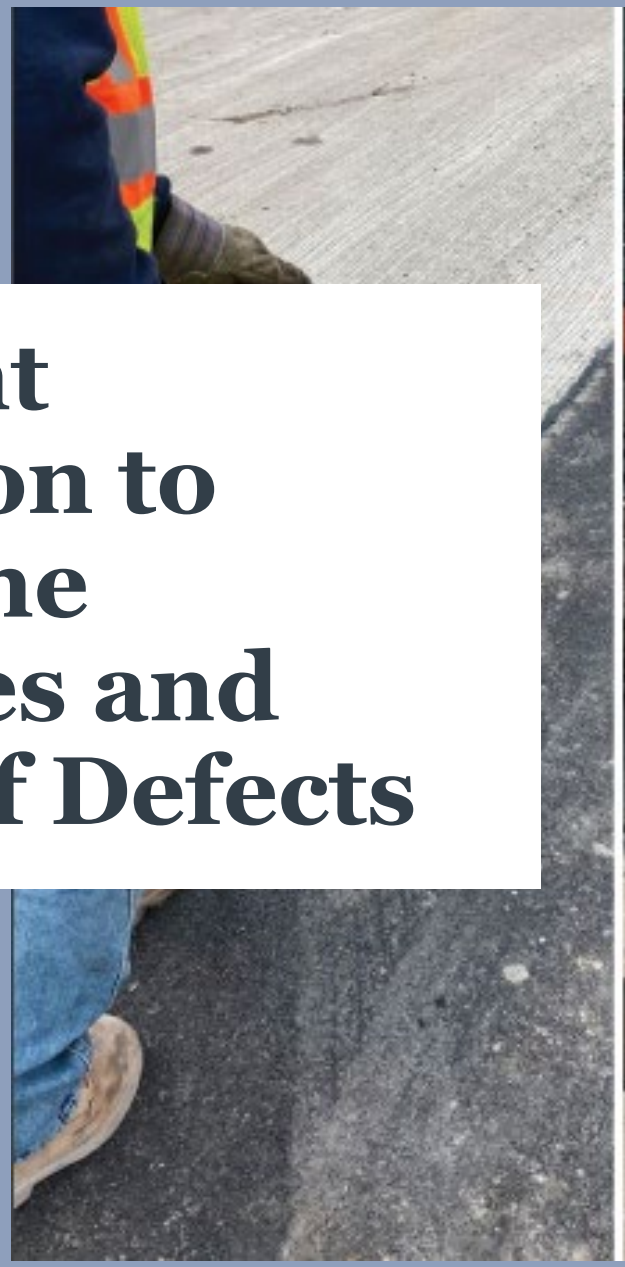
Preventive Maintenance vs Pavement Preservation

- **What is Preventive Maintenance?**
  - Planned strategy of cost-effective treatments
  - Applied to structurally sound pavements with significant remaining life
  - Maintain or improve functional condition

- **What is Pavement Preservation?**
  - Long-term strategy for enhancing pavement performance
  - Focus on extending pavement life and restoring functional condition
  - Accomplished with a collection of preventive maintenance treatments and a few minor rehabilitation and routine maintenance treatments

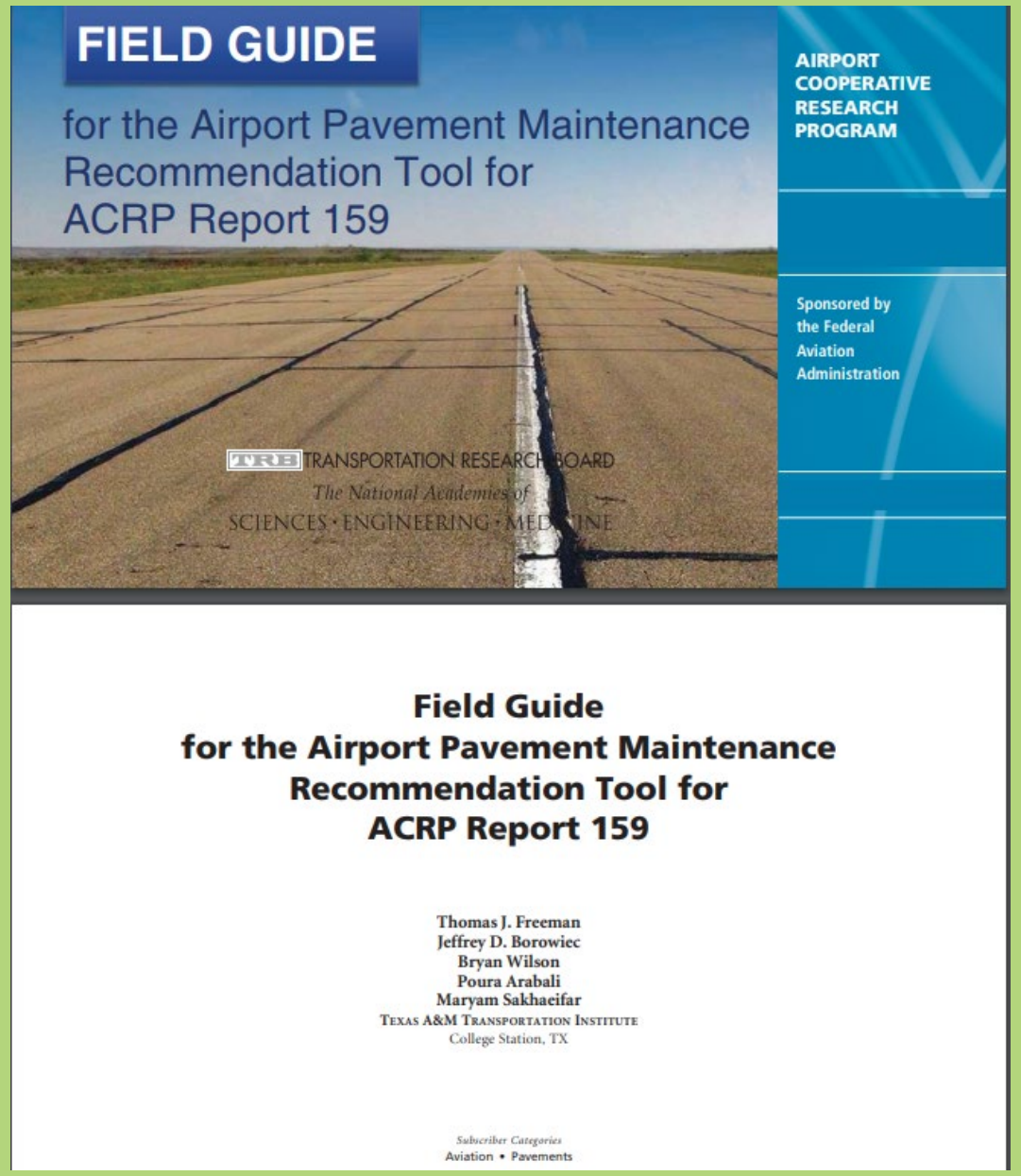


Pavement Evaluation to Determine Distresses and Causes of Defects



Pavement Evaluation

- Collected as-built info, perform distress surveys, NDT (?), sampling (?)
- Identify distress types
- Determine causes of deterioration
- Determine treatment
- Develop appropriate alternatives
- Concrete pavement treatment tables
- Concrete pavement maintenance treatment hierarchy



Investigating Defects

- Evaluation of the defects involves:
  - Visual examination of the concrete
  - *Helpful to know:*
    - Time of year concrete was placed.
    - Any test results of the concrete,
    - Contractor who placed the concrete.
    - Supplier of the concrete.
    - Concrete Mix design.
    - Placing methods.

Causes of Pavement Defects

- Defects in concrete may be caused by many different reasons:
  - Wrong concrete design.
  - Improper batching (mixing).
  - Wrong aggregate proportions.
  - Improper aggregates.
  - Inadequate support.
  - Improper placing.
  - Improper finishing.
  - ***IMPROPER CURING***

Determining Cause of Defect

- Table 12.2 for the Concrete Pavement Preservation Guide identifies the types of pavement distresses and probable cause of the distress
- Additional notes on each type of distress are also included

Table 12.2. Concrete Pavement Distress Types and Causes (adapted from Hall et al. [2001] and Miller and Bellinger [2003])

Distress	Causes	Notes
Linear cracking (transverse, longitudinal, or diagonal)	Fatigue damage, often in combination with slab curling and/or warping; drying shrinkage; improper transverse or longitudinal joint construction; or foundation movement	Low-severity transverse cracks in JRCP and CRCP are not considered structural distress; medium- and high-severity deteriorated cracks are. All severities of linear cracking are considered structural distress in JPCP.
Corner breaks	Fatigue damage, often in combination with slab curling and/or warping and/or erosion of support at slab corners	The presence of corner breaks suggests structural deterioration. Medium- and high-severity levels can significantly impact ride quality.
D-cracking	Freeze-thaw damage in coarse aggregates	This initiates as hairline cracks in the slab corners and progresses along joints, cracks, or free edges where moisture is available.
Alkali-aggregate distress	Compressive stress building up in slab, due to swelling of gel produced from reaction of certain susceptible aggregates with alkalis in the cement	Alkali-aggregate reaction includes ASR and ACR.
Map cracking and crazing	Alkali-aggregate reaction or overfinishing	Hairline cracks in upper surface of slab are cosmetic but can deteriorate into scaling.
Scaling	Overfinishing, inadequate air entrainment, or reinforcing steel too close to the surface	This is typically limited to the upper few inches of the slab surface.
Joint seal damage	Inappropriate sealant type, improper sealant reservoir dimensions for the sealant type, improper joint sealant installation, and/or aging	Loss of adhesion of sealant to joint walls, extrusion of sealant from joint, infiltration of incompressibles, oxidation of sealant, and cohesive failure (splitting) of the sealant are all considered joint seal damage.
Joint spalling (also called joint deterioration)	Compressive stress buildup in the slab (due to incompressibles or alkali aggregate reaction); D-cracking; misaligned or corroded dowels; poorly consolidated concrete in vicinity of joint; or damage caused by joint sawing, joint cleaning, cold milling, or grinding	Joint spalling includes cracking, breaking, chipping, or fraying of slab edges within 0.3 m (1 ft) of transverse or longitudinal joint.
Blowups	Compressive stress buildup in the slab (due to infiltration of incompressible, or alkali-aggregate reaction)	A blowup may occur as a shattering of the concrete for several feet on both sides of the joint, or an upward buckling of the slabs.
Pumping	Excess moisture in the pavement structure, erodible base or subgrade materials, and high volumes of high-speed, heavy wheel loads	Pumping can lead to loss of support beneath the slabs and the development of faulting. Dowel bars and nonerodible bases can control pumping.
Faulting	Pumping of water and fines from under slab corners, loss of support under the leave corner, and buildup of fines under the approach corner	Faulting becomes a significant factor in ride quality when it is greater than 2–3 mm (0.08–0.12 in.).
Roughness caused by curling/warping	Moisture gradients through the slab thickness, daily and seasonal cycling of temperature gradients through the slab thickness, and/or permanent deformation caused by a temperature gradient in the slab during initial hardening	Curling and warping are often influential factors affecting the structural (e.g., cracking) and functional (e.g., smoothness) performance of concrete pavements.
Bumps, heaves, and settlements	Foundation movement (frost heave, swelling soil) or localized consolidation, such as may occur at culverts and bridge approaches	These detract from riding comfort and at high severity may pose a safety hazard.
Polishing	Abrasion by tires	Polished wheelpaths may pose a wet-weather safety hazard.
Popouts	Freezing in coarse aggregates near the concrete surface	This is a cosmetic problem rarely warranting repair.

Suggested Data Collection Needs for Concrete Pavement Treatment Alternatives

- Newly released Concrete Pavement Preservation Guide includes a Table identifying data collection needs for different types of concrete pavement treatment alternatives noting three categories:
  - Definitely needed
  - Desirable
  - Normally not needed

Table 3.1. Suggested Data Collection Needs for Concrete Pavement Treatment Alternatives (adapted from AASHTO [1993])

Data Item	Full-Depth Repair	Partial-Depth Repair	Thin Concrete Overlay	Diamond Grinding	Diamond Grooving	Slab Stabilization	Slab Jacking	Retrofitted Edgedrains	Joint Resealing	Crack Sealing	Dowel Bar Retrofit	Cross Stitching	Slot Stitching
Pavement Design	X	X	X	X		X	X	X	X	X	X	X	X
Original Construction Data			*	*	*			*	*	*	*	*	*
Age	*	*	*	*	*			*					
Materials Properties	*	*	X	X	X	*	*	X					
Subgrade			X			*	*	X	X	X			
Climate			X			X	X	X	X	X			
Traffic Loading and Volumes	X	X	X	X	X	*	*	X	*	*	X	X	X
Distress	X	X	X	X	X	X	X	X	X	X	X	X	X
Friction			*	*	*								
Crashes			*	*	*								
Potential NDT[1]	* (a, b, c, d)		X (a, b, c, d)			X (a, b, d)	X (a, b, d)				X (a, b, d)	* (a, b, c, d)	* (a, b, c, d)
Potential Destructive Testing/ Sampling[2]	X (e, h, i)	X (e, h, i)	X (e, f, g, h, i)	* (e, h, i)	* (h, i)	* (e, f, g)	* (e, f, g)	X (e, f, g)			* (e, f, g, h, i)	* (e, h, i)	* (e, h, i)
Roughness			*	*	*	*	*						
Surface Profile			*	X	X	*	*						
Drainage	X		X	X	X	X		X	X				
Previous Maintenance	*	*	*	*	*	*		*	*	*			
Bridge Transitions	X	X	*						X				
Utilities	X		X			*	*	*					
Traffic Control Options	X	X	X	X	X	X	X	X	X	X	X	X	X
Vertical Clearances			X										
Geometrics			X										

[1] See Section 6 of this Chapter
[2] See Section 8 of this Chapter

a = FWD (falling weight deflectometer); b = GPR (ground-penetrating radar);
c = MIT (magnetic imaging tomography) Scan 2; d = MIRA device
e = coring; f = DCP (dynamic cone penetrometer); g = subsurface material testing/characterization;
h = strength testing; i = MRD (materials-related distress) evaluation

KEY: X Definitely Needed * Desirable [blank] Normally Not Needed

Distress Treatment Matrix

(Source: Concrete Pavement Preservation Guide, Third Edition, NCPTC Table 12.3)

Distress	Concrete Pavement Preservation Treatment											
	Slab Stab-ilization	Slab Jacking	Partial-Depth Repair	Full-Depth Repair	Retrofitted Edge Drains	Dowel Bar Retrofit	Cross Stitching/ Slot Stitching	Diamond Grinding	Diamond Grooving	Joint Resealing	Crack Sealing	Thin Concrete Overlay
Corner breaks			✓	✓							✓[a]	
Linear cracking				✓			✓[b]				✓[a]	
Punchouts				✓								
D-cracking				✓[c]								✓[c]
Alkali-aggregate reaction				✓[c]								✓[c]
Map cracking, crazing, scaling			✓									✓
Joint seal damage										✓		
Joint spalling			✓	✓								✓
Blowup				✓								
Pumping	✓				✓	✓	✓					
Faulting						✓		✓				✓
Bumps, settlements, heaves		✓		✓				✓				✓
Polishing/Low Friction								✓	✓			✓

Why would one leave distressed or defective concrete in place?

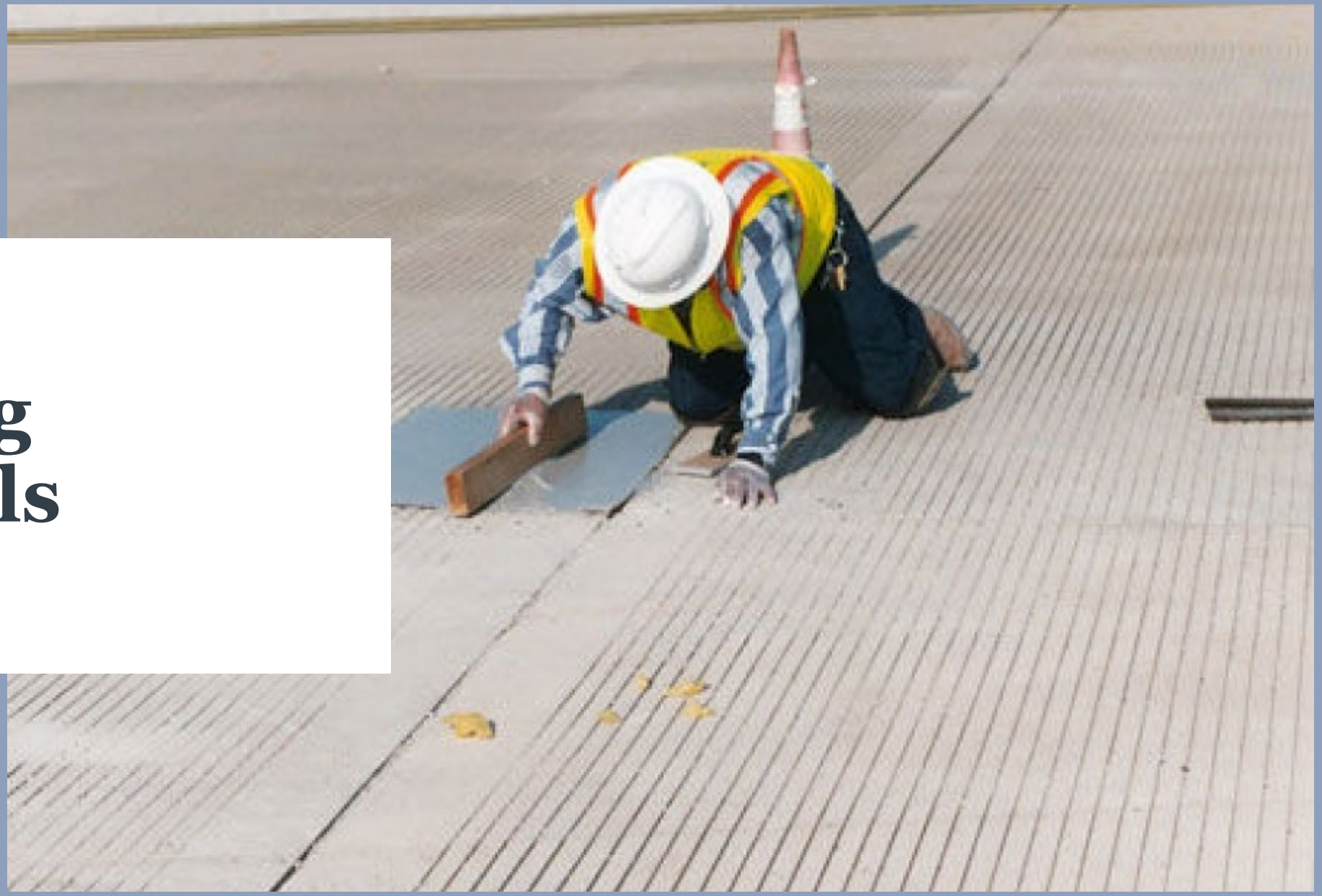
(Following is an excerpt from the Supplemental Report for UFGS 32 13 11)

3.9 REPAIR, REMOVAL AND REPLACEMENT OF NEWLY CONSTRUCTED SLABS

3.9.1 General Criteria

Although care is taken during most airfield concrete pavement construction to ensure that a quality pavement is constructed, there are occasions when marginal concrete pavement areas are constructed. These marginal areas, not meeting project specification requirements, will require repair or complete removal and replacement. It is not in the interest of the Government or in the interest of the Contractor to have large areas of the new pavement designated for repair or removal. Pavement repair and pavement removal and replacement usually result in pavement areas with marginal properties that may not provide the same level of service as the originally constructed pavement. Marginal pavement areas can be designated as deficient and as defective. Deficient areas are allowed to remain in place after corrective work and may be subject to payment reduction. Areas considered defective should be removed and replaced. If left in place, defective areas will provide only a few years of acceptable service and will require removal and replacement while the facility is under operation. The Contracting Officer should always err on the side of caution and operational readiness when considering the treatment of defective pavement areas.

Patching Materials



KwikBond Polymers Repair Material

- **PPC™ -1121 MM MIX**
  - Polyester-based overlay and patching system
  - High strength properties in both compression and tensile
  - Achieves over 27.6 MPa compressive strength within 24 hrs and 5.5 MPa tensile strength
  - Open to traffic within 1.5 to 3 hrs
  - Low viscosity for easy mixing
  - KBP 204 Primer applied

PHYSICAL PROPERTIES	
PPC Binder Resin	
Weight per gallon (resin binder only)	9.0-9.4
Viscosity	75-200 cps
Flash Point (Seta flash)	90 F
Adhesion (Cal-Trans Test Method 551)	>500 psi
Tensile Strength (ASTM D-638, ¼")	>2500 psi
Tensile Elongation (ASTM D-638, ¼")	35%, min.
Meets CARB	
Silane Coupler	1.0% min by weight of polyester resin
Styrene content	40-50%

Contact: Dan Uldall DUldall@KwikBondPolymers.com

TRANSPO Industries Repair Material

- **TRANSPO T-17 Polymer Concrete**
  - 100% polymer MMA resin (no mess, no odor and no water)
  - Can be used neat or extended with prepackaged aggregate (3/8 or ¾ inch)
  - Doesn't shrink
  - Fully cures in less than 1 hrs
  - Airports can be operational in 1 hour due to fast set and high strength property
  - Shallow or full-depth repairs can be made at temperatures below zero because no water used
  - High early strength (34.4 MPa minimum in 90 min)
  - Chemical resistant

Contact: Thomas Donnelly, <tdonnelly@transpo.com>

MAPEI Repair Materials

- **Planitop 18:**
  - 1 component high initial resistance
  - Rapid set 17 MPa in 1-hrs
  - Low temperature application (0° C or -8° C when add Planitop Accelerator)
  - Can be applied from 12 mm to 50 mm neat or 200 mm with aggregate
- **Planitop 18 ES**
  - 1 component horizontal high-early strength
  - Rapid set 24 MPa in 3 hrs and 34 MPa in 1 day
  - Can be applied 12 mm to 25 mm neat or up to 150 mm with aggregates

Contact: Hamza Ouziame, <houziame@mapei.com>

Euclid Chemical Repair Materials

- **VERSASPEED 100**
  - One part repair compound
  - High early strength material
    - 35 MPa in 3 hrs
    - 41.1 MPa in 24 hrs
    - 72.4 MPa in 28 days
  - Wide range of temperature applications 2°C to 29°C (35°F to 85°F)
  - 35 MPa in 3 hrs and 41.1 MPa in 24 hrs
- **EUCO-SPEED MP**
  - Rapid set magnesium phosphate repair mortar
    - 35 MPa in 3 hrs,
    - 41 MPa in 24 hrs and
    - 52 MPa in 28 days
  - Virtually no shrinkage
  - No bond agent required
  - Self-curing (no curing required)
  - Excellent F/T resistance

Contact: Brian Salazar, <B.Salazar@euclidcanada.com>

Sika Repair Material

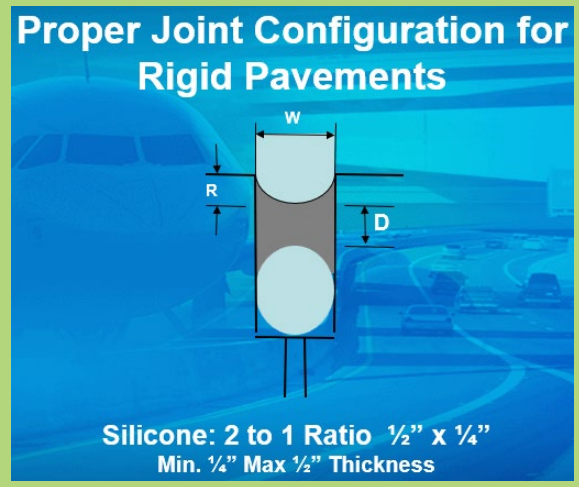
- **SikaSet 45:**
  - very rapid-setting,
  - early-strength gaining,
  - magnesium phosphate-based patching and repair mortar for concrete
- **Sikacrete 211 Flow Plus and King MS S-6 & MS S-10**
  - Pre-packaged concrete reinforced with silica-fume,
  - contains 6 or 10 mm aggregate,
  - adapted for horizontal repair applications exposed to chlorides
  - Contains integral corrosion inhibitor
  - 1 hour Opening to traffic
- **SikaTop 122 Plus**:
  - A polymer-modified patching mortar,
  - migrating corrosion inhibitor added,
  - cementitious,
  - two-component,
  - fast setting,
  - trowel-grade

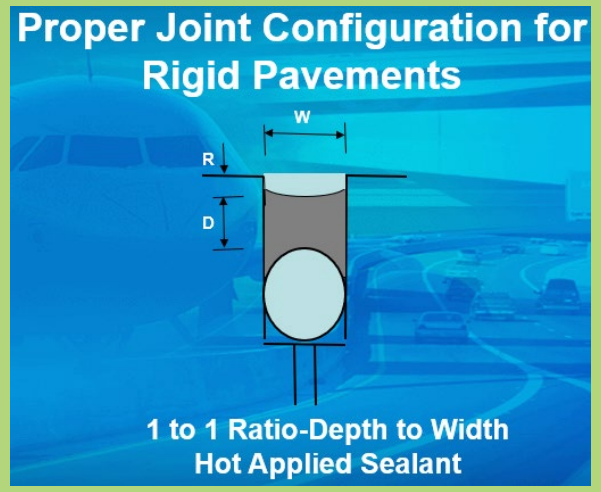
Contact: Michel Ross <ross.michel@ca.sika.com>

Joint Sealants and Crack Repair Materials

Crafco Joint Sealants

- **Silicone sealant**
  - ASTM D5893 and FAA – P605
  - 10 years plus life cycle
  - Jet Fuel resistant
  - Wide movement capabilities
  - Wide temperature range
  - 14 day full cure through
  - Non-sag or self-leveling
- **Asphalt modified sealant**
  - ASTM D-6690 and FAA P-605
  - Modified asphalt based sealant
  - 2 to 7 year life cycle
  - Different grades available
  - Requires proper joint configuration





Contact : Mike Sucee <Mike.Sucee@crafco.com>

Sika Joint Sealants

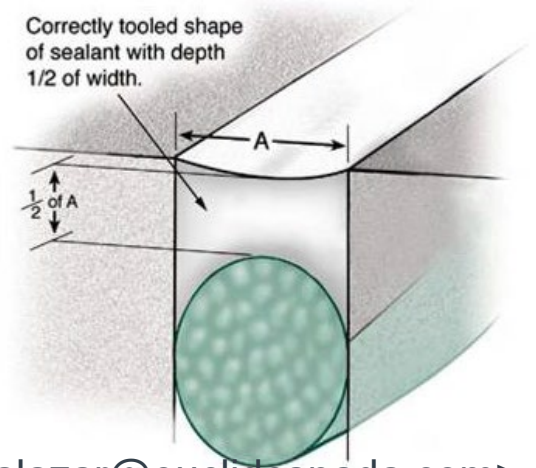
- **Sika Duoflex NS/SL Polysulphide Sealant**
  - Fuel and oil resistance
  - High resistance against various chemicals
  - High mechanical resistance
  - Conformance to legal regulations and approvals

- **Sikasil 728 NS/SL and Sikaflex 2c NS/SL**
  - All-temperature adhesion & flexibility
  - Resistance to heavy equipment traffic from airplanes, maintenance vehicles and trucks
  - Resistance to aggressive chemicals (de-icing, jet fuel etc.)
  - Sikasil 728 SL is a one component self-levelling
  - Sikaflex 2C SL is a two component self leveling premium-grade

Contact: Michel Ross <ross.michel@ca.sika.com>

Euclid Joint Sealant

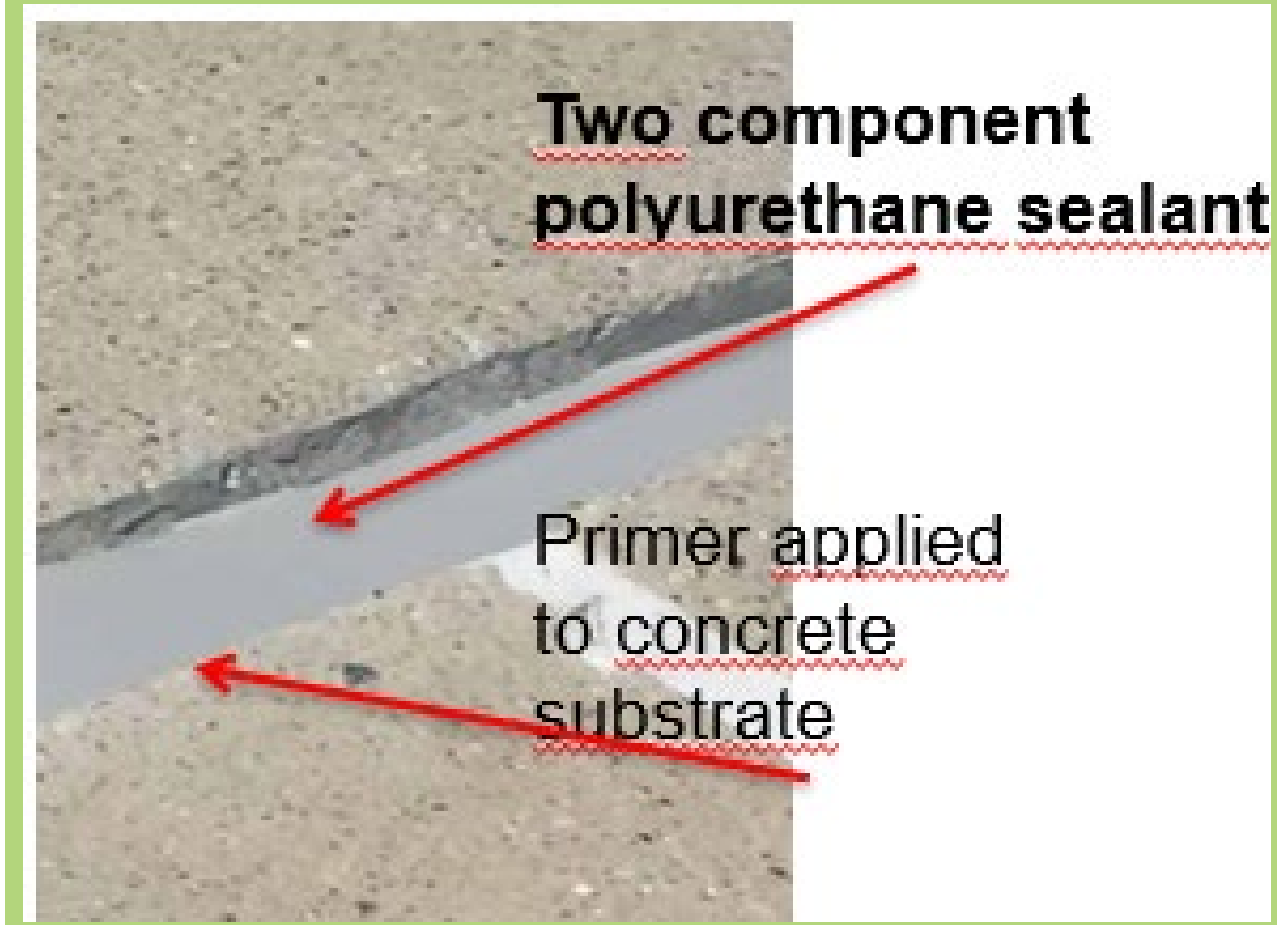
- **Single-component Eucolastic 1SL**;
  - Self-levelling sealant installation
  - Movement & slope capabilities
  - Used in horizontal joints up to 6 % slope
  - Can handle +100% to -50% movement
  - Joint width should be 4-times the anticipated movement
  - Joint depth = ½ joint width



Contact: Brian Salazar, <B.Salazar@euclidcanada.com>

MAPEI Joint Sealant and Injection Material

- **Mapeflex P2 SL, P2 NS**
  - 2 component elastomeric polyurethane
  - Self-levelling or non-sag
  - Fill joints and cracks with / without movement
  - Elongation at break: min 300%
  - Fuel and jet fuel resistant
- **Polyurethane injection/sealant**
  - To waterproof and protect cracks in concrete
- **Epoxy injection**
  - To structurally repair concrete cracks.



Contact: Hamza Ouziame, <houziame@mapei.com>

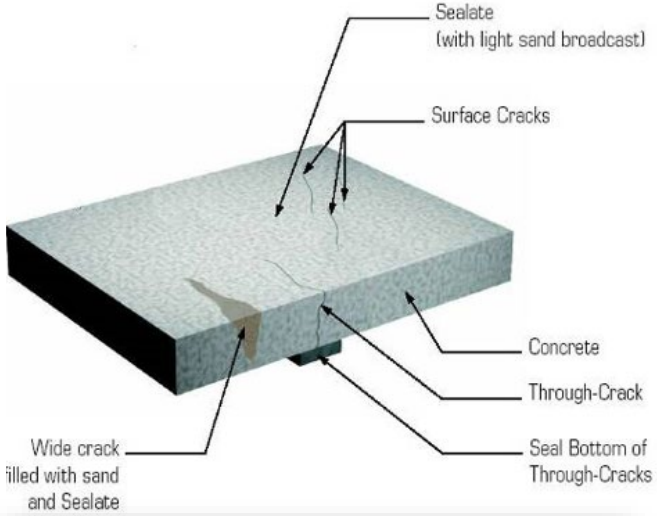
TRANSPO Industries Crack Sealers

- **T-70 HMWM Crack Sealer and T-78 Methyl Methacrylate Crack Sealer**
  - Designed to seal concrete cracks as small as 0.25 mm
  - Crack sealing is permanent, and reapplication is not required
  - bond to crack walls is greater than the tensile strength of existing concrete > 1.7MPa
  - Seal surface
  - Seal small shrinkage cracks
  - seal larger individual cracks

Contact: Thomas Donnelly, <tdonnelly@transpo.com>

Features & Benefits

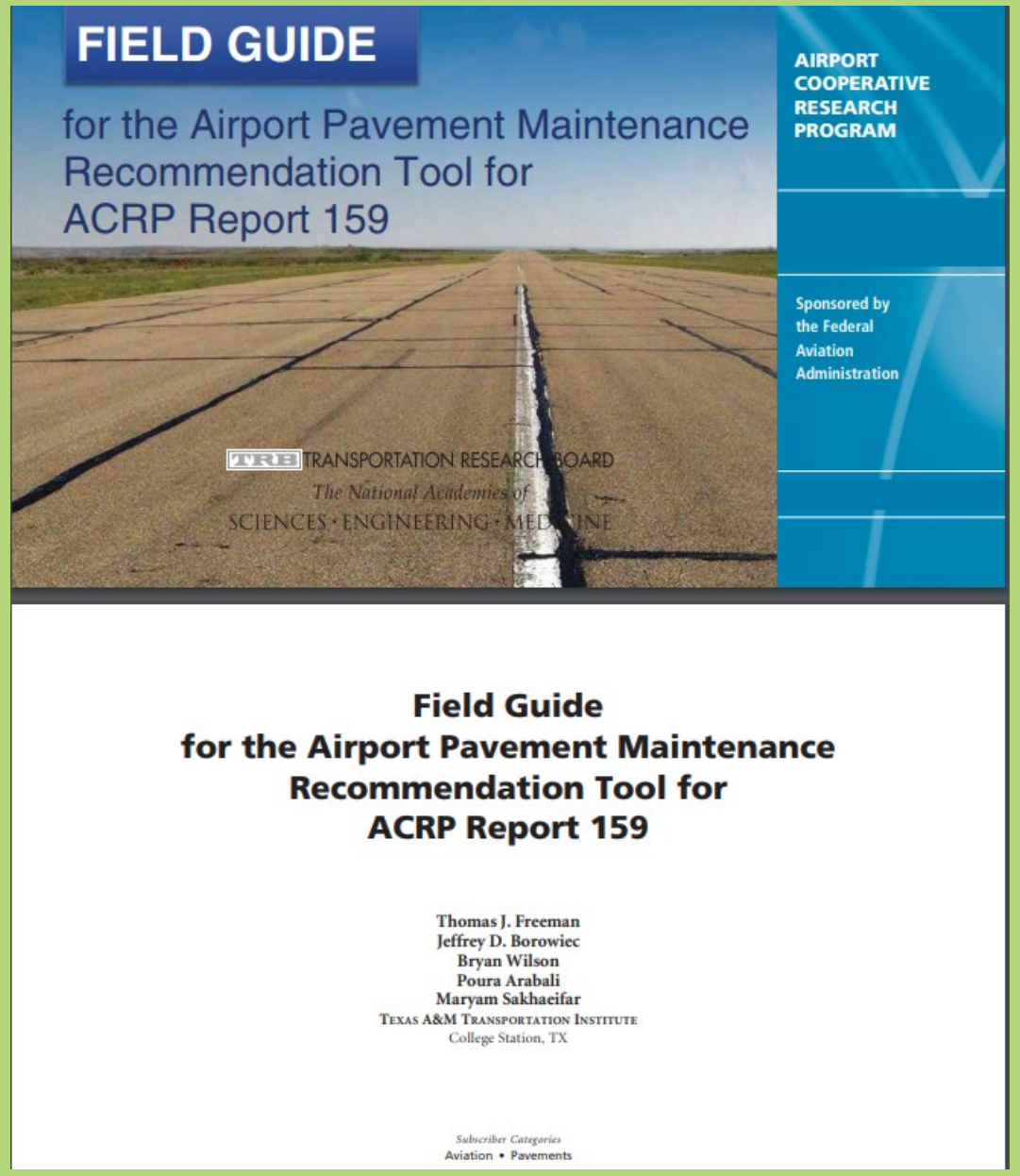
- Low Viscosity and Surface Tension
- Deep Crack Penetration
- Easy Single Application
- No Special Equipment
- Formation for vertical surface application
- Can be Pressure Injected



Resources

Field Guide for the Airport Pavement Maintenance Recommendation Tool for ACRP Report 159

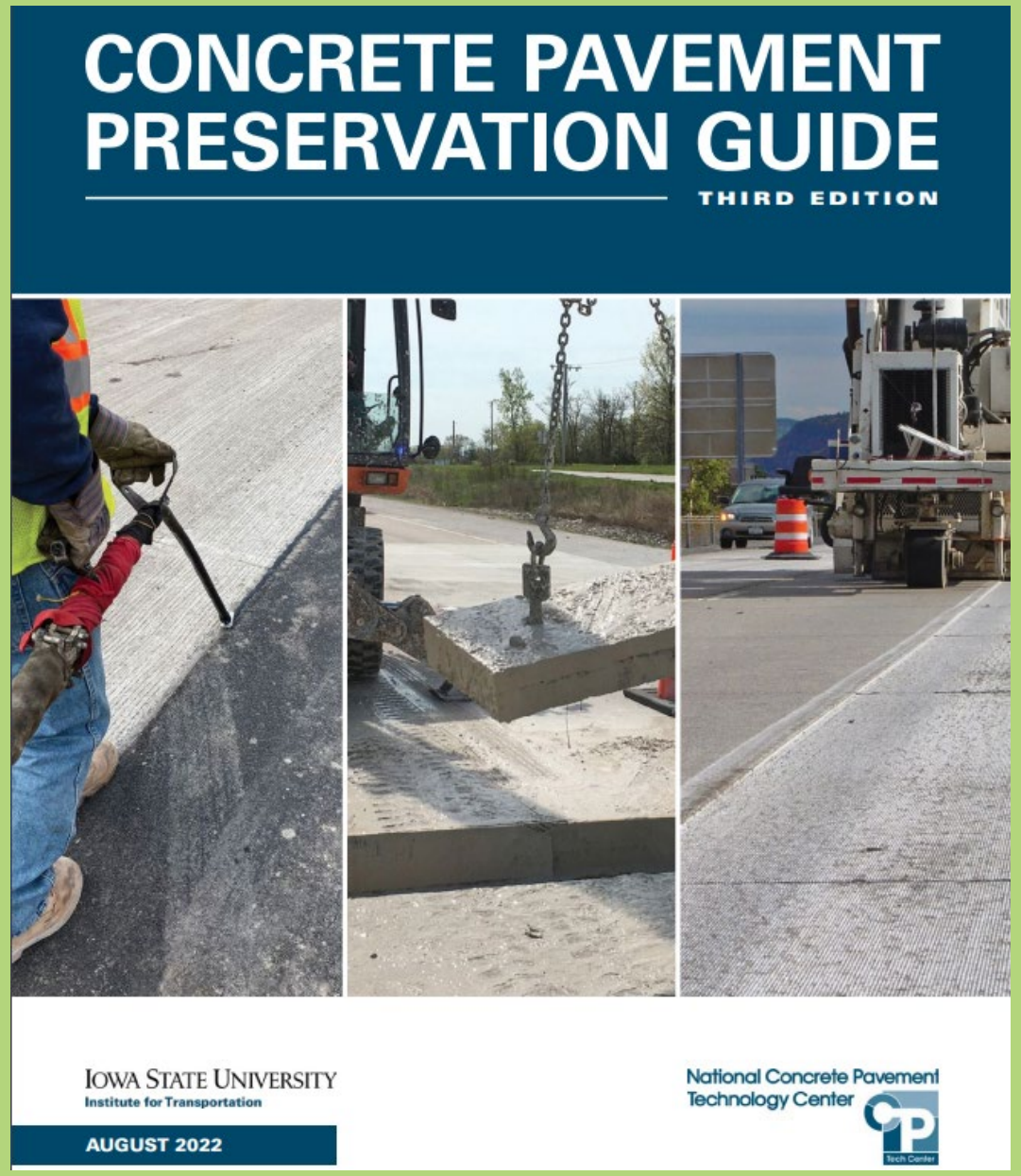
- Step 1. Determine Airport Classification
- Step 2. Choose Climatic Zone
- Step 3. Identify Distress
- 4. Determine Treatment
- Concrete Pavement Treatment
- Concrete Pavement Maintenance Treatment Hierarchy



https://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_159_FieldGuide.pdf

Concrete Pavement Preservation Guide

- Pavement Maintenance and Pavement Preservation Concepts
- Concrete Pavement Evaluation
- Slab Stabilization and Slab Jacking
- Partial-depth Repairs
- Full Depth Repairs
- Retrofitted Edge Drains
- Dowel Bar Retrofit, Cross Stitching and Slot Stitching
- Diamond Grinding and Grooving
- Joint Resealing and Crack Sealing
- Concrete Overlays
- Strategy Selection



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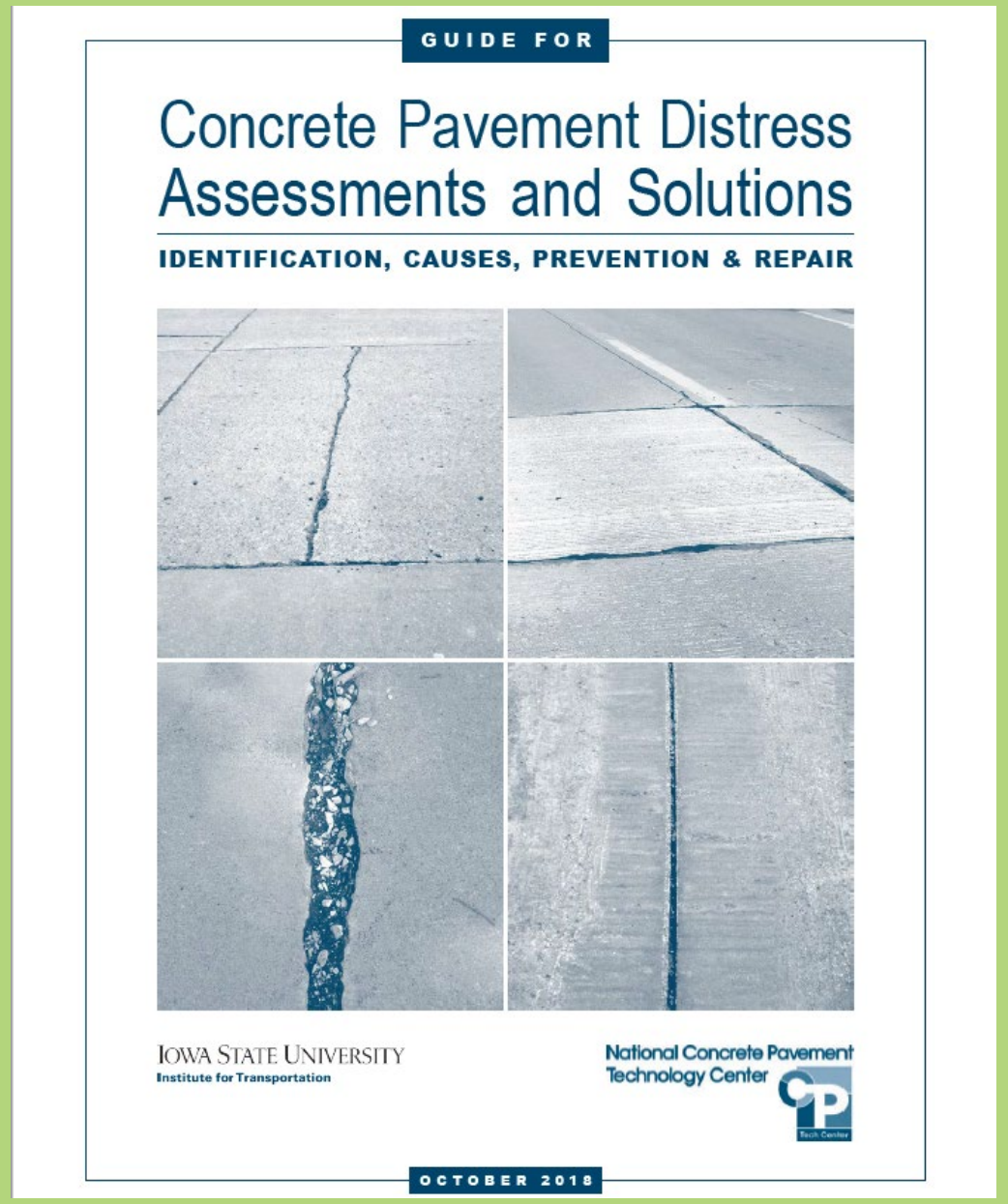
Concrete Pavement Distress Assessments and Solutions

- Surface Defects
- Surface Delamination
- Materials- Related Cracks
- Transverse and Diagonal Cracking
- Corner Cracking
- Spalling – Transverse and Longitudinal Joints and Cracks
- Faulting
- Joint Curling and Warping
- Blowups
- Subgrades and Base Support Conditions



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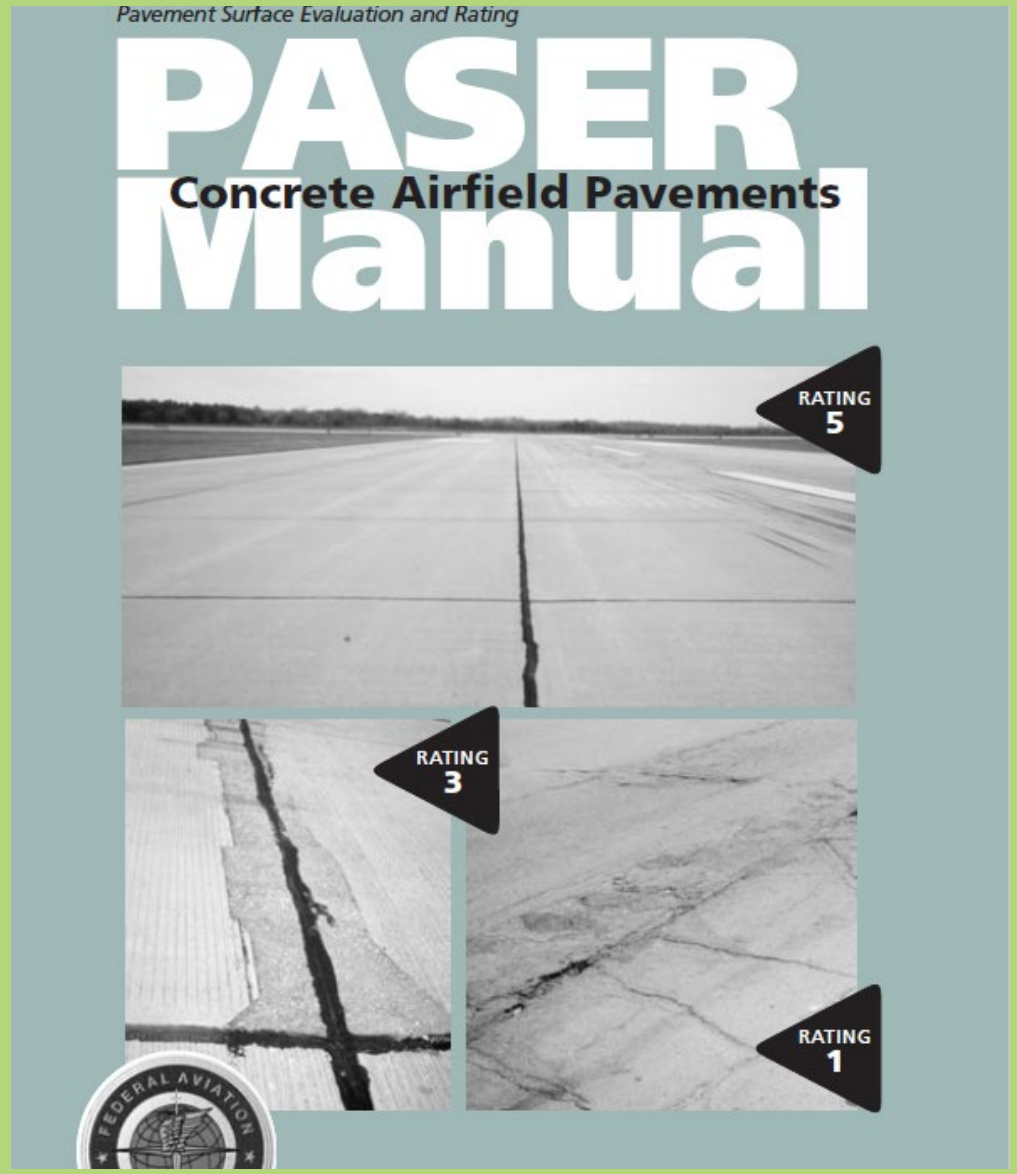
PASER Manual – Concrete Airfield Pavements

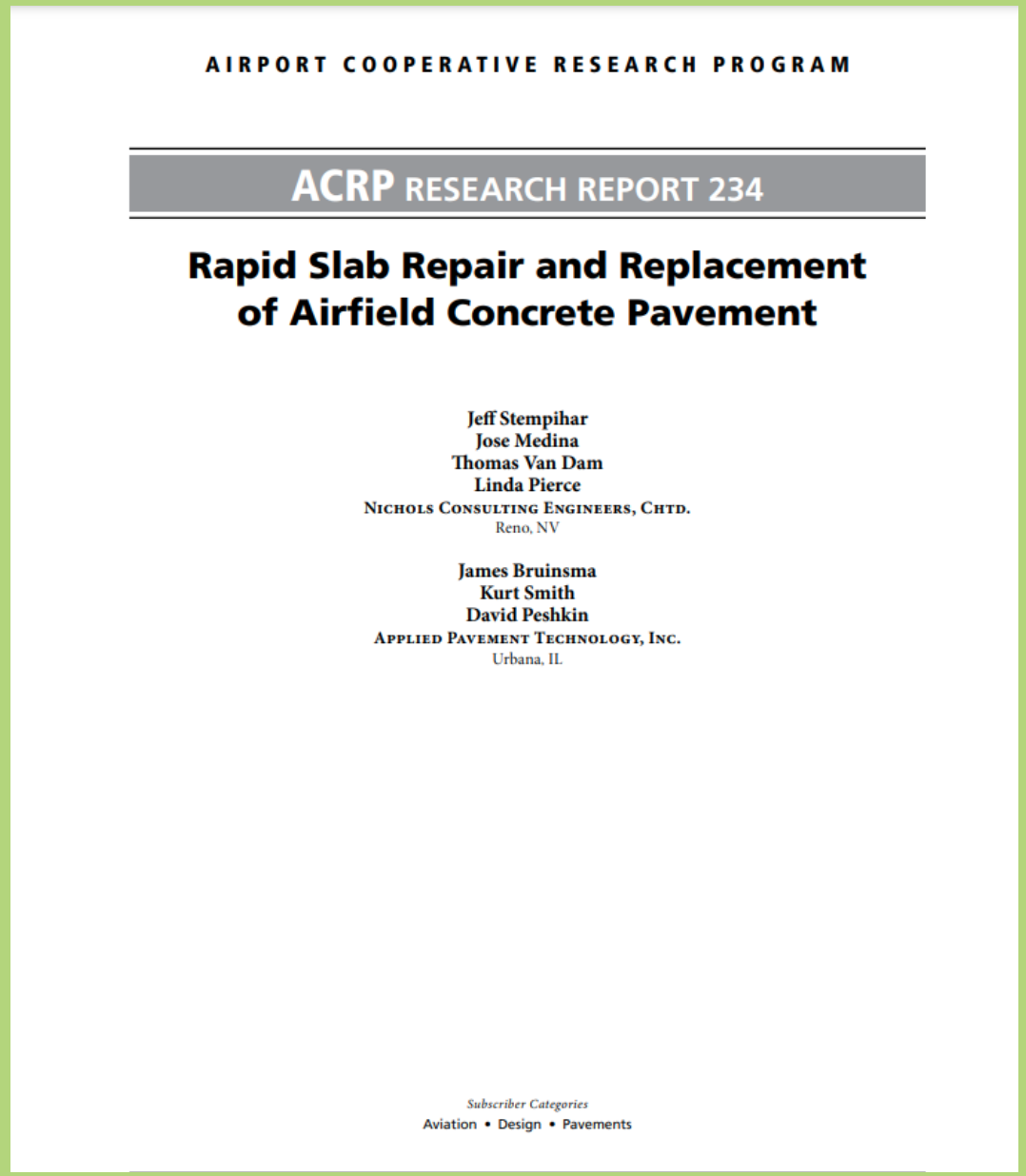
- Federal Aviation Administration (FAA) Document
- Evaluating Pavement Condition
  - Surface Defects
  - Joints
  - Pavement Cracks
  - Pavement Distortion
- Rating Pavement Surface Conditions
  - Rating System Description
  - Rating from 1 to 5 (Failed to Excellent)
- Practical Advice on Rating Airfield Pavements



https://www.faa.gov/documentLibrary/media/advisory_circular/150-5320-17/150_5320_17_part3.pdf

Rapid Slab Repair and Replacement of Airfield Concrete Pavement

- Planning Repairs
- Partial-Depth Repairs
- Full-Depth Repairs
- Airport Case Examples
- Examples of Rapid Slab Repair and Replacement Projects



AIRPORT COOPERATIVE RESEARCH PROGRAM

ACRP RESEARCH REPORT 234

Rapid Slab Repair and Replacement of Airfield Concrete Pavement

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Subscriber Categories
Aviation • Design • Pavements

https://nap.nationalacademies.org/catalog/26322/rapid-slab-repair-and-replacement-of-airfield-concrete-pavement

Pay Attention to Details

THANK YOU / QUESTIONS

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