Breathing New Life into Old Pavements: Concrete Solutions

MATT ZELLER, CPAM

JOHN CUNNINGHAM, ARM

Available Resources

Local industry experts

ARM

CPAM

Technical education and training

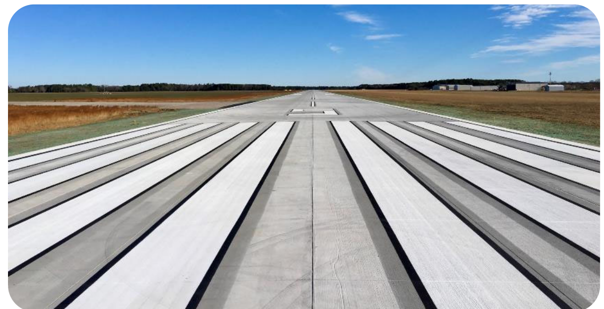
- ACI certifications
- NRMCA certifications
- Nat. CP Tech Center webinars/seminars

Technical publications and software

- American Concrete Pavement Association
- Nat. Ready Mixed Concrete Assn.
- Nat. Stone, Sand, & Gravel Assn.
- Nat. CP Tech. Center
- National Road Research Alliance
- Am. Soc. of Concrete Contractors
- American Concrete Institute

Breathing New Life into Old Pavements

1. Pavement distresses
2. Mix of fixes
3. Preservation techniques with concrete materials
   1. For existing concrete pavement
   2. For existing asphalt pavement
4. Concrete overlays
   1. On asphalt pavements
   2. On concrete pavements



Pavement Distresses

From AC 150/5380-6C

- Cracking
- Joint seal damage
- Disintegration
- Distortion
- Loss of skid resistance

AC 150/5380-6C

Includes guidance on pavement inspection and identification of distresses

Flexible

b. Disintegration. Disintegration in a flexible pavement is typically caused by climate, insufficient compaction of the surface, insufficient asphalt binder in the mix, loss of adhesion between the asphalt coating and aggregate particles, or severe overheating of the mix. The following types of disintegration commonly occur.

(1) Raveling. Raveling is the wearing away of the pavement surface caused by the dislodging of aggregate particles. This distress may indicate that the asphalt binder has aged and hardened significantly. As the raveling continues, larger pieces break free, and the pavement takes on a rough and jagged appearance which can produce a significant source for FOD.

(2) Weathering. Weathering is the wearing away of the asphalt binder and fine aggregate matrix from the pavement surface. The asphalt surface begins to show signs of aging which may be accelerated by climatic conditions. Loss of fine aggregate matrix is noticeable and may be accompanied by fading of the asphalt pavement color.

(3) Potholes. A pothole is defined as a disruption in the pavement surface where a portion of the pavement material has broken away, leaving a hole. Most potholes are caused by fatigue of the pavement surface. As fatigue cracks develop, they interlock forming alligator

Rigid

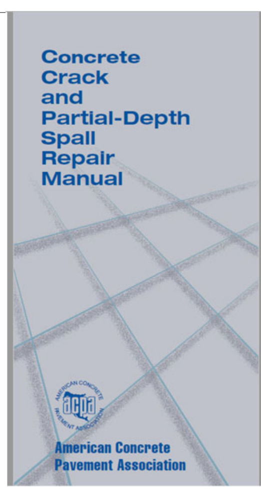
c. Disintegration. Disintegration is the breaking up of a pavement into small, loose pieces including the dislodging of aggregate particles. Improper curing and finishing of the concrete, unsuitable aggregates, and improper mixing of the concrete can cause this distress. Disintegration typically falls into the following categories.

(1) Scaling, map cracking, and crazing. Scaling is the disintegration and loss of the wearing surface. A surface weakened by improper curing or finishing and freeze-thaw cycles can lead to scaling. Map cracking or crazing refers to a network of shallow hairline cracks that extend only through the upper surface of the concrete. Crazing usually results from improper curing and/or finishing of the concrete and may lead to scaling of the surface.

(2) Alkali-Silica Reactivity (ASR). ASR is another source of distress associated with map cracking. ASR is caused by an expansive reaction between alkalis and certain reactive silica minerals, which forms a gel. The gel absorbs water, causing expansion, which may damage the concrete and adjacent structures. Alkalis are most often introduced by the portland cement within the pavement. ASR may be indicated by cracking of the concrete pavement (often in a map pattern); white, brown, gray or other colored gel or staining that may be present at the crack surface; and/or an increase in concrete volume (expansion) that may result in distortion of adjacent or integral structures or physical elements.

(3) Joint spalling. Joint spalling is the breakdown of the slab edges within 2 feet (0.6 m) of the side of the joint. A joint spall usually does not extend vertically through the slab but intersects the joint at an angle. Joint spalling often results from excessive stresses at the joint or crack caused by infiltration of incompressible materials or weak concrete at the joint (caused by overworking) combined with traffic loads. Joint spalling also results when dowels, which

Concrete Pavement Distress



Cracks and Spalls (UFC Guidance)

2.4. Cracks – Cracks less than 3/16 in. (5 mm) wide and without any surface spalling do not require repair or sealing. Seal all cracks between 3/16 in. (5 mm) and 2 in. (50 mm) wide. Cracks larger than 2 in. (50 mm) require full-depth patching. Use of a backer rod is recommended for all crack sealing, unless irregular crack dimensions preclude its use. If spalling is present adjacent to a crack (of any width), repair the damaged area by treating the crack the same as a joint. The sealed crack protects the repaired area from damage that might result from movement of the slab along the crack faces.

2.5. Spalls – Spalling is generally caused by incompressible materials in the joints and cracks that prevent the necessary movement of the slab due to thermal fluctuations, thereby causing breaks in the concrete adjacent to the joint or crack (Figure 2.1). Minor spalls may also be caused by snowplows, overworking of the plastic concrete, or popouts. To repair a spalled area, remove incompressible materials from the joint or crack, patch the spalled area, and replace the sealant. Additional repairs of previous spall repairs due to failure of the material or poor repair practices are also common. If the spall depth is greater than 1/3 the slab depth, full-depth patching is needed. Full-depth patching will not be covered in this manual but is addressed in Reference 1.3.8 or ACPA TB002P. Cracking of slabs can be due to load-related failure or environmental stress on the slab.

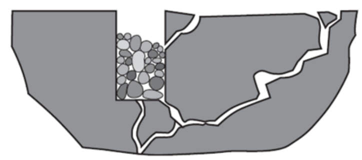
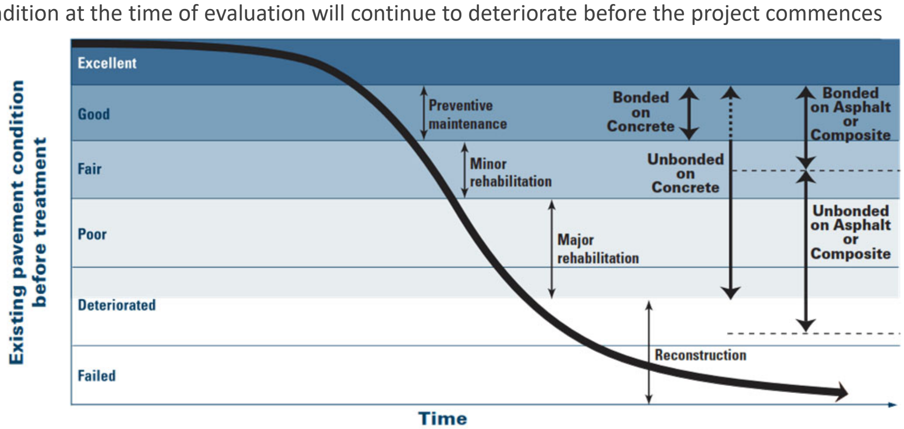


Figure 2.1. Incompressibles causing spalling in joint or crack.

Pavement Condition

Make certain you're considering the condition that is likely at the time the project <u>begins</u>

- Condition at the time of evaluation will continue to deteriorate before the project commences



Mix of Fixes for Pavement Distress

What repairs are covered in FAA guidance?

What are the options if the pavement is beyond repair?

What is the design procedure for concrete overlays?
- On concrete
- On asphalt

What does the construction process look like for concrete overlays?

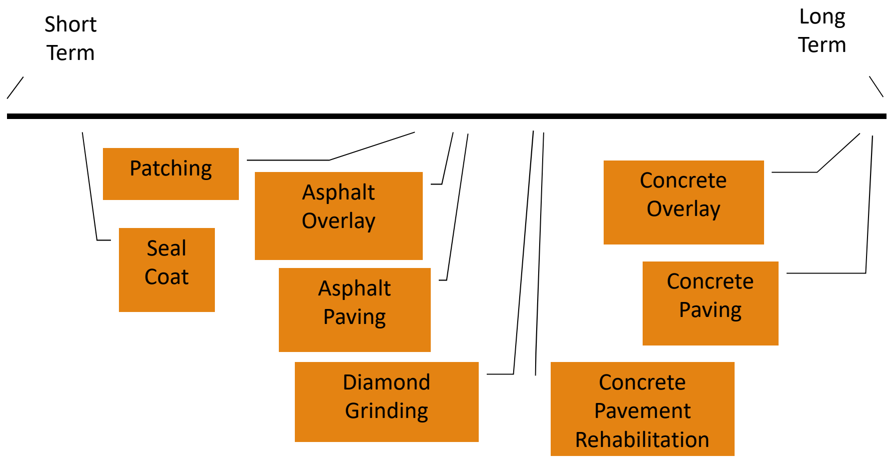
What is the performance of concrete overlays?

Benefits of Mix of Fixes

Using an array of techniques that includes both longer term and shorter term solutions

- Optimizes your investment over time
- Increases competition for work overall
- Makes annual budgeting easier for the future
- Allows you to have all techniques available to you
- Allows you to choose the best technique for the facility

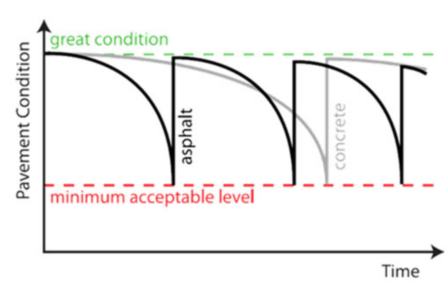
Mix of Fixes



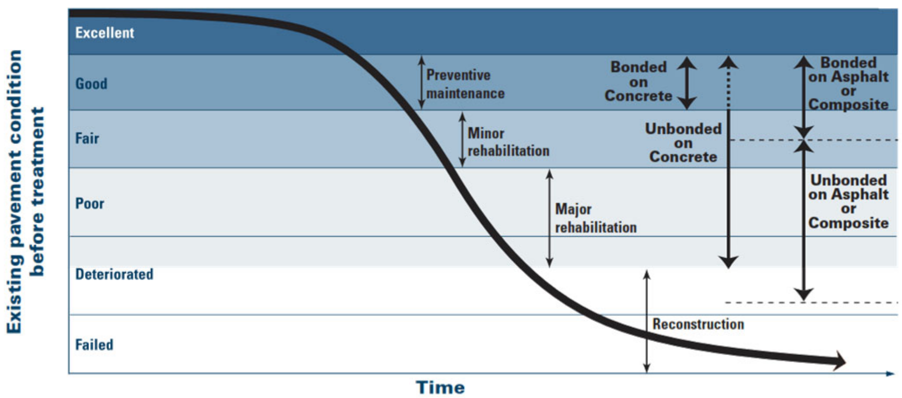
Economic Benefits of Multiple Solutions

Generally speaking

- Longer term solutions have higher initial costs
- Shorter term solutions have lower initial costs
- Using both solutions allows for optimization of dollars over time and over a system



Timing is Everything…



Effectiveness of Treatments

Estimated Life Extension (years)			
Treatment	Good PCI > 80	Fair PCI > 60	Poor PCI >40
Fog Seal/Rejuvenator	< 1	-	-
Spray Applied Seal	3-5	1-3	1-2
Chip Seal*	5-7	3-5	1-3
Slurry Seal	5-7	3-5	1-3
Micro-surface	8-12	5-7	2-4
Thin HMA	10-12	5-7	2-4

NOTE:
- Table is based on AAPTP Report 05-07 Table 4-1
- Not FAA Policy to date,
- For PCI < 60 typically do not recommend surface treatment but if can not do rehabilitation/reconstruction - will buy a little time.

* Typically not recommended on airports…FOD potential…Hard on tires

Federal Aviation Administration

Why a Mix of Fixes?

- An airport's needs are diverse and require more than one solution
- Current needs cannot be ignored while focusing on the future
- Future needs cannot be ignored to focus on today
- Consultants with multiple airports need to be able to apply the fix that best fits the facility
- Pavement investments can be optimized

Pavement Preservation Tools

Concrete Solutions

- Concrete Overlays
  - On concrete pavements
  - On asphalt or composite pavements
  - On rubblized concrete pavements
- Concrete Inlays
- Diamond Grinding and Grooving
- Full-depth Reclamation
- Full-depth Patching

Flexible Distresses

Guidance provided in FAA Advisory Circular 150/5380-6C

AC 150/5380-6C 10/10/2014

Table 6-1. Quick guide for maintenance and repair of common flexible pavement surface problems

Problem	Repair	Probable Cause
Weathering/ Oxidation	- Apply surface treatment - Overlay	- Environment - Lack of timely surface treatments
Cracks	- Remove old sealer material if present - Clean and prepare cracks - Seal/reseal cracks - Joint heating may be an option for longitudinal cracks when under the direction of an engineer. (Operate heaters to avoid excessive heat on the pavement.)	- Age - Environmental conditions - Bitumen too hard or overheated in mix - Sealant defects (e.g., incorrect application temperature, improper sealant selection, improper crack preparation)
Alligator or fatigue cracking	- Remove and replace damaged pavement, including the base and/or subbase course if required.	- Base and/or Subgrade failure - Overload - Under-designed surface course (too thin)
Patches	- Remove/replace. - Repair and Resurface	- Inadequate/Improper repair detail/material - Age
Surface irregularities (e.g., rutting, wash-boarding, birdbaths)	- Remove and replace damaged areas - Surface grinding/milling	- Traffic - Age
Loss of Skid Resistance	- Remove rubber/surface contamination - Apply surface treatment	- Rubber deposits/surface contamination - Polished aggregate - Improper surface treatment
Bleeding	- Blot with sand and remove sand prior to resuming aircraft operations. Excessive bleeding may require removal and replacement of pavement.	- Overly rich mix/low air void content. Bleeding may be a precursor to other surface deformities forming, e.g., rutting, wash-boarding, etc.
Drainage	- Grade pavement shoulders, clear drainage path - Clean out drainage structures, e.g., edge drains, outfalls, etc.	- Poor maintenance of drainage facilities - Poor maintenance of grade

Rigid Distresses

Guidance provided in FAA Advisory Circular 150/5380-6C

10/10/2014 AC 150/5380-6C

Table 6-2. Quick guide for maintenance and repair of common rigid pavement surface problems

Problem	Repair	Probable Cause
Joint sealant damage	- Remove old sealant, clean joints, reseal	- Age - Environmental conditions - Sealant defects (e.g., incorrect application temperature, improper sealant selection, improper joint preparation)
Cracks	- Clean and seal cracks - Repair/replace slab - Evaluate adequacy of pavement structure; may require strengthening	- Loss of slab support - Load repetition; curling stresses; and shrinkage stresses
Corner Breaks	- Seal and maintain until full depth patch	- Loss of slab support - Load repetition and curling stresses
Joint spalling	- Remove lose material; refill with approved product; reseal - Partial depth repair	- Latent defects, i.e., excessive finishing - Incompressible matter in joint spaces - Snow plow damage
Slab blowup	- Replace slab in blowup area; clean and reseal joints.	- Incompressible material in joints preventing slab from expanding
Loss of Skid Resistance	- Remove rubber/surface contamination. - Grinding.	- Rubber deposits/surface contamination - Age, i.e., surface wear
Drainage	- Grade pavement shoulders, clear drainage path - Clean out drainage structures, e.g., edge drains, outfalls, etc.	- Poor maintenance of drainage facilities - Poor maintenance of grade
Popouts	- Remove FOD	- Material
Patches	- Remove/replace	- Inadequate/Improper repair detail/material - Age

AC 150/5380-6C

Helpful details for preservation of both pavement types

10/10/2014

AC 150/5380-6C
Appendix A

A1. PROCEDURE FOR CRACK REPAIR OF FLEXIBLE PAVEMENT

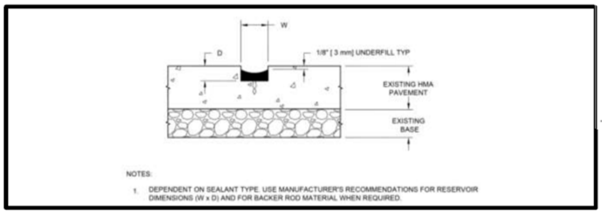


Figure A-1. Crack repair of flexible pavement

A2. PARTIAL DEPTH CRACK REPAIR IN FLEXIBLE PAVEMENT

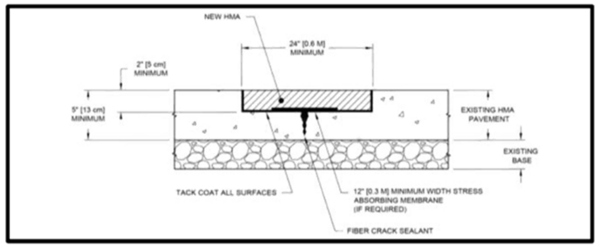


Figure A-2. Partial depth crack repair in flexible pavement

AC 150/5380-6C Details

A3. FULL DEPTH CRACK REPAIR IN FLEXIBLE PAVEMENT

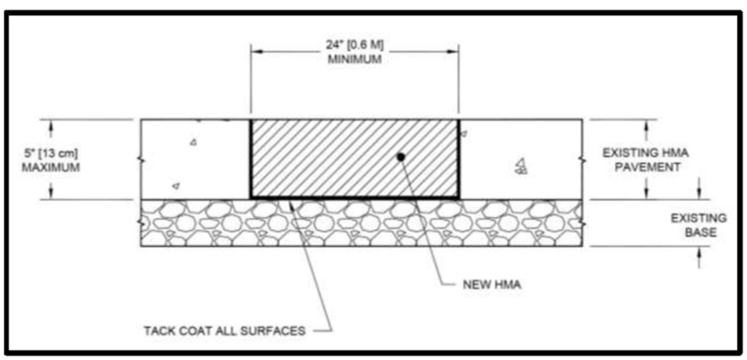
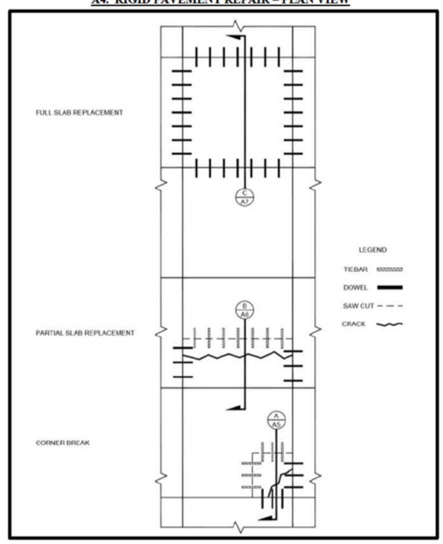


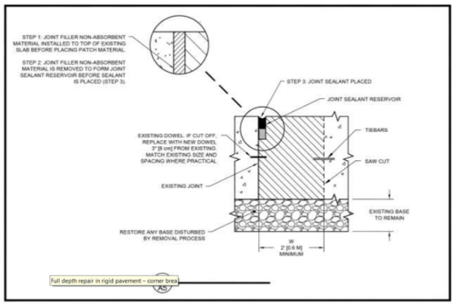
Figure A-3. Full depth crack repair in flexible pavement

AC 150/5380-6C Details

A4. RIGID PAVEMENT REPAIR – PLAN VIEW

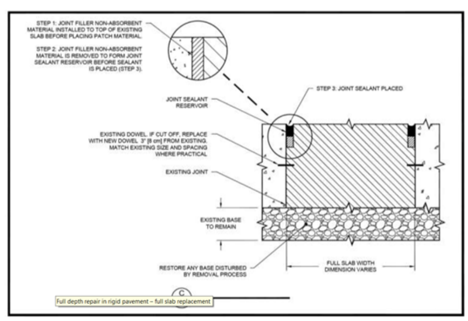


A5. FULL DEPTH REPAIR IN RIGID PAVEMENT – CORNER BREAK

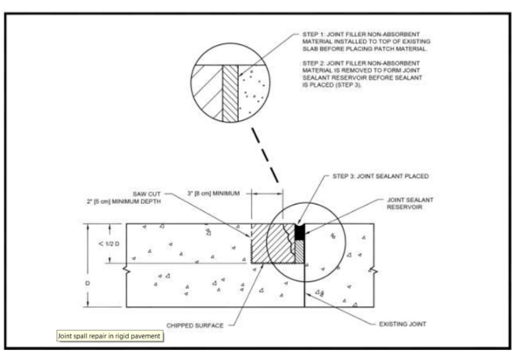


AC 150/5380-6C Details

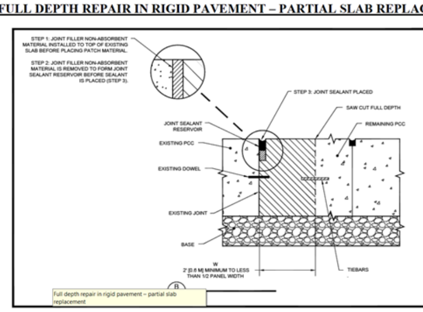
A7. FULL DEPTH REPAIR IN RIGID PAVEMENT – FULL SLAB REPLACEMENT



A8. JOINT SPALL REPAIR IN RIGID PAVEMENT



A6. FULL DEPTH REPAIR IN RIGID PAVEMENT – PARTIAL SLAB REPLACEMENT



Partial Depth Patching

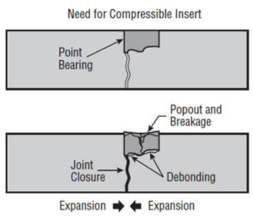


Figure 9.3. Point bearing occurs when partial-depth patch bridges joint or crack without compressible insert.

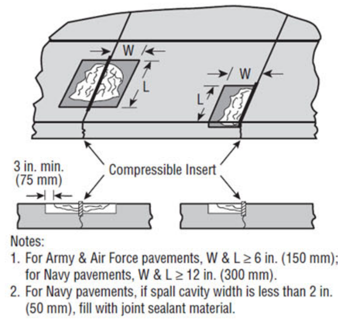


Figure 9.1. Typical spall repair layout.

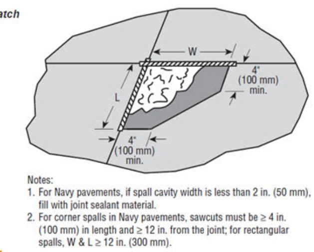


Figure 9.2. Corner spall repair for Navy pavements.

*From Guide to Cracks and Spalls (UFC doc)

Figure 12.1. A partial-depth repair spanning both sides of the joint.

Wikipave

http://wikipave.org/index.php/Early_Cracking

Table 6. Recommended Repairs of Cracking in Concrete Pavement Construction.

Defect	Orientation	Approximate Location[a]	Description	Recommended Repair	Alternate Repair
Plastic Shrinkage	Any	Anywhere	Only partially penetrates depth and more than 0.18 mm (0.007 in.) wide	Do nothing	Fill with HMWM[b]
Uncontrolled Crack	Transverse	Mid-panel (Mid-slab)	Full-depth	Saw & seal crack	LTR[c]
Uncontrolled Crack	Transverse	Crosses or ends at transverse joint	Full-depth	Saw & seal the crack; Epoxy uncracked joint saw cut	
Uncontrolled Crack	Transverse	Relatively parallel & w/in 1.5 m (4.5 ft) of joint	Full-depth	Saw & seal the crack; Seal joint	FDR[d] to replace crack and joint
Damaged Saw cut or Uncontrolled Crack	Transverse	Anywhere	Spalling; more than 3.0 in. (75 mm) wide	Repair spall by PDR[e] if crack not removed	
Uncontrolled Crack	Longitudinal	Relatively parallel & w/in 0.3 m (1 ft.) of joint; May cross or end at longitudinal joint	Full-depth	Saw & seal the crack; Epoxy uncracked joint saw cut	Cross-stitch[f] or Slot-stitch crack
Uncontrolled Crack	Longitudinal	Relatively parallel & in wheel path 0.3 -1.5 m (1-4.5 ft) from joint	Full-depth, hairline or spalled	Remove & replace panel (slab)	Cross-stitch[f] or Slot-stitch crack
Uncontrolled Crack	Longitudinal	Relatively parallel & further than 1.5 m (4.5 ft) from a long. joint or edge	Full-Depth	Cross-stitch[f] or Slot-stitch crack	
Saw cut or Uncontrolled Crack	Longitudinal	Anywhere	Spalled	Repair spall by PDR[e] if crack not removed	
Uncontrolled Crack	Diagonal	Anywhere	Full-depth	FDR[d]	
Uncontrolled Crack	Multiple per panel (slab)	Anywhere	Two full depth cracks dividing panel (slab) into 3 or more pieces	Remove & Replace panel (slab)	

Table 6. Recommended Repairs of Cracking in Concrete Pavement Construction

Concrete Overlays

Benefits of Concrete Overlays

- Easier/faster Construction
- Sustainability
- Resilience
- Safety
- Quality
- Performance
- Low Maintenance
- Built-in Skid Resistance

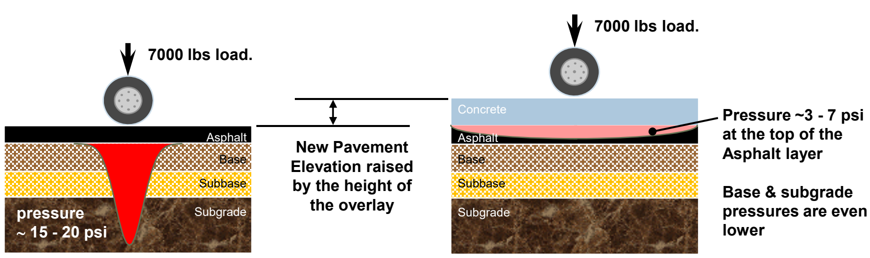
Improved Resilience

Henderson Field (Wallace, NC)

Offutt AFB (Omaha, NE)

- When a concrete overlay is used, **it takes the old pavement and turns it into a good stabilized base** for the new surface…It hardens the system!
  - It also RAISES the pavement surface off of possible high water table

HOW CONCRETE OVERLAYS IMPROVE ASPHALT PAVEMENT'S RESILIENCE TO FLOODING

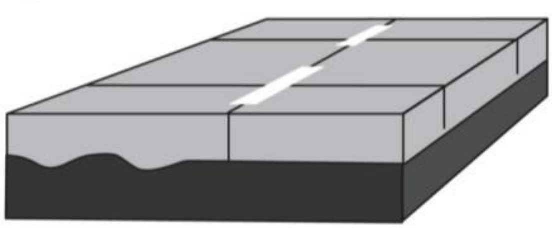


Concrete overlay increases both the height and the structural strength of the pavement

Overlay Design

- FAA AC 150/5320-6G – Chapter 4
- Reason for Rehabilitation
  - Why is pavement ready for rehabilitation
  - Structural, material distress, other
- Start with condition assessment
  - Complete assessment of pavement materials and structural integrity
  - Thickness, condition, nature and strength of each layer
- Design must correct reason for rehabilitation

Concrete Overlays



6/7/2021 AC 150/5320-6G

Table 3-4. Minimum Layer Thickness for Rigid Pavement Structures[1]

Layer Type	FAA Specification Item	Maximum Aircraft Gross Weight Operating on Pavement, lbs (kg)		
		<60,000 (27,215)	< 100,000 (45,360)	≥ 100,000 (45,360)
Rigid Surface[2]	P-501, Cement Concrete Pavement	6 in (150 mm)[2]	6 in (150 mm)[2]	6 in (150 mm)[2]
Drainable Base (When Used)	P-407[5], P-307		6 in (150 mm) when used	6 in (150 mm) When used
Stabilized Base[3]	P-401 or P-403; P-304; P-306	Not Required	Not Required	5 in (125 mm)
Base[4]	P-209, P-207, P-208, P-210, P-211, P-212, P-213, P-219, P-220	Not Required	6 in (150 mm)	6 in (150 mm)
Subbase[5]	P-154	6 in (100 mm)	As needed for frost or to create working platform	As needed for frost or to create working platform

Notes:
1. Complete structural design to determine rigid surface layer thickness required to support actual traffic.
2. Use greater of FAARFIELD thickness to the nearest 0.5 inch (10 mm), or minimum layer thickness, if all aircraft < 30,000 lbs (11,520 kg) 5 in (125 mm) minimum thickness.
3. See paragraph 3.5, Stabilized Base Course, for requirements and limitations. P-220 may be used under concrete with minimum thickness of 12" and when concrete thickness is increased by 3"
4. P-207, P-219 require laboratory testing to establish if it will perform as a base or subbase. If CBR > 80 may be used in place of P-209, CBR >60 in place of P-208. Both may be used as a subbase under stabilized base.
5. Any base material may be used as a subbase.
6. See EB 102, *Asphalt Treated Permeable Base Course*.

3-21

Concrete Overlays

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3-21

Overlay of Asphalt Pavement: Construction Considerations

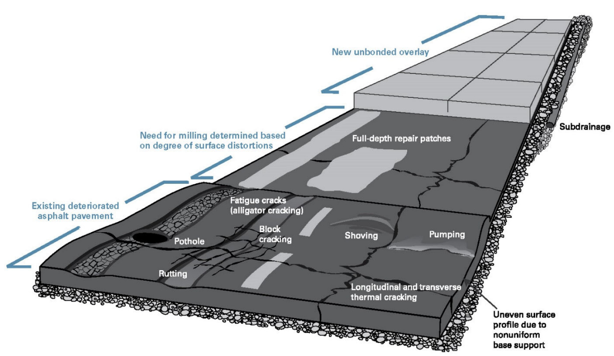
Must keep a minimum of 3" good asphalt for thin concrete overlays (<6")
- AFTER milling

Consider potential impact of construction traffic on existing asphalt

Cool existing surface if necessary
- Keep surface temp below 120°

Paving almost immediately after rain
- Go when there is no ponded water on surface

Maturity monitoring can speed completion time



Unbonded Concrete Overlay of Asphalt

Increases pavement structural capacity

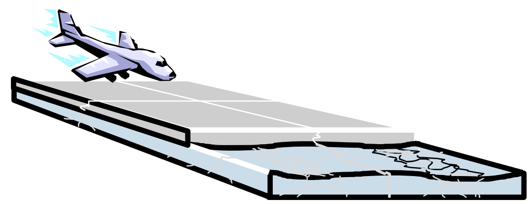
Overlay can be placed directly on existing pavement

Only minor repair of existing surface may be needed

Quick and easy construction

Construction traffic can use existing pavement

Raises the surface further above the water table



Concrete Overlay Performance

Rigid over Asphalt (WT)

AIRPORT	Thickness	Last PCI	Year C
South Carolina			
Lancaster Co RW	7.5	99	2010
Berkeley Co RW	9	99	2010
Laurens Co RW	5	99	2013
Greenwood Co RW	5	100	2014
Iowa			
Storm Lake RW	5	89	**1971**
Corning RW	5	75	**1987**
Carroll RW	5	85	**1988**
Ft. Madison RW	6	94	**1991**
Spencer (RW 12 / RW 18)	5 / 6	91 / 100	**1992 / 1994**

Exceeds FAA 20-year Design Life

Concrete Overlay Performance

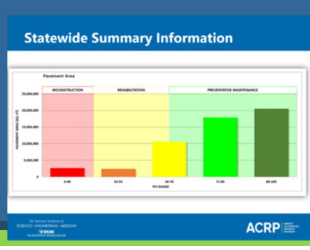
Rigid over Rigid (with Sep Layer)

AIRPORT	Thickness	Last PCI	Year C
South Carolina			
Charleston Exec RW	11	93	2010
Indiana			
Columbus Municipal	10	98	2010
Iowa			
Keokuk RW	6	94	**1996**
Denison RW	6	90	**1997**
Oskaloosa RW	6	87	**1998**

Exceeds FAA 20-year Design Life

Columbus (IN) Municipal Airport

The Opportunities… Where are the Best Places to start?



Airfield Applications

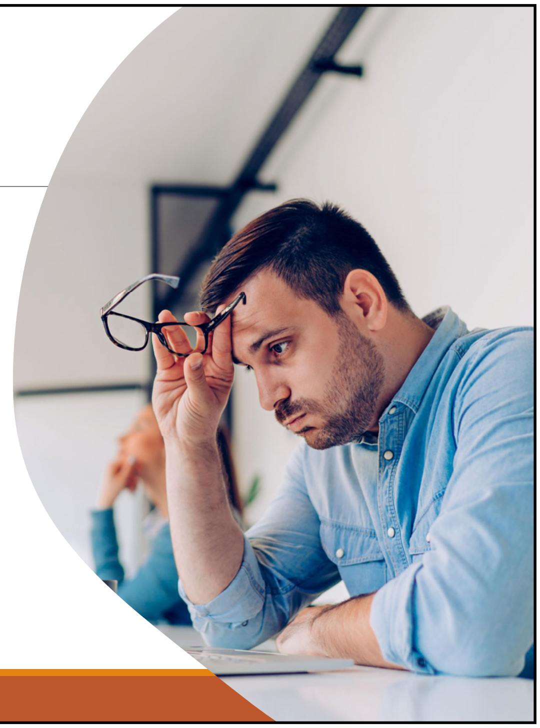
Finding a good overlay candidate…

- Existing Asphalt (or Concrete) in FAIR to POOR Condition
  - Rutting / Cracks in the pavement are normal – can be addressed
- Areas where competitive bids have been lacking
- Enough pavement structure where milling (profiling) can be accomplished that helps with project economics
- **Looking to improve pavement resiliency**
  - **Harden the system and Raise the grade (off high-water table)**

One Last Thought…

Resources are readily available

- American Concrete Pavement Assn.
- Nat. Ready Mixed Concrete Assn.
- Nat. Stone, Sand, & Gravel Assn.
- Nat. CP Tech. Center
- National Road Research Alliance
- Am. Soc. of Concrete Contractors
- American Concrete Institute



General Aviation Airport Workshop

https://web.concretestate.org/events/GA-Concrete-Workshop-1575/details

ACPTP:

- Federal Aviation Administration (FAA)
- National Concrete Pavement Technology Center (CP Tech Center)

Thank you

MATT ZELLER, CPAM

JOHN CUNNINGHAM, ARM OF MINNESOTA