DESIGNING FOR IMPROVED AIRFIELD PAVEMENT RESILIENCE

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American Concrete Pavement Association - SE Chapter

American Concrete Institute

Orlando, FL
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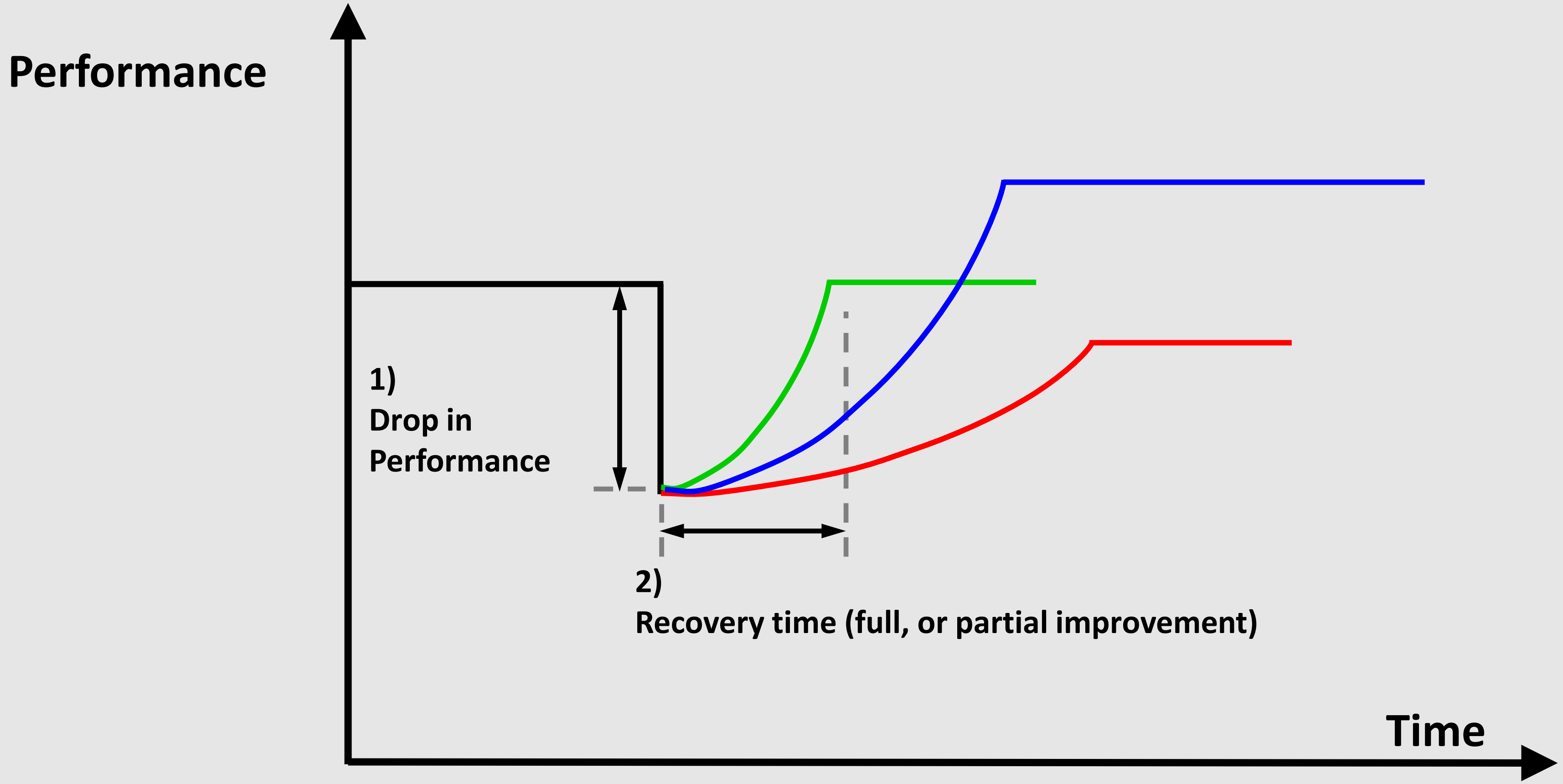
ACI Spring Convention

ACPA

INTRODUCTION TO RESILIENCE

The ability to … anticipate, prepare for, and adapt … withstand, respond to, and recover rapidly…[1]



Green is more resilient than Red
- **Faster recovery time**
- **Higher level of service**

Blue is a hardened [2] system as it has a higher final performance level

Resilience with respect to an event (eg. Flooding, fire, earthquake, etc) is characterized by two parameters:

1. Drop in performance, induced by the event (eg. reduced ability to carry load).
2. Recovery time to reinstate or improve performance.

1. ***FHWA Order 5520****: Transportation System Preparedness and Resilience to Climate Change and Extreme Weather Events*
2. *Hardening Infrastructure* – Elevating, upgrading, relocating assets, flood walls, berms and levees, etc.

Designing for Improved Airfield Pavement Resilience

- WHY the Need for resilient airfield pavements?
- HOW to Design for Improved resilience?
- Case Studies

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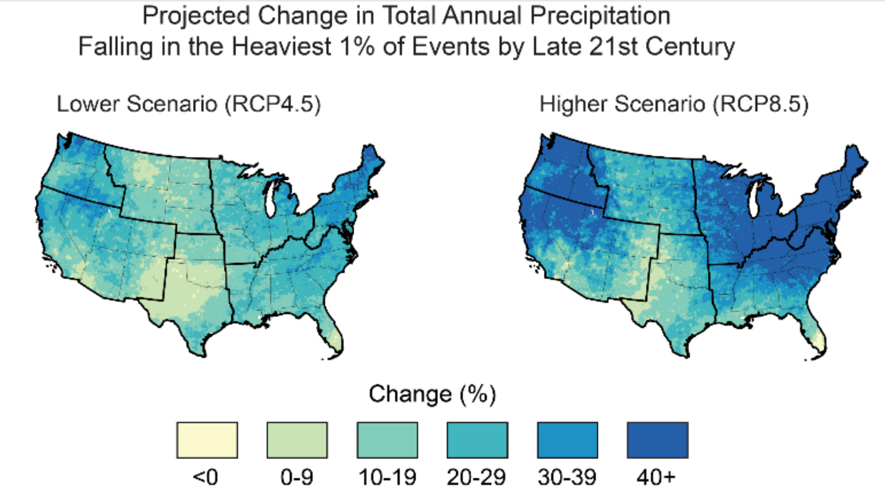
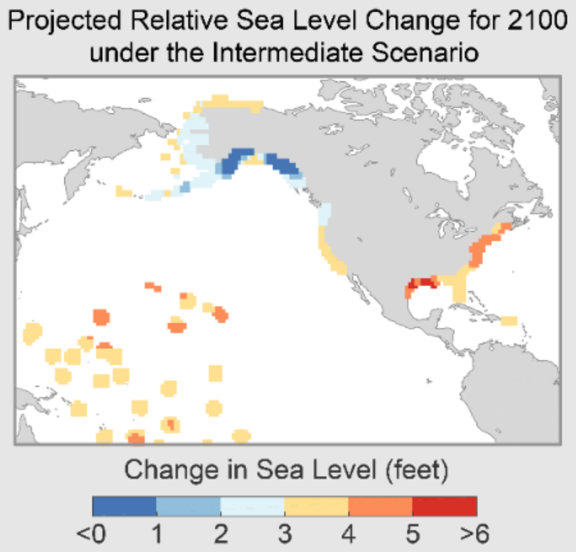
FUTURE CLIMATE CONDITIONS WILL NOT RESEMBLE THE PAST

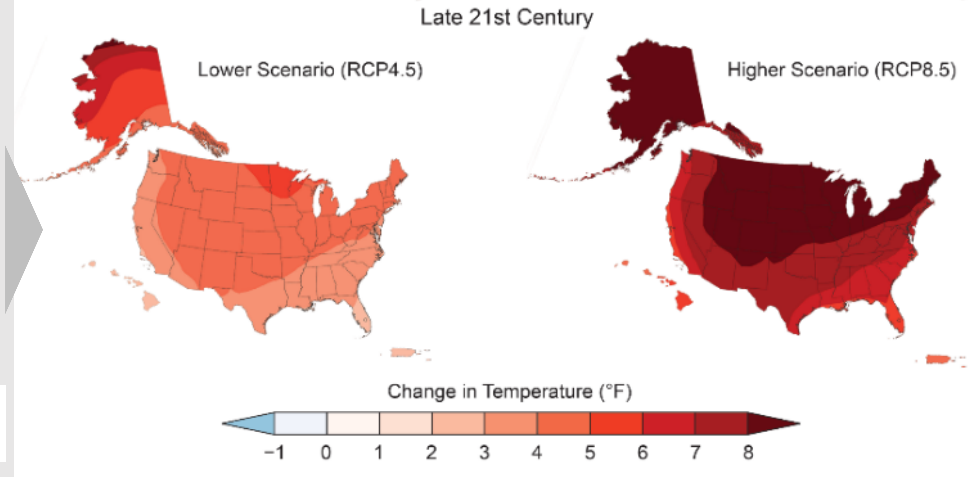
U.S. severe storms, heavy precipitation events:
Greater intensity *and* frequency
Continued increases expected





Global mean sea level:
7–8 inches higher since 1900 - about half since 1993
Expected to rise by 1–4 feet by 2100

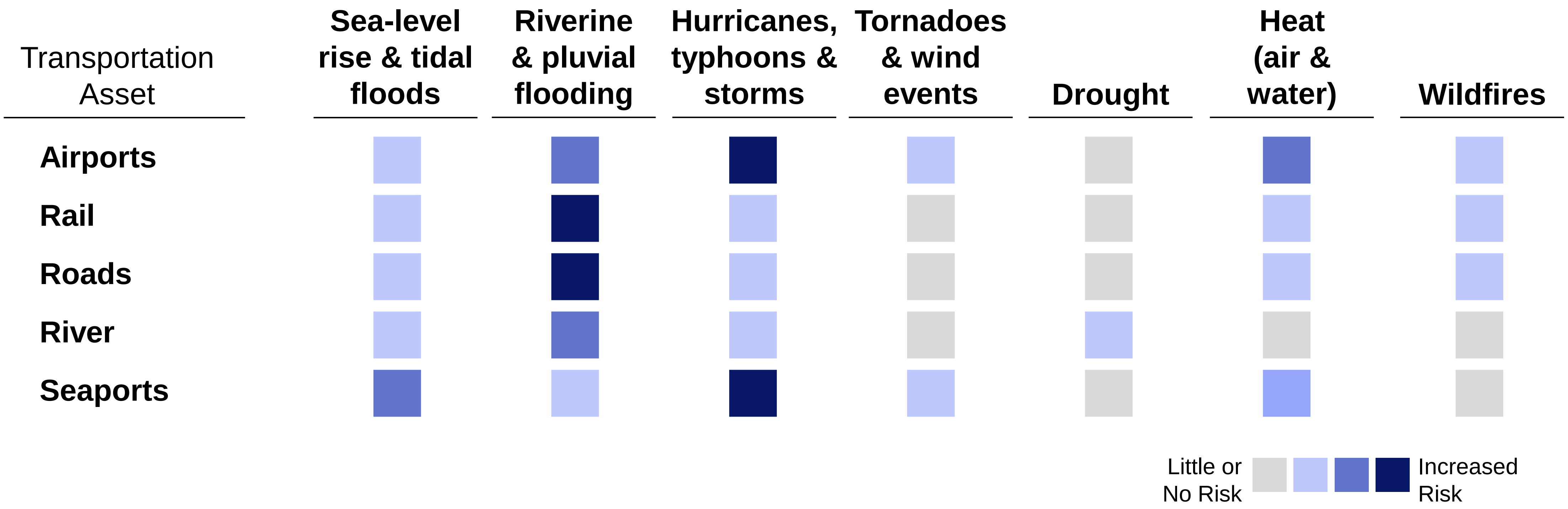
Increased Extreme heat events and drought:
Increased incidence of large forest fires



USGCRP, 2018: Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II: Report-in-Brief [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 186 pp.

FLOODING IS THE PRIMARY CLIMATE RISK TO INFRASTRUCTURE

Risk can occur as both sudden shocks & long-term recurring chronic pressures

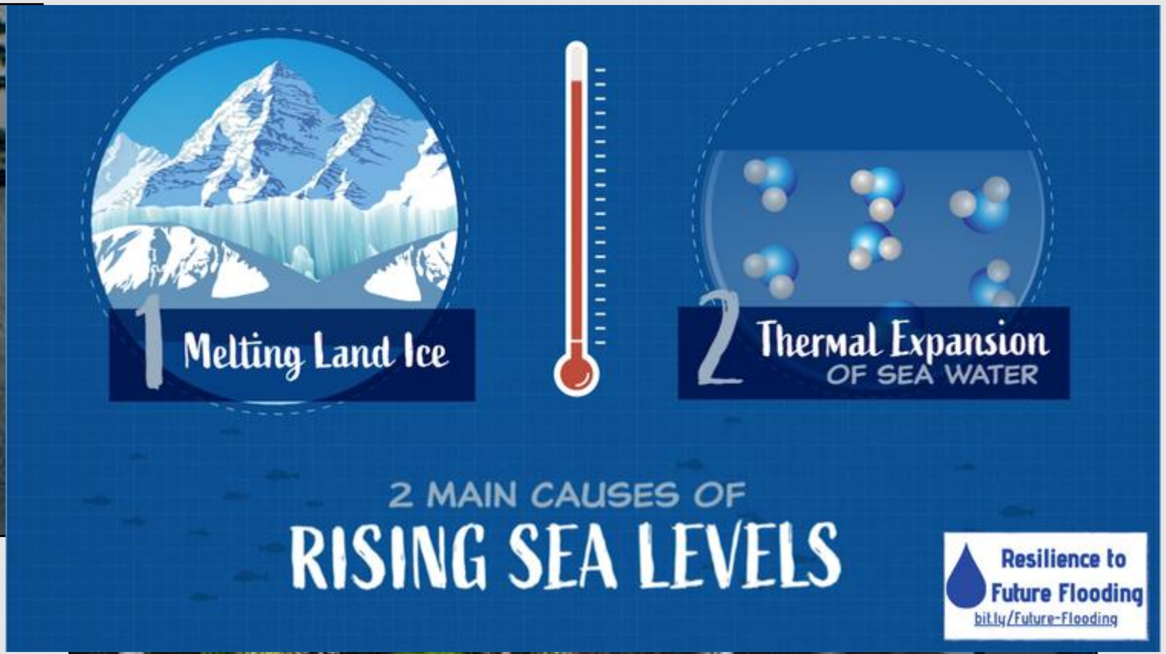


Climate risk increases operating costs & exacerbates the infrastructure funding gap

Source: *McKinsey & Company, Will infrastructure bend or break under climate stress?, McKinsey & Company,* August 19, 2020
https://www.mckinsey.com/Videos/video?vid=6180836320001&plyrid=HkOJqCPWdb&aid=A21DD0A9-7DA8-44A2-87E0-B4944177F295

SEA LEVEL RISE IS ALREADY IMPACTING COASTAL ZONES

Sunny sky flooding is becoming a too common occurrence

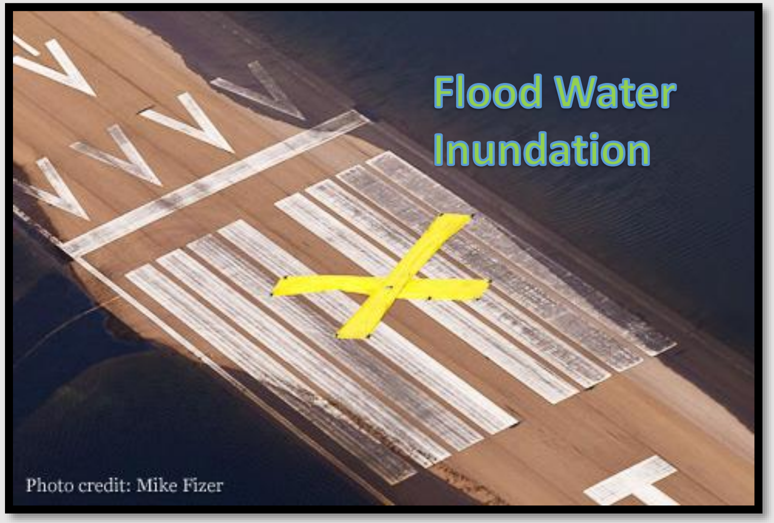


DE Photos courtesy of Jim Pappas, DELDOT; FL Photos courtesy of Amy Wedel, FC&PA

Why the Need for Improved Resilience?

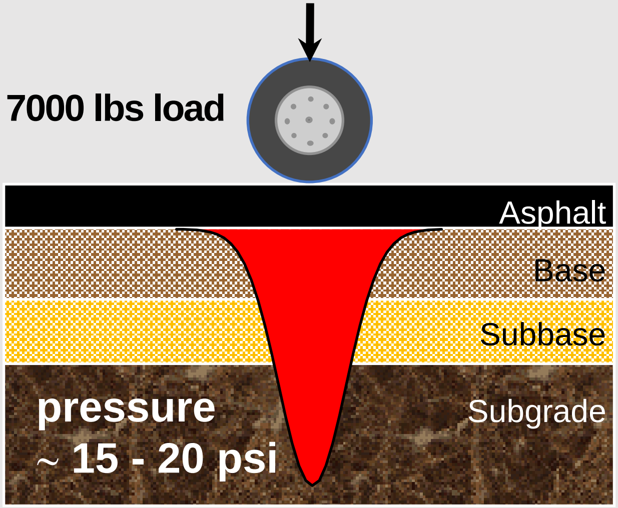
Ocracoke Island, NC (Outer Banks)

Vicksburg, MS



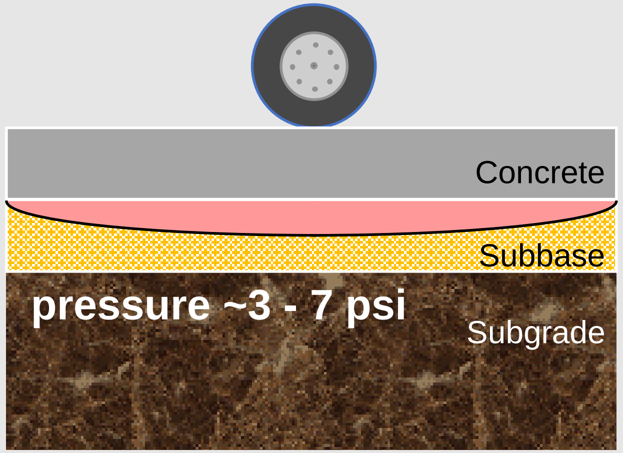
- Pavement deterioration curves accelerate when flooding (or high water) occurs
  - When flood waters recede, studies indicate subgrades remain moist > 1 yr
  - Pavements are often re-loaded before subgrades dry

CONCRETE AND ASPHALT PAVEMENTS ARE DIFFERENT
> DUE TO HOW THEY TRANSMIT LOADS TO THE SUBGRADE <



Asphalt Pavements are Flexible

- Load - more concentrated & transferred to the underlying layers
- Higher deflection
- Subgrade & base strength are important
- Requires more layers / greater thickness to protect the subgrade



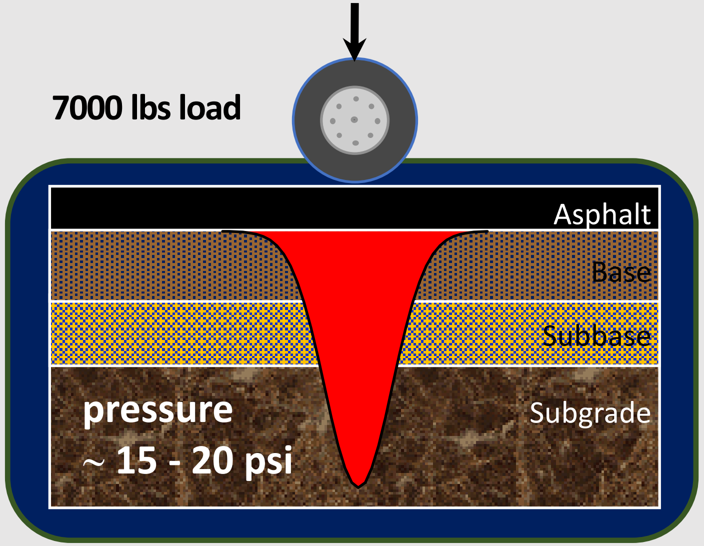
Concrete Pavements are Rigid

- Load – Carried by concrete and distributed over a large area
- Minor deflection
- Low subgrade contact pressure
- Subgrade uniformity is more important than strength

Concrete's rigidity spreads the load over a large area & keeps pressures on the subgrade low

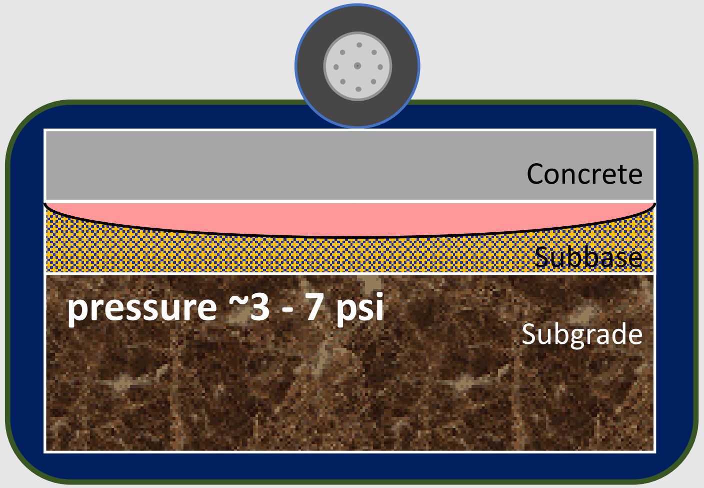
FLOODING CAUSES THE SUBGRADE TO BECOME SUPERSATURATED

Moisture infiltrates base, pushes the subgrade particles apart and weakens the system



Asphalt Pavements are FLEXIBLE

- Lowered subgrade strength & reduced modulus
  - Reduced load carrying capacity
  - Takes ~1 year to regain strength
- Loading during this times accelerates pavement damage / deterioration
  - Reduced pavement life

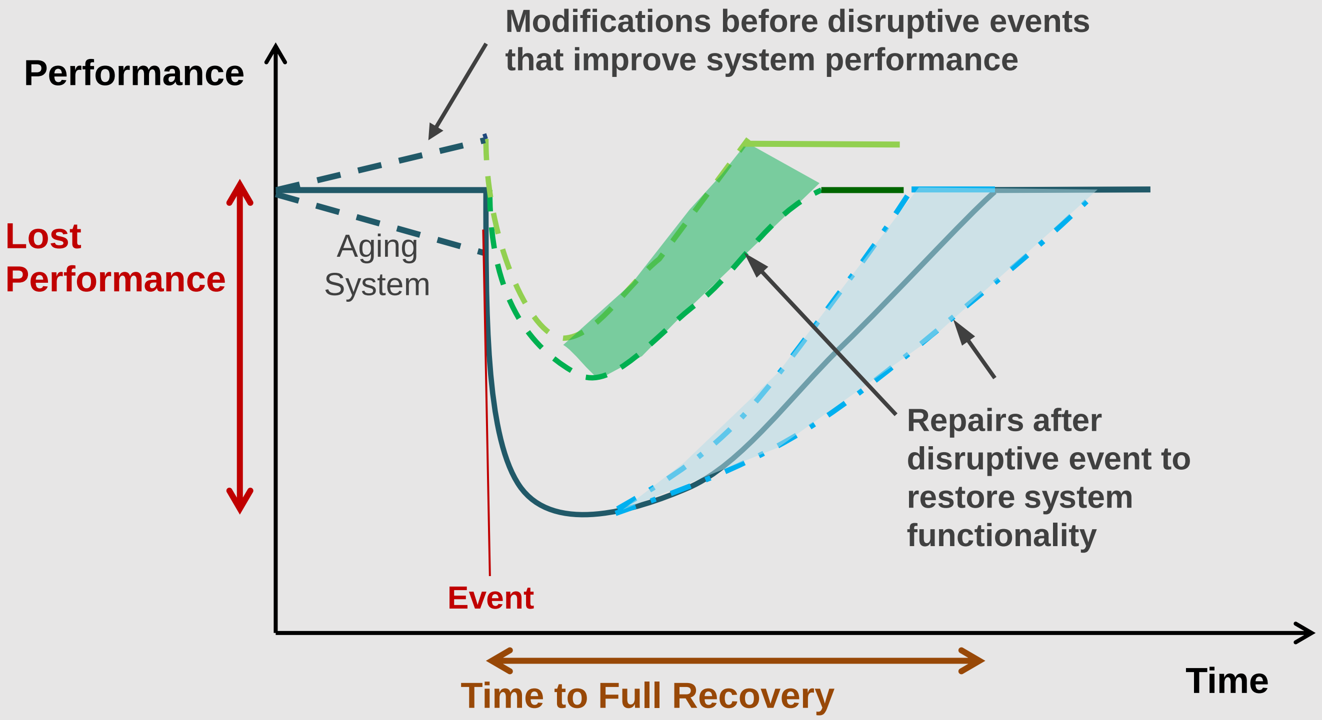


Concrete Pavements are RIGID

- Maintains high level of strength / stiffness
- Subgrade is weak, but still uniform
- Spreading of the load means subgrade is not overstressed
- Little impact on the serviceability / life

Flooding does not impact the concrete's load carrying capacity to the same degree as asphalt's

THERE ARE WAYS TO IMPROVE AN AIRFIELD'S / PAVEMENTS RESILIENCE



Actions to consider when dealing with flood prone or high- water pavements:

Hardening Activities

- Stiffen the system
- Improve Designs by using soaked subgrade strength values

Adaptive resilience – Capacity to learn and make decisions to avoid future loss based on the type of disturbance

Adapted from Bruneau, 2003 and McDaniels, 2008

Federal Aviation Administration Design Circulars
Comparison of 2016 & 2021

AC 150/5320-6F (Nov 2016)

- The term "water inundation" is NOT mentioned within the prior circular
- The term "water table" mentioned Four times within the prior circular

NEW AC 150/5320-6G (June 2021)

- The term "water inundation" used TWO times within new circular
- The term "water table" used Five times within new circular
- Added discussion regarding subgrade stabilization (Chapter 2)
- Expanded discussion of stabilized base course and drainage layers
- P-207 Full Depth Reclamation (FDR) shown as a viable stabilized base course when certain conditions are met

Federal Aviation Administration

Advisory Circular 150/5320-6G (June 2021)

2.4 **Subgrade Stabilization**

2.4.3 In addition, **consider subgrade stabilization** if any of the following conditions exist: poor drainage, adverse surface drainage, frost, periodic water inundation or the need to establish a stable working platform. Use chemical agents, mechanical or geosynthetic methods to stabilize subgrades.

2.4.4 Stabilize subgrade materials to a minimum depth of 12 in (300 mm), or to the depth recommended by the geotechnical engineer.

Potential Concrete and Cement based Solutions

(HOW) To Improve Airfield Pavement Resilience

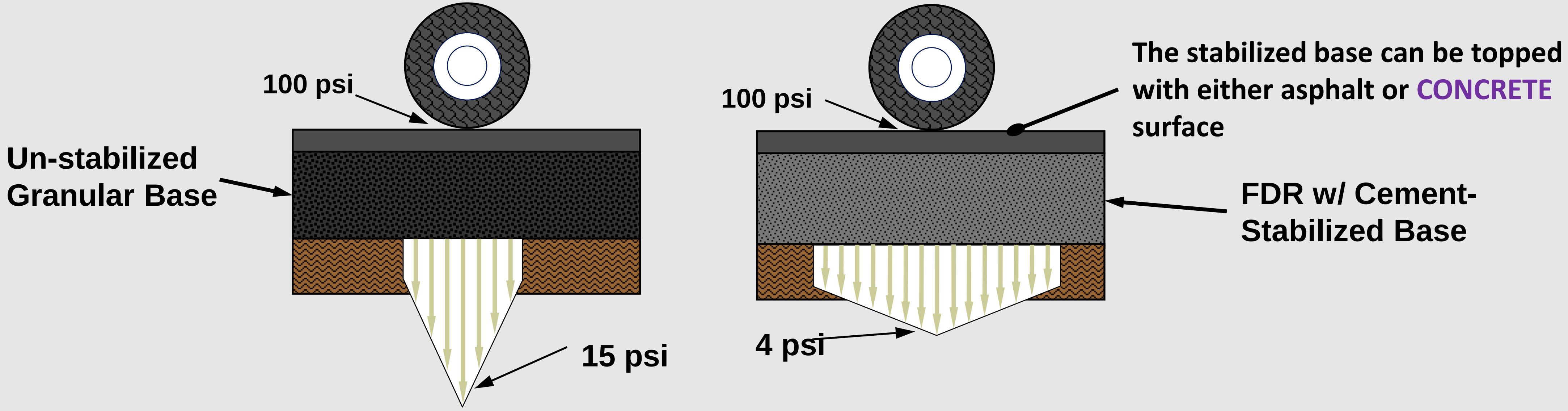
Stabilize Base (P-207, P-304, P-306, P-307)

Use a Concrete Overlay Strategy

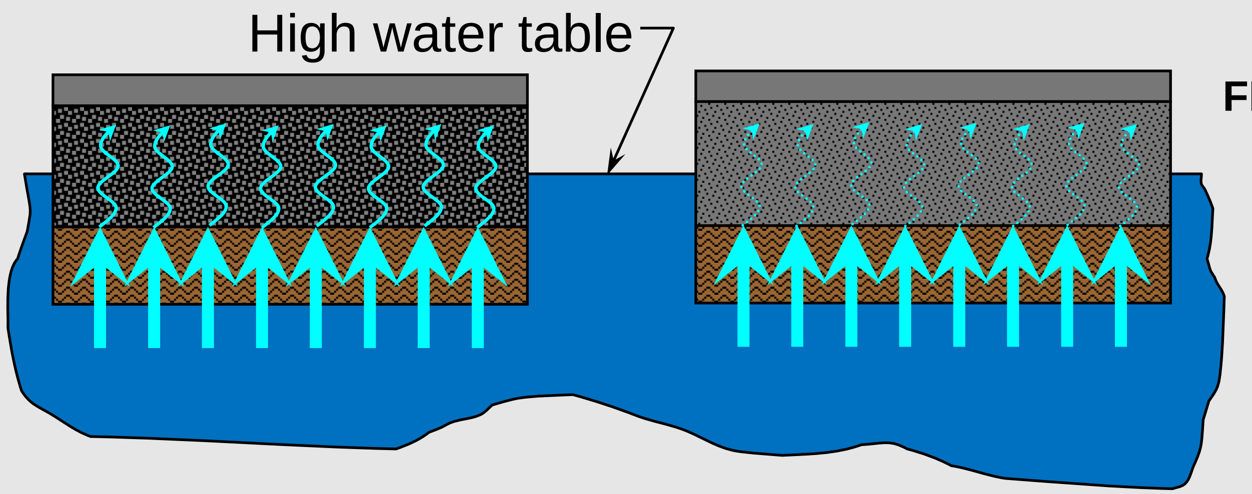
- Unbonded of Asphalt
- Unbonded on Concrete

FDR as a Resilience Hardening Solution

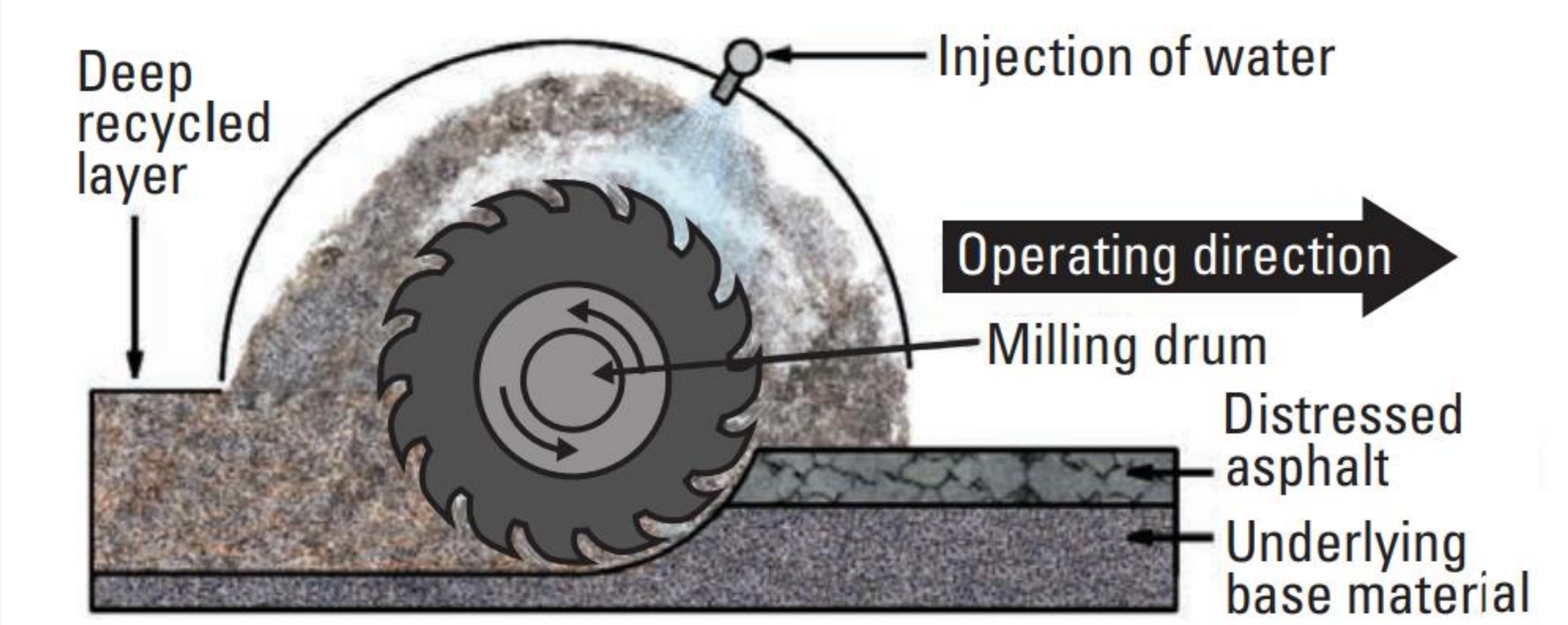
Increases rigidity, reduces permeability, & reduces moisture susceptibility

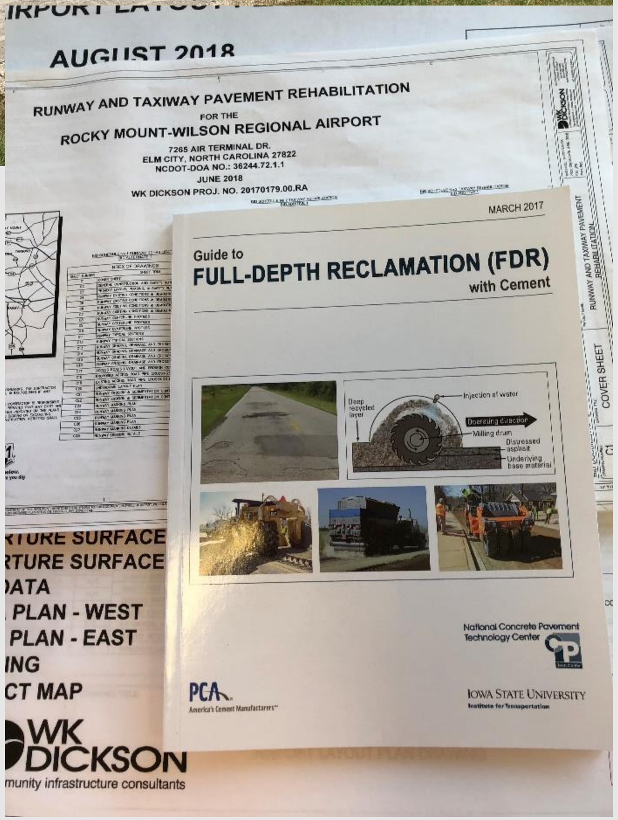


Moisture infiltrates base
- **Through high water table**
- **Capillary action**
- **Causing softening, lower strength, and reduced modulus**



FDR reduces permeability
- **Helps keep moisture out**
- **Maintains high level of strength and stiffness <u>even when saturated</u>**

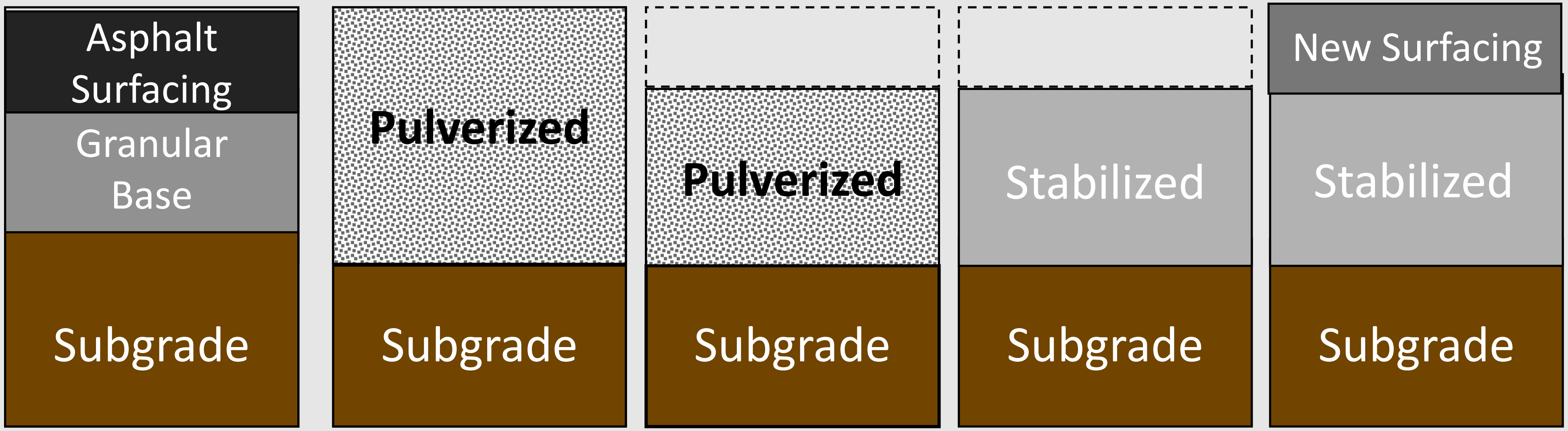




Typical FDR Operation [1]

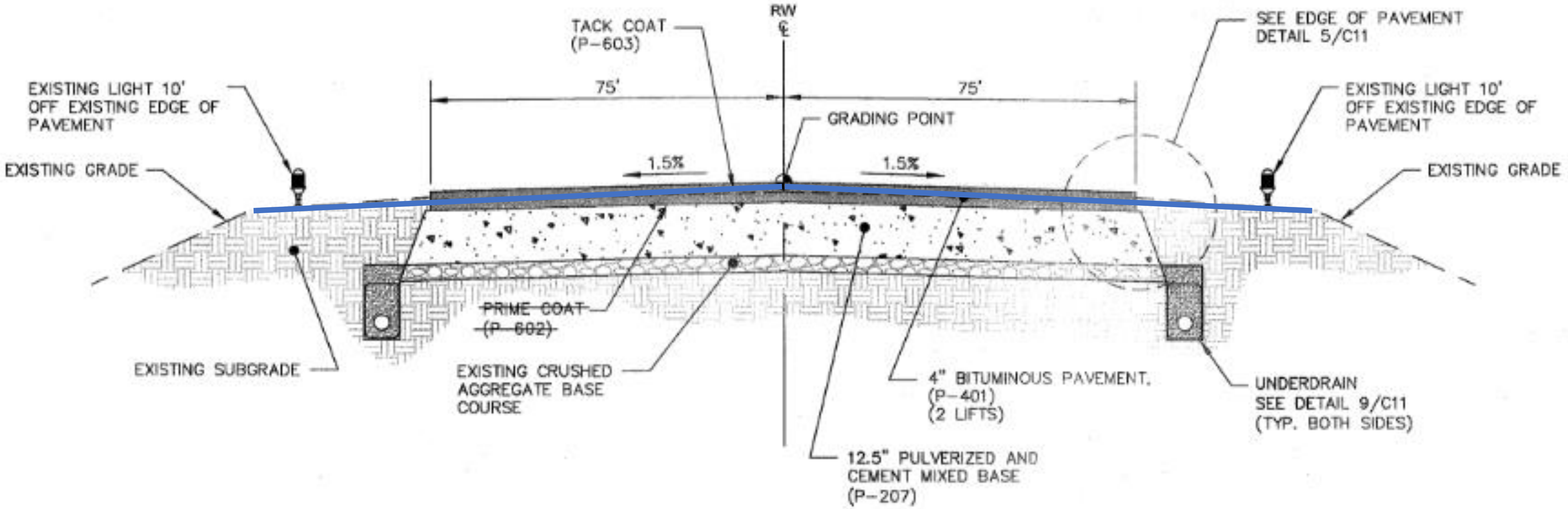
[1]Guide to Full-Depth Reclamation (FDR) with Cement, National Concrete Pavement Technology Center, & Iowa State University Institute for Transportation, March 2017.

FDR Construction Process



Existing Runway Taxiway Apron	Pulverization to desired depth	Removal of excess material (if necessary) and shaping	Addition of cement, mixing, reshaping, and compaction	Final surface application

Typical GA Runway Section using FDR



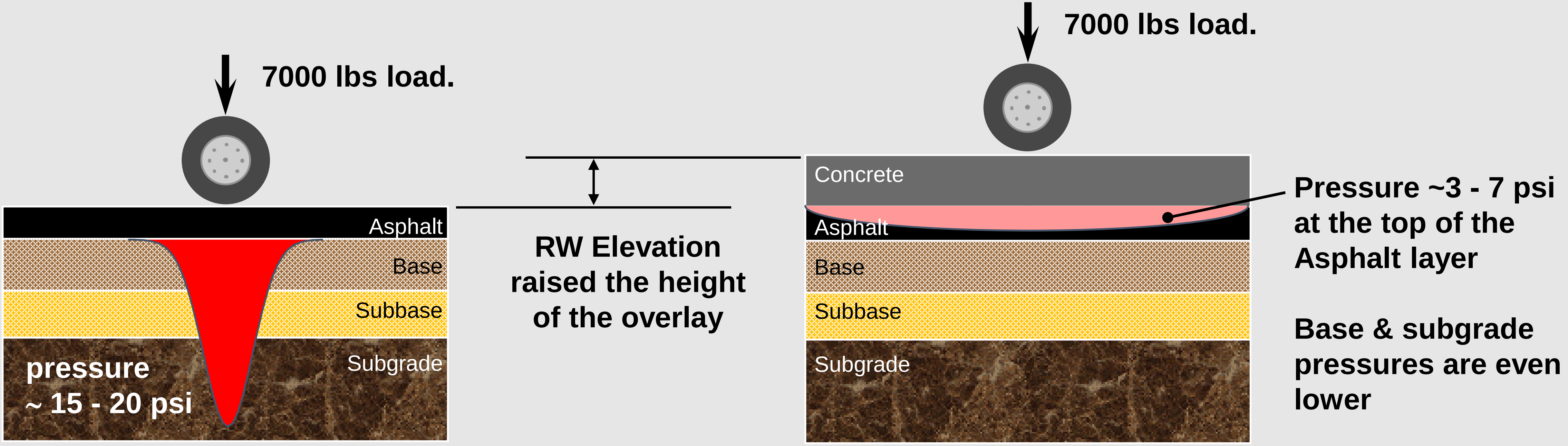
- Underdrain Use – Cost versus value for General Aviation (GA) airports?
- Strength of stabilized material? Can it ever be too strong?
- Crack Relief Layers – Cost versus value?

Elizabeth City Regional Airport

FDR & P-501 (Concrete) combine for a RESILIENT Pavement Solution!

ACTIVITIES THAT CAN BE USED TO "HARDEN THE PAVEMENT SYSTEM"

Use Concrete Overlays



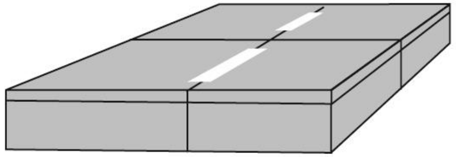
Concrete overlay increases both the height and the structural strength of the runway

TYPES OF CONCRETE OVERLAYS

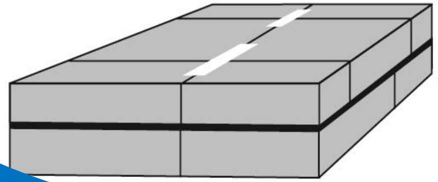
Bonded

Unbonded

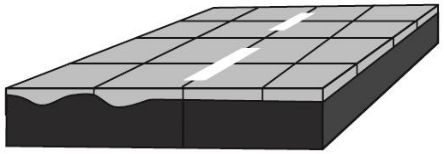
Bonded Concrete Overlays of Concrete Pavements
–previously called bonded overlays–



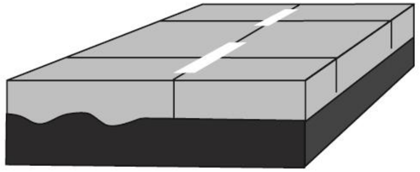
Unbonded Concrete Overlays of Concrete Pavements
–previously called unbonded overlays–



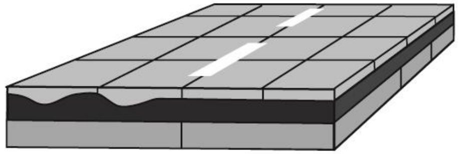
Bonded Concrete Overlays of Asphalt Pavements
–previously called ultra-thin whitetopping–



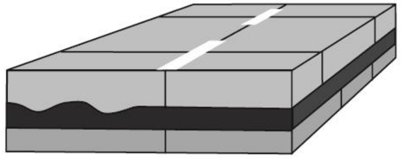
Unbonded Concrete Overlays of Asphalt Pavements
–previously called conventional whitetopping–

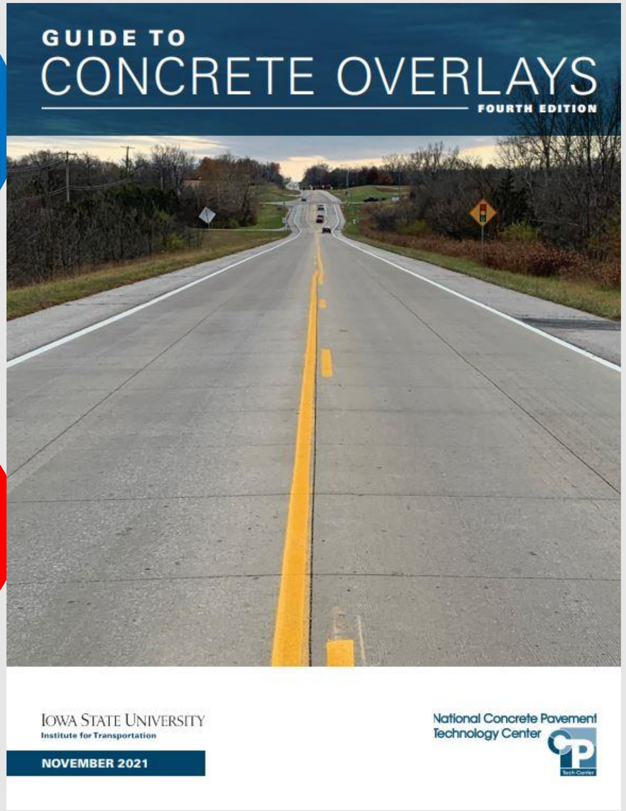


Bonded Concrete Overlays of Composite Pavements



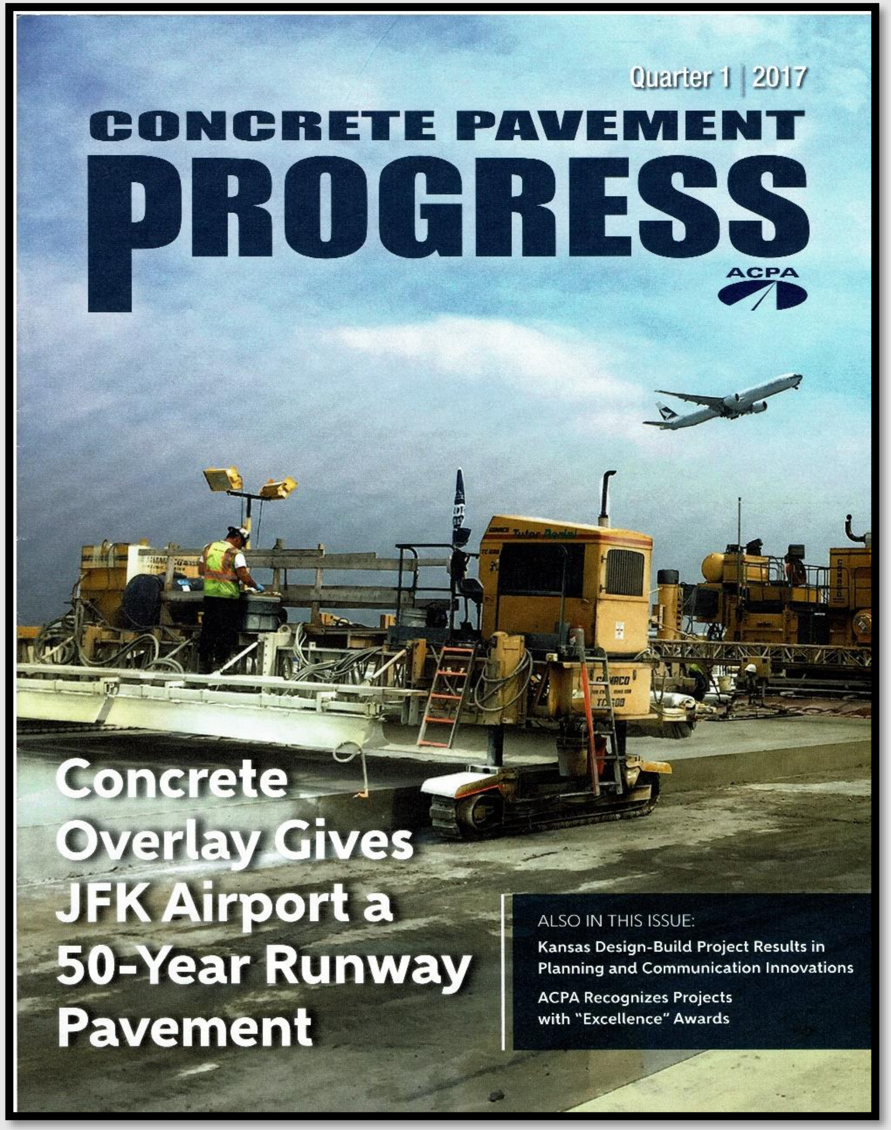
Unbonded Concrete Overlays of Composite Pavements





November 2021, 4th edition

Airfield Concrete Overlays



South Carolina General Aviation Airports

About 28% of pavement area at 51 General Aviation Airports is concrete!

Open Houses

Opportunities to see construction up close

Lancaster County Airport

Concrete Overlay of Asphalt

Charleston Exec Airport

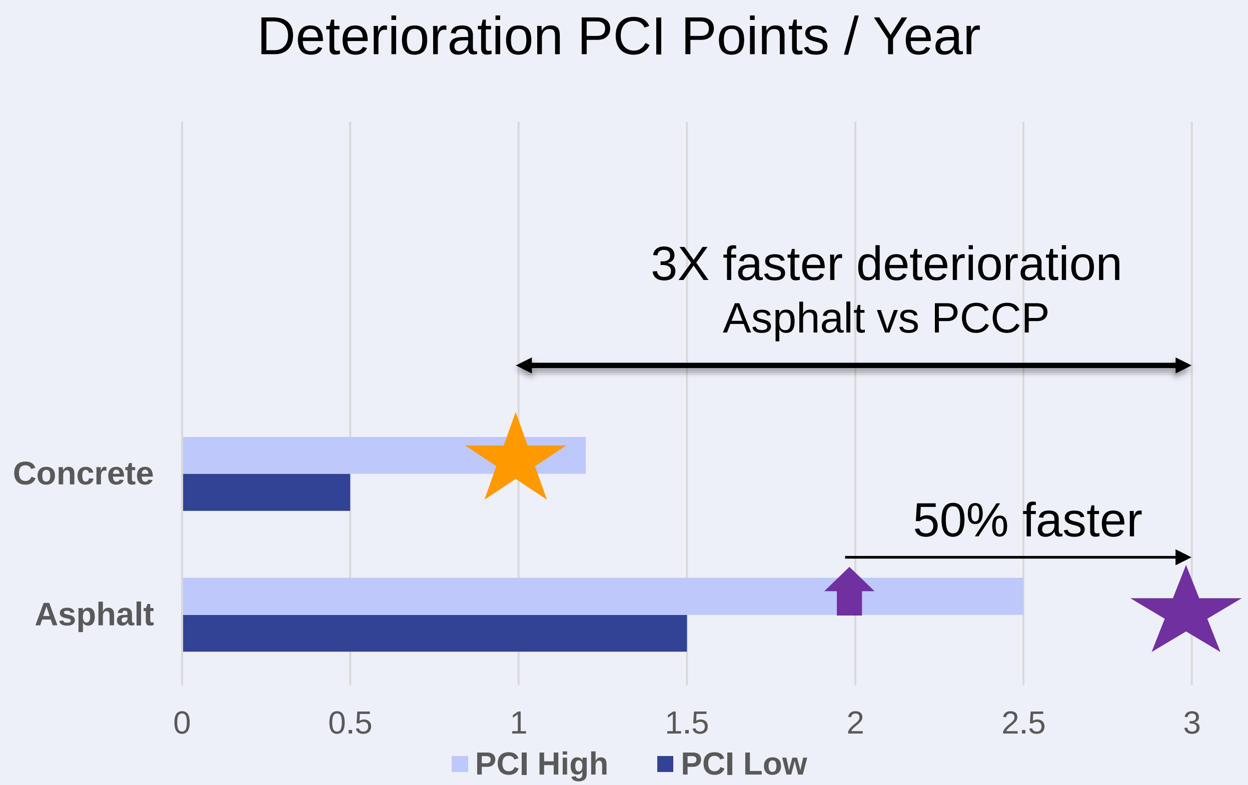
Concrete Overlay of Concrete

Quotes from (JZI) Open House

Owner's representative

- A Concrete Overlay kept us "out of the subgrade" vs. reconstruction option.
- A Concrete Overlay raised our pavement elevation out of the high-water table (e.g. Improved Resilience)
- Inch per Inch concrete was less expensive than the asphalt leveling (sep) layer
- Our original concrete surface lasted 60+ years, no reason why this (new concrete) surface cannot last another 60 years!

High Water / Flood Inundation Matters
Charleston Exec (JZI) Airport



Concrete pavements deteriorate at rate of 0.5 to 1.2 PCI points per year

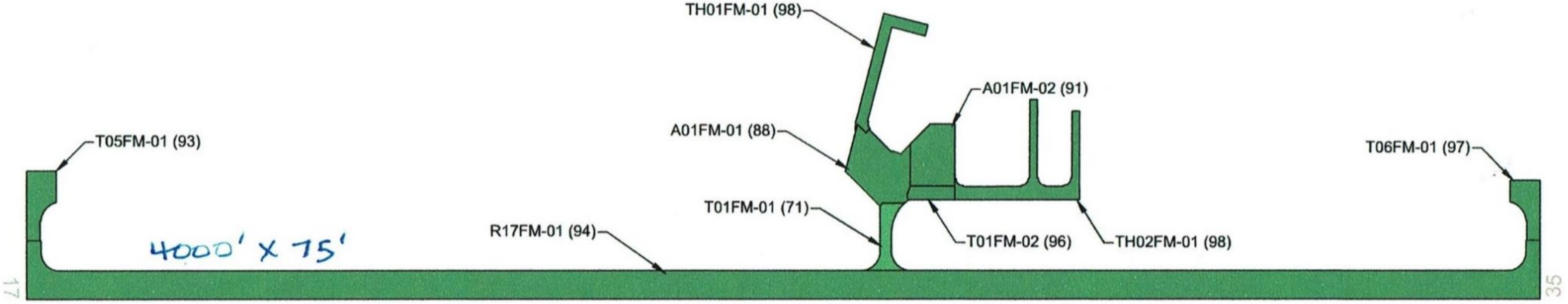
- **JZI Concrete (RW) deteriorating at 1 point per year**

Asphalt pavements deteriorate at rate of 1.5 to 2.5 PCI points per year (avg = 2)

- **JZI Asphalt (TW) deteriorating at 3 points per year (50% faster than typical)**

Source: Performance Trends in Airport Runway Pavements (2014 FAA Worldwide Airport Tech Transfer Conference) and SC 2016 Airfield Pavement Management Report (JZI PCI data)

Fort Madison (IA) Municipal Airport



RW PCI = 94
LCD = 1991 (26 YEARS)
NOMINAL 6" PCCP OVERLAY (WT)
12.5' X 12.5' SLABS

2017

LEGEND
BRANCH IDENTIFIER
SECTION IDENTIFIER
PCI VALUE
R17FM-01 (94)
SECTION BREAK LINE

PAVEMENT CONDITION INDEX
PCI
85-100
71-85
56-70
41-55
26-40
11-25
0-10

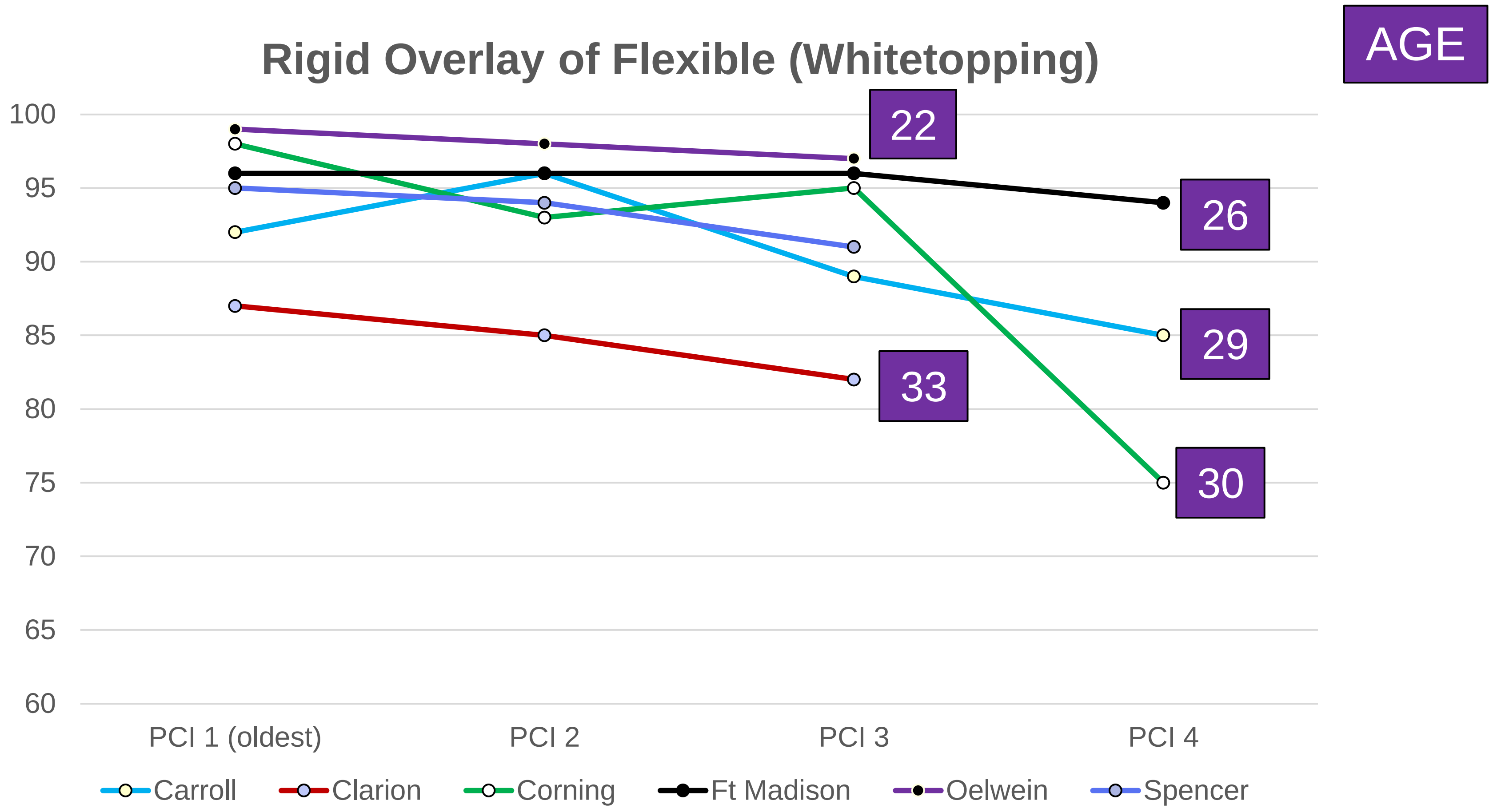
applied pavement TECHNOLOGY
Robinson Engineering Company

AGENCY: Iowa Department of Transportation, Office of Aviation
LOCATION: Fort Madison Municipal Airport, Fort Madison, Iowa
PAGE TITLE: 2017 Pavement Condition Index Map

PROJECT DATE	CREATION DATE	PROJECT MANAGER	JOB NUMBER
SEP. 2017	SEP. 2017	LJR	2017-020-AM0
DRAWING SCALE	LAST MODIFIED DATE	REVISED BY	DRAWN BY
1"=300'	MAY 2018	ABF	DSP
FILENAME		LAYOUT NAME/NUMBER	PAGE NUMBER
Fort Madison.dwg		PCI	8

Iowa Airports

PCI Trends for Overlays Constructed in 1980's - 1990's



ALL of these Overlays have survived well beyond the FAA (20-year) design life!

North Platte (NE) Regional Airport

Olsson Engineers project write-up…

Runway 17/35 overlay in 2011.

Before the project, the pavement consisted of 70-year-old concrete overlaid with four to 12 inches of asphalt of various ages.

In addition, the airport is adjacent to the Platte River where a high-water table contributed to frost heave.

Our team evaluated a number of options, including complete reconstruction, asphalt overlay, and whitetopping (concrete overlay). Whitetopping with eight inches of concrete was selected.

Dowel bars were installed at every joint to reduce frost heave.

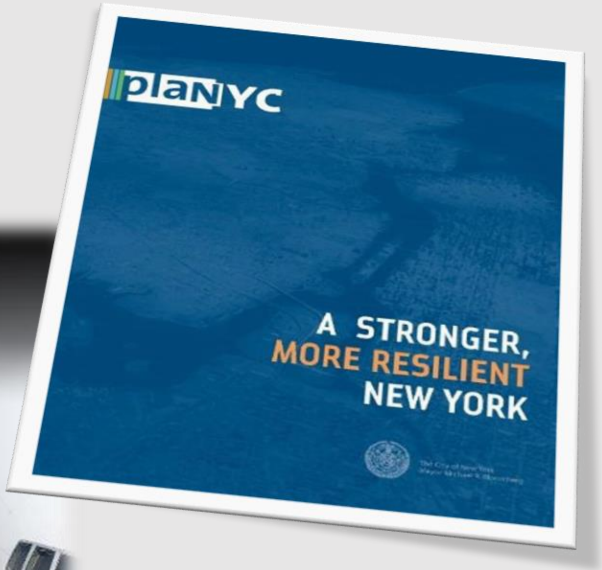
10 years later (2021), PCI = 98

Concrete Overlay was less than ½ the cost of reconstruction!

Resiliency of Concrete Recognized

*"The rehabilitation will provide aircraft a solid concrete runway that is more **RESILIENT** than asphalt and will increase the useful life of runway by four times"*

Rehabilitation of Runways at JFK
Port Authority of NY & NJ <u>Press Release</u> (April 2019)



"Use of Concrete will extend runway's useful life to 40 years, rather than 8-12 years with asphalt."

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Comments or Questions? GDean@acpa.org

ACPA Southeast Chapter

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