DESIGNING FOR IMPROVED AIRFIELD PAVEMENT RESILIENCE

Greg Dean,
American Concrete Pavement Association –
SE Chapter

Concord, NC
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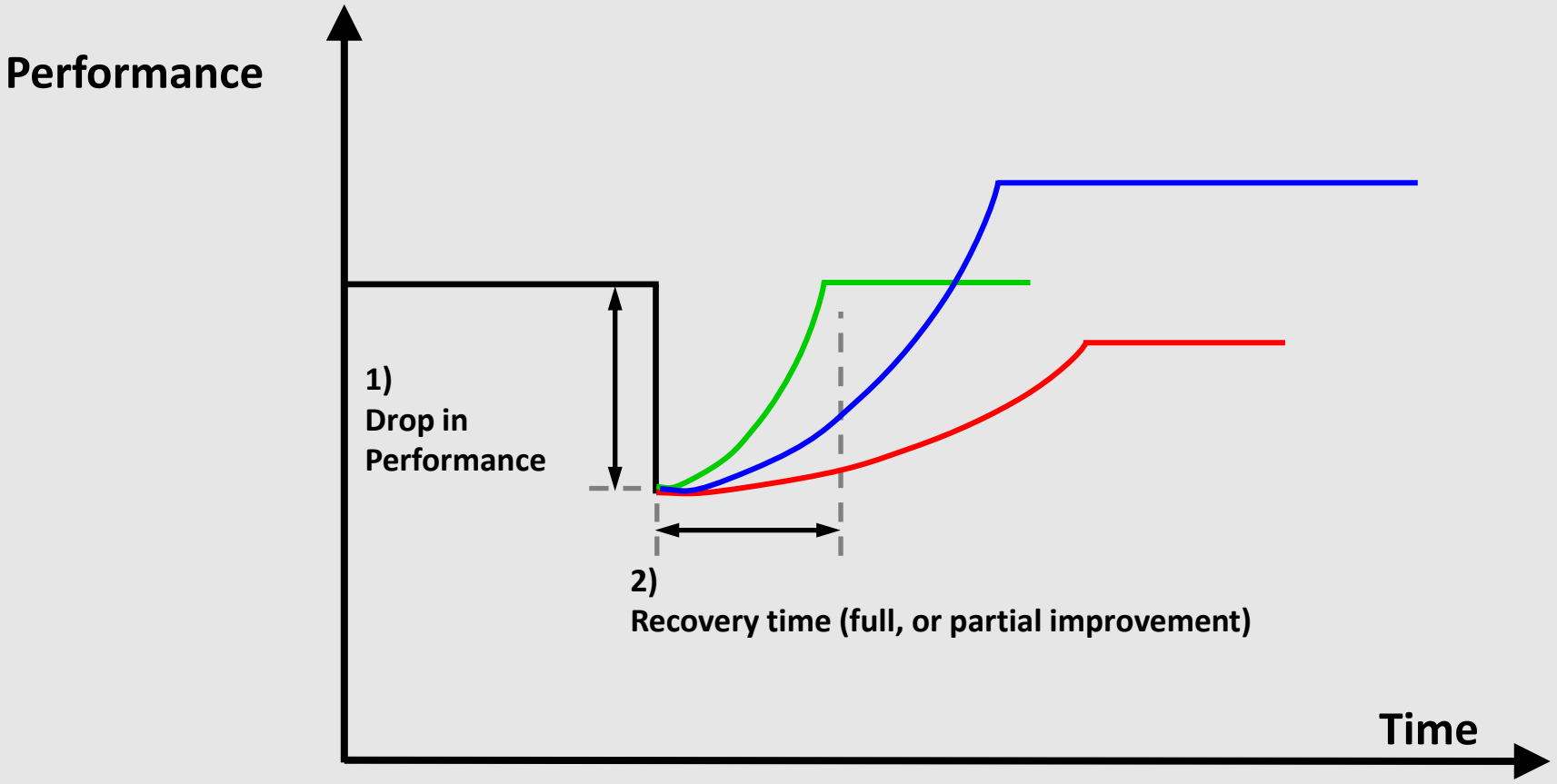
NC Concrete Pavement Conference

ACPA
Southeast Chapter

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.

A resilient runway at PDX saves over 50:1

Cost $140+ M; benefit >$7 B

Saves lives: medevac worth $460 million in health and medical benefits

Speeds return to homes and workplaces: $5.7 billion saved when experts arrive to help people return to 600,000 safe buildings

Avoids business interruption: protects $1.2 billion in regional, US economy reliant on PDX

Reduces repair cost: $4 million in avoiding predictable runway damage

National defense: $170 million saved by protecting ORANG 142nd Wing mission.

Plus: equity, jobs, taxes, response & recovery $...

Resilient Pavement Examples are near….

Brunswick-Golden Isles (BQK)

- 10-inch Pavement
- Stabilized subbase
- 70-years old
- Partial Depth patching & Joint reseals
- 95 PCI (2018)
- 66 Hurricane / TS Events

Source: https://www.acpa.org/

CASE STUDY: PERMANENT PAVEMENTS

69-YEAR-OLD AIRPORT CONCRETE PAVEMENT HOLDS 95 PCI

The apron of the Brunswick-Golden Isles Airport (BQK) in Glynn County, GA, was constructed in June of 1953 and boasts a 95 pavement condition index (PCI; on a 0-100 scale) measured as recently as 2018. This regional airport is adjacent to a deep-water port and serves as a vital connection point for business travel, plane repair and tourism. With exceptional performance metrics, this permanent pavement is only scheduled for preventative maintenance, and authorities plan to depend on the concrete for years to come.

The Georgia Department of Transportation (GDOT) estimated that the Brunswick-Golden Isles Airport generates nearly $155 million in economic activity annually, supports over 1,600 jobs and serves as a vital regional connection for local business. BQK's apron was completed on June 2, 1953, when the U.S. Navy owned the airfield. The pavement has undergone no major maintenance or repair since its construction, lasting three and a half times longer than its design life. The 10-inch concrete pavement was built atop 6 inches of stabilized subbase with 12.5-by-15-foot panels, similar to modern specifications. Over the last 69 years, BQK has been steadfast in serving approximately 28,000 operations annually, including thrice daily flights to Atlanta Hartsfield-Jackson airport, two maintenance and repair operations (MROs) and a high volume of private flights from both small and commercial aircraft.

According to a 2019 Work History Report published by GDOT, the concrete apron was not touched between 1953 and 2006, then routine preventative maintenance of joint-sealing and partial-depth patching was applied. The records indicate that in addition to the apron, a concrete unway and taxiway had also been constructed in 1953 nd were in active service until they were replaced in 2014, n aning the concrete pavement had performed for 61

at an average of every 17 years. The investment made into concrete pavement for the Brunswick-Golden Isles Airport has paid dividends.

DURABILITY IS KEY TO SUSTAINABILITY

The engineers who designed the BQK apron in 1953 were not concerned about the carbon intensity of the pavement, but the choice they made to use concrete delivered a sustainable result. Georgia has been hit by 66 hurricanes and many other extreme weather/inundation events while the concrete apron has been in service. By avoiding the environmental and economic costs associated with rebuilding the pavement, the concrete apron has proved to be a resilient and sustainable asset to Brunswick-Golden Isles Airport.and will continue to do so well into the future.

KEY BENEFITS

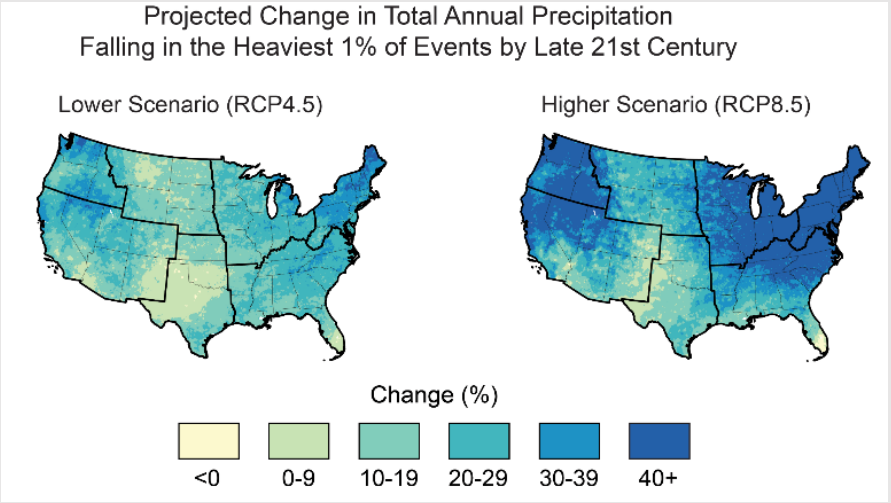
- Holds an exceptional 95 PCI after nearly seven decades of service
- Saved taxpayer dollars by serving its purpose with minimal repairs
- Conserved resources by not needing reconstruction or replacement
- Freed up resources to pursue infrastructure projects in other parts of the region without

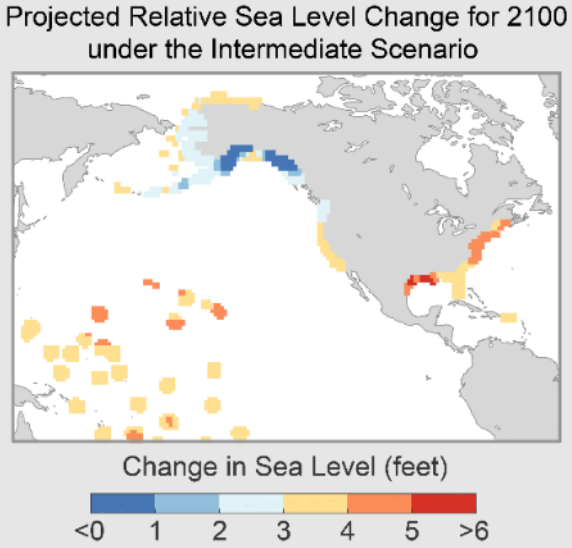
Designing for Improved Airfield Pavement Resilience

- WHY the Need for resilient airfield pavements?
- HOW to Design for Improved resilience?
- Case Studies
- Research (ACPTP)
  - RFP coming

FUTURE CLIMATE CONDITIONS WILL NOT RESEMBLE THE PAST

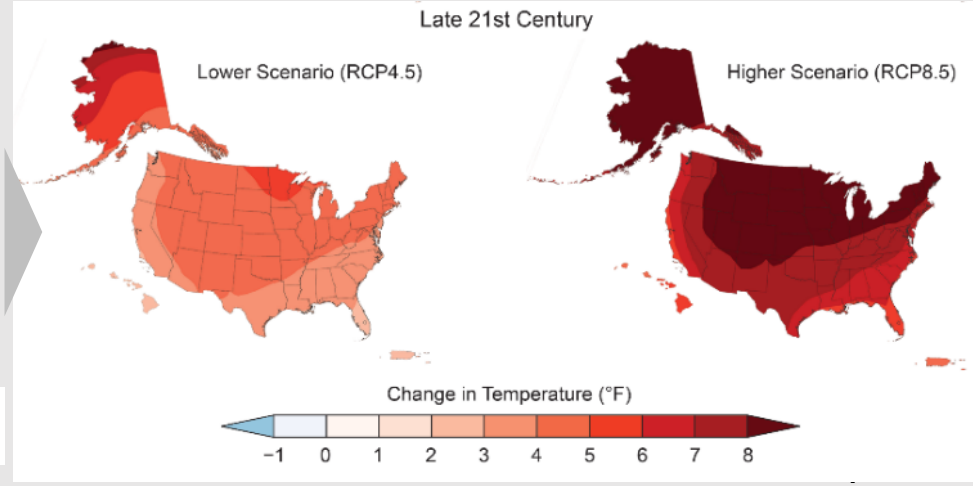
U.S. severe storms, heavy precipitation events:
Greater intensity *and* frequency
Continued increases expected





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

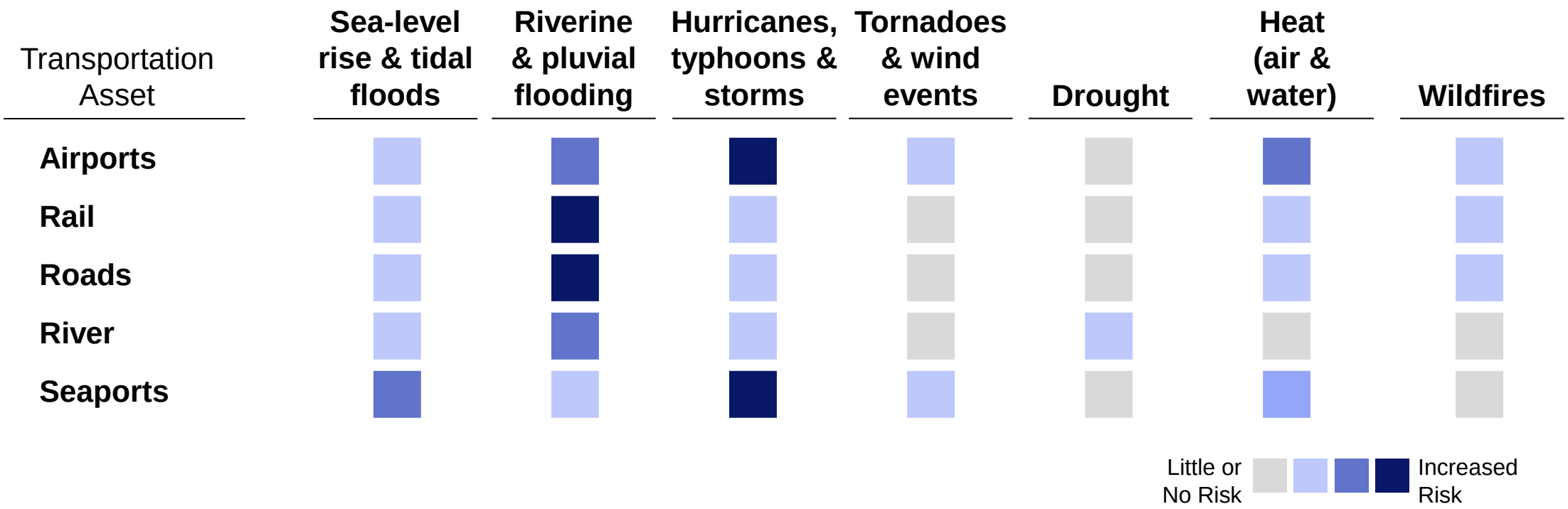
Increased Extreme heat events and drought:
Increased incidence of large forest fires



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

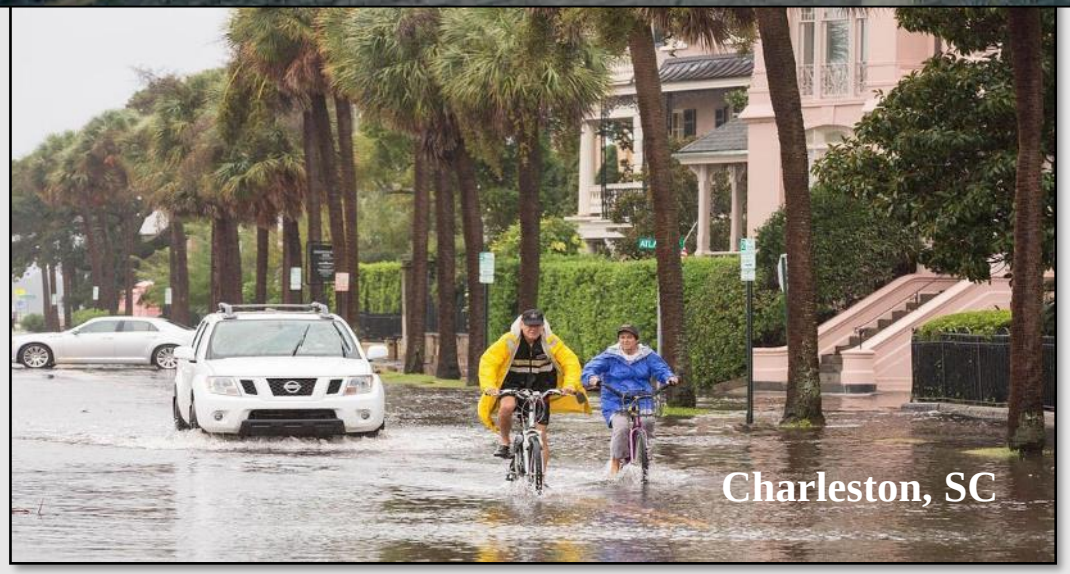


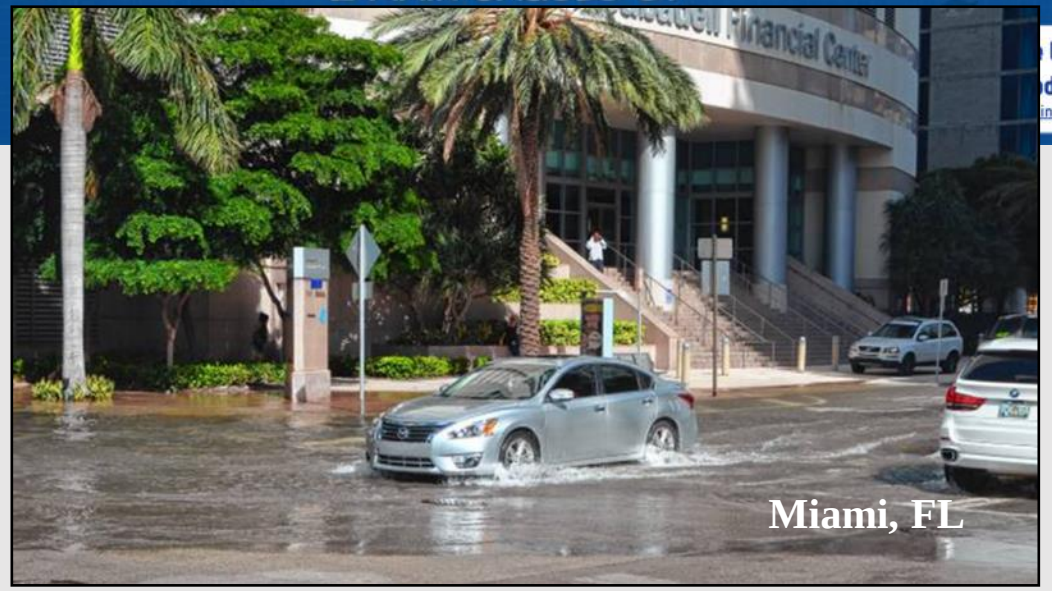
Climate risk increases operating costs & exacerbates the infrastructure funding gap

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

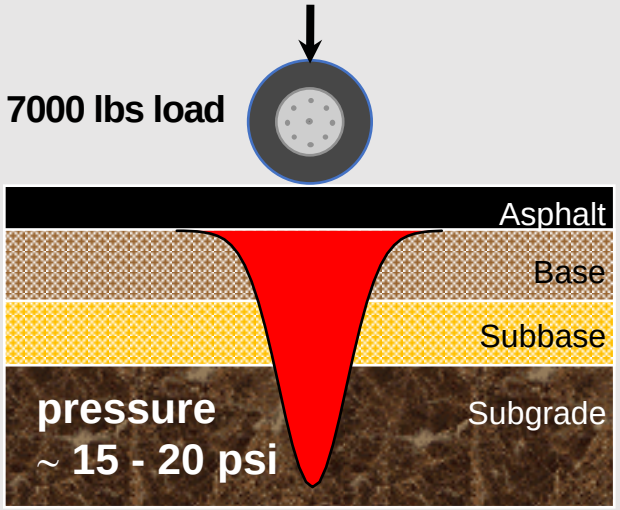
Why the Need for Improved Resilience?

Ocracoke Island, NC (Outer Banks)

Vicksburg, MS

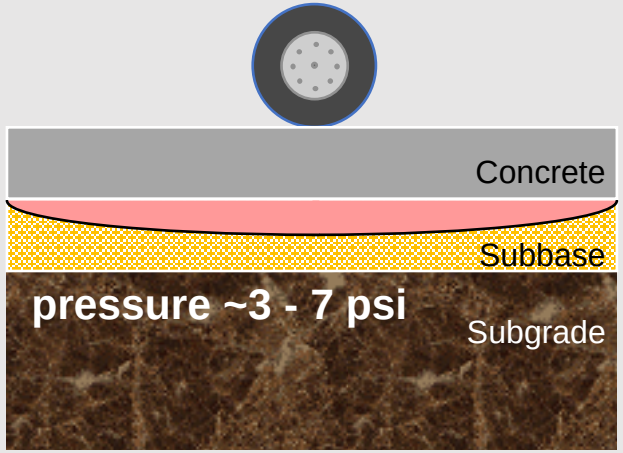
- Pavement deterioration curves accelerate when flooding, or high-water tables occur
  - When flood waters recede, studies indicate subgrades remain moist > 1 year
  - Pavements are often re-loaded before subgrades dry

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**



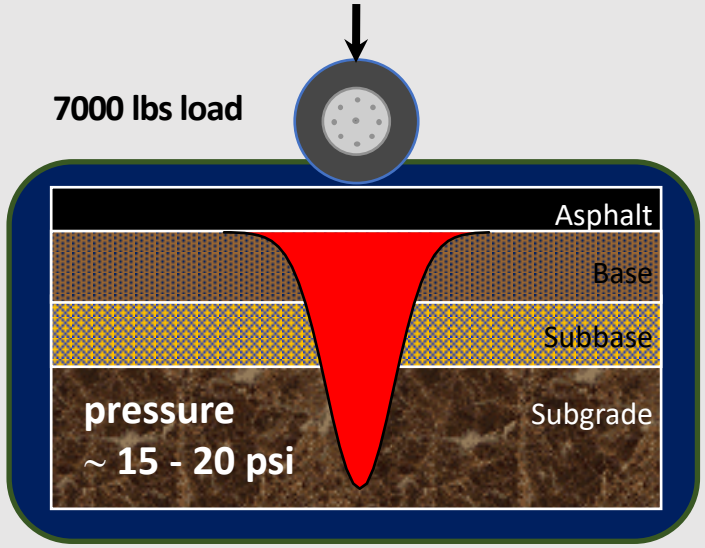
Concrete Pavements are Rigid

- **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

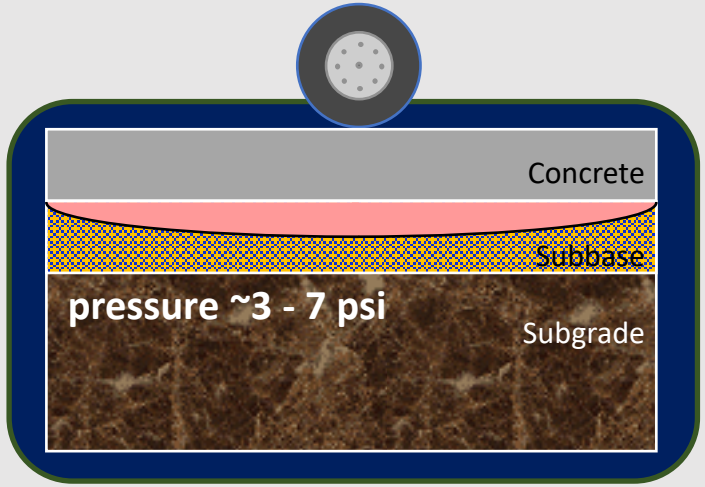
FLOODING CAUSES THE SUBGRADE TO BECOME SUPERSATURATED

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**

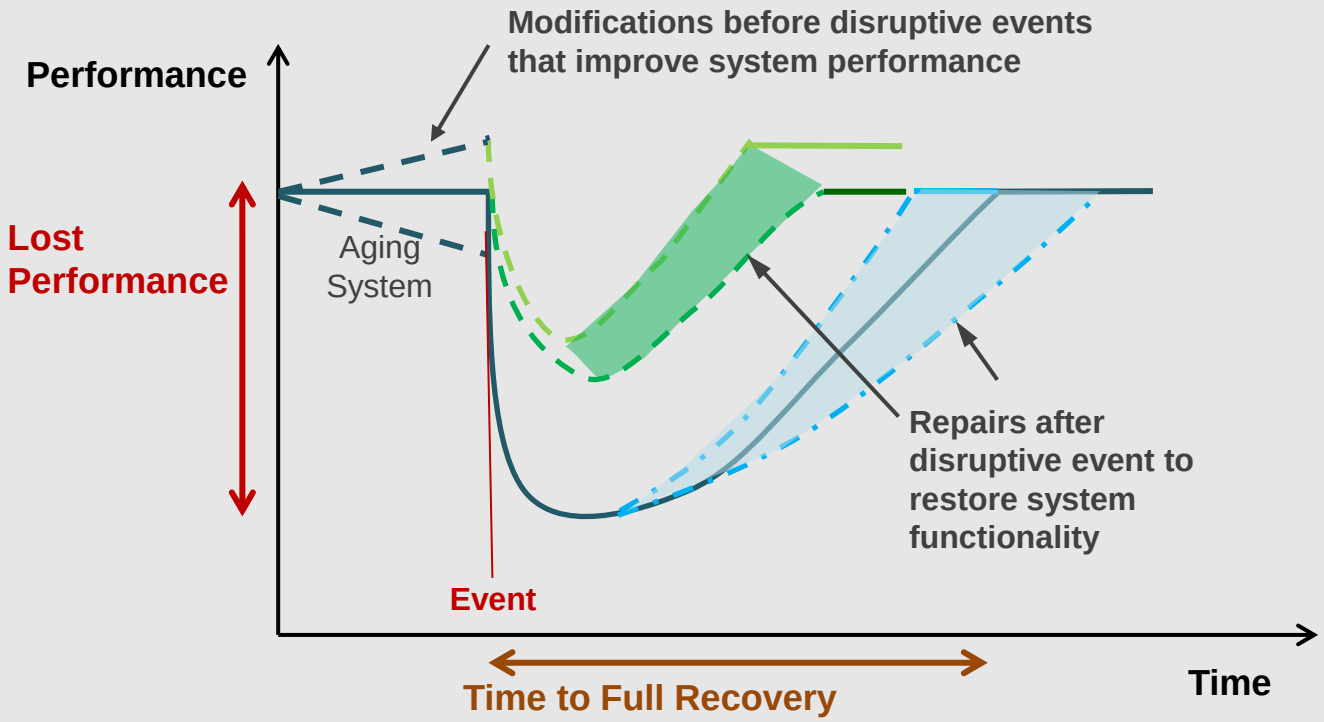


Concrete Pavements are RIGID

- **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

Latest 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

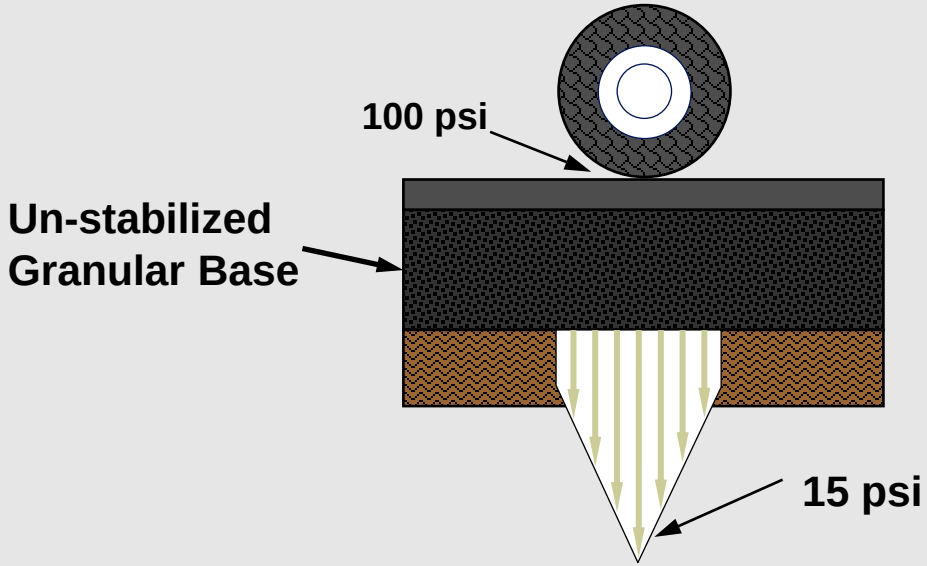
Stabilize Base (P-207, P-304, P-306, P-307)

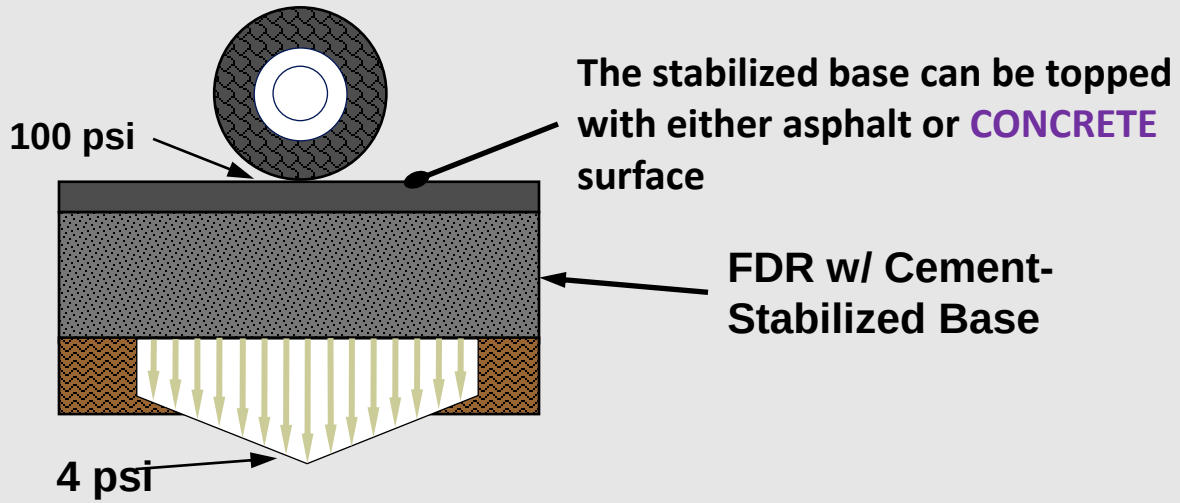
Use a Concrete Overlay Strategy

- Unbonded of Asphalt
- Unbonded on Concrete

FDR as a Resilience Hardening Solution

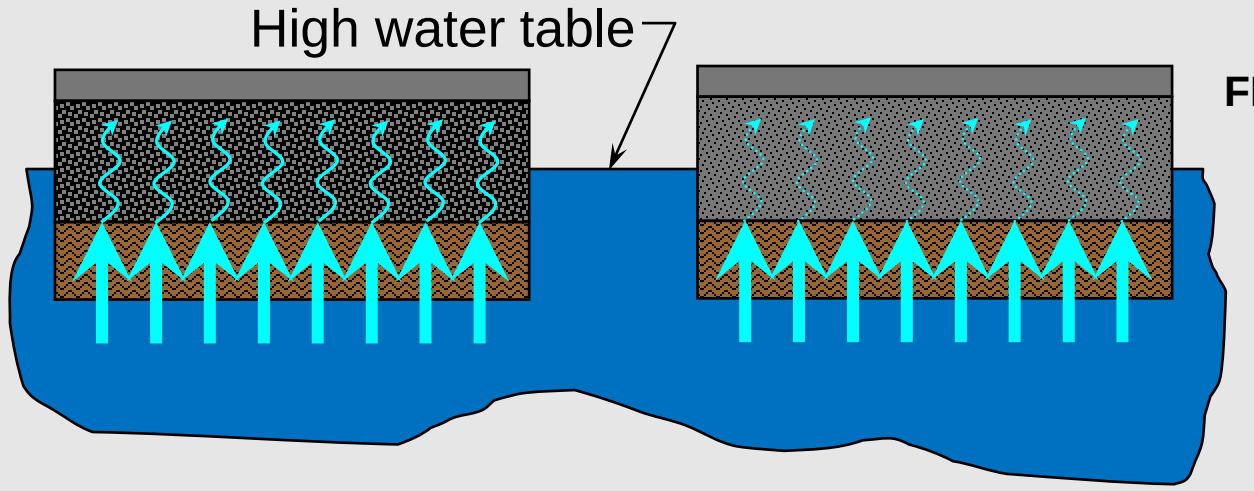
Increases rigidity, reduces permeability, & reduces moisture susceptibility





Moisture infiltrates base

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



FDR reduces permeability

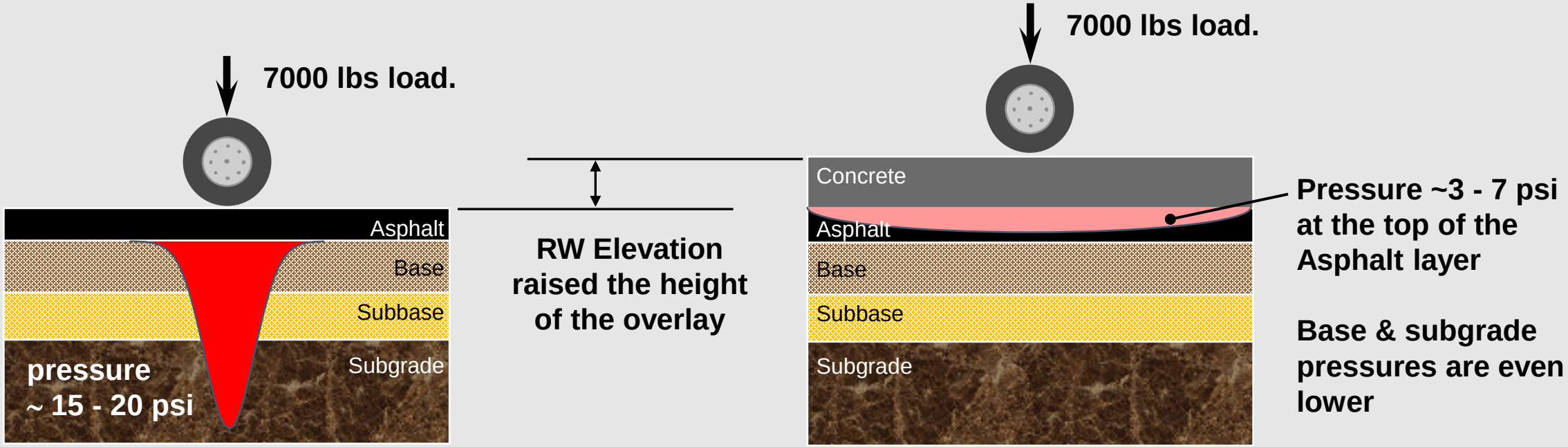
- **Helps keep moisture out**
- **Maintains high level of strength and stiffness even when saturated**

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



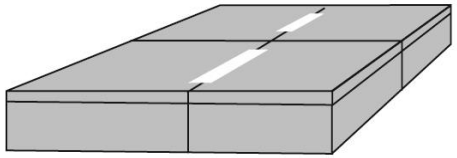
Concrete overlay increases both the height and the structural strength of the runway

TYPES OF CONCRETE OVERLAYS

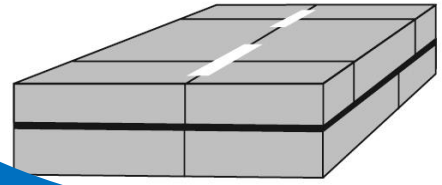
Bonded

Unbonded

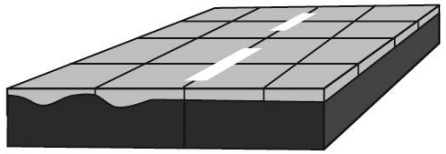
Bonded Concrete Overlays of Concrete Pavements
–previously called bonded overlays–



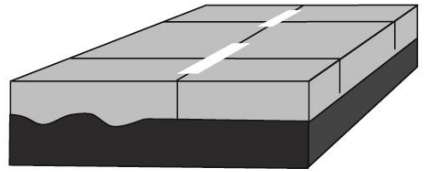
Unbonded Concrete Overlays of Concrete Pavements
–previously called unbonded overlays–



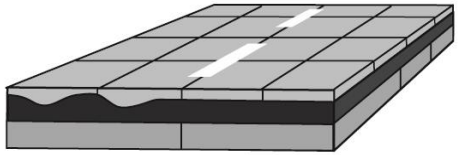
Bonded Concrete Overlays of Asphalt Pavements
–previously called ultra-thin whitetopping–



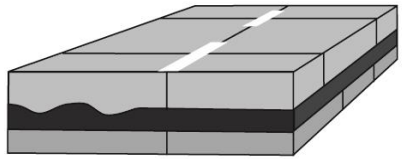
Unbonded Concrete Overlays of Asphalt Pavements
–previously called conventional whitetopping–

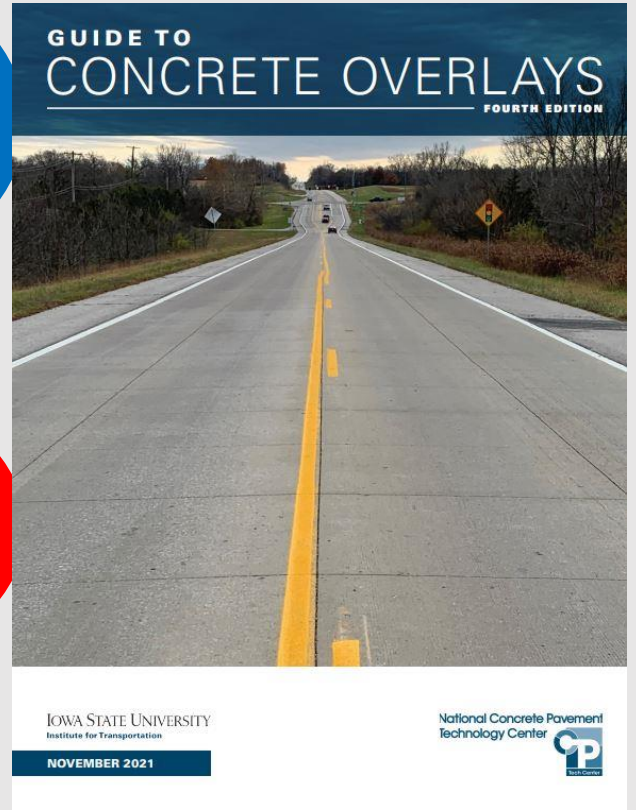


Bonded Concrete Overlays of Composite Pavements



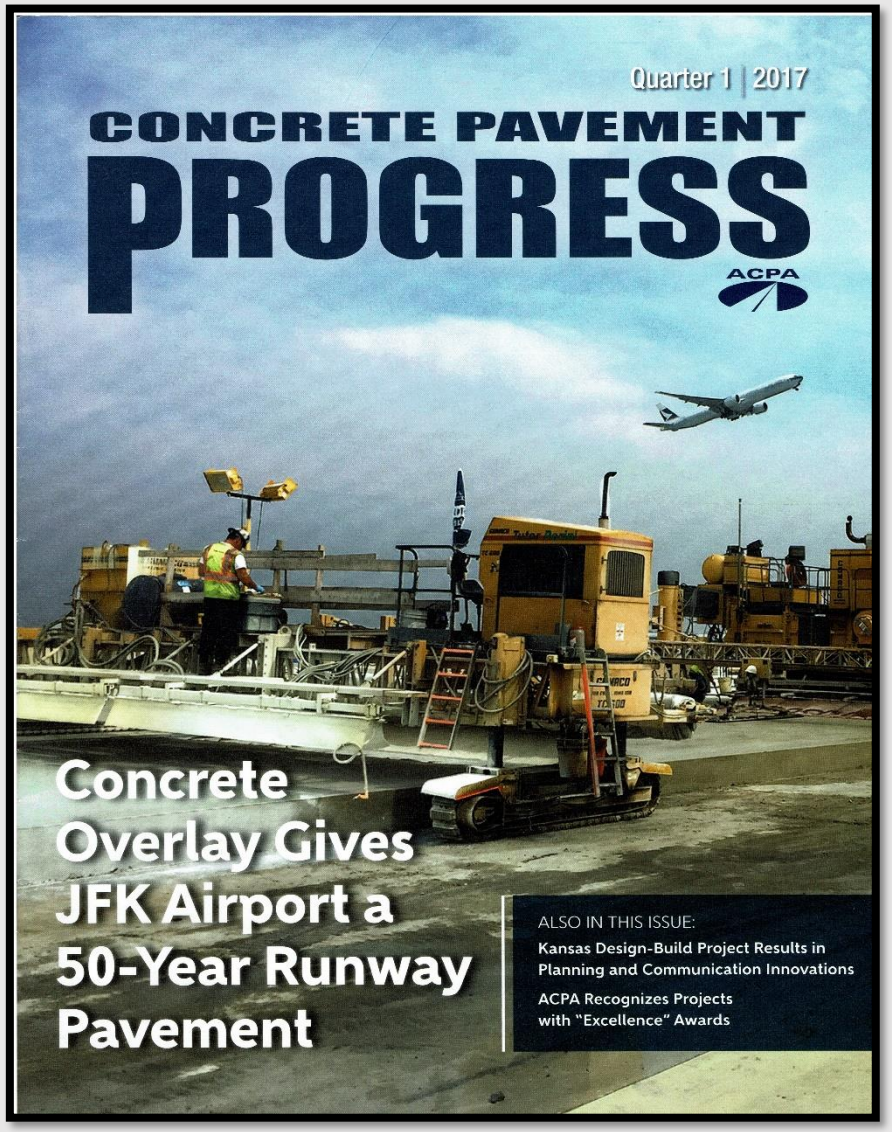
Unbonded Concrete Overlays of Composite Pavements





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

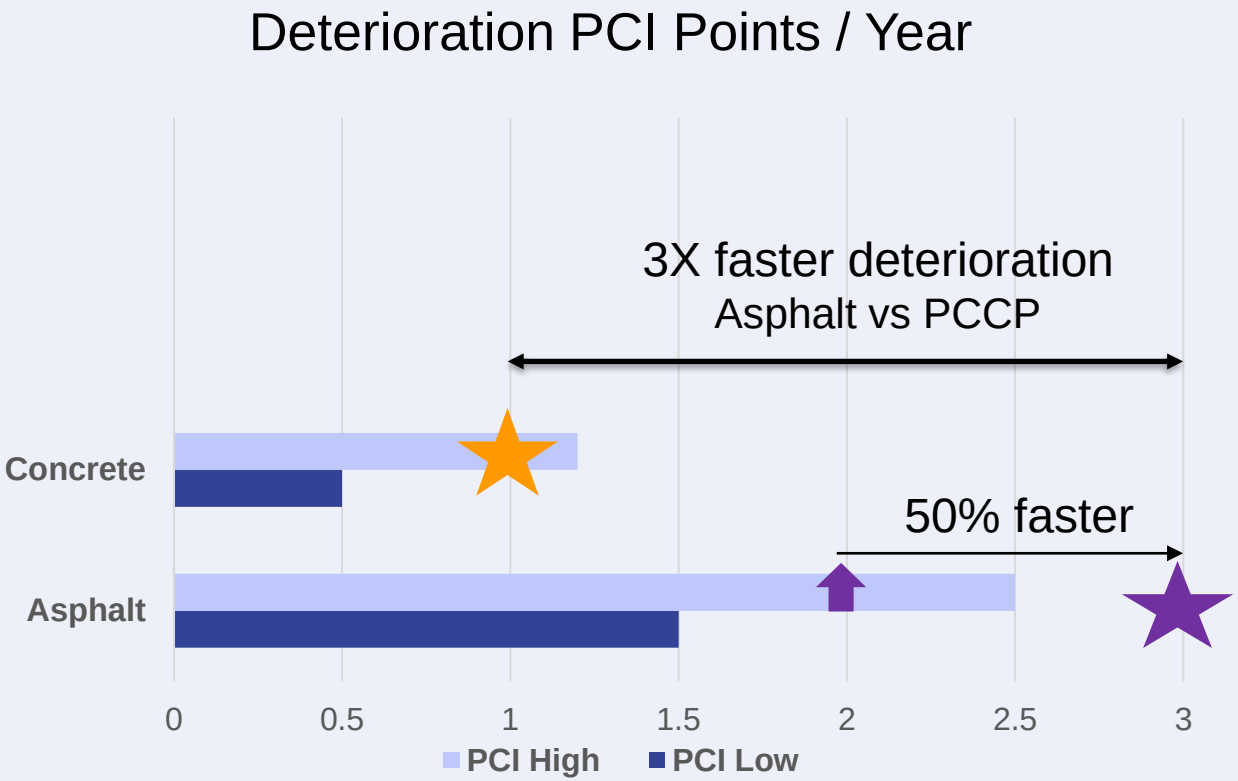
Concrete Overlay of Concrete

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

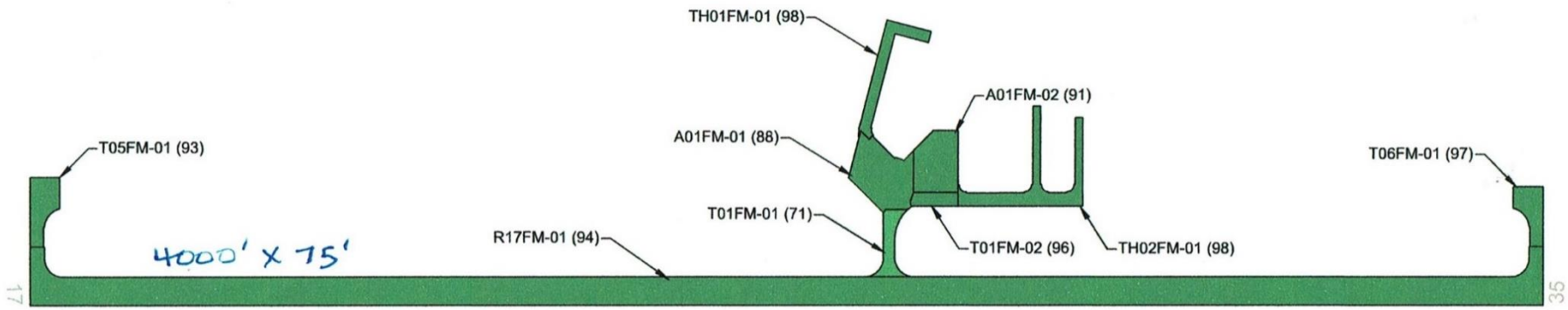
- **JZI Concrete (RW) deteriorating at 1 point per year**

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)**

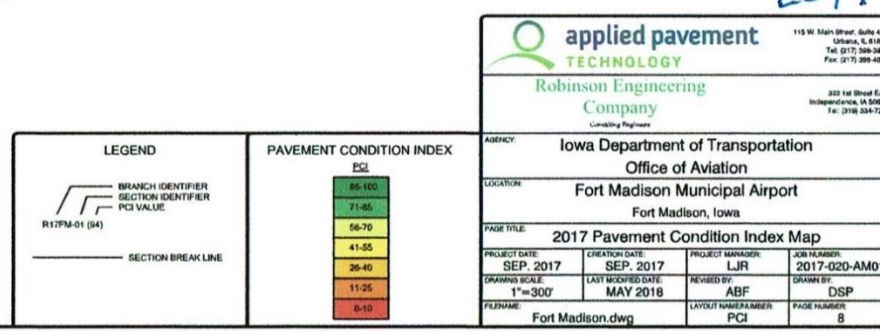
Source: Performance Trends in Airport Runway Pavements (2014 FAA Worldwide Airport Tech Transfer Conference) and SC 2016 Airfield Pavement Management Report (JZI PCI data)

Fort Madison (IA) Municipal Airport



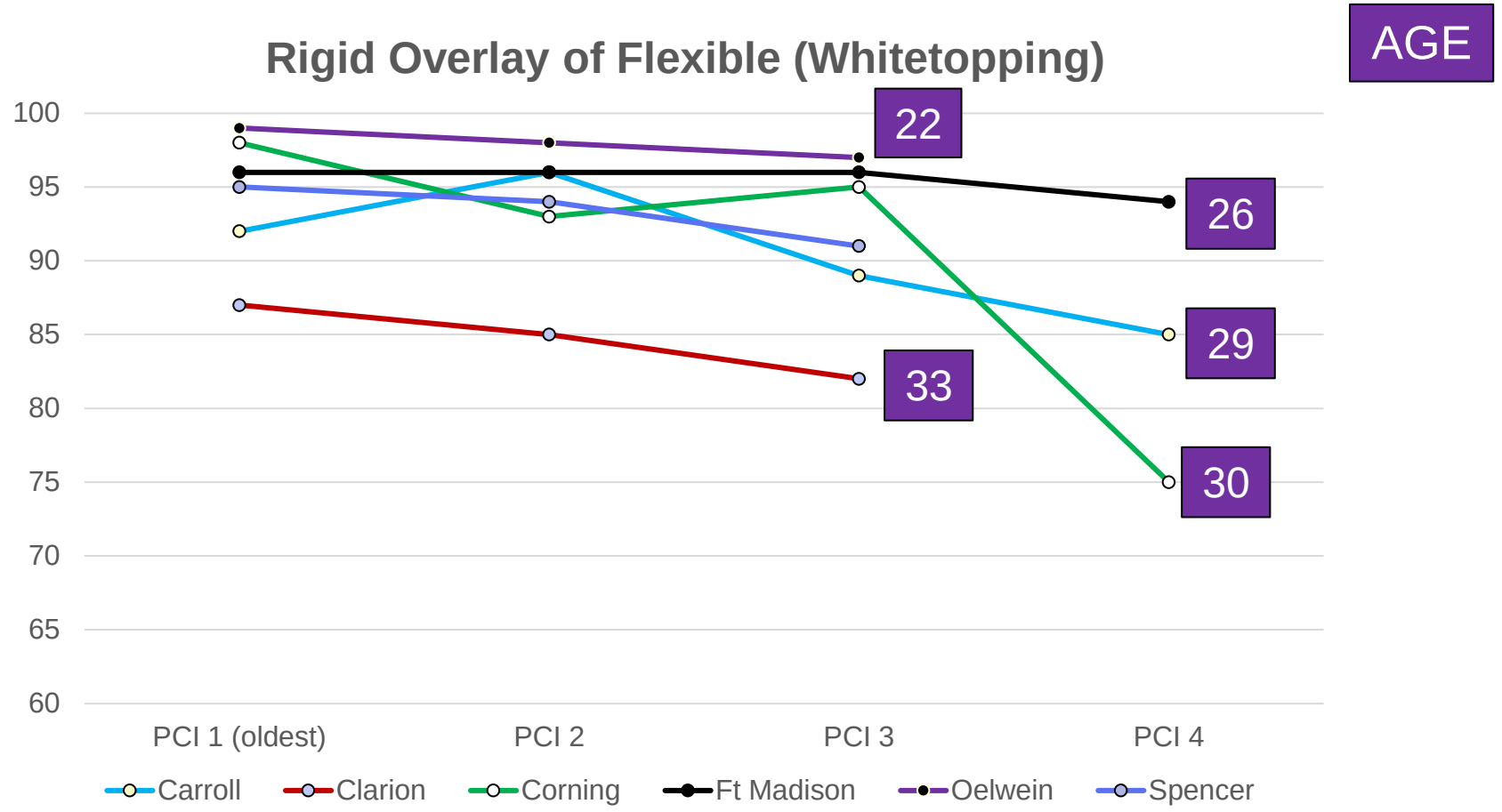
RW PCI = 94
LCD = 1991 (26 YEARS)
NOMINAL 6" PCCP OVERLAY (WT)
12.5' X 12.5' SLABS

2017



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.

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

Number of options evaluated:

- reconstruction
- asphalt overlay
- 8-in concrete overlay

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

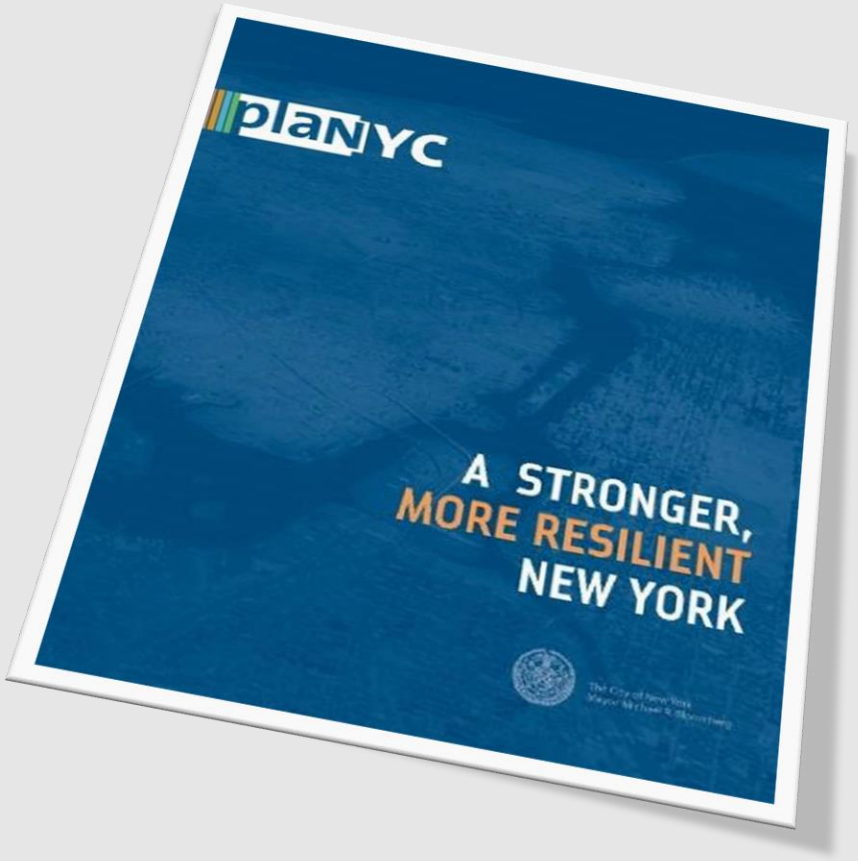
10 years later (2021), PCI = 98

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 Press Release (April 2019)



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

RESEARCH

Airport Concrete Pavement Technology Program

Flooding Resilience of Airfield Pavements (Upcoming)

- Review Performance of Airfields that have had flood occurrences or located with high water tables
- Focus on thinner airfield pavements (GA Airports)
- Prediction of pavement life reduction
- Recommended changes to FAARFIELD and to ACs
- Best Practices Guide for post flooding

Design and Performance of Thin Concrete Pavement for Airfields

Consultant Team Selected

- Review Performance History (less than 9-in)
  - Panel Sizes = Performance
  - Concrete Overlays
  - Aircraft loadings (Design vs Actual)
- Recommendations to refine FAARFIELD Design for general aviation

Fernandina Beach Airport

6-in Concrete Overlay
Constructed 2003

20-year RESILIENT
Pavement Solution!

Photo credit: Brad Wente, Passero

CONCLUSIONS

Airfield pavements are being negatively impacted by our changing climate. Green and Grey solutions will be required to improve our nation's infrastructure resilience.

1. There is greater recognition toward making our pavements more "Resilient"
   - Need to define specific actions that agencies should consider when dealing with pavements
   - Need to define how each specific "climate risk" will impact the system

2. In areas where pavements have a history of flooding (or in high water tables)
   - Require pavement designs be based on lowered subgrade strength
   - Use Stiffer or stiffen the existing pavement
   - Viable low-cost solutions, such as concrete overlays and cement stabilization strategies can be used as mitigation / hardening strategies and offer cost : benefits.

DESIGNING FOR IMPROVED AIRFIELD PAVEMENT RESILIENCE

Thank you!

gdean@acpa.org

ACPA Southeast Chapter

2023 Fall Concrete Pavement Conference
Attendance Log
Day 2 – Airport Technology PM Session

Please scan the QR code and sign in so your attendance is documented