Improving a Pavement's Resiliency

Part II

Concrete Pavement Solutions

Greg Dean

Executive Director

Carolinas Concrete Paving Association

VA Concrete Conference

February 28 2020

CAROLINAS CONCRETE PAVING ASSOCIATION

Topics Covered

Improving Pavement Resiliency & (Flood) Disaster Recovery

1. The Need for Resilient Pavements (9am)

2. Defining Resiliency (9am)

3. Improving a Pavement's Flood Resiliency (9am)
    a. Concrete Pavement Solutions (Part II – Starts Now)
    b. How to Implement Resiliency into your pavement policies?

Pavement (Flooding) Resiliency

GOOD resources can be found…

<u>Articles & New Polling</u>

How Severe Weather Damages our Roadways **(August 2019)**

Extreme Weather and Climate Adaptation **(June 2019)**

Federally Funded Infrastructure Must Be Flood Ready **(PEW, April 2019)**

Public Roads - Boosting Pavement Resilience **(Autumn 2018)**

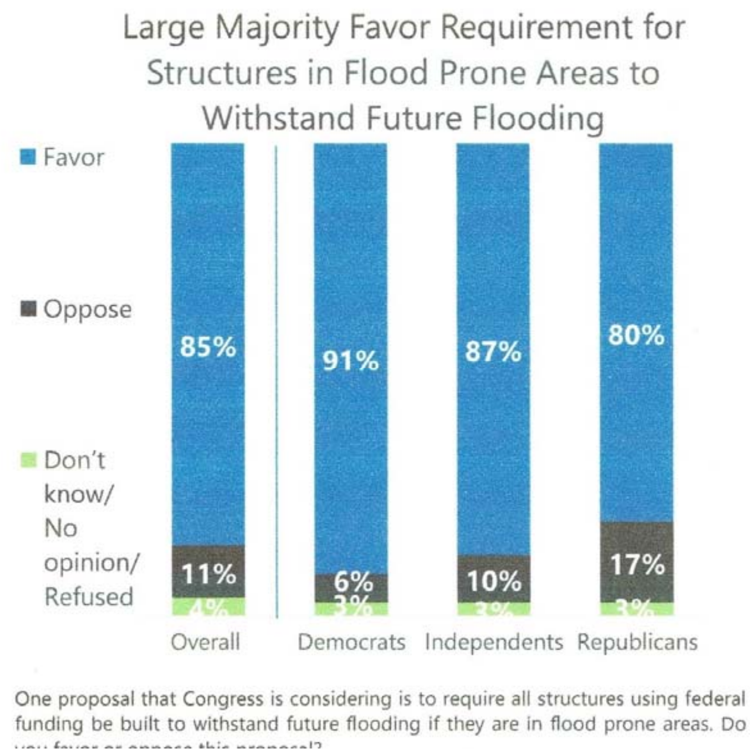
Texas Roadways Proven Resilient After Hurricane Flooding **(May 2018)**

PEW Charitable Trusts Flood Infrastructure Survey **(Feb 2020)**

<u>Reports and Publications</u>

LTPP Tech Brief - Impact of Environmental Factors on Pavement Performance

FHWA - Climate Change Adaptation For Pavements **(August 2015)**



INCREASED FLOODING IS IMPACTING OUR PAVEMENT STRUCTURES

Need to distinguish between Inundation and Washout Impacts

Inundation

The rise of water that submerges the pavement.
No rapid flow or current that erodes base

Pavement type does have an impact on long-term performance

Washout

Rapid flow of flood water / high current that scours and washes out the pavement structure

Pavement type has little impact

FLOODING CAUSES THE SUBGRADE TO BECOME SUPERSATURATED

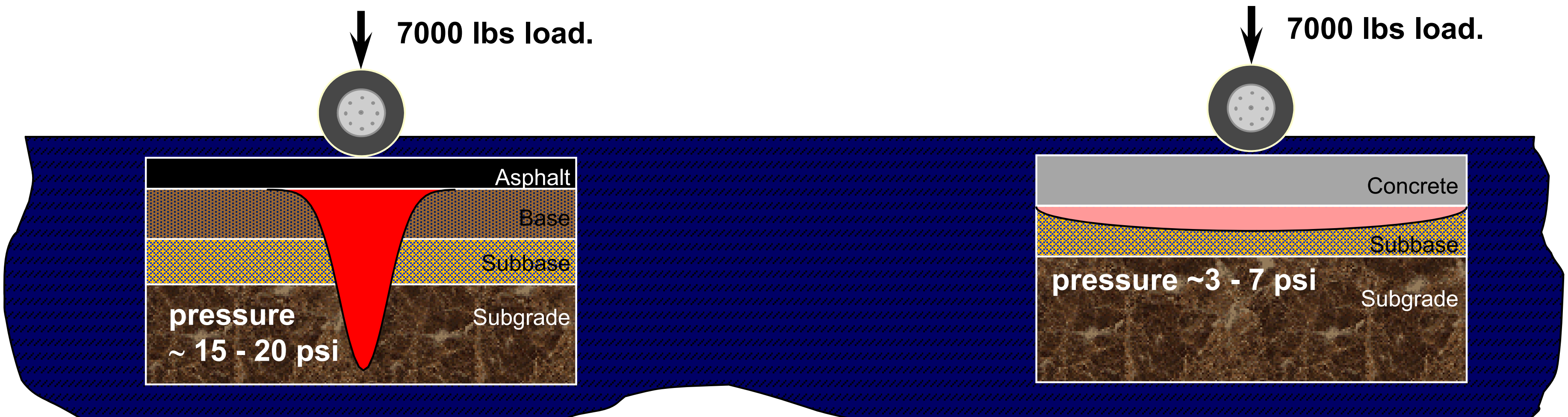
Moisture infiltrates base, pushes the subgrade particles apart and weakens the system

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

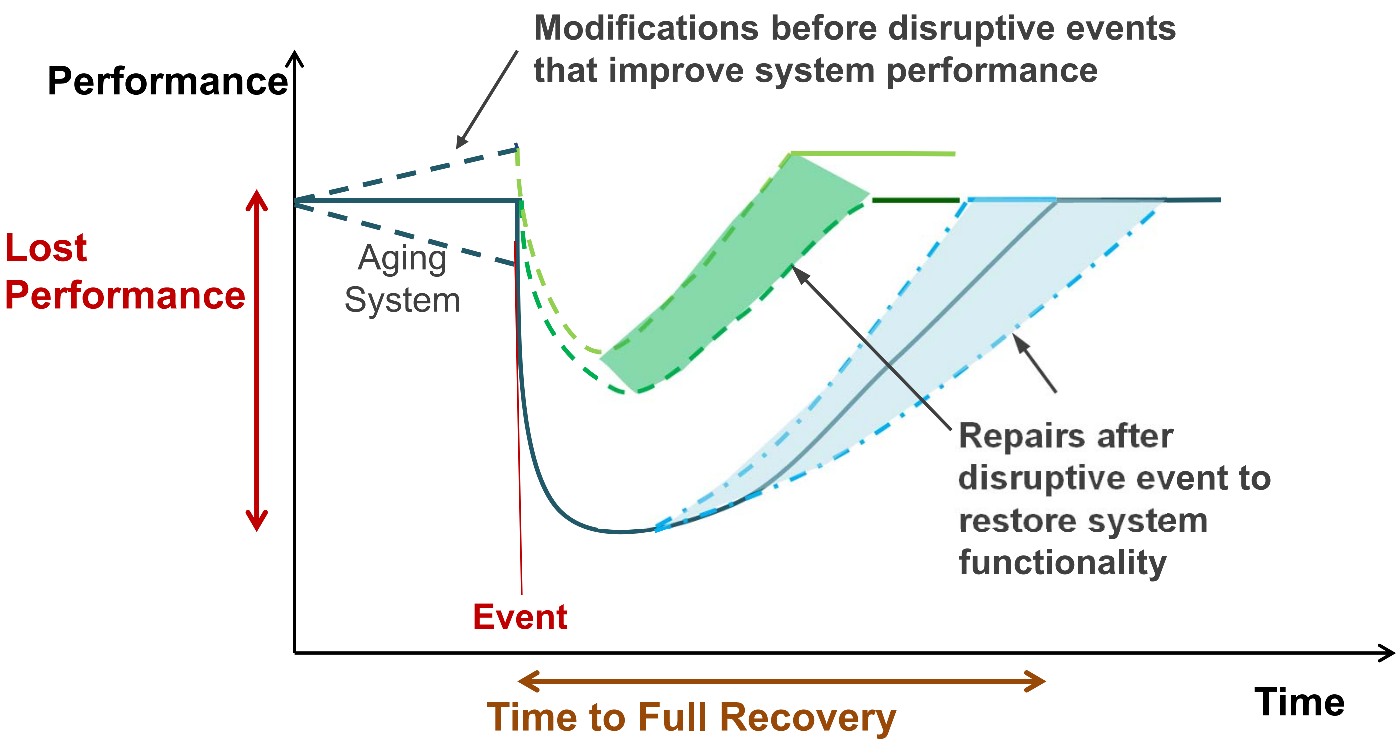
Concrete Pavements are Rigid

- 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 A HIGHWAY'S / PAVEMENTS RESILIENCE



Actions to consider when dealing with flood prone 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

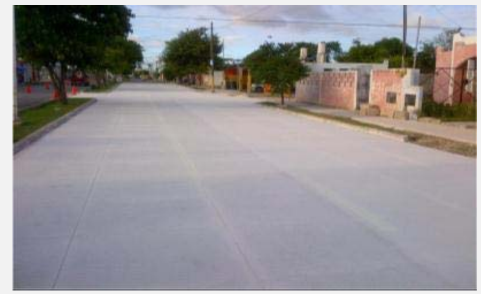
Adapted from Bruneau, 2003 and McDaniels, 2008

SOME RESILIENT CEMENT-BASED PAVEMENT SOLUTIONS THAT CAN BE USED AS HARDENING TECHNIQUES

Conventional Concrete Pavement

Thin Concrete Pavement

Concrete Overlays



Roller Compacted Concrete (RCC)

Full Depth Reclamation (FDR) w/ Cement

Pervious Concrete

Expanded Use of Conventional Concrete Pavements

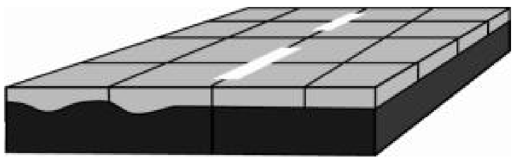
How are your Roundabouts performing?

Project Details

[NCDOT's First Use of Concrete Roundabout]

- New CSX Facility under construction in vicinity
- Pavement design changed in the 11th hour
  - ➢ 9.5-inch doweled PCCP upon Agg Base
- Project bid without a jointing detail
- Contractor required to submit jointing plan for approval prior to starting
- ACPA Tech Bulletin was referenced as part of bidding documents

CONCRETE OVERLAYS OF ASPHALT HAVE UNTIL RECENTLY BEEN CALLED "WHITETOPPING OVERLAYS"

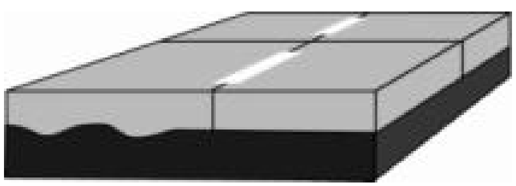


Used since 1998

Bonded Concrete Overlays of Asphalt Pavements (BCOA)

- Small square panels reduce curling, warping, & shear stresses.
- if necessary, mill to correct crown, remove surface distresses, improve bond
- Need a 3-inch minimum of asphalt after milling.

Typical Thickness = 3 to 6 inches



Used since 1919

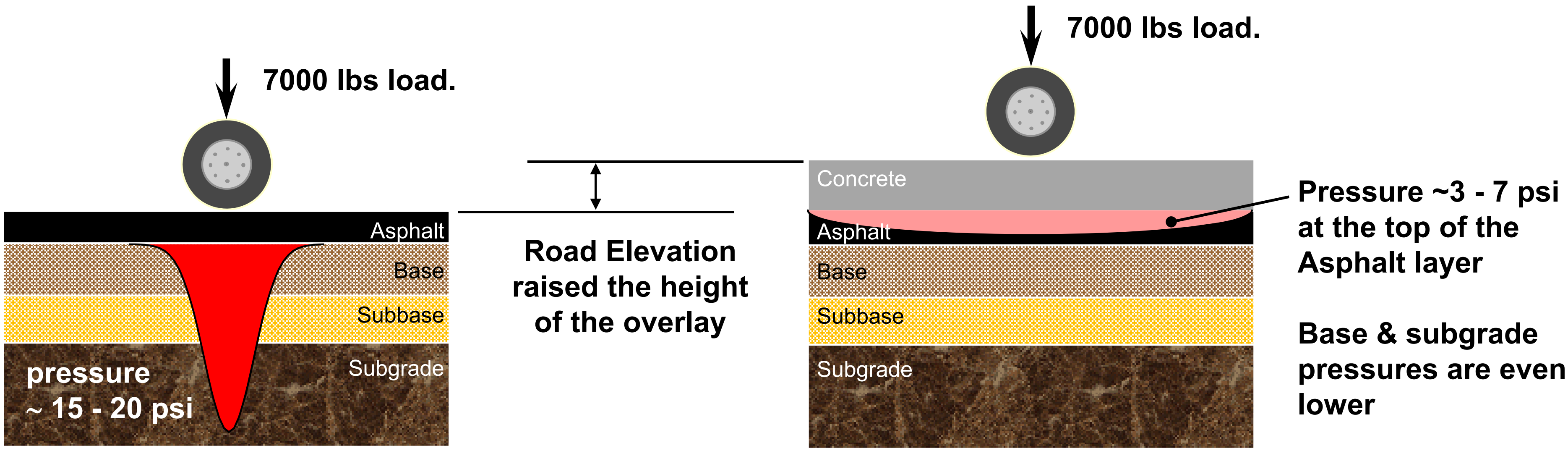
Unbonded Concrete Overlay of Asphalt Pavements

- No minimum thickness of Asphalt (used only as base)
- Normal to slightly smaller than normal joint spacing. Based on unbonded overlay thickness

Typical Thickness = 5 to 10+ inches

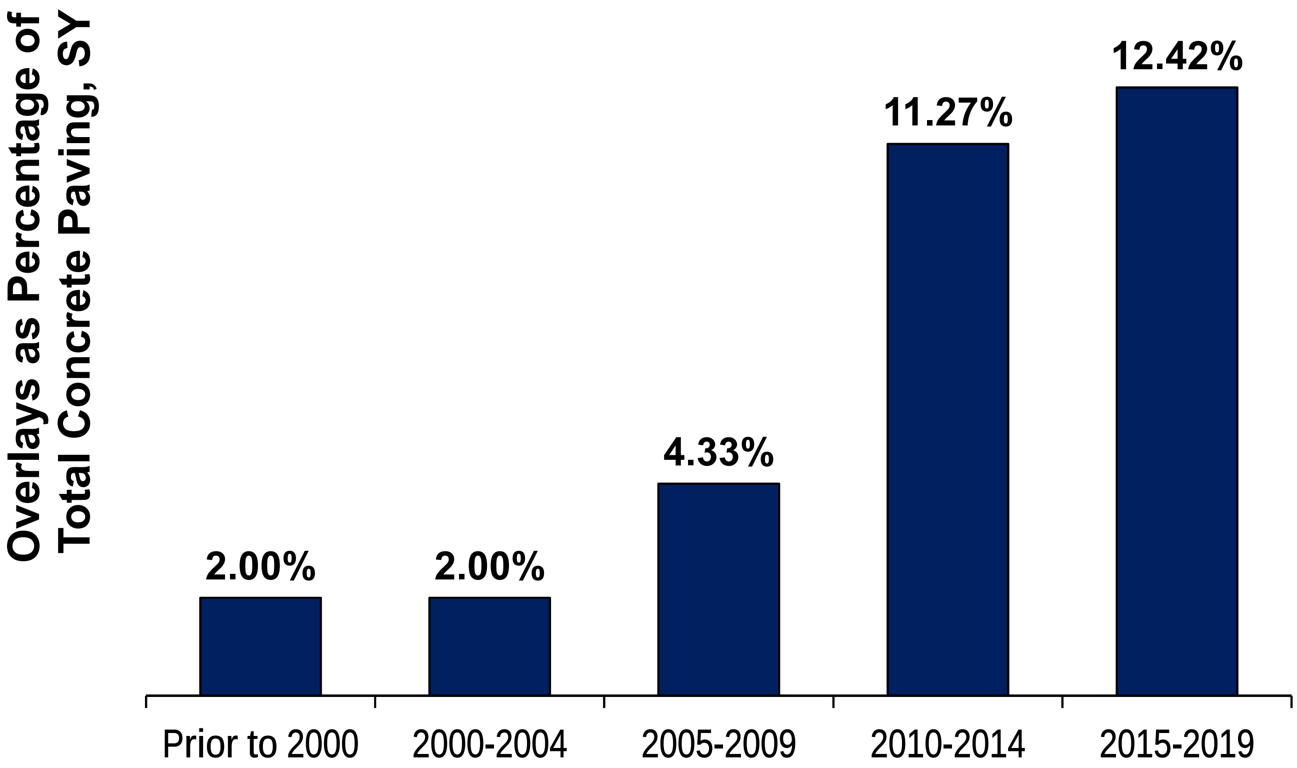
Both systems bond to the underlying asphalt, but bond is not accounted for in the DESIGN for unbonded overlays

HOW CONCRETE OVERLAYS IMPROVE ASPHALT PAVEMENT'S RESILIENCE TO FLOODING



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

NATIONWIDE CONCRETE OVERLAY USAGE IS GROWING



BCOA Examples

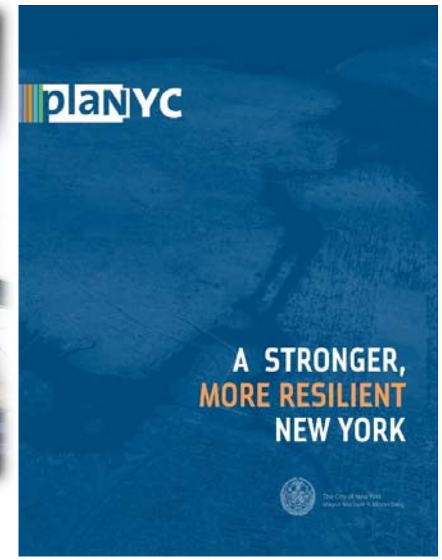
Source: From data submitted by ACPA chapters/state paving associations and other sources, including Oman Systems, Bid Express and DOT websites.

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"*

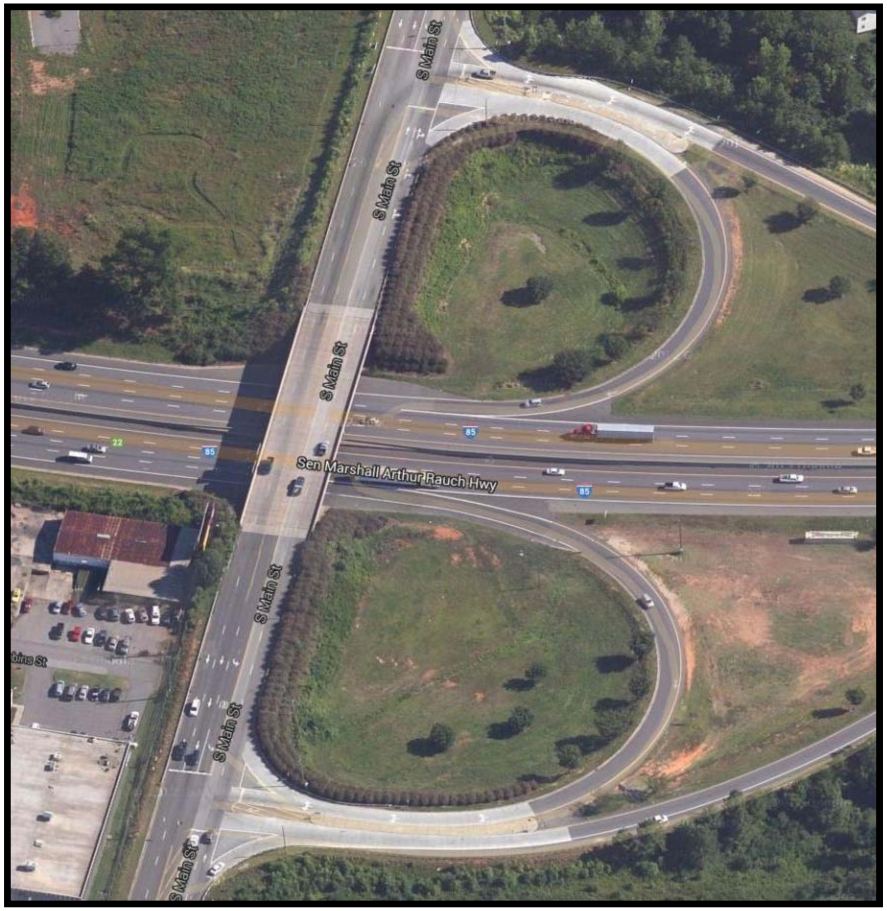
Reconstruction of Runway 13L-31R at JFK

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."

Exit 22 at I-85
Gastonia, NC



7-inch BCOA / Binder Base Coarse, B-25
Constructed in 2010

Governors Club - Chapel Hill, NC

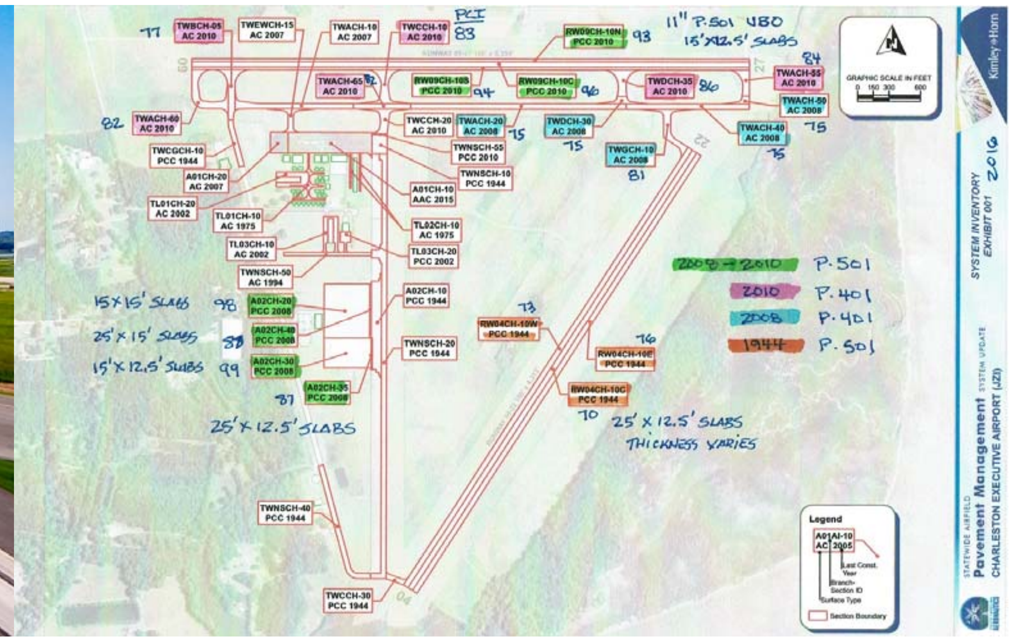
7-in Unbonded Concrete Overlay Construction

Governors Club Concrete Overlay

Charleston Executive Airport

Johns Island, SC

11-inch Unbonded Overlay (2010 Construction)



<u>2016 PCI Data</u> from Pavement Management Report

2010 LCD-RW **Concrete Overlay** range from 93 to 96 (weighted average 94, 1 point per year drop)
2010 LCD-TW Connectors (Tie-Ins) **Asphalt** range from 77 to 86 (weighted average 82, 3 points per year drop)
2008 LCD – Taxiway A **Asphalt** = 75 (drop of 3.1 points per year)

Concrete Overlays
South Carolina General Aviation Airports

Airports are commonly found in low elevation (flat) areas, prone to flooding in hurricane events

Grand Strand (N. Myrtle Beach, SC)

Grand Strand Airport Concrete Overlay

Airport	Overlay	RW, TW, Apron
Charleston Exec	11-inch UBO	Runway (RW)
Lancaster Co	7.5-in WT	RW
Berkeley Co	9-in WT	RW
Laurens Co	5-in WT	RW, TW, Apron
Greenwood Co	5-in WT	RW
Lexington Co	6-in + 6-in CMB	RW
Grand Strand	7.5-in WT	RW
Darlington Co	7-in WT	RW, TW Tie-ins

UBO = Unbonded Overlay; WT = Whitetopping; CMB = cement modified base

Lots (100's) of Lane-Miles of Unbonded Concrete Overlays
Mostly constructed since late 1990's

Asphalt Separation Layer

1960 era Concrete

I-85 Vance & Warren Counties (S. of VA Border)

[Fast Forward North Carolina - I85 UBO]

Bonded Concrete Overlay of Asphalt (BCOA) Design and Construction Recommendations based on Caltrans PPRC 4.58B Project

John Harvey, Angel Mateos, Fabian Paniagua, Julio Paniagua, Rongzong Wu
University of California Pavement Research Center

Julie Vandenbossche, John DeSantis
University of Pittsburgh

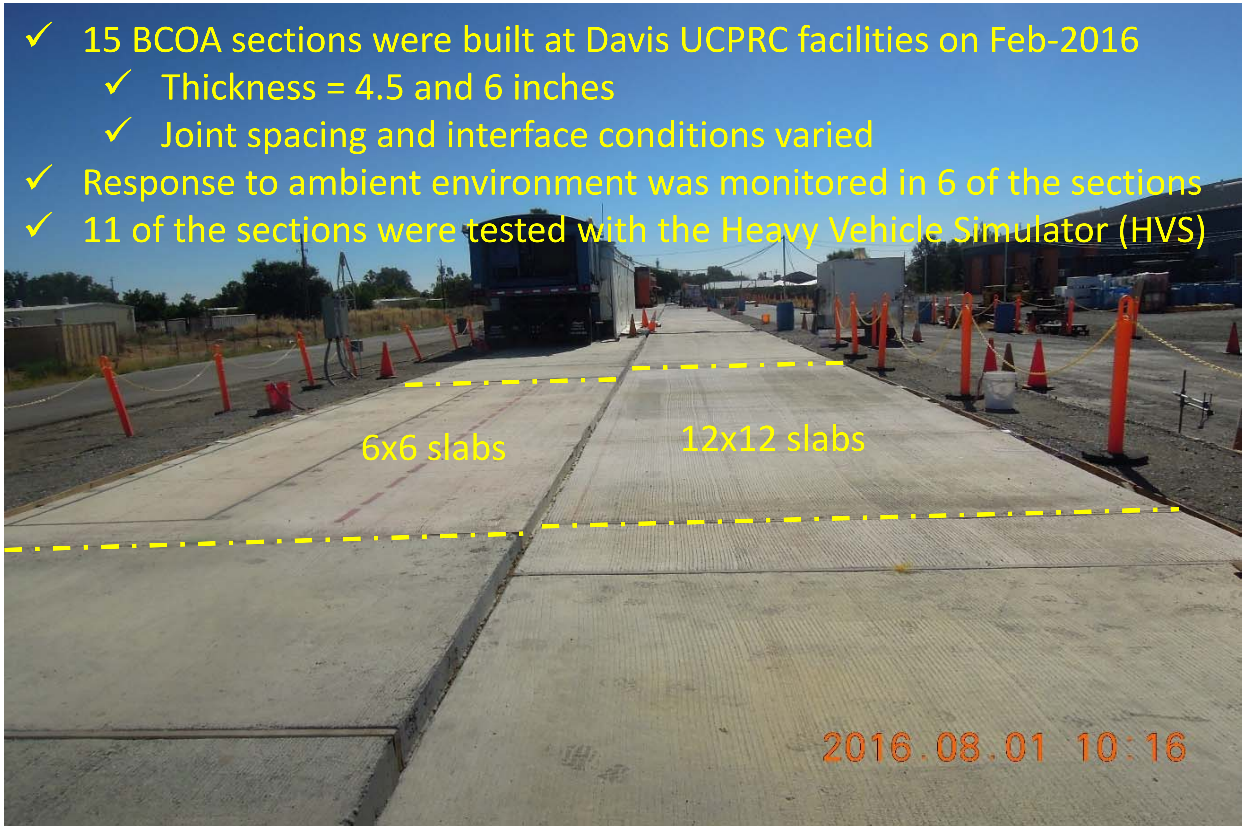
Deepak Maskey
California Department of Transportation

Charles Stuart
Southwest Concrete Pavement Association

Introduction

4.58B Project experimental data sources:

1. Laboratory testing of concrete, asphalt, and concrete-asphalt interface
2. Monitoring the response of BCOA to the ambient environment
3. Heavy Vehicle Simulator testing

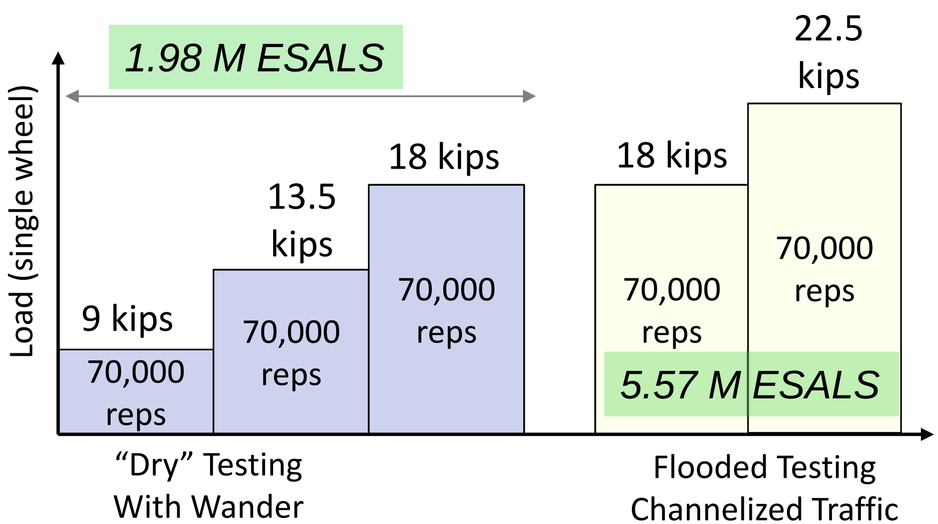


Summary of HVS Testing at UCPRC

11 full-scale BCOA sections tested with the HVS

After testing 10 out of the 11 sections*...

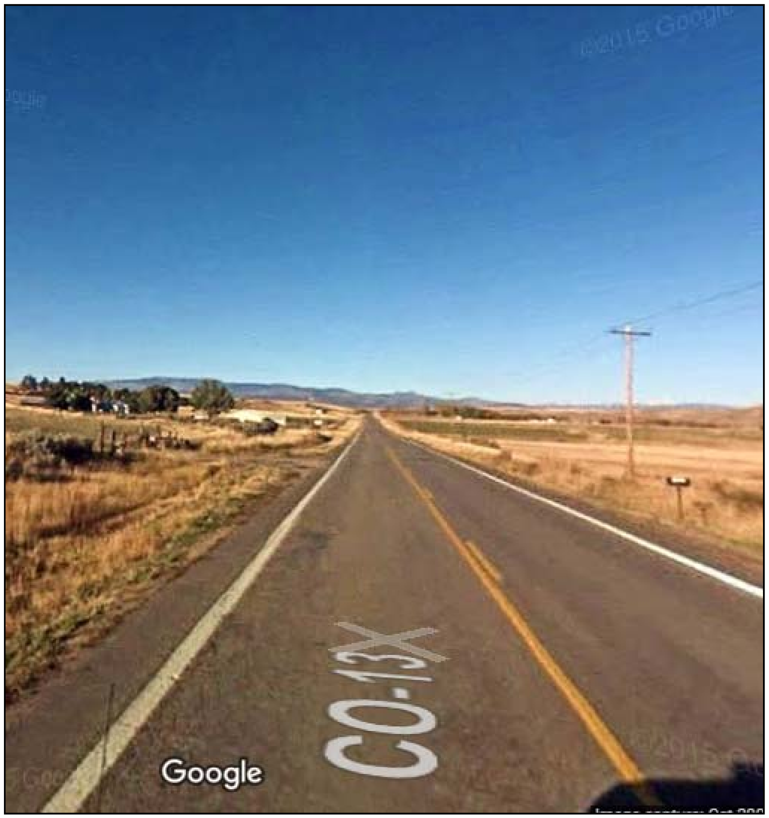
- ✓ No cracking at any section, no faulting, no noticeable slabs movements
- ✓ To induce cracking, pavement was flooded and loaded - “wet” Loading (140,000 Reps)
- ✓ One panel crack after 7.55 M ESALs (8 times the loading for a normal BCOA application)



* One section was for environment studies only

CONCRETE OVERLAYS OF ASPHALT ARE COST EFFECTIVE

State Highway 13 – North of the city of Craig, CO



SH 13 Existing Condition before overlay

Project Bid in December 2015 as AD/AB*

Hot Mix Asphalt (HMA) Alternative

- 2-in SX(75) PG 58-34 (surface AC) over 4-in of SX(75) PG 58-28 (Base AC) over 8-in of Full Depth Reclamation
- Initial Const = $5,385,980.85
- Rehab & Maint = $2,456,560
- Users Cost = $596,170

Total Life Cycle Cost = $8,438,710.85

Concrete Alternative

- 6-in Unbonded Concrete Overlay on Asphalt
- Initial Const = $5,338,308.82
- Rehab & Maint = $1,674,060
- Users Costs = $718,490

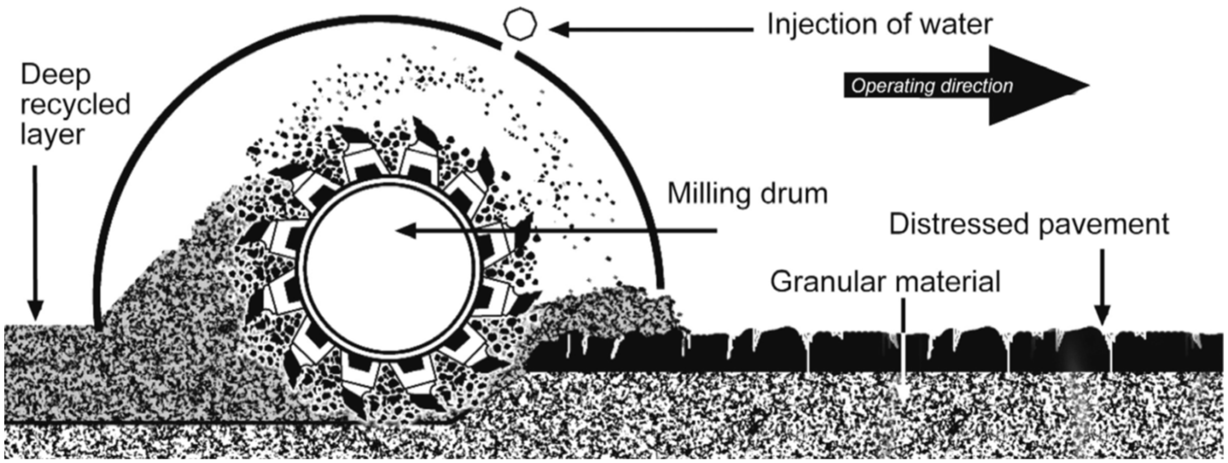
Total Life Cycle Cost = $7,730,858.82

Concrete overlay was $47k lower in Initial cost & $708k Lower in Life Cycle Costs

* AD/AB = Alternate Design / Alternate Bid: Essentially two pavement designs (1 concrete & 1 Asphalt) are developed and bid competitively against each other in order to increase competition

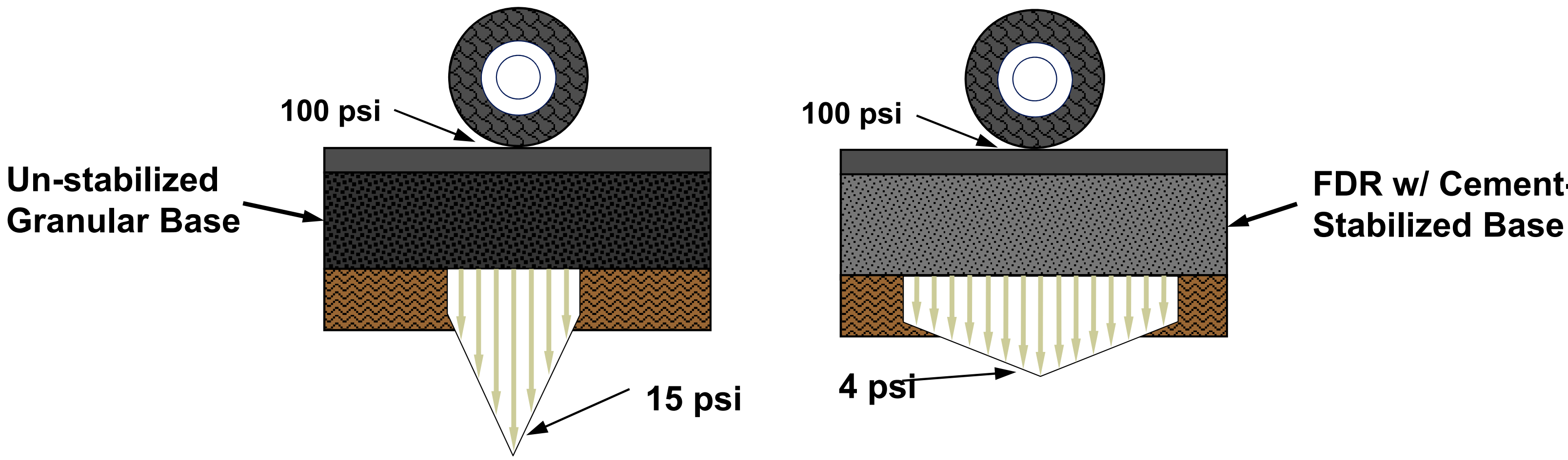
FULL-DEPTH RECLAMATION (FDR) WITH CEMENT RECYCLES AN EXISTING DETERIORATED ASPHALT PAVEMENT INTO A NEW STABILIZED BASE

The stabilized base can be topped with an asphalt or concrete surface



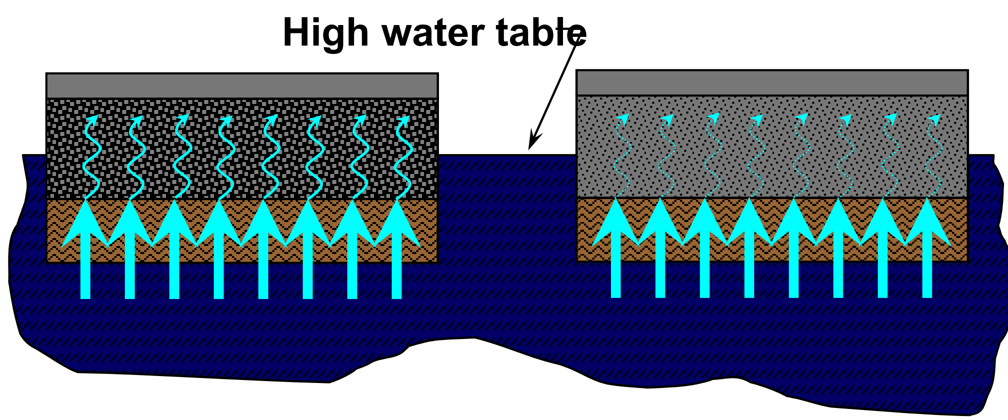
- **Utilizes In-Place Materials (reduces cost)**
- **Saves Energy by Reducing Trucking Requirements**
- **Increased Rigidity Spreads Loads**
- **Minimizes Rutting**
- **Reduced Moisture Susceptibility**

FDR W/ CEMENT INCREASES RIGIDITY TO SPREADS LOADS AND REDUCES PERMEABILITY TO REDUCE MOISTURE SUSCEPTIBILITY



Moisture infiltrates base

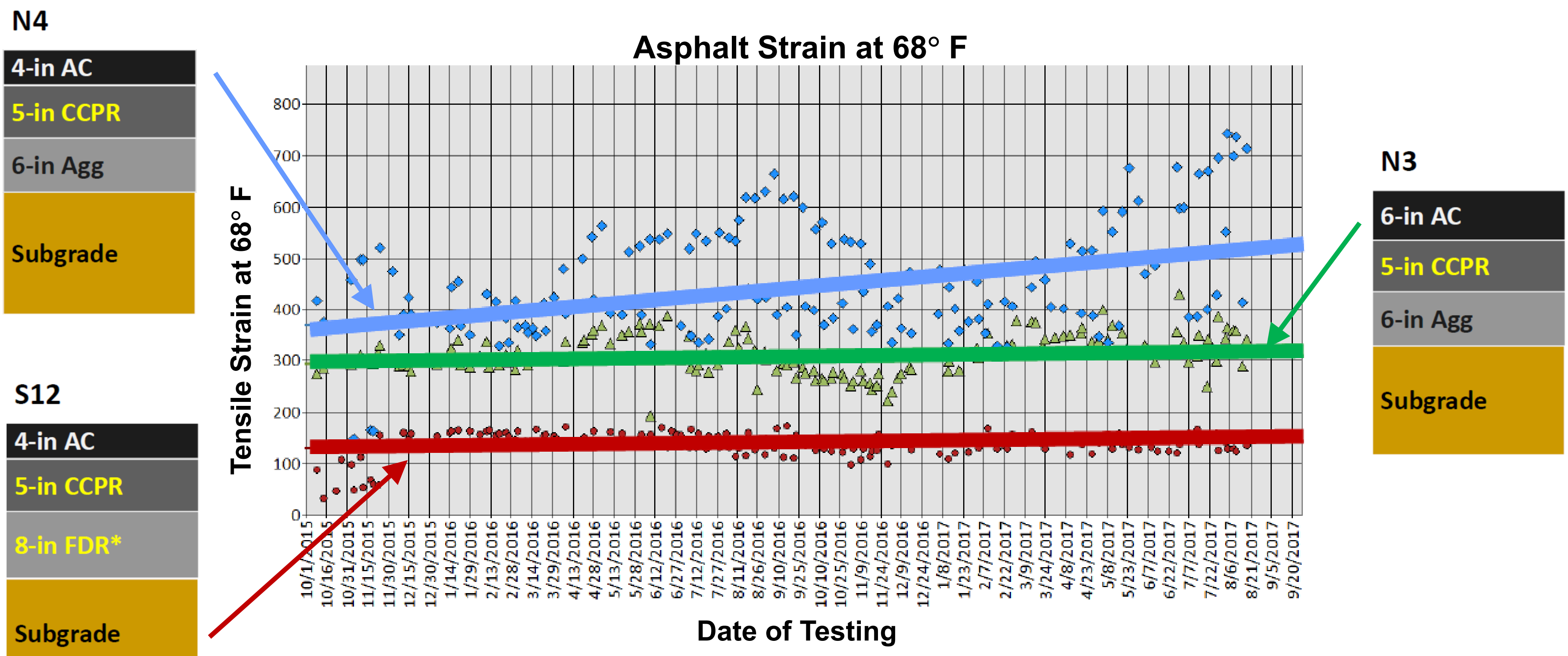
- Through high water table
- Capillary action
- Causing softening, lower strength, and reduced modulus



Cement stabilization reduces permeability

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

FULL DEPTH RECLAMATION WITH CEMENT REDUCES THE STRAINS UNDER THE ASPHALT PAVEMENT



* FDR = 6-in aggregate base + 2-in subgrade stabilized in-place with 4% Type II Portland Cement

Structural Study of Cold Central Plant Recycling Sections at the National Center for Asphalt Technology (NCAT) Test Track,
Brian K. Diefenderfer, Ph.D., P.E., Benjamin F. Bowers, Ph.D. (VTRC), Miguel Díaz Sánchez, David H. Timm, Ph.D., P.E., Auburn University
http://www.virginiadot.org/vtrc/main/online_reports/pdf/17-r9.pdf

AGENCIES SHOULD MODIFY "DESIGN STANDARDS" TO BE BASED ON WEAKENED SUBGRADE CONDITION

Almost All Pavement Designs in Australia are based on soaked subgrade conditions

NSW GOVERNMENT

Roads and Maritime Supplement to Austroads Guide to Pavement Technology

Part 2: Pavement Structural Design

Document No: RMS 11.050 Version 3.0 | August 2018

Supersedes: RMS 11.050 Version 2.2

5.6.2 Determination of Moisture Conditions for Laboratory Testing

Fine-grained materials wet up through capillary action in high rainfall areas. For this reason, use a soaked CBR for design in these areas with a 10-day soaked period in accordance with test method T117 for cohesive soils, unless the rainfall and testing conditions shown in Table 7 support 4-day soaking.

For dry inland regions of NSW prepare the sample at the field moisture content (or the equilibrium moisture content (EMC) where applicable) and test with no soaking period unless the road is subject to inundation or located adjacent to irrigation channels. This approach is to be used in lieu of Table 7.

Table 7: Typical moisture conditions for laboratory CBR testing

Median annual rainfall (mm)	Specimen compaction moisture content	Testing condition	
		Excellent to good drainage	Fair to poor drainage
< 600	OMC	Unsoaked	4-day soak
600 – 800	OMC	4-day soak	10-day soak
> 800	OMC	10-day soak	10-day soak

Does not require any changes to current design practices other than changing the subgrade input
(Especially important in flood prone areas)

CONCLUSIONS

1. Everyone recognizes the need to make our infrastructure "Flood Ready"
   - Need to define specific actions that agencies should consider when dealing with flooded pavements
2. In areas where pavements have a history of flooding (or in flood prone areas), or in areas of danger due to climatic changes,
   - Use Stiffer or stiffen the existing pavement
   - Require pavement designs be based on Lowered subgrade strength
3. Concrete pavement / cement based solutions have shown a remarkable resiliency to flooding
   - There are many solutions that are viable that are low costs, such as concrete overlays that can be used as mitigation / hardening strategies

Utilities Industry has promoted their resiliency for years…

- Their ability to prepare (minimize outages)
  - Resist & Absorb
- Their ability to quickly inform and restore power
  - Accommodate & Recover

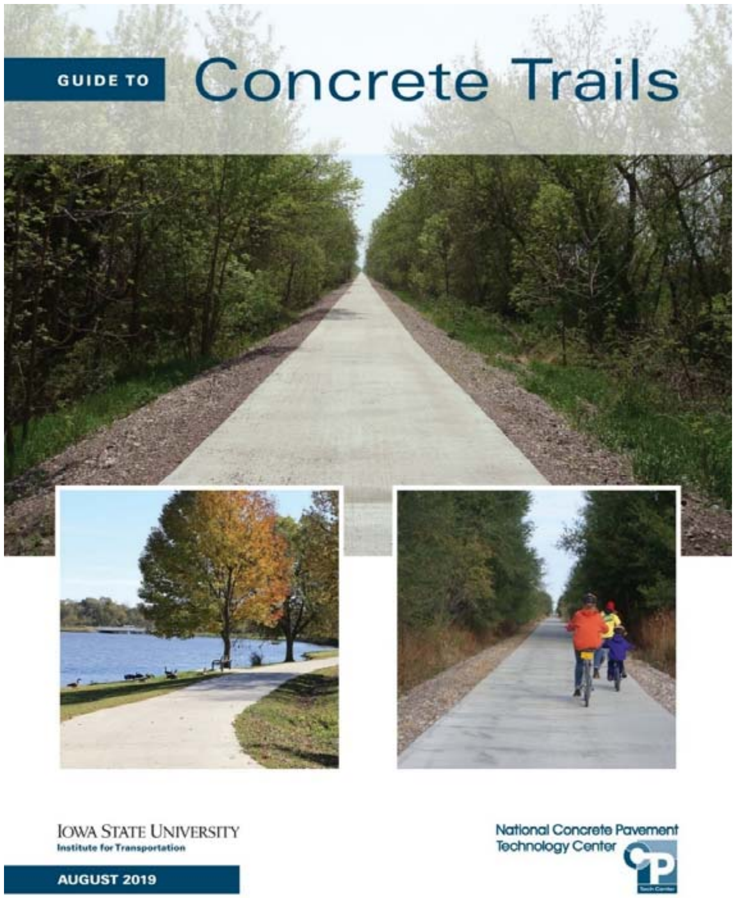
2017 Duke Energy Sustainability Report

Invest $25B during 2017-2026 to create a smarter, greener energy grid that also will be even more reliable and ***RESILIENT*** *during severe weather events*

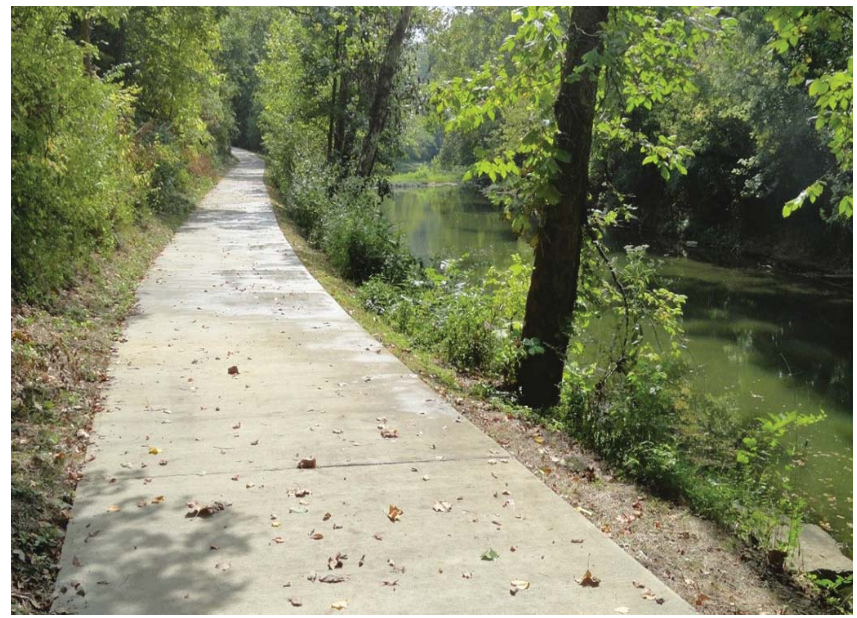
It’s time for our Concrete Industry to partner with our agencies…

Count on
CONCRETE

One last idea…



CASE STUDY
PARKLAND OF FLOYDS FORK TRAILS
JEFFERSON COUNTY, KY
8 Miles in flood plain



Concrete Trails Design Guide & Case Studies

Thank you

Comments & Questions?

Greg Dean
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CAROLINAS CONCRETE PAVING ASSOCIATION

ONE LAST ITEM – PLEASE SUPPORT PAVEMENT FLOODING RESEARCH

Proposal for AASHTO Research Advisory Committee (RAC)

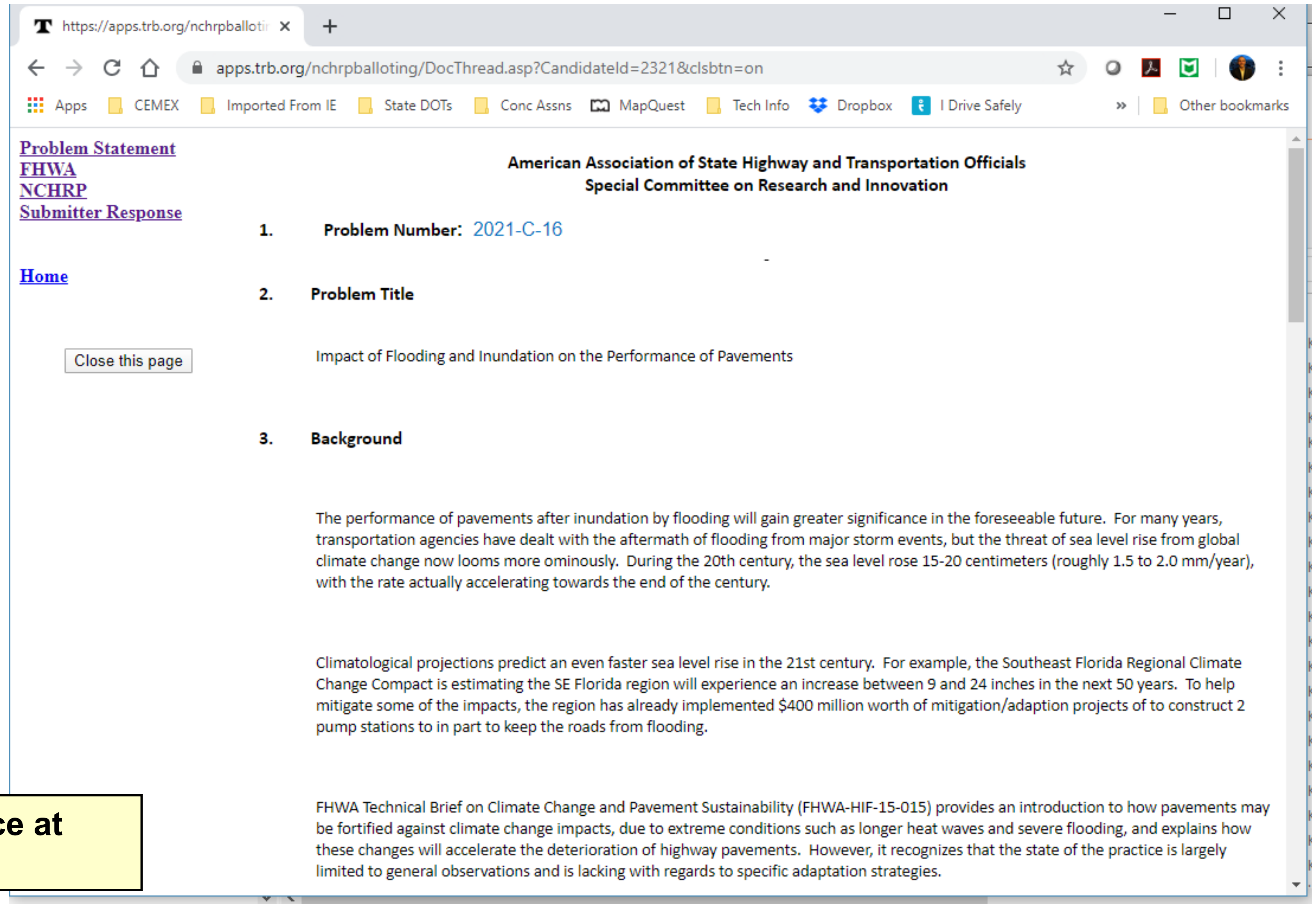
Problem Number:
2021-C-16

Problem Title:
Impact of Flooding and Inundation on the Performance of Pavements

Recommended Funding:
$1,000,000

Research Period:
36 months

Project selection takes place at the end of this Month



American Association of State Highway and Transportation Officials
Special Committee on Research and Innovation

1. **Problem Number:** 2021-C-16

2. **Problem Title**

Impact of Flooding and Inundation on the Performance of Pavements

3. **Background**

The performance of pavements after inundation by flooding will gain greater significance in the foreseeable future. For many years, transportation agencies have dealt with the aftermath of flooding from major storm events, but the threat of sea level rise from global climate change now looms more ominously. During the 20th century, the sea level rose 15-20 centimeters (roughly 1.5 to 2.0 mm/year), with the rate actually accelerating towards the end of the century.

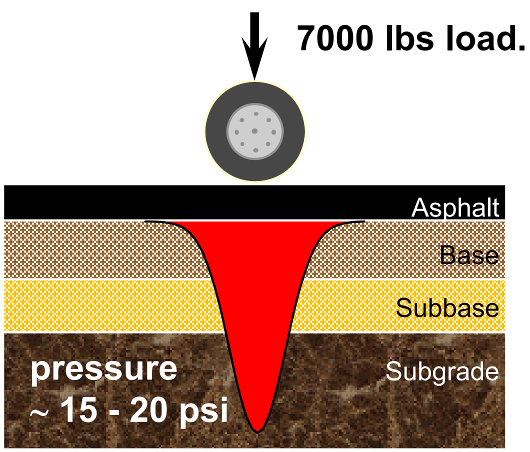
Climatological projections predict an even faster sea level rise in the 21st century. For example, the Southeast Florida Regional Climate Change Compact is estimating the SE Florida region will experience an increase between 9 and 24 inches in the next 50 years. To help mitigate some of the impacts, the region has already implemented $400 million worth of mitigation/adaption projects of to construct 2 pump stations to in part to keep the roads from flooding.

FHWA Technical Brief on Climate Change and Pavement Sustainability (FHWA-HIF-15-015) provides an introduction to how pavements may be fortified against climate change impacts, due to extreme conditions such as longer heat waves and severe flooding, and explains how these changes will accelerate the deterioration of highway pavements. However, it recognizes that the state of the practice is largely limited to general observations and is lacking with regards to specific adaptation strategies.

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

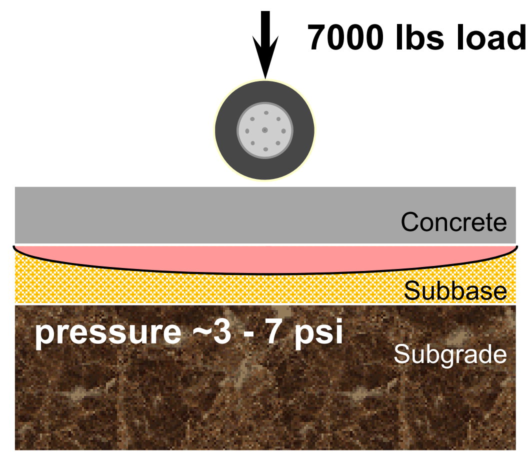
Asphalt Pavements are Flexible

- 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