Designing a Wisconsin Concrete Overlay

WCPA Annual Concrete Workshop

February 9 – 10, 2023

ACPA

AMERICAN CONCRETE PAVEMENT ASSOCIATION

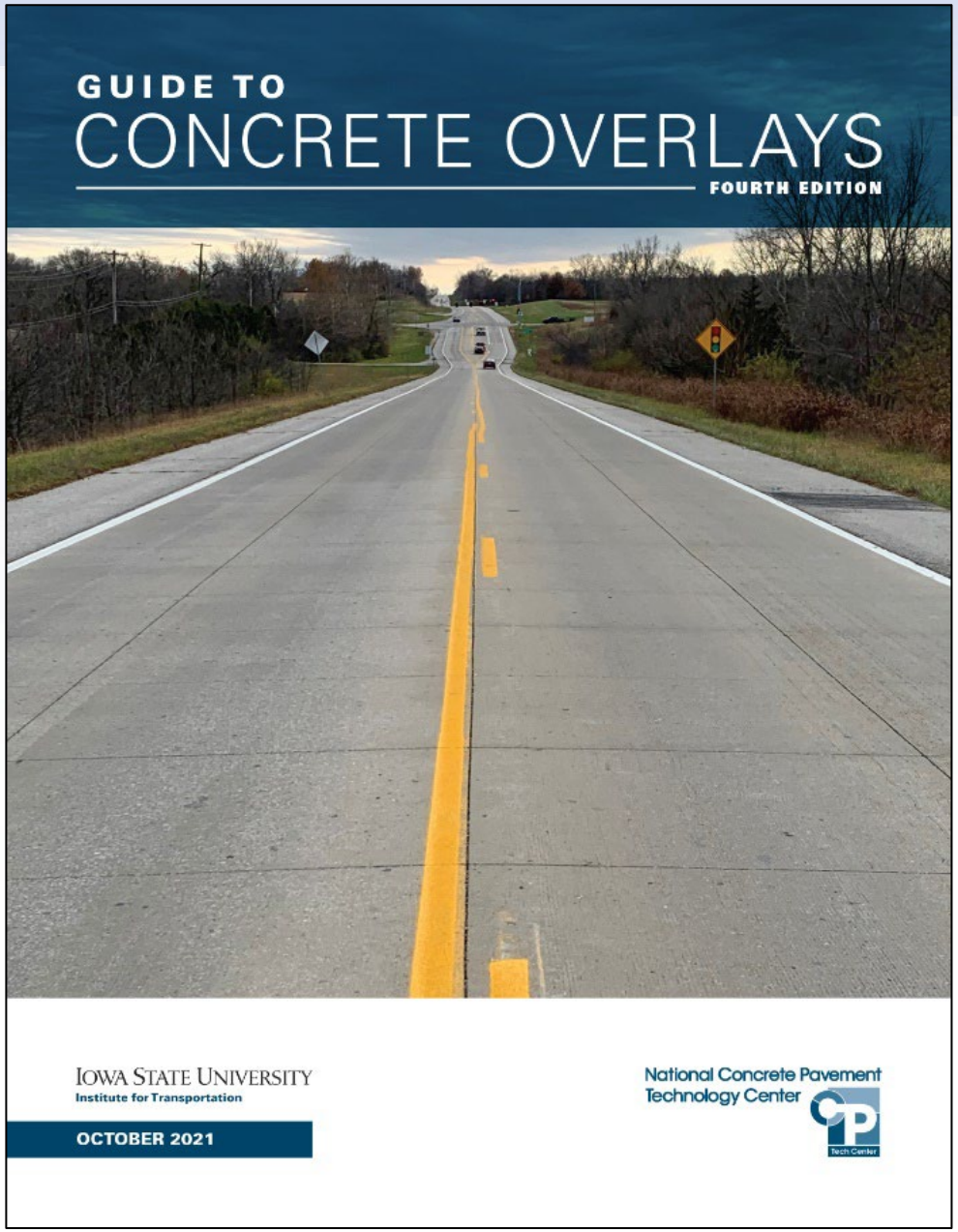
Eric Ferrebee, P.E.

Senior Director of Technical Services

ACPA

Overlay Design Process

- Pavement Evaluation
- Determine Overlay Type
- Determine Design Life and Traffic
- Use Pavement Design Software
- Consider Additional Design Features
- Consider Construction Process
- Create Construction Documents

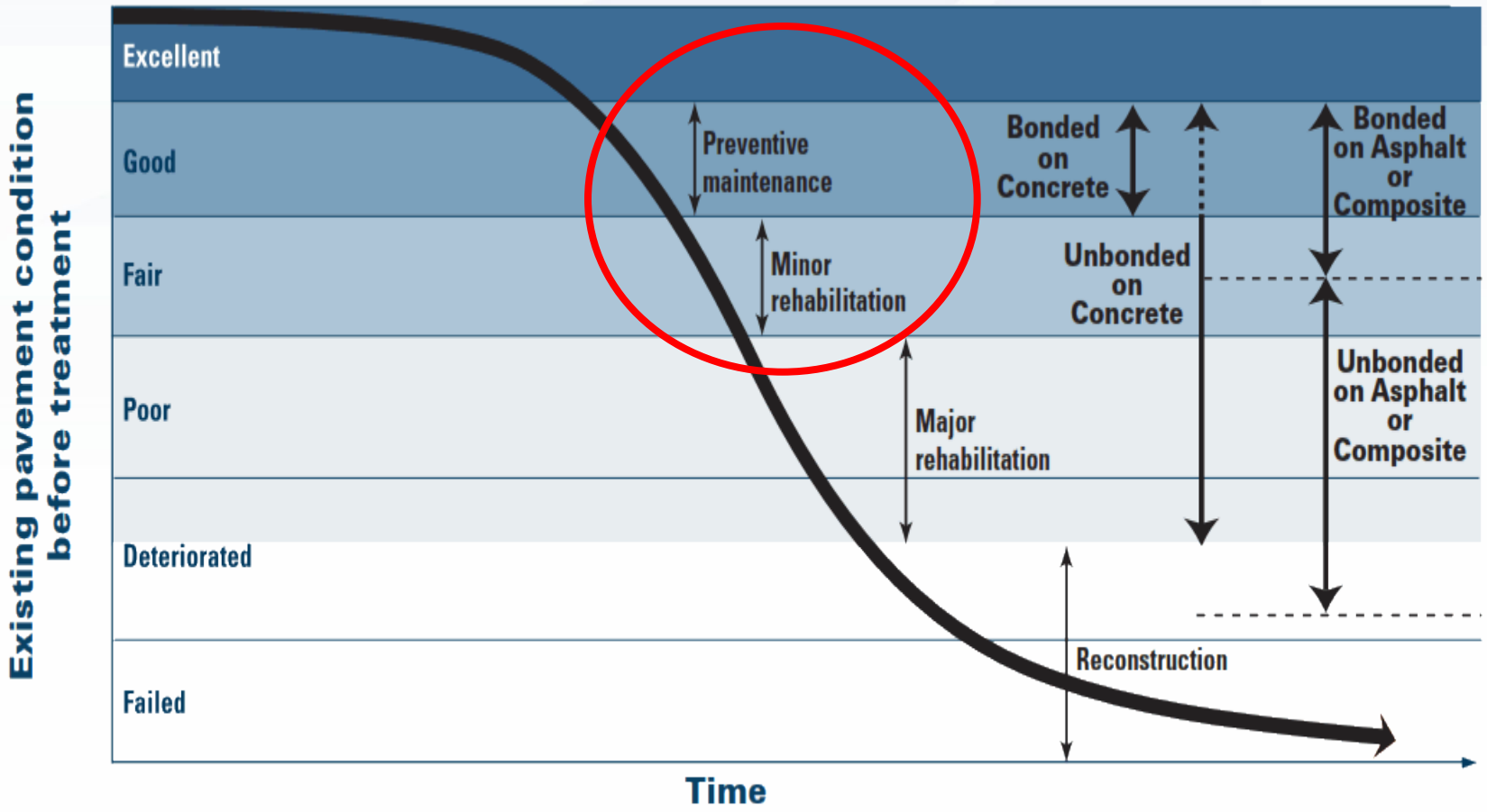


Evaluation Informs Design

Maintenance

Resurfacing

Reconstruction



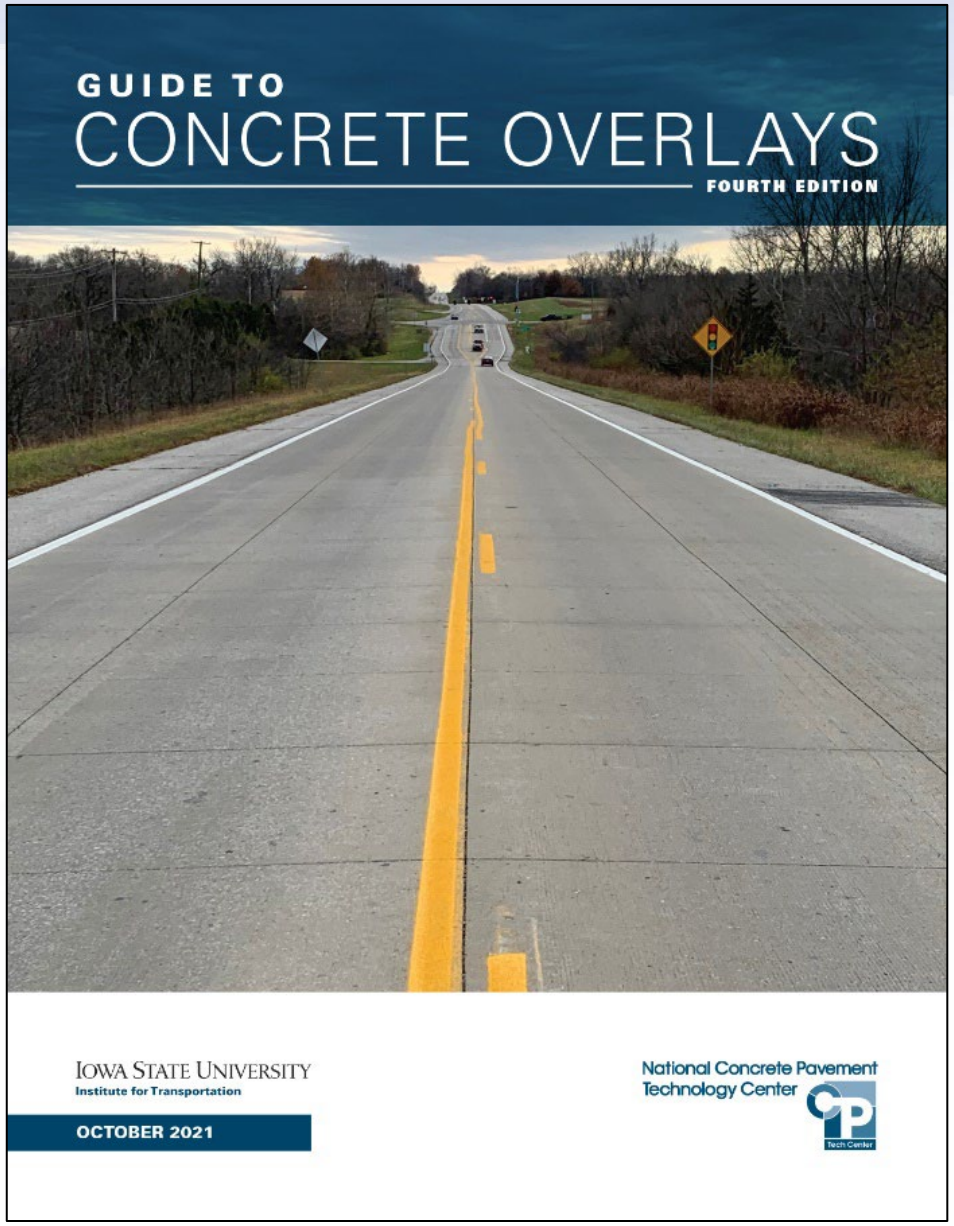
Evaluation and Survey Information

- Existing Pavement History Evaluation
  - Layer materials, properties, depths, & age
  - Widening material type, depths, widths, & age
  - History of full depth patching by location, type & age
- "As Built" Plan Information
  - Vertical & horizontal alignment
  - Previous test sections in project limits
  - Previous drainage structure remains

Where are the problem areas? What maintenance has been done? Are any pre-overlay repairs required?

Overlay Design Process

- Pavement Evaluation
- Determine Overlay Type
- Determine Design Life and Traffic
- Use Pavement Design Software
- Consider Additional Design Features
- Consider Construction Process
- Create Construction Documents

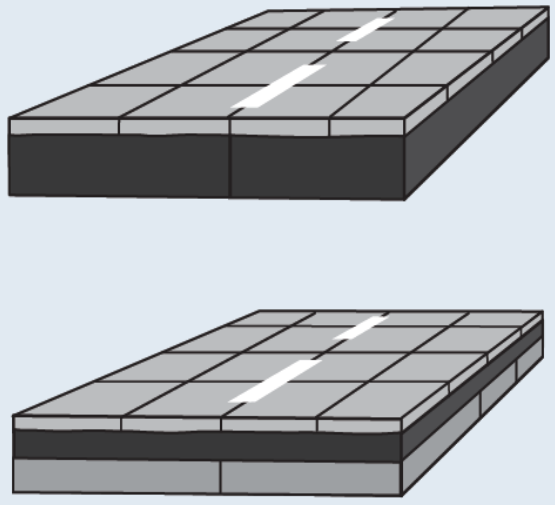


Overlay Type Selection

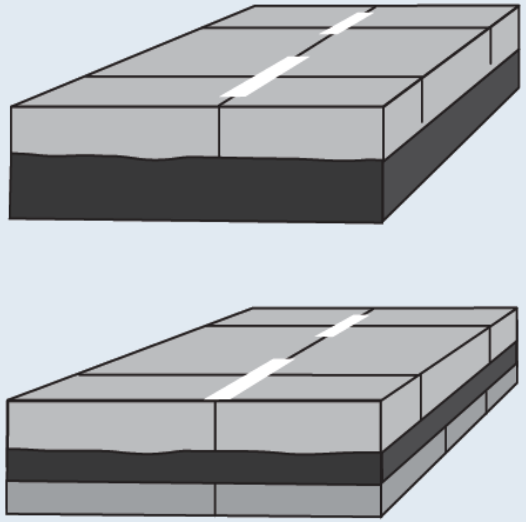
Concrete on Asphalt

Concrete on asphalt (COA) overlays can be designed to address a broad range of existing pavement conditions on both composite and full-depth asphalt pavements. Both bonded (COA–B) and unbonded (COA–U) options enable designs to cost-effectively match the condition of the existing asphalt—from deteriorated to good—as well as geometric parameters.

COA–B (Full Depth and Composite)



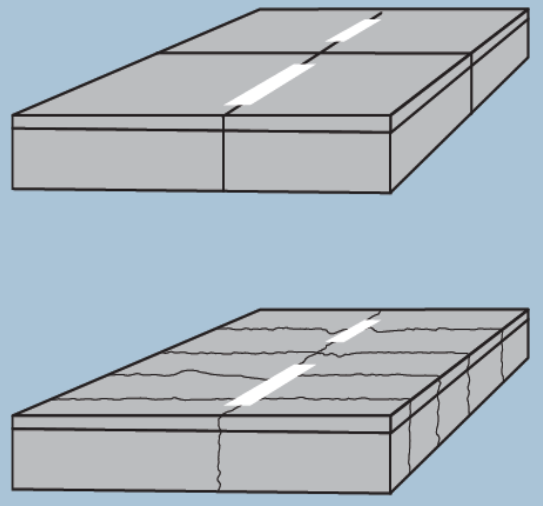
COA–U (Full Depth and Composite)



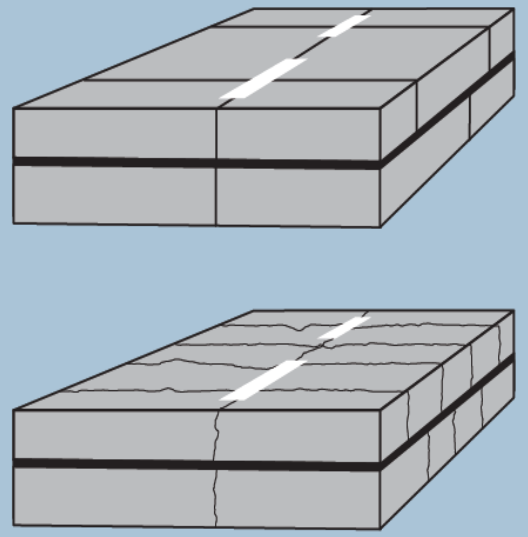
Concrete on Concrete

Concrete on concrete (COC) overlays can be designed for applications on both existing jointed plain concrete pavement (JPCP) and continuously reinforced concrete pavement (CRCP). The predominance of COC overlay designs are unbonded (COC–U) systems; however, bonded (COC–B) applications can be successful, provided the existing pavement is in good condition.

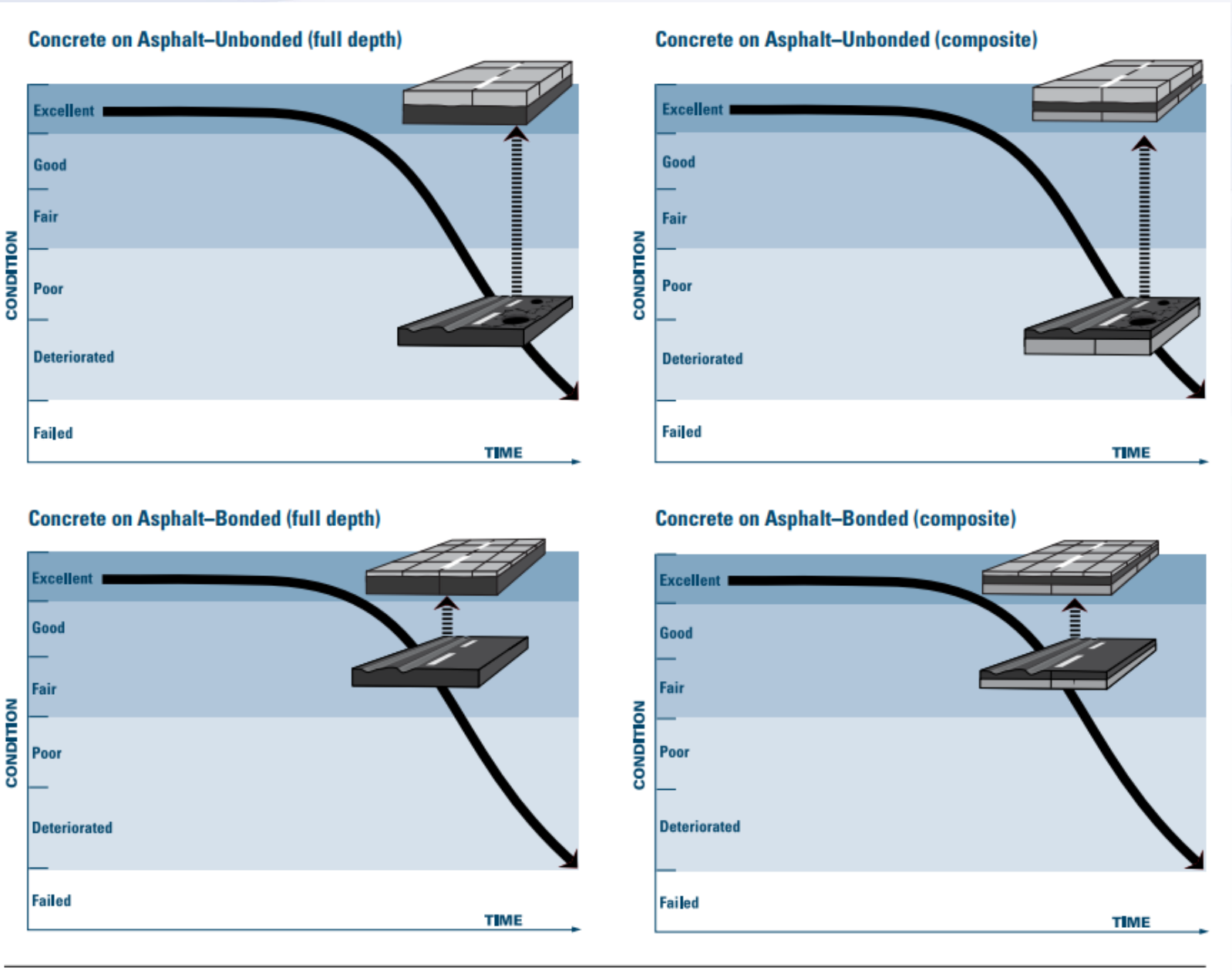
COC–B (JPCP and CRCP)



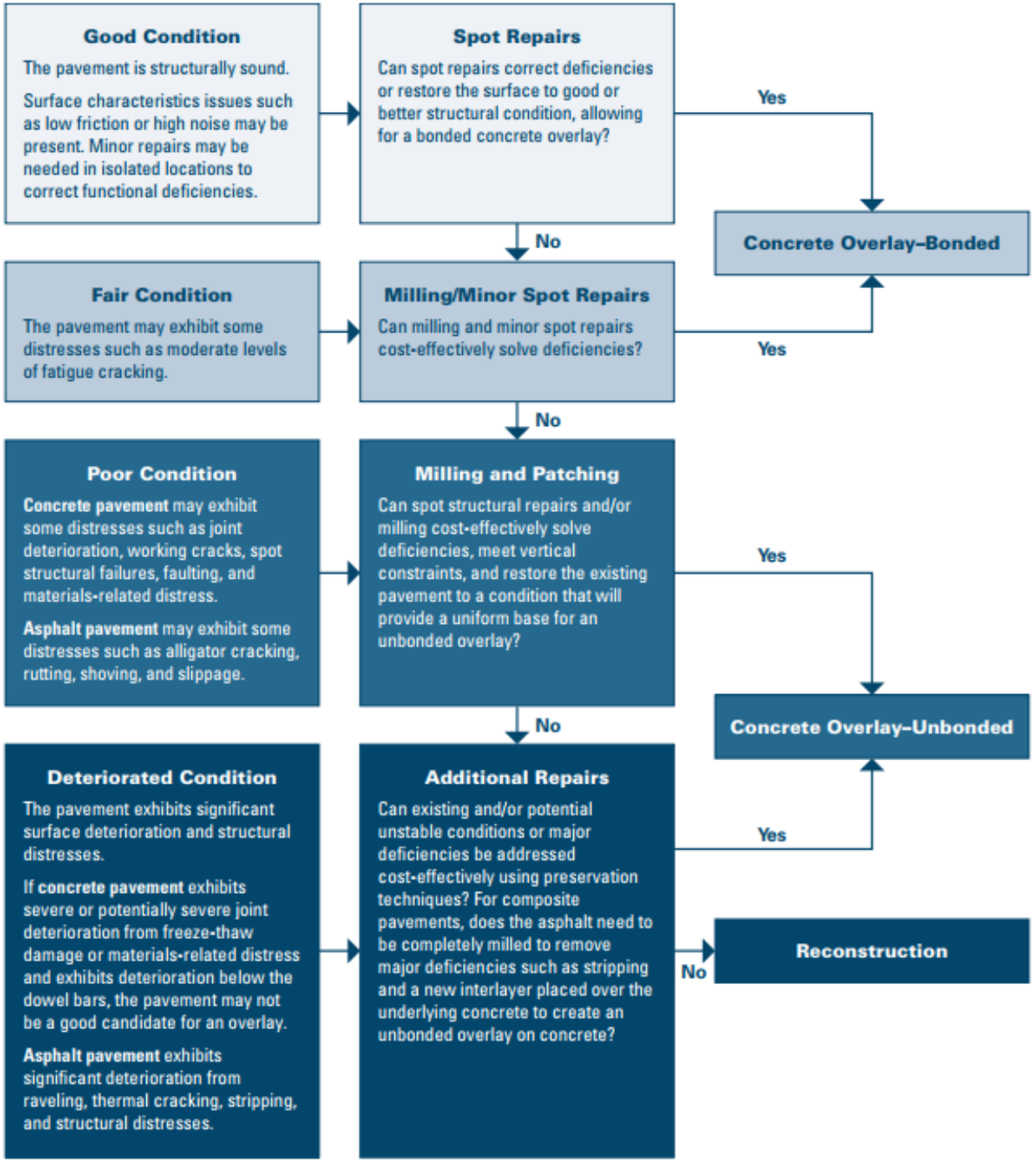
COC–U (JPCP and CRCP)



Overlay Type Selection



Overlay Type Selection



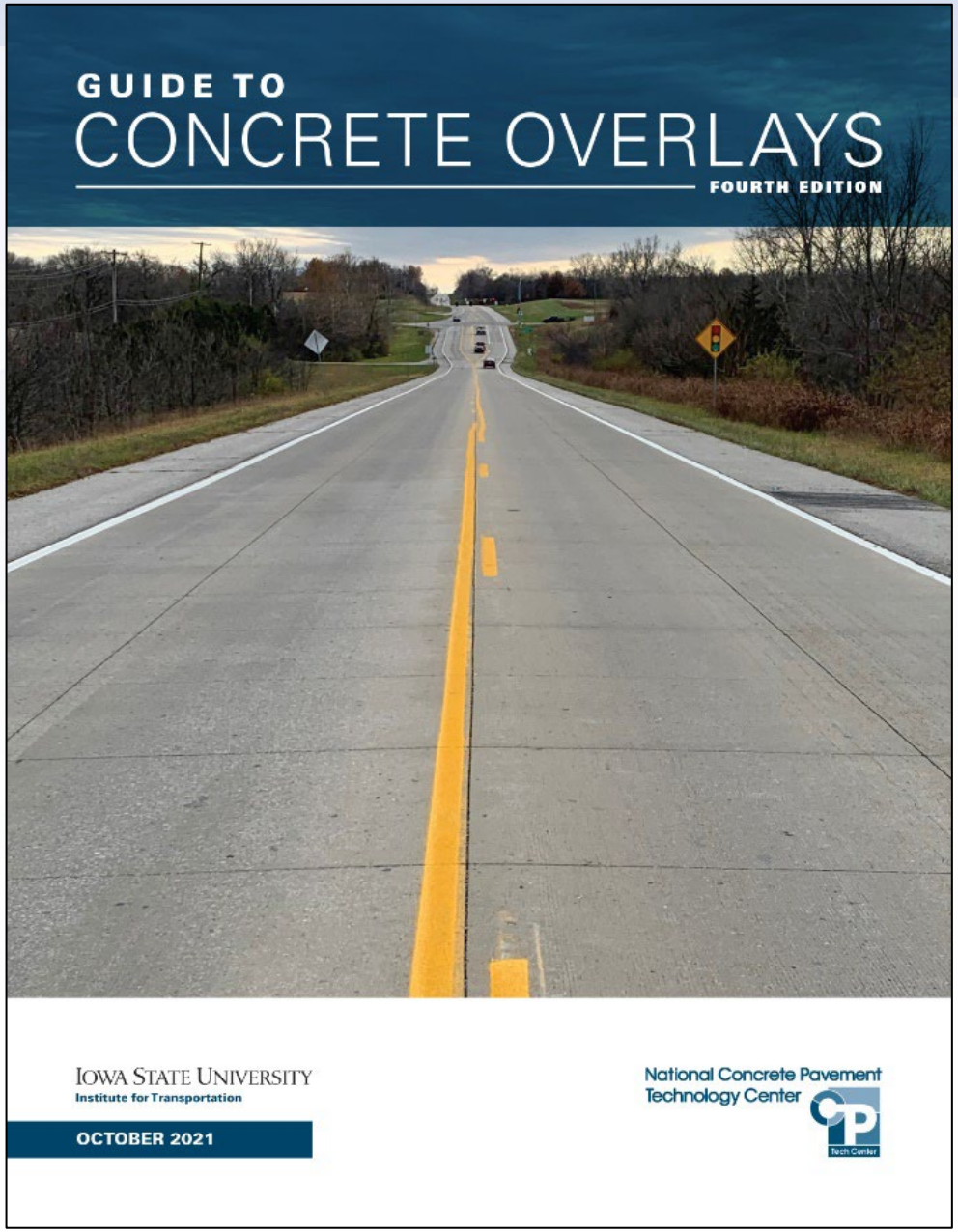
Design Life and Traffic

Planning Information

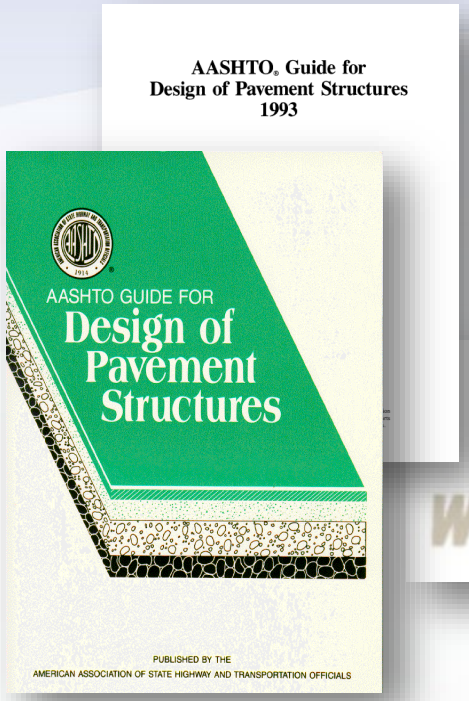
- Determine **Design Life**
  - Usually between 20 – 40+ years
- Current & Projected **Traffic** – ADT & ADTT
  - Directional & lane distribution
  - Current & Expected Adjacent Land Use

Overlay Design Process

- Pavement Evaluation
- Determine Overlay Type
- Determine Design Life and Traffic
- Use Pavement Design Software
- Consider Additional Design Features
- Consider Construction Process
- Create Construction Documents



Selecting a Pavement Design Tool



AASHTO 93 (72?)
(software as ACPA WinPAS)

FREE Industry Developed Tool Based on PCA Method

PavementDesigner.org

AASHTOWare Pavement ME
(previously known as DARWin-ME and MEPDG)

BCOA ME
University of Pittsburgh

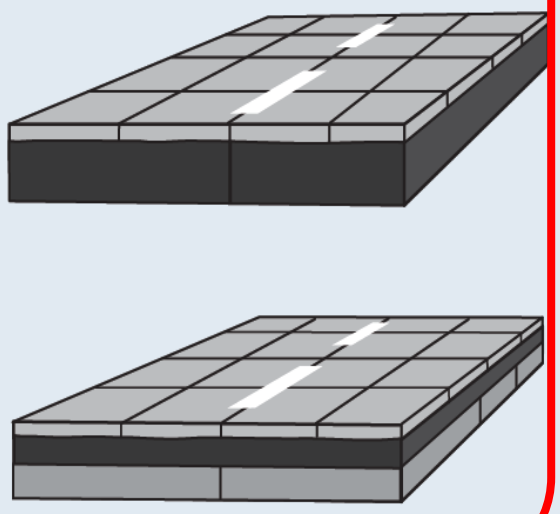
FREE – FHWA Pooled Fund TPF-5(165)
Google "BCOA ME"

Selecting a Pavement Design Tool

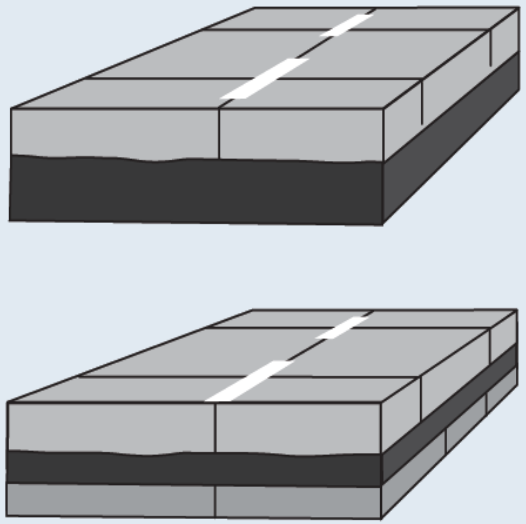
Concrete on Asphalt

Concrete on asphalt (COA) overlays can be designed to address a broad range of existing pavement conditions on both composite and full-depth asphalt pavements. Both bonded (COA–B) and unbonded (COA–U) options enable designs to cost-effectively match the condition of the existing asphalt—from deteriorated to good—as well as geometric parameters.

COA–B (Full Depth and Composite)



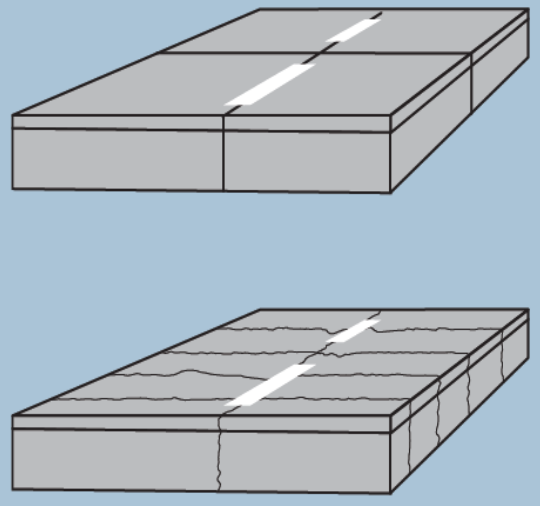
COA–U (Full Depth and Composite)



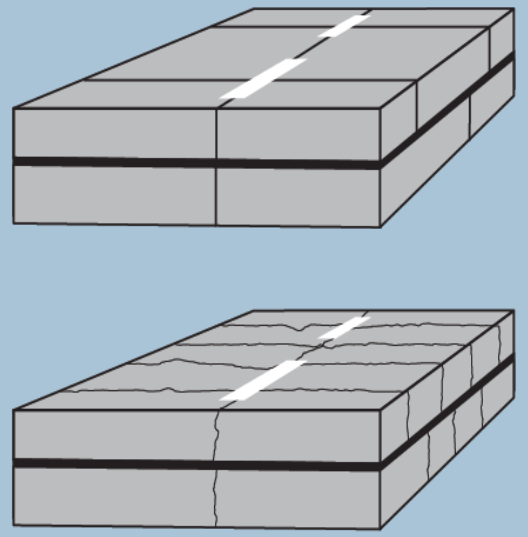
Concrete on Concrete

Concrete on concrete (COC) overlays can be designed for applications on both existing jointed plain concrete pavement (JPCP) and continuously reinforced concrete pavement (CRCP). The predominance of COC overlay designs are unbonded (COC–U) systems; however, bonded (COC–B) applications can be successful, provided the existing pavement is in good condition.

COC–B (JPCP and CRCP)

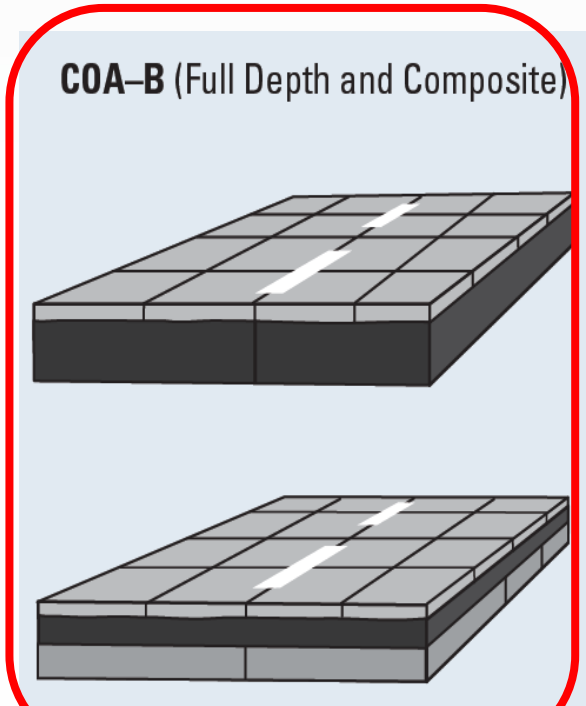


COC–U (JPCP and CRCP)



Selecting a Pavement Design Tool

Best Design Tools for Concrete Overlays on Asphalt – Bonded:



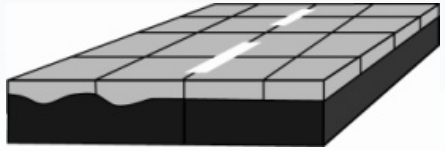
BCOA ME

University of Pittsburgh

PvD AASHTOWare Pavement ME Design

BCOA – ME

Can Design:



Bonded on Asphalt

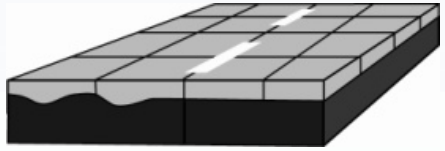
- FREE Mechanistic – Empirical design tool specifically for Concrete Overlays of Asphalt
  - Assumes a partially bonded condition
- Developed at University of Pittsburgh under FHWA Pooled Fund TPF-5(165)
- Incorporates climatic loading
- Joint spacing is featured as an input
- Allows for design with macrofibers directly

Google “BCOA ME” or click:

https://www.engineering.pitt.edu/Sub-Sites/Faculty-Subsites/J_Vandenbossche/BCOA-ME/BCOA-ME/

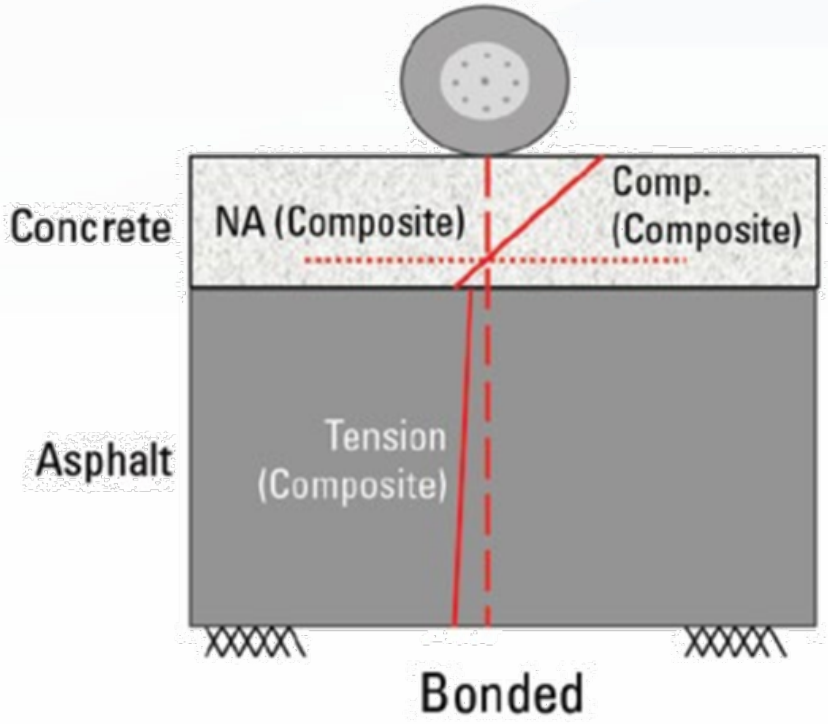
BCOA – ME

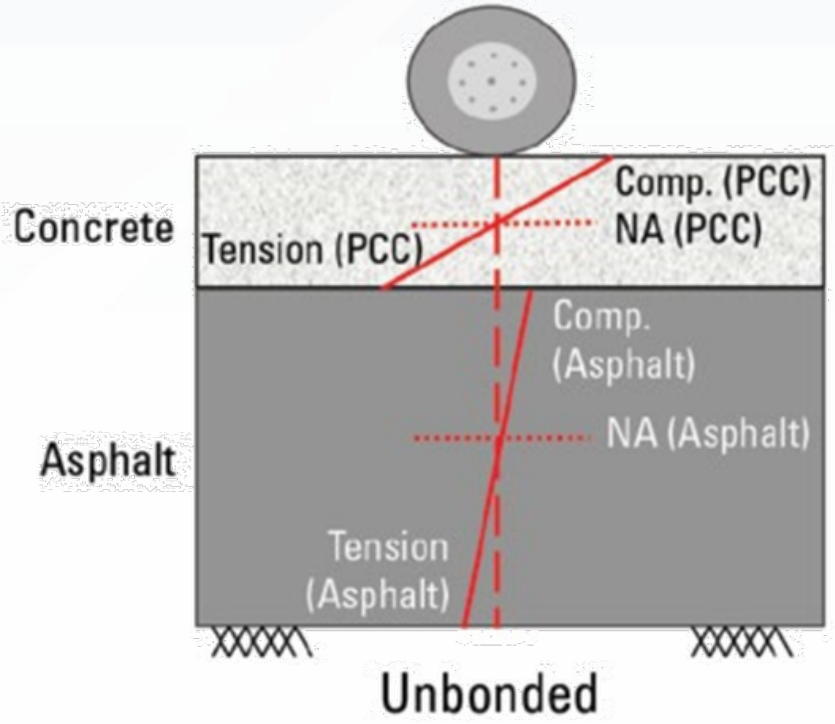
Can Design:



Bonded on Asphalt

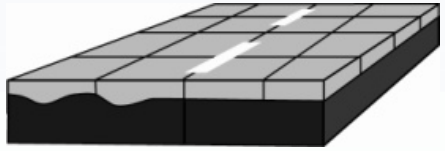
The Impact of Bonding on Asphalt





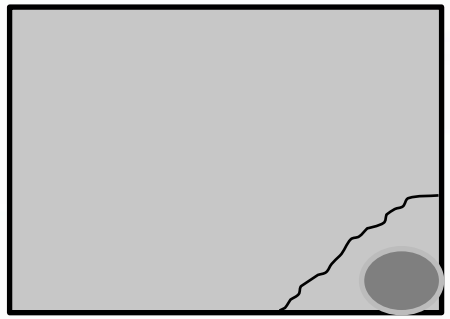
BCOA – ME

Can Design:

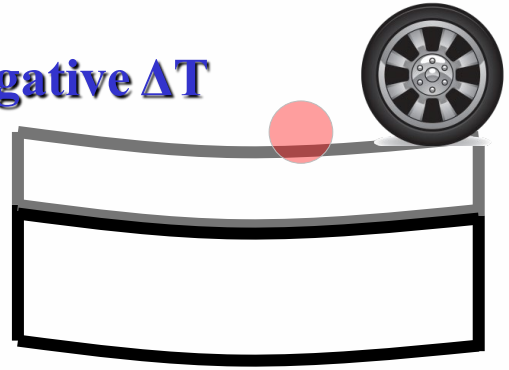


Bonded on Asphalt

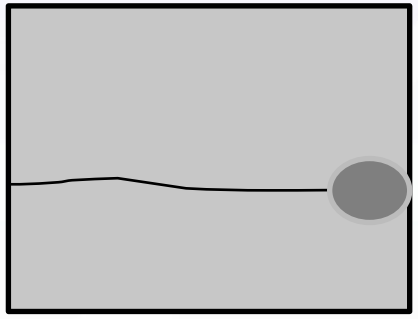
≤ 4.5 ft
Corner Break



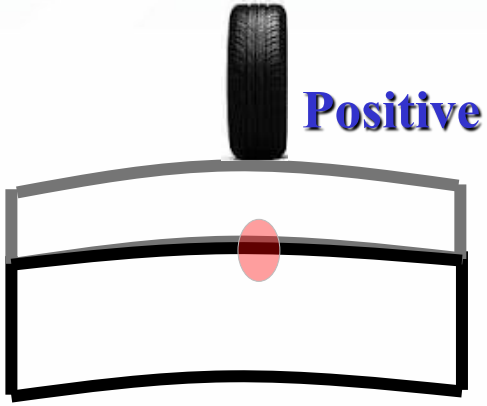
Negative ΔT



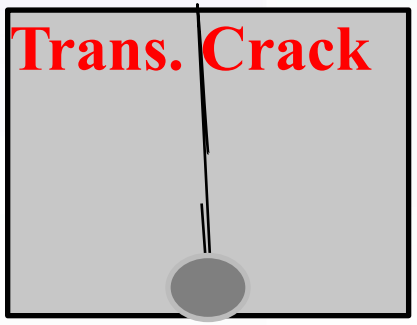
5 to 7 ft
Long. & Diag Crack



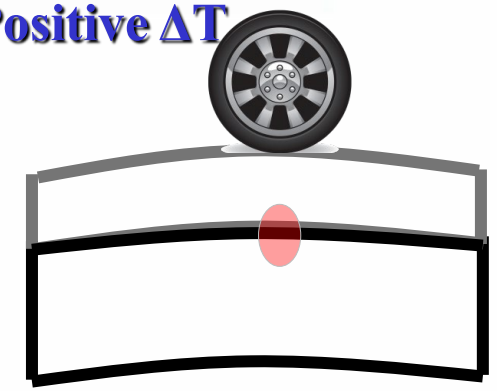
Positive ΔT



10 x 12 ft
12 x 12 ft
12 x 15 ft
Trans. Crack



Positive ΔT



(Last updated: December 2021)

Note: *Please specify ESALs before proceeding to the rest of the inputs.*

GENERAL INFORMATION

Latitude (degree)	:	44.56	GEOGRAPHIC INFO
Longitude (degree)	:	-89.38	
Elevation (ft)	:	1192	
Estimated Design Lane ESALs	:	9949000	ESALS CALCULATOR
Maximum Allowable Percent Slabs Cracked (%)	:	15	
Desired Reliability against Slab Cracking (%)	:	85	

CLIMATE

AMDAT Region ID	1	
Map of Sunshine Zone	5	

EXISTING STRUCTURE

Post-milling HMA Thickness (in)	:	5	
Composite Modulus of Subgrade Reaction, k-value (psi/in)	:	150	K-VALUE CALCULATOR
Does the existing HMA pavement have transverse cracks?		(•) Yes ( ) No	TRANSVERSE CRACKING
HMA Fatigue	:	Adequate	FATIGUE EXAMPLE

HMA properties in the wheelpath:

P200 of HMA (%)	:	4.3
P200 of subbase (%)	:	50
Effective Binder Content by Volume (%)	:	12.5
Air Voids (%)	:	7

PCC OVERLAY PROPERTIES

PCC OVERLAY PROPERTIES

PCC Properties

Average 28-day Flexural Strength (three-poi	650	
Estimated PCC Elastic Modulus (psi) :	4000000	EXECUTE EPCC CALC.
Coefficient of Thermal Expansion (10^{-6} in/in/°F) :	3.8	CTE CALCULATOR
Cement Content (lb/cyd) :	500	
Fiber Type :	No Fibers	FIBER GUIDE

Joint Design

Joint Spacing (ft) :	6 x 6	
Dowel Bar Diameter (in) :	0	
Shoulder Type :	Not Tied	

CALCULATE DESIGN

PERFORMANCE ANALYSIS

PERFORMANCE ANALYSIS

Residual Strength from fibers (if any), f_{150} (psi)

0

Calculated PCC Overlay Thickness (in)

4.78

Design PCC Overlay Thickness (in)

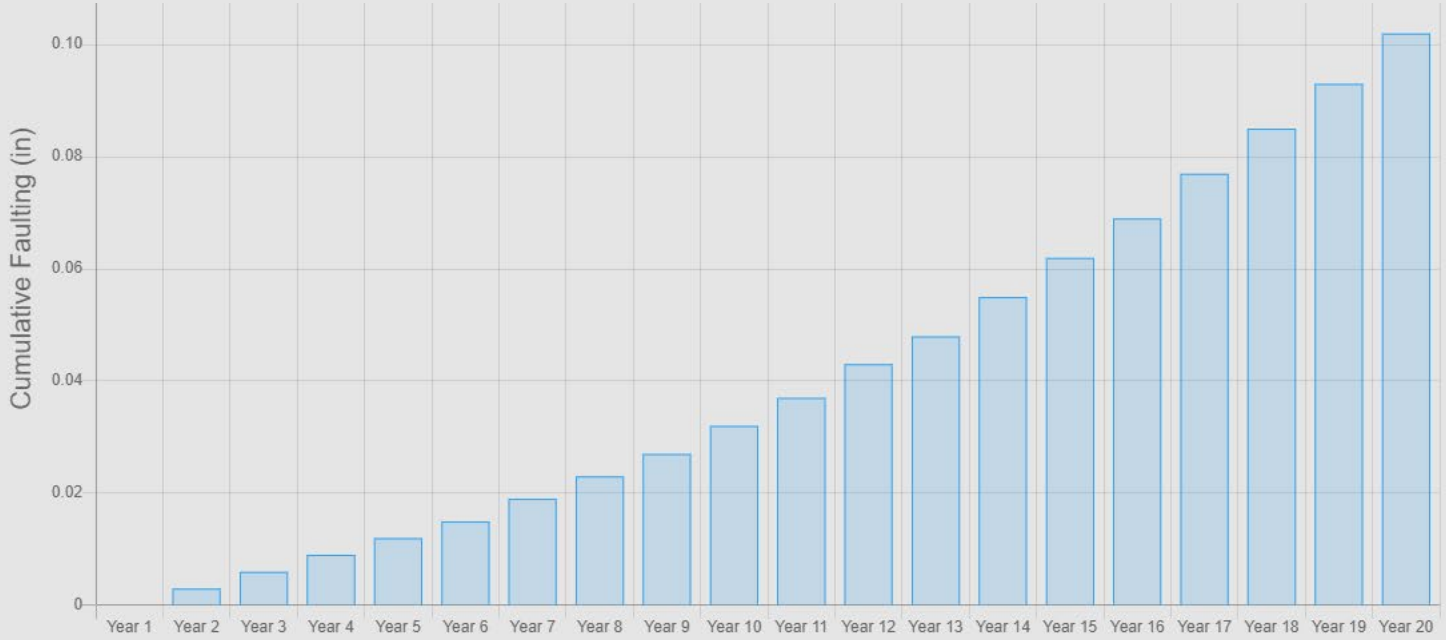
5

Is there potential for reflective cracking?

No

Predicted Faulting (in)

(Effect of fibers, if any, on faulting is not directly considered)

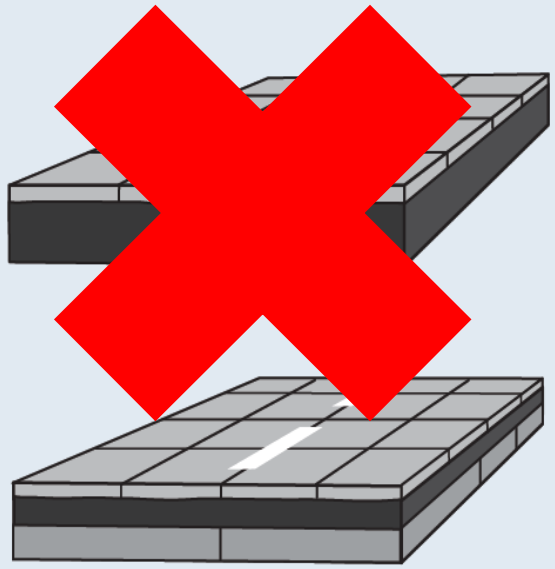


Selecting a Pavement Design Tool

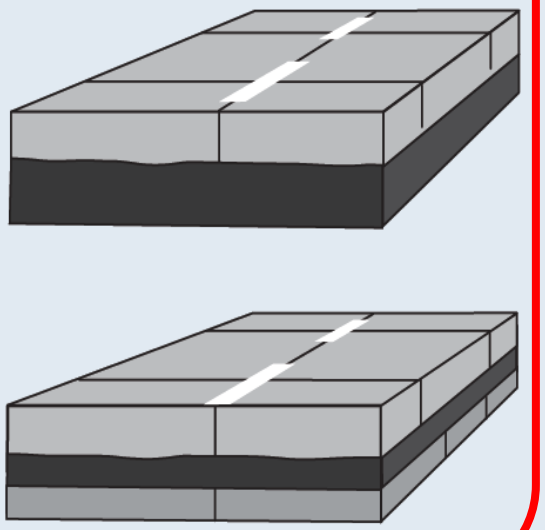
Concrete on Asphalt

Concrete on asphalt (COA) overlays can be designed to address a broad range of existing pavement conditions on both composite and full-depth asphalt pavements. Both bonded (COA–B) and unbonded (COA–U) options enable designs to cost-effectively match the condition of the existing asphalt—from deteriorated to good—as well as geometric parameters.

COA–B (Full Depth and Composite)



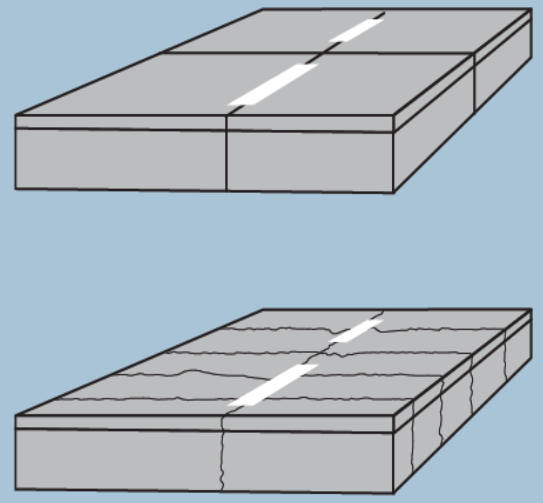
COA–U (Full Depth and Composite)



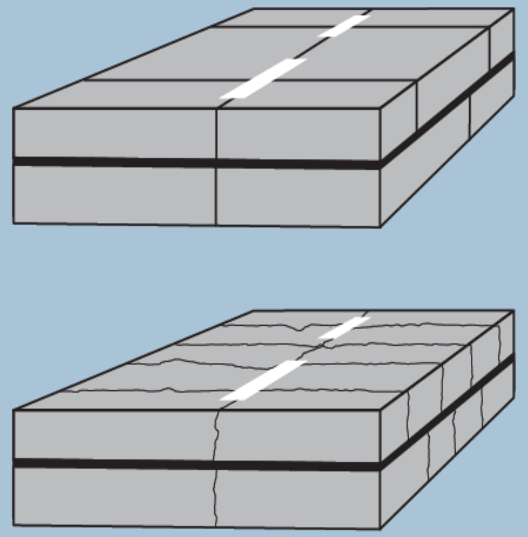
Concrete on Concrete

Concrete on concrete (COC) overlays can be designed for applications on both existing jointed plain concrete pavement (JPCP) and continuously reinforced concrete pavement (CRCP). The predominance of COC overlay designs are unbonded (COC–U) systems; however, bonded (COC–B) applications can be successful, provided the existing pavement is in good condition.

COC–B (JPCP and CRCP)

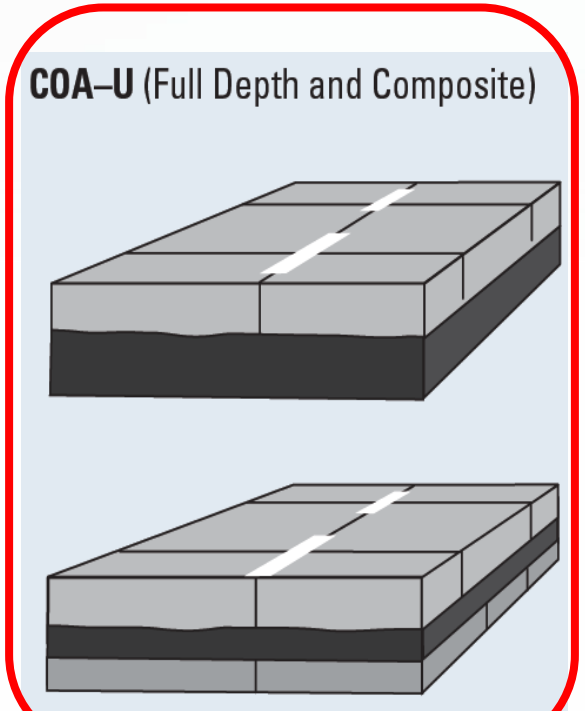


COC–U (JPCP and CRCP)



Selecting a Pavement Design Tool

Best Design Tools for Concrete Overlays on Asphalt – Unbonded:



FREE Industry Developed Tool Based on PCA Method

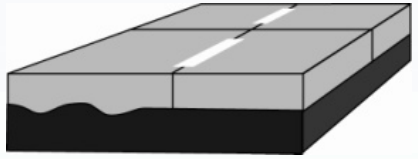
PavementDesigner.org

AASHTOWare Pavement ME Design

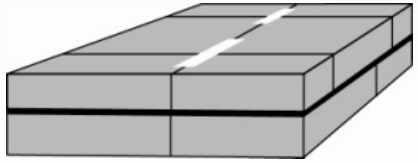
PavementDesigner

PavementDesigner.org

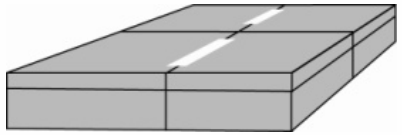
Can Design:



Unbonded on Asphalt



Unbonded on Concrete

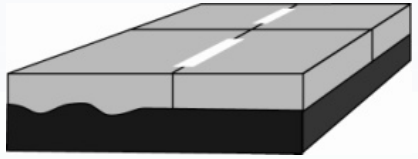


Bonded on Concrete

- FREE, industry-developed, mechanistic-empirical design method
  - Primarily for cities, counties, streets and roads, parking & industrial
- Utilizes PavementDesigner Method (formerly StreetPave/PCA method) developed for JPCP with modifications
- Allows for the use of synthetic macrofibers
- Joint spacing provided as an output
- Failure mechanisms of Cracking and Erosion

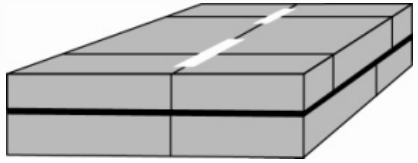
PavementDesigner.org

Can Design:



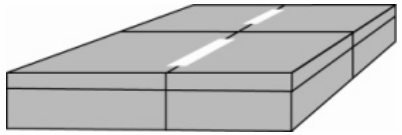
Unbonded on Asphalt

- Unbonded Concrete on Asphalt (UCOA)
  - Treats existing asphalt as a subbase layer



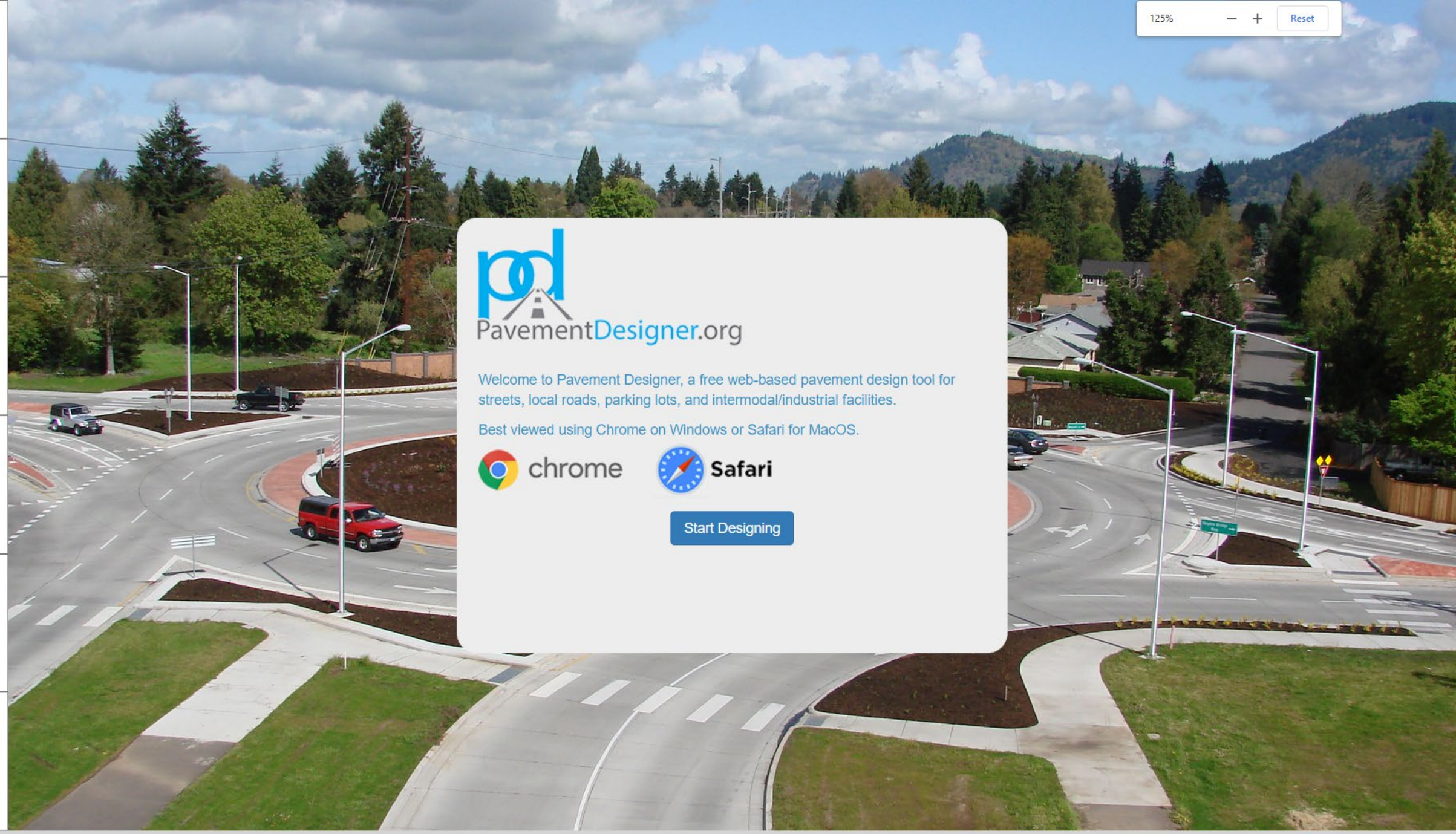
Unbonded on Concrete

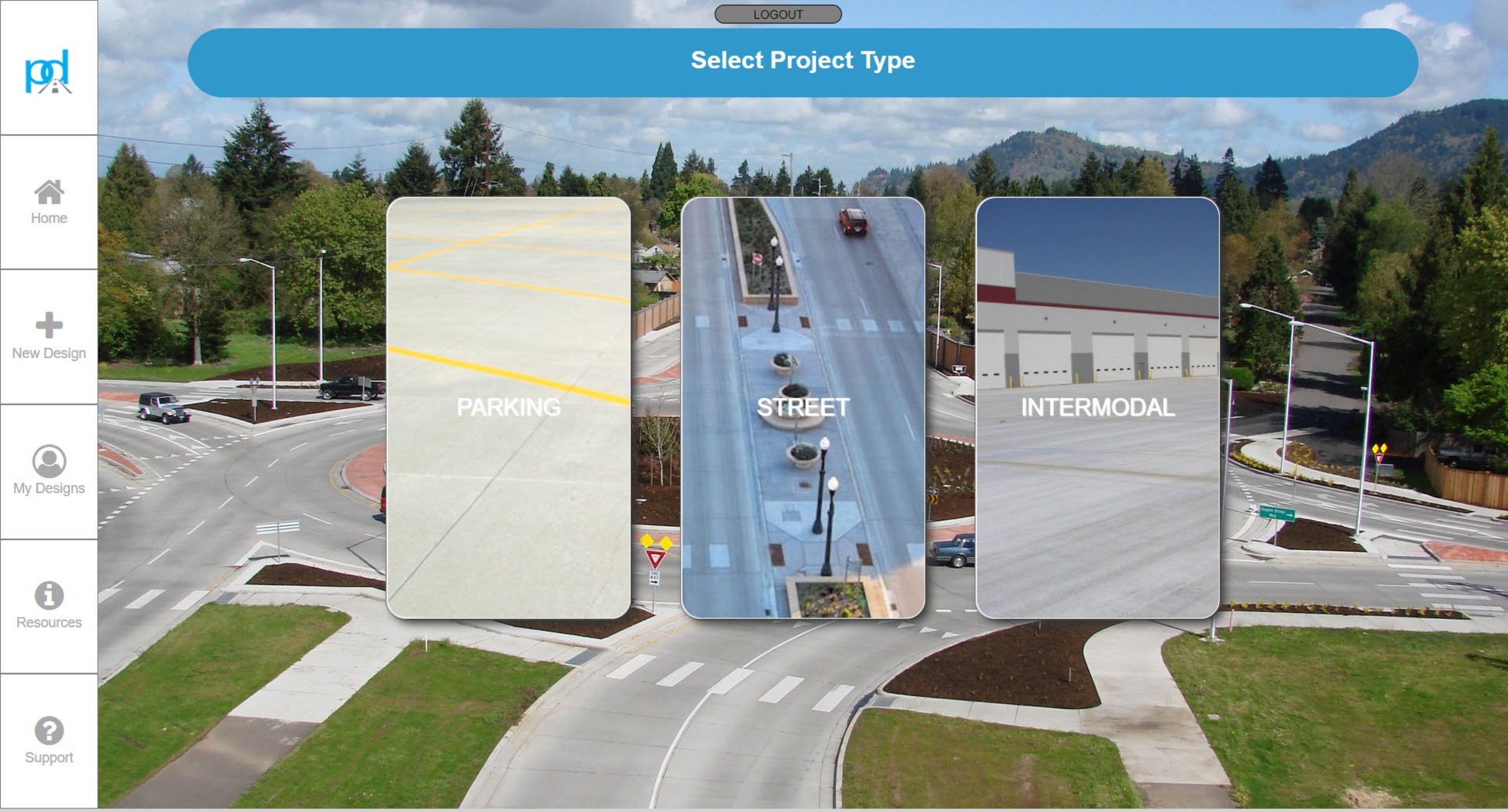
- Unbonded Concrete on Concrete (UCOC)
  - $T_{UCOC} = \sqrt{T_{required}^{\ 2} - T_{effective}^{\ 2}}$



Bonded on Concrete

- Bonded Concrete on Concrete (BCOC)
  - $T_{BCOC} = T_{required} - T_{effective}$


125%
Reset
Home
New Design
My Designs
Resources
Support
PavementDesigner.org
Welcome to Pavement Designer, a free web-based pavement design tool for streets, local roads, parking lots, and intermodal/industrial facilities.
Best viewed using Chrome on Windows or Safari for MacOS.
chrome
Safari
Start Designing
Privacy Policy
Terms of Service


LOGOUT
Select Project Type
Home
New Design
My Designs
Resources
Support
PARKING
STREET
INTERMODAL
Privacy Policy
Terms of Service

LOGOUT

Select Project Type

Home

New Design

My Designs

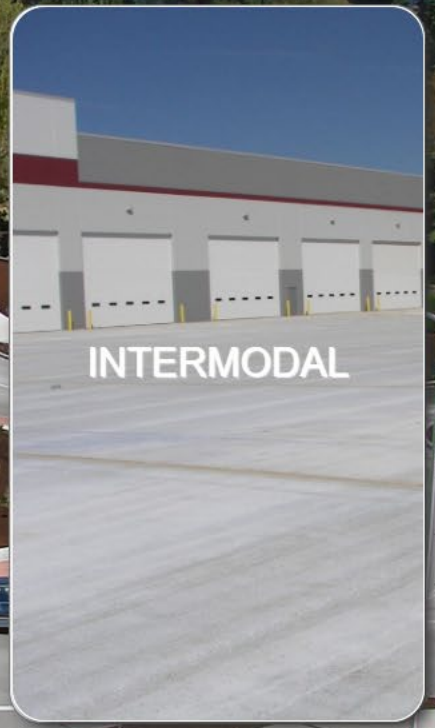
Resources

Support

PARKING

CONCRETE STREETS

A long-lasting solution for conventional over the road traffic. This module can be used to design jointed plain concrete pavement (JPCP), continuously reinforced concrete pavement (CRCP), roller-compacted concrete pavement (RCC), overlays, and composite pavements with stabilized bases and soils. This module should be used for the design of county, town, and city streets.



LOGOUT

Select Project Type

Select Street Project Type

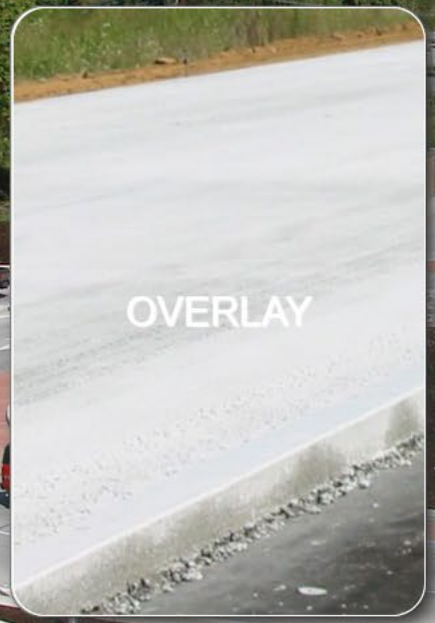
Home

New Design

My Designs

Resources

Support



LOGOUT

Select Project Type

Select Street Project Type

Home

New Design

My Designs

Resources

Support

OVERLAY

For existing pavements that require additional capacity or rehabilitation. Overlays can be unbonded or bonded to existing asphalt or concrete pavements. By utilizing the existing structure, overlays provide a long-lasting pavement.

METHODOLOGY: ACPA StreetPave/PCA Method, AASHTO 93

LOGOUT

1 PROJECT LEVEL | 2 PAVEMENT STRUCTURE | 3 SUMMARY

Home

New Design

My Designs

Resources

Support

Units US METRIC

Help ?

Project Type: Street ❯ Overlay

TRAFFIC

Select Spectrum Type

Design Life

(Years)

User Defined Traffic Info

Trucks/Day

Traffic Growth Rate

(% per year)

Directional Distribution

(%)

Design Lane Distribution

(%)

GLOBAL

Reliability

(%)

% of Slabs Cracked at End of Design Life

(%)

CALCULATED TRAFFIC RESULTS

Avg Trucks/Day in Design Lane over the Design Life

Total Trucks in Design Lane over the Design Life

TRAFFIC SUMMARY DETAILS

Single		Tandem		Tridem	
AXLE LOAD (kips)	AXLES/ 1000 TRUCKS	AXLE LOAD (kips)	AXLES/ 1000 TRUCKS	AXLE LOAD (kips)	AXLES/ 1000 TRUCKS
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0

‹ Change Design Type

SAVE PAVEMENT STRUCTURE

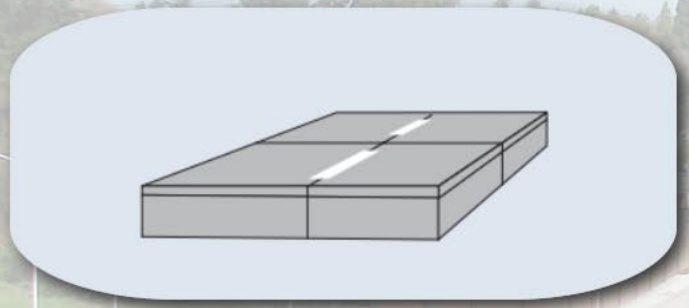
LOGOUT

1 PROJECT LEVEL

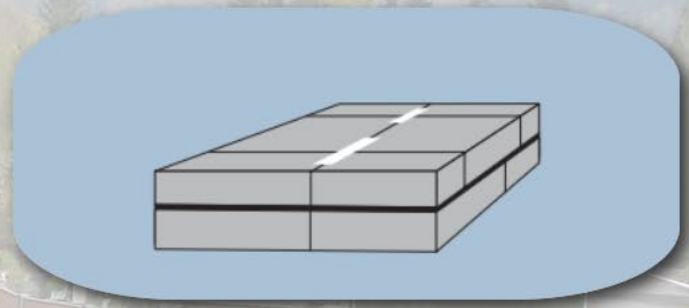
2 PAVEMENT STRUCTURE

3 SUMMARY

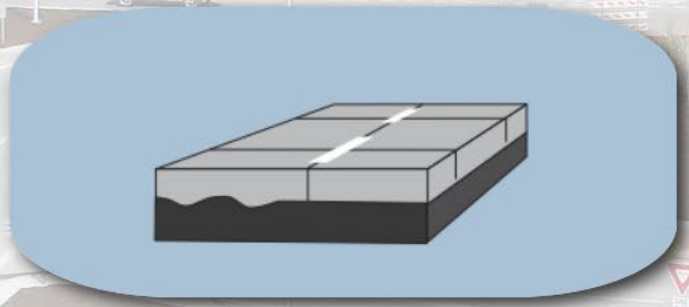
Select Overlay Type



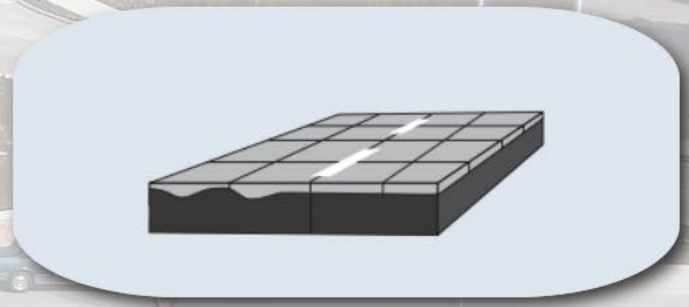
Bonded Concrete



Unbonded Concrete



Unbonded Asphalt



Bonded Asphalt

Home

New Design

My Designs

Resources

Support

Project Level

Privacy Policy

Terms of Service

LOGOUT

Calculation was successful

1 PROJECT LEVEL | 2 PAVEMENT STRUCTURE | 3 SUMMARY

Street › Overlay › Unbonded Asphalt

Units US

Help

Home

New Design

My Designs

Resources

Support

SUBGRADE

CBR (California Bearing Ratio)

CBR VALUE

3 %

Calculated MRSG Value

4,118 psi

CONCRETE

28-Day Flex Strength

3rd Point Loading 28-Day Flex Strength

600 psi

Modulus of Elasticity

4,000,000 psi

Macrofibers in Concrete: Yes / No

Edge Support: Yes / No

STRUCTURE

Subbase Layers: 2

Layer Type	Resilient Modulus	Layer Thickness
CONCRETE OVERLAY (UNBONDED)		
Existing Asphalt	350,000 psi	3 in
Granular Base	25,000 psi	6 in
SUBGRADE		

Calculated Composite K-Value of Substructure: 284 psi/in

Override

Project Level | Privacy Policy | Terms of Service | SAVE | DESIGN SUMMARY

LOGOUT

1 PROJECT LEVEL | 2 PAVEMENT STRUCTURE | 3 SUMMARY

Project Type: Street › Overlay › Unbonded Asphalt

Home

New Design

My Designs

Resources

Support

Calculated Minimum Required Thickness

Doweled	Undoweled
6.29 in	6.29 in

Recommended Design Thickness

Doweled	Undoweled
6.50 in	6.50 in

Maximum Joint Spacing

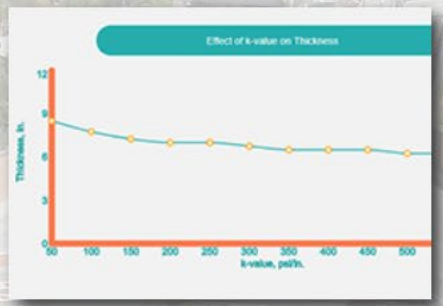
Doweled	Undoweled
11 ft	11 ft

PavementDesigner.org

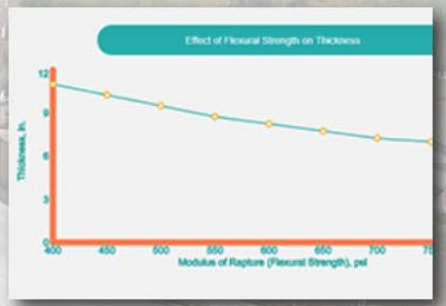
Analysis and Guidance

SENSITIVITY | CRACKING | EROSION | LOAD TRANSFER | JOINT SPACING

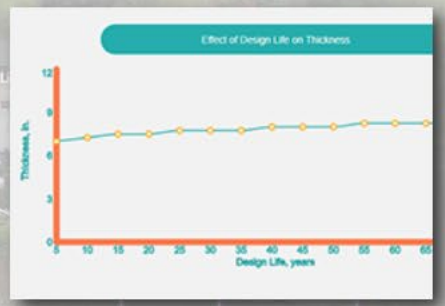
DOWELED | UNDOWELED



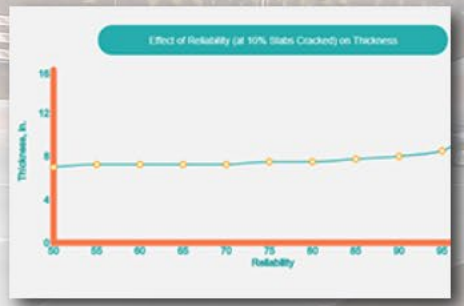
K-Value



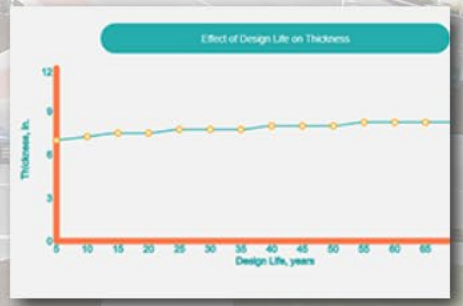
Flexural Strength



Design Life



Reliability



% Slabs Cracked

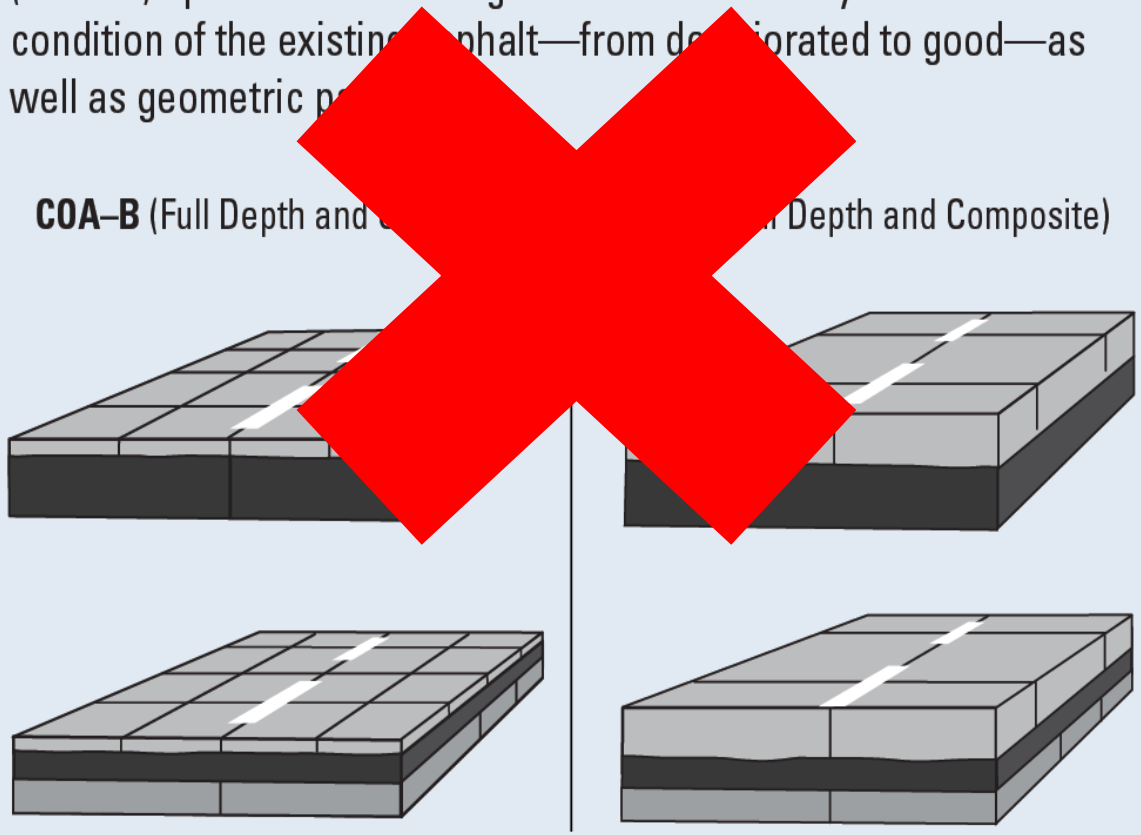
PAVEMENT STRUCTURE | Privacy Policy | Terms of Service | SAVE | GENERATE REPORT

Selecting a Pavement Design Tool

Concrete on Asphalt

Concrete on asphalt (COA) overlays can be designed to address a broad range of existing pavement conditions on both composite and full-depth asphalt pavements. Both bonded (COA–B) and unbonded (COA–U) options enable designs to cost-effectively match the condition of the existing asphalt—from deteriorated to good—as well as geometric p

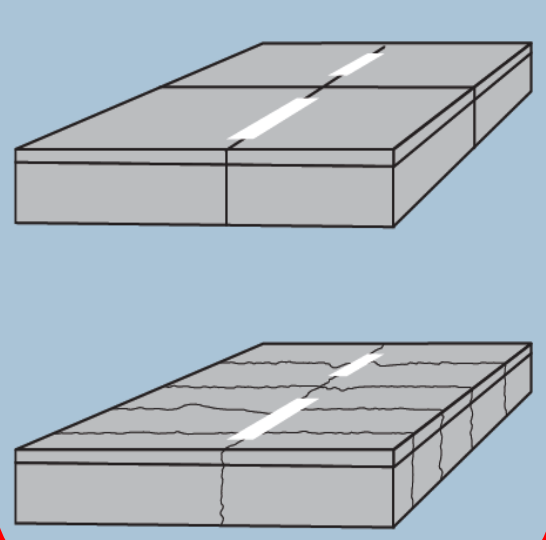
COA–B (Full Depth and Depth and Composite)



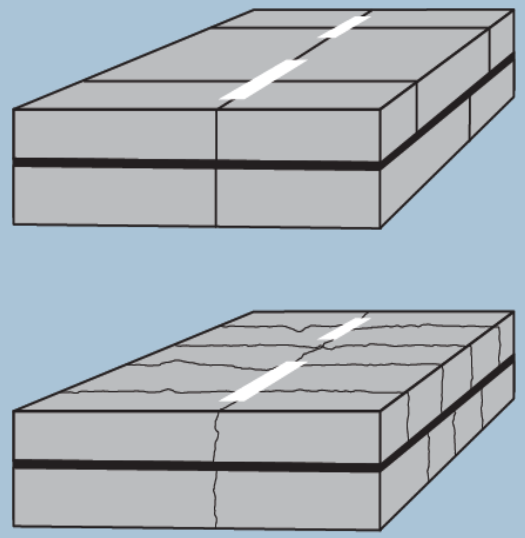
Concrete on Concrete

Concrete on concrete (COC) overlays can be designed for applications on both existing jointed plain concrete pavement (JPCP) and continuously reinforced concrete pavement (CRCP). The predominance of COC overlay designs are unbonded (COC–U) systems; however, bonded (COC–B) applications can be successful, provided the existing pavement is in good condition.

COC–B (JPCP and CRCP)



COC–U (JPCP and CRCP)



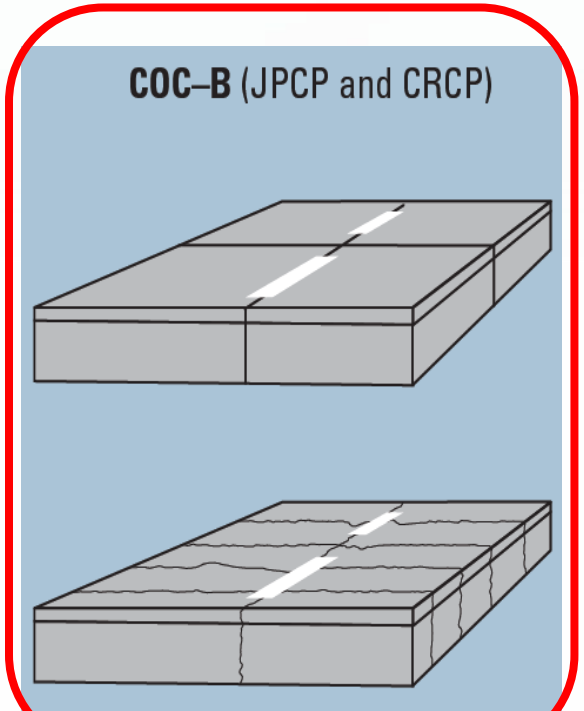
Selecting a Pavement Design Tool

Best Design Tools for Concrete Overlays on Concrete – Bonded:

FREE Industry Developed Tool Based on PCA Method

PavementDesigner.org

AASHTOWare Pavement ME Design



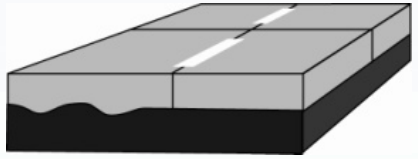
May want to call an expert!

WCPA, ACPA, CP Tech are happy to help!

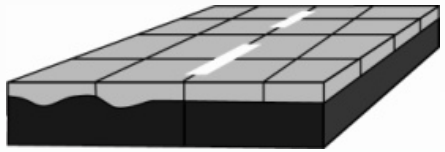
Pavement ME

A.K.A. MEPDG

Can Design:

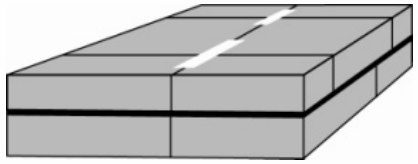


Unbonded on Asphalt

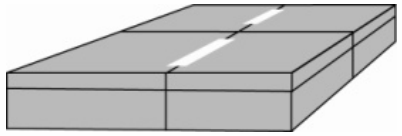


Bonded on Asphalt

"SJPCP"



Unbonded on Concrete



Bonded on Concrete

- AASHTO's current design/analysis tool
  - Current version is 2.6 (Version 3 coming soon!)
- License is yearly-based subscription
- Incorporates climate data
- Allows most control of all design tools
- Features joint spacing as an input
- Failure mechanisms include IRI, Faulting, and Cracking
  - SJPCP only includes longitudinal cracking

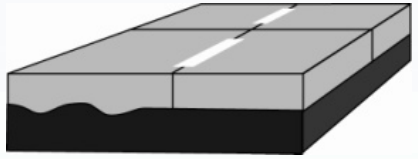
- https://me-design.com/MEDesign/

Pavement ME

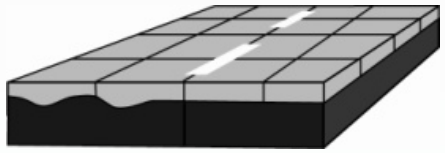
A.K.A. MEPDG

AASHTOWare Pavement ME Design

Can Design:

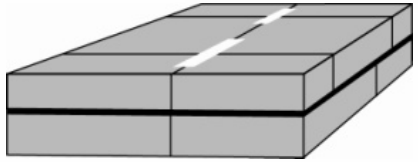


Unbonded on Asphalt

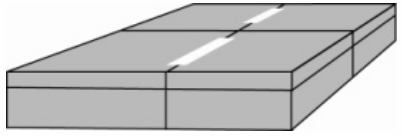


Bonded on Asphalt

"SJPCP"



Unbonded on Concrete



Bonded on Concrete

AASHTOWare Pavement ME Design 2.5.5 (US)

Explorer

- Projects
  - Project1
    - Traffic
      - Single Axle Distribution
      - Tandem Axle Distribution
      - Tridem Axle Distribution
      - Quad Axle Distribution
    - Climate
    - JPCP Design Properties
    - Foundation Support
    - JPCP Rehabilitation
    - Pavement Structure
    - Backcalculation
    - Maintenance Strategy
    - Project Specific Calibration Factors
      - New Flexible
      - Rehabilitation Flexible
      - New Rigid
      - Restore Rigid
      - Bonded Rigid
      - Unbonded Rigid
    - Sensitivity
    - Optimization
    - PDF Output Report
    - Excel Output Report
  - Multiple Project Summary
  - Batch Run
- Tools
- ME Design Calibration Factors

Menu

Recent Files | New | Open | SaveAs | Save | SaveAll | Close | Exit | Run | Batch | Import | Export | Undo | Redo | Help

Progress

Stop All Analysis

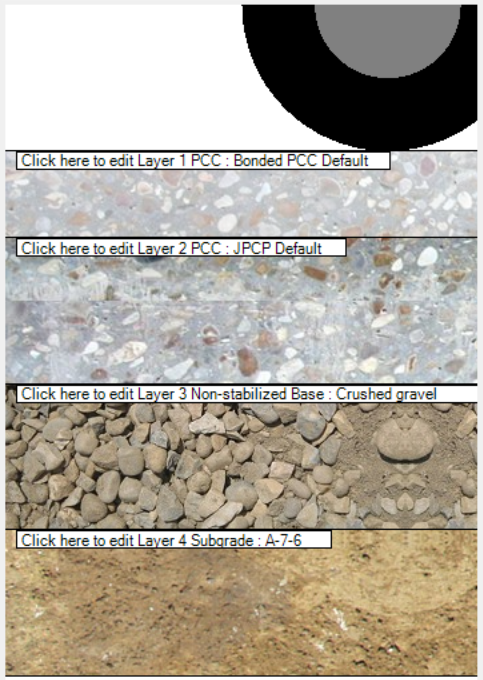
Project1:Project | Project1:Climate*

General Information

Design type:	Overlay	
Pavement type:	Bonded PCC/JPCP	
Design life (years):		20
Existing construction:	May	2023
Pavement construction:	June	2024
Traffic opening:	September	2024

Special traffic loading for flexible pavements

Add Layer | Remove Layer



Performance Criteria	Limit	Reliability	Report Visibility
Initial IRI (in/mile)	63		☑
Terminal IRI (in/mile)	172	90	☑
JPCP transverse cracking (percent slabs)	15	90	☑
Mean joint faulting (in)	0.12	90	☑

Layer 1 PCC : Bonded PCC Default

PCC	
Poisson's ratio	☑ 0.2
Thickness (in)	☑ 6
Unit weight (pcf)	☑ 150
Thermal	
PCC coefficient of thermal expansion (in/in/deg F x 10^-6)	☑ 4.9
PCC heat capacity (BTU/lb-deg F)	☑ 0.28
PCC thermal conductivity (BTU/hr-ft-deg F)	☑ 1.25
Mix	
Aggregate type	Dolomite (2)
Cementitious material content (lb/yd^3)	☑ 600
Cement type	Type I (1)
Water to cement ratio	☑ 0.42
Curing method	Curing Compound
Reversible shrinkage (%)	☑ 50
PCC zero-stress temperature (deg F)	☑ Calculated
Time to develop 50% of ultimate shrinkage (days)	☑ 35
Ultimate shrinkage (microstrain)	☑ 632.3 (calculated)
Strength	
PCC strength and modulus	☑ Level:3 Rupture(690) Modulus(4200000)
Identifiers	
Approver	

Approver
Person who approved use of this object/material/project

Error List

Project	Object	Property	Description

Output

```
Loaded integrated defaults for "SingleAxleDisDefaults.dat".
Loaded integrated defaults for "TandemAxleDisDefaults.dat".
Loaded integrated defaults for "TridemAxleDisDefaults.dat".
Loaded integrated defaults for "QuadAxleDisDefaults.dat".
Loaded integrated defaults for "AxlesPerTruck.dat".
Loaded integrated defaults for "TODInput.dat".
Loaded integrated defaults for "DistributionDefault.dat".
Loaded integrated defaults for "Design\AnalysisLimit.xml".
Loaded integrated defaults for "Design\DefaultJPCPDesign.xml".
```

Compare

Clear Comparison

	Type	Display Name	Project 1

Type here to search

13°F Partly sunny

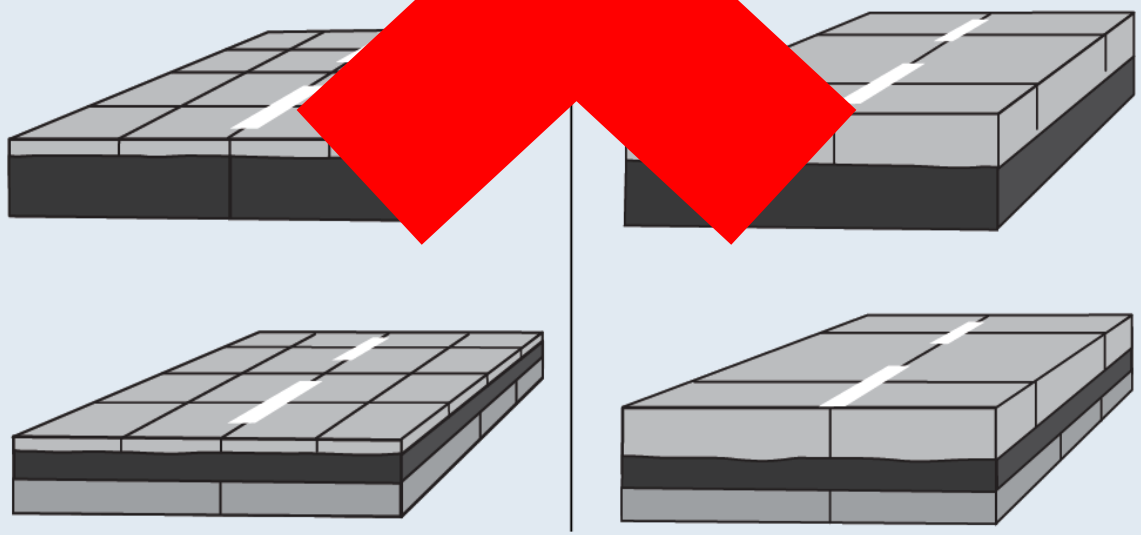
1:40 AM
2/2/2022

Selecting a Pavement Design Tool

Concrete on Asphalt

Concrete on asphalt (COA) overlays can be designed to address a broad range of existing pavement conditions on both composite and full-depth asphalt pavements. Both bonded (COA–B) and unbonded (COA–U) options enable designs to cost-effectively match the condition of the existing asphalt—from deteriorated to good—as well as geometric p

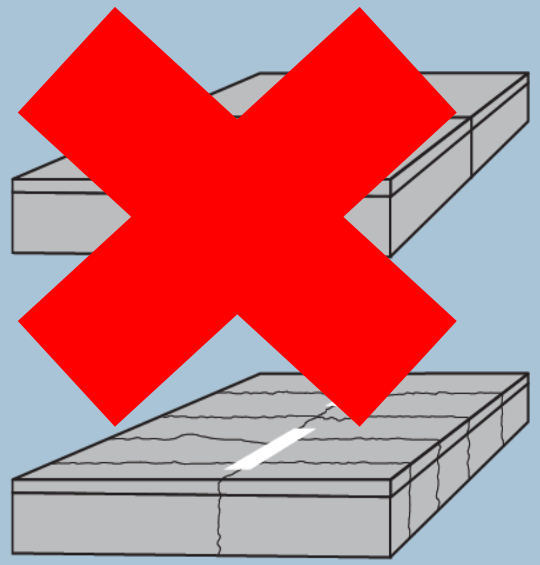
COA–B (Full Depth and Depth and Composite)



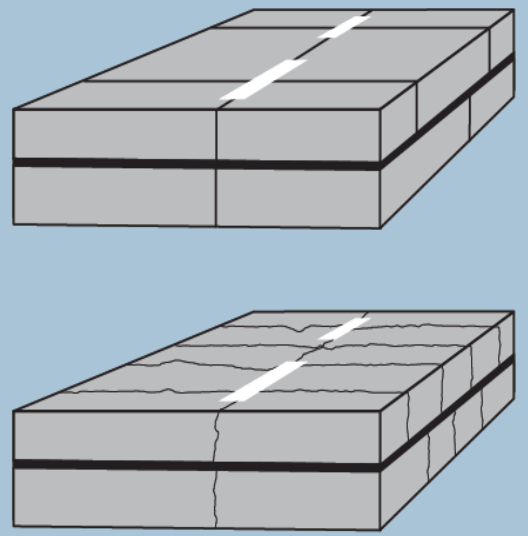
Concrete on Concrete

Concrete on concrete (COC) overlays can be designed for applications on both existing jointed plain concrete pavement (JPCP) and continuously reinforced concrete pavement (CRCP). The predominance of COC overlay designs are unbonded (COC–U) systems; however, bonded (COC–B) applications can be successful, provided the existing pavement is in good condition.

COC–B (JPCP and CRCP)



COC–U (JPCP and CRCP)

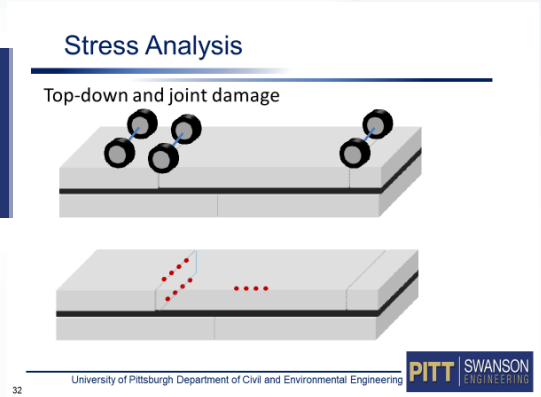


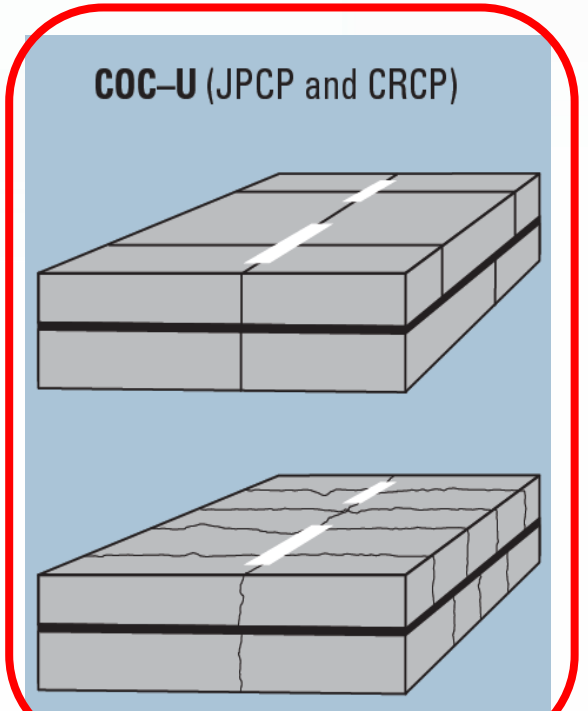
Selecting a Pavement Design Tool

Best Design Tools for Concrete Overlays on Concrete – Unbonded:

PITT | SWANSON ENGINEERING

UNOL





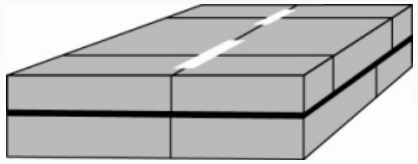
FREE Industry Developed Tool Based on PCA Method

PavementDesigner.org

PvD AASHTOWare Pavement ME Design

UNOL – Unbonded Overlay Design

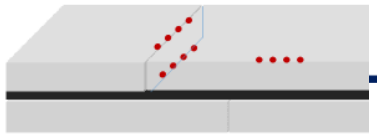
Can Design:



Unbonded on Concrete

Stress Analysis

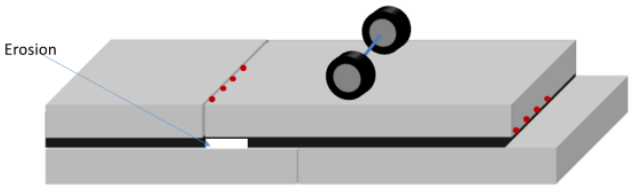
Top-down and joint damage



University of Pittsburgh Department of Civil and Enviror

32

Effect of Interlay Erosion



2 cases

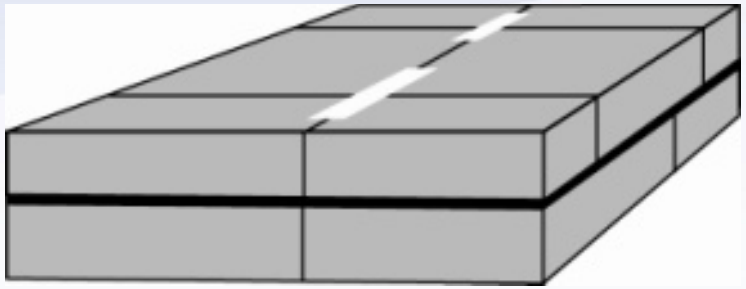
- No void
- 24-in long, lane-wide void

University of Pittsburgh Department of Civil and Environmental Engineering

33

https://software.pavements.pitt.edu/UNOL

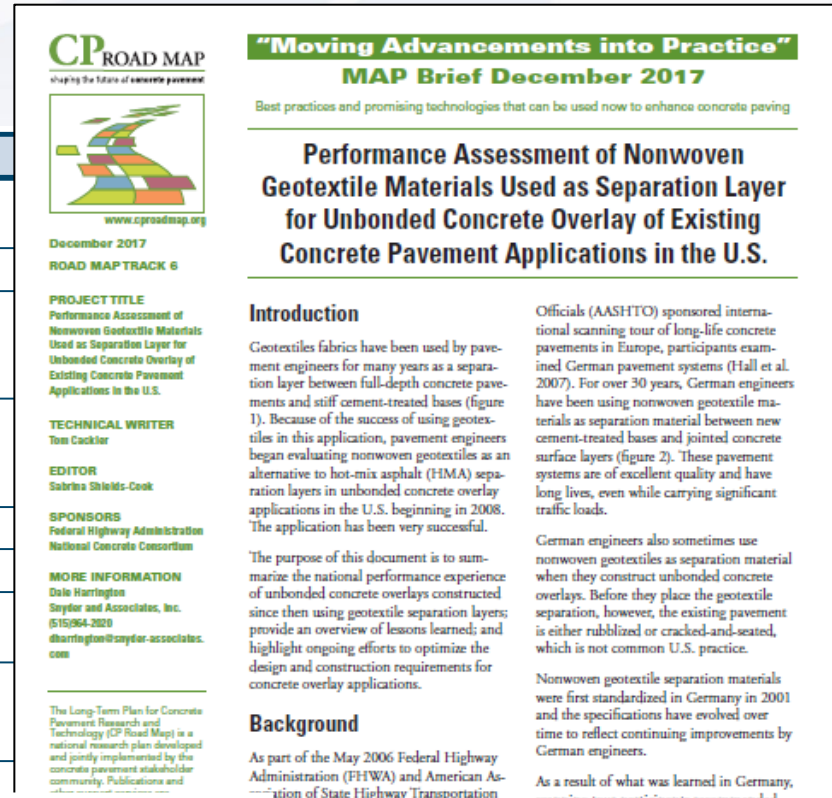
UNOL – Accounts for Bond Breaker Type



- Nonwoven Geotextile or Asphalt Interlayer

Property	Requirements	Test Procedure
Geotextile Type	Nonwoven, needle-punched, no thermal treatment to include calendaring†	EN 13249, Annex F (Certification)
Color	Uniform/nominally same color fibers	(Visual Inspection)
Mass per unit area	≥ 450 g/m² (13.3 oz/yd²)* ≥ 500 g/m² (14.7 oz/yd²) ≤ 550 g/m² (16.2 oz/yd²)	ISO 9864 (ASTM D 5261)
Thickness under load (pressure)	[a] At 2 kPa (0.29 psi): ≥ 3.0 mm (0.12 in.) [b] At 20 kPa (2.9 psi): ≥ 2.5 mm (0.10 in.) [c] At 200 kPa (29 psi): ≥ 0.10 mm (0.04 in.)	ISO 9863-1 (ASTM D 5199)
Wide-width tensile strength	≥ 10 kN/m (685 lb/ft)	ISO 10319 (ASTM D 4595)
Wide-width maximum elongation	≤ 130 percent	ISO 10319 (ASTM D 4595)
Water permeability in normal direction under load (pressure)	≥ 1 x 10^{-4} m/s (3.3 x 10^{-4} ft/s) at 20 kPa (2.9 psi)	DIN 60500-4 (modified ASTM D 5493)
In-plane water permeability (transmissivity) under load (pressure)	[a] ≥ 5 x 10^{-4} m/s (1.6 x 10^{-3} ft/s) at 20 kPa (2.9 psi) [b] ≥ 2 x 10^{-4} m/s (6.6 x 10^{-4} ft/s) at 200 kPa (2.9 psi)	ISO 12958 (ASTM D 6574)* or ISO 12958 (modified ASTM D 4716)
Weather resistance	Retained strength ≥ 60 percent	EN 12224 (ASTM D 4355 @ 500 hrs exposure for
Alkali resistance	≥ 96 percent polyproplene/polyethylene	

- https://cptechcenter.org/geotextiles/
- http://www.acpa.org/wp-content/uploads/2018/10/ACPAGeotextileGuideSpec-v1-5.pdf



CP ROAD MAP

shaping the future of concrete pavement

www.cproadmap.org

December 2017

ROAD MAP TRACK 6

PROJECT TITLE
Performance Assessment of Nonwoven Geotextile Materials Used as Separation Layer for Unbonded Concrete Overlay of Existing Concrete Pavement Applications in the U.S.

TECHNICAL WRITER
Tom Cackler

EDITOR
Sabrina Shields-Cook

SPONSORS
Federal Highway Administration
National Concrete Consortium

MORE INFORMATION
Dale Harrington
Snyder and Associates, Inc.
(515)964-2020
dharrington@snyder-associates.com

The Long-Term Plan for Concrete Pavement Research and Technology (CP Road Map) is a national research plan developed and jointly implemented by the concrete pavement stakeholder community. Publications and

"Moving Advancements into Practice"

MAP Brief December 2017

Best practices and promising technologies that can be used now to enhance concrete paving

Performance Assessment of Nonwoven Geotextile Materials Used as Separation Layer for Unbonded Concrete Overlay of Existing Concrete Pavement Applications in the U.S.

Introduction

Geotextiles fabrics have been used by pavement engineers for many years as a separation layer between full-depth concrete pavements and stiff cement-treated bases (figure 1). Because of the success of using geotextiles in this application, pavement engineers began evaluating nonwoven geotextiles as an alternative to hot-mix asphalt (HMA) separation layers in unbonded concrete overlay applications in the U.S. beginning in 2008. The application has been very successful.

The purpose of this document is to summarize the national performance experience of unbonded concrete overlays constructed since then using geotextile separation layers; provide an overview of lessons learned; and highlight ongoing efforts to optimize the design and construction requirements for concrete overlay applications.

Background

As part of the May 2006 Federal Highway Administration (FHWA) and American Association of State Highway Transportation Officials (AASHTO) sponsored international scanning tour of long-life concrete pavements in Europe, participants examined German pavement systems (Hall et al. 2007). For over 30 years, German engineers have been using nonwoven geotextile materials as separation material between new cement-treated bases and jointed concrete surface layers (figure 2). These pavement systems are of excellent quality and have long lives, even while carrying significant traffic loads.

German engineers also sometimes use nonwoven geotextiles as separation material when they construct unbonded concrete overlays. Before they place the geotextile separation, however, the existing pavement is either rubblized or cracked-and-seated, which is not common U.S. practice.

Nonwoven geotextile separation materials were first standardized in Germany in 2001 and the specifications have evolved over time to reflect continuing improvements by German engineers.

As a result of what was learned in Germany, scanning tour participants recommended

Table 4. Recommended geotextile thickness

Overlay Thickness	Recommended non-woven geotextile thickness
< 5 in.	13.3 oz./yd²
≥ 5 in.	14.7 oz./yd²

re 1. Placement of nonwoven geotextile rlayer

Figure 2. Core from Germany showing nonwoven geotextile interlayer between surface concrete (left) and cement-treated base (right)

UNOL: Unbonded Overlay Design Version 1.0

Project Report

Reliability Analysis: Yes

Evaluate Faulting?

Climate Station: MILWAUKEE WI

Design Life, years: 25

Cracking Reliability, %: 85

Faulting Reliability, %: 85

Two-way AADTT in Year 1: 2000

Linear Yearly Growth, %: 3

Number of Lanes (two way): 2

Joint Spacing, ft: 13.5

Dowel Diamater, in: 1.25

Shoulder Type: Asphalt/Non-Tied PCC/Aggregate

PCC Flexural Strength, psi: 650

Existing PCC Thickness, in: 9

Existing PCC Modulus, psi: 4000000

Interlayer Type: Fabric

Show Settings

Run

Results

Required PCC Overlay Thickness:	Cracking at Specified Reliability:	Cracking at 50% Reliability:
7.3 in	**13.62 %**	**4.49 %**

Faulting at Specified Reliability:	Faulting at 50% Reliability:	Design Traffic :
0.007 in	**0.003 in**	**21.78 million ESALs**

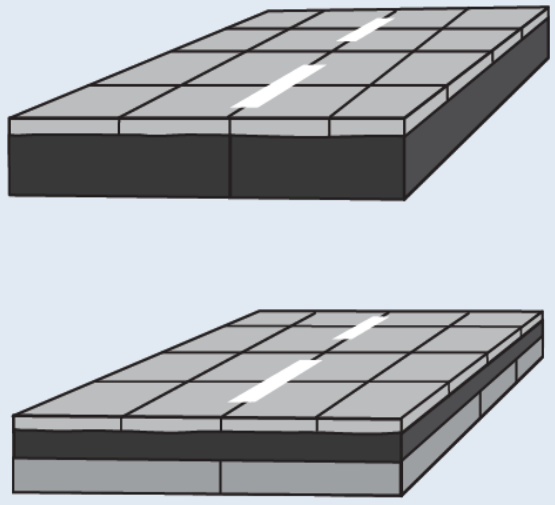
Print Solution

Selecting a Pavement Design Tool

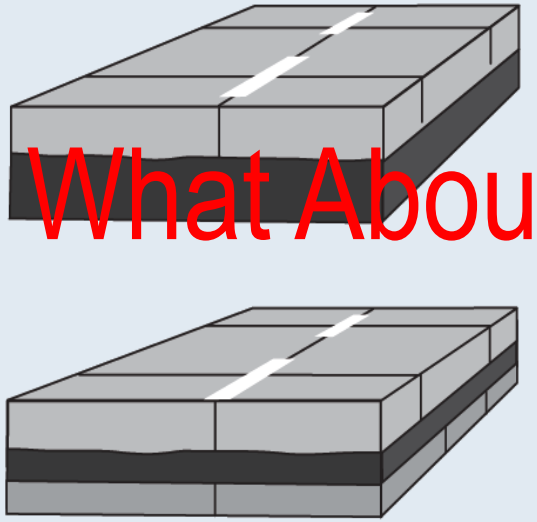
Concrete on Asphalt

Concrete on asphalt (COA) overlays can be designed to address a broad range of existing pavement conditions on both composite and full-depth asphalt pavements. Both bonded (COA–B) and unbonded (COA–U) options enable designs to cost-effectively match the condition of the existing asphalt—from deteriorated to good—as well as geometric parameters.

COA–B (Full Depth and Composite)



COA–U (Full Depth and Composite)

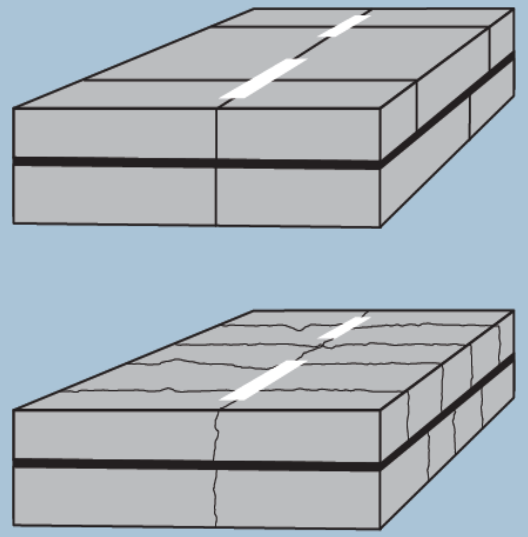


Concrete on Concrete

Concrete on concrete (COC) overlays can be designed for applications on both existing jointed plain concrete pavement (JPCP) and continuously reinforced concrete pavement (CRCP). The predominance of COC overlay designs are unbonded (COC–U) systems; however, bonded (COC–B) applications can be successful, provided the existing pavement is in good condition.

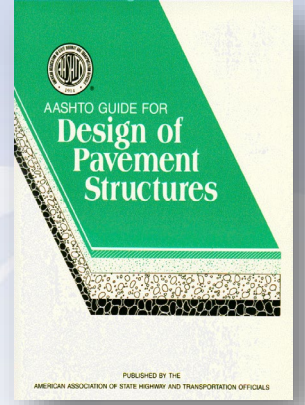
COC–B (JPCP and CRCP)

COC–U (JPCP and CRCP)

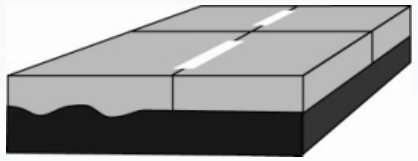


What About AASHTO 93?

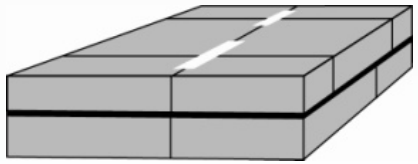
AASHTO 93 (or 72)



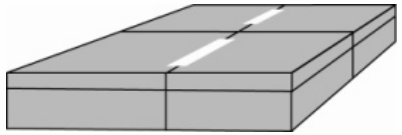
Can Design:



Unbonded on Asphalt



Unbonded on Concrete



Bonded on Concrete

- Utilizes AASHTO 93/86 design equations with modifications

Change in Serviceabi

Standard Normal Deviate

Overall Standard Deviation

Thickness

$$Log(ESAL) = Z_R * s_o + 7.35 * Log(D+1) - 0.06 + \left[\frac{Log\left[\frac{\Delta PSI}{4.5-1.5}\right]}{1 + \frac{1.624*10^7}{(D+1)^{8.46}}} \right]$$

"Traffic"

Terminal Serviceability

Modulus of Rupture

Drainage Coefficient

$$+(4.22-0.32*p_t)*Log\left[\frac{S_c'*C_d*(D^{0.75}-1.132)}{215.63*J*\left[D^{0.75}-\frac{18.42}{(E_c/k)^{0.25}}\right]}\right]$$

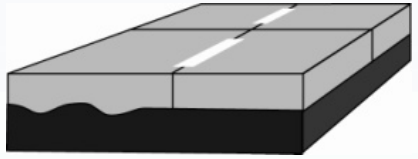
Load Transfer

Modulus of Elasticity

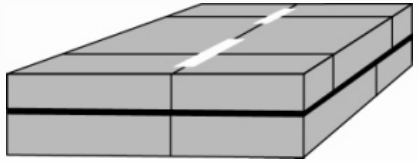
Modulus of Subgrade Reactio

AASHTO 93

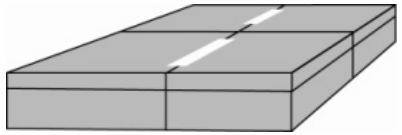
Can Design:



Unbonded on Asphalt



Unbonded on Concrete

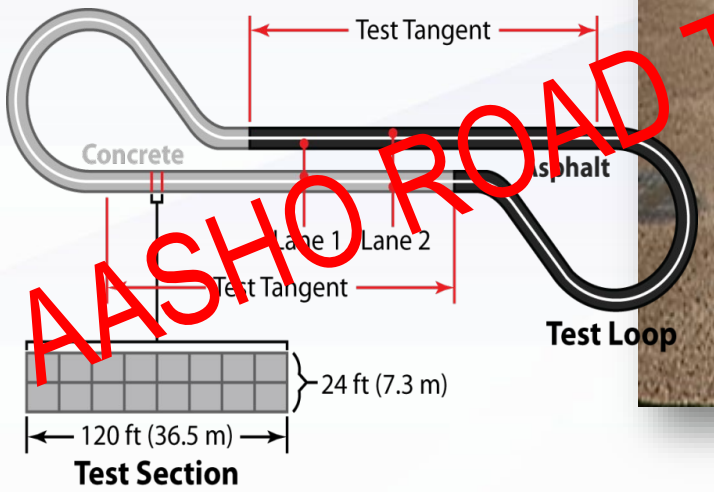


Bonded on Concrete

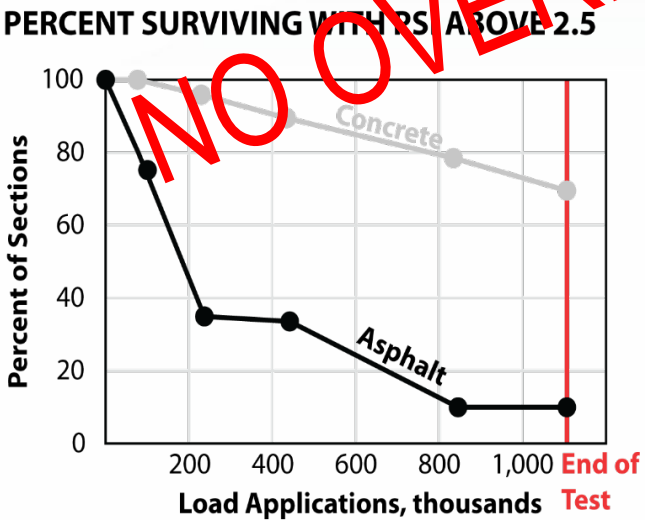
- Unbonded Concrete on Asphalt (UCOA)
  - Treats existing asphalt as a subbase layer
- Unbonded Concrete on Concrete (UCOC)
  - $T_{UCOC} = \sqrt{T_{required}^{\ 2} - T_{effective}^{\ 2}}$
- Bonded Concrete on Concrete (BCOC)
  - $T_{BCOC} = T_{required} - T_{effective}$

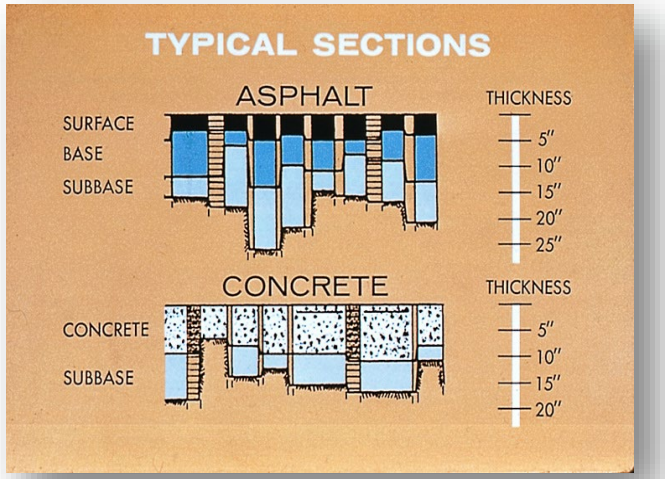
AASHTO 93 and 72

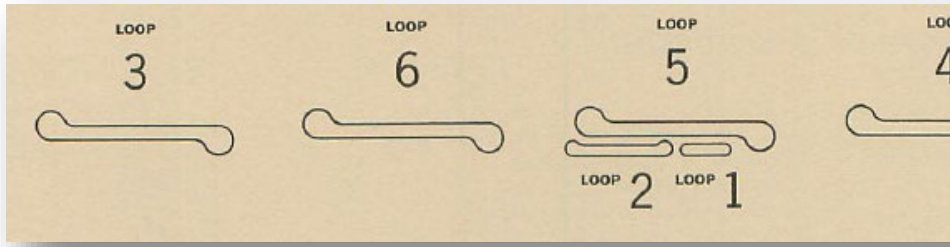
- Wholly empirical – AASHO Road Test
- Limited inference space:
  - Materials
  - Structural sections
  - Soils
  - Traffic
  - Climate
- Failure is "Serviceability"



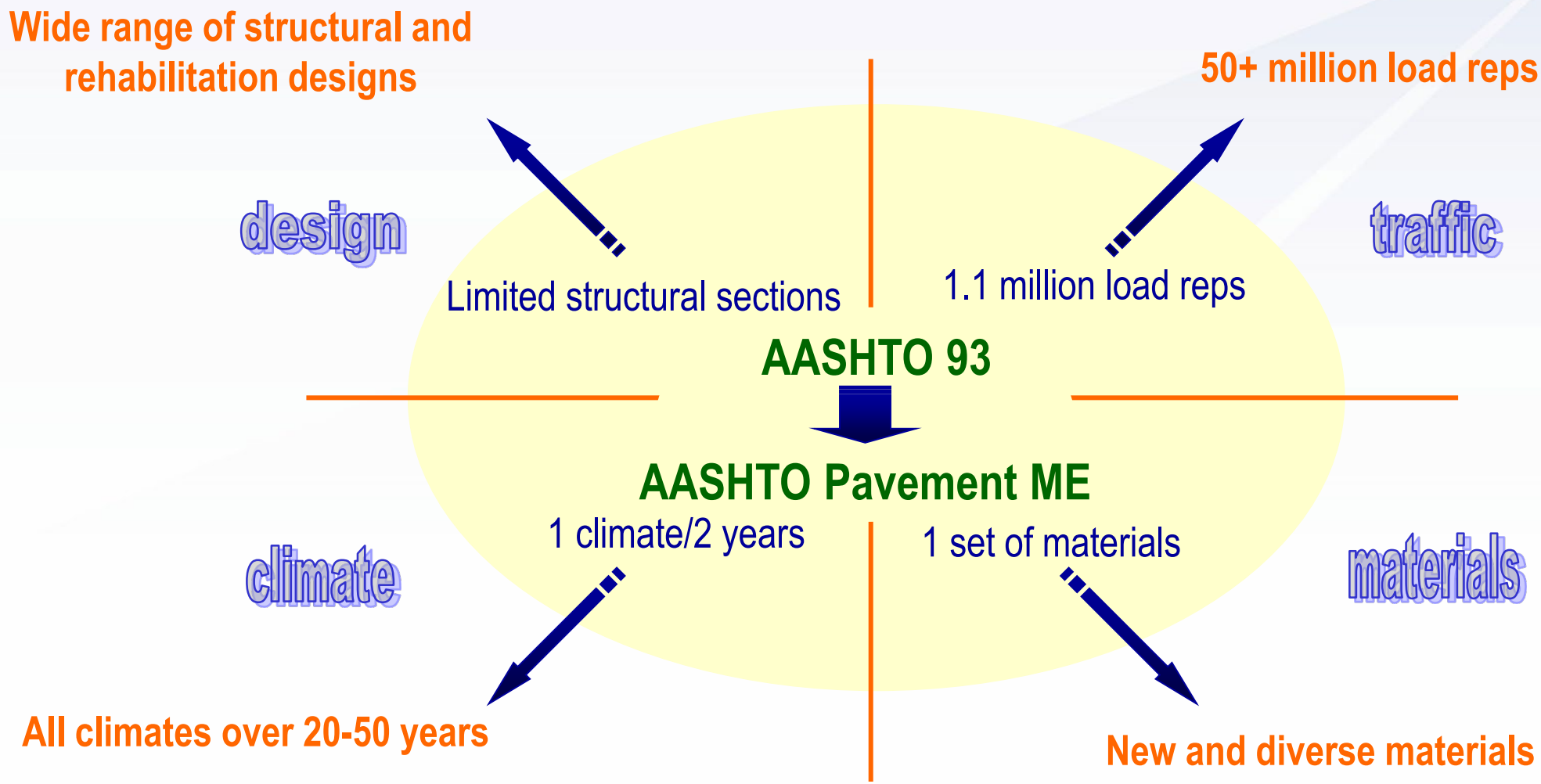
NO OVERLAYS AT AASHO ROAD TEST!!!!!







AASHTO 93 vs. ME



Design Tool Summary

	AASHTO 93	PavementDesigner	BCOA – ME	UNOL	Pavement ME
Designs for:					
Unbonded on Asphalt	Yes[1]	Yes[1]			Yes
Bonded on Asphalt		Links to BCOA-ME	Yes		Yes (SJPCP)
Unbonded on Concrete	Yes[1]	Yes[1]		Yes	Yes
Bonded on Concrete	Yes[1]	Yes[1]			Yes
Failure Criteria:					
Cracking		Yes	Yes	Yes	Yes
Faulting		Yes	Yes	Yes	Yes[2]
IRI					Yes[2]
Additional Design Information:					
Mechanistic – Empirical		Yes	Yes	Yes	Yes
Climatic Loading			Yes	Yes	Yes
Joint Spacing		Output	Input	Input	Input
Design with Fibers in Tool		Yes	Yes		

[1] Via modifications to conventional JPCP design
[2] Not in SJPCP Module

Overlay Jointing Practices

Joint Spacing

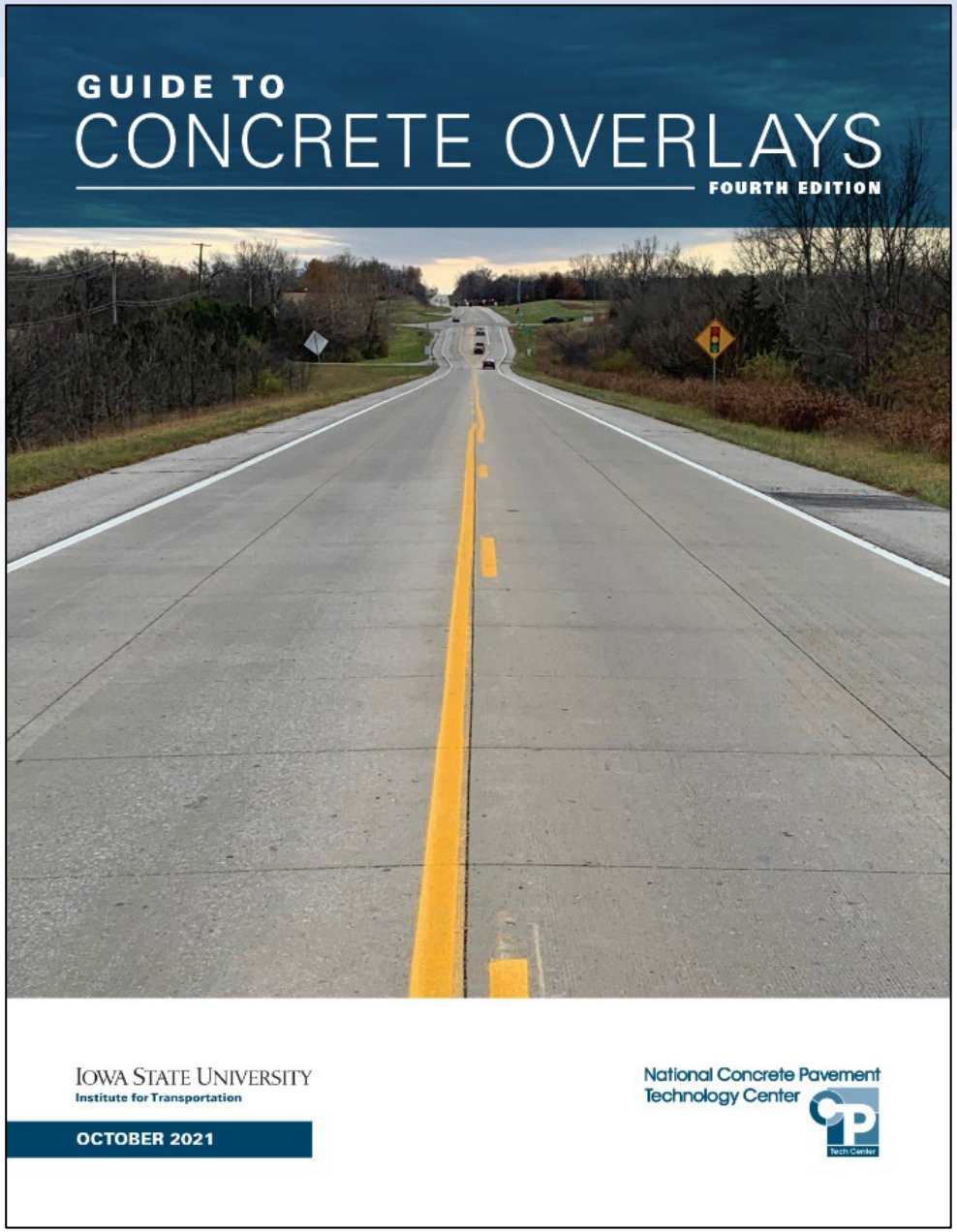
- Thinner overlays tend to have shorter joint spacings
- See Guide to Overlays for detailed information

Dowel & tie bar use

- Dowels normally not necessary for overlay thicknesses < 7 in.
- For unbonded overlays ≥ 5 in., use tie bars at longitudinal joints

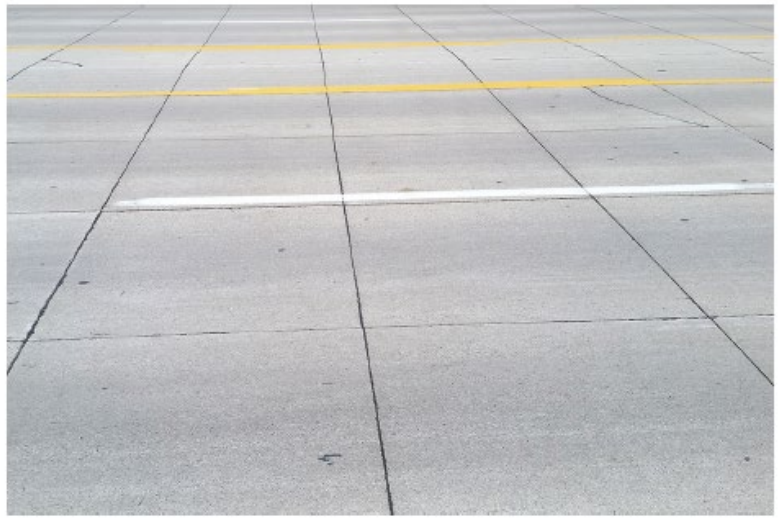
Overlay Design Process

- Pavement Evaluation
- Determine Overlay Type
- Determine Design Life and Traffic
- Use Pavement Design Software
- Consider Additional Design Features
- Consider Construction Process
- Create Construction Documents



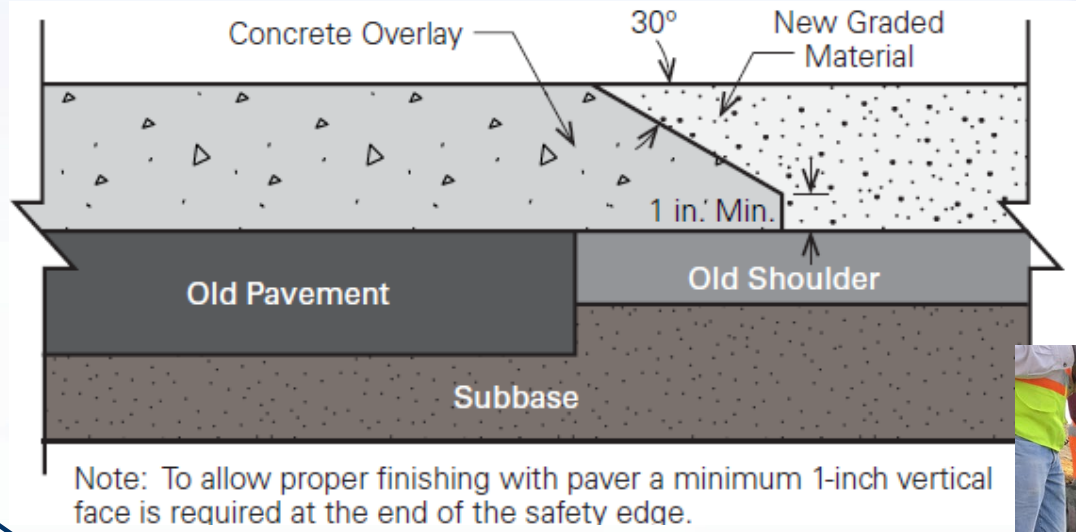
Additional Considerations in Overlay Design

- Shoulders / Widening
- Vertical Grade Changes
  - Overhead Clearance
  - Barriers and Rails
  - Safety Edge
  - Drainage Structures
- Transitions

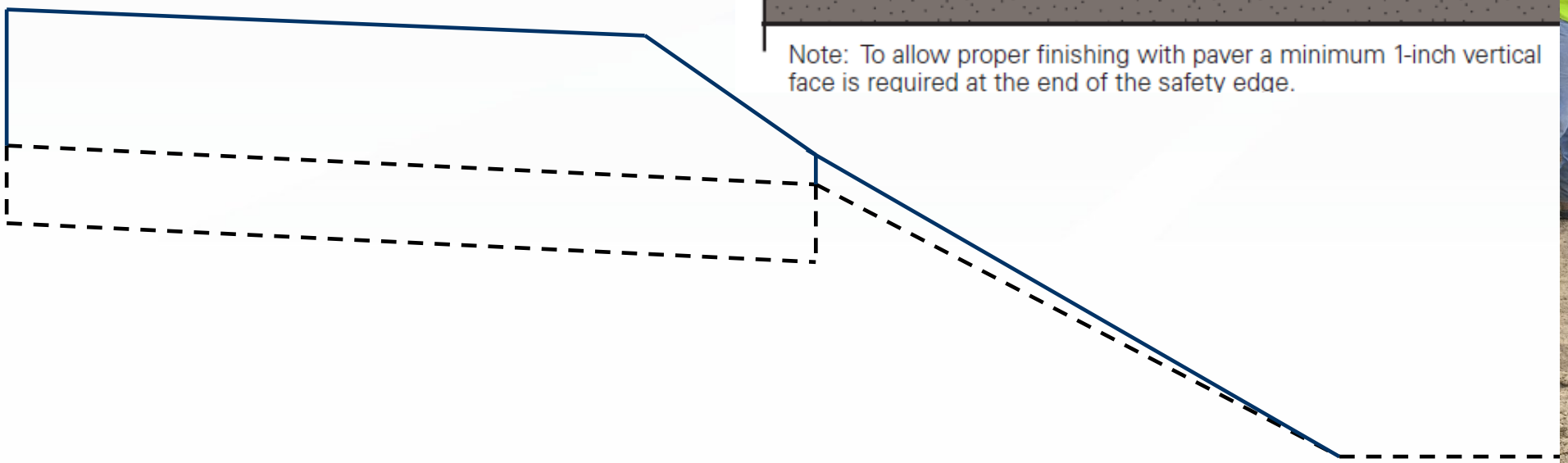


Foreslope Adjustment Options

- Safety Edge



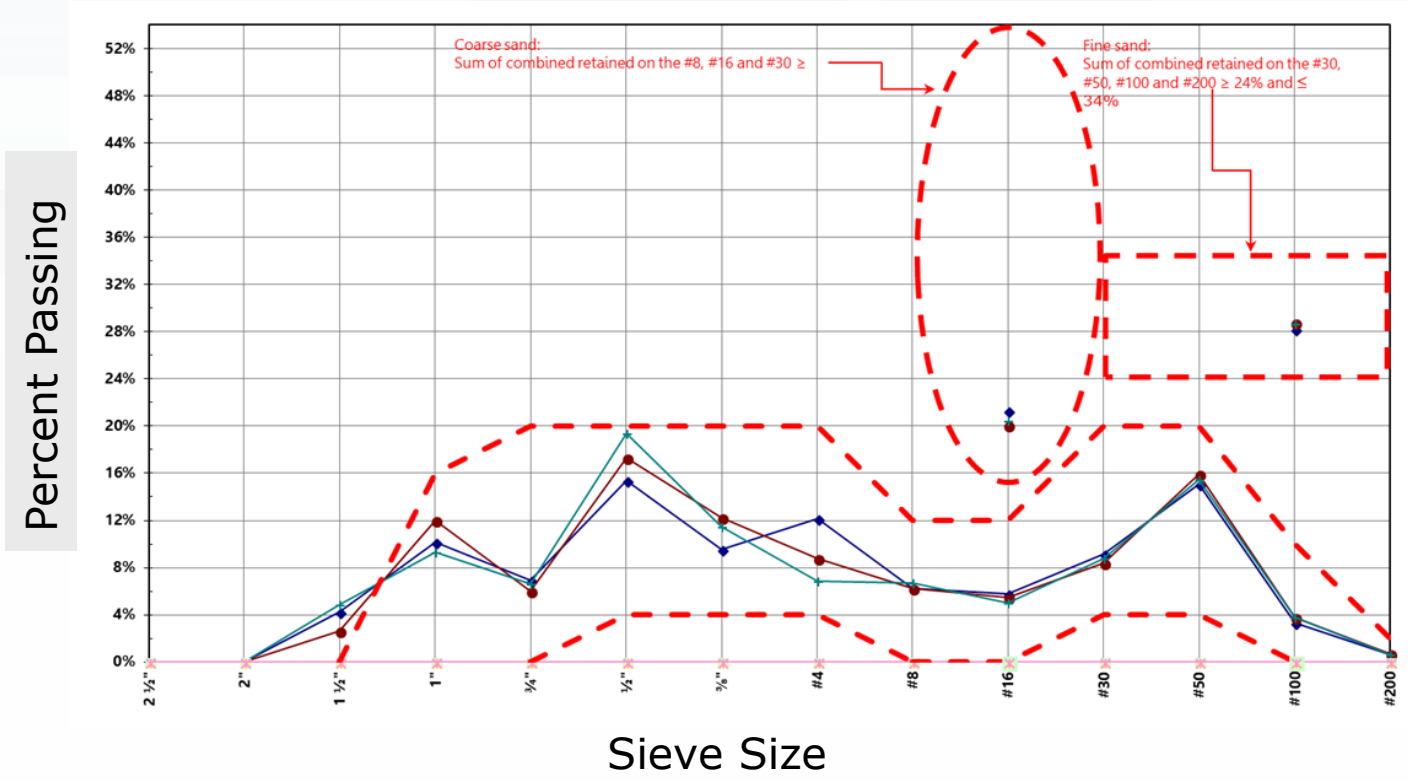
Note: To allow proper finishing with paver a minimum 1-inch vertical face is required at the end of the safety edge.



Materials – Mixture Design

Performance Engineered Mixtures - https://cptechcenter.org/performance-engineered-mixtures-pem/

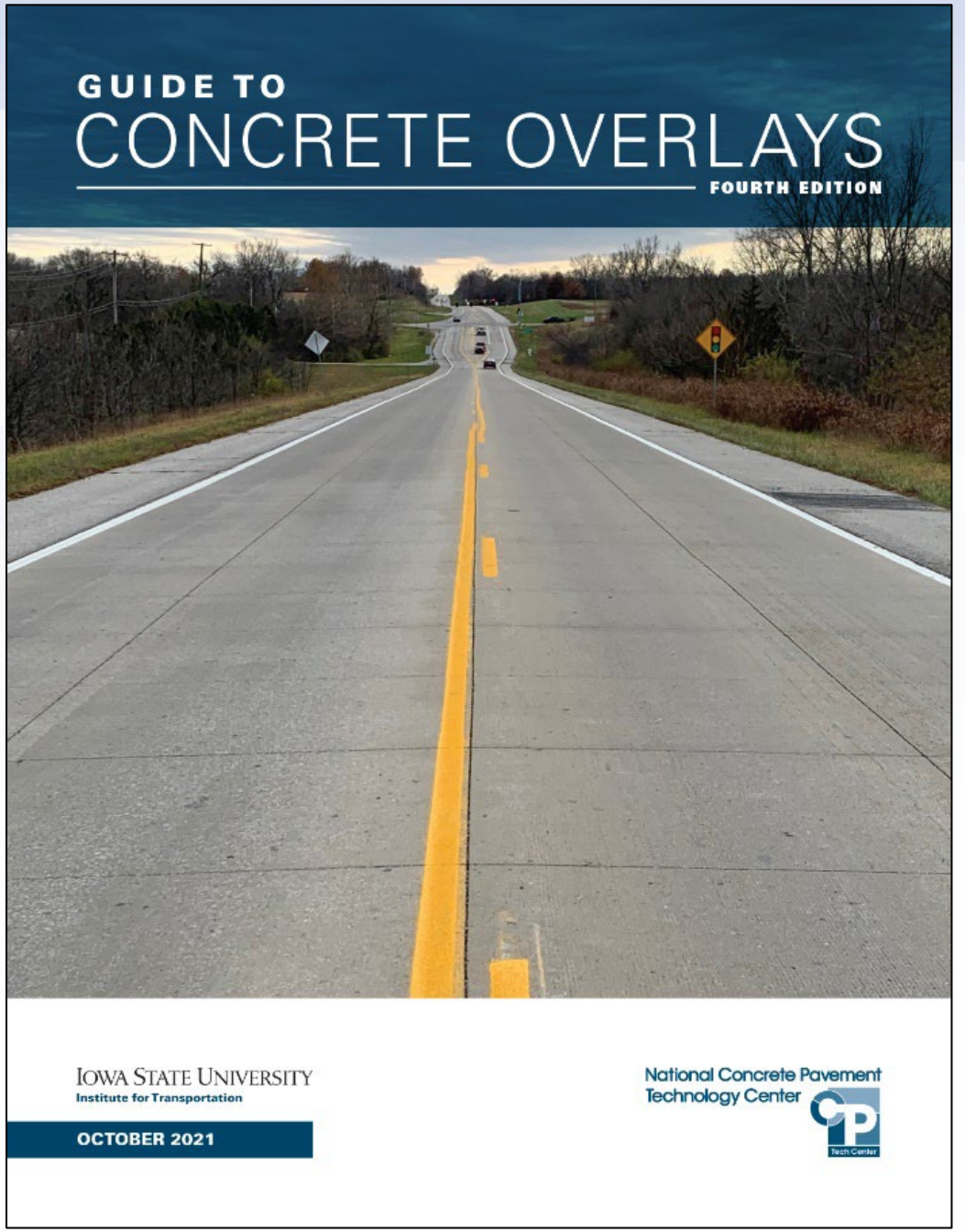
- Standard concrete mixtures whenever possible
- Minimize the use of accelerated mixtures
- Focus on project sequencing to accommodate maintenance of traffic
- Optimized gradation – Tarantula Curve / Shilstone Chart
- Reduced paste content – durability and shrinkage
- Inclusion of Fibers?



Webinars and resources at https://cptechcenter.org/concrete-overlays/

Overlay Design Process

- Pavement Evaluation
- Determine Overlay Type
- Determine Design Life and Traffic
- Use Pavement Design Software
- Consider Additional Design Features
- Consider Construction Process
- Create Construction Documents



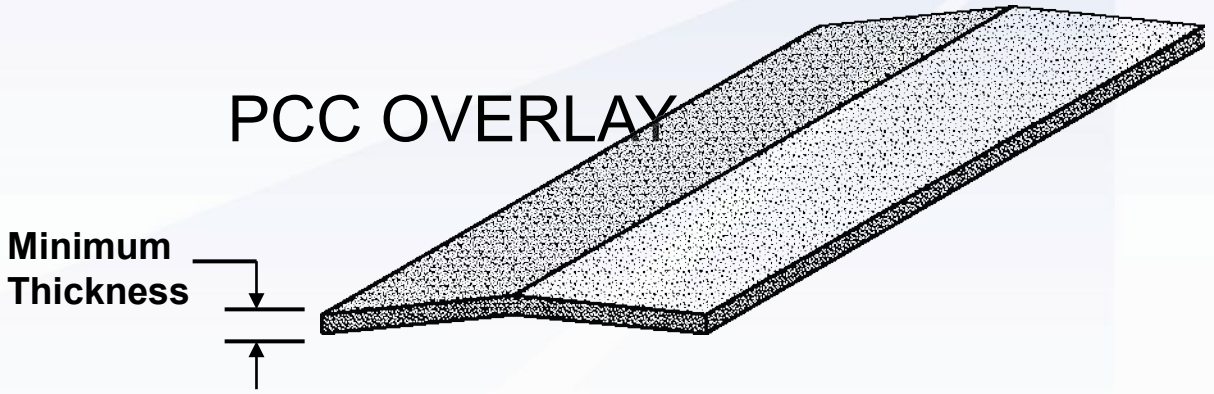
Concrete Overlay Quantity Control

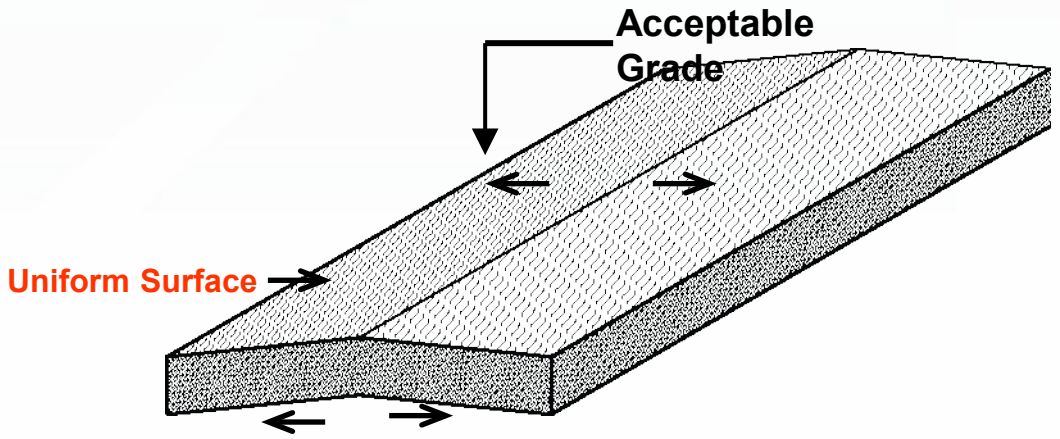
Concrete Overlay Quantities
IDEAL SITUATION

- Quality of PCC is Uniform (set milling depth to remove exactly overlay depth and not worry about profile or smoothness)

- Profile is Perfect (never is)

- Concrete is bid in sq. yards; (Should be cu. yds for material & sy.yds. for placement)

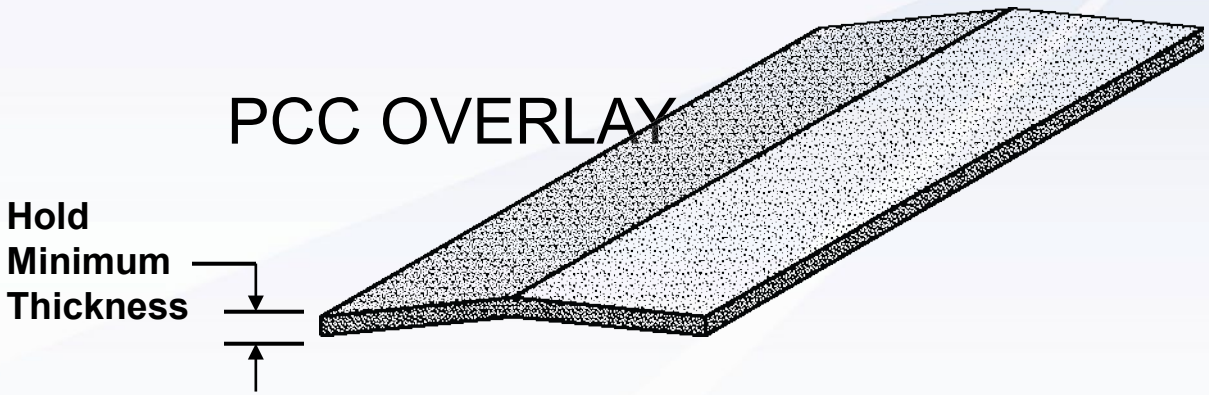




EXISTING PAVEMENT

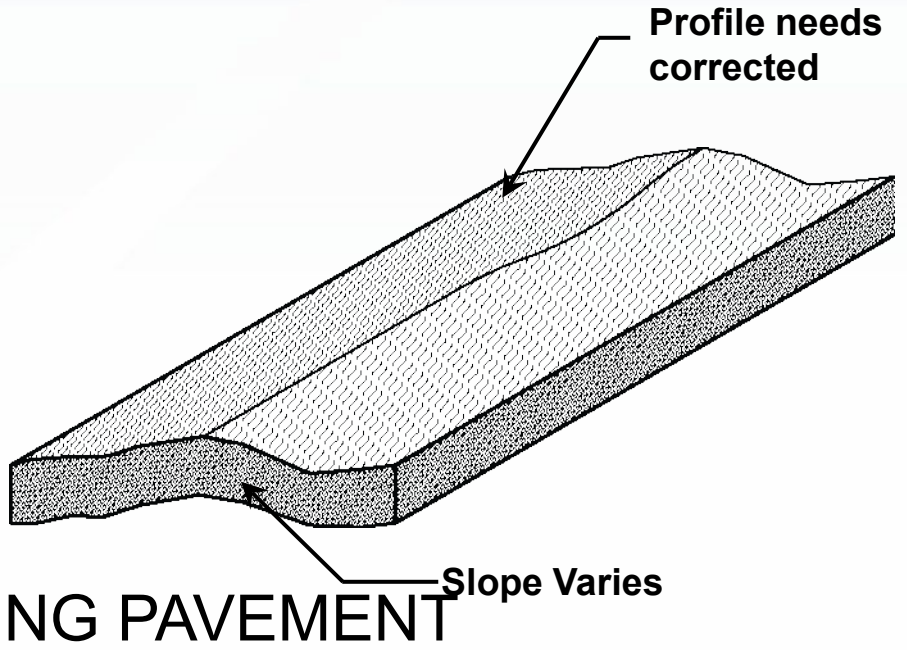
Concrete Overlay Quantities
-REALITY SITUATION-

- Concrete is bid in sq. yards for placement, cubic yards for material



- Profile is not perfect and needs corrected

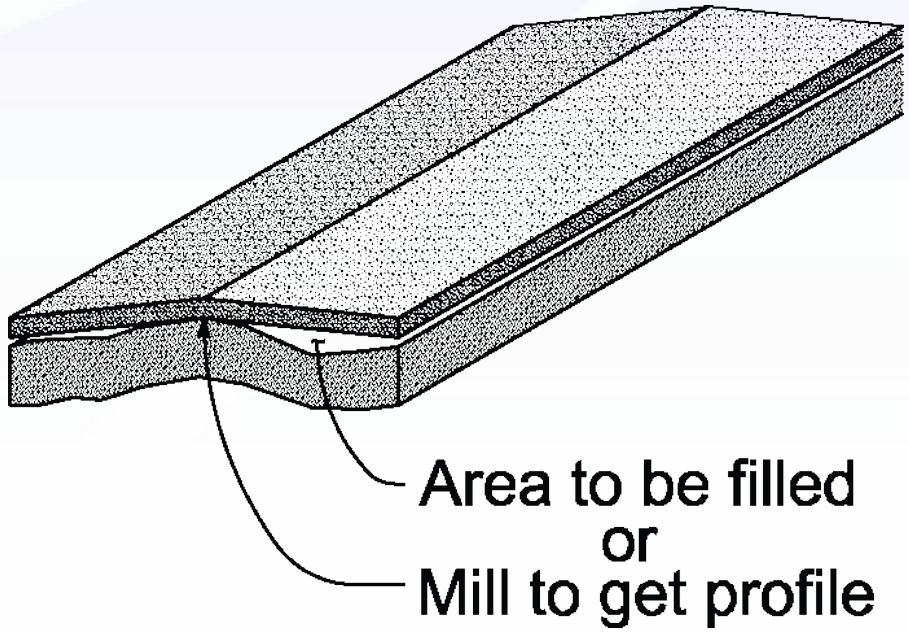
- Cross slope needs correction



Concrete Overlay Approach

If existing surface needs some improvement in cross slope or profile grade and want minimum survey:

- Must maintain minimum pavement thickness
- Contractor sets recommended grade
- Allow to mill to get cross slope and profile



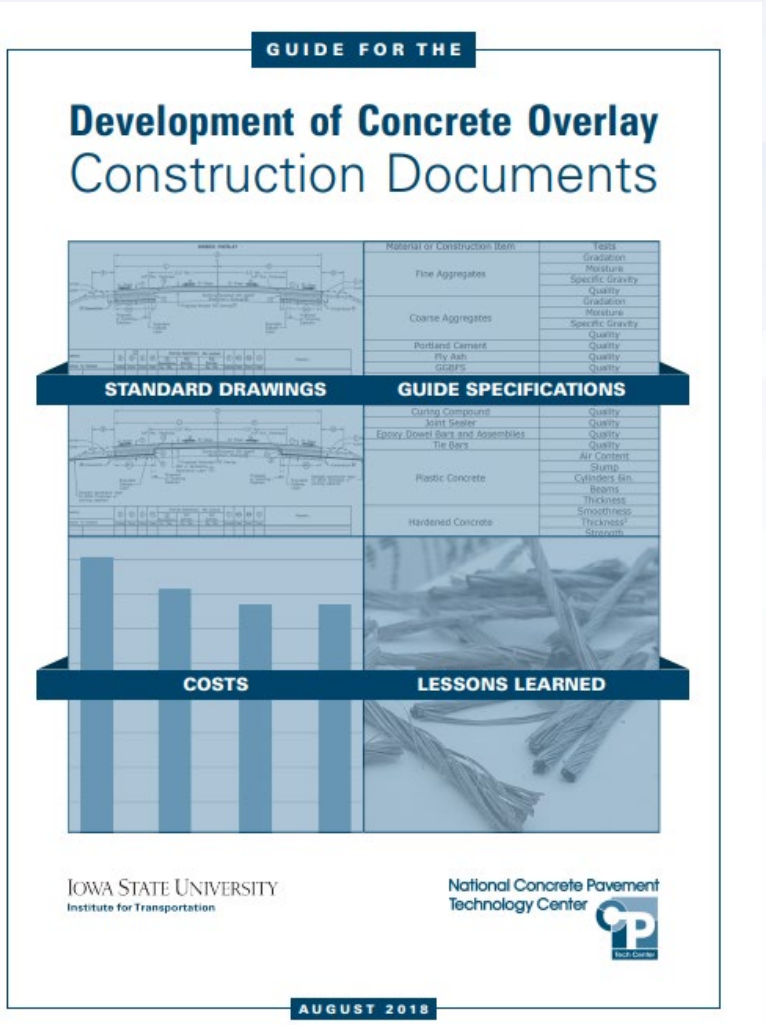
Quantity Estimates

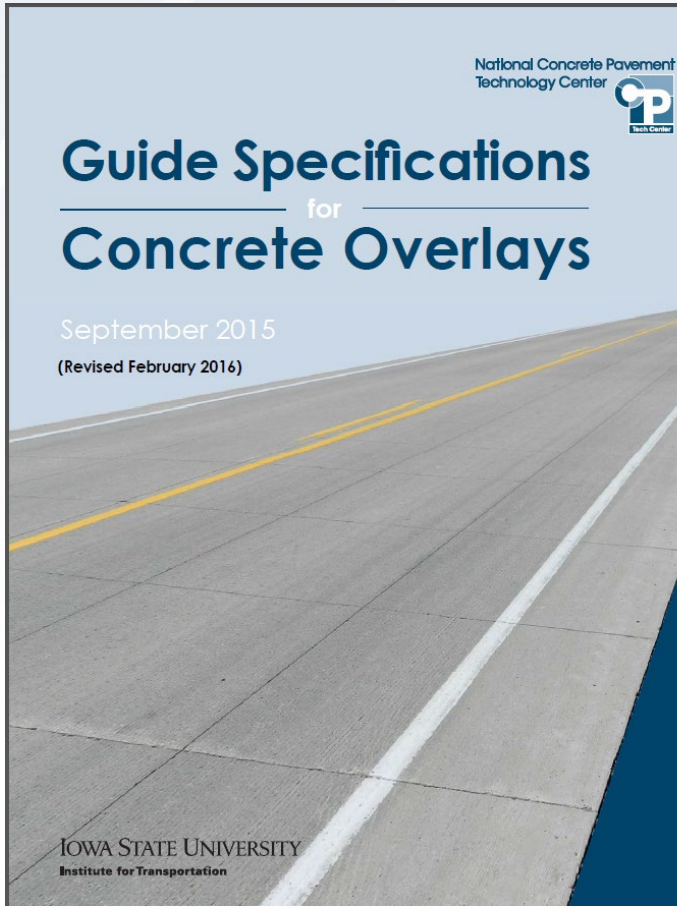
- Estimating plan quantity
  - Overlay cubic yard pay item is to adjust the theoretical volume by an appropriate factor that accounts for the non-uniformity of the existing surface

Concrete Overlay Thickness	½" Placement Tolerance as a % of Design Thickness	Additional % Adjustment for Gross Surface Irregularities in the Existing Surface	Total Adjustment Factor to be Applied to Theoretical Volume
4"	12.5%	5%	17.5%
6"	8.3%	5%	13.3%
8"	6.3%	5%	11.3%
10"	5.0%	5%	10.0%
12"	4.2%	5%	9.2%

Specifications and Construction Documents

- Guide specifications and standard drawings and design details available in CP Tech Center Resources
- Plans can be simple
  - Typical Section





- https://cptechcenter.org/concrete-overlays/
- https://intrans.iastate.edu/app/uploads/2018/09/overlay_construction_doc_dev_guide_w_cvr.pdf

Overlay Explorer – overlays.acpa.org

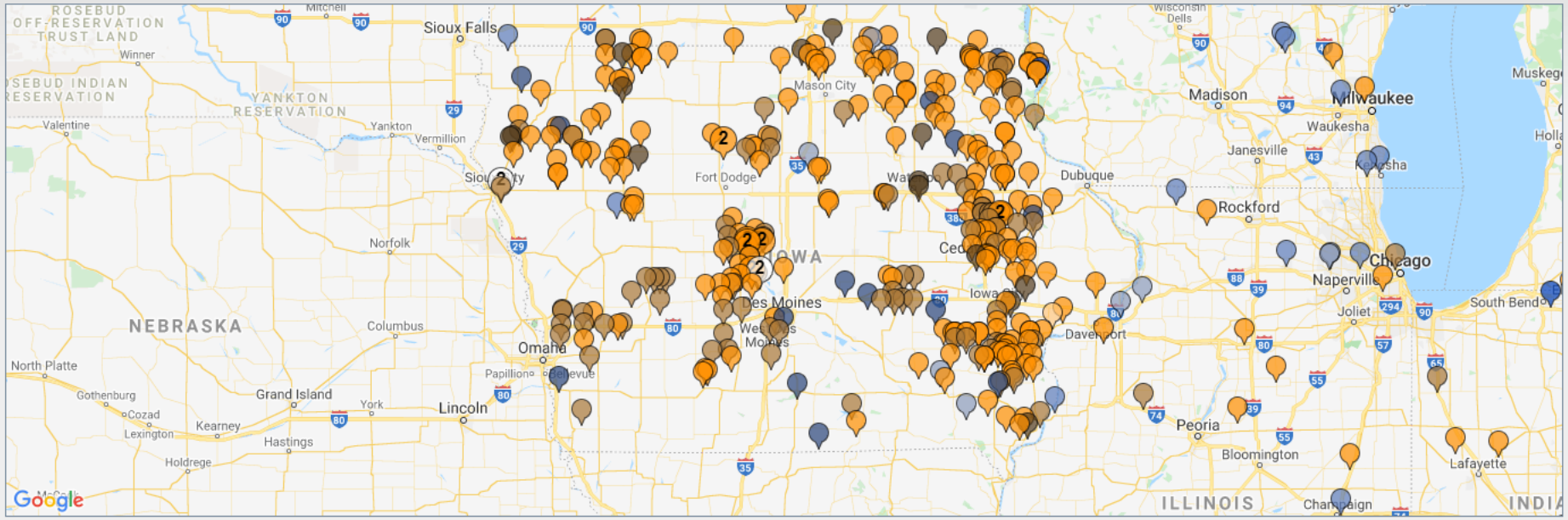
The National Concrete Overlay Explorer

Instructions

MAP VIEW • TABLE VIEW • DETAILS VIEW

1289 Items

640 results out of 1289 cannot be plotted.



Bonded Concrete Resurfacing of Asphalt Pavement (UTW) Bonded Concrete Resurfacing of Composite Pavement Bonded Concrete Resurfacing of Concrete Pavement (Bonded Overlay) Bonded on Asphalt Bonded on Composite Bonded on Concrete Item Unbonded Concrete Resurfacing of Asphalt Pavement (Conventional Whitetopping) Unbonded Concrete Resurfacing of Composite Pavement Unbonded Concrete Resurfacing of Concrete Pavement (Unbonded Overlay) Unbonded on Asphalt Unbonded on Composite Unbonded on Concrete mixed

Special Thanks to ACPA's Chapters and Affiliated State Paving Associations for Populating this Overlay Explorer Database

Search

Concrete Overlay Type

16 Bonded Concrete Resurfacing of Asphalt Pavement (UTW)
5 Bonded Concrete Resurfacing of Composite Pavement
5 Bonded Concrete Resurfacing of Concrete Pavement (Bonded Overlay)

Application

844 Highway
218 Street/Road
169 Airport
35 NA

State

1 AB
3 AL
13 AR
6 AZ

Overlay Thickness (in.)

1 0 - 1
3 1 - 2
46 2 - 3
81 3 - 4

Year Constructed

15 1900 - 1905
2 1910 - 1915
4 1915 - 1920
9 1920 - 1925

Project Size (SY)

352 0 - 50000
153 50000 - 100000
66 100000 - 150000
17 150000 - 200000

Joint Spacing (ft)

130 15
65 15 Skewed
64 12
55 6

Thank You!

Questions / Comments?

Main Website | **acpa.org**
Concrete Wiki | **wikipave**.org
App Library | **apps**.acpa.org
Design Software | **PavementDesigner**.org
Resources | **resources**.acpa.org
On-Demand Training | **ondemand**.acpa.org
Live Online Training | **webinars**.acpa.org
Your Local Contact | **local**.acpa.org