Concrete Overlays

Northwest Pavement Management Association 2016 Conference

Jim Powell, P.E.

ACPA NORTHWEST CHAPTER

Concrete Pavement Overlays

- Use of PCC overlays has grown tremendously

- Significant research
  - FHWA (ISTEA Section 6005)
  - NCHRP and ACPA Studies
  - State studies
  - LTPP
  - MN Roads

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Why Concrete Overlays?

- Do not require extensive repairs of existing pavement
- Long performance life
- Low maintenance requirements
- High load-carrying capacity
- Withstands heavy truck traffic
- Effective life-cycle costs

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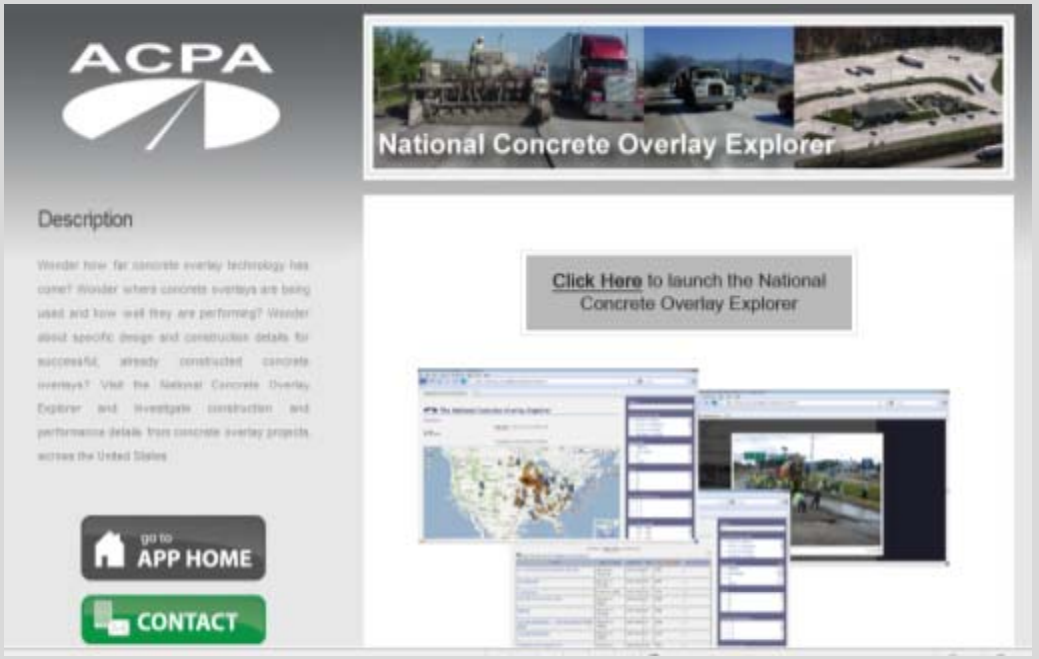
National Concrete Overlay Database

- Consult the National Overlay Explorer App on the ACPA website.
- Data on many projects.



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National Concrete Overlay Explorer

The National Concrete Overlay Explorer

Instructions

MAP VIEW • TABLE VIEW • DETAILS VIEW

1263 Items

640 results out of 1263 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

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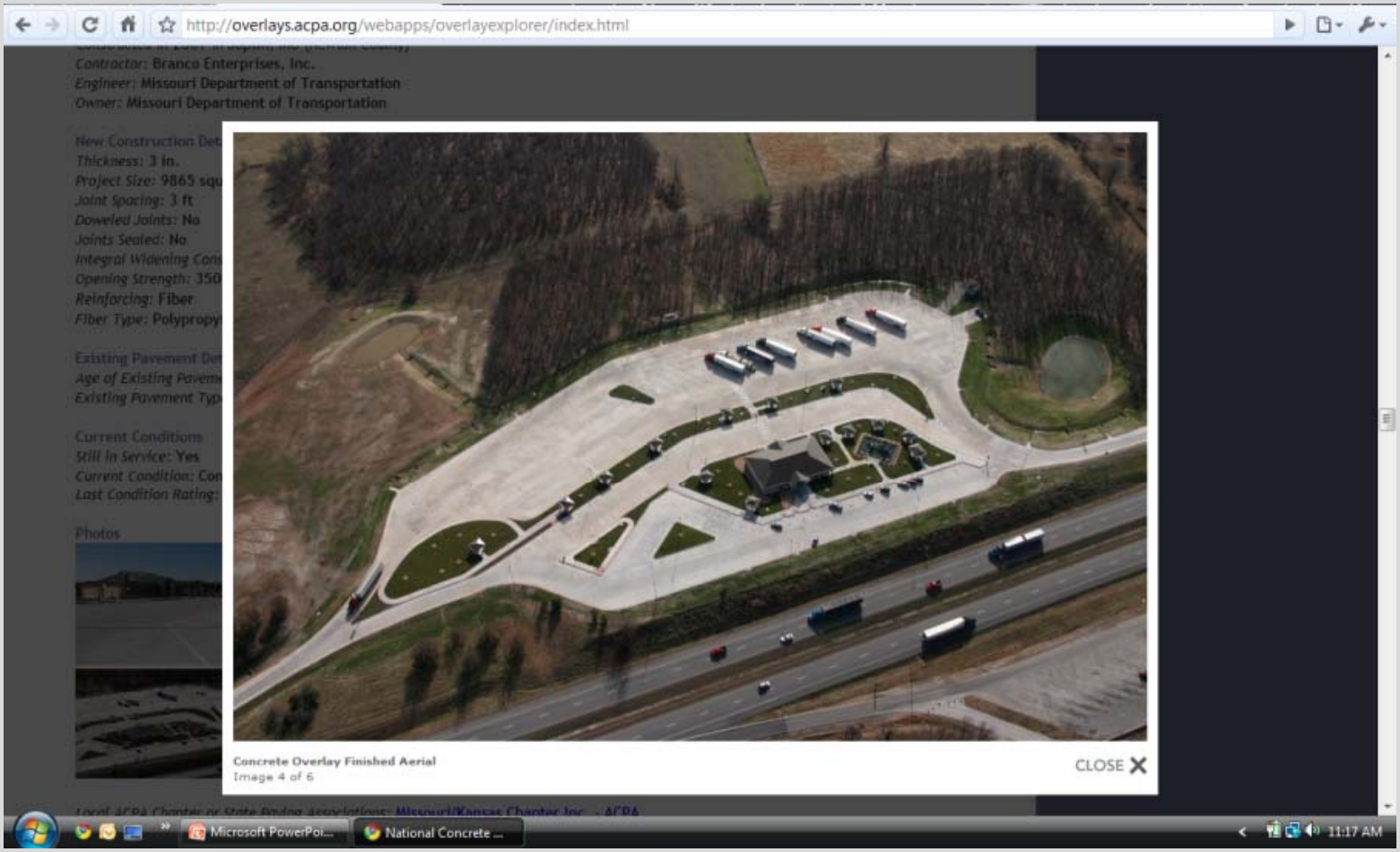
National Concrete Overlay Explorer



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Family of Concrete Overlays

Thinner

Concrete Overlays

Thicker

Bonded Resurfacing Family

Unbonded Resurfacing Family

Bonded Concrete Resurfacing of Concrete Pavements

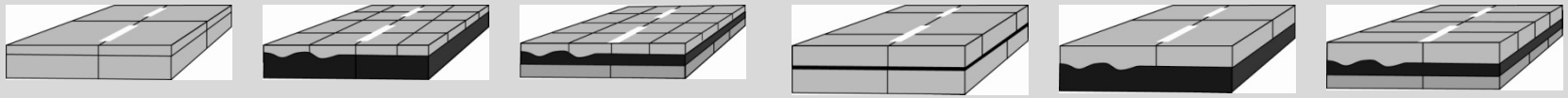
Bonded Concrete Resurfacing of Asphalt Pavements

Bonded Concrete Resurfacing of Composite Pavements

Unbonded Concrete Resurfacing of Concrete Pavements

Unbonded Concrete Resurfacing of Asphalt Pavements

Unbonded Concrete Resurfacing of Composite Pavements



Bond is integral to design

Old pavement is base

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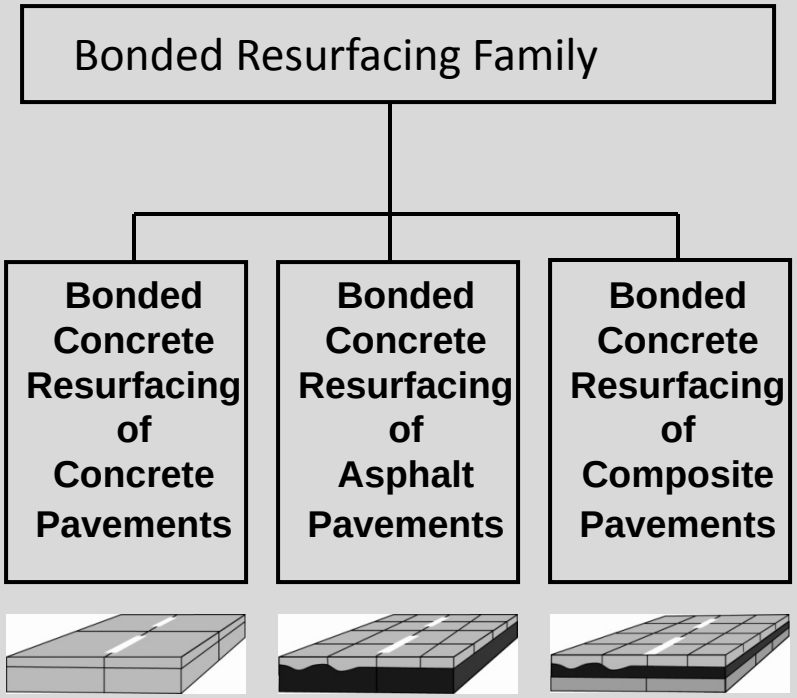
Bonded Resurfacing Family

- Thin Overlays (2” – 6”)
- Over concrete, asphalt, and composites
- Bond is critical



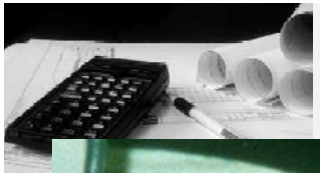
Whitetopping - History

- First Whitetopping
  - South 7th street in Terre Haute, Indiana - 1918
  - Existing flexible pavement was overlaid with 3 - 4 in. of reinforced concrete
- During 40's and 50's -

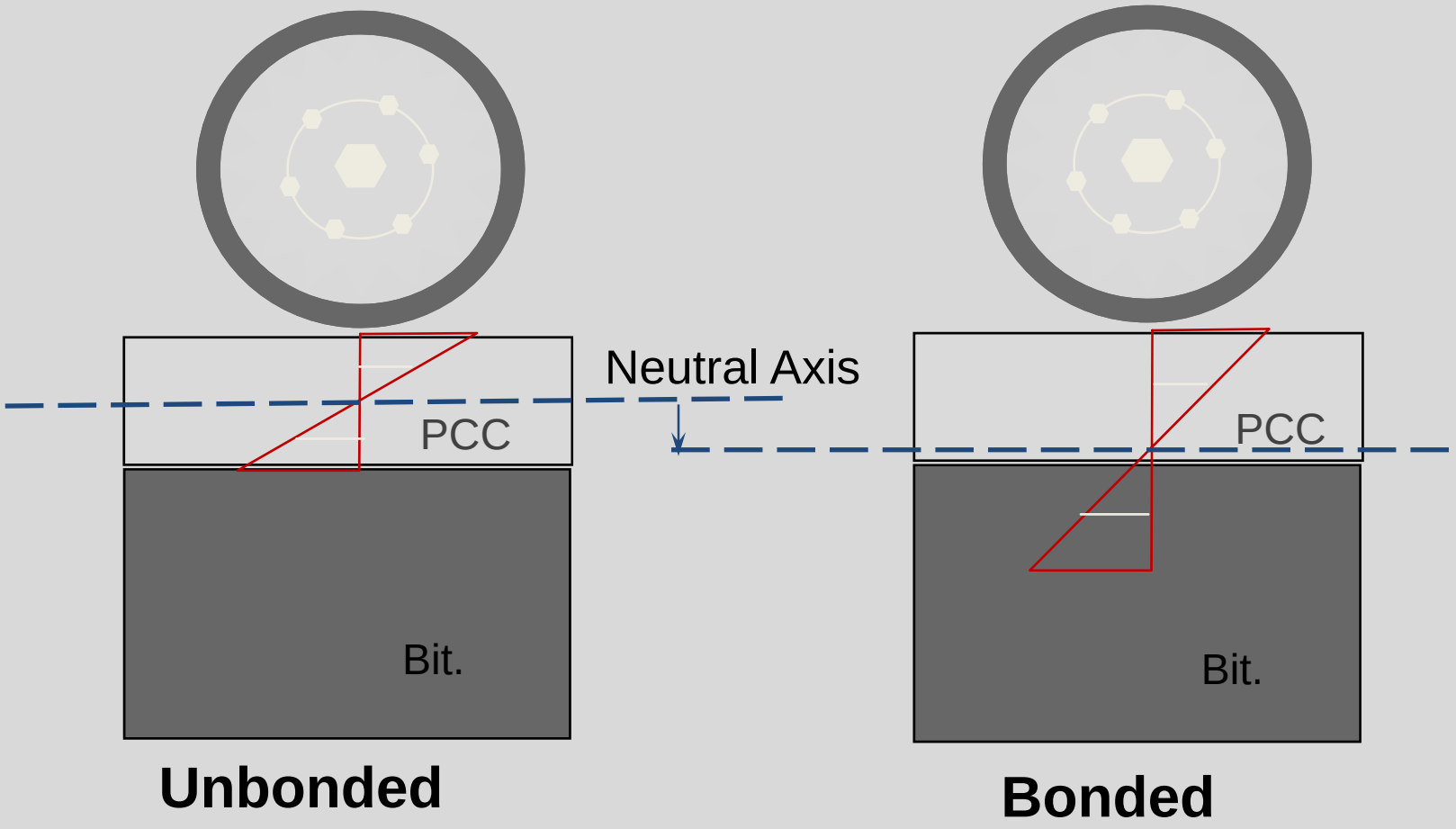
  Used to upgrade military & civil airports
- Highway use
  - Started approx. 1960
  - Types have included JPCP, JRCP, CRCP, FRC

Whitetopping History

- Began in Iowa in 1960's as overlay on farm to market asphalt roads
- Thickness greater than 4"
- Performance was excellent
- Bonding to asphalt layer was noticed

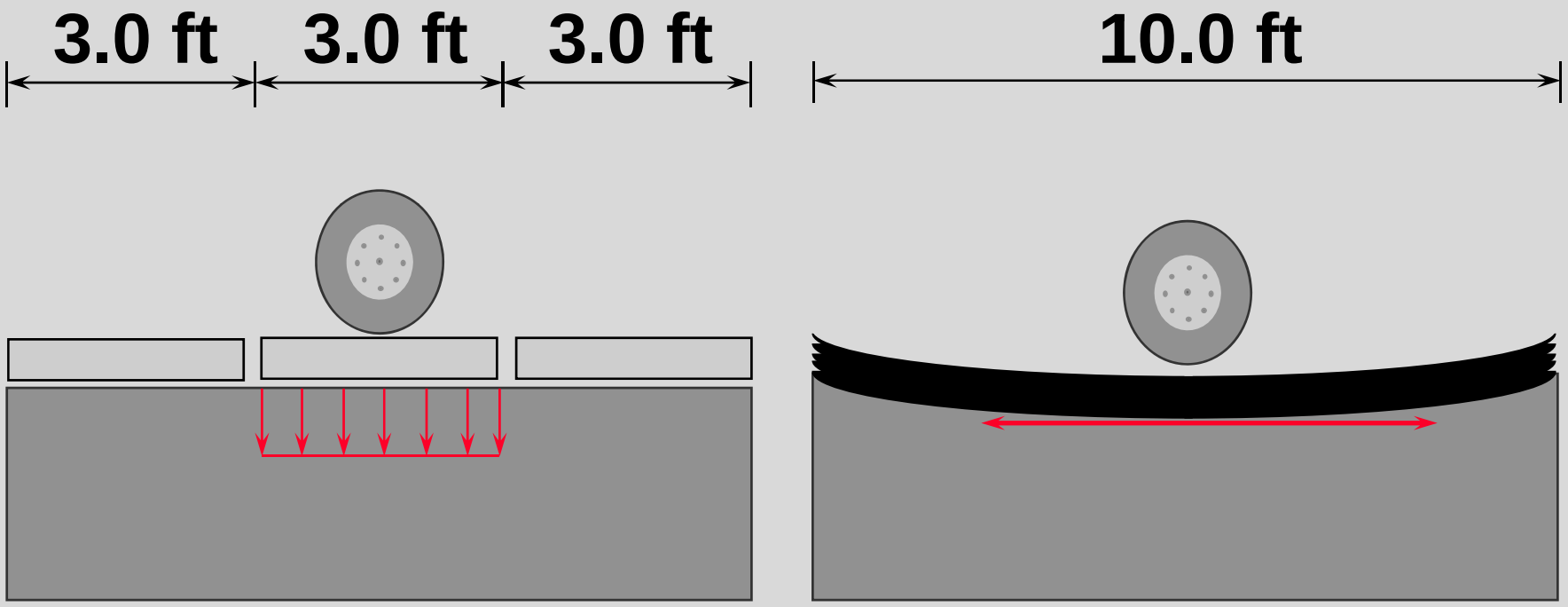


Mechanics of Composite Section



Effects of Joint Spacing:

Bonded Concrete Resurfacing of Asphalt Pavements



Short joint spacing allows the slabs to deflect instead of bend.
This creates the need to balance thickness and joint spacing.

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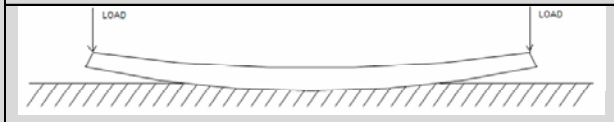
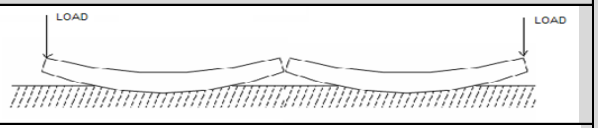
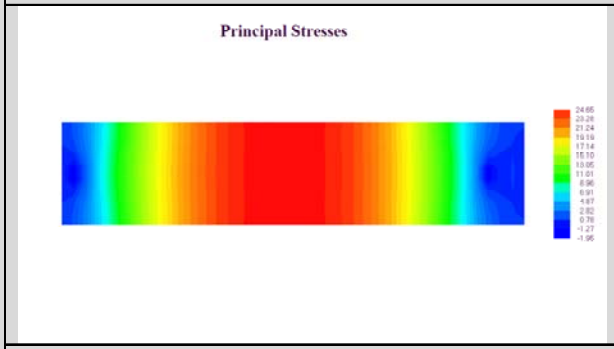
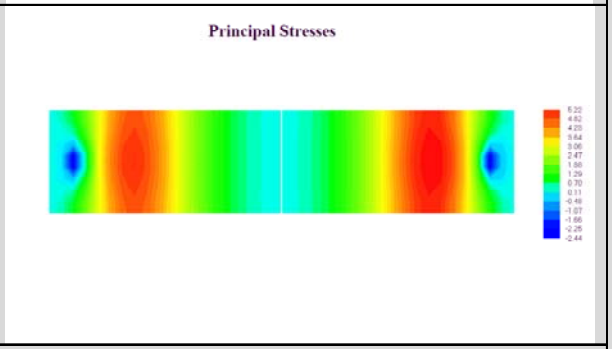
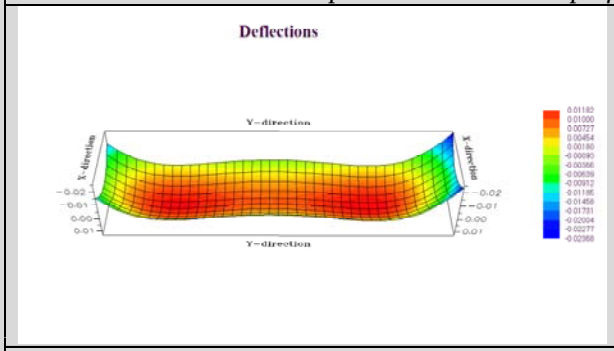
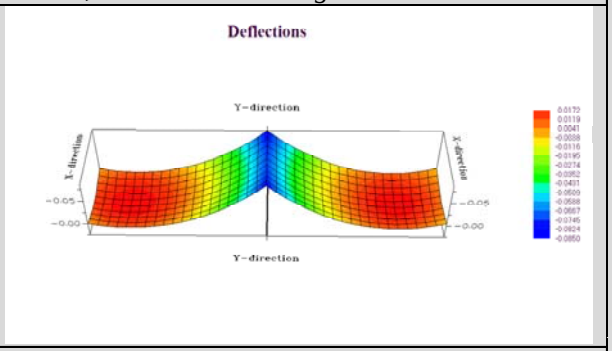
Influence of Slab Geometry on Stresses

15 ft x 3.25 ft	7.5 ft x 3.25 ft
	
	
Maximun tensile stress = 350 psi	Maximun tensile stress = 74.3 psi
Principal stresses on the top of the slab, Red is tensile strength	
	
Deformation of the slab	

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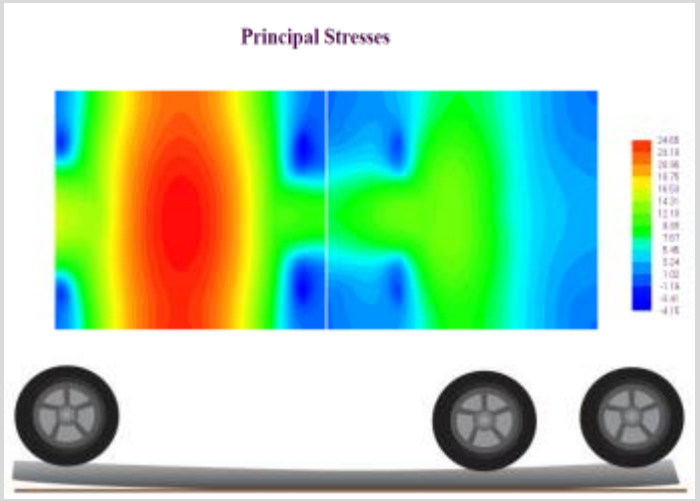
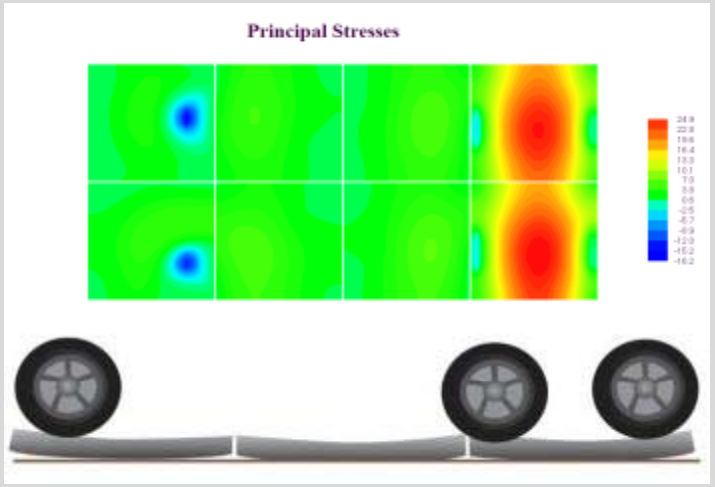
Slabs Sizes and Thickness For Same Top Stress (363 psi)



Concrete Thickness: 10 in.
Slabs: 15 ft x 12 ft



Concrete Thickness: 6.3 in.
Slabs 6 ft x 6 ft

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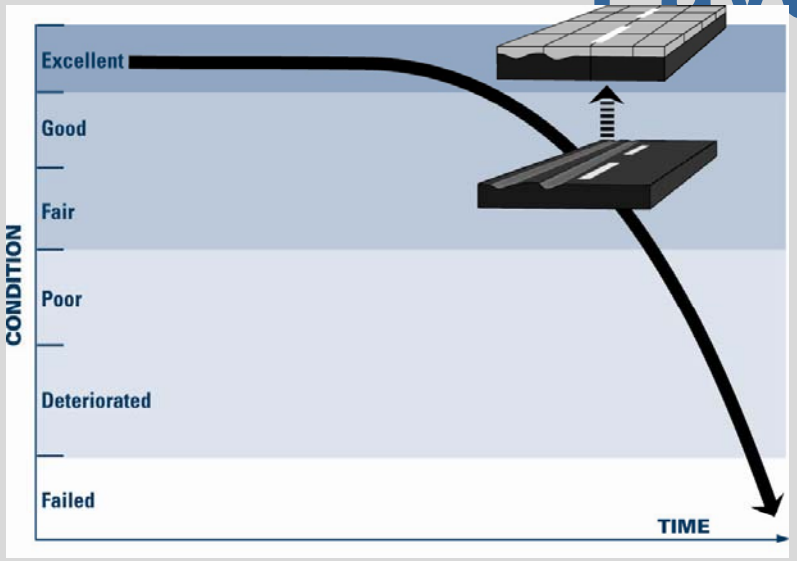
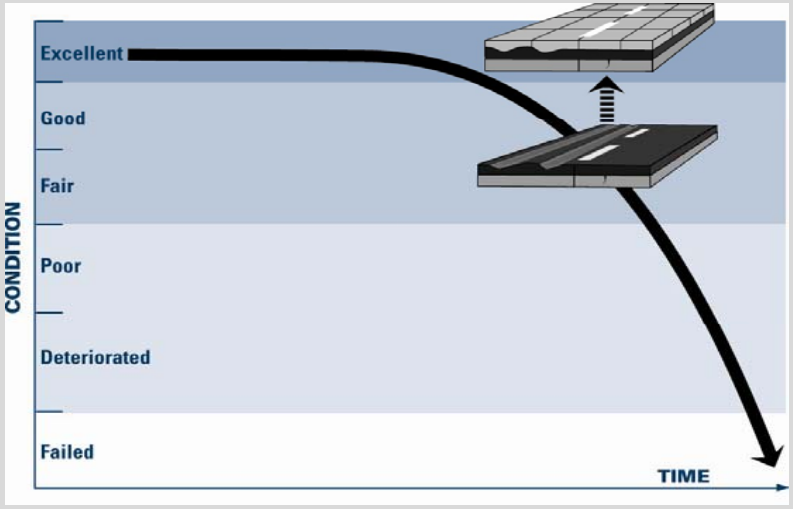
Uses and Advantages- Bonded Resurfacing of Asphalt or Composite Pavements

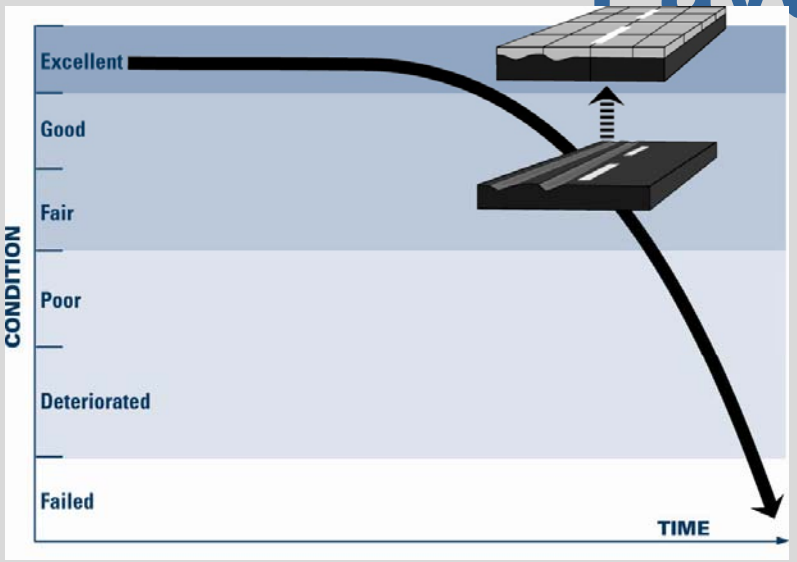


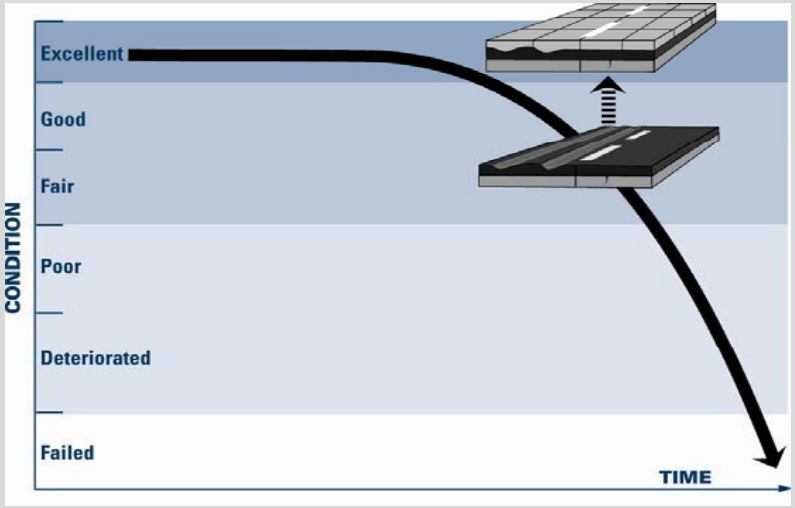


2”–6” thickness

- Use to eliminate any surface defects, increase structural capacity, and improve surface friction and ride.
- Use to avoid reconstruction and make use of existing materials.

Uses and Advantages- Bonded Resurfacing of Asphalt or Composite Pavements

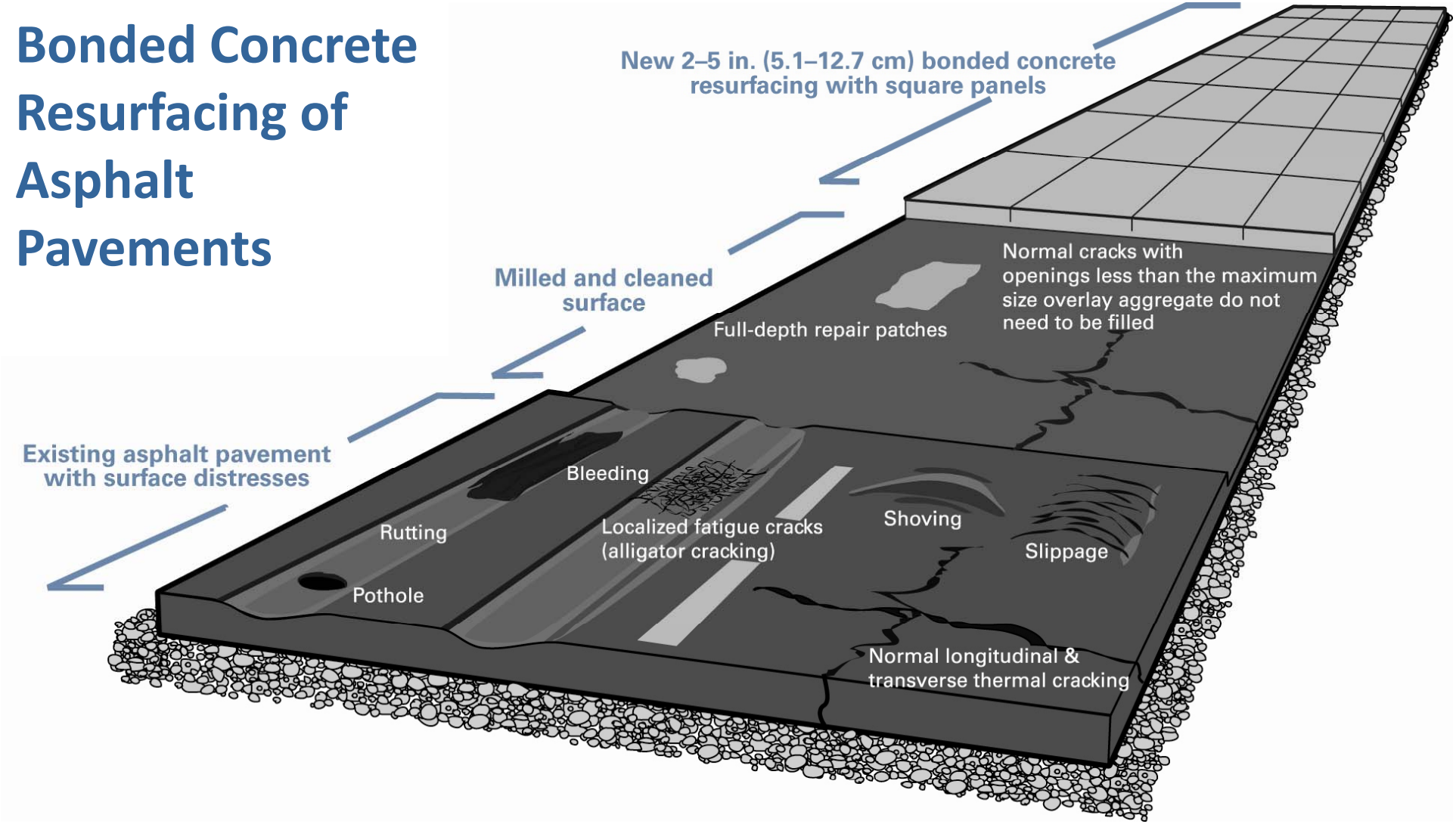




2”–5” thickness

- Typically used directly over asphalt without additional repairs except for milling.
- Working cracks in existing pavement will not reflect through.
- Can used in conjunction with widening.

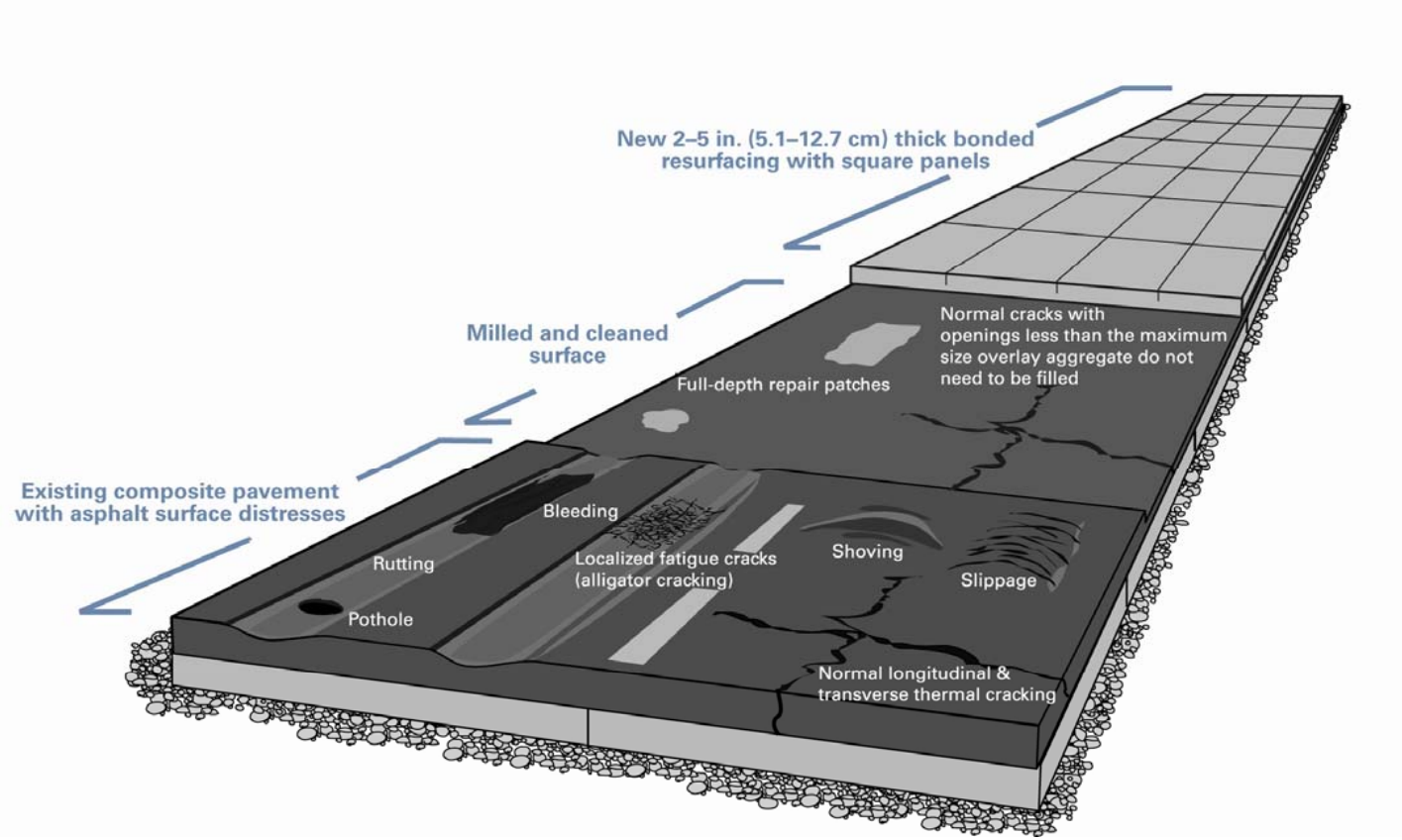
Bonded Concrete Resurfacing of Asphalt Pavements



- Spots of distress that aren't visible can be determined through evaluation such as the stiffness of the asphalt pavement and subgrade support conditions.

- Localized areas of weakness can be strengthen through patching. Milling can remove a number of asphalt surface distresses.

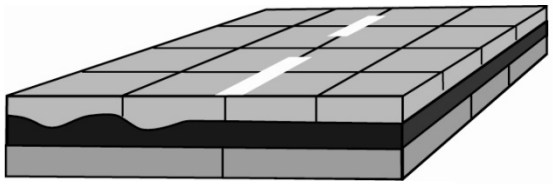
Bonded Concrete Resurfacing of Composite Pavements

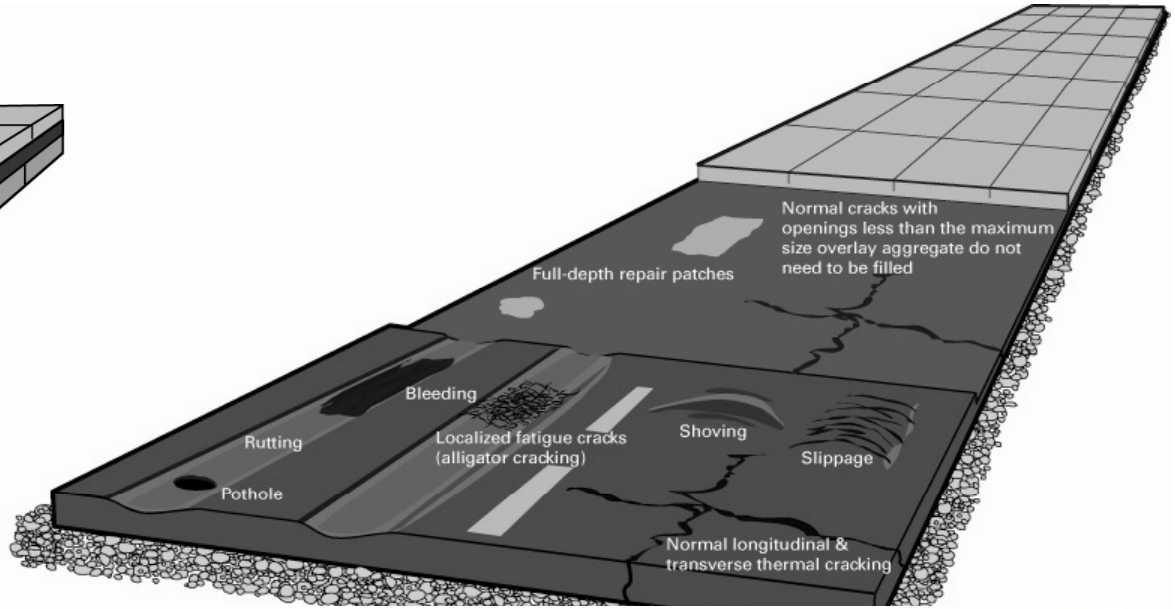


- Asphalt is a good reflector of underlining concrete pavement condition.

- A review of the existing profile grade line should be conducted and areas of significant deviation investigated through analysis of core samples in the laboratory.

Repairs-Bonded Resurfacing of Asphalt or Composite Pavement





Existing pavement distress	Spot repairs to consider
Fatigue cracking	Full-depth repair patch
Pothole	Full-depth repair patch
Deep rutting	Milling
Shoving, slippage	Milling
Thermal cracking	None

Milling: Bonded Resurfacing of Asphalt or Composite Pavements

The three main objectives of milling:

1. to remove significant surface distortions that contain soft asphalt material, resulting in an inadequate bonding surface
2. to reduce high spots to help ensure minimum resurfacing depth and reduce the quantity of concrete needed to fill low spots; and
3. to roughen a portion of the surface to enhance bond development between the new concrete overlay and the existing asphalt. (don’t leave a thin lift)

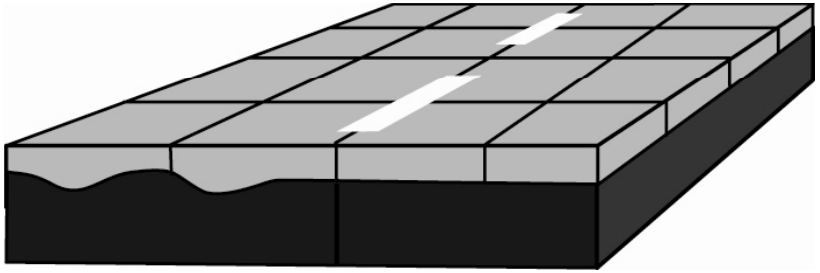
Milling: Bonded Resurfacing of Asphalt or Composite Pavements

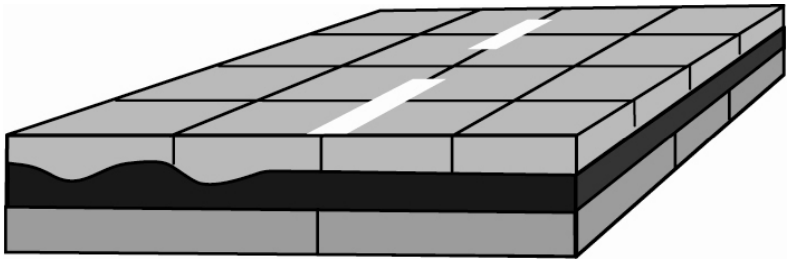
- Complete removal of ruts is not needed when rutting in the existing asphalt pavement does not exceed 2”.

- Any ruts in the existing pavement are filled with concrete, resulting in a thicker concrete overlay above the ruts.

- A minimum of 3"–4" of asphalt should be left after milling because of the reliance on the asphalt pavement to carry a portion of the load.

Important Elements-Bonded Resurfacing of Asphalt/Composite Pavement





- Clean Surface/Bond is important for good performance
- Thin milling may be required to eliminate significant surface distortions of 2” or more and provide good bond.
- Leave at least 3” remaining asphalt after milling.

- Control surface temperature of existing asphalt to below 120ºF.
- Try to keep joints out of wheel paths.
- Curing should be timely and adequate.
- Small joint spacing to minimize bonding shear stress

BCOA Thickness Designer

ACPA Application Library

http://apps.acpa.org/apps/bcoa.aspx

ACPA

Background

This bonded concrete overlay on asphalt (BCOA) thickness design web application is based primarily on the results of FHWA-ICT-08-016, "Design and Concrete Material Requirements for Ultra-Thin Whitetopping", a research project conducted in cooperation with the Illinois Center for Transportation at the University of Illinois (ICT), the Illinois Department of Transportation (IDOT), and the Federal Highway Administration (FHWA). The web application reflects the views of the ACPA, who is responsible for the facts and accuracy of the data presented within it. The contents do not necessarily reflect the official views or policies of ICT, IDOT, or FHWA, and this application does not constitute a standard, specification, or regulation. Designers should understand the assumptions/limitations of the research on which this tool is based and also be knowledgeable about the various types of concrete overlay offerings and design/construction details of each type.

General Design Details

Design Lane ESALs: Estimate ESALs	0	Help
Slabs Cracked at End of Design Life (%):	20 %	Help
Reliability (%):	85 %	Help
Effective Temperature Gradient (°F/in.):	-1.4	Help
Time at Effective Temperature Gradient (%):	58 %	Help

Existing Pavement Structure Details

Remaining Asphalt Thickness (in.):	4	Help
Asphalt Modulus of Elasticity (psi):	700,000	Help
Modulus of Subgrade Reaction (pci):	150	Help

Calculate *k*-Value

Microsoft PowerPoi... Bonded Concrete O... 10:24 PM

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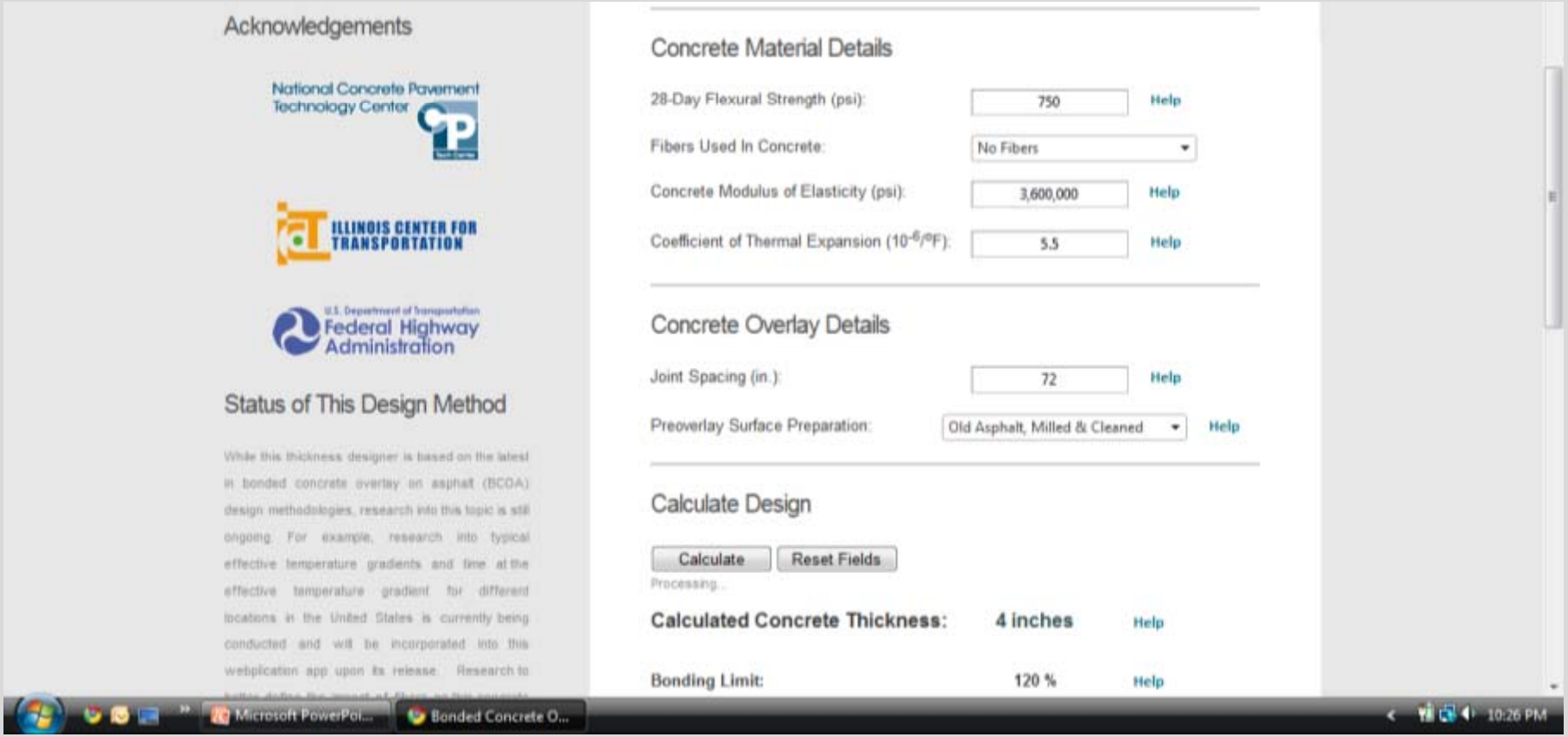
BCOA Thickness Designer



View @ http://apps.acpa.org/apps/bcoa.aspx

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BCOA Thickness Designer

- Available 24-7 from web
- Calibrated with available overlay performance data (Illinois, Iowa)
- Research underway to improve some criteria (by CP Tech Center)
  - Temperature modeling
  - Calibration
- Will incorporate technology into ACPA's StreetPave along with other design models

BCOA - ME

PITT | SWANSON ENGINEERING

VANDENBOSSCHE

- BACKGROUND
- COURSES
- RESEARCH
- LAB TOUR
- BCOA-ME

ADMISSIONS ACADEMICS RESEARCH STUDENTS ALUMNI & GIVING RESOURCES

I AM

BCOA-ME

BCOA ME University of Pittsburgh

(Last site update Jan. 2016/Last guide update April 2015)

The bonded concrete overlay of asphalt mechanistic-empirical design procedure (BCOA-ME) was developed at the University of Pittsburgh under the FHWA Pooled Fund Study TPF 5-165. This pavement structure has been referred to as thin and ultra-thin whitetopping. This site is a repository for all information relating to the BCOA-ME. The information has been sorted based on its intended use and can be retrieved by clicking on the appropriate tab below. The BCOA-ME can be run directly from this site by clicking on the "Design Guide" tab below.

DESIGN GUIDE

PRACTITIONER'S INFO TRAINING TOOLS TECHNICAL DOCS

SPONSORING AGENCIES

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BCOA ME Sponsors

VANDENBOSSCHE

- BACKGROUND
- COURSES
- RESEARCH
- LAB TOUR
- BCOA-ME
  - BCOA-ME Home
  - Design Guide
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BCOA ME

University of Pittsburgh

SPONSORS

pennsylvania DEPARTMENT OF TRANSPORTATION

DOT

Kansas Department of Transportation

NCDOT NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

MDOT MISSISSIPPI DEPARTMENT OF TRANSPORTATION

Iowa Department of Transportation

MaDOT

New York State Department of Transportation

BCOA ME
Main Screen

GENERAL INFORMATION

Latitude (degree):	45.35	Geographic Information
Longitude (degree):	-122.36	
Elevation (ft):	223	
Estimated Design Lane ESALs:	12787000	ESALs Calculator
Maximum Allowable Percent Slabs Cracked (%):	15	
Desired Reliability against Slab Cracking (%):	90	

CLIMATE

AMDAT Region ID	3
Map of Sunshine Zone	6

EXISTING STRUCTURE

Post-milling HMA Thickness (in):	4	
HMA Fatigue	Adequate	Fatigue Cracking Example
Composite Modulus of Subgrade Reaction, k-value (psi/in):	150	k-Value Calculator
Does the existing HMA pavement have transverse	○ Yes ◉ No	Transverse Cracking

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BCOA ME
Traffic

ESALS ESTIMATION:

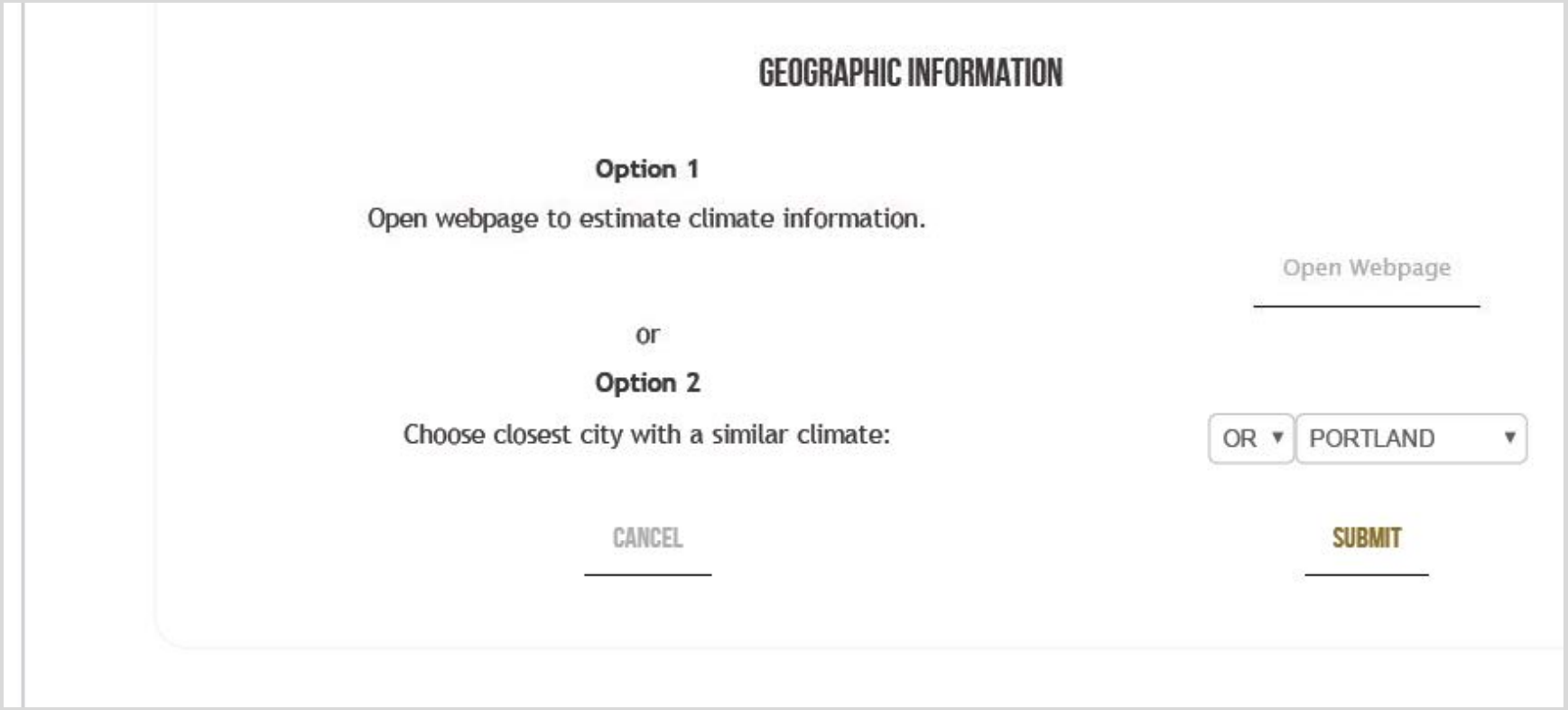
Is One-Way ADT Available? (●) Yes ( ) No

ESTIMATE ESALS:

Design Life (yrs):	30
Terminal Serviceability:	2.5
Number of Lanes in Each Direction:	2
Percent Trucks(%):	8
ADTT Growth Rate (%):	2
Traffic Growth Rate Type:	Non linear
Road Category:	Major arterial
One-Way Average Daily Traffic (ADT):	15000

CANCEL SUBMIT

BCOA ME Environment



BCOA ME
Main Screen

PCC OVERLAY PROPERTIES

Average 28-day Flexural Strength (three-point bendi ▾	650	
Estimated PCC Elastic Modulus (psi):	3930000	Epcc Calculator
Coefficient of Thermal Expansion (10-6 in/°F/in)	6	CTE Calculator
Fiber Type:	No Fibers ▾	

JOINT DESIGN

Joint Spacing (ft): 6 x 6 ▾

CALCULATE DESIGN

PERFORMANCE ANALYSIS

Calculated PCC Overlay Thickness (in)	5.13
Design PCC Overlay Thickness (in)	5
Is there potential for reflective cracking?	No
	Solved.

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Macro Fibers

Table 1. Concrete Mix Proportions and Fresh and Mechanical Concrete Properties

Materials (kg/m^3)	Plain concrete	0.32% synthetic macrofibers	0.48% synthetic macrofibers	0.35% hooked-end steel fibers	0.50% crimped-steel fibers
Coarse aggregate	995	975	976	965	983
Fine aggregate	823	806	807	796	813
Cement	363	360	360	347	363
Water	178	182	183	163	172
Daracem (mL/100 kg)	925	1,116	1,117	868	1,328
Water-to-cement ratio	0.49	0.51	0.51	0.49	0.47
Air content (%)	1.8	2.9	2.8	6	3.2
Slump (mm)	200	150	115	110	190
Compressive (MPa)	41.1	36.1	31.8	34	37.2
Flexural strength (MPa)	4.73	4.69	4.82	4.68	5.28
[a]$R_{e,3}$= values (%)	2	24	39	43	35
Slab thickness (mm)	139.7	131.8	131.8	131.8	131.8

[a]$R_{e,3}$= equivalent flexural strength ratio at 3-mm deformation.

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BCOA ME
Design w/ Fibers

PCC OVERLAY PROPERTIES

Average 28-day Flexural Strength (three-point bendi ▾	650	
Estimated PCC Elastic Modulus (psi):	3930000	Epcc Calculator
Coefficient of Thermal Expansion (10-6 in/°F/in)	6	CTE Calculator
Fiber Type:	Synthetic Structural Fibers ▾	
Fiber Content (lb/yd3):	3	

JOINT DESIGN

Joint Spacing (ft): 6 x 6 ▾

CALCULATE DESIGN

PERFORMANCE ANALYSIS

Calculated PCC Overlay Thickness (in)	4.16
Design PCC Overlay Thickness (in)	**4.5**
Is there potential for reflective cracking?	No
	Solved.

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Overlay Experiences

- Spokane, WA
  - 3 sections on I-90, 3”, 4”, 5”
  - Constructed in 2004
  - Eastbound AADT 40,000
  - Excellent performance in 4” and 5” sections
  - Reconstructed in 2011

NORTHWEST CHAPTER

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Overlay Experiences

- Kalispell
  - 5” on ?”-5” of HMA
  - 6’ joint spacing
  - 18,000 ADT in 2000
  - 30% Trucks
  - Built in 2000
  - Performing very well

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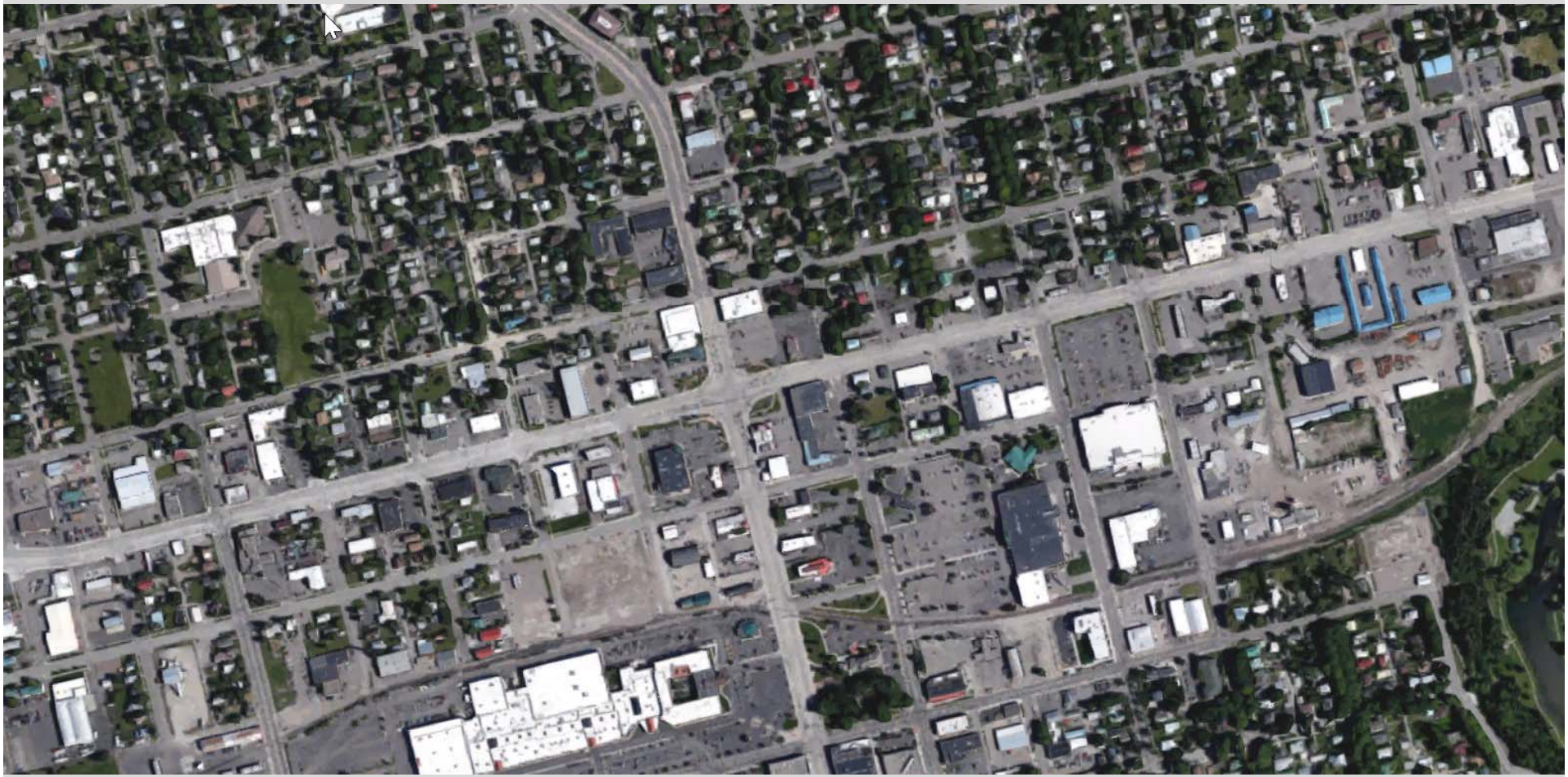
CENEX
Zip Mp
285
285



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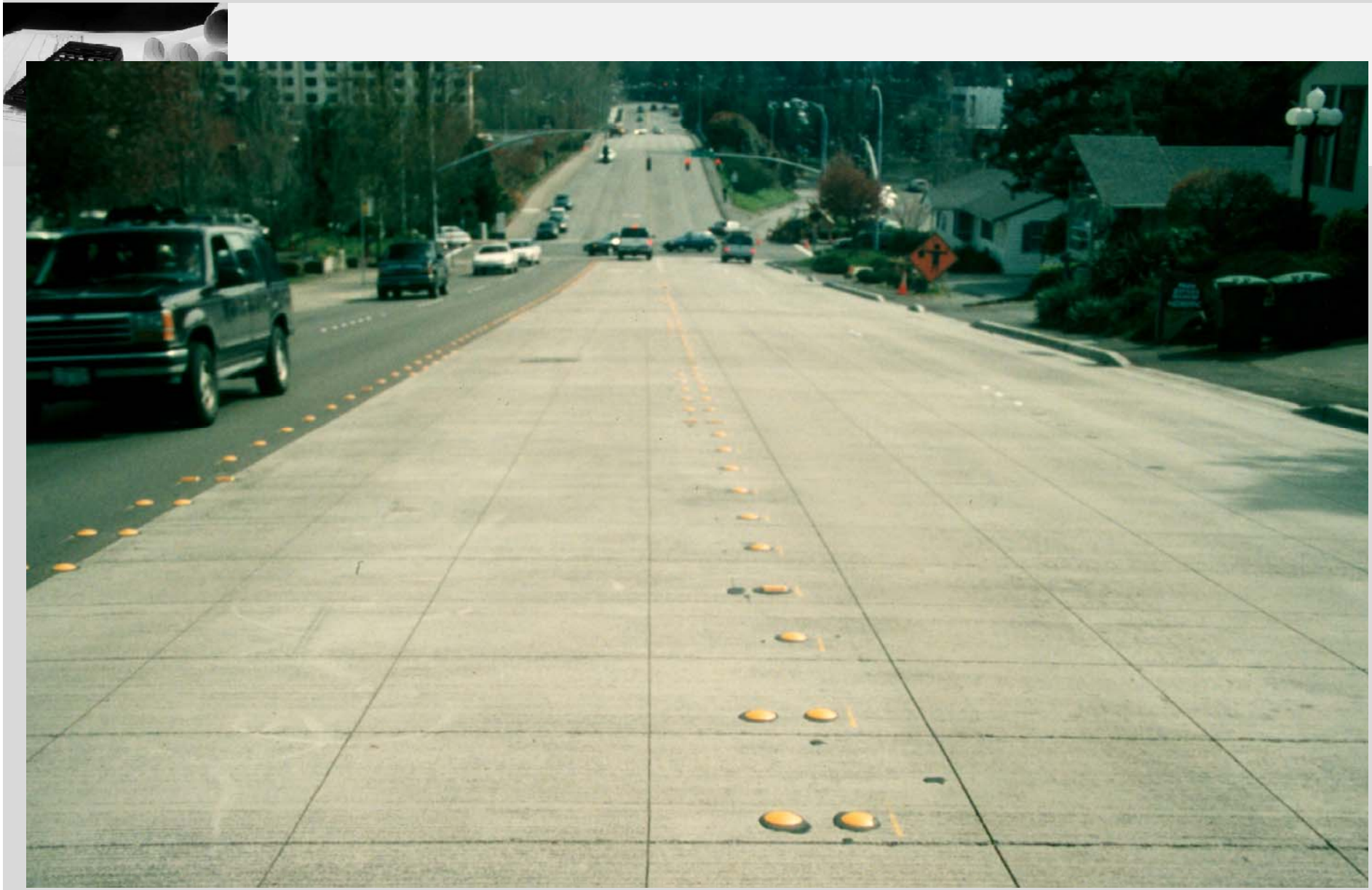
Overlay Experiences

- Bellevue
  - 3” PCC on 3” AC
  - Built 1998
  - Still in service
  - Cracking in edge panels due to lack of support. Edge panels have been replaced.



Overlay Experiences

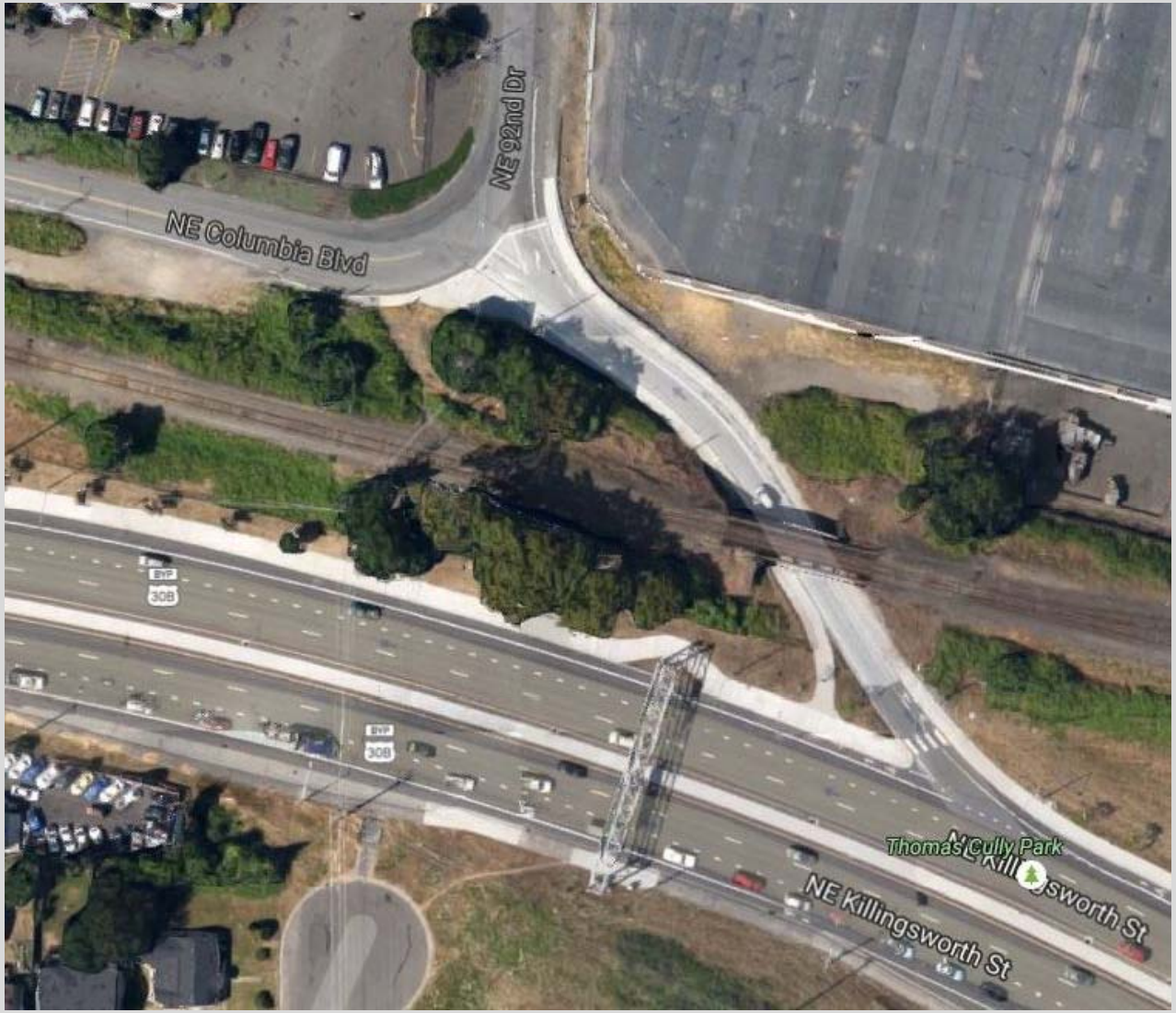
- US 20/26 & Middleton Road
- Built in 2005
- 4” on 4”
- Still in service
- Excellent performance


09/08/2010

Other NW Projects

- Portland
  - NE Columbia Blvd.
    - 4” – 6” PCC on 0” – 4” Asphalt
  - N. Denver Avenue
    - 2.5” PCC on Variable Sections
- Eugene
  - Coburg Rd.
  - 6” PCC on 4” Asphalt
- Yakima
  - 40th and Knob Hill
  - 6” PCC on 2” – 4” Asphalt

Portland



NORTHWEST CHAPTER

Yakima

QUESTIONS?