End of Life Considerations in Pavement Type Selection

Randy C. West, Ph.D., P.E
Director and Research Professor
National Center for Asphalt Technology
Auburn University

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The National Center for Asphalt Technology

NCAT main office and lab
277 Technology Parkway
Auburn, AL

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NCAT History

- Established in 1986 as a partnership between Auburn University and the National Asphalt Pavement Association Research & Education Foundation
- Best known for the “NCAT Textbook”, the ignition method, the Professor Training Course, the *Asphalt Technology News* newsletter, the NCAT Test Track, and applied research.
- The majority of funding for research comes from state Departments of Transportation.

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Pavement Test Track

Asphalt Pavement Proving Ground

- 2018 started our 7th research cycle
- 46 Test Sections, 200 ft. each
- 5 trucks each pulling 3 heavily loaded trailers make 400 laps/day
- Test sections are evaluated continuously over 3 year cycles.


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NCAT Lead Researchers


Dr. Nam Tran


Dr. Buzz Powell


Mr. Jim Musselman


Dr. Randy West

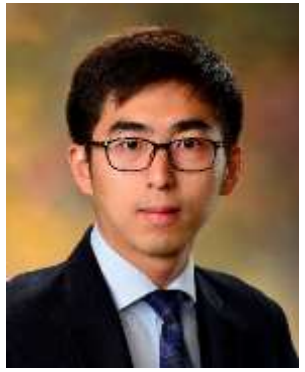

Dr. David Timm


Dr. Carolina Rodezno


Mr. Travis Walbeck


Dr. Fabricio Leiva


Dr. Adriana Vargas


Dr. Fan Yin


Dr. Fan Gu


Dr. Raquel Moraes


Dr. Ben Bowers

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Access detailed information about key research projects in our publications and technical reports.

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Facilities

Our Test Track and state-of-the-art laboratories make us a world leader in asphalt pavement research.

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Our Team

Our researchers and staff are instrumental in bringing new concepts and technologies to practice across the country.

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NCAT's mission is to provide innovative, relevant and implementable research, technology development and education that advances safe, durable and sustainable asphalt pavements.

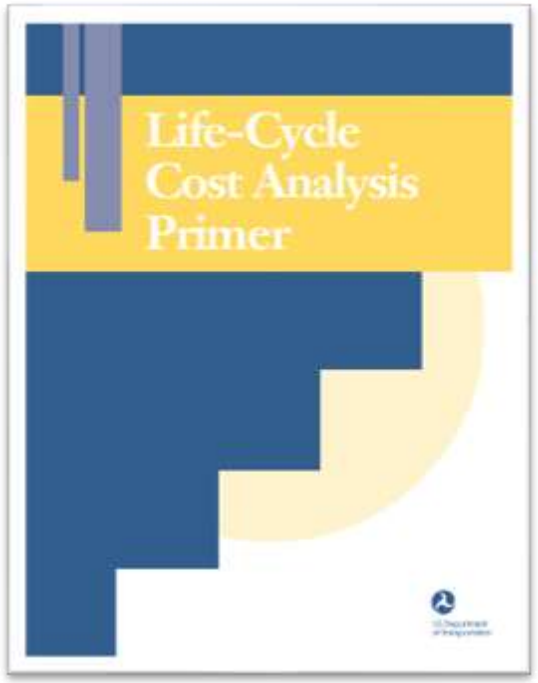
What is an LCCA and how is it used?

Life-Cycle Cost Analysis is a structured process for conducting an economic analysis of competing investment alternatives that takes into account all costs over the life of an investment.

Pavement related uses:

- Pavement Type Selection: asphalt versus concrete;
- Pavement Structural Design: Perpetual Pavement versus conventional design

Steps in an LCCA



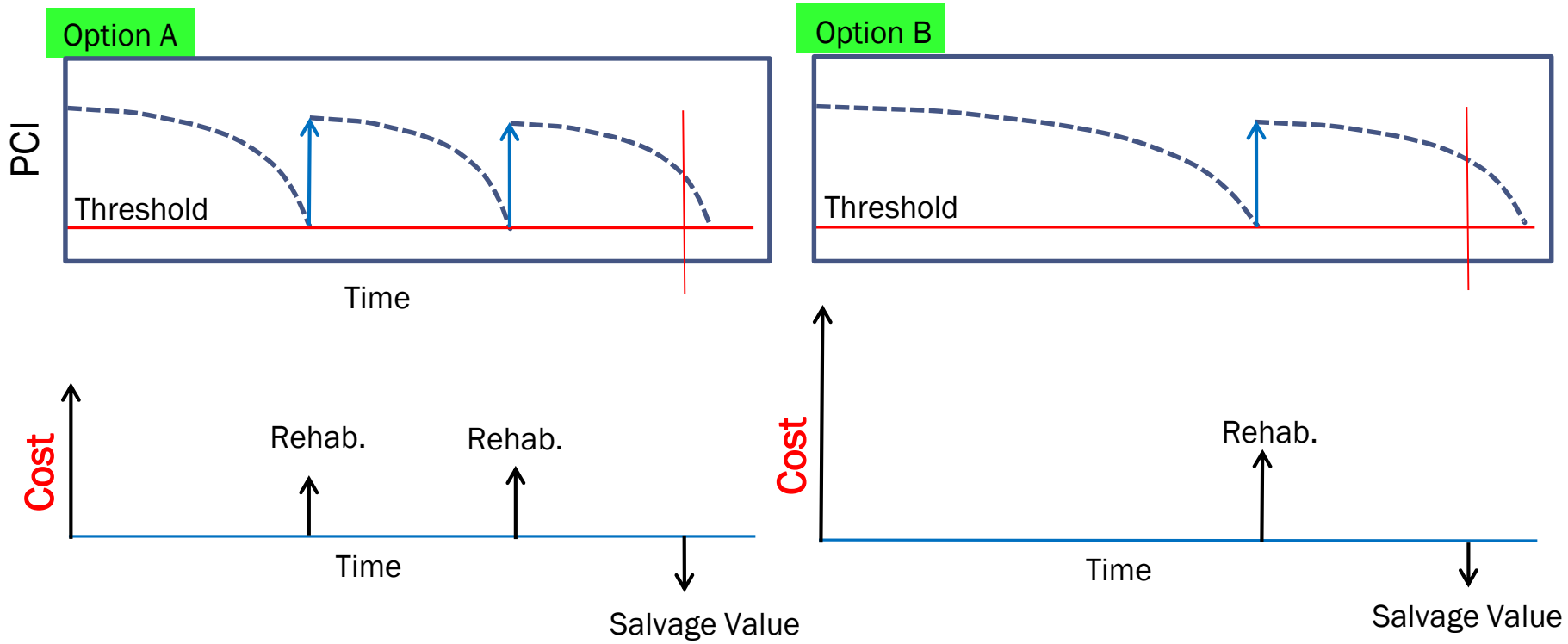
FHWA Primer, 2014

1. Establish alternative strategies
2. Estimate timing of future activities
3. Estimate costs
    a. Initial construction
    b. Rehabilitation activities to maintain service of roadway
        i. Agency costs
        ii. User impact costs
    c. Salvage value
4. Compute the discounted total life-cycle costs
5. Analyze the results
6. Determine the best alternative

Some Challenges with LCCA

- Predicting future traffic
- Predicting timing of future maintenance
- Estimating future maintenance costs
- Estimating future user costs
- Dealing with end of pavement life uncertainties
- Changes in technology

LCCA Basics



$$NPV = Initial\ Const.Cost + \sum_{k=1}^{N} Future\ \ Cost_k \left[\frac{1}{(1+i)^{n_k}}\right] - Salvage\ Value \left[\frac{1}{(1+i)^{n_e}}\right]$$

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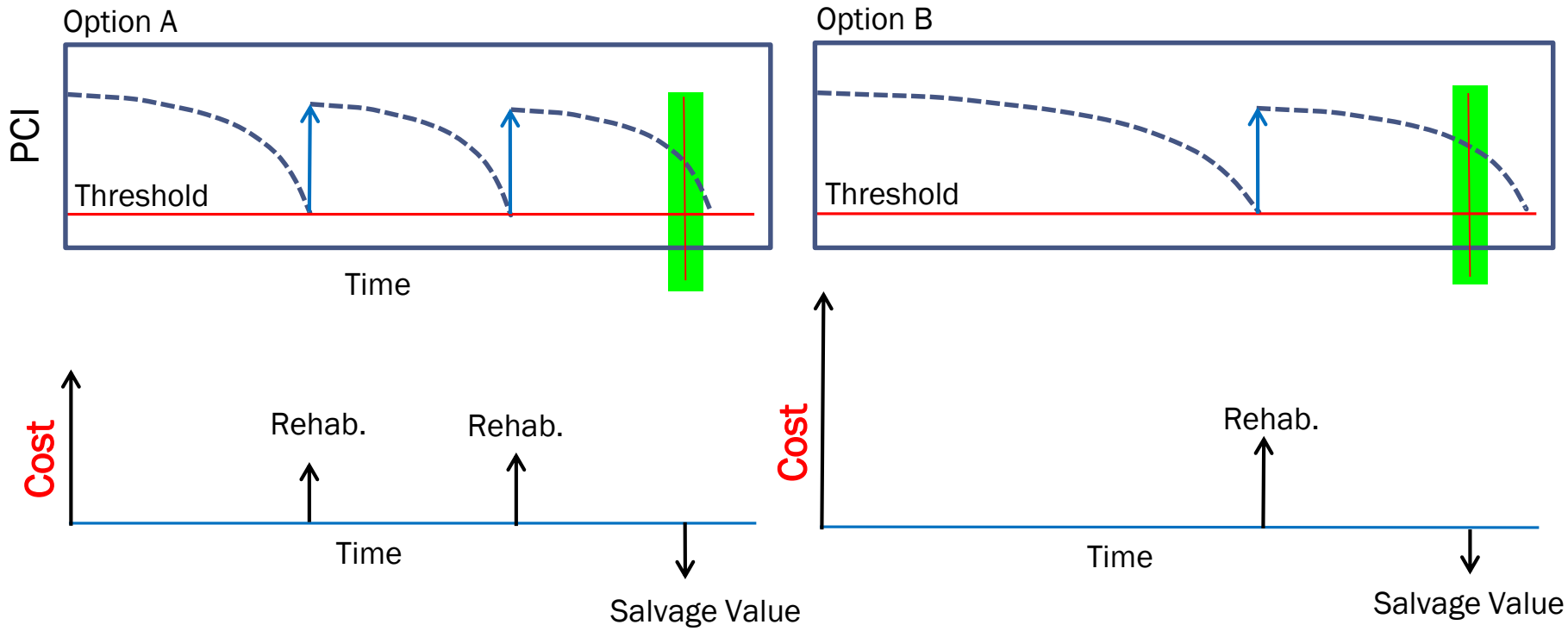

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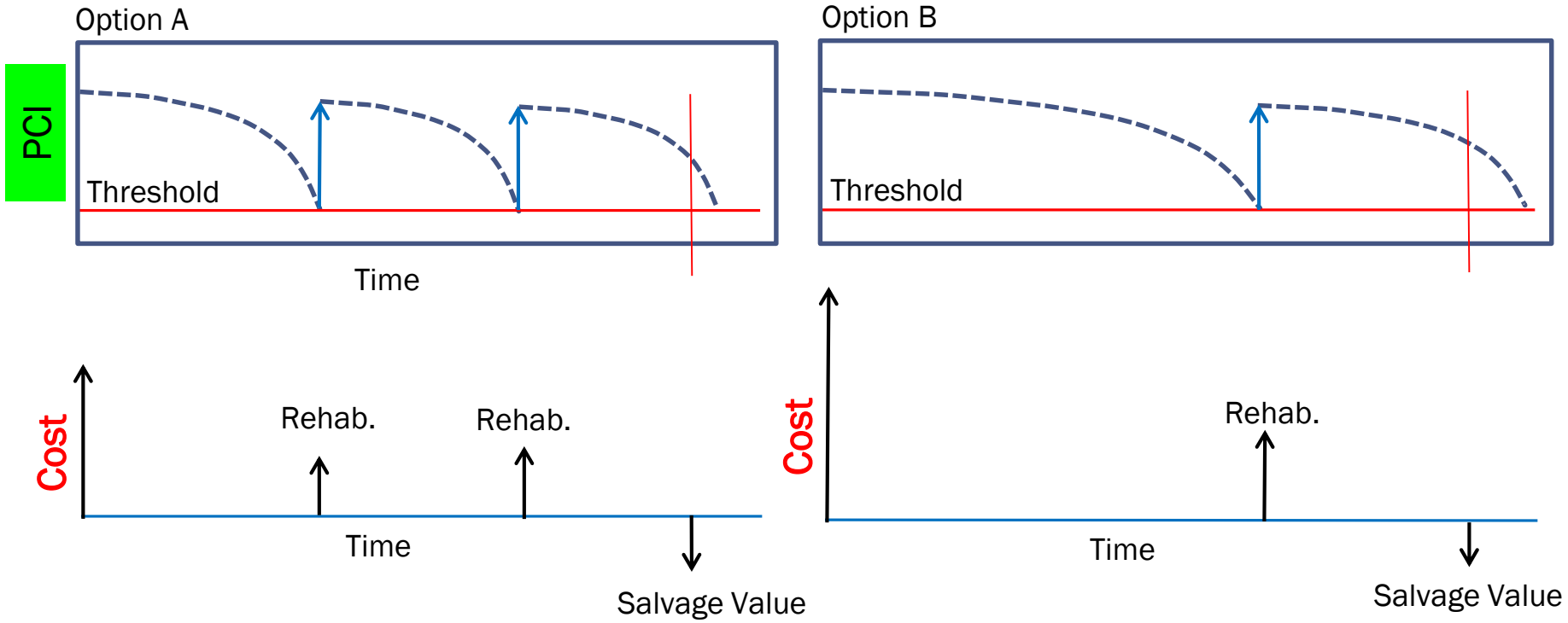

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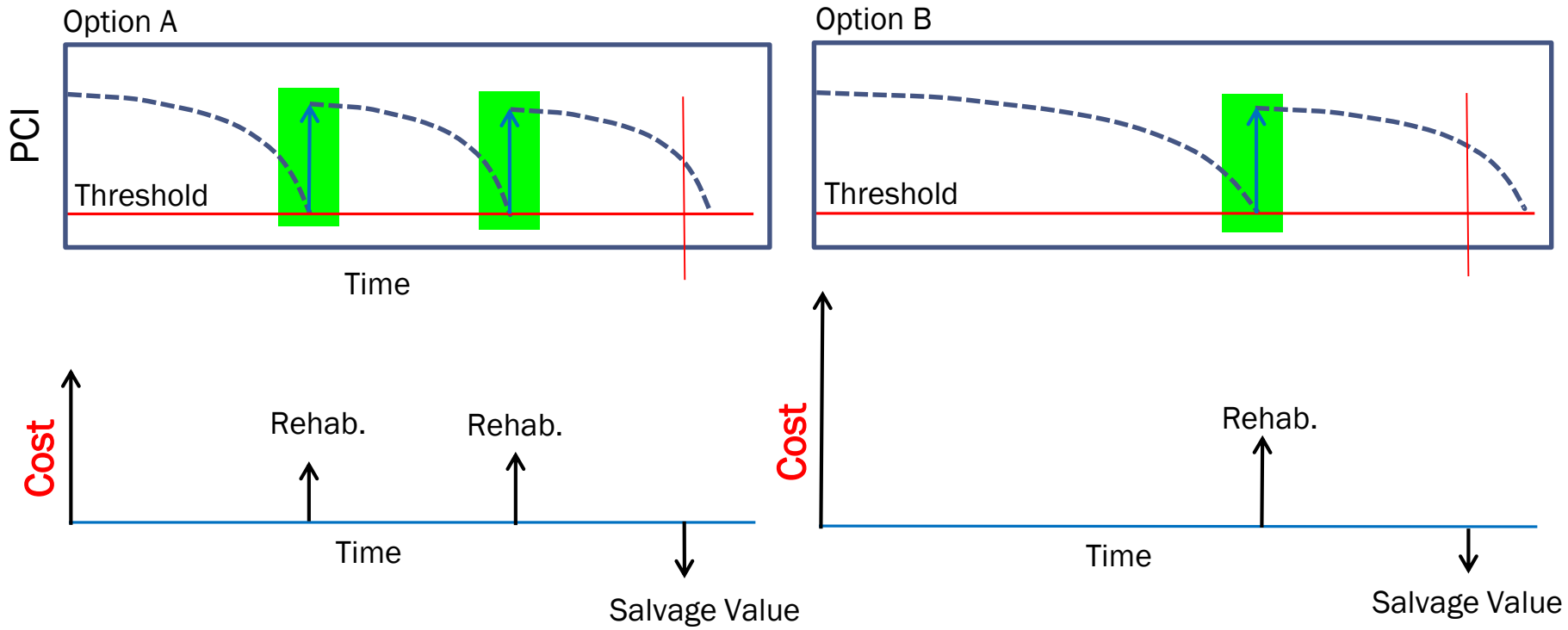

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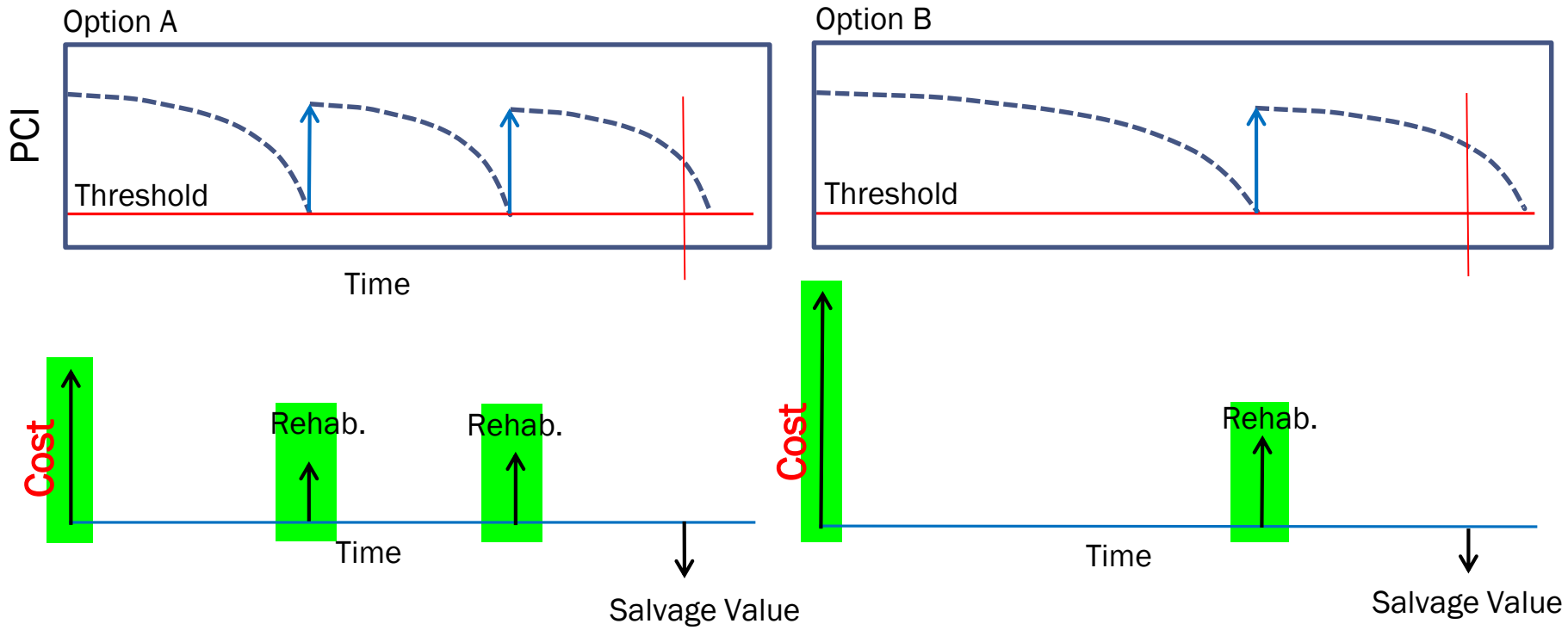

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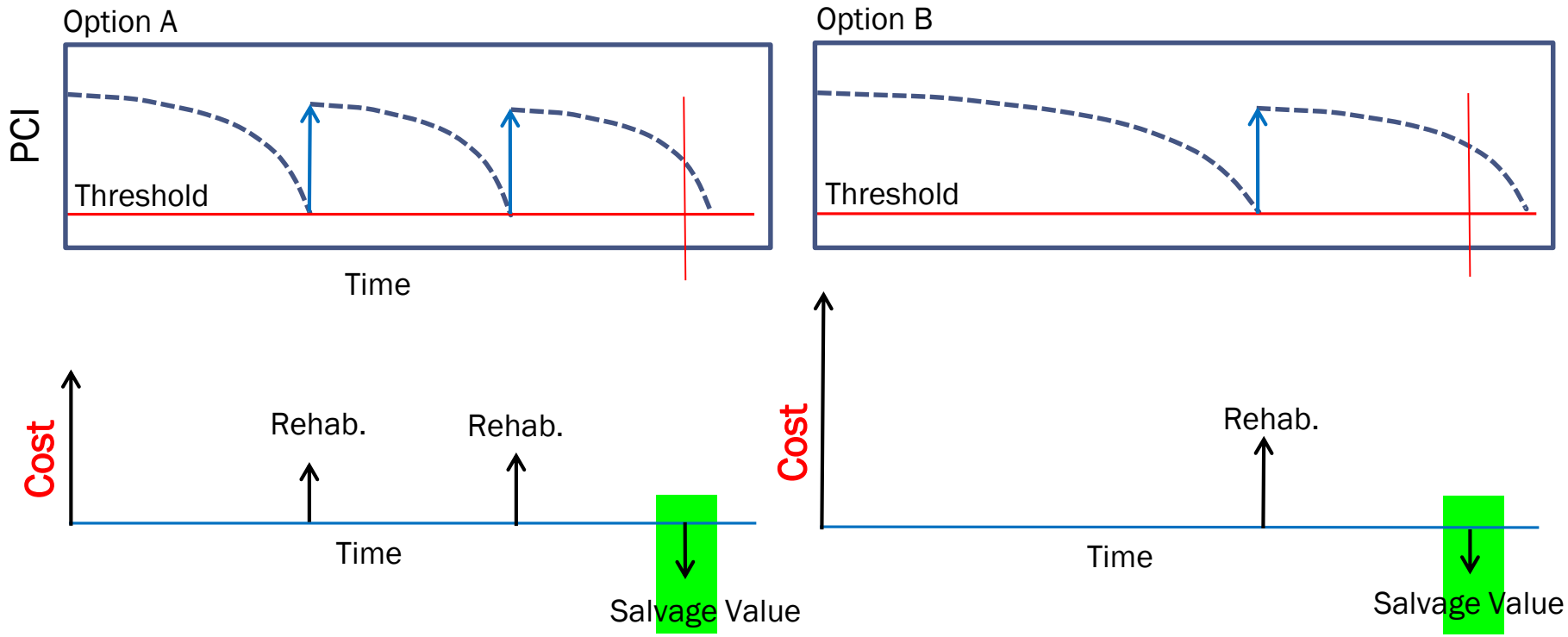

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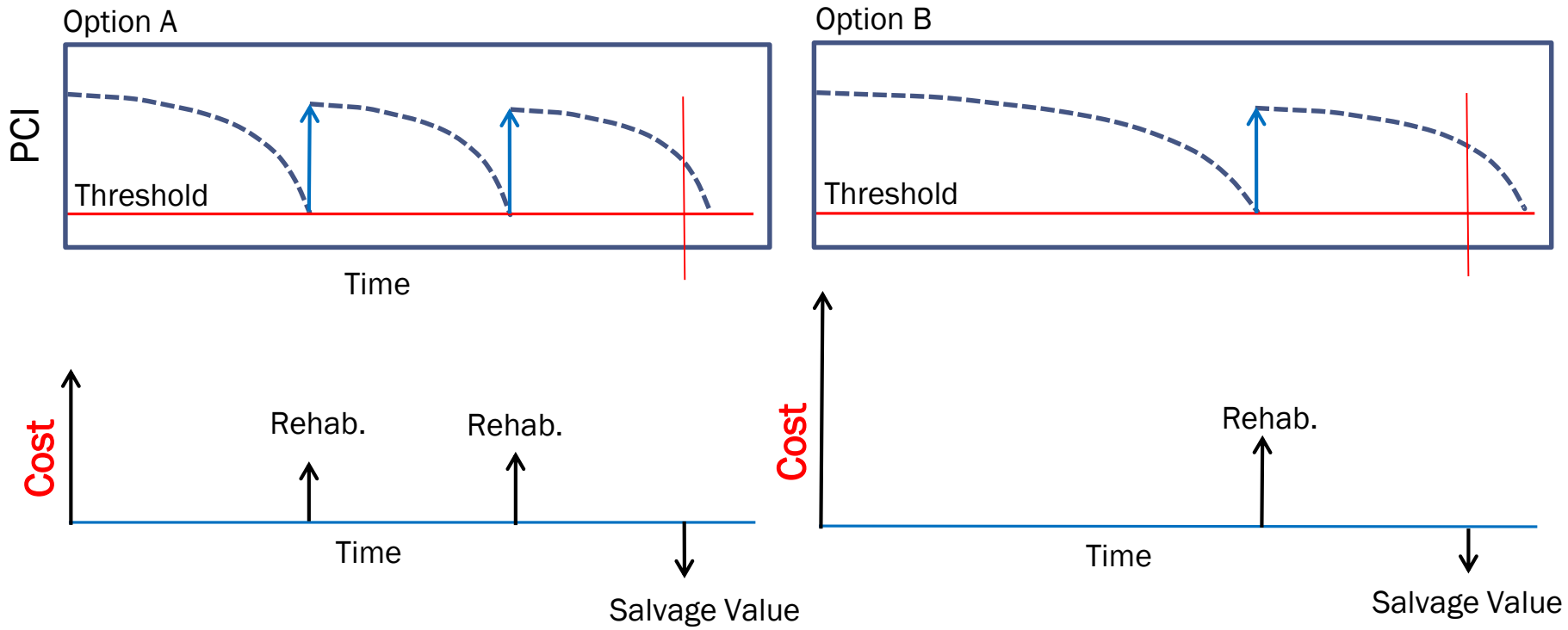

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Initial Construction Cost Data

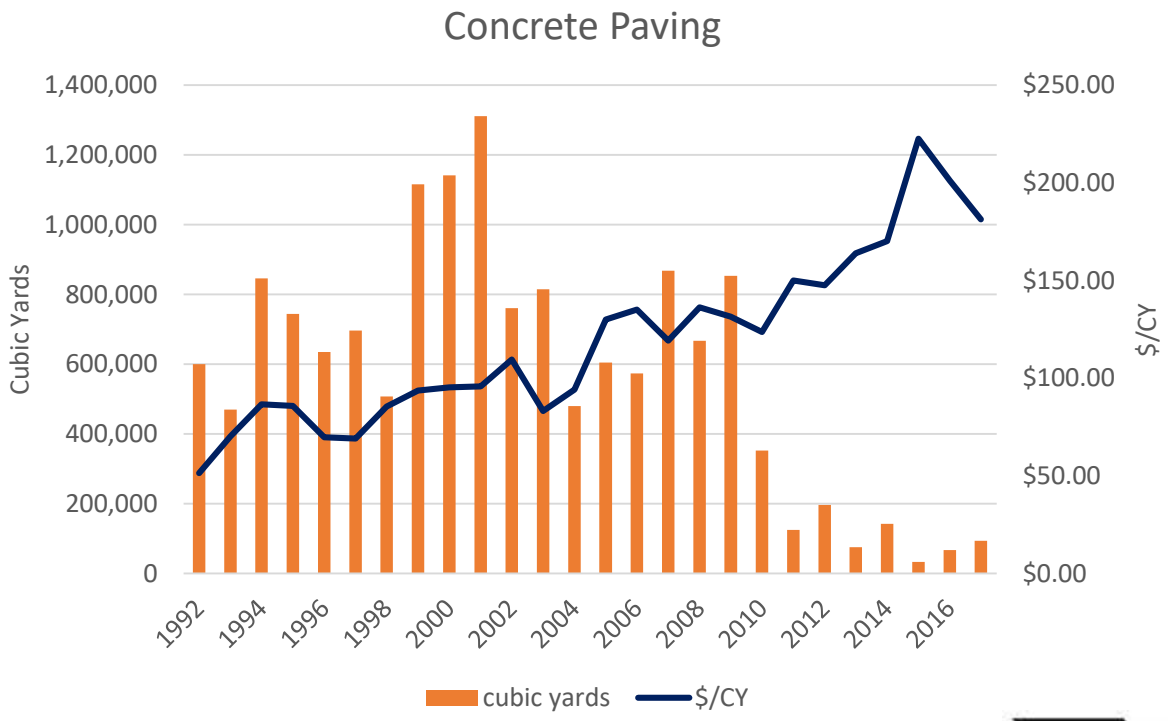
Initial costs for asphalt and concrete pavements are a function of:

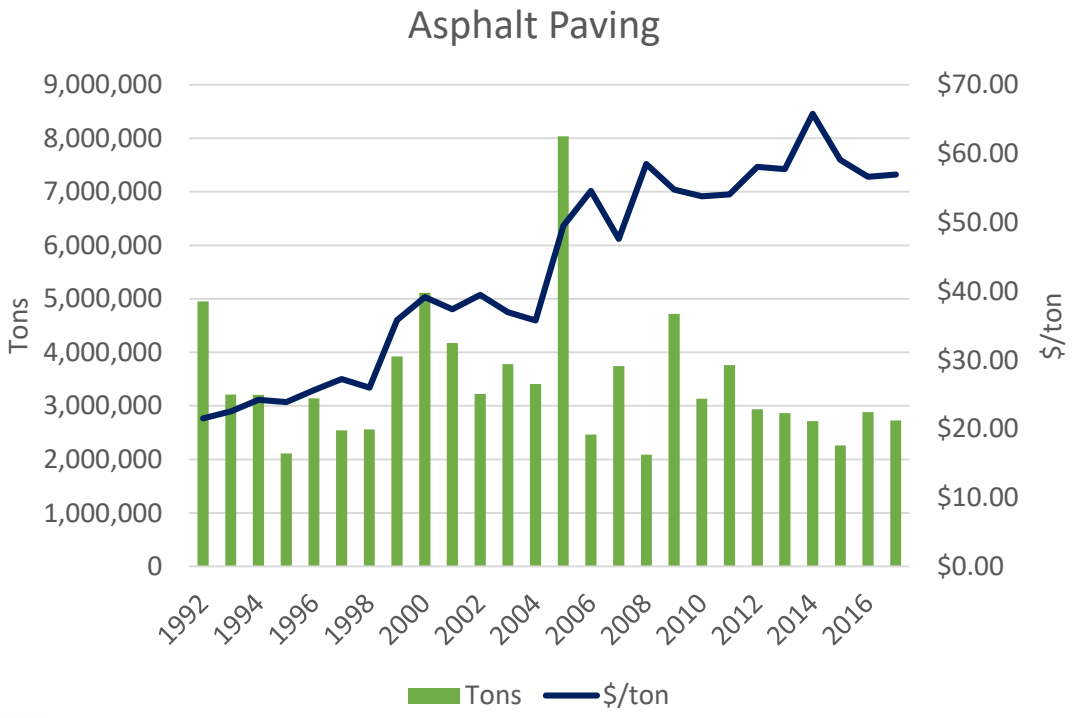
- Pavement design thicknesses
- Price of raw materials (e.g. aggregates, binder, cement, recycled)
- Material quantities (scale of project)

Initial cost data used in LCCA should be based on recent bids for the region of the project

Comparison of Bid Prices from Missouri, a State with a “Two Pavement System”

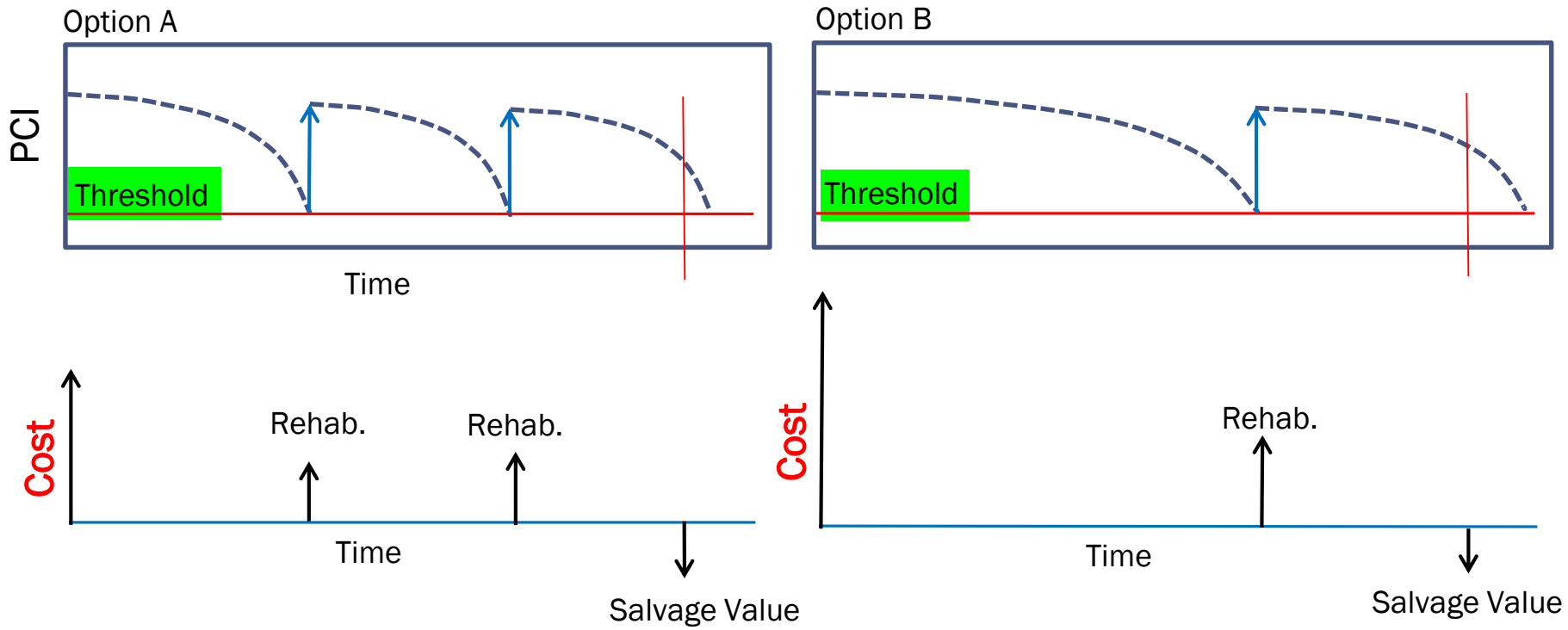
Annualized cost growth rate for both pavement types from 1992 to 2009 was the same.





Comparisons of prices were not made beyond 2009 since the volume of concrete dropped dramatically since then.

LCCA Basics



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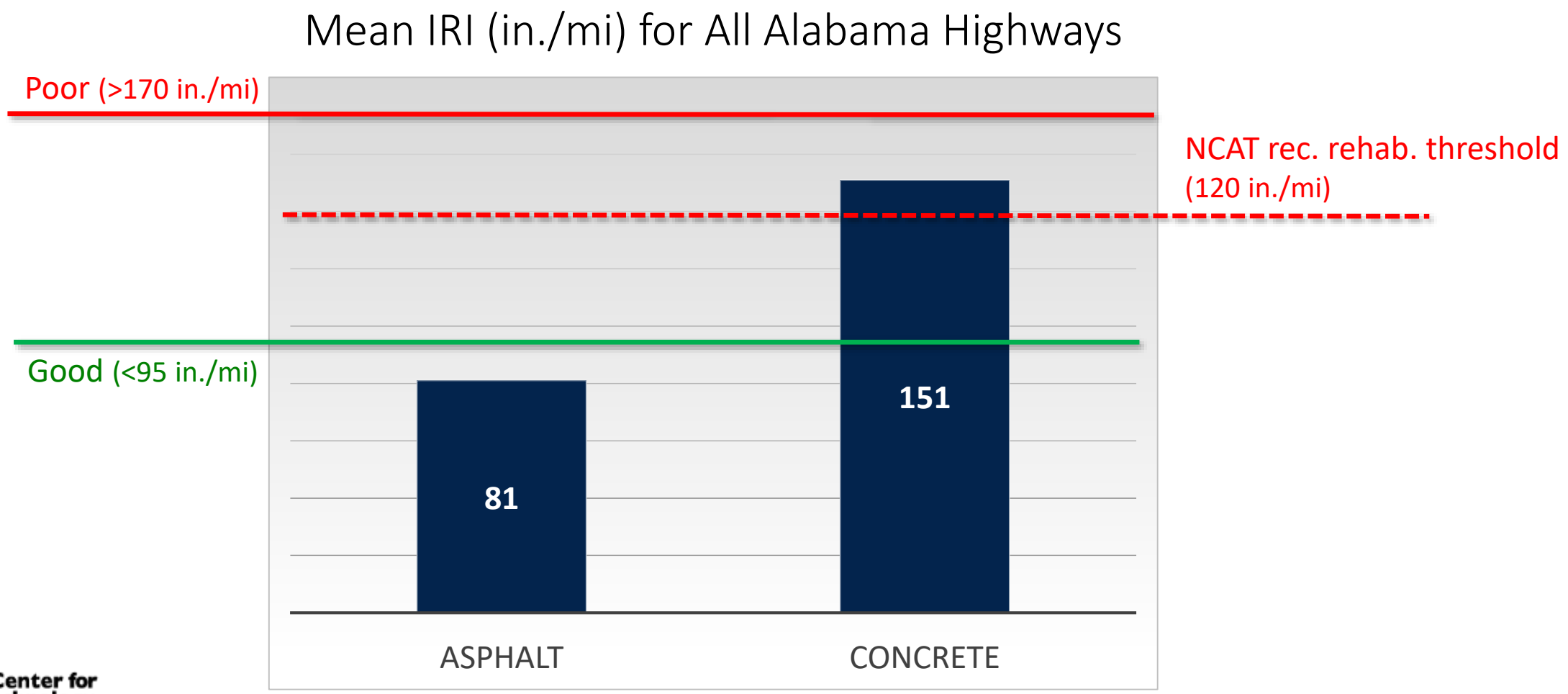
Pavement Condition Thresholds

- Asphalt and concrete pavements have different performance metrics
- States use different condition (e.g. PCI) thresholds for different pavement types
- NCAT examined LTPP data for service lives:
  - Asphalt – avg. time to 1st rehab. **18** years; mean IRI = 112 in./mi.
  - Concrete – avg. time to 1st rehab. **24** years; mean IRI = 129 in./mi

Pavement Performance



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Rehabilitation in LCCA

asphalt pavement rehab.

concrete pavement rehab.

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Major Rehabilitation

Concrete

• Asphalt Overlay	71%
• Max. Restoration of PCC	17%
• Slab Fracturing plus HMA	5%
• Remove & Replace with PCC	3%
• Remove & Replace with HMA	3%
• PCC Overlay	1%

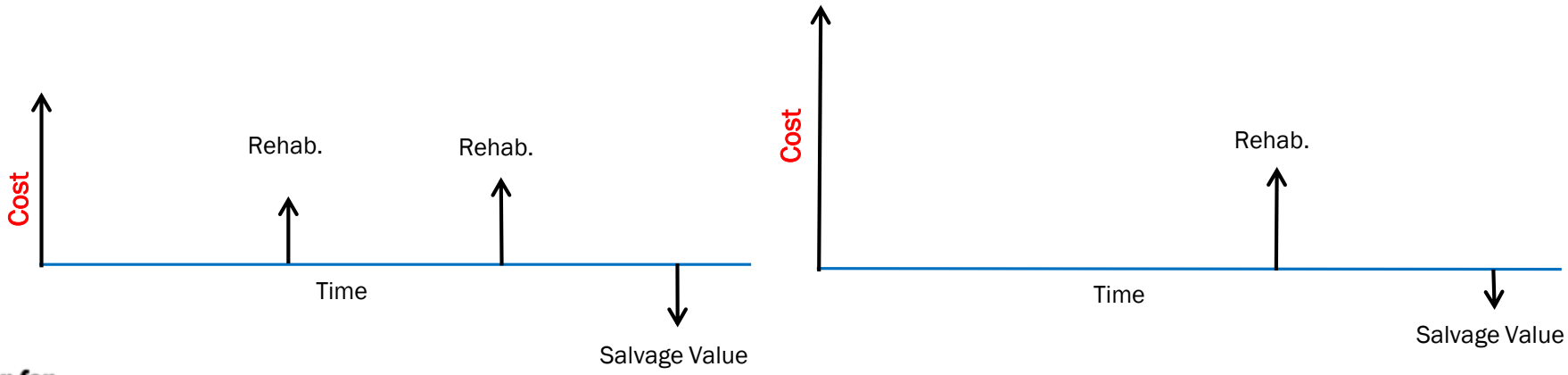
Asphalt

• Mill & Overlay	56%
• Asphalt Overlay	42%
• Full Reconstruction	2%

Avg. of data from 9 states

Rehabilitation in LCCA

- Concrete requires rehabilitation sooner than most DOTs use in LCCA
- Rehabilitation costs have two parts to consider:
  1. agency costs
  2. user costs
- A key input in LCCA is the timing of rehab. activities.



Auburn University Work Zone Analysis

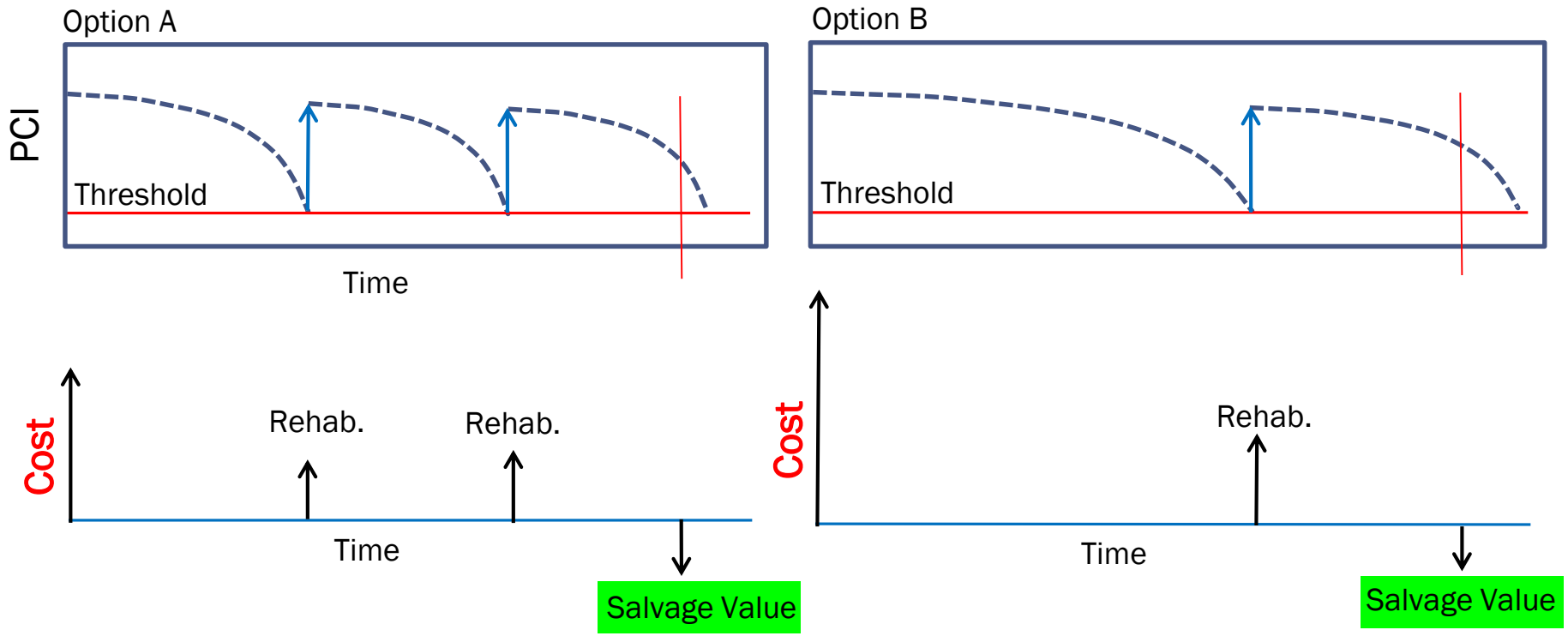
- Developed a comprehensive set of data-driven, nationally transferrable metrics that quantify the costs associated with asphalt and concrete pavement rehabilitation in terms of (a) road user costs, (b) crash mitigation costs, and (c) local business impact costs.
- Excel tool developed for engineers/project managers:
  - Input project variables
  - Output associated direct and indirect costs
  - Can do analysis of road rehabilitation scenarios requiring lane closers to determine the least impactful course of action.

LaMondia, J., M. Fisher, R. Turochy, W. Zech, *Calculating Road User, Crash Mitigation and Local Business Impact Costs Generated by Pavement Rehabilitation, Maintenance and Other Roadway Reconstruction Projects*. Final Report, National Asphalt Pavement Association, 2019.

Auburn University Work Zone Analysis

- A generalized example shows that PCC work zones cost 55% more than asphalt work zones due to the additional time to reconstruct PCC.
- This example considers the costs and time associated with building and maintaining a typical 2 lane arterial highway in Alabama:
  - 20,000 ADT (and 15% freight)
  - Traffic speeds operating at 35mph from a 55mph posted speed.
  - Assumes asphalt rehab on 14 year intervals and reconstruction of the concrete pavement at year 42.
  - Examines the road user costs generated from the different times associated with curing the roadway materials. Times to install and remove work zone traffic control are incorporated in the example.

LCCA Basics



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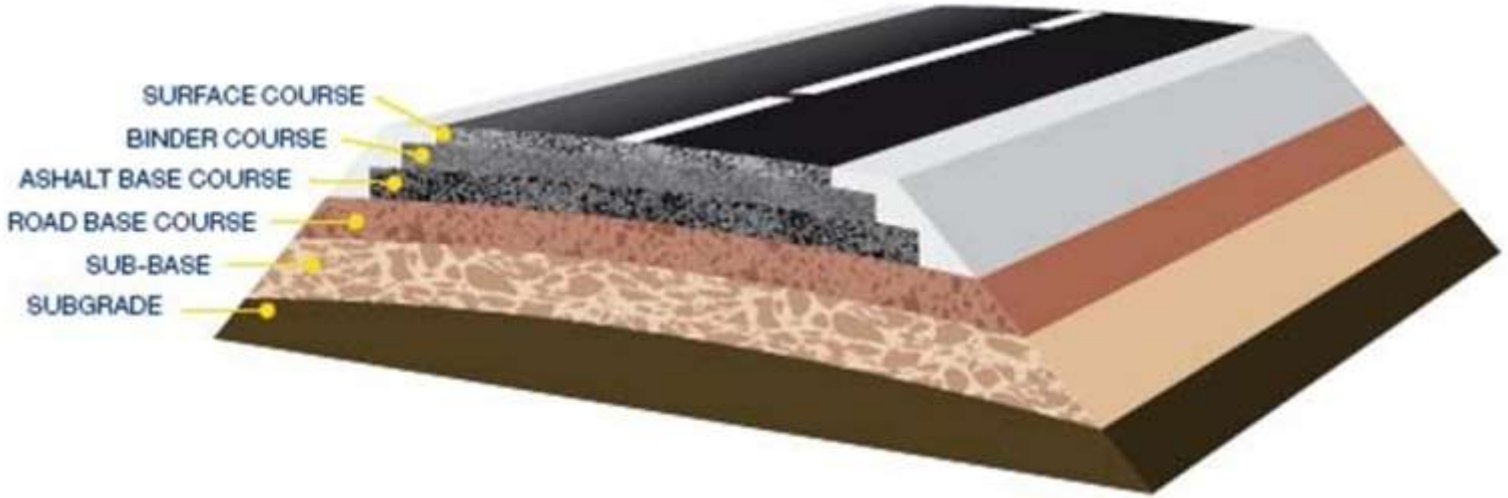
Salvage Value

- Often considered to have a negligible impact on LCCA
- However, that is typically due to the way salvage value is estimated.
- All of the asphalt has value, not just the last overlay.

See NCAT report 19.03 for further recommendations on salvage value



Composite Pavements…

- A term used for concrete pavements that have been overlayed with asphalt
- Only 15 DOTs keep up with their lane miles of composite pavements
  - All 15 have more lane miles of composite pavements than remaining concrete pavements
  - Missouri has 9,240 lane miles of composite pavement and 4,813 lane miles of concrete pavement.

- For the remaining 35 DOTs, Composite Pavements = Forgotten Mistakes

Reconstruction

- Concrete pavements often reach a point where ongoing rehab. is unwise and the PCC reaches the End of its Life.
- Dealing with that event is expensive!

Major Rehabilitation

Concrete

- Asphalt Overlay 71%
- Max. Restoration of PCC 17%
- Slab Fracturing plus HMA 5%
- Remove & Replace with PCC 3%
- Remove & Replace with HMA 3%
- PCC Overlay 1%

Reconstruction

Avg. of data from 9 states

Reconstruction

- Demolition/removal of existing pavement
- Traffic delays/detours
- Crash costs
- Business impact costs
- Changes in final elevation
  - Adjusting bridges, drainage elements, guardrail, other structures in ROW
- All of those cost must be accounted for in the LCCA

Concrete Pavement Performance

- Many state DOTs have realized over the long term, concrete pavements are more costly to maintain when the actual cost of PCCP reconstruction is considered.
- Concrete pavements are often patched well beyond their performance lives because **reconstruction** is very expensive and disruptive to traffic. Consequently, many surviving concrete pavements exceed the FHWA limits for roughness.
- Twelve* state DOTs no longer design or build concrete pavements due to poor historical performance, traffic congestion to repair and reconstruct, and high initial costs.

*AK, DE, CT, HI, MA, MD, ME, MS, MT, NH, RI and VT

Crack & Seat and Break & Seat

Crack & Seat: used on plain (unreinforced) concrete pavements; crack spacing 1 to 5 ft.

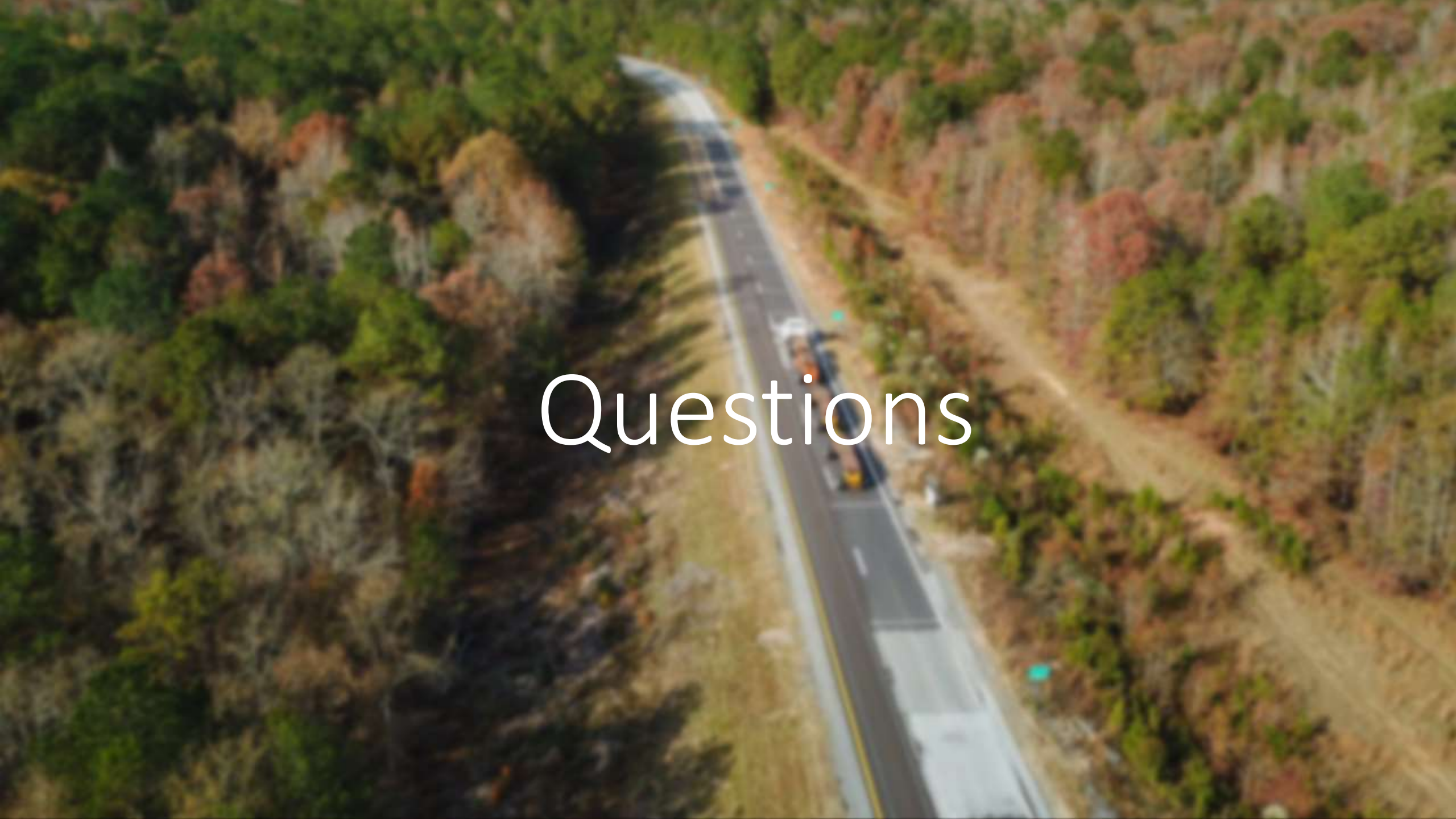
Break & Seat: used on reinforced concrete pavements; crack spacing 0.5 to 2 ft.

Rubblization of Concrete

- 32 years old - the average age of rubblized concrete pavements in Alabama.
- 34 years old – the average age of concrete pavements rubblized in Louisiana
- 28 years old – the average age of concrete pavements rubblized in Florida
- Other states have similar data.

Summary

- The concrete paving industry continues to push for a political fix of market share.
- Real performance data do not support the claim of maintenance free concrete pavements for 40 years.
- Many states do not account for pavements that have to be reconstructed.
- Agency and User Costs of reconstructing concrete pavements must be considered in Life Cycle Cost Analyses.


Questions

Thank You

Randy West
randy.west@auburn.edu

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Balanced Mix Design
An Overview

Randy West, Ph.D., P.E.
Director, National Center for Asphalt Technology

BMD – a definition

An asphalt mix design that uses practical performance tests on appropriately conditioned specimens to ensure resistance to common distresses and considers mix aging, traffic, climate and location within the pavement structure.

Why change?

Most asphalt technologists are not satisfied with the current long term performance of our pavements. There is a desire to significantly improve the life of asphalt pavements.

Why change?

- Volumetric properties do not tell us anything about the *quality* of the binder, or about the interactions of different binder components and additives.
- V_{be} = the volume of effective asphalt = VMA – V_a
- V_{be} is dependent on G_{sb} which is not a reliable property
  - G_{sb} of source materials are subject to change over time, but not often verified.
  - G_{sb} has a low level of precision
  - G_{sb} of RAP aggregate is questionable

With the current volumetric mix design system…

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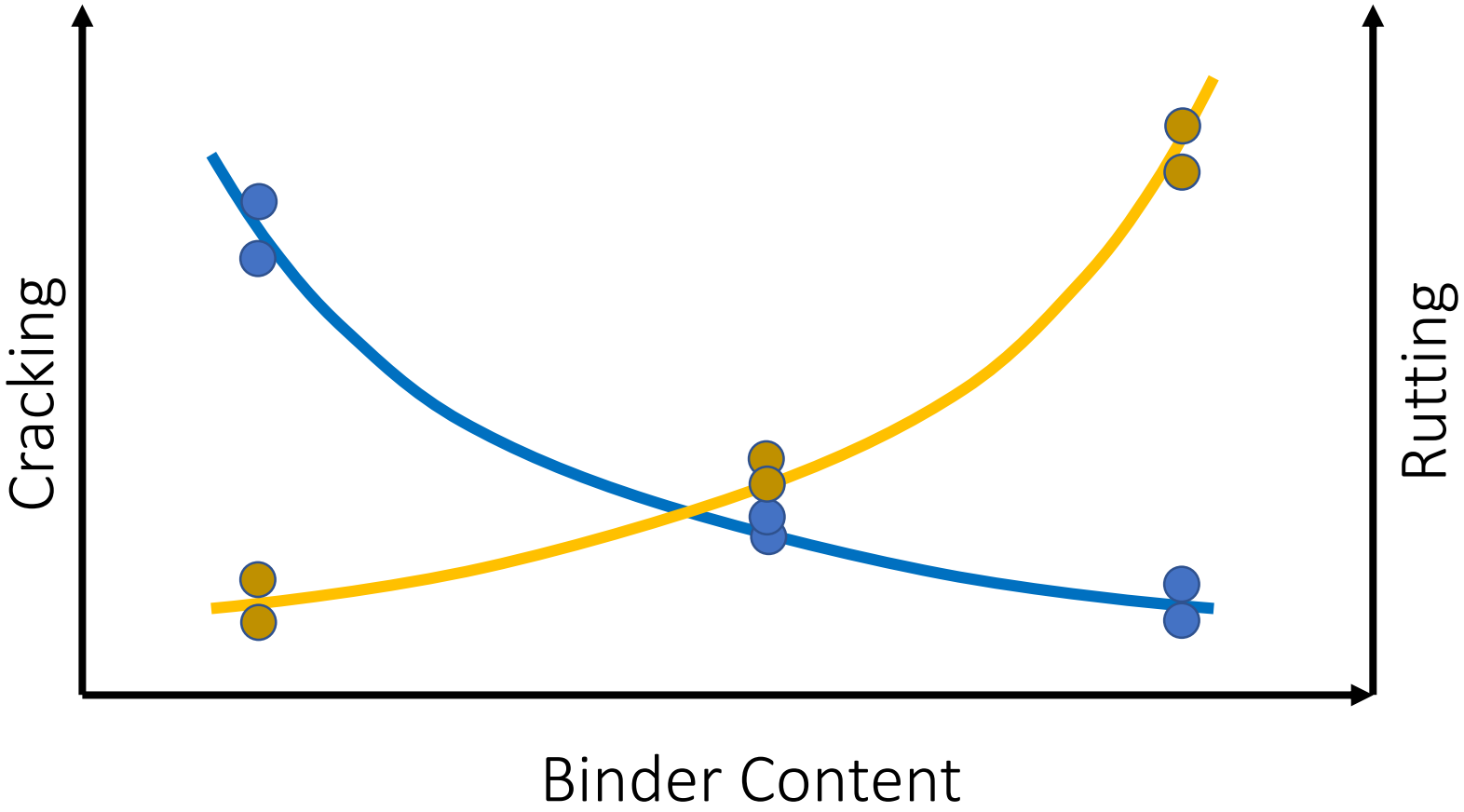
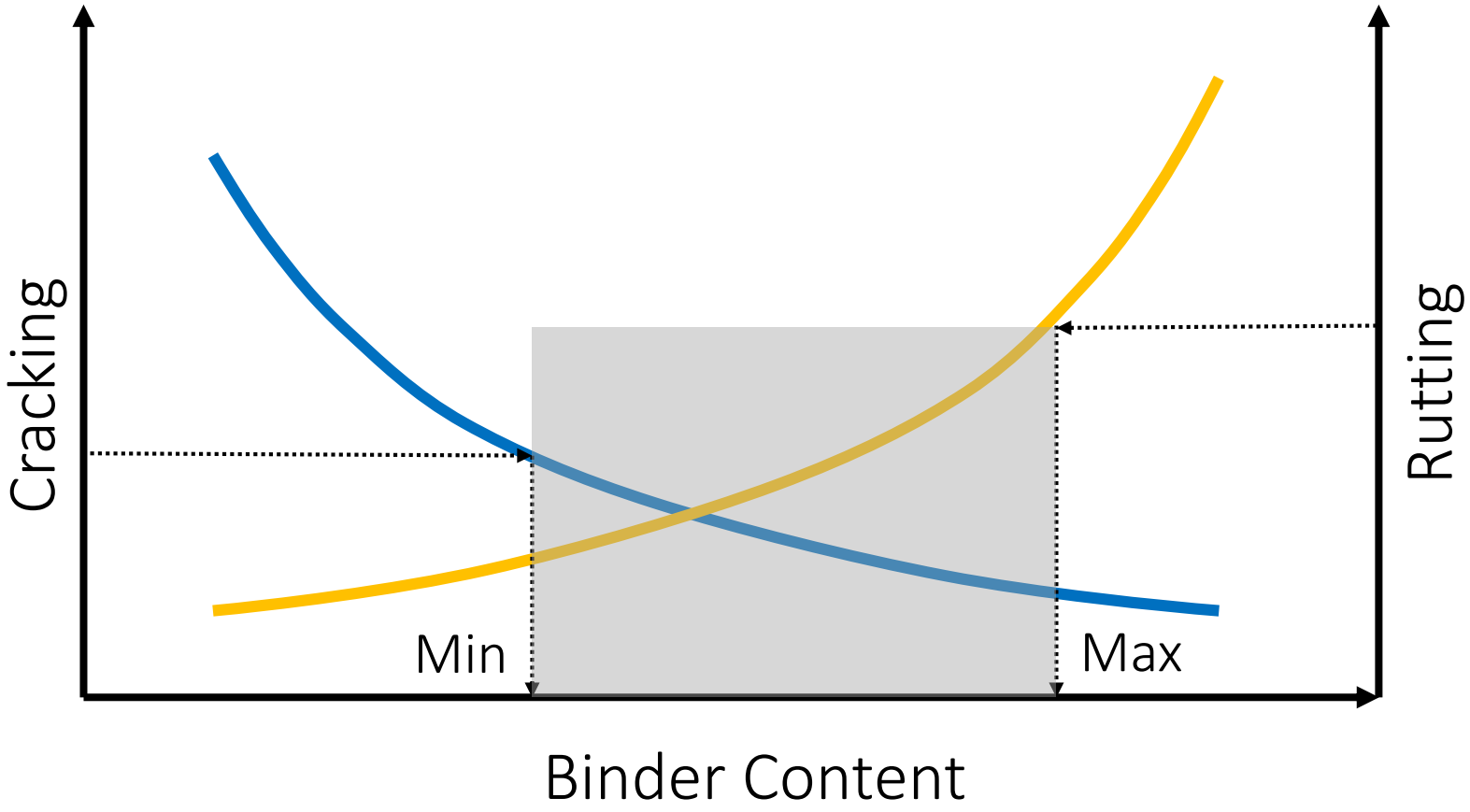
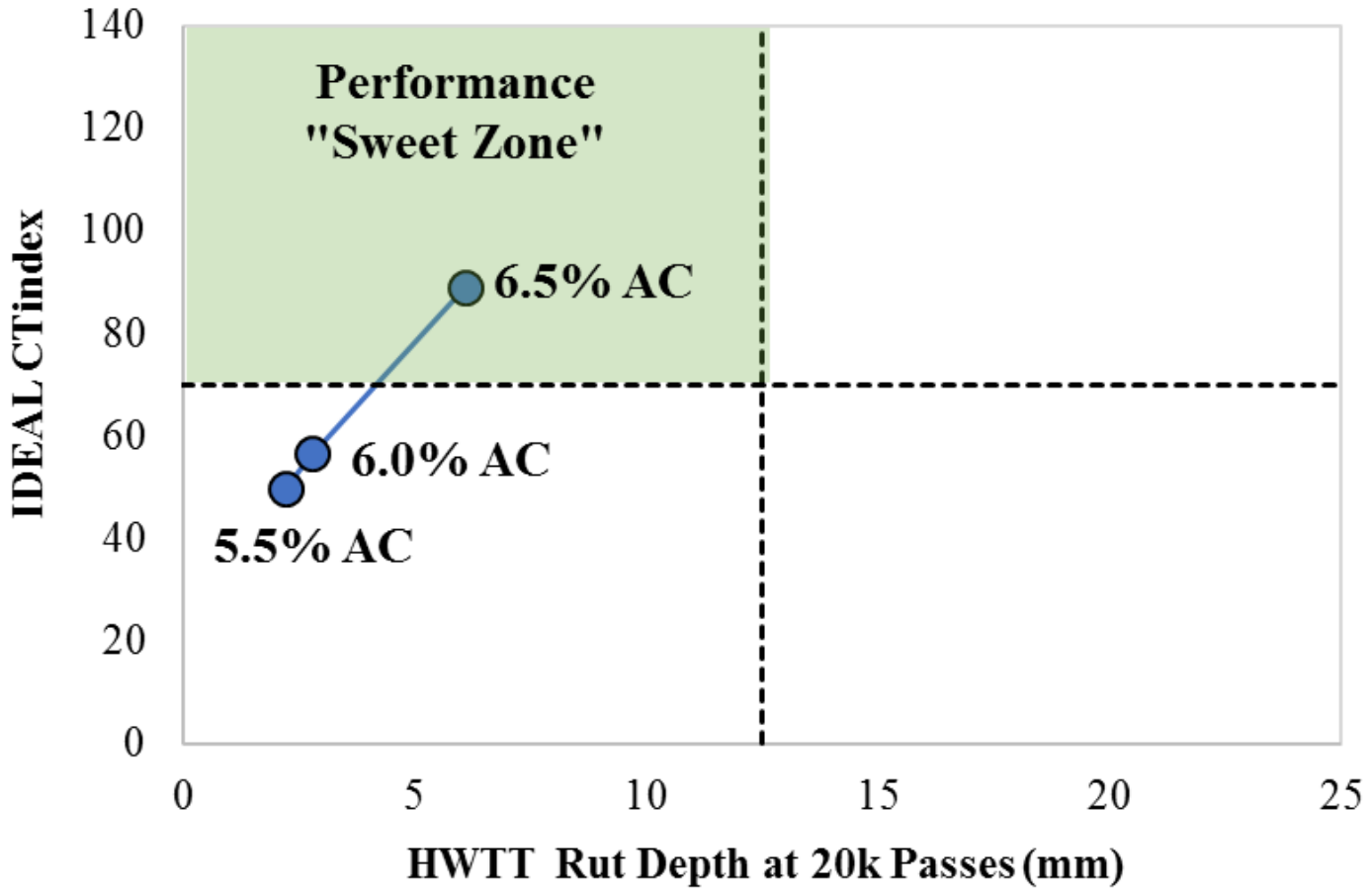
BMD Optimum Asphalt Content



BMD Optimum Asphalt Content



BMD Performance Diagram



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Numerous options to adjust mixes

Gradation

Asphalt Content

Modifiers

RAP Content

RAS Content

Rejuvenator

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The BIG questions

1. What performance tests will be used in BMD for your state?
2. How will the performance tests be used? Where will they fit in the mix design process? (The Framework)
3. What criteria should be used in specifications?
4. What aging/conditioning protocols should be used for mixtures in BMD?
5. How will the performance tests be used in Quality Assurance?

Cracking Group Studies

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Cracking Group Experiments

NCAT Test Track

Top-down cracking

MnROAD

Low-temperature cracking

NCAT Test Track

America's asphalt pavement proving ground

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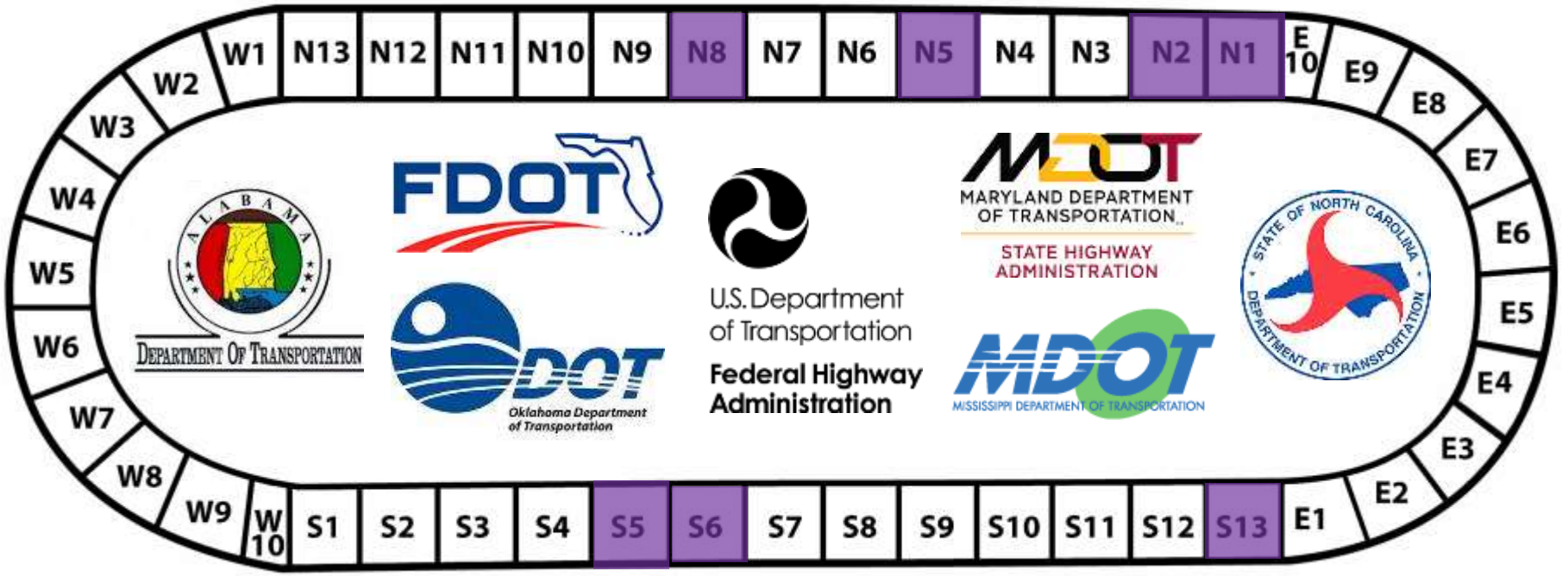

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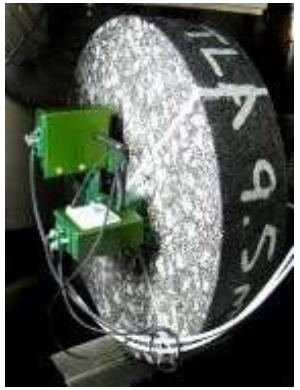
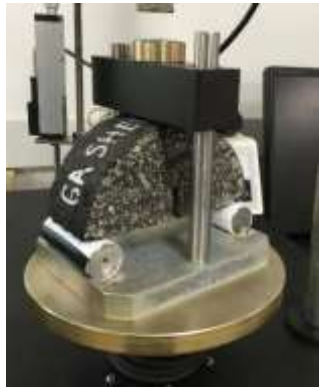
Selected Top Down Cracking Tests



Energy Ratio

SCB-LA



IFIT

OT-TX

OT-NCAT

IDEAL-CT

All tests have been conducted on:

1. lab prepared mix after short-term aging
2. lab prepared mix after short-term and critical aging
3. plant mix samples that were reheated
4. plan mix samples that were reheated and critically aged

critical aging for Auburn, AL = loose mix oven aging at 135C for 8 hours

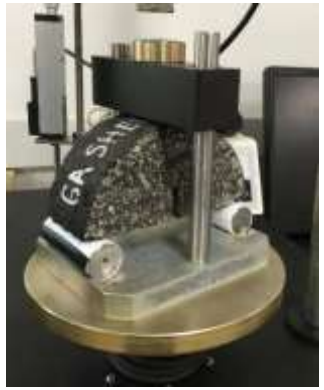
NCAT CG Field Performance

Section	Description	Cracking (% of lane area)		Crit. Aged CT Index
		Start of this Cycle	12/6/19	
N1	20% RAP (Control)	10.3	10.6	8.1
N2	Control w/ High Density	6.9	7.5	5.1
N5	Low AC, Low Density	3.5	9.3	8.6
N8	20% RAP 5% RAS	16.6	70	2.4
S5	35% RAP PG 58-28	0	0	16.3
S6	Control w HiMA	0	0	18.7
S13	AZ Rubber Mix	0	0	68.4

Selected Top Down Cracking Tests


Energy Ratio


SCB-LA


IFIT


OT-TX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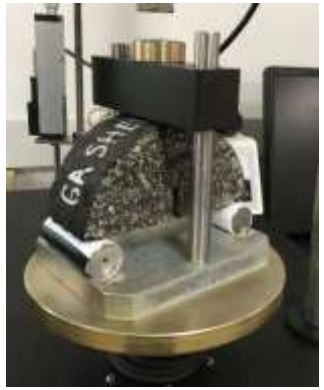
IDEAL-CT

Not practical enough for routine mix design

Selected Top Down Cracking Tests

SCB-LA



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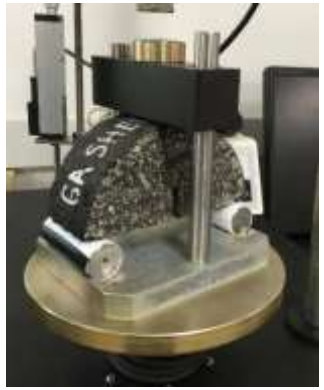
IDEAL-CT

Unable to identify worst and best performing mixes

Selected Top Down Cracking Tests



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IDEAL-CT

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MnROAD Cracking Group Test Sections

Test sections constructed August 2016

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Safer, Smarter, Sustainable Pavements Through Innovative Research

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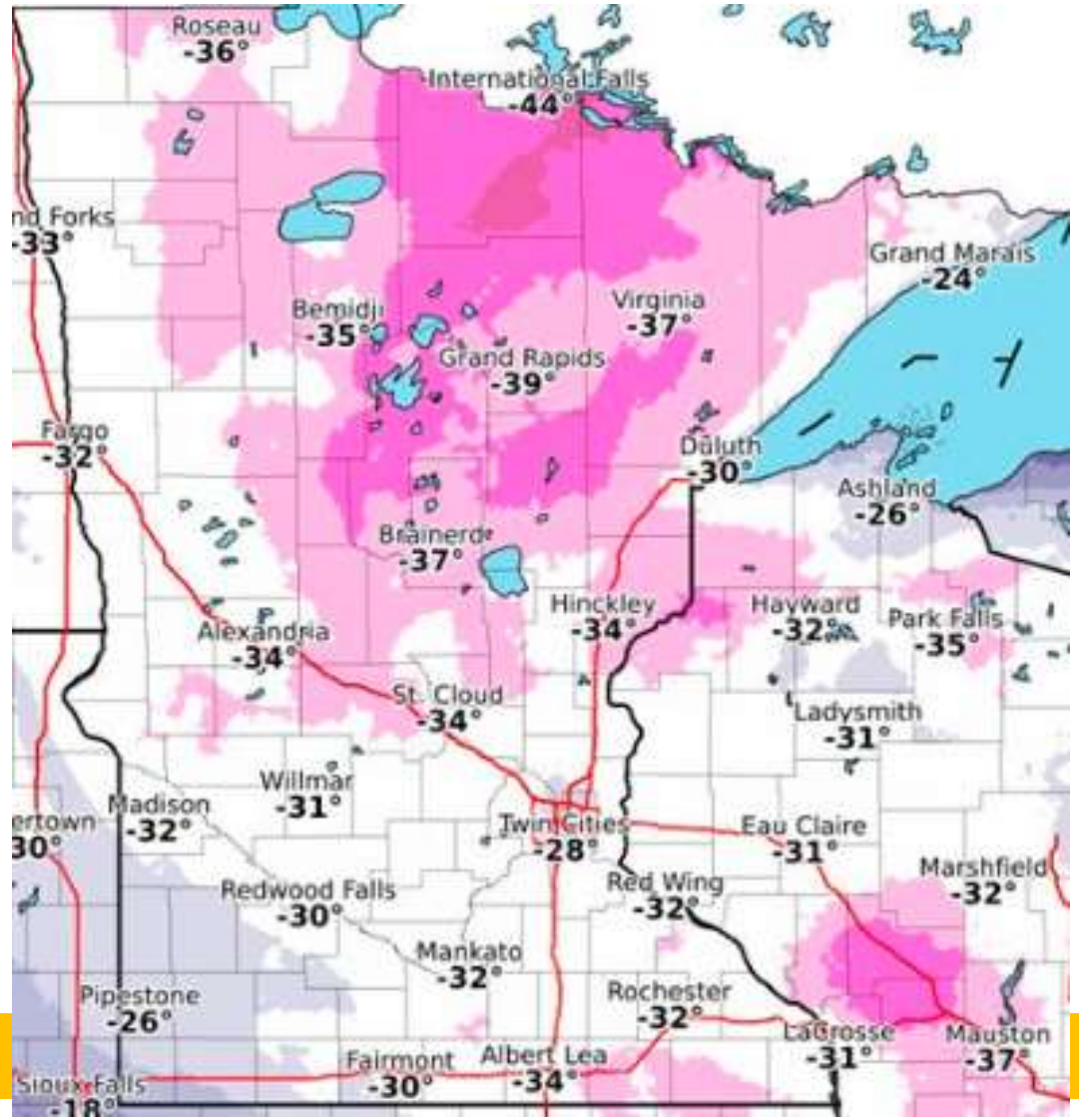

Low temperatures
January 30, 2019

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at AUBURN UNIVERSITY

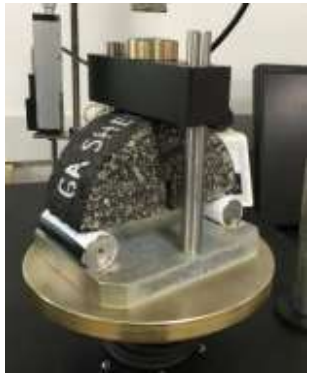
MnROAD
Safer, Smarter, Sustainable Pavements Through Innovative Research

MnROAD Cracking Group
Field Performance through April 2019

Cell	Key Mix Factors	Transverse Cracking (ft.)	Load Related Cracking (% of lane area)
16	Moderate RAP + RAS	58	1.5
17	Low RAP + RAS	70	6.3
18	Moderate RAP	35	3.8
19	Moderate RAP, extra AC	61	0.4
20	High RAP, softer binder	0	0.2
21	Moderate RAP, softer binder	28	1.1
22	Limestone agg. and 9.5 mm NMAS	50	4.4
23	Moderate RAP, Highly mod. binder	43	14.9

MnROAD Cracking Group Tests

Intermediate Temperature Tests


IFIT

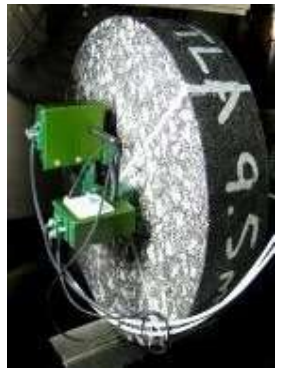
Cantabro


OT-NCAT


IDEAL-CT

Low Temperature Tests


DCT


IDT Creep Compliance & Strength


Low Temp. SCB

other tests are being performed by other research organizations

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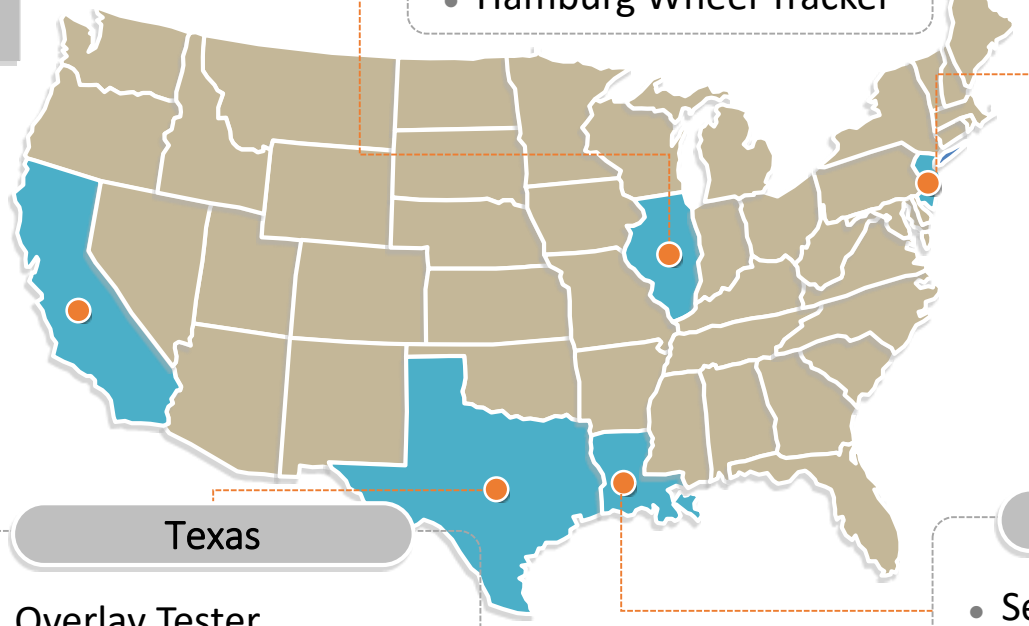
BMD Implementation Status



Illinois

- Illinois Flexibility Index
- Hamburg Wheel Tracker

New Jersey

- Overlay Test
- Hamburg Wheel Tracker

California

- Bending Beam Fatigue
- Superpave Shear Test

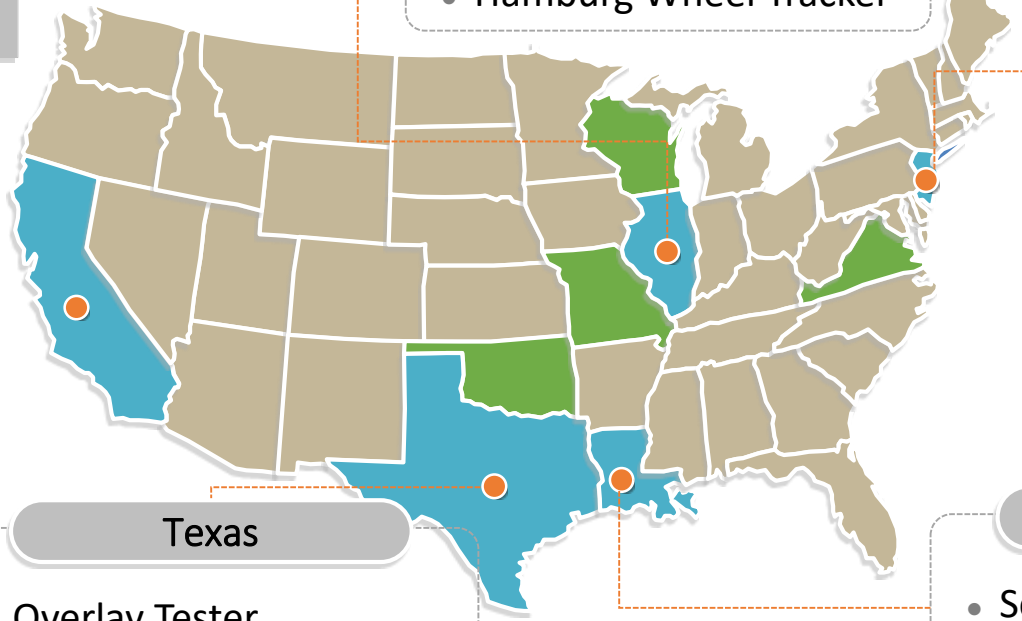
Texas

- Overlay Tester
- Hamburg Wheel Tracker

Louisiana

- Semi-Circular Bend Test
- Hamburg Wheel Tracker

BMD Implementation Status



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Getting all stakeholders to agree on a common BMD Approach will be like….

Work Ahead

- Selection of Tests
- Ruggedness and ILS studies
- Benchmarking current mixes
- Setting criteria
- Training
- Pilot Projects

95th AAPT Annual Meeting and Technical Sessions

The 2020 Annual Meeting will be held March 22-25, 2020
Westin San Diego Gaslamp Quarter, San Diego, California USA

Our 2020 venue

Westin San Diego Gaslamp Quarter

AAPT
Association of Asphalt Paving Technologists

2020 Annual Meeting

The Annual Business Meeting and Technical Sessions of the Association of Asphalt Paving Technologists (AAPT) will be March 22-25, 2020 in San Diego, California at Westin San Diego Gaslamp Quarter. The annual meeting includes asphalt-related technical sessions comprised of peer-reviewed papers, and invited presentations on specific topics in the AAPT-ISAP International Forum, and Symposium as well as a Student Poster Session.

Visit http://asphalttechnology.org/annual-meeting.html for more details as they become available.

Important dates

December 2019 – Annual Meeting registration opens
March 22-25, 2020 - Annual Business Meeting and Technical Sessions

For the latest information please check our web site at: http://www.asphalttechnology.org

AAPT Office:
6776 Lake Drive, Suite 215
Lino Lakes, MN 55014
Phone: 651-293-9188
Email: aapt@asphalttechnology.org

THE VALUE OF AAPT MEMBERSHIP

The Association of Asphalt Paving Technologists is committed to providing members with resources and opportunities for communicating with fellow professionals and staying up-to-date on the latest developments in the asphalt paving industry.

INFORMATION

Expand your knowledge with access to the latest industry research, cutting-edge technologies and concepts.

COMMUNITY

Become involved in an international community that represents all disciplines of the industry.

JOURNAL

Receive the AAPT Journal of technical papers, discussion and conference proceedings.

NETWORK

Connect with colleagues and build relationships through annual meetings and events.

Contact an AAPT member or visit asphalttechnology.org to learn more.

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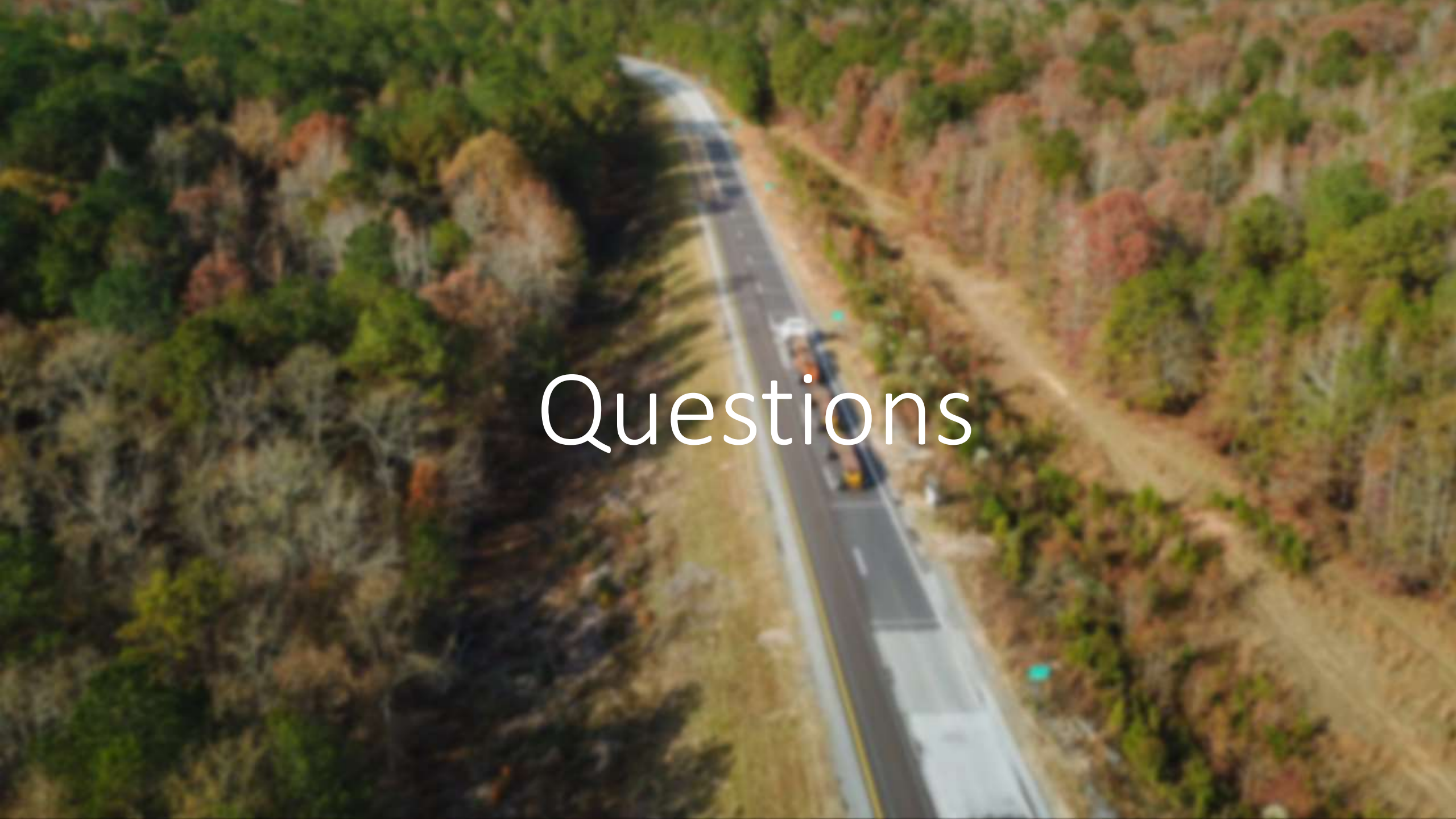
Questions

Thank You

Randy West
randy.west@auburn.edu

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