10th International Conference on Maintenance and Rehabilitation of Pavements

(MAIREPAV10) | Guimarães | Portugal | July 24-26, 2024

OVERVIEW AND TRENDS IN ASPHALT TECHNOLOGY

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July 26, 2024

Pavement Preservation Systems, LLC
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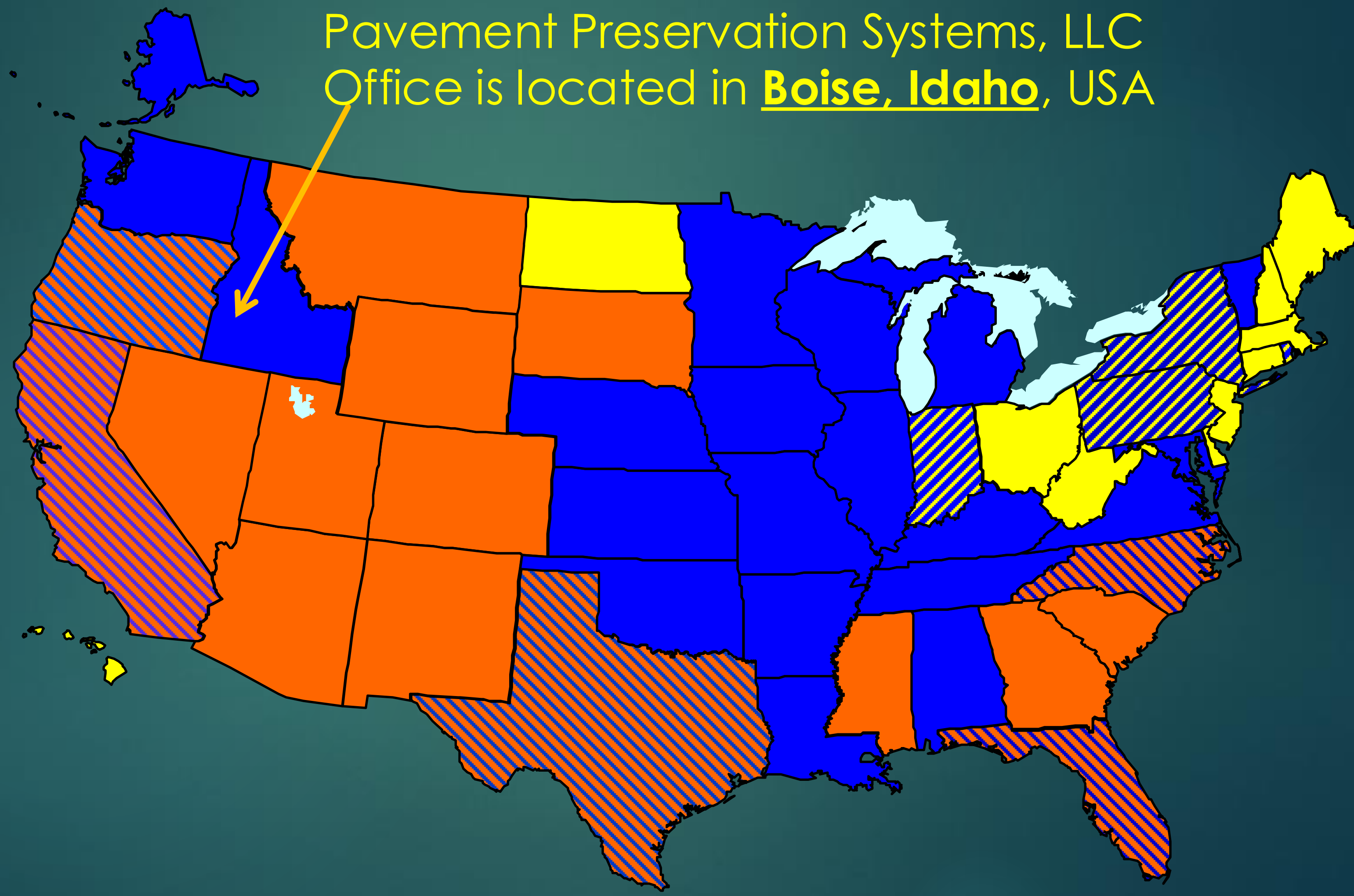


Pavement Preservation Systems LLC

International and Domestic Operations

- Technical and Business Consulting
- Non-Destructive testing of asphalt
- Asphalt Marketing and Training

Organizations

- Rocky Mountain Asphalt User Producer Steering Committee
- ASTM International Committee; Sub-committee Chairman D04.33 Formed In-Place Sealants for Joints and Cracks in Pavements
- Friend of AASHTO COMP TC 2a, 2b, 2c
- Member Canadian Technical Asphalt Association
- Emeritus Member: American Chemical Society

Acknowledgements

- Geoff Rowe: “Developments in Specifications for Binders in USA
- University of Nevada(Reno): “Development and Deployment of Innovative Asphalt Pavement Technologies” programs with FHWA (2023-2028): 23 WORKSHOPS on BMD across US.
- Phil Blankenship, “Balanced Mix Design (101): Need and Background”
- Amit Bhasin, University of Texas(Austin) for Poker Chip Test of Asphalt Binder (AASHTO Ballot closed July 19,2024: for Provisional Standard)
- Iowa State University, for Bio polymers derivatives of Soybean
- NCAT and NCHRP reports as cited
- Alaska DOT and other DOT’s pespectives on Flexible pavements
- Rocky Mountain Asphalt User Producer Group (RMAUPG)
- Task Force on Asphalt Standards Specifications (TFASH): AASHTO and ASTM International standards harmonization.
- Instituto de la Construcción y Gerencia: Ing. Angel Gomez, Lima, Peru
- Louisiana Tech University: N. Wasiuddin
- 10^{th} International Conference on Maintenance and Rehabilitation of Pavements, Guimaraes, Portugal

OUTLINE

- Transportation logistics: CO_2 reduction
- Asphalt: formulations and specifications
- From laboratory to practice: formulations/specifications/Mix design
- Pavement Preservation
- Quality Control and conclusions: other at-line tools

Traditional Asphalt Logistics vs Nontraditional : sustainable storage and Ecological transport

- CO_2 emission factor for diesel is 2.68 kg/l Example heating 20 MT of asphalt at 150 C
- Assume heating system uses diesel @ 0.5 l/hr for one MT of asphalt at 150 C
- 10 l/hr will be consumed for 20 MT
- For 5 days will be 120 hrs for 20 MT with consumption of 1200 l
- Total CO_2 emission 1200 l x 2.8kg/l = 3216 CO_2 emission
- 20 MT of bitubag in a warehouse will in general have no CO_2 emission

Asphalt BITUBAGS storage

TO TOP OF THE ROAD

FOM BOTTOM OF THE BARREL

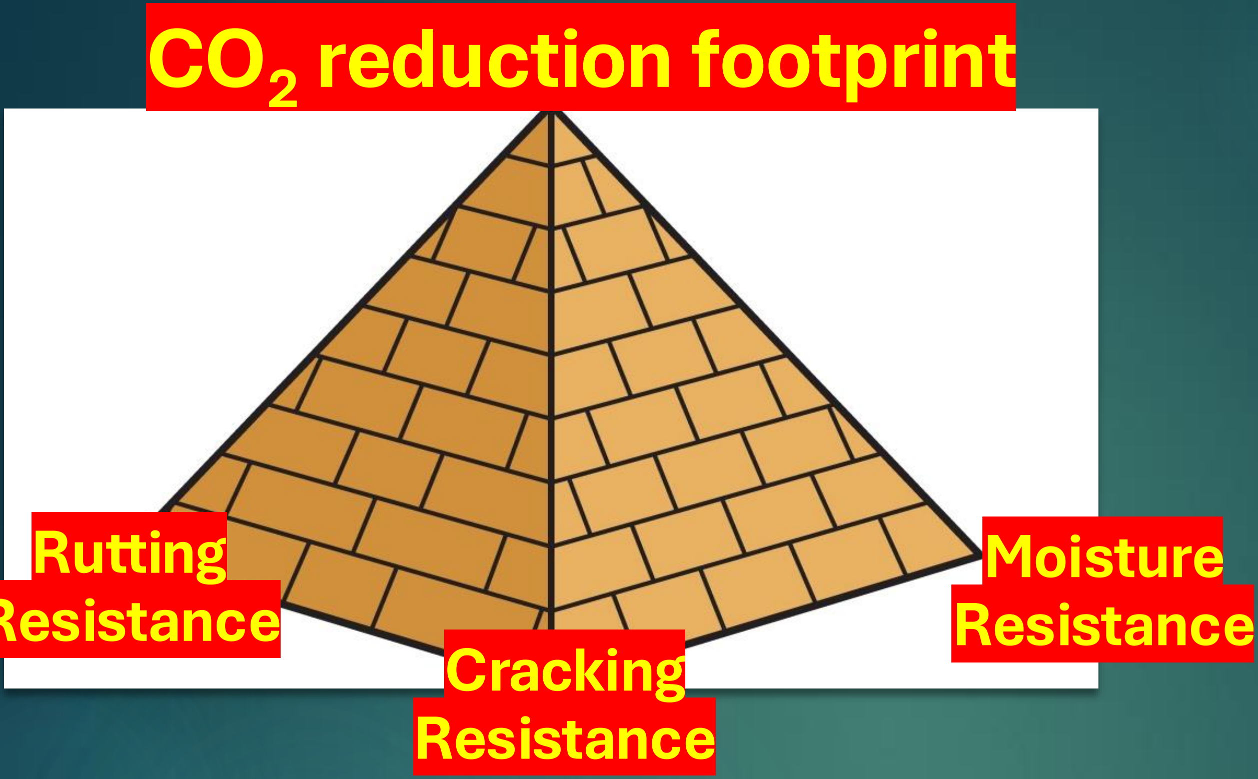
Magic Pyramid of Pavement Technology

CO_2 reduction footprint

Rutting Resistance

Cracking Resistance

Moisture Resistance



The Magic Pyramid of Road Performance

The Magic Triangle of Tire Performance

Product Performance of two industries

- Rolling resistance, wet grip performance and abrasion resistance are the three points of the magic triangle for tire performance.
- What needs to balance is tread composition: A mixture of rubber (polymer) that is optimized with reinforcing filler materials.

- Cracking resistance
- Rut resistance
- Moisture resistance
- The decisive factor here is asphalt which today can be a mixture of polymers, oligomers, and RAM*(RAP, RAS, plastics,GTR, etc.)
- *RAM: recycled asphalt materials (see NCHRP 09-65)

The Road Ahead

Developments in last 40-years

TRB 1984,1987 SHRP 1994 implementation – Superpave Rheology Based Specifications	• Special Report 202: America's Highways: Accelerating the Search for Innovation
1995-2005 Changes to temperature considerations	• Low temperature changes to consider that T_{Low} pavement $\neq T_{Low}$ air • High temperature moved to degree days rather than 7-day high
2008 to 2011 Development and implementation of Multi Stress Creep Recovery Test (MSCR) : Low/medium modified asphalt	• Polymer and chemical modification, Impact on specifications
Identify parameters for durability	• ΔTc, Glover-Rowe, R value, crossover frequency parameters
MAP-21: July 6,2012 : Pavement Preservation, Bridge incorporated into US legislation	• Moving Ahead for Progress in the 21st Century Act (MAP-21): streamlined performance-based programs
2015 onwards, see NCHRP research	• Look at for examples outputs from NCHRP activities, various research projects 9-58, 9-59, 9-60, 9-61, 9-65

Some key projects (and parameters)

NCHRP Project	Title / Link	Note on work and recommendations for BINDER
9-58	Evaluating the Effects of Recycling Agents on Asphalt Mixtures with High RAS and RAP Binder Ratios	Binder – focus is on **PG_{High}**, **G-R*** or **$T_{\delta=45°}$** from DSR and **ΔTc** from BBR
9-59	Relationships Between the Fatigue Properties of Asphalt Binders and the Fatigue Performance of Asphalt Mixtures	Recommends **R-value**, **G-R***, etc. Need to consider climate in better way Report 982 (June,2019)!
9-60	Addressing Impacts of Changes in Asphalt Binder Formulation and Manufacture on Pavement Performance through Changes in Asphalt Binder Specifications	Final report due 31-7-2024 – researchers have published papers on **ΔTc** and **ΔTf** approach
9-61	Asphalt Binder Aging Methods to Accurately Reflect Mixture Aging	Some modifications to aging methods for **ΔTc** and to better simulate long term effects
9-65	Capturing Durability of High Recycled Binder Ratio (RBR) Asphalt Mixtures	To maximize use of recycled asphalt materials –binder focus is on → **PG_{High}**, **G-R*** and **ΔTc; draft standard practice proposed: updated 15-7-2024**
20-44(19)	Implementation project - http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4829	Looked at projects including 9-59, 9-60 and 9-61 outputs for implementation study

*G-R = Glover-Rowe

What is new and where we headed

- Glover-Rowe parameter (GRP = |G*| (cos δ)2/sin δ) replacement for binder fatigue parameter in |G*| sin δ, AASHTO M 320 and M 332
- nonload-associated cracking and load-associated fatigue cracking
- Christensen-Anderson Model: Tentative allowable ranges for R-value are from 1.5 to 2.5 for binders 2.0 to 3.2 for binders aged with RTFOT followed by 40-hour PAV
- See NCHRP Project 09-61, "Short- and Long-Term Binder Aging Methods to Accurately Reflect Aging in Asphalt Mixtures,"

Our industry choice ....

- Four physical characteristics of binders being considered that all define the shape of the master curve in the high stiffness region, these are:
  - R the R-value from the Christensen-Anderson model
  - ΔTc TS – Tm from BBR CORRELATED with R value?
  - Gc cross-over modulus
  - δ phase angle at a defined stiffness
- Do we need all four – or do we adopt just one! On going discussion
- Some parameters are not independent - dependent on others
  - Other parameters can be dependent when extrapolated to values in a model fit
- What better using rheological parameters can be used?

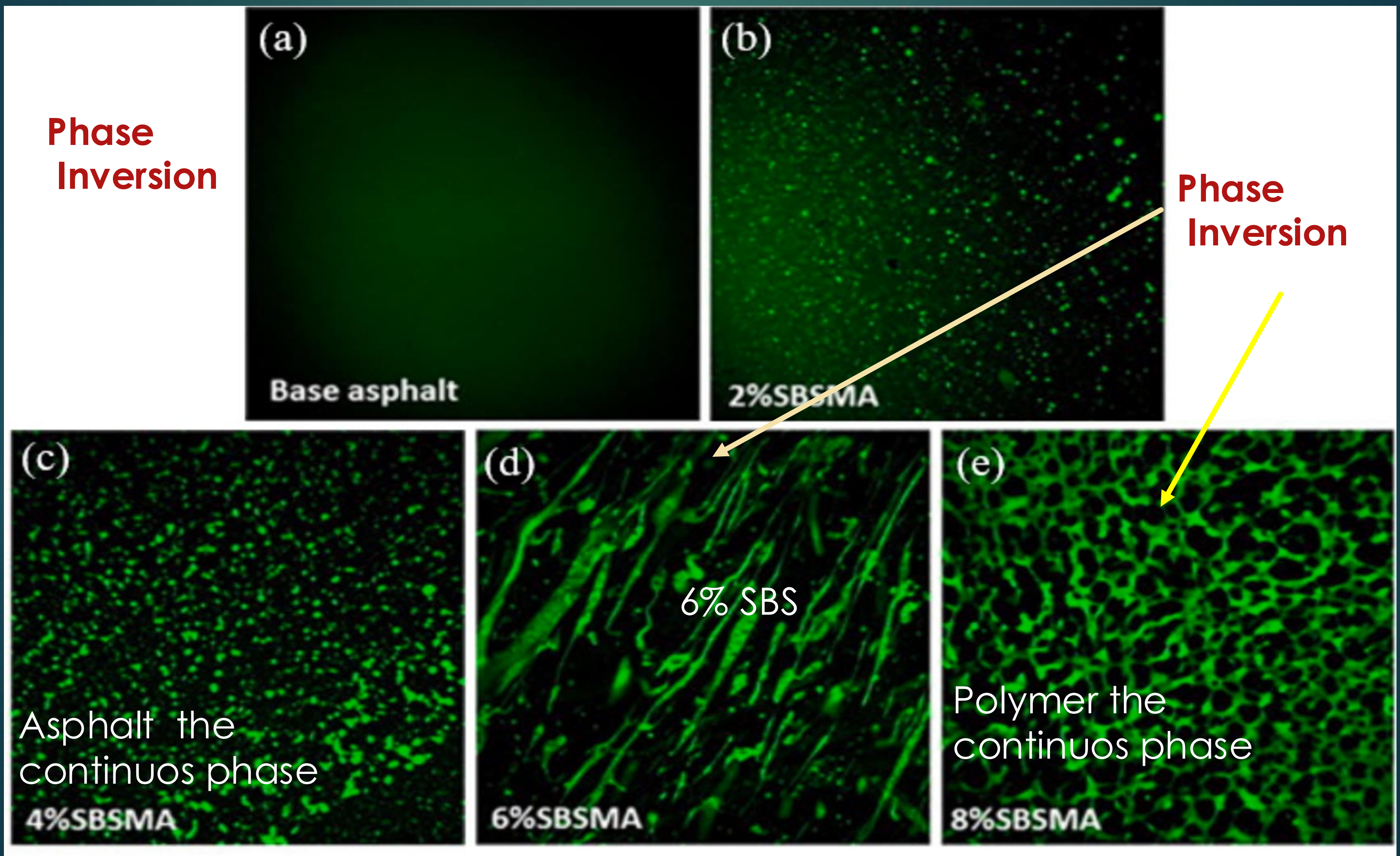
$\Delta Tc = Tc(S) - Tc(m)$ and MSCR relation to polymer modification

- parameter $\Delta Tc = Tc(S) - Tc(m)$, the critical temperature based on stiffness (S, 300) minus the critical temperature based on m-value (m, 0.300)
- Low temperature : ΔTc becomes too negative, a failure through non-load associated cracking is more likely to occur.
- ΔTc specification warning limit value of –2.5°C at 20-hour PAV aging
- –5°C is more negative than –2.5°C; therefore a ΔTc value of –5°C is perceived as more susceptible to cracking

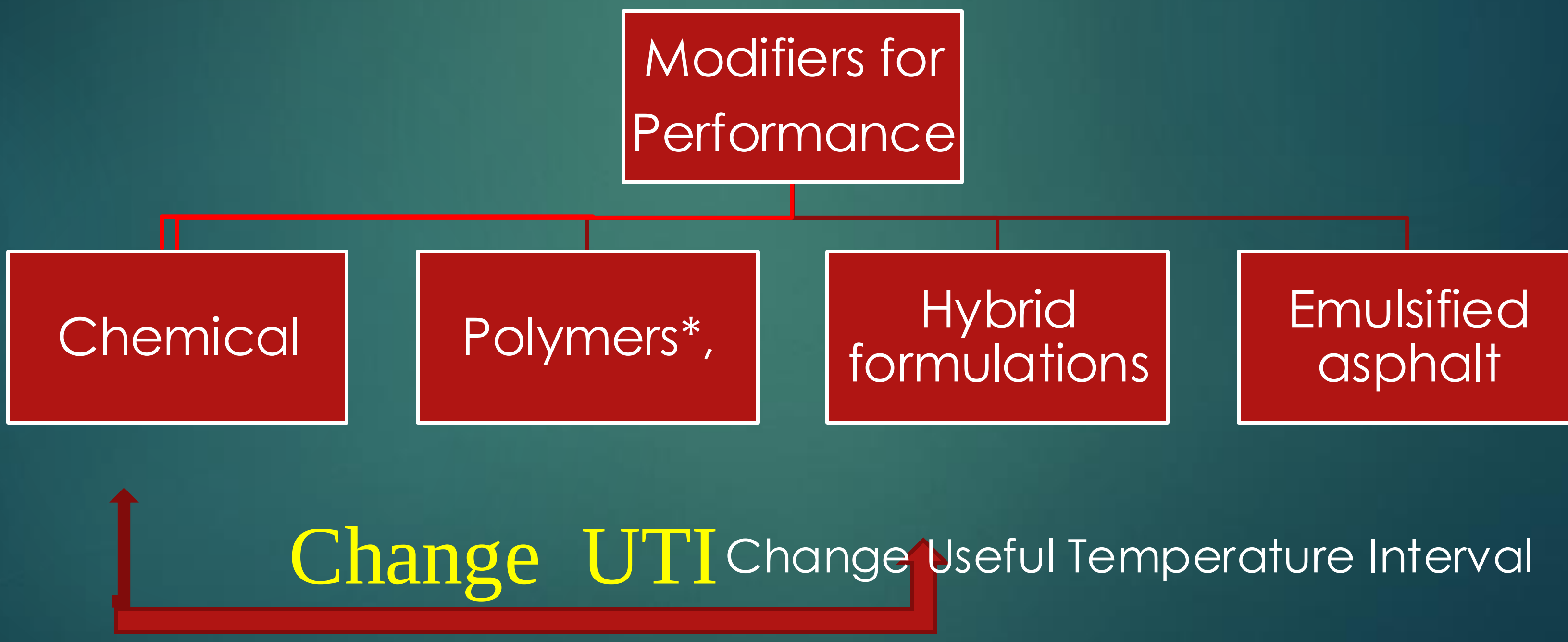
ΔT_c and MSCR: issue of polymer modified asphalt (low and high)

- PG 64-22 (Neat) Delta Tc –3.6
- PG 64-22 + 3.0% Styrene-Butadiene-Styrene (SBS) –3.9
- PG 64-22 + 7.5% SBS (SBS) – ΔT 7.5 ; generally the more negative material is poor performer, but polymer formulated appears to be performing
- State DOTs adopted a minimum limit for ΔTc of –5.0°C.
- G*(cosδ)2 /sinδ Glover-Rowe (G-R) parameter has been considered as a surrogate to ΔTc.
- G-R more responsive to stiffness and ΔTc more responsive to relaxation
- REFERENCE: FHWA-HIF-21-042 September 2021

Fluorescent images of asphalt modified with different contents of SBS: Volume 260, 10 November 2020, 119835: Construction and Building materials; see also: Chen et al., *Construction and Building Materials,* 2021



Classification of asphalt modifiers



*Includes Bio-binders made from renewable resources like soy bean, vegetable oil, lignin

Additive Overview - Classification and Purpose

- Additives for
  - Performance (Change UTI) — Rutting resistance, thermal cracking, fatigue
  - workability* — Reduce Mix/Compaction Temperatures
  - adhesion — Improve resistance to water

***Carbon reduction footprint**

Additives for Asphalt

- Modifiers
  - SBS
  - Elvaloy
  - PPA
  - Plastics
  - GTR
  - Hybrid formulations
  - Gilsonite
  - others
- Non Traditional
  - Soy bean derivative
  - Other vegetable oils
  - Lignins
  - Nanomaterials
- Antistripping
- Aminess
- rejuvenators

Bio additives* for sustainability and reduction of carbon footprint

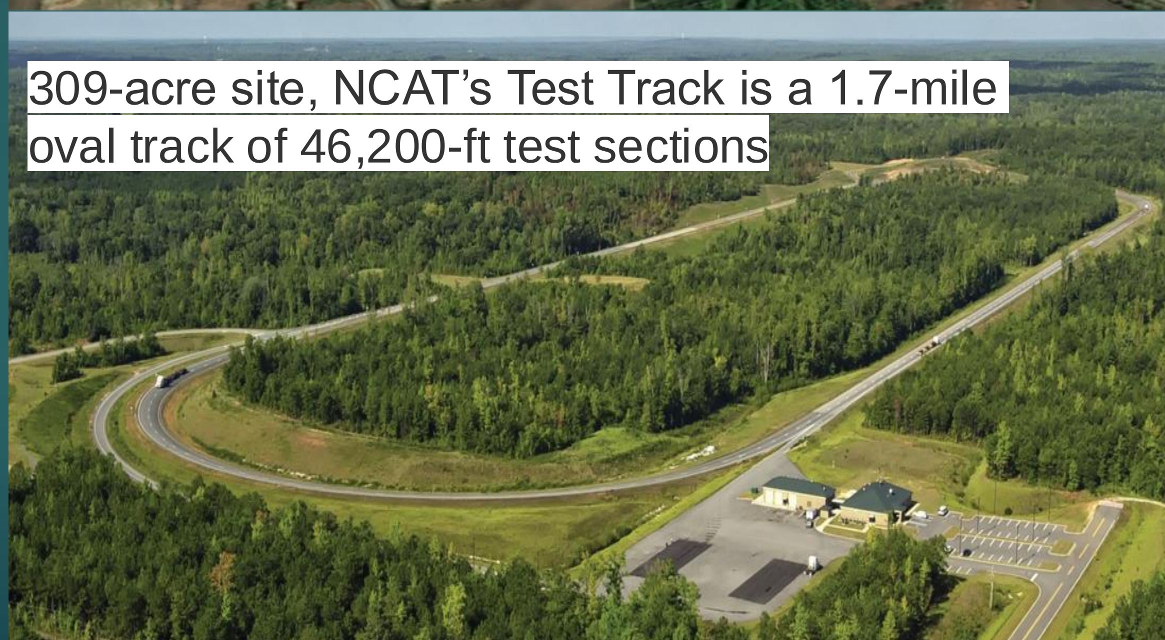
- **Fatty Acid Methyl Esters (FAME); use with chemistry of vegetable oils: result are rejuvenators**
- BIO-POLYMERS: Bio-polymers can be synthesized from plant-based materials such as starch, cellulose, and other polysaccharides.
- **Bio-Oils from Pyrolysis:** Bio-oils can be derived from the pyrolysis of biomass such as wood, agricultural residues, and other plant materials. CHAR??
- **Tall Oil:** byproduct of the kraft pulping process used in the paper industry.
- Lignin: binder extender or modifier to improve the stiffness and durability of asphalt mixtures.
- **Soybean Oil**: , corn oil, canola oil

*Plant derivatives, often referred as bio-based additives or bio-binders are: renewability

Examples of Bio additives evaluated at NCAT

- Cargill's AnovaTM asphalt rejuvenator
- *Collaborative Aggregates LLC* bio-based Delta S
- United Soybean Board sponsored : biopolymer from soybean (similar styrene-butadiene copolymer)

High volume I-94 Interstate bypass mainline test sections at MnROAD



309-acre site, NCAT's Test Track is a 1.7-mile oval track of 46,200-ft test sections

What is Balanced Mix Design

"As defined by AASHTO PP 105 (2022)* Asphalt mix design using performance tests on appropriately conditioned specimens that address multiple modes of distress taking into consideration mix aging, traffic, climate and location within the pavement structure."

See AASHTO MP 46-22: Standard Specification for Balanced Mix Design : defines

**Standard Practice for Balanced Design of Asphalt Mixtures*

Balance mix design implementation

- **Several approaches: 1. volumetric design with performance verification ($$); 2. volumetric design with performance optimization ($$); 3. performance modified volumetric design ($$$) ; 4. Performance Design ($$$$)**
- **EXAMPLES:**
- **Virginia Department of Transportation (VDOT): APA, IDEAL-CT, Cantabro and Tensile strength ratio(TSR)**
- **Louisiana Department of Transportation & Development (LaDOTD): Semi-Circular Bend Test and HWTT**
- **Illinois Department of Transportation (IDOT):** Illinois Flexibility Index Test (I-FIT); Hamburg Wheel Tracking Test (HWTT)

Hajj, E. Y., Aschenbrener, T. B., Nener-Plante, D. (2021). Case Studies on the Implementation of Balanced Mix Design and Performance Tests for Asphalt Mixtures: Illinois Department of Transportation (IDOT).

Performance Tests

Rutting Tests

- Hamburg Wheel Tracking : AASHTO T 324 (rutting and moisture sensitivity)
- Asphalt Pavement Analyzer (APA): AASHTO T 340
- *Rutting o High Temperature Indirect Tensile (HT-IDT) Strength: > 30 psi at 44oC (No standard)

Moisture

Resistence of Compacted Asphalt Mixtures to Moisture-Induced Damage

Durability

Cantabro AASHTO Determine abrasion loss ofcompacted

Cracking tests

- IT-Indirect Tensile cracking : ASTM D 8225 (CT $_{Index}$ (top down cracking)
- IT-Illinois Flexibility Index: AASHTO T 393
- IT-Semi-circular bend: ASTM D8044
- LT-Semi-circular bend: AASHTO T 394
- LT-BBR mixture : AASHTO TP 125 (University of Utah)
- LT-Indirect Tensile Creep Compliance: AASHTO T 322
- Asphalt Mixture Performance Tester(AMPT): Cyclic Fatigue Test: AASHTO TP 132
- Poker Chip of Asphalt Binder (balloting 7/21/24 for AASHTO Provisional standard TP XXXX)
- Simplified viscoelastic continuum damage (S-VECD) model to predict asphalt pavement fatigue life.
- IDEAL-CT as a surrogate test to OT for BMD

*HT-IDT test as a surrogate to HWTT for BMD production testing

Compaction

- Intelligent Compaction (IC)(1990)
- Rollers with GPS: feedback on stiffness, Temperature, : ensures uniform compaction
- Alternative fuels: Hydrogen fuel cell; battery electric vehicles
- Diesel remains predominant fuel for compactors the shift to other fuels is on the horizon(zero-emission capability and high energy density.

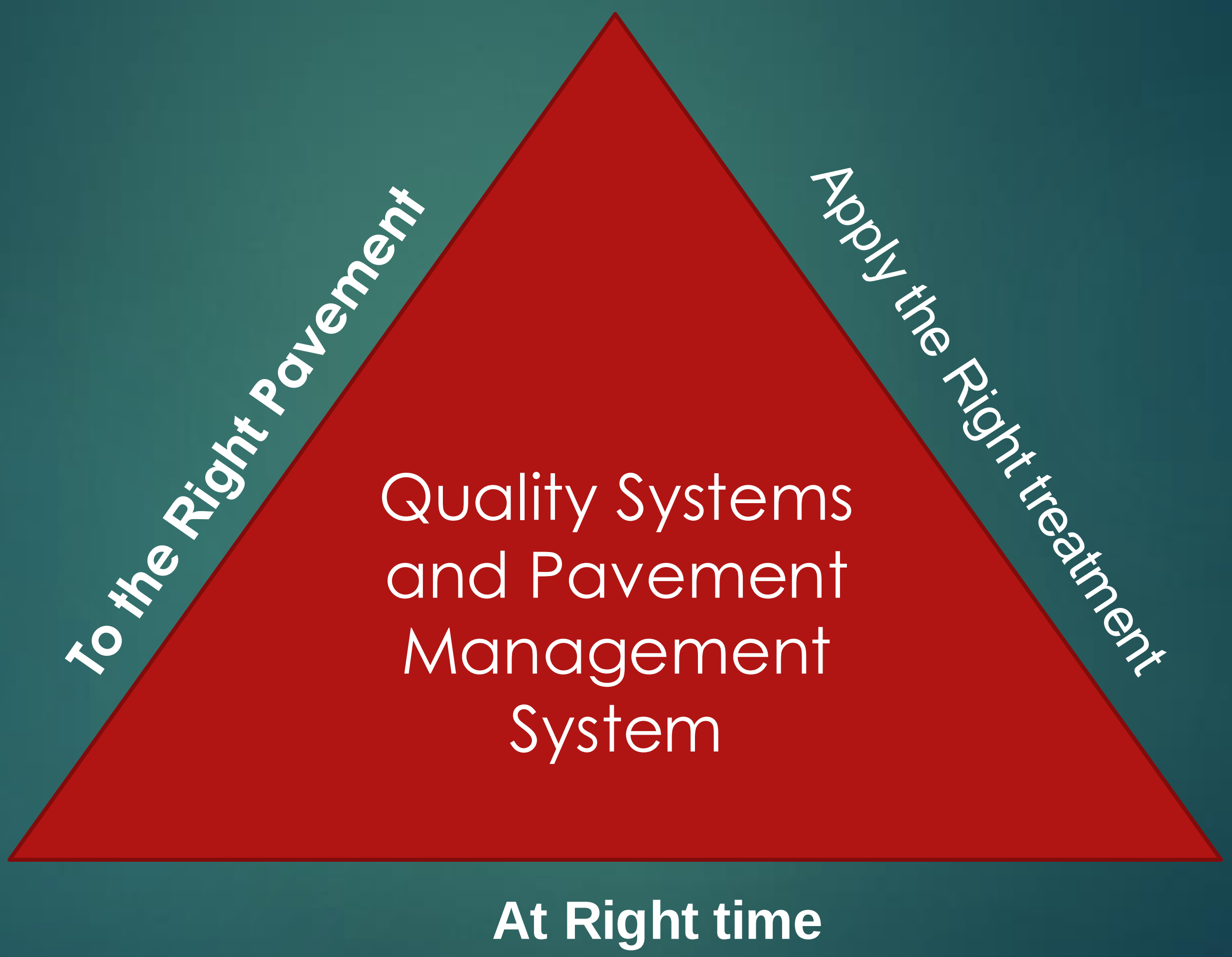
Carbon reduction footprint moment: construction equipment

Wirtgen Group Benninghoven burner as the world's first unit which can be fuelled with 100% green hydrogen. Used to produce asphalt for road surfacing, the new burner is intended to reduce emissions related to road construction.

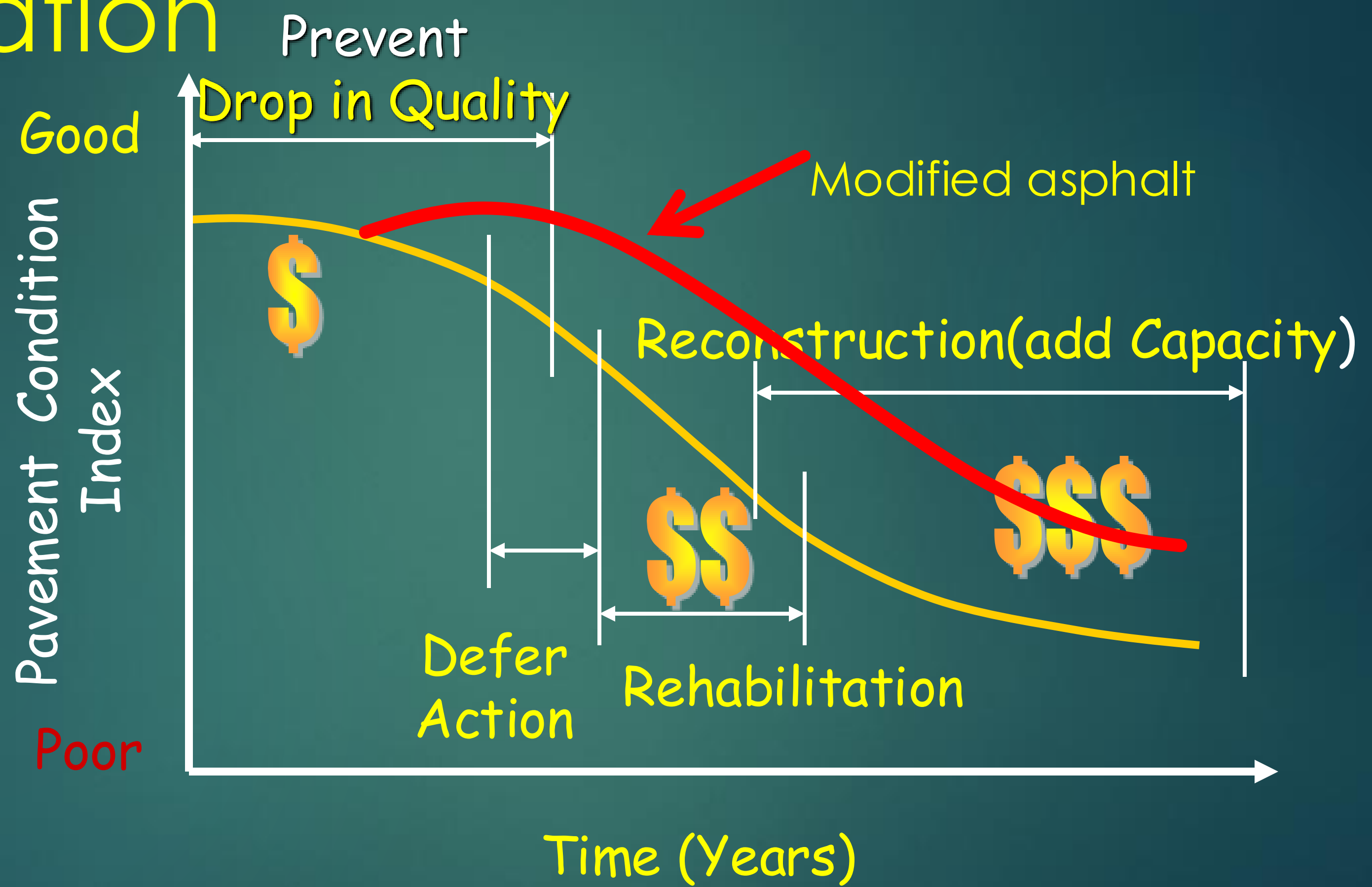
BENNINGHOVEN have unveiled a world first for the asphalt and road construction industry – a burner that can be run with 100% green hydrogen. February 2024

New hydrogen-fuel burner for asphalt production (Photo: Wirtgen Group)

MAP-21: Moving Ahead for Progress in the 21st Century Act: July 6, 2012



Extend Pavement Life with modification



Source: US Department of Transportation Federal Highway Administration, Selecting a Preventive Maintenance for Flexible Pavements, August, 2000, FHWA-IF-00-027, Figure 1.2 “Typical Variation In Pavement Condition as a Function of Time”

Pavement Preservation with Emulsified Asphalt Applications

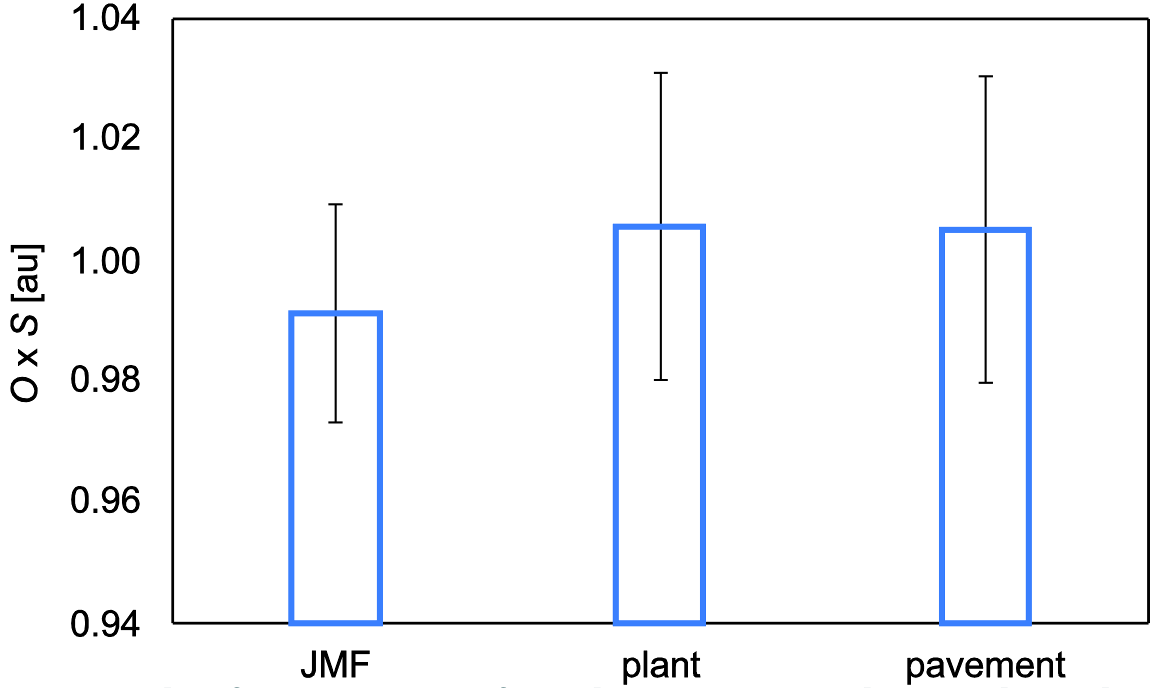
- Surface treatments (functional) (relative costs)
  - Fog seal (1.25)
  - Crack sealing (1.0)
  - Chip seal(5.0)
  - Tack coat(1.1)
  - Slurry Seal(5.25)
  - Microsurfacing(6.75)
  - Cape seal
  - Scrub sea(5.5)
  - Ultrathin HMA (14.25)
- Structural
  - Cold in place recycling (CIR)
  - Cold Central Plant Recycling (CCPR)
  - Hot-in-place Recycling (HIR)
  - Full depth reclamation (FDR)

Other Quality tools for field measurement: RAP in asphalt mixtures

%

- Portable Infrared Spectroscopy(PIRS): Nondestructive testing (Idaho)
- PIRS: destructive testing with microextraction in the field and measurement (Louisiana)

Non Destructive Testing in the Field (Portable Infrared Spectroscopy)



Nondestructive testing PIRS*

Fingerprinting the
Mix design, JMF, Pavement

Example of Comparison of Oxidation in JMF, Plant, and in-place Pavement Samples

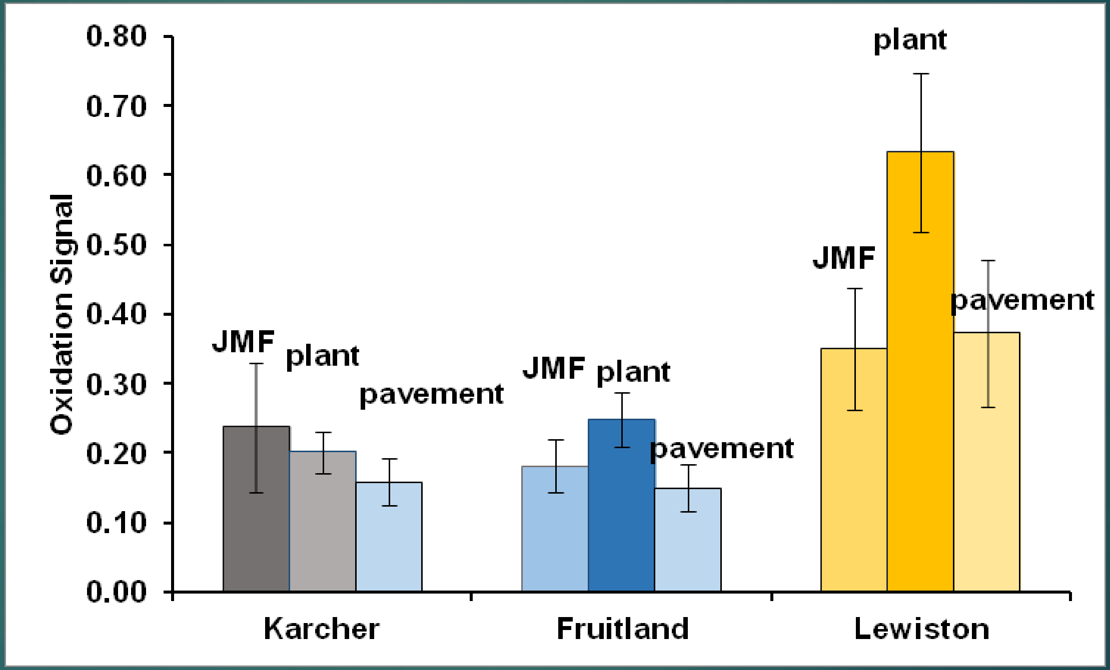
Standard Method of Test forEvaluation of Oxidation Level of Asphalt Mixtures by a Portable Infrared Spectrometer AASHTO Designation: TP 128 (2022)[1] :

***Improving Quality Control of Asphalt Pavement with RAP Using a Portable Infrared Spectroscopy Device** RP 249, April 2016 for Idaho Transportation Department

First Demonstration Study – Idaho
At line process control

Objective of analysis:

Detect deviation of plant and pavement samples from the JMF: Karcher(17% RAP); Fruitland (50% RAP); Lewiston (30% RAP: night paving)



Results:

✓All pavement measurements remained within 1 st.d. from JMF

✓Plant signals were higher than pavement ones.

Field testing for percent RAP in the asphalt mixtures

Portable FT-IR spectrometer in the field as a tool for quality control of RAP Mixture

Dr. Nazimuddin M. Wasiuddin
Louisiana Tech University

Dr. Delmar Salomon, Pavement Preservations Systems, LLC
Md Shams Arafat, Louisiana Tech University

Summary : LATECH University & Louisiana Transportation Research Center (LTRC): Portable FTIR (PIRS) field application for Quality Assurance and RAP determination

Asphalt mixture

↓

Binder Micro extraction (~15 min)

↓

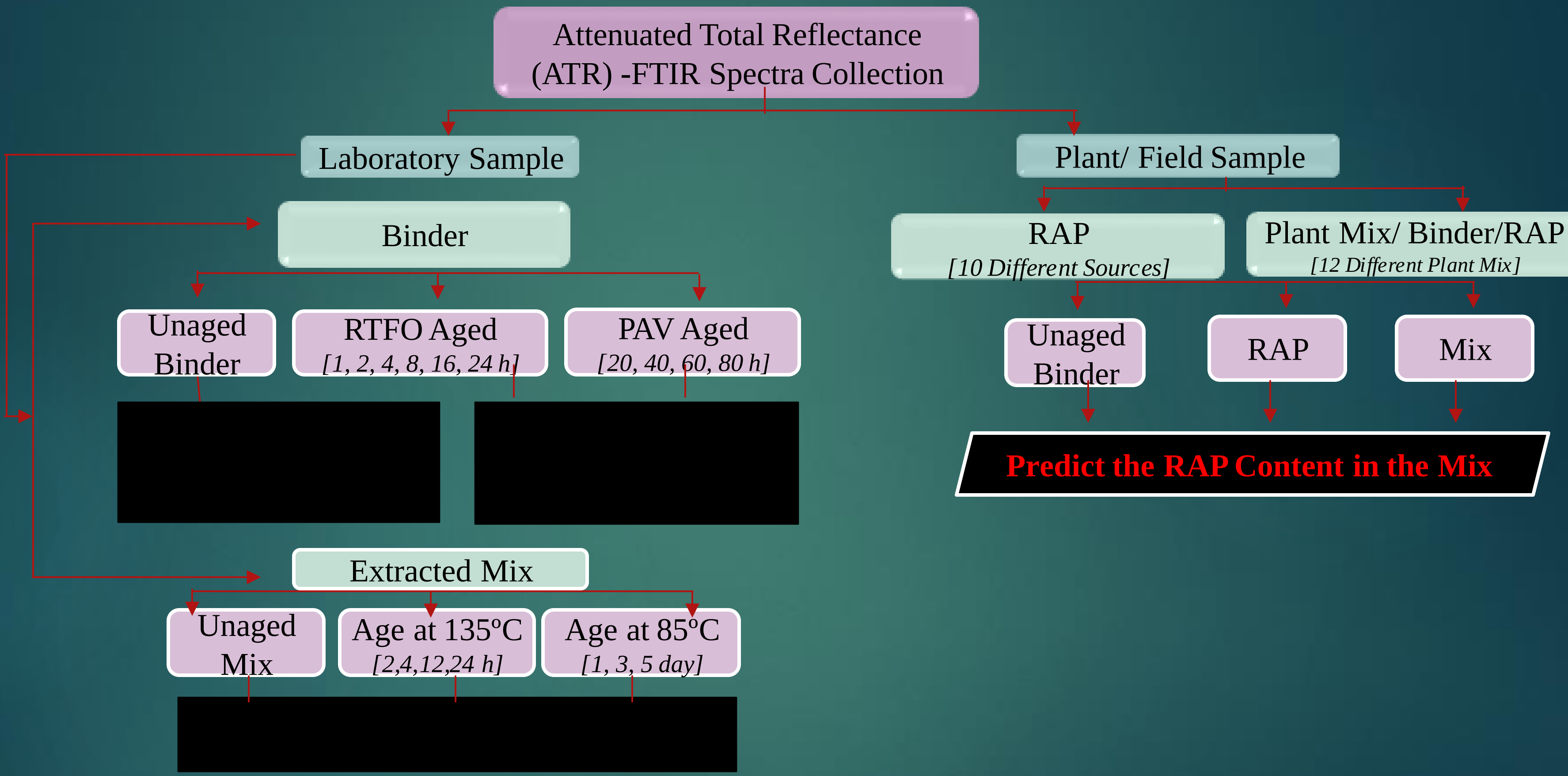
Portable FTIR (ATR accessory) measurement

↓

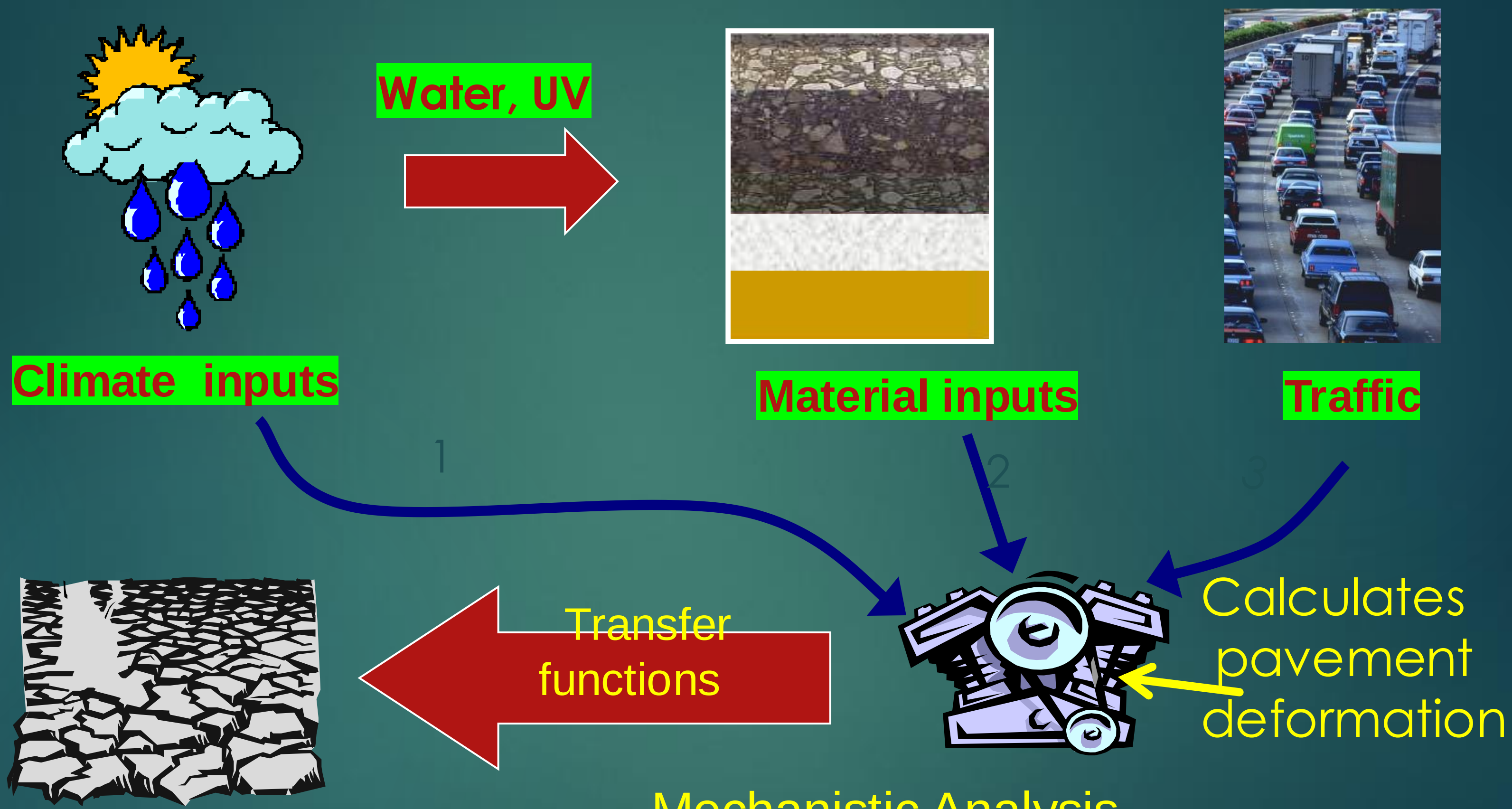
Collect Spectra, transfer data and analyze

↓

Spectra correlation/Index Predict


Attenuated Total Reflectance (ATR) -FTIR Spectra Collection
Laboratory Sample
Plant/ Field Sample
Binder
Unaged Binder
RTFO Aged [1, 2, 4, 8, 16, 24 h]
PAV Aged [20, 40, 60, 80 h]
Extracted Mix
Unaged Mix
Age at 135ºC [2,4,12,24 h]
Age at 85ºC [1, 3, 5 day]
RAP [10 Different Sources]
Plant Mix/ Binder/RAP [12 Different Plant Mix]
Unaged Binder
RAP
Mix
Predict the RAP Content in the Mix

General Overview



Predicts pavement performances
Related to pavement distresses

Mechanistic Analysis
MEPDG**: AASHTO design guide for pavements

MEPDG = Mechanistic-empirical pavement design guide
Guía de Diseño Mecanístico-Empírico de Pavimentos, 3ª Edicion

Muito Obrigado!
Thank you!

Preservation and SHRP 2 renewal research References

- **Evaluation Applications of Field Spectrocospy Devices to Fingerprint Commonly Used Construction Materials, Zofka, Chrysochoou,Yut, Johnston, Sun, Mahoney, Farquharson, Donahue, SHRP 2 Report S2-R06B-RR-1, 2013**
- **NCHRP Report 742 (Project 14-24) : Communicating the Value of Preservation: A Playbook: Crossett, Schneweis, McDonnell, Parris Communications, Smith , 2012**
- **Guidelines for the Preservation of High-Traffic Volume Roads: SHRP 2 Renewal Research, Report S2-R26-RR-2 : Peshkin, Smith,Wolters,Krstulovich,Moulthrop, Alvarado, June, 2011.**
- **Transportation System Preservation Research, Development, and Implementation Roadmap (January, 2008): FP^{2}, AASHTO,**
- **Pavement Preservation: Practices, Research Plans, and Initiatives: NCHRP 20-07, Task 184 (Peshkin & Hoerner): May 2005**
- **NCHRP Report 523: Optimal Timing of Pavement Preventive Maintenance Treatment applications, Peshkin, Hoerner, Zimmerman, 2004**
- **Richard Miller , Why (Not How) Kansas DOT Pavement Management System Works and How Preventive Maintenance Actions are Integrated, TRB 2002**

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- NCHRP 9-60 **:** Addressing Impacts of Changes in Asphalt Binder Formulation and Manufacture on Pavement Performance through Changes in Asphalt Binder Specifications:Jean-Pascal Planche, due July 31, 2024
- NCHRP 9-59 BBR ΔTc & ABCD device critical cracking temperature, Tcr
- AASHTO R 30 Mixture conditioning of HMA
- AASHTO M 320 Performance-Graded Asphalt Binder
- AASHTO T 283 Resistance of compacted Asphalt Mixtures to Moisture-Induced Damage
- AASHTO T 313 Determining the Flexural Creep Stiffness of Asphalt Binder Using the Bending Beam Rheometer
- AASHTO T 315 Determining the Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer

References for R value, ΔT_c high recycled materials cracking group at MnROAD/NCAT

- NCHRP 9-59 Report 982: Relationships Between the Fatigue Properties of Asphalt Binders and the Fatigue Performance of Asphalt Mixtures (2022) National Academies of Sciences, Engineering, and Medicine. 2022, Donald W. Christensen, Nam Tran
- **Proposed Standard Practice Development of Balanced and Durable Asphalt Mixtures with High Recycled Asphalt Materials Contents: APPENDIX C from NCHRP 09-65, July,2024, Amy Epps Martin**
- **MnROAD Cracking Group Experiment: Validation of Low-Temperature Cracking Tests for Balanced Mix Design**
  NCAT REPORT 23-03, July 2023

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Decarbonization, recycled plastics for infrastructure, New provisional test method

1.Ballot Number: COMP_TS2B_2024_2: Ballot Name: TS 2b **TS Ballot on Poker Chip for Provisional Standard**: Ballot closed Date: 07/19/2024

2. The Carbon Footprint of Asphalt Pavements, A Reference Document for decarbonization, *Joseph Shacat, Richard Willis, Ben Ciavola , NAPA , SIP-109, March 2024*

3. **Recycled Plastics in Infrastructure: Current Practices, Understanding, and Opportunities (2023): National Academies of Sciences, Engineering, and Medicine. 2023.** *Plastics in Infrastructure: Current Practices, Understanding, and Opportunities*. Washington, DC: The National Academies Press.https://doi.org/10.17226/27172.

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for Balanced Mix Design (BMD) and cracking group

- **Summary of Four Balanced Mix Design Case Studies for CRH Americas Materials Companies , NCAT Report 23-1, June, 2023**
- **BMD State of the Practice Wisconsin, May 2023**
- **NCAT Report 18-04 : Findings Cracking study; Delta S rejuvenator**