

59th Idaho Asphalt Conference

October 24, 2019

the **2019** Presentations

- 1** [Advanced tools for comprehensive evaluation of pavement surface and subsurface conditions](#)
Tom Scullion, P.E.
- 2** [ITD Asset Management - An Overview](#)
James Poorbaugh, P.E.
- 3** [You have Pavement Preservation Questions - Road Resource Has Answers](#)
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- 4** [Development and Evaluation of Performance Measures to Augment Asphalt Mix Design in Idaho](#)
Dr. Emad Kassem, PE, and Hamza Alkuime
- 5** [Improving Service Life of HMA in Washington State](#)
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- 6** [Pavement Fabrics / Fibers to improve Pavement Performance](#)
Kevin Bussert and Jordan Rabine
- 7a** [Use of RAP in Pavement Preservation Techniques - Parts 1.](#)
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- 8** [Implementation and Calibration of AASHTOWare Pavement ME Design for Idaho](#)
Dr. Fouad Bayomy, P.E.



Speakers of the 59th Idaho Asphalt Conference, October 24, 2019

From Left: Fouad Bayomy, Kevin Bussert, Jordan Rabin, Emad Kassem, Dave Johnson, James Poorbaugh, Melynda Boswell, Joe DeVoi, Rod Thompson, Doug Olsen, Mike Santi, Tom Scullion, Hamza Alkuime and Jeff Miles.

59th Idaho Asphalt Conference – October 23, 24, 2019 – Attendee List

Ken Acree

Senior Research Analyst
Idaho Transportation
Department
ken.acree@itd.idaho.gov

Amanda Anderson

Materials Engineer
City of Spokane Construction
Management
amanderson@spokanecity.org

Alannah Bailey

*Transportation/Water Project
Supervisor*
City of Lewiston
shood@cityoflewiston.org

Andrew Balavage

*Construction Service
Manager/Senior Technician*
Budinger & Associates, Inc.
abalavage@budingerinc.com

Terri Ballard

Laboratory Manager
Budinger & Associates, Inc.
tballard@budingerinc.com

Don Barr

Street Superintendent
City of Nampa Street Division
barrd@cityofnampa.us

Fouad Bayomy

Professor
University of Idaho
bayomy@uidaho.edu

Chip Becker

TTE
Idaho Transportation
Department
chip.becker@itd.idaho.gov

Riley Bender

Idaho Transportation
Department
Riley.Bender@itd.idaho.gov

Jim Biggar

*Street Maintenance
Foreperson*
CITY OF SPOKANE STREET DEPT
pgarland@spokanecity.org

John Bilderback

*Construction/Materials
Engineer Manager*
Idaho Transportation
Department
john.bilderback@itd.idaho.gov

Joe Blake

Idaho Asphalt Supply, Inc.
jblake@idahoasphalt.com

Daniel Block

Project Scoping
Idaho Transportation
Department
daniel.block@itd.idaho.gov

Scott Bontrager

Assistant City Engineer
City of Moscow, ID
sbontrager@ci.moscow.id.us

Melynda Boswell

Boswell Asphalt Paving
Solutions
boswellapsolutions@gmail.com

Walter Burnside

Idaho Transportation
Department
walter.burnside@itd.idaho.gov

Kevin Bussert

Sales Manager
Specialty Construction Supply
kbussert@specialtysupply.com

Tony Butler

*Construction P.M. / Inspector ,
CES*
David Evans and Associates, Inc,
tgbu@deainc.com

Bob Buvel

Staff Engineer
City of Moscow, ID
bbuvel@ci.moscow.id.us

Sam Carroll

Chemist
Idaho Transportation
Department
sam.carroll@itd.idaho.gov

Zac Childress

*Materials Lab Transportation
Engineer 2*
WSDOT - South Central Region
zac.childress@wsdot.wa.gov

Chad Clawson

Idaho Transportation
Department
D2Admin@itd.idaho.gov

Stacy Coston

Construction Observer
J-U-B ENGINEERS, Inc.
scoston@jub.com

Tyler Coy

Materials
Idaho Transportation
Department
tyler.coy@itd.idaho.gov

Scott Cron

Construction Services Manager
STRATA, Inc.
scron@stratageotech.com

AJ Dahlberg

Senior Maintenance Worker
City of Moscow
adahlberg@ci.moscow.id.us

59th Idaho Asphalt Conference – October 23, 24, 2019 – Attendee List

Ryan DeBaun

Senior Maintenance Worker
City of Moscow
rdebaun@ci.moscow.id.us

Joe DeVol

Washington State Department
of Transportation
devolj@wsdot.wa.gov

Shawn Enright

Idaho Transportation
Department
shawn.enright@itd.idaho.gov

Darin Ery

Senior Maintenance Worker
City of Moscow
dery@ci.moscow.id.us

Robert Fleming

Materials Lab Engineer
WSDOT - South Central Region
robert.fleming@wsdot.wa.gov

Derrick Fontes

Division Manager
MTI
fontesd@mti-id.com

Scott Forrey

*Pavement Management
Engineer*
Ada County Highway District
sforrey@achdidaho.org

Garrett Frei

Project Manager
J-U-B ENGINEERS, Inc.
gfrei@jub.com

Paul Frei

Idaho Transportation
Department
Paul.Frei@itd.idaho.gov

Kevin Funke

Testing Manager
ALLWEST Testing &
Engineering, Inc.
kfunke@allwesttesting.com

Michael Garz

Operations
Idaho Transportation
Department
michael.garz@itd.idaho.gov

Kris Gayda

Materials
Idaho Transportation
Department
kris.gayda@itd.idaho.gov

Dave George

Project Manager
Morgan Pavement
dgeorge@morganpavement.com

Steven Greene

Principal Engineering Geologist
HWA GeoSciences Inc
sgreene@hwageo.com

Jose Guzman

Idaho Asphalt Supply, Inc.
jguzman@idahoasphalt.com

John Hall

Operations
Idaho Transportation
Department
john.hall@itd.idaho.gov

Mike Hammond

*Materials Lab Assistant
Engineer*
WSDOT - South Central Region
mike.hammond@wsdot.wa.gov

Charles Hanshaw

*Street Maintenance Operator
II*
City of Spokane Street Dept
mstevenson@spokanecity.org

Clint Harris

Director
City of Spokane Street Dept
dmitchell@spokanecity.org

Drew Harris

Project Manager
Knife River
drew.harris@kniferiver.com

Chris Hartman

Project Manager
Knife River
chris.hartman@kniferiver.com

Carrie Ann Hewitt

Staff Engineer
Idaho Transportation
Department
CarrieAnn.Hewitt@itd.idaho.gov

Danny Hoey

*Certified Materials Testing
Supervisor*
City of Spokane Engineering
Construction Management
dhoey@spokanecity.org

Jason Hood

West Sales
Envirotech Services Inc
jhood@envirotechservices.com

Jared Hopkins

Idaho Transportation
Department
Jared.Hopkins@itd.idaho.gov

59th Idaho Asphalt Conference – October 23, 24, 2019 – Attendee List

Fred Howe

Materials TE3
Washington State Department
of Transportation
HoweF@wsdot.wa.gov

Bryan Jensen

Engineer-in-Training
J-U-B ENGINEERS, Inc.
bjensen@Jub.com

Alex Jondal

Staff Engineer
T-O Engineers
ajondal@to-engineers.com

Justin Joy

Idaho Asphalt Supply, Inc.
jjoy@idahoasphalt.com

Emad Kassem

University of Idaho
ekassem@uidaho.edu

Zach King

Staff Manager
MTI
kingz@mti-id.com

Cindy Kinzer

*Sr. Water/Wastewater
Engineer*
HDR
ckinz777@gmail.com

Brian Lamoreaux

Idaho Transportation
Department
brian.lamoreaux@itd.idaho.gov

David Lauder

Engineer
GeoEngineers
dlauder@geoengineers.com

Andrew Linder

Design/Construction
Idaho Transportation
Department
andrew.linder@itd.idaho.gov

Scott Malone

Idaho Transportation
Department
scott.malone@itd.idaho.gov

Michael Martin

Idaho Transportation
Department
michael.martin@itd.idaho.gov

Ty Mashburn

TTE
Idaho Transportation
Department
ty.mashburn@itd.idaho.gov

Myron McCarty

Streets
City of Heyburn
myronmccarty6@gmail.com

Jack McCoy

WSECO
jack.mccoy@wseco.com

Heather Miley

Research Analyst Principal
Idaho Transportation
Department
heather.miley@itd.idaho.gov

Marti Miller

Project Manager
Division of Public Works
marti.miller@adm.idaho.gov

Jason Morgan

TTE
Idaho Transportation
Department
jason.morgan@itd.idaho.gov

Timothy Morgan

Director of Transportation
MTI
morgant@mti-id.com

Doug Olsen

Idaho Asphalt Supply, Inc.
dolsen@idahoasphalt.com

Anson Parke

Streets manager
City of Heyburn
aparke@heyburncity.org

Ned Parrish

Idaho Transportation
Department
Ned.Parrish@itd.idaho.gov

John Perfect

jperfect@roadrunner.com

Erik Peterson

Engineering Technician
City of Moscow, ID
epeterson@ci.moscow.id.us

Ken Pierson

Idaho Transportation
Department
Ken.Pierson@itd.idaho.gov

Brian Poole

Engineering Manager
Idaho Transportation
Department
brian.poole@itd.idaho.gov

James Poorbaugh

Idaho Transportation
Department
james.poorbaugh@itd.idaho.gov

Jordan Rabin

Tensar
jrabin@tensarcorp.com

59th Idaho Asphalt Conference – October 23, 24, 2019 – Attendee List

Dana Rand

Senior Maintenance Worker
City of Moscow
drand@ci.moscow.id.us

Mike Rhoades

Materials Lab Transportation Engineer 3
WSDOT - South Central Region
mike.rhoades@wsdot.wa.gov

Alejandro Rosales

Technical Services Manager
Idaho Asphalt Supply, Inc.
arosales@idahoasphalt.com

Mike Santi

Idaho Transportation
Department
mike.santi@itd.idaho.gov

Alan Scharbrough

Supervisor
Payette County Road & Bridge
alans@payettecounty.org

Bob Schumacher

Idaho Transportation
Department
bob.schumacher@itd.idaho.gov

Tom Scullion

Texas A&M Transportation
Institute
t-sculion@tti.tamu.edu

Pat Severance

Dev. Review Supervisor
City of Lewiston
publicworks@cityoflewiston.org

Todd Sherwood

Idaho Transportation
Department
todd.sherwood@itd.idaho.gov

Brett Siweck

Civil Engineer
Mead & Hunt, Inc
brett.siweck@meadhunt.com

Josh Smith

Asphalt Operations Manager
Knife River
julie.erickson@kniferiver.com

Kevin Smith

Project Manager
J-U-B Engineers, Inc
ksmith@jub.com

Logan Sorensen

Assistant Construction Manager
JUB Engineers
lsorensen@jub.com

Scot Stacey

Idaho Transportation
Department
scot.stacey@itd.idaho.gov

Nate Steiner

Research Analyst
Idaho Transportation
Department
nate.steiner@itd.idaho.gov

David Suhr

Sr. Associate, INW Region Construction Services Manager
David Evans and Associates, Inc.
djsu@deainc.com

Nate Suhr

Staff Engineer
City of Moscow
nsuhr@ci.moscow.id.us

Steve Taylor

Idaho Transportation
Department
Steve.Taylor@itd.idaho.gov

Jessica Towell

Lab Coordinator
Ada County Highway District
jtowell@achdidaho.org

Mike Towne

Idaho Transportation
Department
Mike.Towne@itd.idaho.gov

Kalob Turner

Project Manager
Knife River
kalob.turner@kniferiver.com

Shawn Turpin

Area Manager
ALLWEST Testing &
Engineering, Inc.
sturpin@allwesttesting.com

Jerry Walker

Superintendent
Knife River
jerry.walker@kniferiver.com

Ben Ward

District Materials Engineer
Idaho Transportation
Department
ben.ward@itd.idaho.gov

Justin Wolf

TSEA
Idaho Transportation
Department
justin.wolf@itd.idaho.gov

Don Wright

Superintendent
Knife River
don.wright@kniferiver.com

Bryan Young

Traffic Engineer
Idaho Transportation
Department
bryan.young@itd.idaho.gov

59th Idaho Asphalt Conference – October 23, 24, 2019 – Attendee List

Josh Zigler

Project Manager

Knife River

josh.zigler@kniferiver.com

Muhammad Zubery

Federal-aid Engineer

LHTAC

mzubery@lhtac.org

 **Advanced Tools for Comprehensive Evaluation of Pavement surface and subsurface conditions**

Tom Scullion P.E.
Texas A&M Transportation Institute
College Station Texas

59th Annual Idaho Asphalt Conference
 October 23 -24 2019

 **Overview of Presentation**

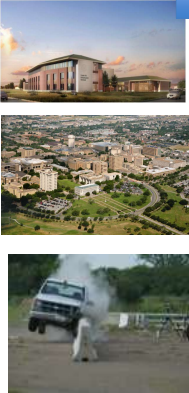
1. Background to TTI and TxDOT
2. Types of Non-Destructive Testing tools
3. Demonstration of PaveCheck Software
4. Use of NDT in FDR Projects
5. Use of NDT in Pavement Forensic Investigations
6. Use of NDT in Corridor Studies
7. Future Directions

CENTER FOR INFRASTRUCTURE RENEWAL (CIR)

1. Background to TTI and TxDOT

Texas Transportation Institute

- 1) Part of the College of Engineering at Texas A&M University
- 2) 60+ Years of research on Transportation Systems
- 3) Largest University-Affiliated Transportation Research Organizations in the USA
- 4) Major Source of Educated Transportation Professionals
- 5) Partners Extensively with TxDOT, other Public & Private Organizations
- 6) New Lab 2018 new TTI Building 2019



 **Flexible Pavement Program**

- Research Studies
 - Balanced Mix Design for HMA
 - FDR for Energy Sector,
 - Development and implementation of new Technologies
- Interagency Agreements
 - Agency support with Forensics, Pavement Rehab
- Training Workshops
 - Seal Coats/Thin Overlays
 - FDR
 - Rubblization
 - Pavement Design
 - Nondestructive Testing
 - Intro to Paving Materials

 **TEXAS DEPARTMENT OF TRANSPORTATION**

Top 100 Most Congested Roads

Which Roads are the Most Congested? >

- Manages close to 200,000 lane miles of roadway
- Does not include County or City Roads
- 2018 TxDOT Budget \$13 B
 - \$9 B State Roads \$4 B Toll Road Construction
- For State Roads: Designs mostly done in house
- Governor and Citizens want more funding for roads
- 1000 people a day coming to Texas
 - Massive construction/widening projects underway
 - Energy Sector Boom (still booming)




TxDOT Design Work

- 25 Districts; all manage roughly 6000 to 8000 lane miles
- Each District has 3 to 4 Area Offices managed by an Area Engineer who comes up with proposed rehabilitation strategies and pavement designs
- Most work: rehabilitating – widening old roadways
- Area Offices supported by
 - District Pavement Engineer
 - Austin Divisions
 - University Researchers
 - Private Consultants (2017 on)

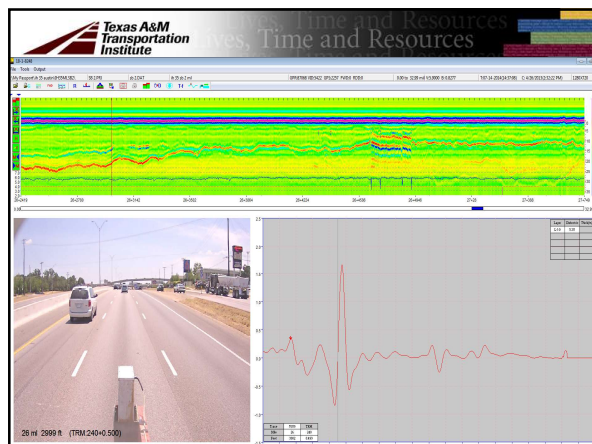
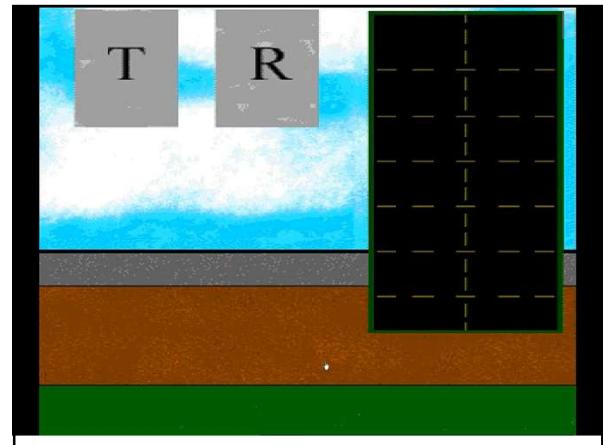
2. NDT Evaluation Tools



Used extensively for selecting rehab options when pavement performance is poor or premature failures exists

NDT Air-Coupled GPR

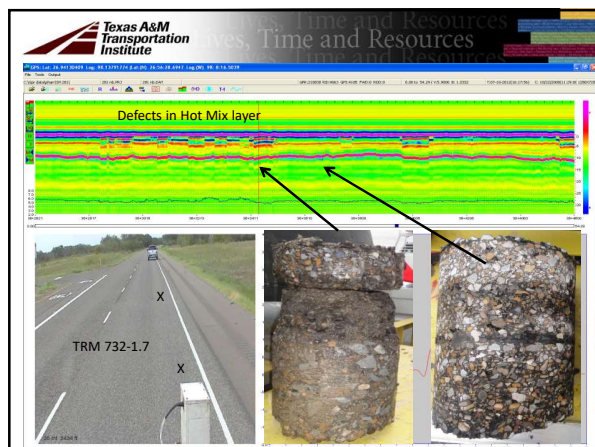
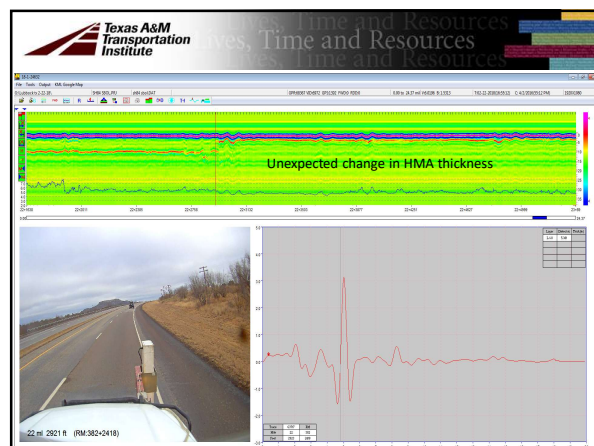
- Data Collection and Processing software developed by TTI
- Training schools taught by TTI
- TxDOT has 5 available units
- Data collected and processed by TxDOT
- Data collected at highway speed (60 - 70 mph)
- Effective depth of penetration 20 ins
- Measures layer thickness, locates subsurface defects and section breaks

Successful GPR Applications

- Thickness of Pavement Layers
- Defects in Base (Wet areas)
- Defects in Hot Mix layers (stripping, trapped moisture)
- Identifying areas of segregation and poor joint density
- Deterioration in asphalt covered bridge decks
- Water filled voids under PCC
- Pavement Rehabilitation studies (identifying changes in structure)

Does not eliminate but permits smarter coring



5. Use of NDT Tools in Forensics Studies

Objectives of Forensic Studies

- What is the cause of the problem
- What should the TxDOT District do now
- How can the problem be avoided in the future
 - “More research is needed”
 - New Specs
 - New test procedures
 - New Equipment



Forensics Studies and their Products

Sulfate Heave

Spectrophotometer
Tx Method 145E

Thermal Segregation

Pave-IR system

Forensics Studies and their Products

Balanced Mix Design 2004

Premature Cracking

Balanced Mix Design
Scullion/Zhou 2004

Austin District's Guidelines on the Use of Thin Surface Mixes (TSMs)

Balanced Mixes CAM 2008
TOM 2009 and SMA 2014

IH 10 2002
Tony Yrigoyen – Richard Williammee
Charles Gaskin – Dale Rand

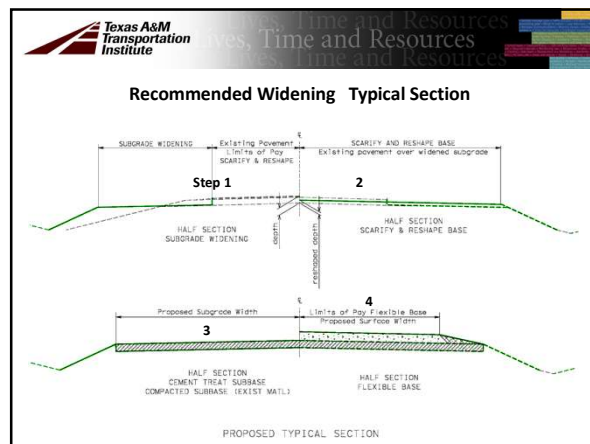
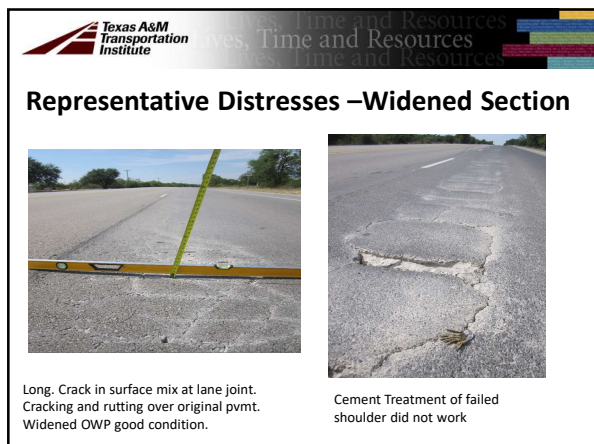
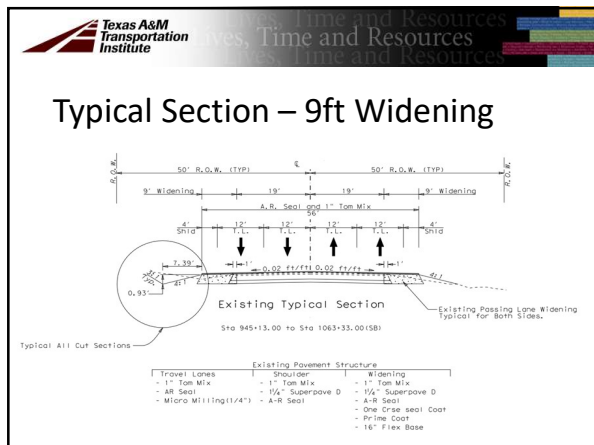
Recent Forensics Studies

- Case 1 Differential Widening problems
- Case 2 Drainage not pavement Problems
- Case 3 Damage from Truck Overloads
- Case 4 Early Cracking of New Concrete

Case 1 Differential Widening

6 months after Construction

Case 1 Differential Widening

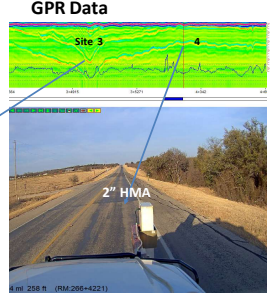


Case Study 2
Frequent Repairs – what is wrong with pavement



2 mi 874 ft (RM:273+2704)

GPR Data



Site 3

4

2" HMA

18-20" HMA

2" HMA

3 mi 4994 ft (RM:271+4298)

8 mi 208 ft (RM:268+4221)



Site 3

Site 4

Nasty clay found at all sites



Very Wet
TRM 264+ .9

HMA = 8 inches

HMA = 12 inches

Poor Drainage at all thick locations



HMA = 20 inches

Conclusion

Not a pavement layer problem

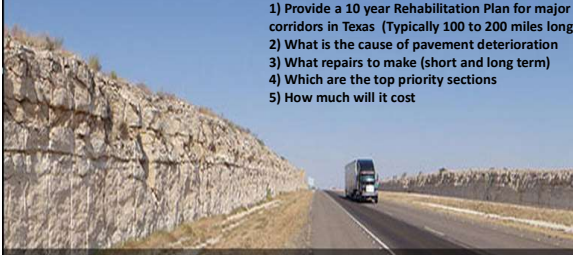
It is a drainage problem

Conclusions



- TxDOT has a very successful forensics program
- This program is a critical part of the research cycle
- Implementation includes new tools, test procedures and specifications
- We get better by learning from our problems not burying them

6. Use of NDT in Corridor Studies



1) Provide a 10 year Rehabilitation Plan for major corridors in Texas (Typically 100 to 200 miles long)
 2) What is the cause of pavement deterioration
 3) What repairs to make (short and long term)
 4) Which are the top priority sections
 5) How much will it cost

Saving Lives, Time and Resources

Many roadway segments on Texas highways have exceeded their design lives and are in need of rehabilitation. To assist in this critical task, TxDOT contracted with TTI to initiate a groundbreaking corridor analysis project. [Read More](#)

Steps in a Typical Corridor Analysis

- Conduct a full GPR survey of each direction of highway
- Meet with DOT personnel to;
 - Define breaks, identify problem sections or upcoming projects
 - Provide traffic estimates for each section
 - Identify their priorities and treatment preferences
- Plan and Execute an FWD and DCP test program
- Plan and Execute a field sampling program including coring to validate defects and auguring (if needed)
- Conduct laboratory testing where required (FDR, Overlay tests, etc.)
- Analyze all of the data collected
- Run Pavement Design options
- Report and Presentation of Findings

Corridor Analysis of IH 20 in the Odessa District



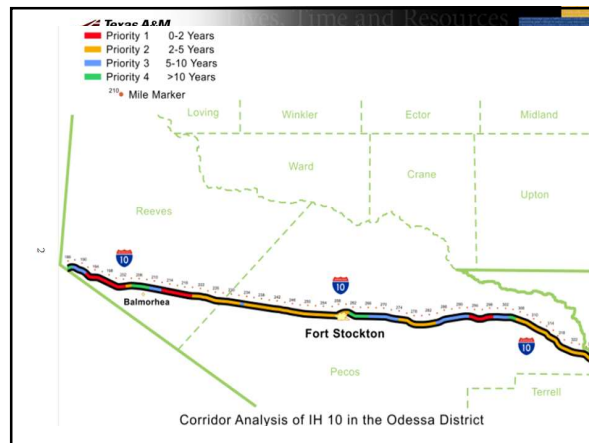
BY
Tom Scullion
 Texas Transportation Institute

STUDY SUPERVISORS
Magdy Mikhail
 TxDOT Construction Division
K.C. Evans
 TxDOT Odessa District



CONTENTS

1. Color Coded Priority Map
2. Table of Priority Projects
3. Additional Work or Modifications to Current practice
4. Section Breakdown

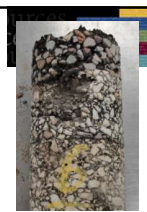


IH 20	County: Reeves	TRM: 19-7-25
Pavement Structure: 1996	Last Treatment: 1996	Type: 4.5 inches of Type B
Base: 21 in Flex	Base: 16 in Flex	Type: 1.5 CMHB - C
Total HMA: 6 - 7 in		
Current Condition:		
		
Distress: Block Cracking with some localized alligator, lots of crack seal		
2009 PMIS: Condition Scores from 31 to 76		
Cause of Problem:		
Severe stripping of the Type B base layer in both lanes both directions and other sections of IH 20 also have severe stripping. An evaluation should be made of the mixes used to identify the cause of this severe deterioration. It is suspected that the problems are both mix and construction related. The local materials we thought to be not stripping susceptible but that does not seem to be the case. Long life pavement concepts involve placing base mixes which do not deteriorate so only surface renewal is required. This is not happening on several sections of IH 20, where complete replacement is now required after 15 years.		
Flexible base layer in good condition; from the FWD modulus 100 + Ksi		
Subgrade strong, 20+ ksi		
Recommended Rehabilitation Approach:		
Complete replacement of all HMA		
Funds should be included in the contract for reworking any suspect areas of base (very few anticipated, less than 5%)		
FPS 19 indicate that 6 inches of new HMA would be required for a 20 year design life		
A fog seal is planned for ASAP to help hold this section together.		
Urgency: High Priority 0 - 2 years		
Cost Estimate: \$ 6 million		



0 - 2 year project
Bad news

IH 20	County: Midland County	TRM: 122 - 136
Pavement Structure: 2002	Last Treatment: 2002	Type: Hot Rubber underseal
Base: 16 in Flex base	Base: 16 in Flex base	Type: CR PMS
Total HMA: 10 in		
Current Condition:		
		
Distress: Longitudinal cracking, rough ride, failures mostly outside lane outside wheel path		
2009 PMIS: Range from 45 to 95		
Cause of Problem:		
From coring and GPR most of the damage is restricted to top 4 inches of HMA; below that the HMA looks solid. However transverse cracks initiating in lowest layer of HMA have reflected and are seen in both lanes. These cracks are source of problem letting moisture into susceptible layers.		
Recommended Rehabilitation Approach:		
The FWD indicated that the base layer in both directions is very good. This is the most heavily traffic section in the District with 29 million ESAL's		
Flexible pavement Option: (Time to First Over 15 years)		
In outside lane only mill 4 inches place a layer to minimize reflection cracks. This could be a 1 inch crack attenuating layer (SS 3165) or a crack retarding fabric layer, 2 inches of new HMA plus PFC. Mill 2 inches inside lane (CAM + PFC)		
Rigid Option If 30 year design required consider, milling 5 inches then full depth CRCP - check with Brownwood for their recent experience with concrete on IH 20		
Urgency: High Priority 0 - 2 years		
Cost Estimate: High \$5 (long section all in poor condition both directions)		



0 - 2 year project
Good News



ives, Time and Resources
ives, Time and Resources
ives, Time and Resources

Questions?



ives, Time and Resources
ives, Time and Resources
ives, Time and Resources



ITD ASSET MANAGEMENT - AN OVERVIEW

1.

ITD ASSET MANAGEMENT - AN OVERVIEW

ORGANIZATIONAL ASPECTS

2.

ITD ASSET MANAGEMENT - AN OVERVIEW

ORGANIZATIONAL ASPECTS

SYSTEMS AND PROCESSES

3.

ITD ASSET MANAGEMENT - AN OVERVIEW

ORGANIZATIONAL ASPECTS

SYSTEMS AND PROCESSES

RESEARCH PROJECTS

4.

ITD ASSET MANAGEMENT - AN OVERVIEW

ORGANIZATIONAL ASPECTS

SYSTEMS AND PROCESSES

RESEARCH PROJECTS



5.



WHAT?



WHY?



WHEN?



HOW?



WHO?

6.

WHAT IS ASSET MANAGEMENT?

Government Definition:

Transportation Asset Management (TAM-21) - "...a strategic and systematic process of operating, maintaining, and improving physical assets, with a focus on engineering and economic analysis based upon quality information, to identify a structured sequence of maintenance, preservation, repair, rehabilitation, and replacement actions that will achieve and sustain a desired state of good repair over the lifecycle of the assets a minimum practicable cost."

Doing the right treatment at the right time for the right reason.

7.

ITD ASSET MANAGEMENT TIMELINE

1978

Pavement
Performance
Information
System

1986

Began Simple
Economic
Analysis

2007

Highway
Economic
Requirement
System (HERS-
ST)

2009

AgileAssets
Transportation
Asset
Management
System (TAMS)

The Times have changed - Mission is Still the Same

Mission

- Monitor assets throughout their life - cycle
- Effectively collecting quality data,
- Developing accurate predictive models and investment scenarios,
- Communicating & prioritizing needs across the state, with a focus on stakeholder engagement,
- Provide continuity & effective service which ensure focused stewardship of tax dollars.

8.

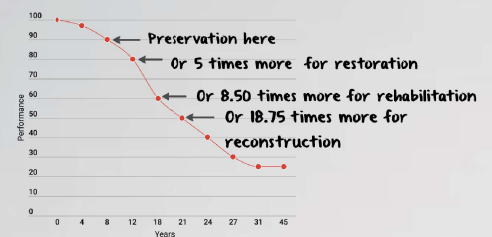
WHY?

IT'S THE RIGHT THING TO DO!
(AND WE HAVE TO)



9.

COST ACROSS THE PAVEMENT LIFE-CYCLE



10.

HIGHWAY PERFORMANCE MONITORING SYSTEM (HPMS)

Federally Mandated



Measure National Performance

Monitor System Condition



Apportionment

11.

TRANSPORTATION ASSET MANAGEMENT PLAN (TAMP)

Focuses on ITD Processes for Asset Performance, Targets and Financial Planning

8 Required Sections

- | | |
|-----------------------|-----------------------|
| Management Objectives | Life-Cycle Planning |
| Summary of Conditions | Risk Management |
| Measures and Targets | Financial Planning |
| Performance Gaps | Investment Strategies |

12.

HOW?

13.

14.

Keys to Success

1. Be "Quality - Centric "
2. Honor the People
3. Define the Process
4. Respect the Tech
5. Life-Cycle -> Go with the flow
6. Align with and Drive Asset Management objectives

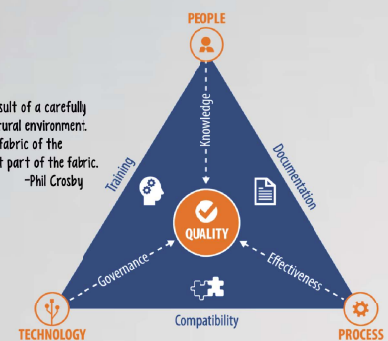
15.

16.



17.

Quality is the result of a carefully constructed cultural environment. It has to be the fabric of the organization, not part of the fabric.
-Phil Crosby



18.

HOW?



19.

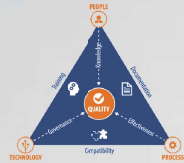
HOW?



20.

HOW?

Life-Cycle



21.

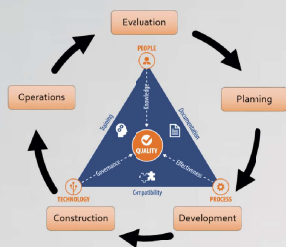
HOW?

Life-Cycle



22.

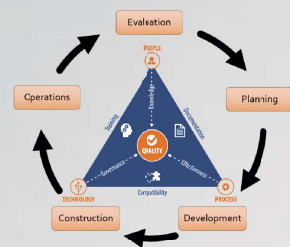
HOW?



23.

HOW?

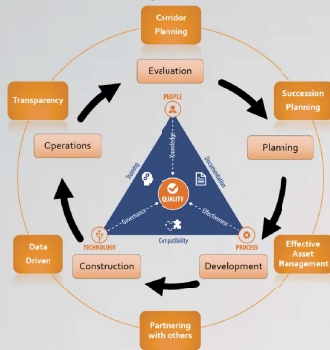
Asset Management Objectives



24.

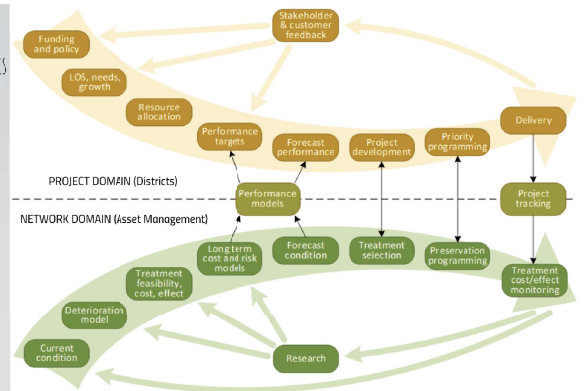
HOW?

Asset Management Objectives



25.

ROLES & RESPONSIBILITIES



26.

ITD ASSET MANAGEMENT - AN OVERVIEW

ORGANIZATIONAL ASPECTS SYSTEMS AND PROCESSES RESEARCH PROJECTS



SYSTEMS AND PROCESSES

RESEARCH PROJECTS

27.

ITD ASSET MANAGEMENT - AN OVERVIEW

ORGANIZATIONAL ASPECTS SYSTEMS AND PROCESSES RESEARCH PROJECTS



SYSTEMS AND PROCESSES

RESEARCH PROJECTS

28.

TAMS ASSET MANAGEMENT MODULE OVERVIEW

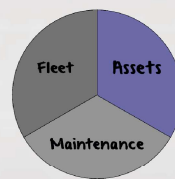
3 Modules Comprise ITD's Transportation Asset Management System (TAMS)



29.

TAMS ASSET MANAGEMENT MODULE OVERVIEW

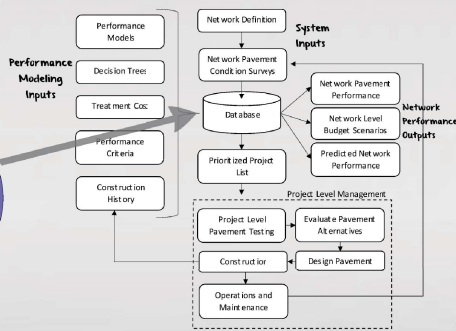
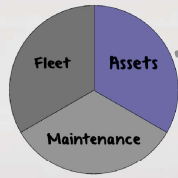
3 Modules Comprise ITD's Transportation Asset Management System (TAMS)



30.

TAMS ASSET MANAGEMENT MODULE OVERVIEW

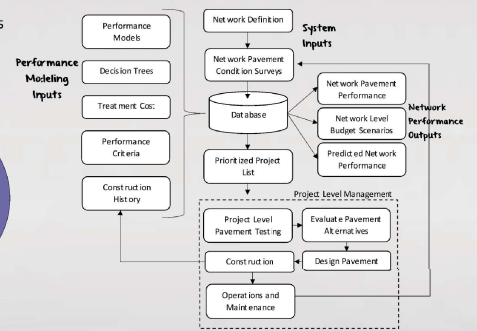
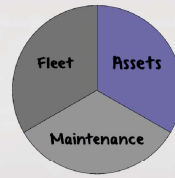
3 Modules Comprise ITD's Transportation Asset Management System (TAMS)



31.

TAMS ASSET MANAGEMENT MODULE OVERVIEW

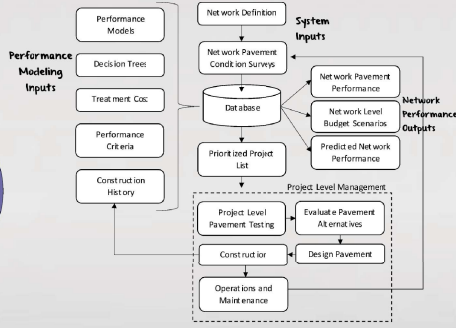
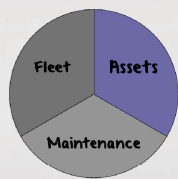
3 Modules Comprise ITD's Transportation Asset Management System (TAMS)



32.

TAMS ASSET MANAGEMENT MODULE OVERVIEW

3 Modules Comprise ITD's Transportation Asset Management System (TAMS)



33.



34.

SYSTEM INPUTS



NETWORK PAVEMENT
CONDITION
SURVEYS

NETWORK PAVEMENT CONDITION SURVEYS - ALL STAR LINEUP

Inertial Profiler



Pavement Friction Tester (PFT)



Falling Weight Deflectometer (FWD)*

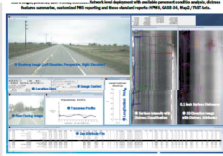


* Used on the project level

35.

36.

PATHWAY INERTIAL PROFILER



- Collects rutting, roughness, cracking, geometrics, GPS position, and roadway images
- Collect entire network every year
- Primary input into TAMS
- Produces the "Video Log"
- 5.2 million points per second
- 15 photos per second
- 15 TB data per year

37.

PAVEMENT FRICTION TESTING

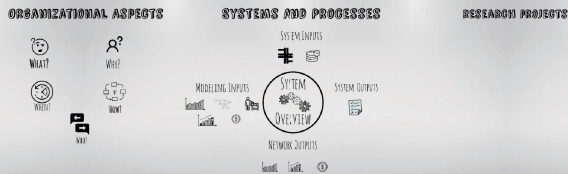
WHY?

- Key component of roadway safety;
- ~20% of crashes occur on wet pavement
- Approximately 14% of all fatal crashes occur on wet pavement;
- Ensuring acceptable friction levels leads to 50-60% decrease in wet weather accidents;



38.

ITD ASSET MANAGEMENT - AN OVERVIEW



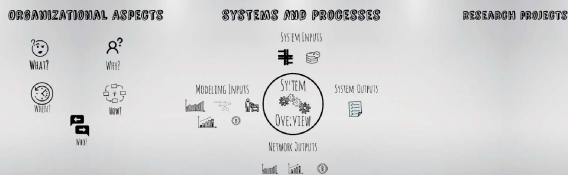
39.

MODELING INPUTS



40.

ITD ASSET MANAGEMENT - AN OVERVIEW



41.

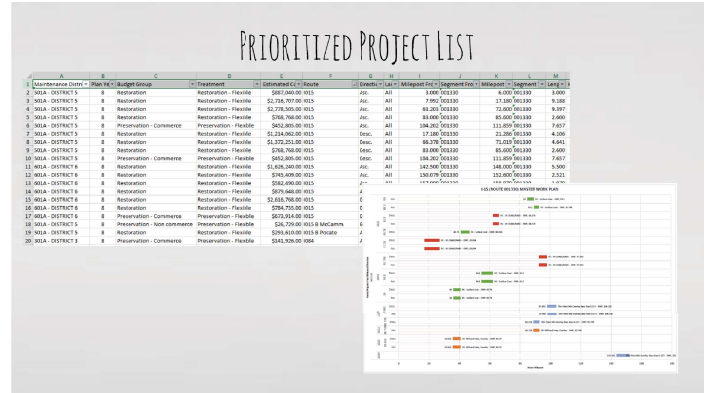
NETWORK OUTPUTS



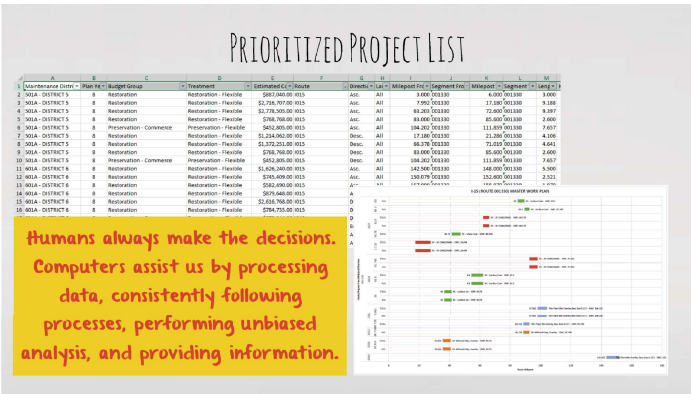
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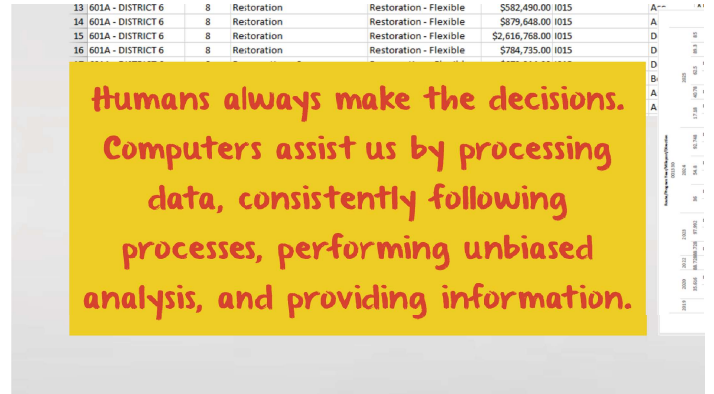
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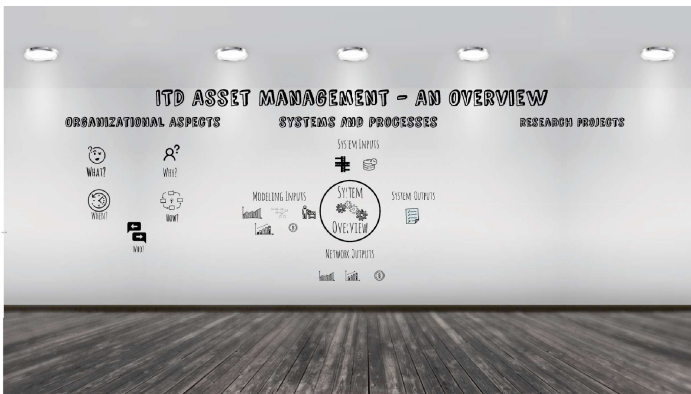
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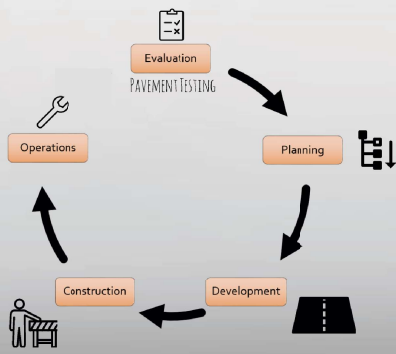


47.



48.

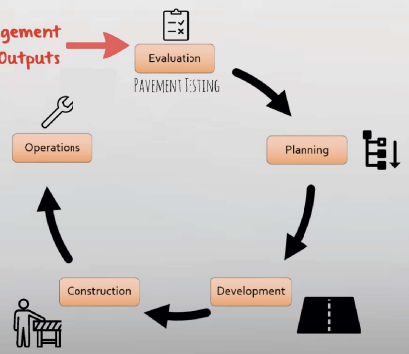
PROJECT LEVEL PAVEMENT MANAGEMENT & LIFECYCLE



49.

PROJECT LEVEL PAVEMENT MANAGEMENT & LIFECYCLE

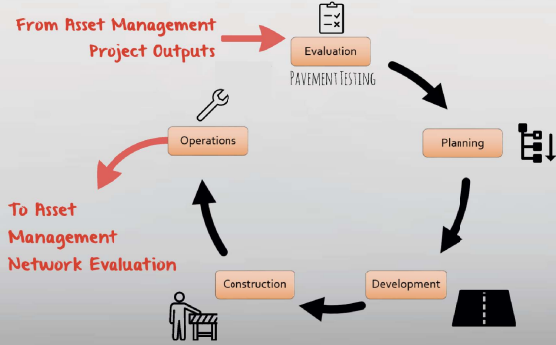
From Asset Management
Project Outputs



50.

PROJECT LEVEL PAVEMENT MANAGEMENT & LIFECYCLE

From Asset Management
Project Outputs



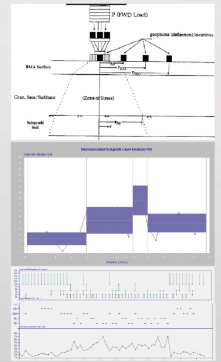
51.

FALLING WEIGHT DEFLECTOMETER (FWD)



WHY?

- Non-Destructive Test;
- Can determine what is failing (i.e. base or pavement);
- Estimate remaining pavement life;
- Simulates the expected deflection from a moving load;
- Can be used in conjunction with distress survey;
- Identify locations for destructive testing;
- Tailor treatments within project limits;
- Recommended for overlay design.



52.

ITD ASSET MANAGEMENT - AN OVERVIEW

ORGANIZATIONAL ASPECTS SYSTEMS AND PROCESSES RESEARCH PROJECTS



53.

ITD ASSET MANAGEMENT - AN OVERVIEW

ORGANIZATIONAL ASPECTS SYSTEMS AND PROCESSES RESEARCH PROJECTS



54.



55.

RESEARCH PROJECTS

Travel Speed
Deflectometer

Next Gen
Performance
Measures

Skid Number
Translation

56.

TRAVEL SPEED DEFLECTOMETER (TSD)



- State of the Art
- Measures structural capacity
- Builds on D6 work
- Part of a 3-year multi-state pooled fund study
- Collecting over 2,500 miles
- Allow ITD to tailor pavement treatments
- High ROI

57.

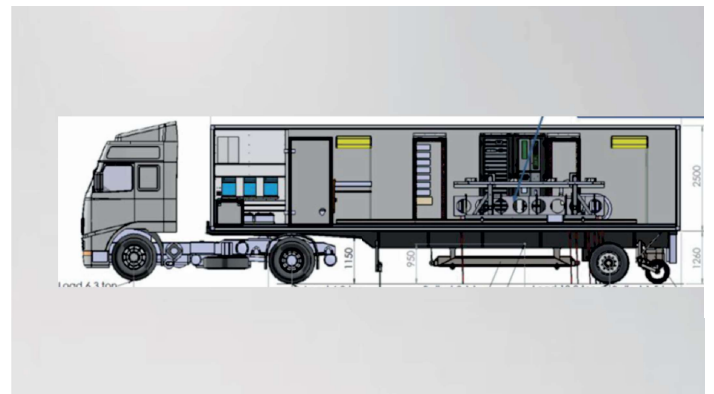
TRAVEL SPEED DEFLECTOMETER (TSD)



58.



59.



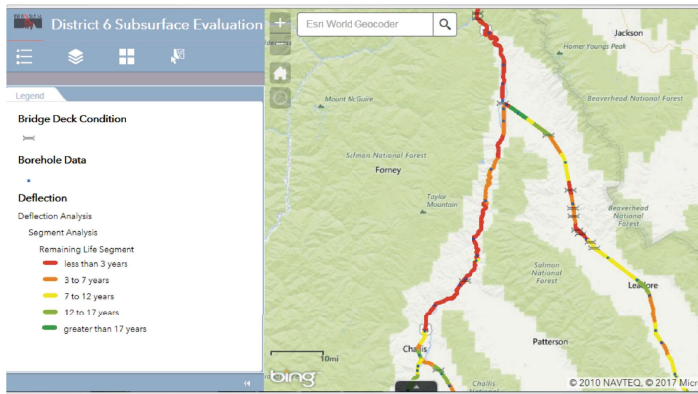
60.



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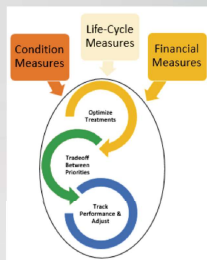
63.



64.

NEXT GEN PERFORMANCE MEASURES

Project Background and Description - Utilizing existing data, processes, and asset management systems, validate and apply 8 leading performance measures and a cross asset optimization to determine benefit of long-term investment strategizing and decision-making.



- Optimize treatments through Life cycle planning and Project selection
- Perform Trade-off Analysis using Cross-asset and Cross-program analysis to build Program
- Monitor Performance using TPM, Level of Service, and State of good repair
- Not a black box solution, this is a framework which will enable and inform ITD decision makers regarding implications of prioritization across competing programs and assets.

65.

SKID NUMBER TRANSLATION

This study had the following objectives:

Examine the correlation between SN, pavement and speed

Investigate the effect of pavement characteristics on the measured SN

Develop a statistical model that can be used to predict SN at a reference speed

Develop a software utility that can be used by operators to easily convert SN to different speeds.

- We got an equation:

$$SN_2 = 0.97145 \cdot SN_1 - 0.58093(V_2 - V_1) + 1.37935^{MPD}$$

Improved SAFETY
Improved EFFECTIVENESS
Showed value of CONSTRUCTIVE CULTURE



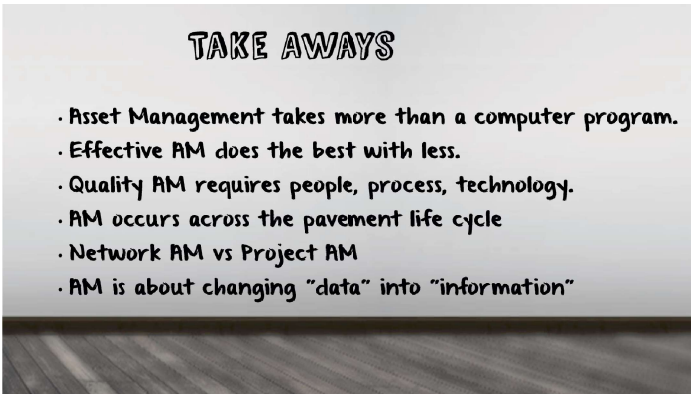
66.



67.



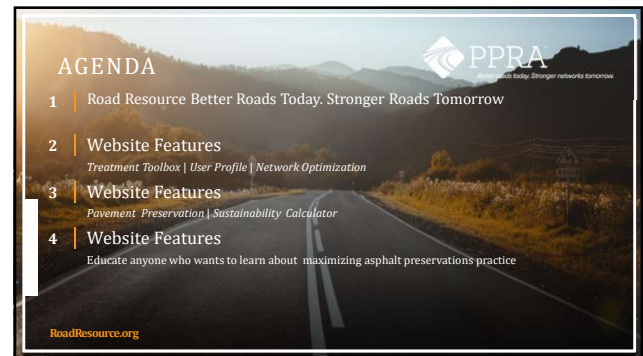
68.



69.



70.



The Situation:

Demand is increasing for asphalt emulsions, preservation and recycling.

However, many city and county agencies are still unaware of benefits and best practices to successfully choose and apply these treatments.

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Three Associations Join Together to Support the Industry at Large





FORMING THE PAVEMENT PRESERVATION & RECYCLING ALLIANCE

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Two Guiding Questions

1 How do we equip road owners & end users with **tools to increase the successful use** of pavement preservation and recycling?

2 How do we better disseminate research, success stories, and learning across all agencies, **making information more accessible**?

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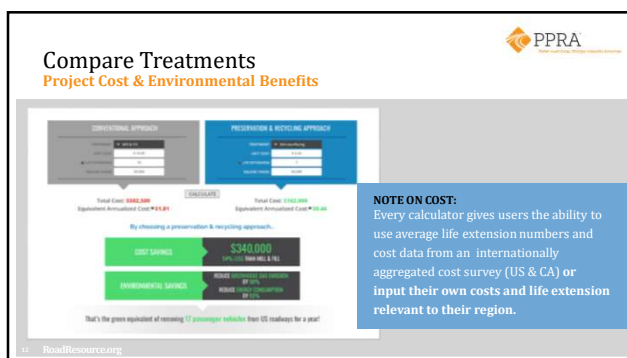
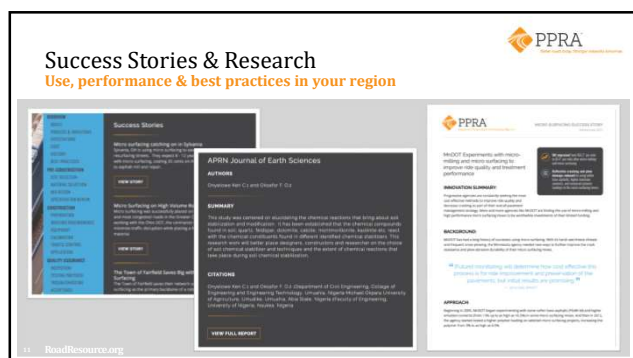
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Research & Collaboration

Competitive exploration & Industry affiliations	International data survey	Retreats with ISSA, AEMA & ARRA leadership
Input from over 45 agency and industry leaders	Interviews & beta-testing with agency-level users, pavement managers, DOTs, & roadway engineers	Page by page technical review from multiple committees

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WEBSITE FEATURES

- SECTION 1 Treatment Toolbox
- SECTION 2 **PPRA User Account**
Tailor tools & calculators to your area
- SECTION 3 Network Optimization

User Account Capabilities

- Enter unit cost, life extension, and structural numbers from your area
- Update units of measure for US or Canada

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My PPRA Account
Input costs and life extension in your area to make the most of the site & tools

Stored Data & Preferences

NOTE: Change aggregate data into costs, life extension, and structural numbers relevant to you. Tools throughout the site automatically re-populate with your data every time you log in.

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WEBSITE FEATURES

- SECTION 1 Treatment Toolbox
- SECTION 2 **PPRA User Account**
- SECTION 3 **Network Optimization**
Information at the Network Level

Calculators & Concepts

- Network How-To
- Equivalent Annualized Cost
- Life Cycle Cost
- Remaining Service Life
- Cost-Benefit Value

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Equivalent Annualized Cost
Compare treatment cost based on Life Extension

Use our nationally aggregated data or enter your own data

Treatment Type	Cost Per Sq. Yd.	Life Extension (Years)	Eq. Cost (\$/Sq. Yd.)
Crack Seal	\$5.50	5	\$1.10
Fog Seal	\$1.00	5	\$0.20
Single Surface T.	\$2.00	5	\$0.40
Double Surface T.	\$4.25	5	\$0.85
Thin Overlays	\$7.00	10	\$0.70
Mix and Fill	\$12.00	10	\$1.20
Cold In Place	\$17.00	10	\$1.70
Reconstructed	\$25.00	20	\$1.25

Eq. Cost by Strategy - 500 Miles

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Life Cycle Cost Calculator
Save big over the life of your pavement with progressive maintenance

CONVENTIONAL PLAN vs. OPTIMIZED PLAN

Cost/100 Over 10 Years: **\$46,000** vs. **\$35,485**

Cost/100 Over 10 Years: **\$35,485**

Optimized Strategy: **\$12,500,000**

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Remaining Service Life
How much life is your network gaining or losing each year?

RSL Calculator

Is your network gaining or losing life each year?

Understanding Remaining Service Life (RSL) is critical to designing a treatment plan that stretches your budget further and maximizes the extent of a distressed network.

CRITICAL CONCEPT
A 500-mile network loses 500 mile-years of life annually. Every year, every mile of your network loses 1 mile-year of life. To avoid losing ground, the network owner must design a treatment plan that adds 500 mile-years of life or more.

See how this agency reallocated funds to inject more life into their network, using the same budget.

YOU ADDED 1,000 MILE-YEARS OF LIFE

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Cost-Benefit Value

Which projects will give the "biggest bang for the buck?"

Cost-Benefit Value

With limited funding, how do I prioritize my projects?

City often ranking managers a way to prioritize projects while accounting for the variable relevant to you and the realities of traffic, cost and the extension.

CBV = $\frac{\text{Traffic} \times \text{Constraint Factor} \times \text{Life Extension}}{\text{Unit Cost} \times \text{PCI}}$

Total Network Lane-Miles: 300
AADT Constraint: 7
Total Budget: \$ 2000000

ROAD 1: Worst First ID Reconstruction, AADT 5000, PCI 30, (5000mi/Tr x 1/25mi) = 15 CBV

ROAD 2: Preservation, AADT 5000, PCI 30, (5000mi/Tr x 1/25mi) = 29 CBV

CRITICAL SHORT
For Road Traffic, Preservation has a Higher Benefit.

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RSL Calculator | Worst First Approach

How do I calculate the RSL for my network?

Total Network Lane-Miles: 300
Average Lane Width (ft): 12
Total Budget: \$ 2000000
Remaining Budget: \$ 1500000

Total Network Impact

Preservation: \$272,214
Rehabilitation: \$1772,275
Reconstruction: \$401,511

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RSL Calculator | Optimized Approach

Total Network Lane-Miles: 300
Average Lane Width (ft): 12
Total Budget: \$ 2000000
Remaining Budget: \$1,312

Total Network Impact

Preservation: \$411,530
Rehabilitation: \$104,130
Reconstruction: \$200,922

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RSL Example to Plug into RoadResource.org Interactive Calculator

January 31, 2019 for Indus Sales Team

200 lane-mile network with avg. 12' width (equals to 1,408,000 sq. y.) and \$800,000 budget

Worst First Approach

Treatment Type	Category	Life Extension	Lane-Miles Treated	Lane-Mile-Years	Unit Cost	Total Cost
Full Depth Reconstruction + 4" HMA	Reconstruction	25	2	50	\$18.54	\$431,843
Major MBI & F&B	Rehabilitation	15	2	30	\$16.64	\$234,291
Minor MBI & F&B	Rehabilitation	11	2	22	\$9.80	\$137,384
Crack Seal	Preservation	2	8	16	\$0.48	\$27,088
TOTALS			12	118		\$801,152

Program results: 87% of funds spent on Reconstruction & Rehabilitation such that only 14 lane-miles were treated (7% of the network) and a net loss of 83 lane-mile-years of network service life (200 lane-mile-years in "Tough event")

Optimized Approach

Treatment Type	Category	Life Extension	Lane-Miles Treated	Lane-Mile-Years	Unit Cost	Total Cost
Full Depth Reconstruction + 4" HMA	Reconstruction	25	1	25	\$18.54	\$269,122
Major MBI & F&B	Rehabilitation	15	1	15	\$16.64	\$117,146
Minor MBI & F&B	Rehabilitation	11	1	11	\$9.80	\$66,992
Crack Seal	Preservation	2	20	40	\$0.48	\$67,184
Rejuvenating Fog Seal	Preservation	3	8	24	\$0.67	\$37,734
Chip Seal	Preservation	6	8	48	\$2.06	\$116,019
Minor - single lift	Preservation	6	6	36	\$2.77	\$117,006
Cap Seal	Preservation	10	2	20	\$5.20	\$73,215
TOTALS			22	219		\$790,618

Program results: Recons/Rehab program cut in half such that 52% of funds could be spent on keeping good roads in good condition and 47 lane-miles could be treated (34% of the network) and a net gain in network service life of 13 lane-mile-years could be achieved.

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FOR MORE INFORMATION

Melynda Boswell
 Boswell Asphalt Paving Solutions, Inc.
 (208)-884-1050
 boswellapsolutions@gmail.com

For Association Information

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Development and Evaluation of Performance Measures to Augment Asphalt Mix Design in Idaho

Emad Kassem, Fouad Bayomy, Hamza Alkuime

October 24, 2019



Outline

- Research Motivation
- Research Objectives
- Research Methodology and Tasks
- Research Findings
- Research Recommendations/Implementation

2



Research Motivation

- Superpave volumetric mix design is conducted without performance criteria to evaluate the mix resistance to cracking and rutting.

Rutting criteria →

Fatigue criteria →

Low-temperature criteria →

Performance Grade	PG 46				PG 52				PG 58				PG 64			
	34	40	46	52	34	40	46	52	34	40	46	52	34	40	46	52
Average annual-day Maximum Pavement Design Temperature, °C	-46				-32				-18				-4			
Minimum Pavement Design Temperature, °C	34	40	46	52	34	40	46	52	34	40	46	52	34	40	46	52
Flash Point Temp. Minimum, °C	230															
Viscosity, ASTM D4402, Maximum, 270 s, Test Temp., °C	135															
Dynamic Shear G* ₁₉ at A, Minimum, 1,000 kPa, Test Temp. at 10 rad/s, °C	46				52				58				64			
Min. Loss, Maximum, Percent	1.00															
Dynamic Shear G* ₁₉ at A, Minimum, 2,000 kPa, Test Temp. at 10 rad/s, °C	46				52				58				64			
PGV Aging Temperature, °C	90				90				90				90			
Dynamic Shear G* ₁₉ at A, Maximum, 1000 kPa, Test Temp. at 10 rad/s, °C	18	22	26	30	22	26	30	34	26	30	34	38	30	34	38	42
Comp. Modulus E, Maximum, 100 MPa, at 10 rad/s, Minimum, 6,000 Test Temp. at 10 rad/s, °C	24	30	36	42	30	36	42	48	36	42	48	54	42	48	54	60
Direct Tension Failure Strain, Minimum, 1.0% Test Temp. at 10 rad/s, °C	24	30	36	42	30	36	42	48	36	42	48	54	42	48	54	60



Research Motivation

- Rutting and cracking have been observed in pavements that were designed using the Superpave method



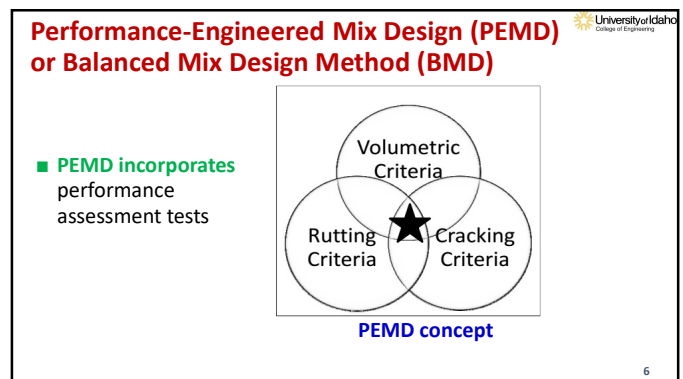
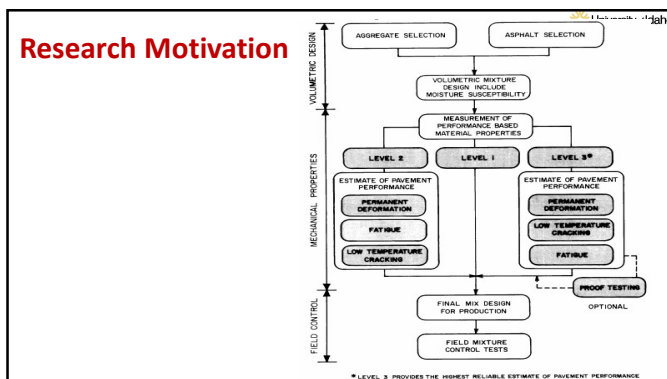
Rutting



Fatigue Cracking



Moisture Damage



Research Objectives

1. Review and document performance tests and indicators used by various transportation agencies to evaluate the resistance of asphalt mixes to cracking and rutting.
2. Propose and develop new analysis method for monotonic cracking assessment test and dynamic cracking assessment test to overcome the limitations of existing indicators and tests
3. Select the most promising performance tests and indicators
4. Examine and evaluate selected tests and indicators to assess the resistance of asphalt mixes to cracking and rutting
5. Develop performance thresholds to ensure adequate resistance to cracking and rutting

7

Research Methodology and Tasks

8

Task 1: Literature review

Rutting assessment tests

Asphalt Pavement Analyzer (APA) rut test



Hamburg wheel tracking test (HWTT)



Performance Indicators

- Maximum rut depth @ 8,000 loading cycles (APA_{8000})
- Maximum rut depth @ 15,000 loading passes ($HWTT_{15000}$)
- Maximum rut depth @ 20,000 loading passes ($HWTT_{20000}$)

9

Task 1: Literature review

Performance thresholds

APA rut test

State DOT	Additional Distinguish criteria (i.e., binder PG, traffic level, etc.)	Limits (Max. rut depth [mm])
Idaho	All mixes (SP3, SP5)	5.0
Alabama	SMA mixes and HMA with traffic ESALs between 1.0E7 and 3.0E7	4.5
Alaska	All mixes	3.0
Georgia	19.0 mm and 25.0 mm NMAS mixes	5.0

Others

HWTT

DOT	Rutting performance threshold (Minimum # of Passes)
TXDOT	Additional Distinguish criteria (i.e., binder PG, traffic level, etc.)
PG 70	15,000
PG 64	10,000
PG 76	20,000
Illinois	PG 58-xx
PG 64-xx	7,500
PG 70-xx	15,000
PG 76-xx or higher	20,000
Oklahoma	PG 64-xx
PG 70-xx	15,000
PG 76-xx	20,000

Others

10

Task 1: Literature review

Documented testing standards to assess cracking

Specimen geometry	SC		IDT
Testing Standards	ASTM D8044	AASHTO TP 124	ASTM D6931 and D8225
Symbol	SCB-Jc	SCB-FI	IDT
Notch (mm) depth	25.4, 32, and 38	15	-----
Diameter (mm)	150	150	150 or 101.6
Loading rate (mm/min)	0.5	50	50
Test output	Load-displacement curve		

Semi-circle (SC)

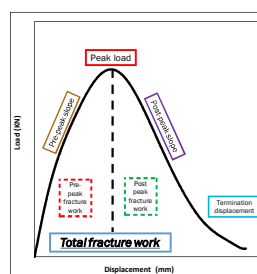


Circular



Task 1: Literature review

Performance indicators and PEMD specification to assess cracking



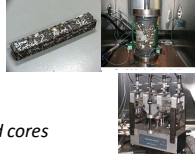
#	Formula	Research group	References
1	$G_{fracture}^{total} = \frac{W_{fracture}}{crack\ face\ area}$	-	(Zhu et al. 2017)
2	$\sigma_{tensile\ IDT} = \frac{2000xP_{peak}}{\pi \times t \times D}$	-	Butler et al. (1998)
3	$IDT_{modulus} = \frac{\sigma_{tensile\ IDT}}{L_{peak\ load}}$	Japan	West and Copeland (2015)
4	$J_c = \left(\frac{1}{t} \right) \frac{dU}{da}$	Louisiana State University	Wu et al. (2005); Bayomy et al. (2009)
5	$FI = 0.01 \times \frac{G_{fracture}^{total}}{P_{post-peak} - P_{injection}}$	University of Illinois at Urbana-Champaign	Al-Qadi et al. (2015)
6	$N_{tex} = \frac{Toughness}{m_{injection}}$	National Center for Asphalt Technology (NCAT)	West et al. (2017)
7	$IDEALCT\ index = \frac{G_{fracture}^{total}}{m_{25\%}} \times \frac{t}{62}$	Texas A&M University	Zhou et al. (2017)
8	$CRI = \frac{G_{fracture}^{total}}{P_{peak}}$	Texas A&M University	Kaseer et al. (2018)

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Task 1: Literature review

Identified limitations of cracking assessment tests

- Current **monotonic performance** indicators
 - Lack the full description of the load-displacement curve
 - Provide illogical trend with air void content and thickness
- Current **dynamic assessment tests**
 - long or unknown testing time
 - Unknown stress/strain levels
 - Complex specimen shape
 - Costly equipment
 - Can not be used to evaluate extracted field cores



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Task 2: Develop new and innovative cracking assessment tests

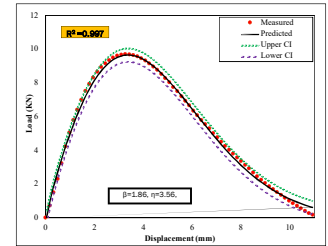
Innovative unified monotonic performance indicator

Curve fitting

$$P = A \times \left(\frac{\beta}{\eta} \right) \left(\frac{u}{\eta} \right)^{\beta-1} \times e^{-\left(\frac{u}{\eta} \right)^{\beta}}$$

where

- P = the applied load or stress
- u = the measured displacement
- β = the *shape parameter*
- η = the *scale parameter*
- A = the *area parameter*

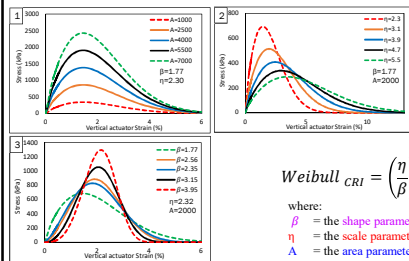


14

Task 2: Develop new and innovative cracking assessment tests

Innovative unified monotonic performance indicator

Indicator derivation



Higher Weibull CRI indicates improved resistance to cracking

$$\text{Weibull } CRI = \left(\frac{\eta}{\beta} \right) \times \log[A]$$

where:
 β = the *shape parameter*
 η = the *scale parameter*
 A = the *area parameter*

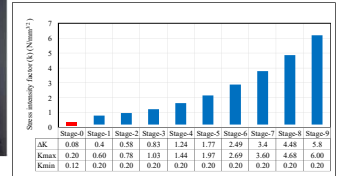
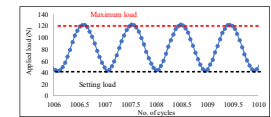
15

Task 2: Develop new and innovative cracking assessment tests

Develop a new dynamic loading cracking assessment

MSSD applies a **series** of different SIF factors

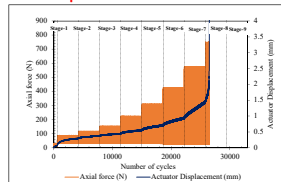
Ten different loading stages with different SIF are applied



Task 2: Develop new and innovative cracking assessment tests

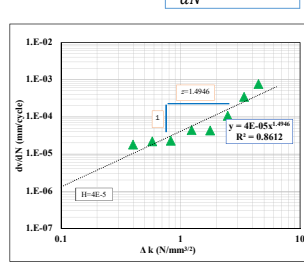
Develop a new dynamic loading cracking assessment test

Data interpretation



Lower slope
(z) Value
Higher intercept
value (Abs log H)

Improving in mix
resistance to
cracking



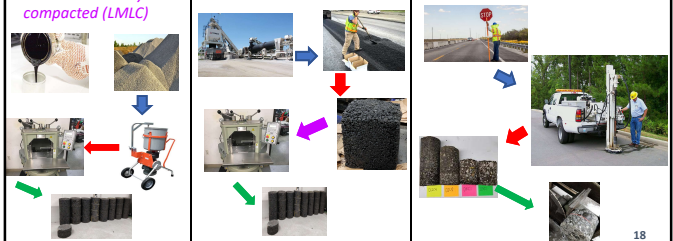
Task 3: Identify and select testing materials and conduct field performance evaluation

Identified test materials

Six Laboratory
Mixed-Laboratory
compacted (LMLC)

10 Plant Mixed-Laboratory
compacted (PMLC)

17 Field Projects

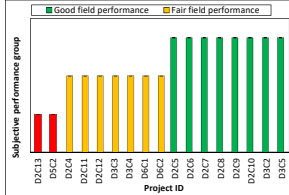


18

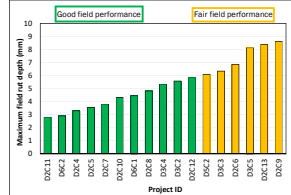
Task 3: Identify and select testing materials and conduct field performance evaluation

Observed field performance -

Observed **cracking** performance



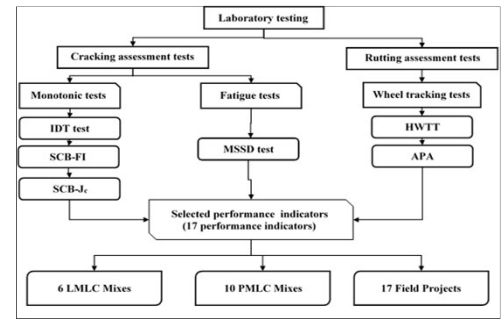
Observed **rutting** performance



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Task 4: Conduct laboratory performance tests

Selected testing standards and Experimental design



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Task 4: Conduct laboratory performance tests

Selected performance indicators

Most promising rutting performance indicators

#	Assessment test	Assessment Indicator
1	APA	APA ₂₀₀₀₀
2	HWTT	HWTT ₁₀₀₀₀
3		HWTT ₂₀₀₀₀

Newly developed cracking performance indicators

#	Assessment test	Assessment Indicator
4	MSSD	Slope (z)
5		Abs log (H)
6	IDT	Weibull _{CRI}

Promising cracking performance indicators

#	Assessment test	Assessment Indicator
7	SCB-Jc	Jc
8		G _{Fracture} ^{Total}
9	SCB-FI	CRI
10		FI
11		G _{Fracture} ^{Total}
12		σ _{residue} ^{IDT}
13		IDT _{modulus}
14	IDT	FI
15		CRI
16		IDEAL - CT _{index}
17		N _{flex}

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Task 4: Conduct laboratory performance tests

Testing devices



AMPT



MTS



APA Jr.

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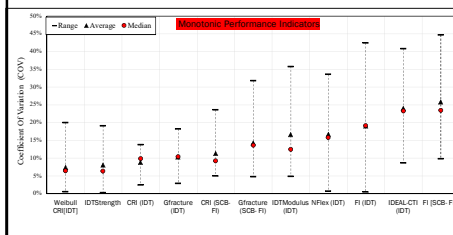
Task 5: Conduct comprehensive evaluation of cracking and rutting performance of laboratory-prepared specimens

- Investigate fundamental understanding of **variation** in the load-displacement curve in terms of mix cracking resistance
- Examine performance indicators **sensitivity** to the variation in **binder content**
- Examine performance indicators **sensitivity** to the variation in **binder grade**
- Examine performance indicators **variability**
- Examine performance indicators **correlation with each other**
- Examine performance indicators **statistical grouping** for mixes performance
- Investigate the **expected** cracking and rutting **resistance** of currently produced asphalt mixes in Idaho

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Task 5: Conduct comprehensive evaluation of cracking and rutting performance of laboratory-prepared specimens

Performance indicators variability



Variability	Average COV
Low	<10%
Moderate	10% < COV < 30%
High	> 30%

Performance indicator	Variability
G _{Fracture} (IDT)	Moderate
G _{Fracture} (SCB-FI)	Moderate
CRI (IDT)	low
CRI (SCB-FI)	Moderate
FI (IDT)	Moderate
FI (SCB-FI)	Highest
IDEAL-CT _{index}	Moderate
Nflex factor	Moderate
IDT _{strength}	low
IDT _{modulus}	Moderate
J _c	NA
Weibull _{q1} (IDT)	Lowest

Task 5: Conduct comprehensive evaluation of cracking and rutting performance of laboratory- prepared specimens

Summary

Performance indicator	LMLC mixes		PMLC mixes							PMLC and LMLC mixes
	Binder PG	Binder Content	DLL2 and DLL1 to have the best cracking resistance	DLL1 to have the best cracking resistance	DLL1 to have better cracking resistance than DLL2	DLL1 to have better cracking resistance than DLL3	DLL1 to have better cracking resistance than DLL4	DLL1 to have better cracking resistance than DLL5	Number of Failure Groups (PMLC)	
Gross IDT	✓	✓	✓	✓	✓	✓	✓	✓	4	Moderate
Gross DCB-R	✓	✓	✓	✓	✓	✓	✓	✓	4	Moderate
CR IDT	✓	✓	✓	✓	✓	✓	✓	✓	4	Low
CR DCB-R	✓	✓	✓	✓	✓	✓	✓	✓	3	Moderate
IT IDT	✓	✓	✓	✓	✓	✓	✓	✓	2	Moderate
IT DCB-R	✓	✓	✓	✓	✓	✓	✓	✓	2	Highest
IDEAL-C Pass	✓	✓	✓	✓	✓	✓	✓	✓	2	Moderate
Wet Cure	✓	✓	✓	✓	✓	✓	✓	✓	2	Moderate
IDT Index	✓	✓	✓	✓	✓	✓	✓	✓	2	Low
IDT Index	✓	✓	✓	✓	✓	✓	✓	✓	1	Moderate
Δ	✓	✓	✓	✓	✓	✓	✓	✓	NA	NA
Weibull ₁₀ IDT	✓	✓	✓	✓	✓	✓	✓	✓	4	Lowest

✓ indicates worse cracking resistance,
 ✓ indicates better cracking resistance,
 ✓ shows both trends
 ✓ indicates agreements between indicator ranking and the expected ranking
 ✗ indicates disagreements between indicator ranking and the expected ranking

• Best test is IDT
 • Best performance indicator is Weibull₁₀

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Task 5: Conduct comprehensive evaluation of cracking and rutting performance of laboratory- prepared specimens

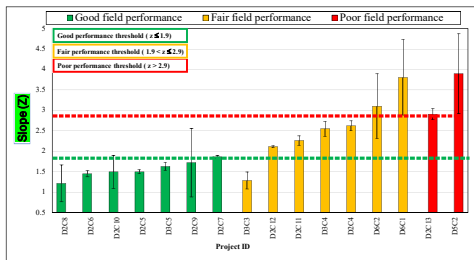
Evaluation criteria	Performance indicator		
	HWTT ₁₅₀₀₀	HWTT ₂₀₀₀	APA ₈₀₀₀
Sensitivity to	Binder content (increase binder content)	✓	✓
	binder PG (using softer binder content)	✓	✓
Statistical sensitivity	7	6	7
Variability	Moderate	Moderate	low/moderate
Advantages	Moisture damage	Moisture damage	N/A
Correlation based on ranking mixes resistance to rutting (Spearman rank correlation coefficient (r_{sj}))	$r_s = 0.10$ (APA ₈₀₀₀ VS HWTT ₂₀₀₀) $r_s = 0.14$ (APA ₈₀₀₀ VS HWTT ₁₅₀₀₀) $r_s = 0.98$ (HWTT ₁₅₀₀₀ VS HWTT ₂₀₀₀)		

✓ indicates worse cracking resistance,
 ✓ indicates better cracking resistance,
 ✓ shows both trends
 ✓ indicates agreements between indicator ranking and the expected ranking
 ✗ indicates disagreements between indicator ranking and the expected ranking

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Task 6: Develop PEMD specifications to assess mix resistance to cracking and rutting

MSSD indicators and Observed field cracking

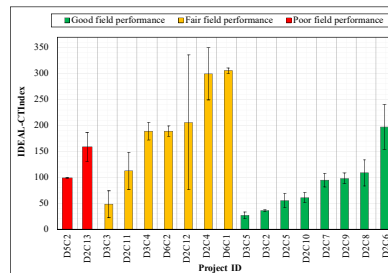


Lower slope (z) value indicates improved resistance to cracking

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Task 6: Develop PEMD specifications to assess mix resistance to cracking and rutting

Monotonic indicators and observed field cracking

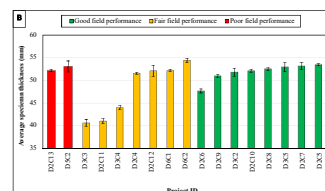
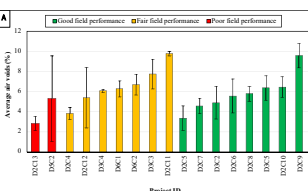


Task 6: Develop PEMD specifications to assess mix resistance to cracking and rutting

Monotonic indicators and Observed field cracking

Explanation

- It was reported that monotonic performance indicators to provide illogical trend with specimen air void content and thickness



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Task 6: Develop PEMD specifications to assess mix resistance to cracking and rutting

Monotonic indicators and observed field cracking

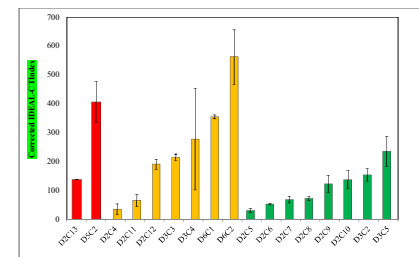
Proposed solution

$$FI_{7\%} = FI_{AV} \times \frac{7\%}{AV\%}$$

$$FI_{7\%} = FI_{AV} \times \frac{0.0651}{AV - AV^2}$$

$$FI_{50} = FI_t \times \frac{t}{50}$$

(Al-Qadi et al., 2015a; Barry, 2016; Rivera, 2017; Kaseer et al., 2018)

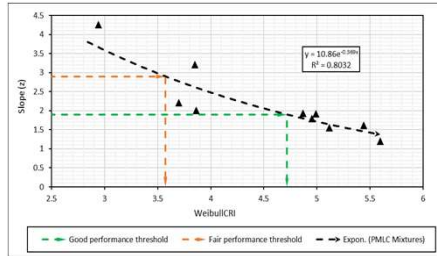


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Task 6: Develop PEMD specifications to assess mix resistance to cracking and rutting

Monotonic indicators and observed field cracking

Alternative New Solution



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Task 6: Develop PEMD specifications to assess mix resistance to cracking and rutting

Monotonic indicators and Observed field cracking

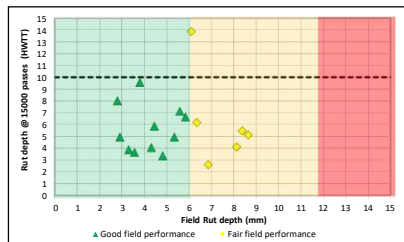
Alternative New Solution

Monotonic indicators	MSSD (Slope)	Proposed Performance Thresholds (Minimum)			Literature
	R ²	Fair	Good	Good	
G _{fracture} (SCB-FI)	0.55	1546	2280	---	
CRI (IDT)	0.59	466	614	---	
FI (IDT)	0.57	11.38	22.55	27	Sreedhar et al., (2018)
IDEAL-CT _{Index}	0.55	26.4	73.7	80	Diefenderfer and Bowers, (2019)
Nflex factor	0.62	0.38	0.70	0.80	West et al., (2017)
J _e	0.46	0.21	0.61	0.60	LADOT, (2016)
Weibull _{CRI}	0.80	3.57	4.7	NA	

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Task 6: Develop PEMD specifications to assess mix resistance to cracking and rutting

Rutting indicators and observed field rutting



Proposed threshold Maximum rut depth of 10 mm at 15,000 passes



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Task 7: Develop recommendations and guidelines for PEMD

Recommended assessment tools to assess cracking and rutting

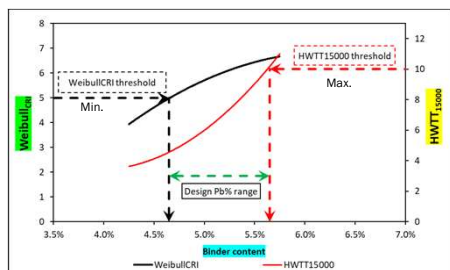
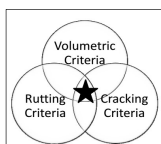
Distress	Test type	Test standard	Performance indicator	PEMD specifications	
				Performance	Thresholds
Cracking	Monotonic	-	Weibull _{CRI}	Good	Weibull _{CRI} > 4.7
				Fair	3.57 < Weibull _{CRI} < 4.7
	MSSD	-	Slope (Z)	Poor	Weibull _{CRI} < 3.57
				Good	Z < 1.9
Rutting	HWT	AASHTO T 324	HWT ₁₅₀₀₀	Fair	1.9 < Z ≤ 2.9
				Poor	Z > 2.9
	HWT	AASHTO T 324	HWT ₁₅₀₀₀	Good/Fair	Rut depth < 10 mm
				Poor	Rut depth > 10 mm

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Task 7: Develop recommendations and guidelines for PEMD

Implementation Guidelines

Design process



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ACKNOWLEDGMENTS

- Dr. SJ Jung
- Dr. Ahmed Muftah
- Mr. Fahmid Tousif
- ITD Project Research Committee Members
- ITD District Materials Engineers
- ITD Asset Management Team

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59th Idaho Asphalt Conference

INCREASING SERVICE LIFE of HMA in WASHINGTON STATE

Joe DeVol, Asst. State Materials Engineer
October 24, 2019

Background

- How we got to where we are
 - SHRP efforts - 1995
 - Implemented PG Binders - 2000
 - Superpave Volumetric Mix Design - 2004
 - Elastic Recovery Specification - 2012

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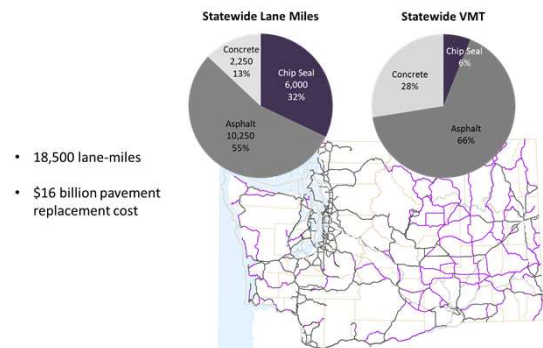
Background

- How we got to where we are
 - Hamburg and IDT Specification - 2014
 - Multiple Stress Creep Recovery - 2018*
 - Included percent recovery - T 350 (R-92)
 - * Worked with PCCAS, AI, Regional Task Group & WAPA

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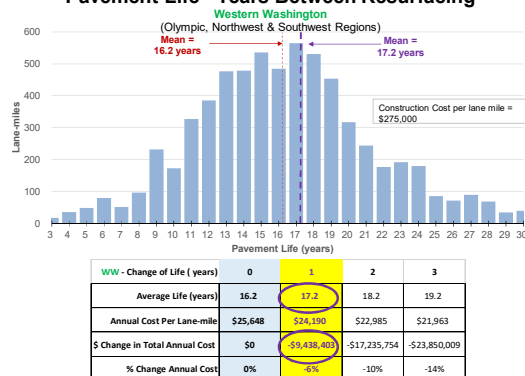
Pavement Management Perspective



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4

Pavement Life - Years Between Resurfacing



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5

2017 - Met w/Industry Open Discussion and Dialogue

WSDOT

Chris Christopher
Jon Deffenbacher
Kurt Williams
Joe DeVol
Jeff Uhlmeier
Bob Dyer

WAPA

Dave Gent, WAPA
Kenton Hill, Granite Construction
Chris Pedersen, CTL
Dave Bell, Lakeside Industries
Brad Griffith, Miles Resources

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6

Two Areas of Focus:

1) Increase Asphalt Content

2) Increase Density

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1) Increase Asphalt Content

Initial Discussions:

- Add asphalt binder to all mixes (0.3% Pb)
- Use air void regression (4.0% to 3.5% Va)
- Revise voids in mineral aggregate (VMA) requirements
- Tighten percent binder (Pb) tolerance
- Tighter gradation control

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1) Increase Asphalt Content

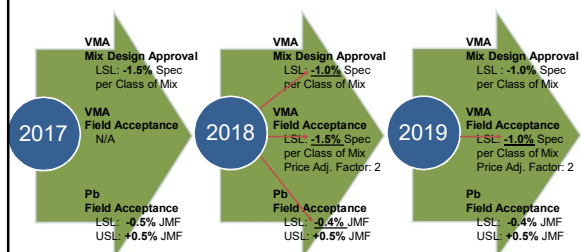
Initial Discussions:

- Add asphalt binder to all mixes (0.3% Pb)
- Use air void regression (4.0% to 3.5% Va)
- Revise voids in mineral aggregate (VMA) requirements
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- Tighter gradation control

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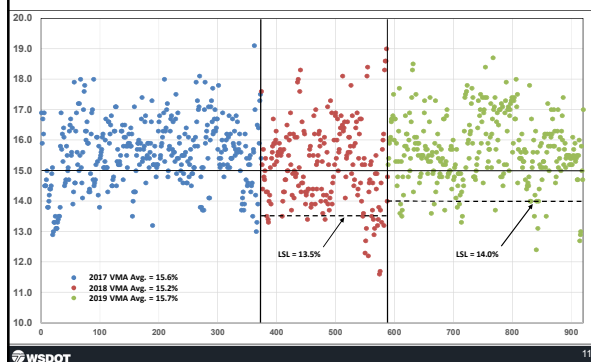
VMA & Pb SPECIFICATION REVISIONS



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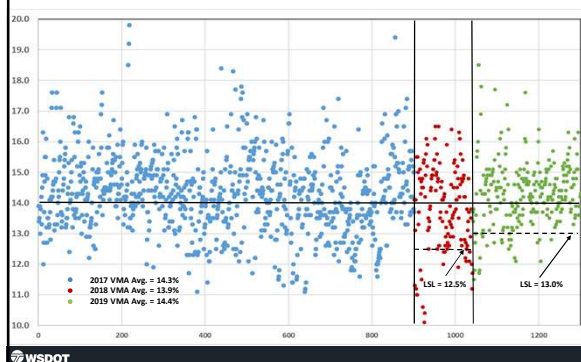
2017-2019 – 3/8 Inch VMA Production Data



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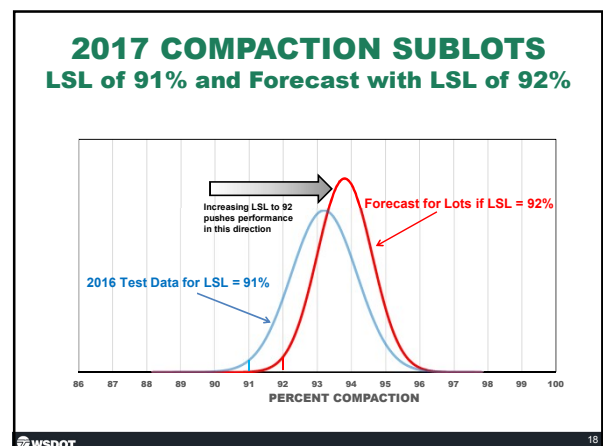
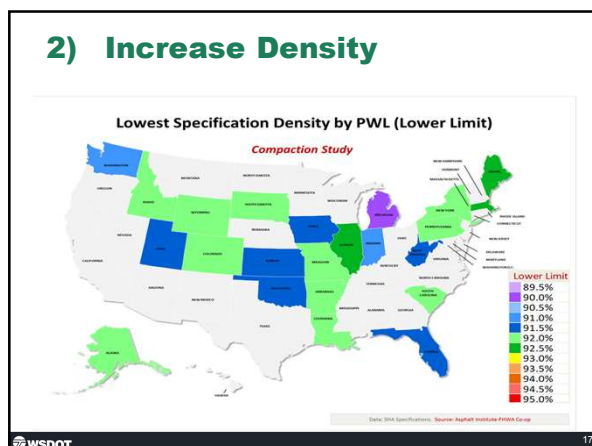
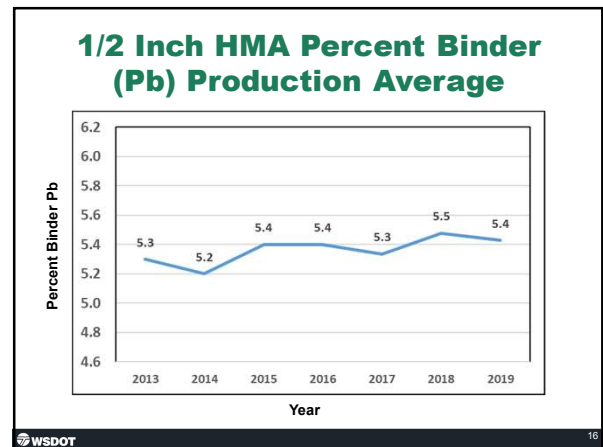
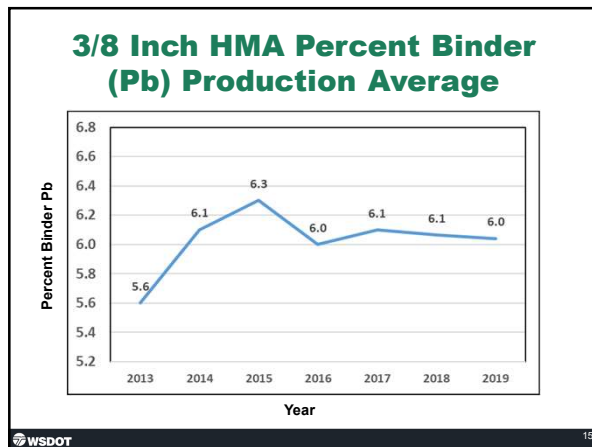
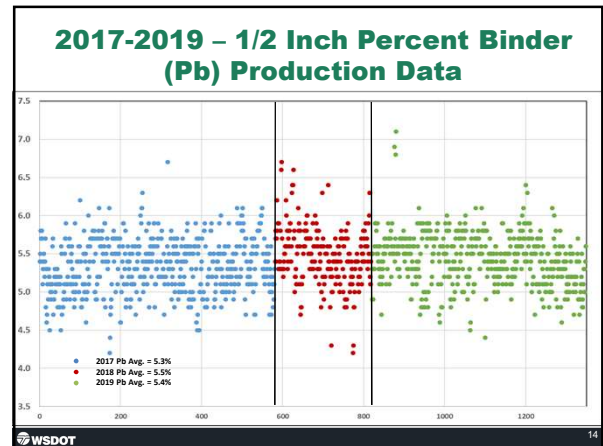
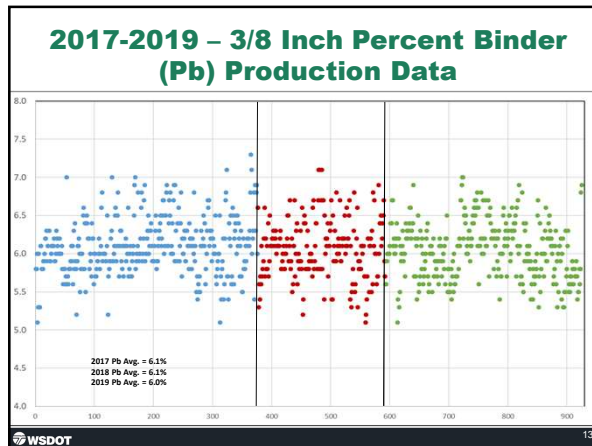
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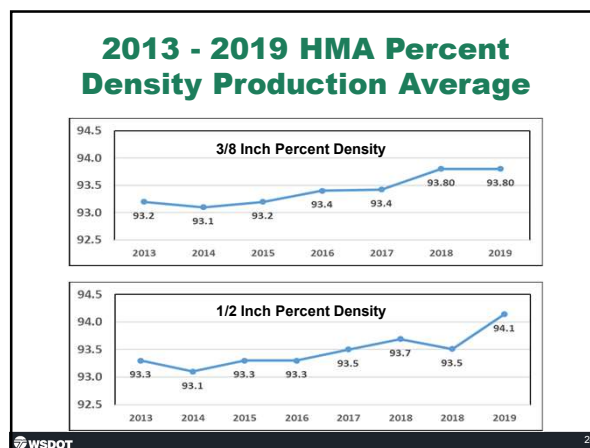
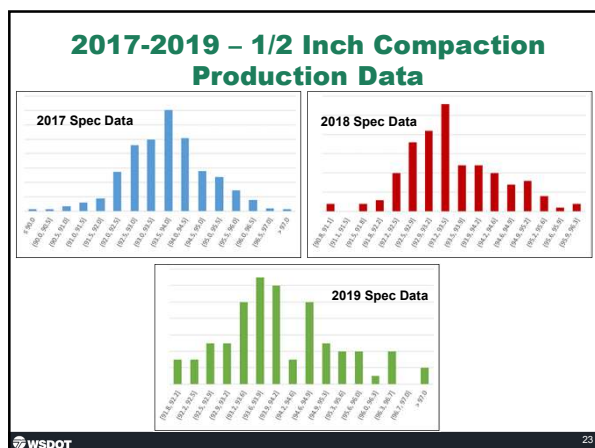
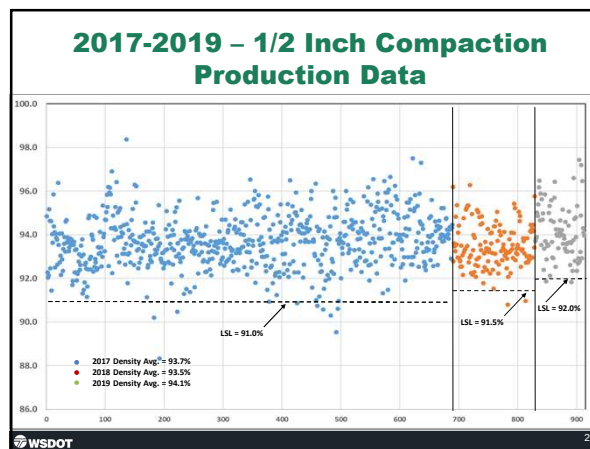
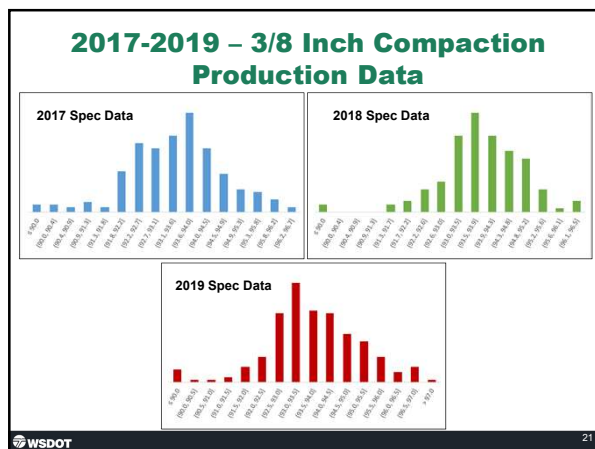
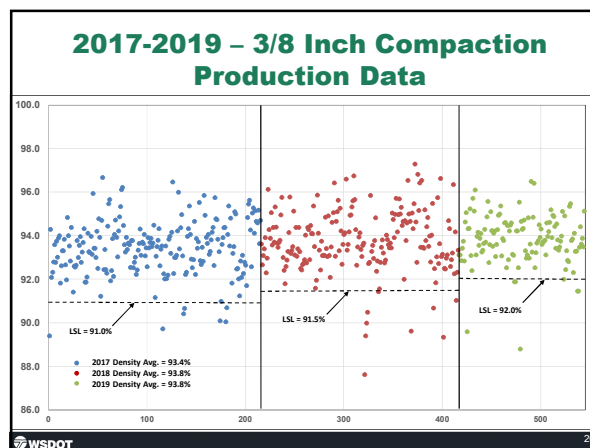
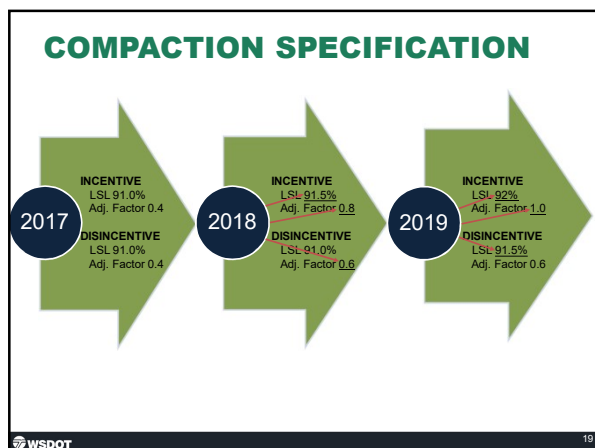
2017-2019 – 1/2 Inch VMA Production Data



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Questions?

Contact Information:
Joe DeVol
jdevol@wsdot.wa.gov
 (360) 709-5421



Other Efforts to Increase Service Life of HMA in Washington State

What We Learned?

- Hamburg – 2010
 - Asphalt and Anti-Strip Compatibility
 - Asphalt Modification – Products and Processes
 - Benefits of Polymer Modification
- *Note: Dual testing AASHTO T 315 & T 350 since 2008

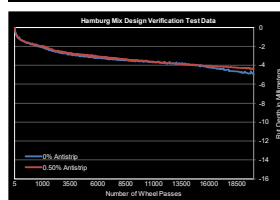
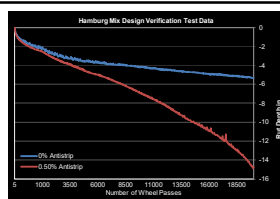
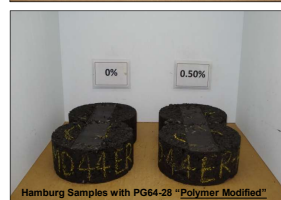


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Hamburg Wheel Track Testing



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Asphalt Binder Testing

Original Formulation

- Met Conventional PG Specs (AASHTO - M 320)
- Met MSCR Specs * (AASHTO - M 332)
- Elastic Recovery = 25% (AASHTO - T 301)

*Excluding R 92

Polymer Modified

- Met Conventional PG Specs (AASHTO - M 320)
- Met MSCR Specs ** (AASHTO - M 332)
- Elastic Recovery = 74% (AASHTO - T 301)

**Including R 92



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2018 Standard Specifications Asphalt Binder Changes

• M 320 Grading System

- PG58-22
- PG64-22
- PG70-22 (60% ER)
- PG64-28 (60% ER)
- PG70-28 (60% ER)
- PG76-28 (60% ER)

• M 332 Grading System

- PG58S-22*
- PG58H-22
- PG58V-22 (30% Rec)
- PG64S-28* (20% Rec)
- PG64H-28 (25% Rec)
- PG64V-28 (30% Rec)

* "S" Grade not used by WSDOT

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2018 Standard Specifications

9-02.1(4) Performance Graded (PG) Asphalt Binder

PG asphalt binder meeting the requirements of AASHTO M 332 Table 1 of the grades specified in the Contract shall be used in the production of HMA. For HMA with greater than 20 percent RAP by total weight of HMA or any amount of RAS the new asphalt binder, recycling agent and recovered asphalt (RAP and/or RAS) when blended in the proportions of the mix design shall meet the PG asphalt binder requirements of AASHTO M 332 Table 1 for the grade of asphalt binder specified by the Contract.

In addition to AASHTO M 332 Table 1 specification requirements, PG asphalt binders shall meet the following requirements:

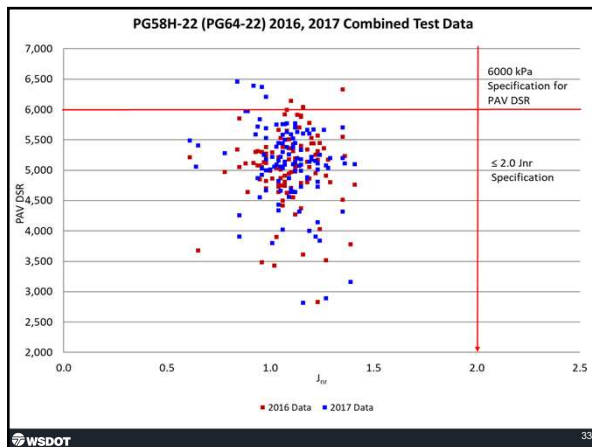
Property	Test Method	Additional Requirements by Performance Grade (PG) Asphalt Binders			
		PG58S-22	PG58H-22	PG64S-28	PG64V-28
RTFO Residue: Average Percent Recovery @ 3.2 kPa	AASHTO T 350 ¹			30% Min.	20% Min.
				25% Min.	30% Min.

¹Specimen conditioned in accordance with AASHTO T 240 – RTFO.

The RTFO JnrDiff and the PAV direct tension specifications of M 332 are not required.

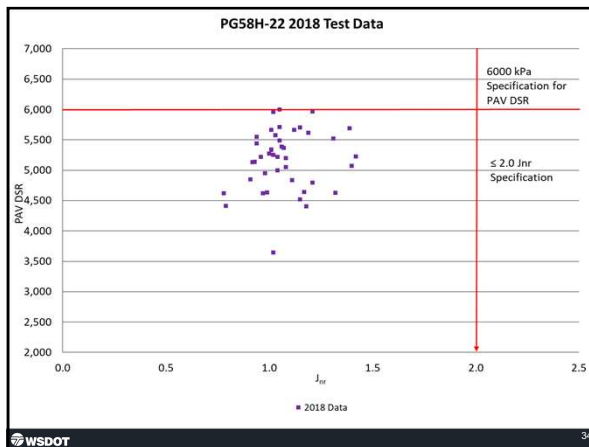
WSDOT

32



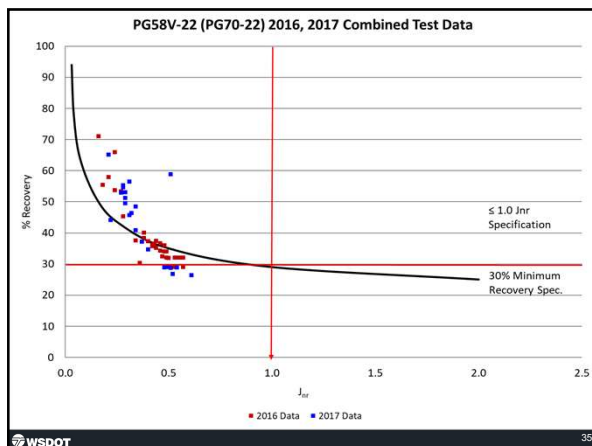
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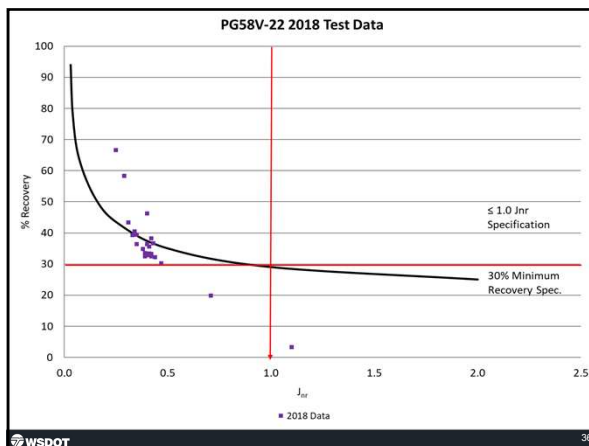
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34



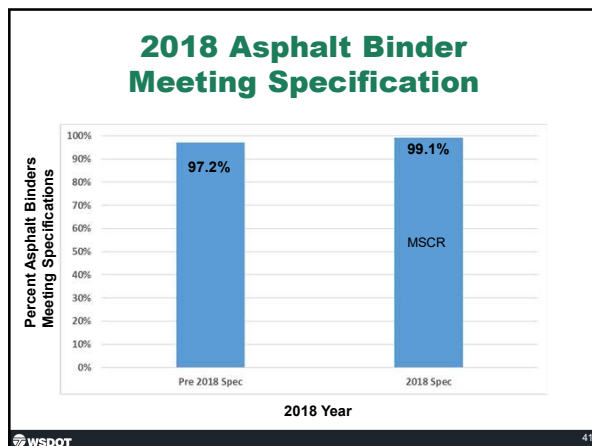
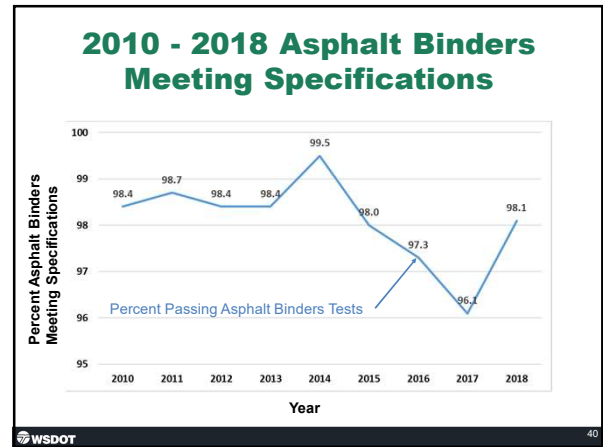
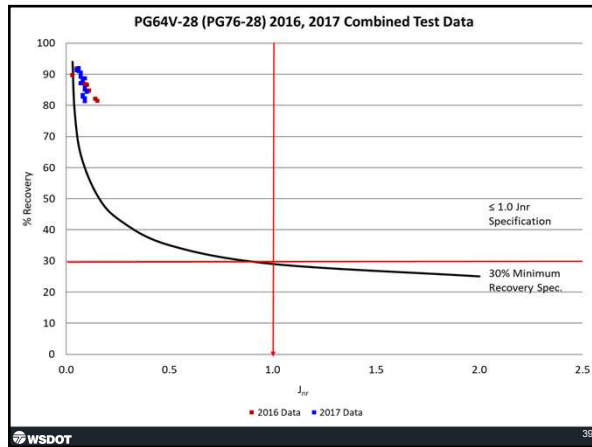
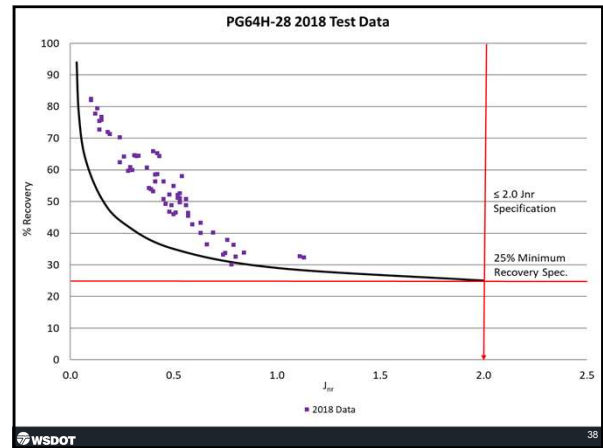
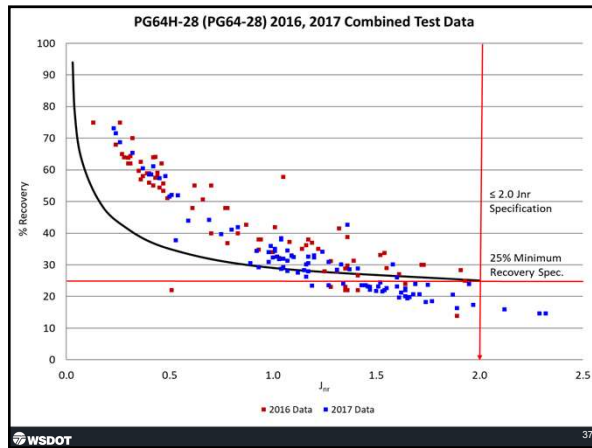
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WSDOT

36

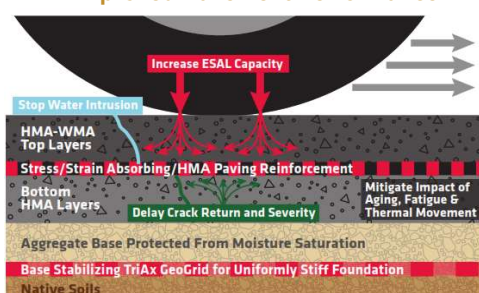


WSDOT

Questions?

Contact Information:
Joe DeVol
jdevol@wsdot.wa.gov
 (360) 709-5421

Pavement Reinforcement Products for Improved Pavement Performance



Jordan Rabin – Pacific North Engineering Rep
2019 Idaho Asphalt Conference

Tensar. THE COMPANY YOU CAN BUILD ON®

Agenda

- The Basics: What Interlayers are, and Why We Use them
- Problems that Pavement Reinforcement Products Solve / Benefits they Bring
- Independent Verification & Project Examples

Tensar. THE COMPANY YOU CAN BUILD ON®

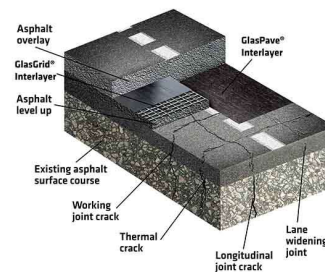
The Basics: What Interlayers are, and Why We Use them

What are Interlayers?

Any material(s) that are used between pavement layers to improve pavement performance.

Functions:

- Moisture barrier
- Reflective crack mitigation
- Reinforcement of asphalt to extend pavement life and loading capacity

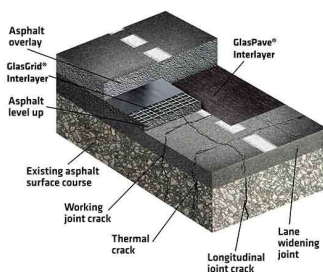


Interlayers ≠ Pavement Reinforcement Products

Any material(s) that are used between pavement layers to improve pavement performance.

Functions:

- moisture barrier
- Reflective crack mitigation
- reinforcement of asphalt to extend pavement life and loading capacity



Why are Interlayers Used?

- To reduce maintenance cost and frequency
- To keep up with increased traffic loading
- Some areas just need a little help

To get more life out of your pavement, at a lower cost, over the course of its life

Tensar. THE COMPANY YOU CAN BUILD ON®

Building Longer Life, **More Maintenance Free HMA Pavements, that Cost Less**

OR JUST KEEP MAINTAINING!

Building Longer Life, **More Maintenance Free HMA Pavements, that Cost Less**

OR NOT!

When Aren't Interlayers be Enough?

Tensar. THE COMPANY YOU CAN BUILD ON®

What Can be Done Instead?

Tensar. THE COMPANY YOU CAN BUILD ON®

STRUCTURAL – Base Issue CORRECTION

Trench Cut- Dig Out Repairs

TriAx Geogrid & Rapid Repair GlasGrid 100 Trench Detail Alternatives

Problems that Pavement Reinforcement Products Solve / Benefits they Bring

Benefits Of Pavement Reinforcement Products

- Reinforcement
- Mitigate Reflective Cracking
- Moisture Barrier
- Sustainability

REINFORCEMENT CRACK RELIEF MOISTURE BARRIER

rensal YOU CAN BUILD ON®

Reinforcement Matters

1. Structural Reinforcement

Continuous high tensile, pre-coated high temp. with elastomeric polymer, fiberglass is to asphalt as steel rebar is to concrete

Steel Reinforcing Bar (rebar)

Fiberglass has a modulus advantage over the asphalt and is not water/temperature sensitive

REINFORCEMENT MATTERS!

No Reinforcement	Reinforced with GlasGrid TF
Run Time 0h 51m	Run Time 5h 30m

Over 6.5 Times Longer

Maximum Load Distribution

Load distribution is one of the primary functions of a pavement

Conventional Pavement Load Distribution Curves

Maximum Load Distribution

Load distribution is one of the primary functions of a pavement

More Cost Effective and Higher Performing HMA Pavements
Most Efficient Pavement Load Distribution Curves

Rehabilitation

New or Reconstruct

Equivalent LOAD Design with Reinforcement

AASHTO Design to Increase Load Capacity

Reinforced Option

2" HMA W/Course
GlasGrid Reinforcing Rebar
Levelling Course &
Existing Pavement

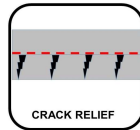
Thicker Equivalent Option

4"

1. HMA section must be critical layer
2. Must be placed in the tension zone of the pavement

Slowing Crack Deterioration

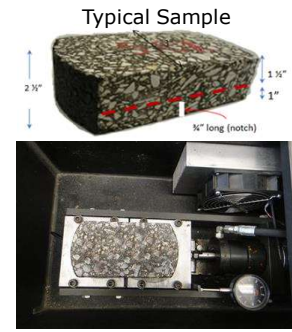
2. Crack Relief



High tensile rebar-type reinforcing
+
Low tensile HMA =
Crack Resistant Pavements

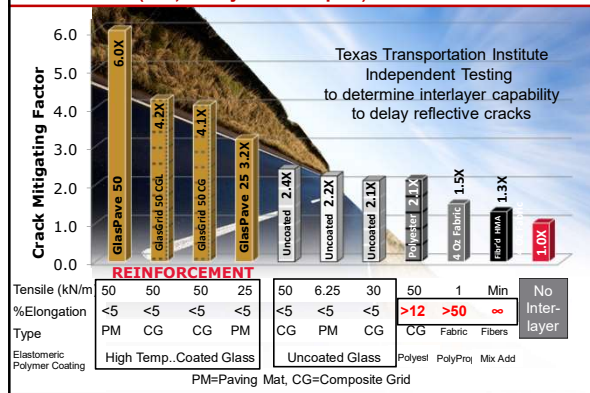
Slowing Crack Deterioration

Texas Transportation Institute Overlay Tester



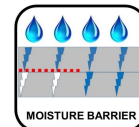
Pavements Ability to Resist Cracks

ALL Pavements (New, Overlay or Patch Repairs) Should Include reinforcement



Slowing Impact of Moisture

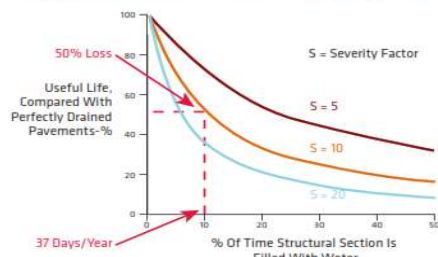
3. Moisture Barrier



Preserve the traffic bearing
capacity of a dry Foundation:
Moisture barrier protects base from top
down moisture intrusion into the base

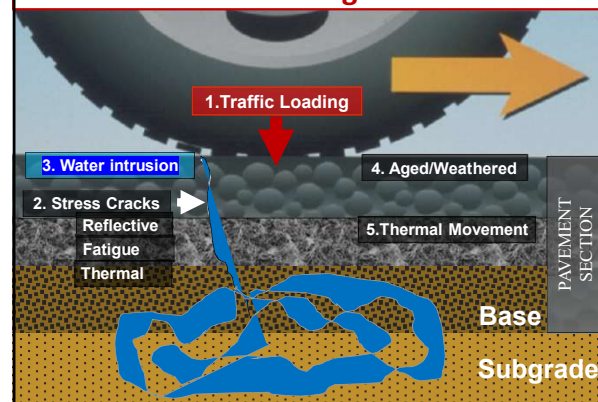
Water in Foundation Deterioration

Deteriorating Impact of Moisture Intrusion



Graphic 8. The Cedergren study shows that a pavement with base saturated as little as 10% of the time (37 days in a year) will lose 50% of its useful life!

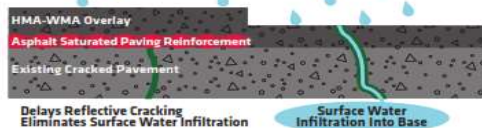
Deteriorating Effect



Mitigate Moisture Intrusion

Interlayer Creates Moisture Barrier

Seals Cracks To Keep Water Out of Base
Preserves Load Bearing Capacity



Graphic 9. Shows how an interlayer creates a moisture barrier to stop top down moisture intrusion

Sustainability

Plus
Sustainable
practices



**Must be completely Millable PLUS
must be Recyclable back into a
new HMA up to 30% with no
detriment to that mix**

Ability to Mill, Recycle + Add to New HMA

New HMA with up to 30% RAP containing milled GlasPave will pass AASHTO testing T283-07 for rutting and moisture susceptibility + T322-07 low temp cracking



Figure 2 Control RAP mixture (left) and RAP mixture containing GlasPave (right).



The Effect of GlasPave™ in RAP on Asphalt Mixture Performance

RESEARCH SYNOPSIS-NCAT REPORT

Rebar Type Reinforcement for HMA

Key Points

Design and Construct HMA Pavements that:

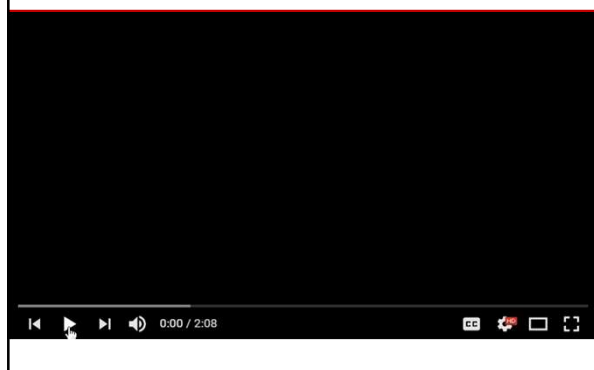
1. have 2X load capacity (ESALs)
2. delayed crack return 3, 6 or 9X longer
3. preserved base structure by keeping top down water out of the base

Plus be completely millable and recyclable

High temperature pre-coated, high tensile, continuous fiberglass rebar type reinforcement in HMA can!

How Flexible Pavements Fail

Source: MODOT youtube site



Independent Verification & Project Examples

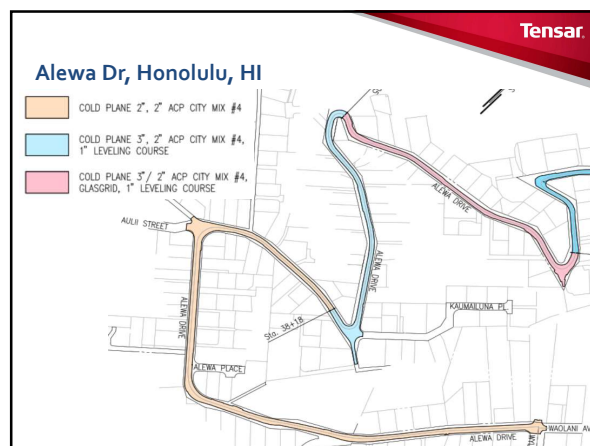


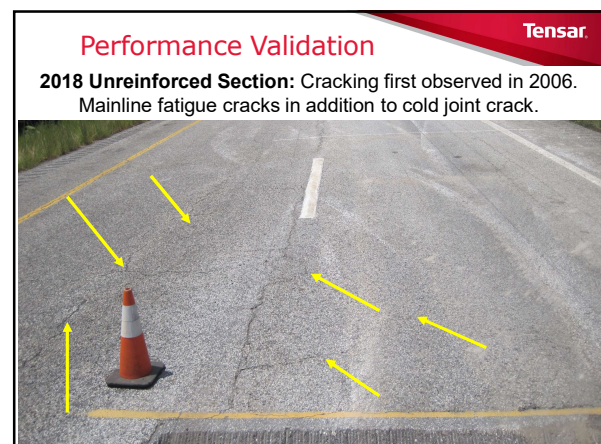
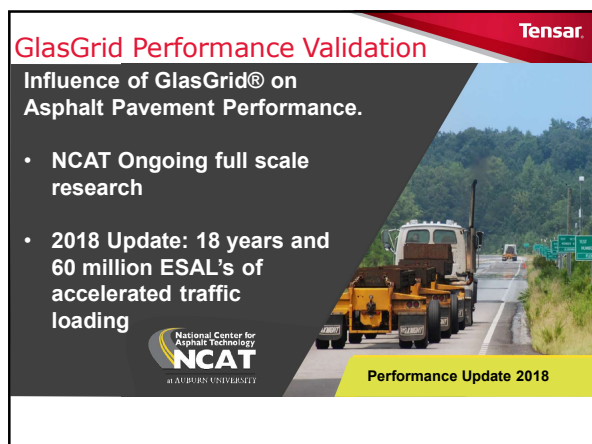
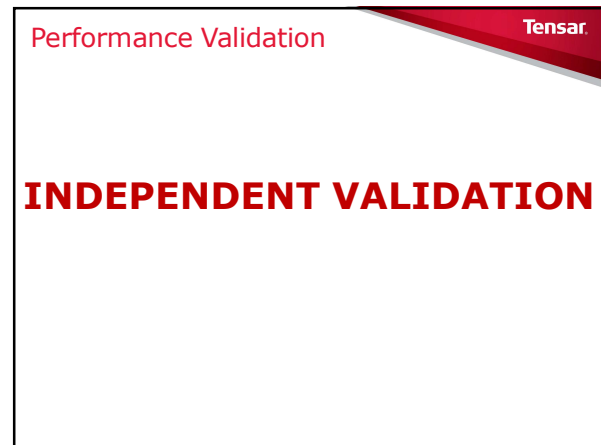
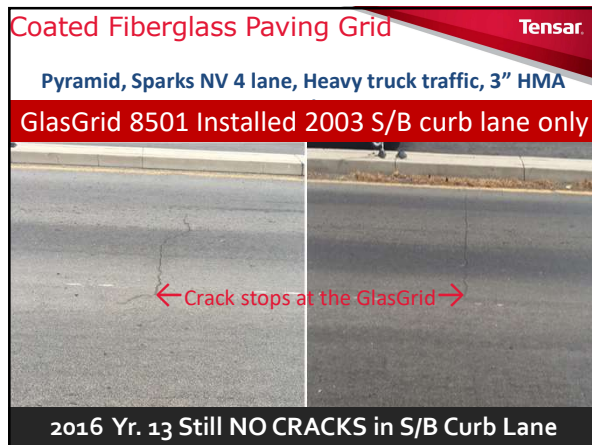
Coated Fiberglass Paving Grid Tensar

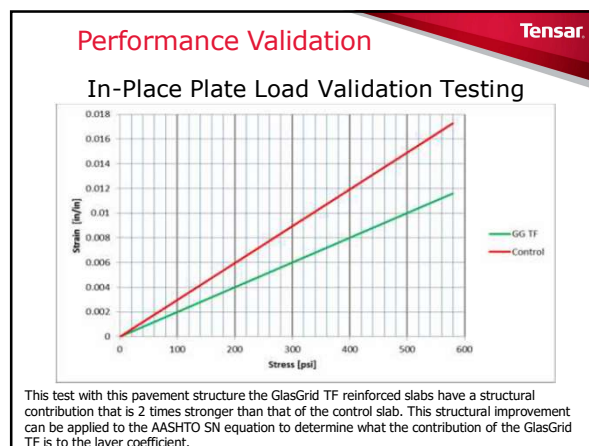
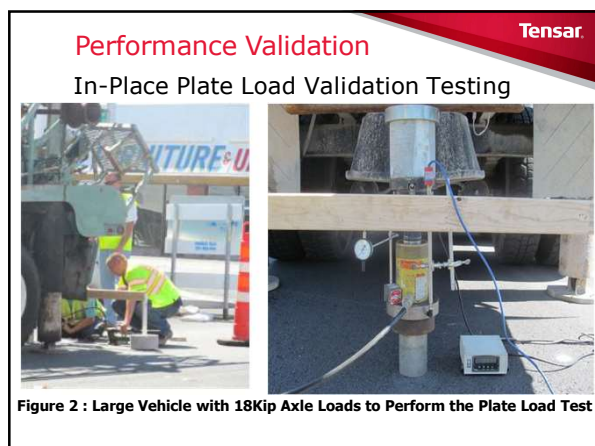
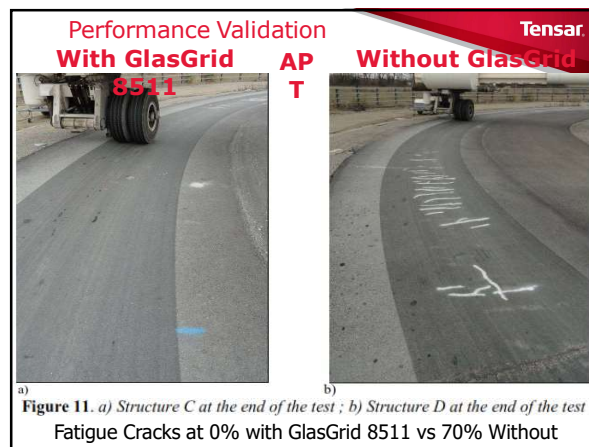
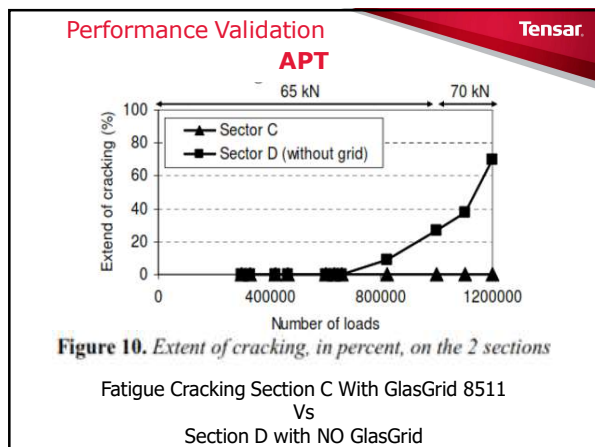
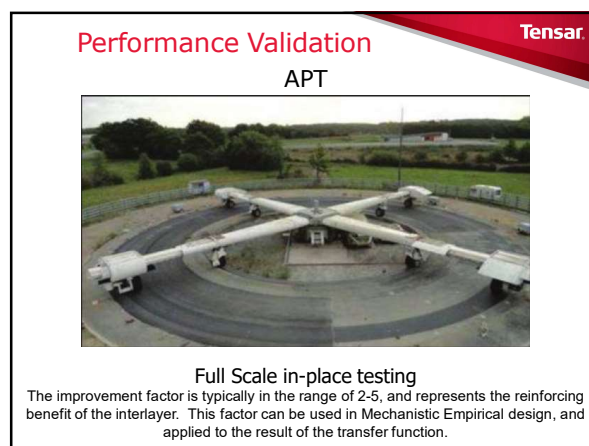
Project Name:
Rehabilitation of Alewa Drive, Unit 49

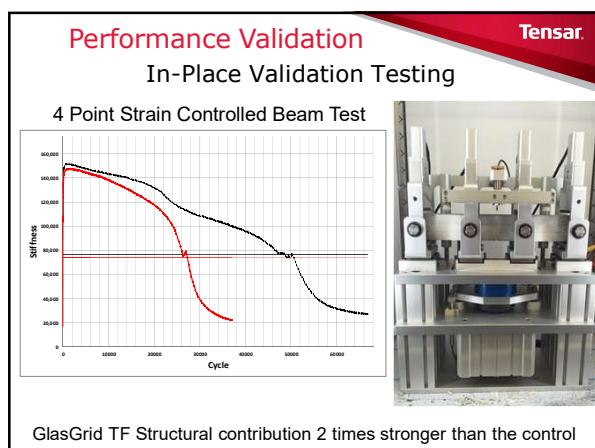
Pavement Condition Assessment (After 12 Years)
In 2007, the City and County of Honolulu rehabilitated the streets on Alewa Drive, Unit 49. Various rehabilitation strategies were installed based on the condition of the streets.

After 12 years of trafficking, the following pictures compare the performance of the reinforced asphalt sections underlain by Tensar GlasGrid compared to asphalt sections without GlasGrid. The asphalt reinforced with GlasGrid is currently providing a superior performance (i.e. less cracks on the surface and improved International Roughness Index) compared to asphalt sections without GlasGrid.









PROVEN ReBar Type HMA Reinforcement

VALIDATED HIGH TENSILE STRENGTH, ELASTOMERIC POLYMER COATED PAVING REINFORCEMENTS

TYPE:	PG or GlasPave 25	GlasPave 50	PG or GlasGrid 100	GlasGrid 100TF
TENSILE:	25kN/140Lb	50kN/280Lb	100kN/560Lb	100kN/560Lb
ELONGATION	< 5%	< 5%	< 3%	< 3%

Proper High Temperature Coated, High Tensile, Low Elongating, Continuous Rebar type Reinforcement will:

- Reinforce to add **LOAD Capacity**
- Delay cracks and their severity
- Waterproof to preserve base

Cost by HMA Reinforcement Type

VALIDATED HIGH TENSILE STRENGTH, ELASTOMERIC POLYMER COATED PAVING REINFORCEMENTS

TYPE:	PG or GlasPave 25	GlasPave 50	PG or GlasGrid 100	GlasGrid 100TF
TENSILE:	25kN/140Lb	50kN/280Lb	100kN/560Lb	100kN/560Lb
ELONGATION	< 5%	< 5%	< 3%	< 3%
Crack Delay	3X	6X	9X	9X
Equiv HMA In.	1+0.5"	1+1"	2"+	2"+
Waterproof	YES	YES	—	—

Take Away:

With Increased ESAL capacity, Delayed Cracks and a Dry Foundation we can:

1. More rapidly improve network PCI
2. Reduce maintenance cost and intervals
3. Less downtime, work zones, liability
4. Better Ride, Better looks, longer

Let us Help You Design & Build More Maintenance free Pavement Structures that Last Longer and Cost Less

Design Services:

HMA Pavement ESAL Increase Worksheet

Project Title: _____ Date: _____

Project Location: _____

Layer	Material	Thickness (inches)	Modulus (ksi)	SN
Asphalt	HMA Overlay	_____	_____	_____
Base	PCC-Other Concrete or Treated Base	_____	_____	_____
Subgrade	Subgrade	_____	_____	_____

ADDITIONAL EXISTING INFORMATION

DESIGNED OUTCOMES

NOTES

Send to: Tensar | Dennis Rogers | Phone: 703.558.3408 | Email: dgr@tensarcorp.com

2. End of Service life ESAL: Existing Section

Parameter	Value	Notes
Zr	85.00	Reliability
So	-1.037	Std. Normal deviate
ΔPSI	0.45	Overall Std. deviation
CBR	0.01	Design serviceability loss
M _s	3.1	Subgrade
Initial	4600	
Terminal	2.01	Serviceability

Layer	thick (in.)	ai	mi	SN _{layer}
AC1	4	0.22		0.88
AC2	0	0.22		0.00
AC3	0	0.22		0.00
ABC	12	0.11	1	1.26
ABC	0	0.11	1	0.00
SBC	0	0.08	1	0.00
SBC	0	0.06	1	0.00
Total	16			2.14
4,697	ESALS		TI=	4.76

Sample of Inputs for: AASHTO 93 Design

REHAB: Unreinforced HMA					
Mill Thickness	5.5				
Layer Thickness	Inch	ai	mi	SN	
New HMA	5.5	0.44		2.42	
ABC	10.5	0.11	1	1.10	
Total	16			3.52	
	614,698	ESAL	TI=	8.49	

REHAB 1: HMA, GlasGrid HMA REINFORCEMENT+HMA					
Mill Thickness	5.5				
Layer Thickness	Inch	ai	mi	SN	
HMA+GGTF	4	0.66		2.64	
LvLup HMA	1.5	0.44		0.66	
ABC	10.5	0.11	1	1.16	
Total	16			4.46	
	2,901,926	ESAL	TI=	10.22	

REHAB 2: New HMA+ GlasPave50 # HMA Reinforcement					
Milling Thickness	6.6				
Layer	Inch	ai	mi	SN	
HMA+GP50	4	0.57		2.28	
HMA	2.6	0.44		1.13	
Existing HMA	0	0.22		0	
ABC	9.5	0.105	1	1.00	
Total	16			4.46	
	2,908,550	ESALS	TI=	10.22	

**Sample
AASHTO
Design:**

Sample Design Results:				
Performance Comparison				
	Existing	GGTF Reinforced	GP Reinforced	Unreinforced
Structural Number	2.14	4.40	4.40	4.41
ESAL's	4,697	2,901,926	2,908,550	2,938,770
TI	4.76	10.22	10.22	10.23
Improvement Factor vs No Reinforcement (Traffic Benefit Ratio):		4.7	2.5	--
Added inches of HMA needed to Achieve Same Performance:		2.7	0.0	2.7
Added Crack Delay compared to no Reinforcement		9X	6X	Min.
Waterproof membrane to keep base dry		NO	Waterproof	NO
RAP containing GG/GP can be added back into a new mix up to 30%		YES	YES	
Cost Benefit Analysis				
Installed Cost of added Paving Reinforcement (per SY):		\$15.00	\$12.00	--
Cost of HMA Installed (per SY):		\$45.82	\$54.64	\$67.89
Total Cost Installed (SY)		\$60.82	\$66.64	\$67.89
Percent Cost Savings vs Equivalent Asphalt		-12%	-2%	

QUESTIONS?

Thank You

Jordan Rabin
Engineering Rep for Pacific North – ID, OR, WA
Jrabin@Tensarcorp.com
206-518-2318

Tensar.

INSTALLATION

Tensar.

Placing HMA Reinforcement

GlasGrid TF Installation

Tensar.



GlasGrid GlasPave Installation

Tensar.





Recycled Asphalt Pavement used in Pavement Maintenance

Doug Olsen
Idaho/Peak/Western

Rod Thompson
Tooele County

What We Know

- ❑ Asphalt has always been Recyclable
- ❑ Valuable material in Hot Mix Asphalt
- ❑ Used when and where feasible



RAP -typical usages – non HMA

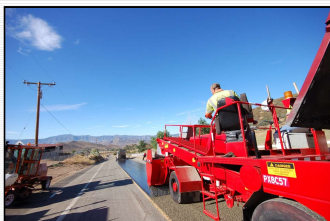
- ❑ RAP Base
- ❑ Shoulder Backing
- ❑ CIR
- ❑ Road Bed Stabilization
- ❑ Hot in place recycle
- ❑ On site Cold Mix

RAP History Pavement Maintenance



Pavement Maintenance Products

Chip Seals



Pavement Maintenance Products

Slurry Seal and Micro Surfacing



RAP – Caution !!!!!

- Not all HMA aggregates are good for PM
- History on Binder would be good homework



RAP Chip and RAP Slurry Aggregates Produced Simultaneously



Common Pavement Maintenance Aggregate Testing

- LA Abrasion
- Sodium Soundness
- Specific Gravity
- SE
- Fines Durability
- Gradation
- Absorption



RAP Slurry Material Consistent Residual Asphalt



Slurry Dust

Very few conglomerations
Residual asphalt remains very consistent

Mixing RAP aggregates



- Residue AC affects mix design
- Need emulsion
- % of blend with virgin Aggregates

RAP Slurry Seal

Component	RAP Slurry Seal	ISSA Type II
	Amount	Amount
Emulsion	10% - 14%	12% - 18%
Residual AC	12.5% Min.	7.5% - 13.5%

Minimum
12.5% Residual @
10% Emulsion

Minimum
7.5% Residual @
12% Emulsion

RAP Utilization example

Crushing Utilization

- Chip Seal 48%
- Slurry Dust 40%
- 12% waste



RAP Chip Material

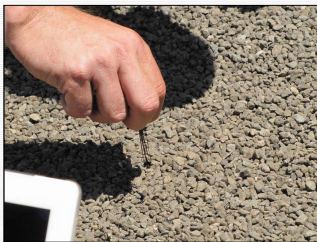
Residual Asphalt



Chips

Single stones and conglomerations
Residual asphalt content will vary by sample

3/8" Chips



Some RAP crushing operations can create excess dust, which will contain asphalt residue

RAP Chips are lighter

Adjust for the lighter material

Typical

5/16 chip - 14 to 20 lbs per SY

3/8 chip - 20 to 24 lbs per SY

1/2 chip - 24 to 30 lbs per SY



Tests on Emulsion Compatibility

- ✓ Penetration
- ✓ Ductility
- ✓ Elastic Recovery
- ✓ Stripping
- ✓ Sweep Test - cohesion

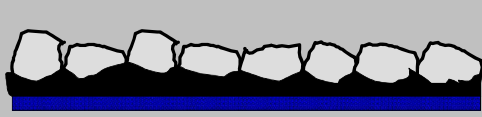


RAP Management - Embedment

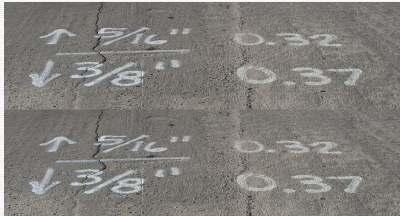
Multiple Sizes



Single Size



Spreading Emulsion



Determine proper application rate for road surface and traffic conditions and climatic conditions

RAP Chip Seal

RAP chip seals will have lower absorption rates

Slower Cohesion

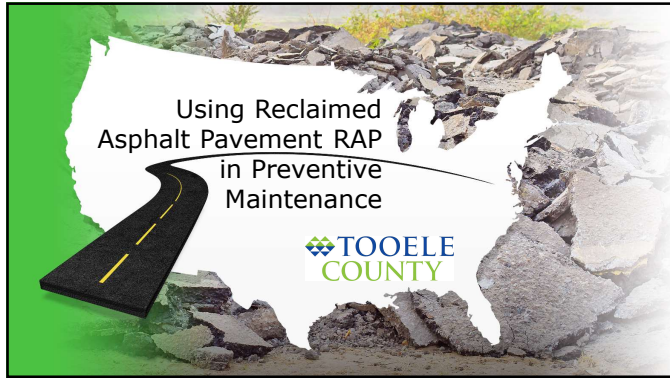


Scrub Seals



Remember

- ☐ Not all RAP is created equal
- ☐ Do your homework
- ☐ Utilize RAP management
- ☐ RAP material will have lower Absorption Rates
- ☐ RAP material is lighter than Virgin Aggregate
- ☐ Step out slow – consider your climate



Reclaimed Asphalt Pavement Past Projects



- Cold Central Plant Mix
- Cold In-place
- Hot In-place
- Shouldering
- Base Course
- Full Depth Reclamation
- Scrub Seal
- RAP Chip Seal

Abundance of RAP Spurs New Uses in Preservation Treatments

By Erik Updyke and Dennis Ruh

Despite recent increases in allowable reclaimed asphalt pavement (RAP) content in hot-mix asphalt concrete, both in the California Standard Specifications and in the Standard Specifications for Public Works Construction ("Greenbook"), a surplus of RAP continues to exist in most urban areas of Southern California. New and innovative uses for RAP in slurry seals, micro surfacing, and chip seals will help consume some of this surplus, as well as

reduce the demand for virgin aggregate. These uses are becoming increasingly common among Southern California agencies. RAP aggregate is produced by crushing and screening RAP to the gradation required for the specific seal coat application. After processing, RAP aggregate will typically have a residual asphalt content of between 5 and 8 percent, a specific gravity of approximately 2.4, and an absorption rate of approximately

1.5 percent, based on testing performed by Los Angeles County.

MAKING RAP CHIPS
The use of RAP aggregate (RAP) chips in chip seals has the longest history. Los Angeles County first used RAP chips in a seal coat on a half-mile section of Avenue J in the unincorporated area of Lake Los Angeles area in February 2008. Since then, RAP chips have been used in numerous chip seals. For chip seals placed under a

Chip Seal Cover Material Properties



- Stripping
- Polishing
- Soundness
- LA abrasion
- Fracture Faces
- Flakiness Index

Emulsion Classifications

IONIC CHARGE Formulated for compatibility with specific aggregates and components	C CATIONIC	ANIONIC	NONIONIC
AGGREGATE COATING THICKNESS Utilizes a chemical formulation that promotes a gel quality to the emulsion, increasing performance	HF HIGH FLOAT	NOT HIGH FLOAT	
SPEED AT WHICH EMULSIONS ARE SET Engineered for optimal break time and workability	RS RAPID SET	MS MEDIUM SET	SS SLOW SET
VISCOSITY & HARDNESS To accommodate specific application methods and climates	1 LOWEST VISCOSITY	2 LOW VISCOSITY	H HIGHER VISC.
POLYMERS & ADDITIVES To achieve strength, adhesion, elasticity, durability or other performance demands	P POLYMER	L LATEX POLYMER	S POLYMER





**In Conclusion
Why Use RAP
Chips**

- Cost
- Availability
- Performance
- Environmental
- Aesthetics





Using Reclaimed Asphalt
Pavement RAP in Preventive
Maintenance

**TOOELE
COUNTY**

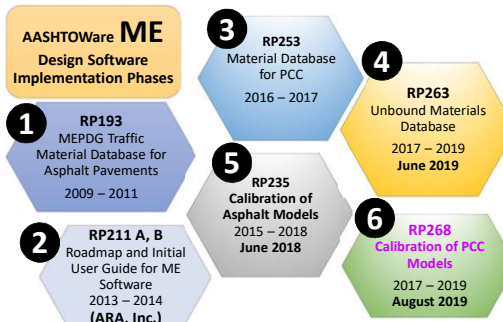
59th Idaho Asphalt Conference, 2019

Implementation and Calibration of AASHTOWare Pavement ME Design for Idaho

Fouad Bayomy
University of Idaho

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ITD – UI Projects to Implement AASHTOWare Pavement ME Design



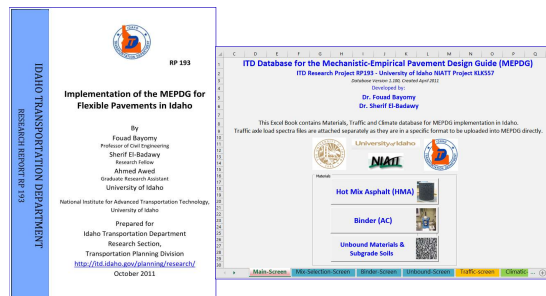
Acknowledgements

RP193, 235, 253, 263, 268 Contributors

- **UI Team (RP193, 253, 263, 235 and 268)**
 - Fouad Bayomy (PI)
 - Emad Kassem (Co-PI)
 - Ahmed Muflih (Post-Doc)
 - Sherif El-Badawy (Co-PI)
 - Ahmed Ibrahim (Co-PI)
 - Christopher Williams (Statistics Consultant)
 - Mumtaz Hasnat (Grad Student)
 - Ahmed Awad (Grad Student)
 - Robin Choudhry (Grad Student)
 - Linda Pierce (External Reviewer)
- **WSU Team (RP253)**
 - Somayeh Nassiri (Co-PI)
 - Milena Rangelov (Grad Student)
- **BSU Team (RP263)**
 - Deb Mishra (Co-PI)
 - Md Jibon (Grad Student)
- **ARA**
 - RP 211 (A, B)
 - Workshops
 - Dec 2012
 - Apr 2018
 - July 2019
- **ITD-TAC's**
 - Mike Santi
 - John Bilderback
 - John Arambarri
 - Dave Richards
 - Chad Clawson
 - Clint Hoops
 - James Poorbaugh
 - Mark Wheeler
 - Ned Parrish (Res. Mgr.)
- **FHWA**
 - Kyle Holman, ITD Office

RP 193

ITD_ME Material and Traffic Database



Binder Characterization

- **Levels 1 and 2: G^* and δ at 10 rad/sec (RTFO)**
- **Level 3: choose binder grade**



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E* for Idaho Superpave Mixes



GS Determination from Servopac
Gyrotory Compactor data



E* Testing using AMPT Machine

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IDT and Creep Compliance

- IDT and Creep Compliance data is necessary for the calibration of the Thermal cracking model.
- A total of 18 mixes were tested for CC and IDT. This was added as a separate task during RP235
- Database was updated in 2017 to include these results

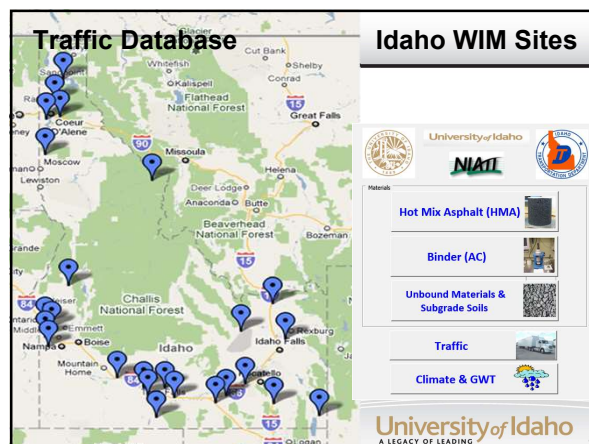


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RP 211 A, B

Road Map and User Guide

<http://itd.idaho.gov/alt-programs/?target=research-program>

IDaho TRANSPORTATION DEPARTMENT
RESEARCH REPORT



RP 211A

Road Map for Implementing
The AASHTO Pavement ME Design
Software for the
Idaho Transportation Department

By
Jagannath Mallik, Leslie Tims-Glover
Bryan Blumhagen, Michael Dene
and
Harold Van Quisen
Applied Research Associates, Inc.

Prepared for
Idaho Transportation Department
Research Program
Division of Highways, Resource Center
<http://itd.idaho.gov/alt-programs/research-program>



RP 211B

Idaho AASHTOware Pavement
ME Design User's Guide,
Version 1.1

By
Jagannath Mallik, Leslie Tims-Glover
Bryan Blumhagen, Michael Dene
and
Harold Van Quisen
Applied Research Associates, Inc.

Prepared for
Idaho Transportation Department
Research Program
Division of Highways, Resource Center
<http://itd.idaho.gov/alt-programs/research-program>

March 2014

IDaho TRANSPORTATION DEPARTMENT
RESEARCH REPORT

RP 253

PCC Materials Database

<http://itd.idaho.gov/alt-programs/?target=research-program>



10

Modulus of elasticity & Compressive strength

- ASTM C39 ASTM C469
- 6 by 12-in cylinders, gypsum capped
- Loading rate: 35 psi/min
- 7-, 14-, 28-, 90-day tests



Mechanical tests- split tensile & Modulus of rupture

- ASTM C496
- 6 by 12-in cylinders
- Three cylinders from one batch for each test day
- 7-, 14-, 28-, 90-day tests
- ASTM C293
- 6 x 6 x 20-in beams
- Three beams from one batch for each test day
- 7-, 14-, 28-, 90-day tests

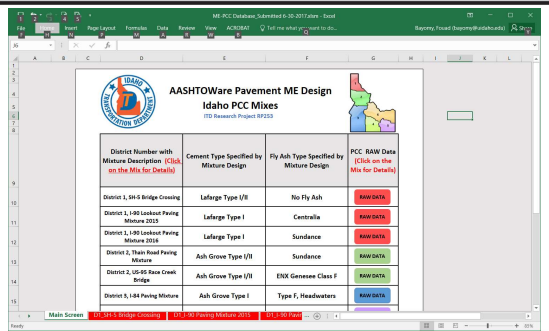


Coefficient of thermal expansion & Drying shrinkage

- AASHTO T 336-15
- Two 4 by 8-in cylinders
- Length change to uniform temp cycling (condition at 50°F, raise to 122°F, cool down to 50°F, repeat)
- FHWA Calibration specimen tested
- ASTM C157
- 2 x 2 x 12-in prisms
- Length change due to drying shrinkage
- Moist cure until 28 days then air cure
- Length measurements 4, 7, 14, 28 days & 8, 16, 32 and 64 weeks of air curing




PCC Material Database



District Number with Mixture Description (Click on the Mix for Details)	Cement Type Specified by Mixture Design	Fly Ash Type Specified by Mixture Design	PCC - RAW Data (Click on the Mix for Details)
District 1, SH-5 Bridge Crossing	Lafarge Type I/II	No Fly Ash	RAW DATA
District 1, I-90 Loopback Paving Mixture 2015	Lafarge Type I	Centralite	RAW DATA
District 1, I-90 Loopback Paving Mixture 2016	Lafarge Type I	Sundance	RAW DATA
District 2, Train Road Paving Mixture	Ash Grove Type I/II	Sundance	RAW DATA
District 2, I-84-Road Cross Bridge	Ash Grove Type I/II	ENX Genesee Class F	RAW DATA
District 3, I-84 Paving Mixture	Ash Grove Type I	Type F, Headwaters	RAW DATA

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ITD_ME Database V2.3

https://www.webpages.uidaho.edu/bayomy/ITD_ME-Database.htm



ITD Database for the AASHTOware Pavement ME Design (PMED)
ITD Research Projects RP193 - RP235 - RP253
Database Version 2.30, Updated May 2019

This Database was developed under series of projects. For info, [Click here](#)

This Excel Book contains Materials, Traffic and Climate database for PMED implementation in Idaho. Traffic axle load spectra files are attached separately as they are in a specific format to be uploaded into PMED directly.

For the Local Calibration Factors Using ME Software V2.5.3 [Click here](#)

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RP 263

Mr for Soils and Unbound Materials

Final Report

Project: Unbound Materials Characterization for Pavement ME Implementation in Idaho

By
Debakanta (Deb) Mishra, Ph.D., P.E. Associate Professor
Md. Jibon, Graduate Research Assistant
Department of Civil Engineering
Boise State University

Emad Kassem, Ph.D., P.E., Associate Professor
Fouad Bayomy, Ph.D., PE, Professor
S M Robibur Mohsin Chowdhury, Graduate Research Assistant
Department of Civil and Environmental Engineering
University of Idaho

Prepared for
Idaho Transportation Department
Research Program, Contracting Services
Division of Engineering Services
<http://itd.idaho.gov/highways/research/>

July 2019

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RESEARCH REPORT

M_R TEST (Univ of Idaho)

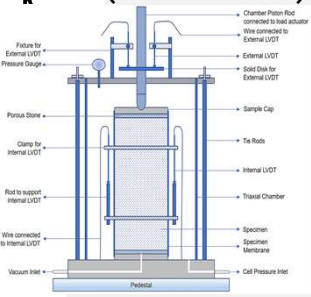
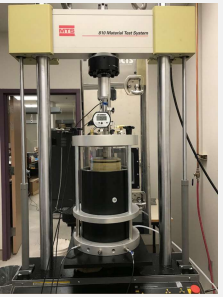



Diagram labels:

- Pressure Transducer connected to load actuator
- Wire connected to External LVDT
- External LVDT
- Solid Disk for External LVDT
- Sample Cap
- Tie Rods
- Internal LVDT
- Triaxial Chamber
- Specimen
- Specimen Manometer
- Cell Pressure Port
- Port for External LVDT
- Wire connected to Pressure Gauge
- Port for Internal LVDT
- Clamp for Internal LVDT
- Rod to support Internal LVDT
- Wire connected to Internal LVDT
- Vacuum Valve
- Port for

M_R TEST

Material ID	MEPDG Model			
	K ₁	K ₂	K ₃	R ²
A	935.207	0.711	-0.075	0.996
B	997.734	0.685	-0.073	0.994
BK-100	849.231	0.717	-0.081	0.994
BK-181	561.249	0.621	0.453	0.993
BK-2	1367.016	0.666	-0.151	0.998
CS-184	748.290	0.643	0.006	0.997
FL-132	819.292	0.755	-0.098	0.994
IMC-140	821.516	0.687	-0.016	0.995
KT-215	699.299	0.664	0.282	0.974
LE-100	974.164	0.648	0.046	0.997
LN-80	895.024	0.675	0.019	0.988
NP-82	944.597	0.706	-0.087	0.997
PW-84	463.894	0.432	0.916	0.980
YU-61	812.296	0.664	0.208	0.988
WCW	864.330	0.666	-0.012	0.999
CN-148 SB	1067.651	0.673	-0.157	0.995
CS-394 SB	388.543	0.152	1.244	0.981
PY-720 SB	1008.901	0.657	-0.142	0.997

MEPDG Model parameters for constitutive models for base/subbase materials

M_R TEST

Material ID	0.5° OMC				OMC				1.10° OMC			
	k ₁	k ₂	k ₃	R ²	k ₁	k ₂	k ₃	R ²	k ₁	k ₂	k ₃	R ²
D1-ML	768.4	0.67	-2.61	0.88	260.6	0.76	-0.72	0.77	-	-	-	-
D1-GM	1001.4	0.84	-2.72	0.91	744.8	0.99	-2.47	0.89	263.5	0.81	0.07	0.78
17-PSL-0101	-	-	-	-	888.4	0.58	-2.25	0.70	-	-	-	-
TP-9	555.9	0.57	-2.46	0.86	377.2	0.68	-2.68	0.76	-	-	-	-
D3-SM	608.9	0.10	-0.57	0.59	563.6	0.21	-1.60	0.79	-	-	-	-
D3-SC	587.8	0.26	-1.82	0.90	541.9	0.18	-1.75	0.89	124.4	0.25	-0.2	0.30
Cs-184	1346.5	0.34	-3.93	0.95	767.2	0.52	-3.1	0.90	-	-	-	-
UN-80	1182.4	0.69	-1.74	0.95	486.9	0.55	0.53	0.84	283.6	0.26	2.17	0.89
BK-180c	410.2	0.23	2.35	0.92	397.6	0.26	1.94	0.85	-	-	-	-
IF-83	371.14	0.22	2.03	0.87	383.1	0.45	0.79	0.74	-	-	-	-
17-PSL-0054	-	-	-	-	340.2	0.09	1.95	0.58	-	-	-	-
17-PSL-0055	327.4	0.17	1.58	0.94	223.6	0.25	2.78	0.94	190.1	0.19	3.17	0.91
17-PSL-0057	273.9	0.25	1.25	0.89	175.2	0.24	2.7	0.94	-	-	-	-
17-PSL-0058	-	-	-	-	667.1	0.38	-1.88	0.78	-	-	-	-

Note: cells with no data indicate the specimen could not be tested for resilient modulus properties

MEPDG Model parameters for subgrade soil materials

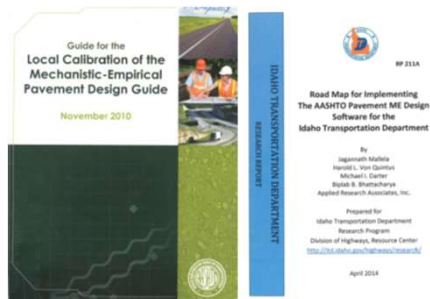
Calibration

RP235 and RP268

- RP235 – Local Calibration of Flexible Pavement Models for ME software v2.3.1
- RP268 – Local Calibration of PCC Pavement Models, and Re-Calibration of Flexible models for ME software v2.5.3

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Calibration

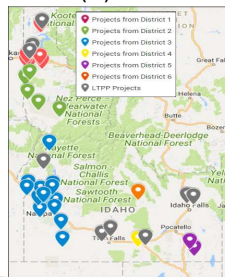


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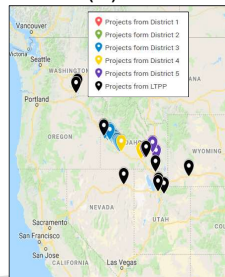
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Selected Section for Flexible and JCP Pavements

Selected Flexible Pavement Sections (34)



Selected Rigid Pavement Sections (39)



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Selected Projects for Flexible Pavements

80% of the selected projects were used for calibration

ITD District #	Construction Year	Route	Bag MP	End MP
D1	2008	US-95	403.5	408.75
	2004	US-95	411.84	415.83
	2002	US-95	415.5	421.3
	2006	SH-3	76.822	84.201
	2013	US-95	477.1	486.36
D2	2008	SH-006	100	104.5
	2004	SH-008	0	1.76
	2003	US-95	344	344.57
	2007	US-95	319.88	337.67
	2009	SH-013	5.00	8.5
D3	2011	SH-013	11.257	18.711
	2010	SH-013	18.68	25.378
	2005	US-95	277.28	279.1
	2010	US-95	64.94	67.14
	2011	US-95	0	16.7
D4	2012	US-95	38.4	46.6
	2011	SH-55	66.1	80.63
	2010	SH-78	0	11.5
	2011	SH-51	60	78.9
	2011	SH-51	47.7	54.6
D5	2011	SH-78	60	76
	2012	SH-55	13.1	18
	2012	US-20/26	0	1.58
	2012	US-95	47.58	60.87
	2012	SH-16	0	13.392
D6	2013	SH-52	14.4	30.42
	2000	SH-77	18.5	23
	2014	US-30	328.6	330.7
D6	2012	US-20	328.6	335.7

20% of the selected projects were set aside for validation

District #	Construction Year	Route	Bag MP	End MP
D1	2013	SH-3	103.15	111.38
D2	2003	US-95	366.59	373.03
D3	2012	SH-55	113.9	115.9
D3	2010	SH-78	29.1	36.7
D6	2011	SH-55	63.2	66.1
D6	1985	U.S.-20	319.6	331

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Selected Projects for Rigid Pavements

80% of the selected projects were used for calibration

ITD District #	Construction Year	Route	Bag MP	End MP
D1	1991	I-90	58.5	62.25
	1924	US-95	0.06	0.11
	2011	SH-008	2.77	3.27
D2	1976	US-95	251.075	261.588
	2004	US-12	2.197	2.62
	1981	I-84	26.35	28.3
D3	2011	I-84	36	38.7
	2009	I-84	41.3	43.8
	2004	I-84	49.15	49.73
D4	1996	I-84	49.73	50.21
	1972	I-84	58.8	59
	2001	I-84	70.1	82.3
D5	1996	I-84	90	94.6
	1983	I-84	94.3	103.5
	1994	I-84	103.5	109.1
D6	1995	I-84	114.5	121.2
	1979	I-84	120.66	127.945
	1972	I-15	30.87	36.207
D6	1960	I-86	14.808	25.98
	1985	US-91	80.15	81.02
	1986	US-91	78.81	79.66

20% of the selected projects were set aside for validation

Number	Construction Year	Route	Bag MP	End MP
1	1986	I-86	24.7	-
2	1985	I-215	28.5	-
3	2004	US-12	2.197	2.62
4	1983	I-84	12.6	17.61
5	1995	I-84	109.1	114.5
6	1986	U.S.-395	26.1	-
7	1979	I-84	120.66	127.95

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ITD ME-Performance Database

Source: TAMS and Video Logs (PathView Software)

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Field and Forensic Investigations Example: SH-8 (Moscow)

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Field and Forensic Investigations Example: SH-8 (Moscow)

ITD ME-Performance Database (Flexible Pavements)

Calibration of the AASHTOware Pavement ME Design Performance Models for Flexible Pavements in Idaho

Flexible Pavements Performance Database, v1.1

ITD Research Project RP235 - University of Idaho NIATT Project KUS372

Performance Database Version 1.1

Downloaded by:
Enad Kassam (PI)
Ahmed Muthaf
Mustapha Yousfi

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Click on your District for projects information

Note: The original Performance Database was created under RP235 in 2017. Performance data accumulated afterwards are included and the Performance Database was updated under RP268.

Performance Data for all sections along with pavement structure data, location map and material information (JMF) are all integrated and documented in a single database for the selected sections for future re-calibration.

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ITD ME-Performance Database (Flexible Pavements)

District 1, Project 1
Project Section: 0+00 to 0+100 (SARV)

Construction time: 2008
Coordinates: 47.4278, -124.9825
Elevation: 2000 ft

DISTRICT 1 - SELECTED PAVEMENT SECTIONS

UP DATE TO DATA SHEET

Performance Measurements

	2008	2010	2012	2014	2016
Algebraic Coefficient (C ₁)	0.05	0.05	0.05	0.05	0.05
Longitudinal Coefficient (C ₂)	11.04	104.52	104.52	104.52	104.52
Surfacting (%)	0.10	0.17	0.28	0.29	0.30
BS (in./in.)	0.25	0.25	0.25	0.25	0.25

Structure

Binder Properties

Performance Measurements

JMF

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ITD ME-Performance Database (PCC Pavements)

Calibration of the AASHTOware Pavement ME Design Performance Models for Rigid Pavements in Idaho

PCC Pavements Performance Database, v1.1

ITD Research Project RP268 - University of Idaho NIATT Project KUS385

Downloaded by:
Enad Kassam (PI)
Ahmed Muthaf
Mustapha Yousfi

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Click on your District for projects information

PCC Performance Database

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ITD ME-Performance Database (PCC Pavements)

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Data Analysis and Development of Local Calibration Factors

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Calibration of Performance Models – Flexible Pavements

RUTTING MODELS

$$\Delta_p(HMA) = \frac{\epsilon_p(HMA)}{\epsilon_r(HMA)} \times h_{HMA} = \beta_{1r} k_z 10^{k_{1r}} n^{k_{2r}} \beta_{2r} T^{k_{3r}} \beta_{3r} \times h_{HMA}$$

$$\Delta_p(soil) = \beta_{s1} k_{s1} \epsilon_v h_{soil} \left(\frac{\epsilon_0}{\epsilon_r} \right) e^{-\left(\frac{\rho}{n} \right)^\beta}$$

FATIGUE CRACKING MODEL

$$FC_{Bottom} = \left(\frac{1}{60} \right) \left(\frac{C_3}{1 + e^{(C_1 C_1 + C_2 C_2 \log(DI_{Bottom}^{*100}))}} \right)$$

$$FC_{Top} = 10.56 \left(\frac{C_4}{1 + e^{(C_1 - C_2 \log(DI_{Top}))}} \right)$$

THERMAL CRACKING MODEL

$$TC = \beta_{t1} N \left[\frac{1}{\sigma_d} \log \left(\frac{C_d}{h_{HMA}} \right) \right]$$

INTERNATIONAL ROUGHNESS INDEX (IRI) MODEL

$$IRI = IRI_0 + C_1(RD) + C_2(FC_{Total}) + C_3(TC) + C_4(SF)$$

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Rutting Model Calibration

$$\Delta_p(HMA) = \beta_{1r} k_z \epsilon_r(HMA) 10^{k_{1r}} n^{k_{2r}} \beta_{2r} T^{k_{3r}} \beta_{3r} h_{(HMA)}$$

$$\Delta_p(soil) = \beta_{s1} k_{s1} \epsilon_v h_{soil} \left(\frac{\epsilon_0}{\epsilon_r} \right) e^{-\left(\frac{\rho}{n} \right)^\beta}$$

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Rutting Model Calibration Example of Data Analysis

Trial	β_{1r}	β_{1s} (coarse)	β_{1s} (fine)	Bias, err	Standard Error, S_e	P-value
NC Factors	0.40	1.00	1.00	-0.0592	0.150	2.74E-06
Trial #1	1.50	1.00	1.00	-6.5	0.210	1.5E-07
Trial #2	1.25	1.00	1.00	-4.47	0.191	5.62E-07
Trial #3	1.00	1.00	1.00	-1.21	0.172	1.13E-06
Trial #4	0.75	1.00	1.00	-0.9	0.165	4.5E-06
Trial #5	0.50	1.00	1.00	-0.21	0.156	7.1E-06
Trial #6	0.25	1.00	1.00	1.4	0.12	4.84E-05
Trial #7	1.25	1.25	1.00	-5.71	0.214	1.17E-07
Trial #8	0.75	0.75	1.00	-0.83	0.158	2.1E-04
Trial #9	0.50	0.50	1.00	-0.11	0.134	4.9E-3
Trial #10	0.25	0.25	1.00	3.4	0.117	1.2E-03
Trial #11	1.25	1.25	1.25	-7.4	0.241	5.48E-07
Trial #12	0.75	0.75	0.75	-0.51	0.148	8.4E-04
Trial #13	0.50	0.50	0.50	1.48	0.128	7.87E-03
Trial #14	0.25	0.75	0.75	0.007	0.114	0.03
Trial #15	0.25	0.50	0.50	3.4	0.105	1.53E-02
Trial #16	0.30	1.00	1.00	-0.02	0.121	8.36E-03
Trial #17	0.30	0.75	1.00	-0.009	0.116	0.08
Trial #18	0.30	1.00	0.75	-0.008	0.115	0.12
Trial #19	0.30	0.86	0.736	0.0002	0.103	0.37
Trial #20	0.30	0.90	0.74	-0.005	0.112	0.24

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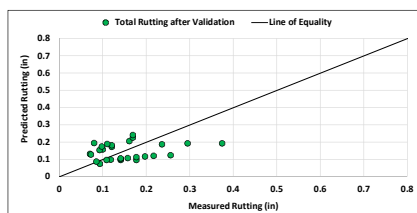
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Rutting Models Calibration - PMED v2.5.3

Calibration Factors	β_{1r}	β_{1s}	β_{2r}	β_{1s} (Coarse)	β_{1s} (Fine)	N	Bias, $e_{(tmean)}$	Standard Error, S_e	P-value (Paired t-test)
Global	0.4	0.52	1.36	1.00	1.00	123	-0.059	0.15	2.74E-07
Local	0.3	0.52	1.36	0.86	0.736	123	0.0002	0.1	0.49

Rutting Models **Validation** - PMED v2.5.3



N	Bias, $e_{f(\text{mean})}$	Standard Error, S_e	P-value (Paired t-test)
28	0.0065	0.074	0.33

Fatigue Models Calibration

$$N_{f-HMA} = k_{f1}(C)(C_H)\beta_{f1}(\epsilon_t)^{k_{f2}}\beta_{f2}(E_{HMA})^{k_{f3}}\beta_{f3}$$

$$FC_{Bottom} = \left(\frac{1}{60}\right) \left(\frac{C_4}{1 + e^{(C_1 C_1' + C_2 C_2' \log(DI_{Bottom} * 100))}} \right)$$

$$FC_{Top} = 10.56 \left(\frac{C_4}{1 + e^{(C_1 - C_2 \log(DI_{Top}))}} \right)$$

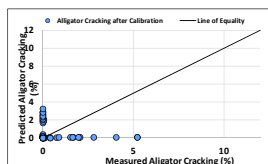
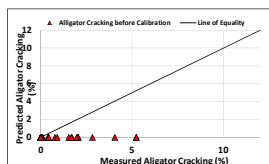
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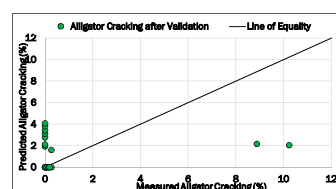
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Alligator Cracking Models **Calibration**



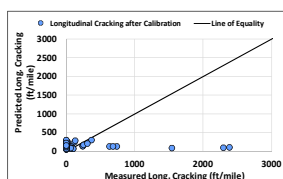
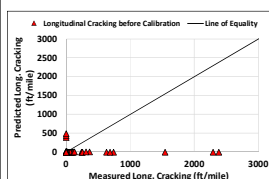
Calibration Factors	C_1	C_2 : $h_{ac} \leq 5$ in.	C_2 : $h_{ac} > 12$ in.	C_2 : $5 < h_{ac} \leq 12$ in.	N	Bias, $e_{f(\text{mean})}$	Standard Error, S_e	P-value (Paired t-test)
Global	1.31	2.1585	3.9666	1	70	0.45	1.20	0.001
Local	0.31	1.1585	3.9666	0.2	70	-0.19	1.07	0.18

Alligator Cracking Models **Validation**



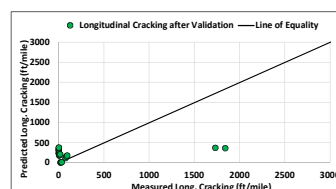
N	Bias, $e_{f(\text{mean})}$	Standard Error, S_e	P-value (Paired t-test)
19	-0.36	3.10	0.31

Longitudinal Cracking Models **Calibration**



Calibration Factors	C_1	C_2	N	Bias, $e_{f(\text{mean})}$	Standard Error, S_e	P-value (Paired t-test)
Global	7.0	3.50	71	132.4	471.7	0.008
Local	3.3	1.0	71	2.3	450	0.48

Longitudinal Cracking Models **Validation**



N	Bias, $e_{f(\text{mean})}$	Standard Error, S_e	P-value (Paired t-test)
18	-1.7	518	0.5

Thermal Cracking Model

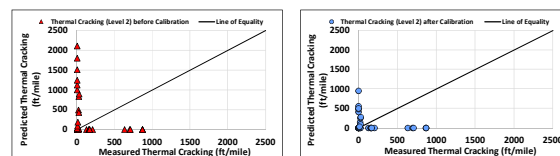
$$TC = \beta_{t1} N \left[\frac{1}{\sigma_d} \log \left(\frac{C_d}{H_{HMA}} \right) \right]$$

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Transverse (Thermal) Cracking Model
Calibration

Calibration Factors	K (Mean Annual Air Temperature (MAAT) <= 57 deg F)	N	Bias, $e_{j(\text{mean})}$	Standard Error, S_e	P-value (Paired t-test)
Global	$[3 * 10^{-7} * \text{MAAT}^{0.032}] * 1 + 0$	35	-174.35	746.201	0.03
Local	$[2.591 * 10^{-7} * \text{MAAT}^{0.032}] * 1 + 0$	35	-0.00029	529.394	0.5

Transverse (Thermal) Cracking Model
Validation

The transverse cracking model at level 2 was not validated in this study due to lack of projects with level 2 low temperature cracking data.

IRI Model Calibration

$$IRI = IRI_o + C_1(RD) + C_2(FC_{Total}) + C_3(TC) + C_4(SF)$$

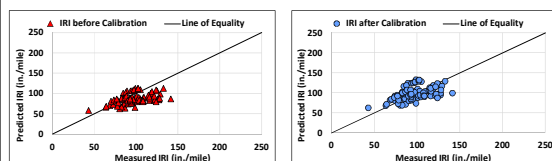
Data collected from TAMS Database

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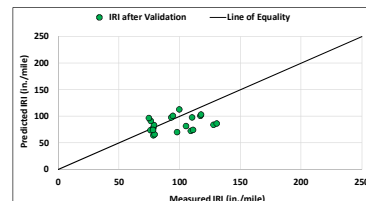
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International Roughness Index Model
(IRI) Calibration

Calibration Factors	C_1	C_2	C_3	C_4	N	Bias, $e_{j(\text{mean})}$	Standard Error, S_e	P-value (Paired t-test)
Global	40	0.40	0.008	0.015	94	10.3	19.5	2.10E-08
Local	80	0.60	0.008	0.02	94	-1.2	17.5	0.24

International Roughness Index Model
(IRI) Validation

N	Bias, $e_{j(\text{mean})}$	Standard Error, S_e	P-value (Paired t-test)
23	2.8	28.7	0.32

Summary of Flexible Pavement Calibration Factors PMED_v2.5.3

Performance Model	Calibration Parameters	Global Factors (as per PMED V2.5.3)	Local Factors for Idaho
AC Rutting	β_{1r}	0.4	0.3
	β_{2r}	0.52	0.52
	β_{3r}	1.36	1.36
Unbound Base Rutting	β_{1u}	1.00	0.86
Subgrade Rutting	β_{1s}	1.00	0.736
Longitudinal Cracking (Top-Down Cracking)	C_1	7	3.3
	C_2	3.5	0.825
	C_3	1.31	0.31
Alligator Cracking (Bottom-Up Cracking)	$C_2: h_{ac} < 5$ in.	2.1585	1.1585
	$C_2: h_{ac} > 12$ in.	3.9666	3.9666
	$C_2: 5 \text{ in.} < h_{ac} < 12 \text{ in.}$	$(0.867 + 0.2583 * h_{ac}) * 1$	$(0.867 + 0.2583 * h_{ac}) * 0.2$
Thermal Cracking (Level 2)	K (MAAT ≤ 57 deg F)	$[3 * 10^{-7} * \text{MAAT}^{4.0313}] * 1 + 0$	$[2.591 * 10^{-7} * \text{MAAT}^{4.0313}] * 1 + 0$
IRI	C_1	40	80
	C_2	0.4	0.6
	C_3	0.008	0.008
	C_4	0.015	0.02

Calibration of Performance Models – PCC Pavements

JOINT FAULTING MODEL

$$Fault_{tm} = \sum_{i=1}^m \Delta Fault_i$$

$$\Delta Fault_i = (F3 + F4 \cdot FR^{0.25}) \cdot (Fault_{Max_{i-1}} - Fault_{i-1})^2 DE_i$$

$$Fault_{Max_i} = Fault_{Max_0} + F7 \sum_{k=1}^i DE_k \cdot \log(1 + F5 \cdot S^{error})^{F6}$$

$$Fault_{Max_0} = (F1 + F2 \cdot FR^{0.25}) \delta_{curing} \left[\log(1 + F5 \cdot S^{error}) \cdot \log\left(\frac{P_{200} \cdot WetDays}{P_s}\right) \right]^{F6}$$

TRANSVERSE CRACKING MODEL

$$TCRACK = (CRK_{Bottom-up} + CRK_{Top-down} - CRK_{Bottom-up} \cdot CRK_{Top-down}) \cdot 100$$

$$Crack = \frac{100 \log(N_{allowable})}{1 + C4 \cdot FD^{C5}} = \frac{100 \cdot C1 \left(\frac{MR}{\sigma}\right)^{C2}}{1 + C4 \cdot \left(\frac{N_{applied}}{N_{allowable}}\right)^{C5}}$$

INTERNATIONAL ROUGHNESS INDEX (IRI) MODEL

$$IRI = IRI_0 + J1 \cdot Crack + J2 \cdot Spall + J3 \cdot Fault + J4 \cdot SiteFactor$$

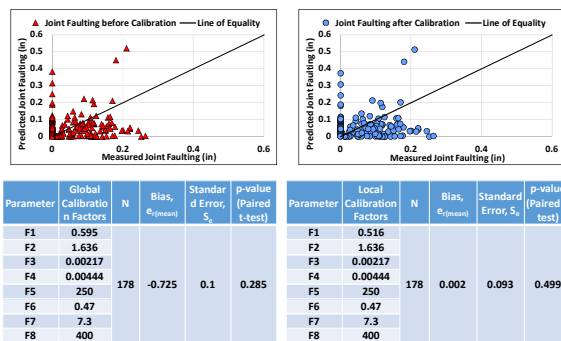
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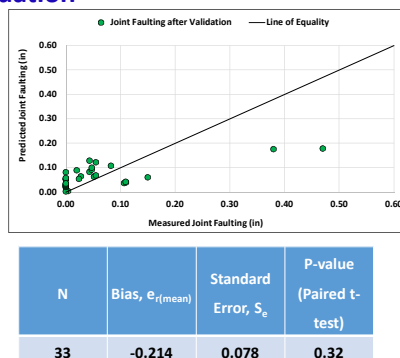
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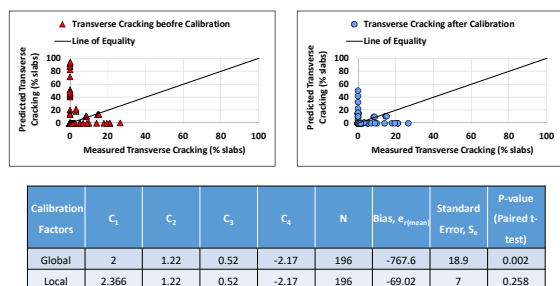
JPCP Mean Transverse Joint Faulting Model – Calibration



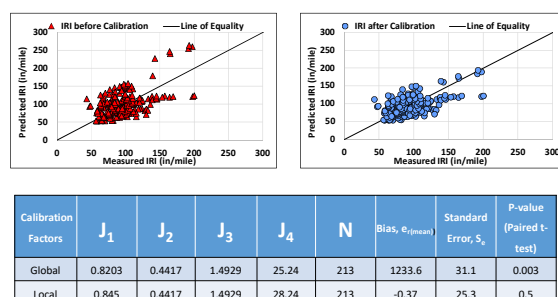
JPCP Mean Transverse Joint Faulting Model – Validation



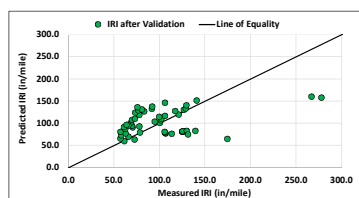
JPCP Transverse Slab Cracking Model – Calibration



PCC IRI Model – Calibration



PCC IRI Model – Validation



N	Bias, $e_{(mean)}$	Standard Error, S_e	P-value (Paired t-test)
59	-11.55	21.04	0.49

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Summary of Rigid JPCP Pavement Calibration Factors PMED_v2.5.3

Performance Model	Calibration Parameters	Global Factors (PMED V2.5.3)	Idaho Local Calibration Factors
Faulting	F1	0.595	0.516
	F2	1.636	1.636
	F3	0.00217	0.00217
	F4	0.00444	0.00444
	F5	250	250
	F6	0.47	0.47
	F7	7.3	7.3
	F8	400	400
Transverse Cracking	C1	2	2.366
	C2	1.22	1.22
	C4	0.52	0.52
	C5	-2.17	-2.17
IRI	J1	0.8203	0.845
	J2	0.4417	0.4417
	J3	1.4929	1.4929
	J4	25.24	28.24

PAPERS – TRB 2019

Chowdhury, R., Kassem, E., Alkuime, H., Bayomy, F., Mishra, D. “**Resilient Modulus Prediction Model for Unbound Coarse Materials**,” The 98th Annual Meeting, Transportation Research Board, January 13-17, 2019, Washington, D.C.

Muftah, A., Bayomy, A., Kassem, E. “**Calibration of the AASHTOWare Pavement ME Design Performance Models for Flexible Pavement in Idaho**,” The 98th Annual Meeting, Transportation Research Board, January 13-17, 2019, Washington, D.C.

PAPERS – TRB 2020

Muftah, A., Bayomy, F., and Kassem, E., “**Calibration of the AASHTOWare Pavement ME Design Performance Models for Flexible Pavements in Idaho**,” Transportation research Board, paper No. TRB 19-02996. Presented at the 2019 TRB Annual meeting, Washington, DC, January 2019

Chowdhury*, R. M., Kassem, E., Alkumie*, H., Bayomy, F., and Mishra, D., “**Resilient Modulus Prediction Model for Unbound Coarse Materials**,” Transportation research Board, paper No. TRB 19-02590. Presented at the 2019 TRB Annual meeting, Washington, DC, January 2019

TRAINING WORKSHOPS

- DARWin ME, Boise 2014
- AASHTOWare PMED, Boise 2018
- AASHTOWare PMED, Boise 2019


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