

55th Idaho Asphalt Conference

October 22, 2015
University Inn, Moscow, Idaho

Presentations for the 2015

- 1 [Pavement Management for Local Agencies](#); John Duval, Pavement Services Inc., (PSI)
- 2 [MnRoad 1½ NCAT Pavement Preservation Research](#); Dr. Randy West, NCAT, Auburn University
- 3 [Compaction Monitoring System for Asphalt Pavements](#); Dr. Emad Kassem, University of Idaho
- 4 [Results of the ITD Project on High RAP](#); Dr. Haifang Wen, Washington State University
- 5 [Improving Asphalt Pavement on the Local System - Project Experiences](#); Jeff Miles, PE, Local Highway Technical Assistance Council, Idaho
- 6 [Tack Coat Best Practices](#); Dave Johnson, PE, The Asphalt Institute
- 7 [New Technologies in Asphalt Testing](#); Wade Collins, Pavement Technology Inc., (PTI),
- 8 [Fiber-Reinforced Asphalt Pavements 1½ Idaho Case Study](#); Dr. Fouad Bayomy, Ahmed Muftah (U of I) and Amir Bahadori (WSU)
- 9 [Utilization of Very High RAP 1½ Lessons Learned from Japan](#); Dr. Randy West, NCAT, Auburn University

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Speakers of the 55th Idaho Asphalt Conference, October 22, 2015

From Left: Dave Johnson, Ahmed Muftah, Emad Kassem, Mike Santi, Randy West, John Duval, Jeff Miles, Haifang Wen, Wade Collins and Fouad Bayomy.

Not Pictured: Joe Iaw and Amir Bahadori

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Amanda Anderson

City of Spokane Engineering
1423 N Normandie St
Spokane, WA 99201
509-625-7722
amanderson@spokanecity.org

John Arambarri

Idaho Transportation Department
8150 W. Chinden
Boise, ID 83707
208 332-7161
john.arambarri@itd.idaho.gov

Amir Bahadori

Washington State University

Lee Barnardi

Idaho Transportation Department - D1
600 W Prairie Ave
Coeur d'Alene, ID 83815
208-772-1200

Don Barr

City of Nampa
106 W. Railroad St
Nampa, ID 83651
208-468-5830
barrd@cityofnampa.us

Jesse Barrus

Idaho Transportation Department - D5
5151 S. 5th Ave.
Pocatello, ID 83224
208-239-3300
jesse.barrus@itd.idaho.gov

Mike Barton

Interstate Concrete & Asphalt
5111 E Broadway Ave
Spokane, WA 99212
mbarton@oldcastlematerials.com

Fouad Bayomy

University of Idaho
UI Campus MS 1022
Moscow, ID 83844
208-885-6784
bayomy@uidaho.edu

Matt Blake

Idaho Asphalt Supply
16425 W. Prairie Ave
Hauser, ID 83854
208-773-0563
mblake@idahoasphalt.com

Scott Bontrager

City of Moscow
PO Box 9203
Moscow, ID 83843
208-883-7030
sbontrager@ci.moscow.id.us

Scott Brown

TerraGraphics Environmental Engineering
108 W. Idaho Avenue
Kellogg, ID 83837
2087861206
scott.brown@terragraphics.com

Kelly Brownsberger

Post Falls Highway District
5629 E. Seltice Way
Post Falls, ID 83854
208-765-3717
kelly@postfallshd.com

Joan Burgert

ITD
P.O. Box 97
Rigby, ID 83442
208-745-5632
JOAN.BURGERT@ITD.IDAHO.GOV

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Kevin Bussert

Specialty Construction Supply
348 NW 13th Place
Meridian, ID 83642
208-322-6800
kbussert@specialtysupply.com

Bob Buvel

City of Moscow
PO Box 9203
Moscow, ID 83843
208-883-7031
bbuvel@ci.moscow.id.us

Chad Clawson

Idaho Transportation Department
2600 Frontage Road
Lewiston, ID 83501
208-799-5090
chad.clawson@itd.idaho.gov

Wade Collins

Pavement Technology, Inc.
9308-A Industrial Dr NE
Covington, GA 30014
770-388-0909

Brian Dagon

Interstate Concrete & Asphalt
5111 E Broadway Ave
Spokane, WA 99212
208-661-4541
bdagon@oldcastlematerials.com

Dann Douglas

City of Spokane Engineering
1423 N Normandie St
Spokane, WA 99201
509-625-7722
dadouglas@spokanecity.org

Eric Druffel

Western States CAT
500 East Overland Rd
Meridian, ID 83642
208-884-2216

John Duval

Pavement Services, Inc.
3835 NE Tillamook St
Portland, OR 97212
503-235-0377
john@psipdx.com

Doug Eakin

City of Nampa
106 W. Railroad St
Nampa, ID 83651
208-468-5830
eakind@cityofnampa.us

Jared Easterlin

Mead & Hunt
1910 W 43rd Ave
Denver, CO 80211
843-819-2186
jared.easterlin@meadhunt.com

Marvin Fenn

Idaho Transportation Department - D1
600 W Prairie Ave
Coeur d'Alene, ID 83815
208-772-1200

Derek Forseth

TerraGraphics Environmental Engineering
121 S. Jackson Street
Moscow, ID 83843
208-882-7858
derek.forseth@terragraphics.com

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Paul Franz

Interstate Concrete & Asphalt
5111 E Broadway Ave
Spokane, WA 99212
509-536-3111
pfranz@oldcastlematerials.com

Dustin Gillmore

City of Nampa
106 W. Railroad St
Nampa, ID 83651
208-468-5830
gillmored@cityofnampa.us

Robert Gordon

Idaho Transportation Department
2600 Frontage Road
Lewiston, ID 83501
208-799-5090

Pat Greyson

Idaho Transportation Department - D5
5151 S. 5th Ave.
Pocatello, ID 83224
208-239-3300

Cara Haley

TerraGraphics Environmental Engineering
121 S. Jackson Street
Moscow, ID 83843
208-882-7858
cara.haley@terragraphics.com

Melody Halstead

Idaho Transportation Department - D5
5151 S. 5th Ave.
Pocatello, ID 83224
208-239-3300

Nathan Herbst

Idaho Transportation Department - D1
600 W Prairie Ave
Coeur d'Alene, ID 83815
208-772-1200

Danny Hoey

City of Spokane Engineering
Construction Management
1423 N Normandie St
Spokane, WA 99201
509-625-7722
dhoey@spokanecity.org

Clint Hoops

Idaho Transportation Dept.
3311 W. State St.
Boise, ID 83703
208-334-4415
clint.hoops@itd.idaho.gov

Tracy Hopkins

Specialty Construction Supply
348 NW 13th Place
Meridian, ID 83642
208-322-6800
thopkins@specialtysupply.com

John Ingram

Idaho Transportation
3311 W. State St.
Boise, ID 83703
208-334-8436
john.ingram@itd.idaho.gov

Caleb Iring

Western States CAT
500 East Overland Rd
Meridian, ID 83642
208-884-2216

Dave Johnson

Asphalt Institute
2501 Montana Ave
Billings, MT 59101
859-288-4960
djohnson@asphaltinstitute.org

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Emad Kassem

University of Idaho
875 Perimeter Dr MS 1022
Moscow, ID 83844
208-885-1025
ekassem@uidaho.edu

Kerby Kirkham

Idaho Transportation Department
2600 Frontage Road
Lewiston, ID 83501
208-799-5090
kerby.kirkham@itd.idaho.gov

Sterling Knipfer

WSDOT
1551 N. Wenatchee Ave.
Wenatchee, WA 98801
509-667-3050
knipfes@wsdot.wa.gov

Butch Lafarge

Western States CAT
500 East Overland Rd
Meridian, ID 83642
208-884-2216

Joe Law

College of Engineering
875 Perimeter Dr MS 1023
Moscow, ID 83844-1023
208-885-7230
joel@uidaho.edu

Jason Lefler

City of Moscow
PO Box 9203
Moscow, ID 83843
208-883-7137
jlefler@ci.moscow.id.us

Matthew Lynch

Western States Asphalt
500 East Overland Rd
Meridian, ID 83642
208-884-2216

Scott Malone

Idaho Transportation Department - D4
216 S. Date St.
Shoshone, ID 83350
208-886-7800
scott.malone@itd.idaho.gov

Adrian Mascorro

ALLWEST Engineering & Testing
255 N. Linder Road, Suite 100
Meridian, ID 83642
208-629-2040
amascorro@allwesttesting.com

Jack McCoy

Western States CAT
500 East Overland Rd
Meridian, ID 83642
208-884-2216
jackmccoy@wseco.com

Gary McGee

Nycon Corporation
5662 E. Gateway Dr.
Boise, ID 83716
208-484-1138
mcgee.nycon@gmail.com

Jeff Miles

Local Highway Technical Assistance Council
3330 W Grace St
Boise, ID 83703
208-344-0565
jmiles@lhtac.org

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Debakanta Mishra

Boise State University
Civil Engineering
1910 University Drive
Boise, ID 83725-2060
208-426-3710
debmishra@boisestate.edu

Mike Monette

Post Falls Highway District
5629 E. Seltice Way
Post Falls, ID 83854
208-765-3717
mike@postfallshd.com

Ahmed Muftah

University of Idaho
875 Perimeter Dr MS 1022
Moscow, ID 83844
muft3556@vandals.uidaho.edu

Tim Murphy

Murphy Pavement Technology
7649 S State St
Chicago, IL 60619
773-874-9800
tmurphy@murphypavetech.com

Ned Parrish

Idaho Transportation Dept.
PO Box 7129
Boise, ID 83707
208-334-8296
ned.parrish@itd.idaho.gov

John Perfect

Idaho Transportation Department - D1
600 W Prairie Ave
Coeur d'Alene, ID 83815
208-772-1200

Brian Poole

Idaho Transportation Department - D5
5151 S. 5th Ave.
Pocatello, ID 83224
208-239-3300

Justin Price

Idaho Transportation Department - D4
216 S. Date St.
Shoshone, ID 83350
208-886-7800
justin.price@itd.idaho.gov

Christian Rescate

Nycon Corporation
300 Ben Fairless Drive
Fairless Hills, PA 19030
215-310-2006
chrisr@alpatterson.com

Dave Richards

Idaho Transportation Department
P.O. Box 8028
Boise, ID 83707
208 332-7193
dave.richards@itd.idaho.gov

Mike Santi

Idaho Transportation Department
PO Box 7129
Boise, ID 83707
208-334-8440
mike.santi@itd.idaho.gov

Joseph Schmidlin

Alliance Geosynthetics
PO Box 98
Drain, OR 97435
919-610-6098
joseph@alliancegeo.com

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Bob Schumacher

Idaho Transportation Department
2600 Frontage Road
Lewiston, ID 83501
208-799-5090

Mark Sikkema

TenCate
5120 NW 17th Cir
Camas, WA 98607
360-448-8968
m.sikkema@tencate.com

Scot Stacey

Idaho Transportation Department - D4
216 S. Date St.
Shoshone, ID 83350
208-886-7800
scot.stacey@itd.idaho.gov

Steve Taylor

Idaho Transportation Department
2600 Frontage Road
Lewiston, ID 83501
208-799-5090

Gary Thompson

Knife River
8844 W. Wyoming Ave
Rathdrum, ID 83585
208-277-5948
GaryO.Thompson@kniferiver.com

Shawn Turpin

ALLWEST Testing & Engineering
2705 East Main Street
LEWISTON, ID 83501
208-743-5710
sturpin@allwesttesting.com

John Vaudreuil

Idaho Transportation Department - D1
600 W Prairie Ave
Coeur d'Alene, ID 83815
208-772-1200

Cody Vizena

Idaho Transportation Department - D5
5151 S. 5th Ave.
Pocatello, ID 83224
208-239-3300

Michael Walton

City of Spokane Engineering
Construction Management
1423 N Normandie St
Spokane, WA 99201
509-625-7722
mjwalton@spokanecity.org

Ben Ward

Idaho Transportation Department - D1
600 W Prairie Ave
Coeur d'Alene, ID 83815
208-772-1200

Haifang Wen

Washington State University
PO Box 642718
Pullman, WA 99164
509-335-2513
haifang.wen@wsu.edu

Randy West

National Center for Asphalt Technology
277 Technology Pkwy
Auburn, AL 36830
334-844-6228
westran@auburn.edu

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Craig Wielenga

Idaho Transportation Department
P.O. Box 8028
Boise, ID 83707
208 332-7176
craig.wielenga@itd.idaho.gov

Jerry Wilson

Idaho Transportation Department - D1
600 W Prairie Ave
Coeur d'Alene, ID 83815
208-772-1200

Jared Wise

Interstate Concrete & Asphalt
8849 W. Wyoming Ave.
Rathdrum, ID 83858
208-765-1144
jwise@oldcastlematerials.com

Greydon Wright

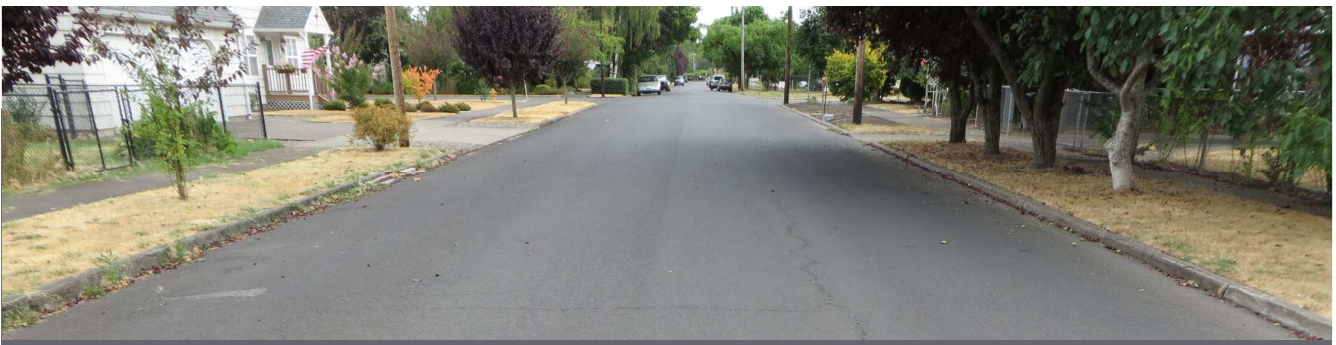
Idaho Transportation Department - D5
5151 S. 5th Ave.
Pocatello, ID 83224
208-239-3300
greydon.wright@itd.idaho.gov

Justin Wuest

Idaho Transportation Department - D1
600 W Prairie Ave
Coeur d'Alene, ID 83815
208-772-1200

Bryan Young

Idaho Transportation Department - D6
P.O. Box 97
Rigby, ID 83442
208-745-5682
bryan.young@itd.idaho.gov



Pavement Management for Local Agencies

John Duval, P.E.

Idaho Asphalt Conference
October 22, 2015
Moscow, ID



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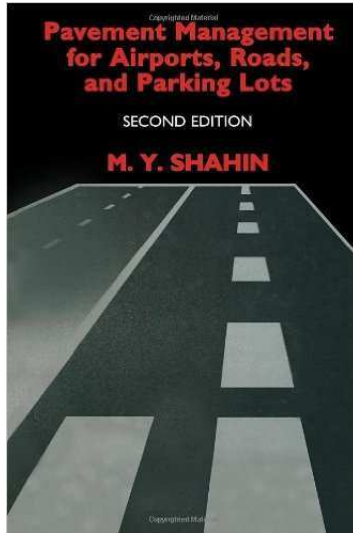
Overview

- Pavement Management Concepts
- Benefits of a Pavement Management System
- PMS Components
- Intro to the PCI Method
- PMS Data Analysis
- PMS Output
 - Project Prioritization
 - Maps

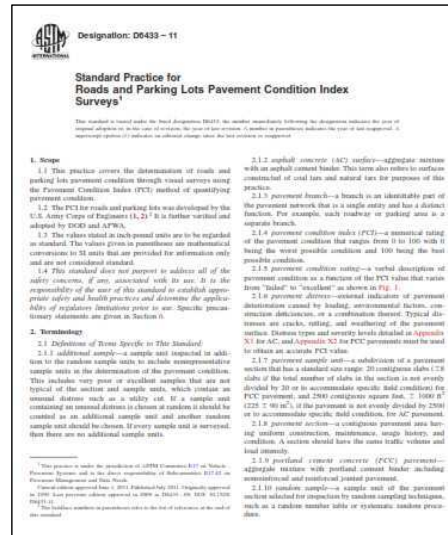


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References



Pavement Management for Airports,
Roads and Parking Lots
M.Y. Shahin

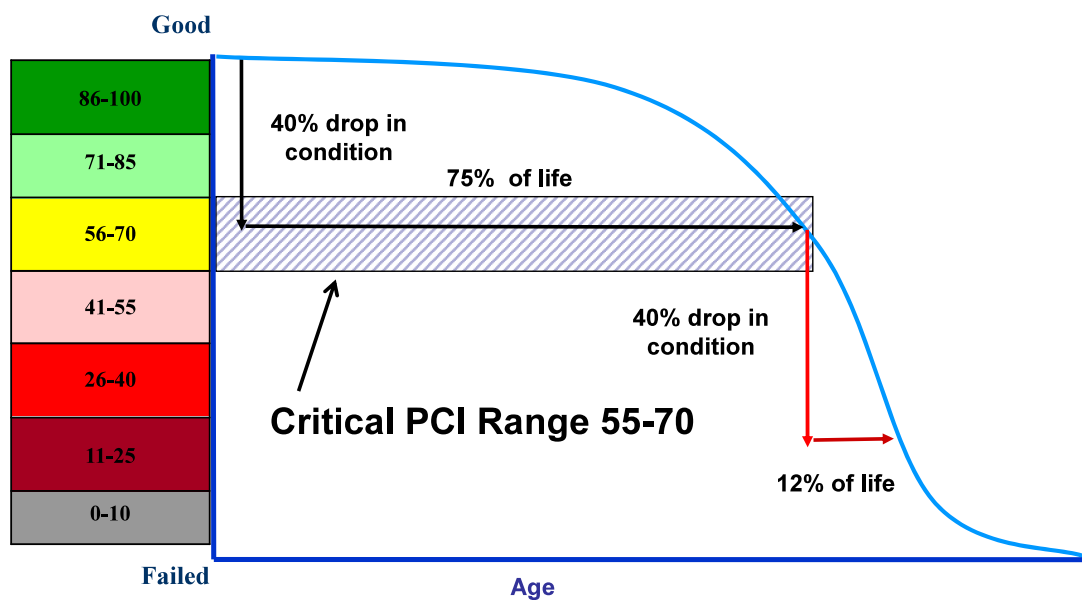


ASTM D6433

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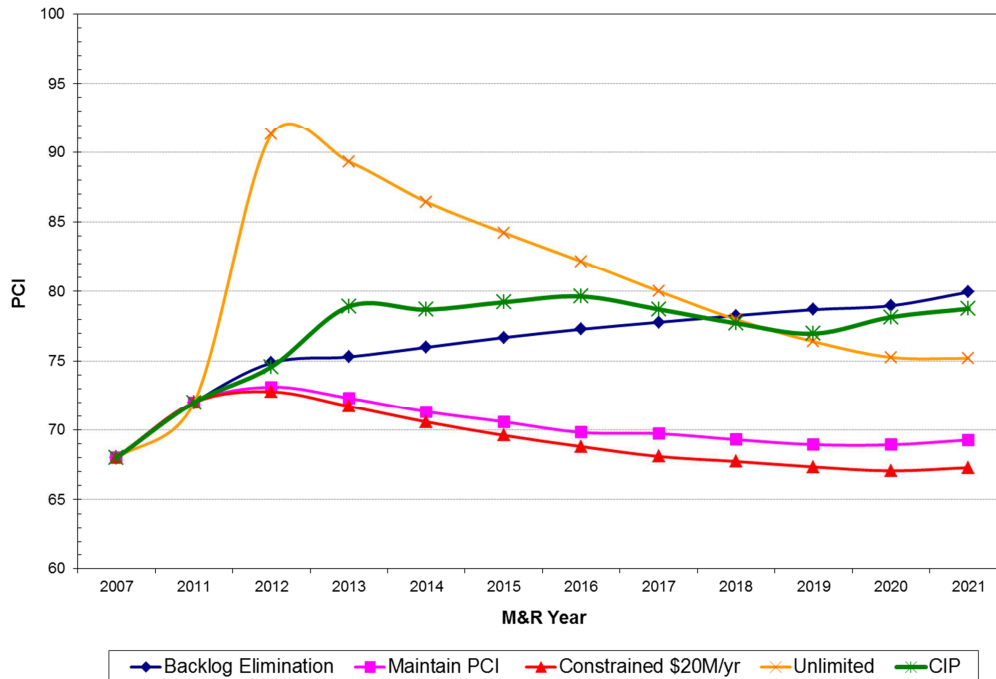
Typical Pavement Life Cycle



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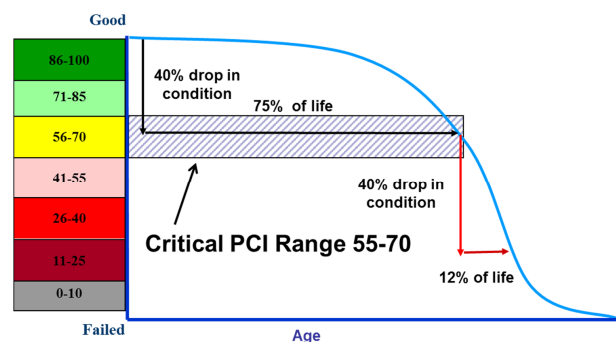
Analysis of Budget Scenarios



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Benefits of Pavement Management

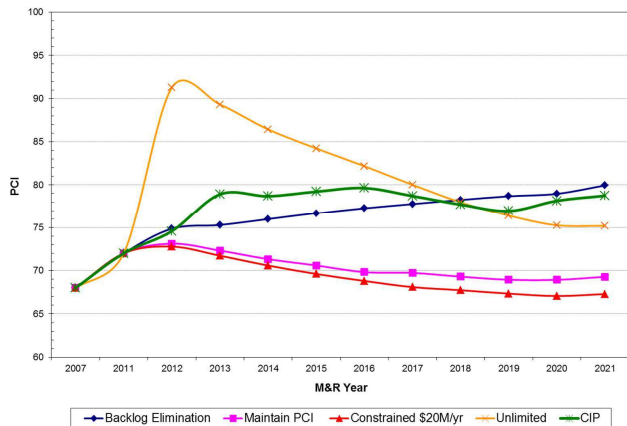
1. Process That Increases Pavement Useful Life
2. Objective and Consistent Condition Assessment
3. Documentation of Current and Future Condition
4. Engineering Basis for Repair Types and Timing



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Benefits of Pavement Management

5. Life Cycle Cost Analysis for Several Repair Options
6. Budget Development for Performance Objectives
7. Performance Consequences for Doing Nothing



Pavement Management Objectives

- Identify Pavement Preservation Types & Timing
- Identify Rehabilitation Types & Timing for 5 to 10 Years
 - Project future conditions
 - Identify feasible repair alternatives
 - Develop budget scenarios
 - Select best repair alternative
 - Build multi-year rehabilitation program



Pavement Management Objectives

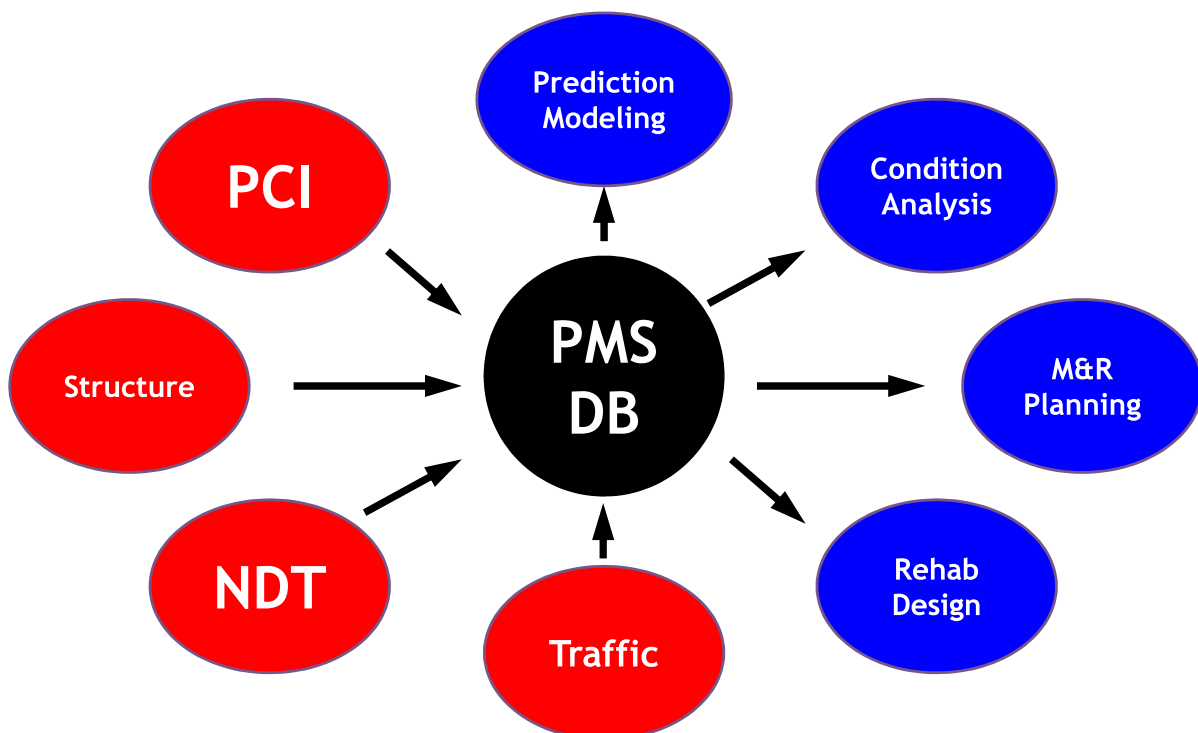
- Justify Preservation and Rehabilitation Expenditures
 - Optimize use of limited funds
 - Maximize Return On Investment
 - Minimize disruptions to traffic
 - Minimize pavement repairs costs with construction efficiency
 - Maximize pavement condition improvement
 - Minimize rate of annual pavement deterioration



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Pavement Management System



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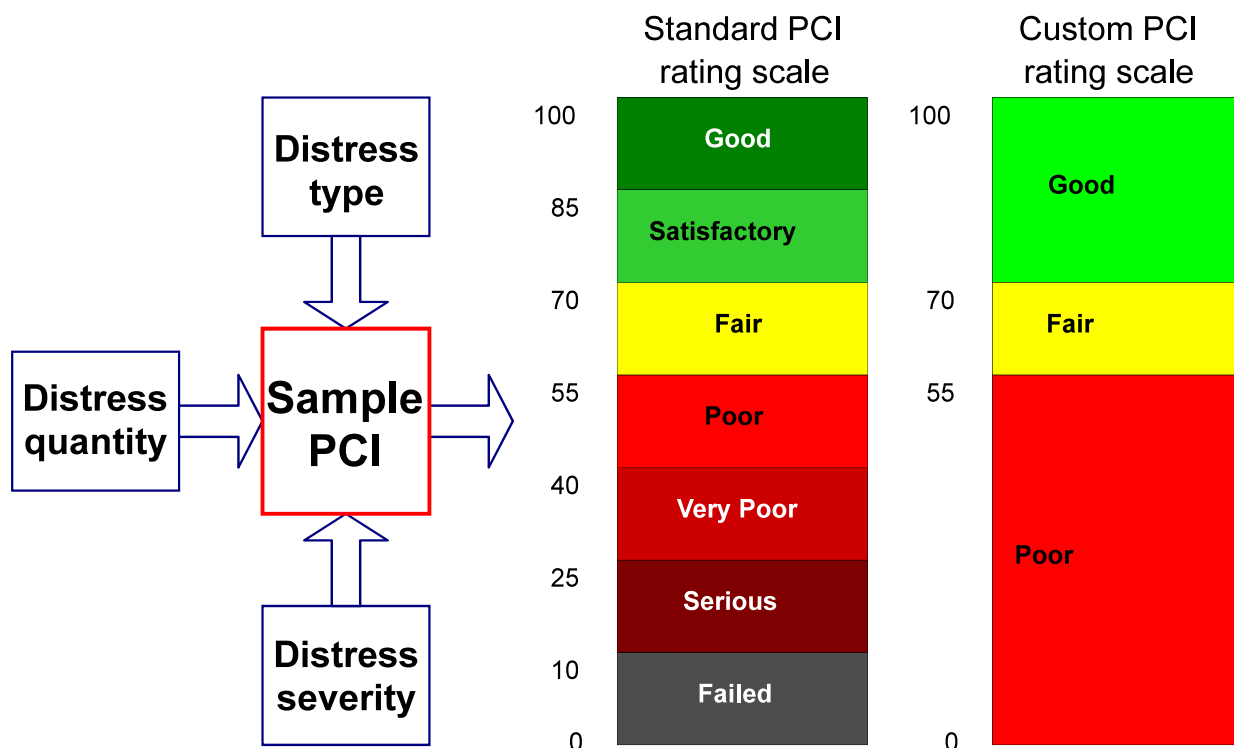
Introduction to PCI



- Pavement Rating is the method of determining the pavement condition through visual observations.
 - Specifically, the type of distress/defect, the severity, and the quantity are recorded.
 - Method to consistently characterize the condition of the pavement surface.
- Pavement Condition Index (PCI) Method
 - *ASTM D6433 - Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys*
 - 20 AC and 19 PCC Distress Types

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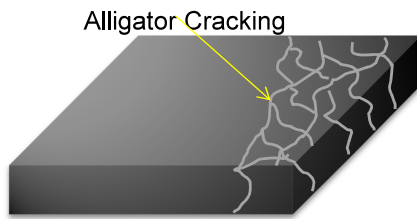
Pavement Condition Index (PCI) - Overview



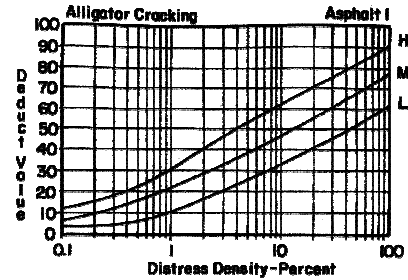
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Pavement Condition Index (PCI) - Overview

Step 1: Determine Distress Type, Severity & Quantity

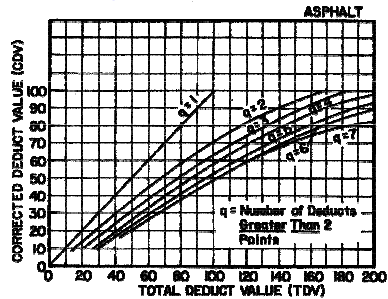


Step 2: Determine Deduct Values



Step 3: Compute the Total Deduct Value

Step 4: Adjust Total Deduct Value, CDV



Step 5: Compute Pavement Condition Index

$$PCI = 100 - CDV$$

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Benefits of Pavement Condition Index (PCI)

- What It Provides: The PCI tells public works officials
 - The current condition of the road network
 - The rate of deterioration of the road network over time
- Benefits of PCI within Pavement Management System:
 - Identify immediate maintenance and rehabilitation needs
 - Monitor pavement condition over time
 - Develop a network preventive maintenance strategy
 - Develop road maintenance budgets
 - Evaluate pavement materials and designs

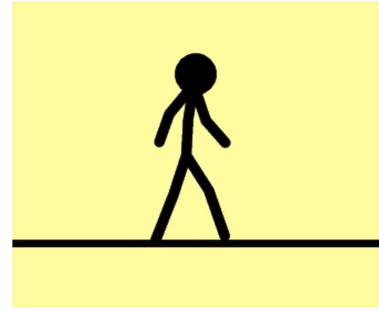
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Rating Considerations

Survey Method

- Manual
 - Walking
 - Windshield
- Automated/ Semi-Automated
- Hybrid
 - Combination



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Rating Considerations

- Manual Survey Method
 - Walking
 - Provides a higher level of detail.
 - Traffic control often not required.
 - Method prescribed by ASTM D6433
 - Time intensive.
 - Uses multiple inspection teams
 - One identifies distress type, severity, and quantity
 - One records data and watches for traffic

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Rating Considerations

- Manual Survey Method
 - Windshield
 - Lowest cost
 - Least time intensive
 - Provides the lowest level of detail
 - Low distress severities are often not visible/recorded
 - Distress and severity levels are easily misjudged or not observed
 - Will result in greater error in rating
 - Does Not Conform to ASTM D6433

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Rating Considerations

- Automated/ Semi-Automated Survey Method
 - Rating vehicles equipped with sensors take images/laser scans of the pavement
 - Data interpreted for Distress Types, Severity & Quantity
 - Manually by people
 - Automatically by software
 - Safest Method
 - Does not conform to ASTM D6433
- Big Question – Does distress data collected from automated/windshield methods match data from walking surveys?
 - Largely, No

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PCI Inspection

HOW DO WE CONDUCT A PCI SURVEY?

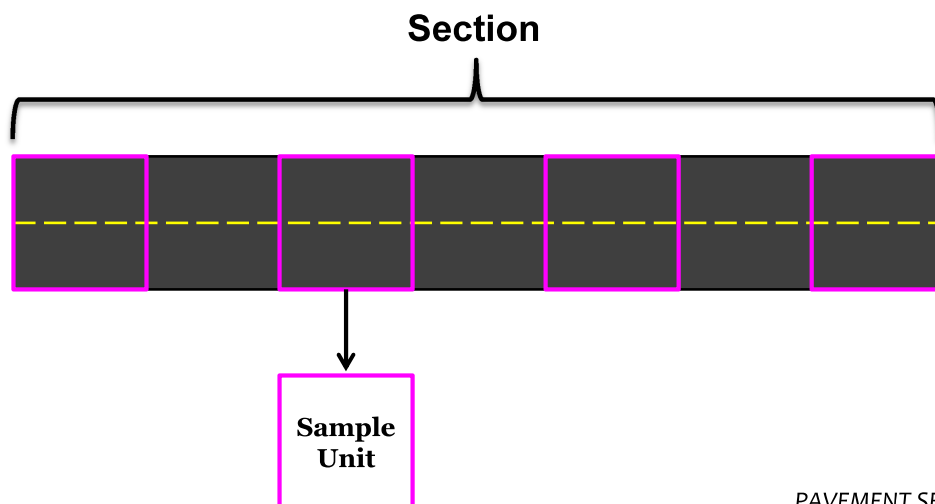
Sample Unit Method

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Sample Unit Definition

Sample Units are portions of the pavement section, designated only for the purpose of a pavement inspection.



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Sample Unit Definition

Sample Unit Sizes

- Asphalt Pavements
 - **2,500 SF** ± 1,000 Square Feet (1,500 – 3,500 SF)
- Concrete Pavements
 - **20 Slabs** ± 8 Slabs (12 – 28 Slabs)
 - Slab size less than or equal to 25 x 25 Ft

Source: ASTM D6433

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Number of Sample Units to Survey

- **Network** Level Inspection:
 - Used for budget planning
 - Limit number of sample units surveyed per section to minimize needed resources.
- **Project** Level Inspection
 - Used to estimate work for plans and contracts
 - Higher number of sample units surveyed per section to achieve higher PCI and distress quantity accuracy.

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Network Level Inspection

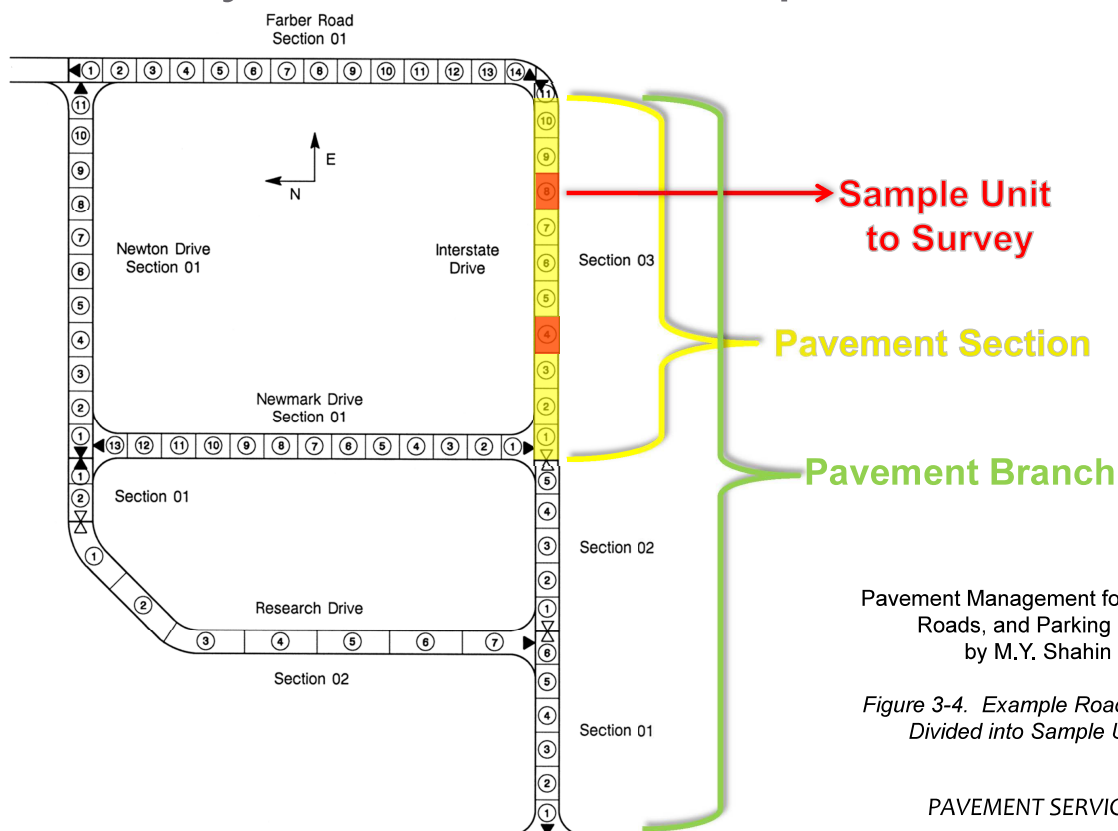
No. of Sample Units in Section (N)	No. of Units to be Inspected (n)
1 to 5	1
6 to 10	2
11 to 15	3
16 to 40	4
over 40	10%
(round up to next whole sample unit)	

Figure 3-10. Example of Network Level Sampling Criteria Used by Some Agencies.

Pavement Management for Airports,
Roads, and Parking Lots
by M.Y. Shahin

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Roadway Divided Into Sample Units



Pavement Management for Airports,
Roads, and Parking Lots
by M.Y. Shahin

Figure 3-4. Example Road Network Divided into Sample Units.

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Distress Identification

ASTM D6433-11: Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys -- ASPHALT DISTRESSES

- Alligator Cracking
- Bleeding
- Block Cracking
- Bumps and Sags
- Corrugation
- Depression
- Edge Cracking
- Joint Reflection Cracking
- Lane Shoulder Drop Off
- Longitudinal/ Transverse Cracking
- Patching/ Utility Cut Patching
- Polished Aggregate
- Pothole
- Railroad Crossing
- Rutting
- Shoving
- Slippage Cracking
- Swelling
- Raveling
- Weathering

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Distress Identification

ASTM D6433-11: Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys -- PORTLAND CEMENT CONCRETE DISTRESSES

- Blow-up
- Corner Break
- Divided Slab
- Durability Cracking
- Faulting
- Joint Seal Damage
- Lane Shoulder Drop Off
- Linear Crack
- Small Patch
- Large Patch
- Polished Aggregate
- Popouts
- Pumping
- Punchout
- Railroad Crossing
- Scaling
- Shrinkage Cracking
- Corner Spall
- Joint Spall

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Field Distress Manuals

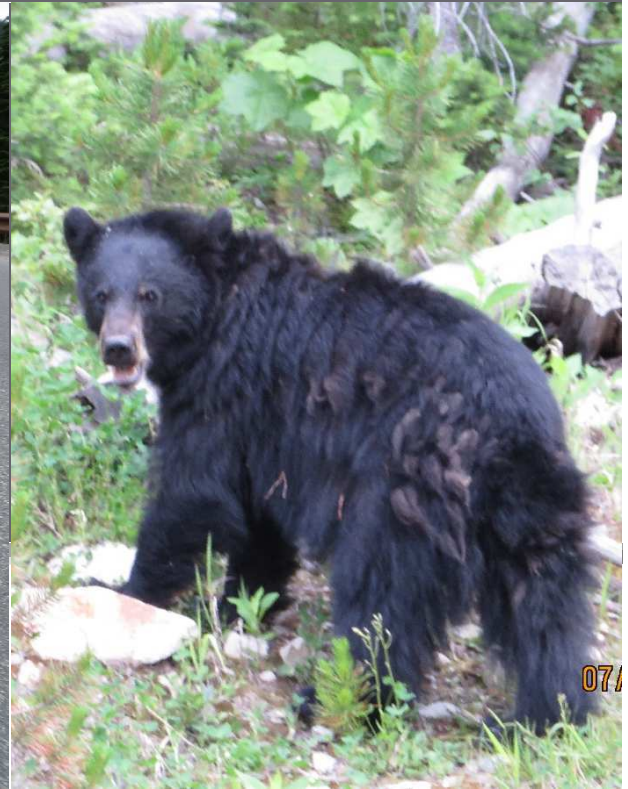


Quality Management Program

- Verify Qualified Raters are Used
- Establish a Quality Control Plan Prior to Rating
- Agency and Consultant should both Verify Collected Data
- Quality Management Programs Minimizes “Garbage In-Garbage Out”

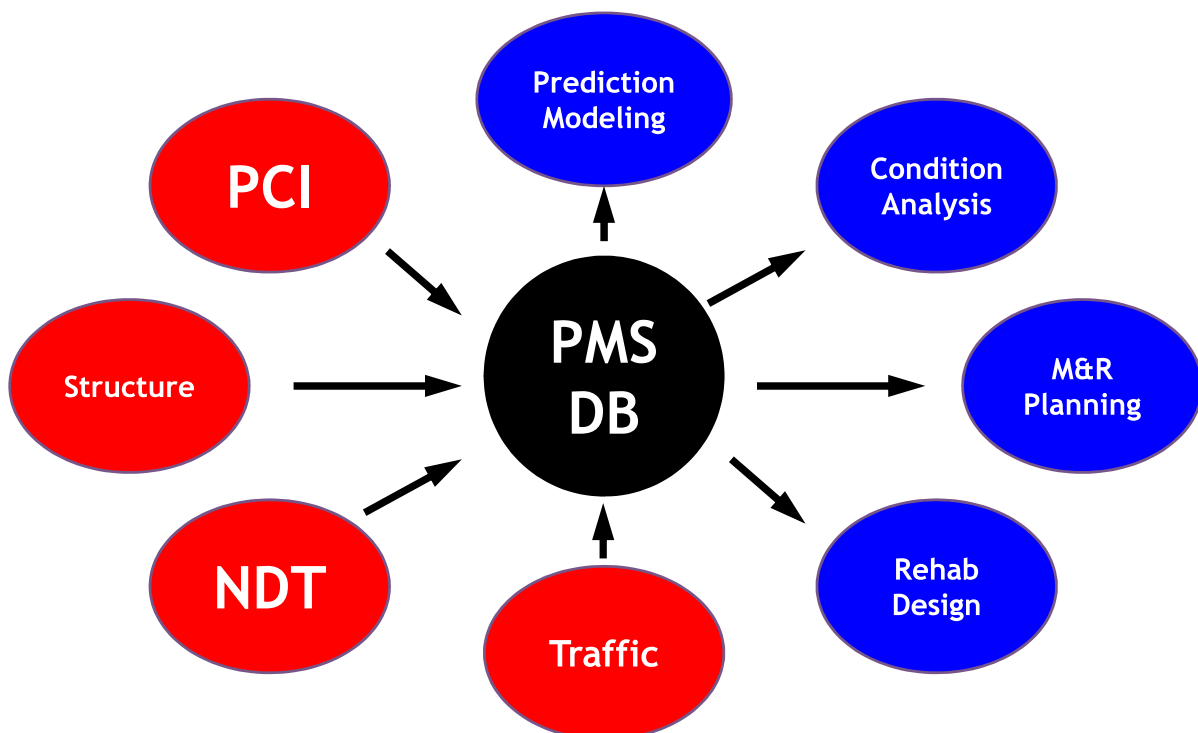


PCI Safety Hazard!



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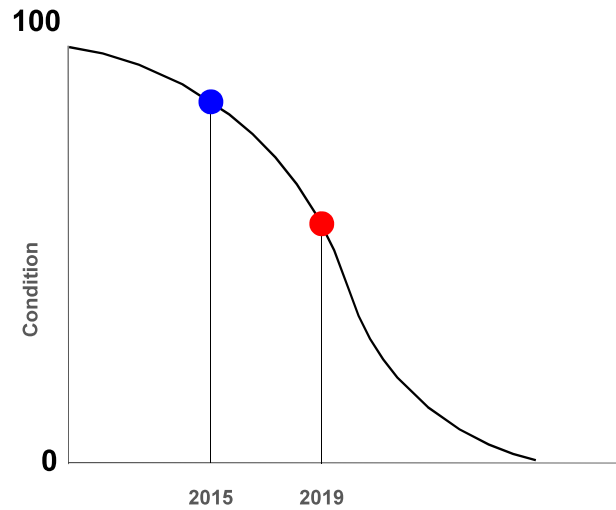
Pavement Management System



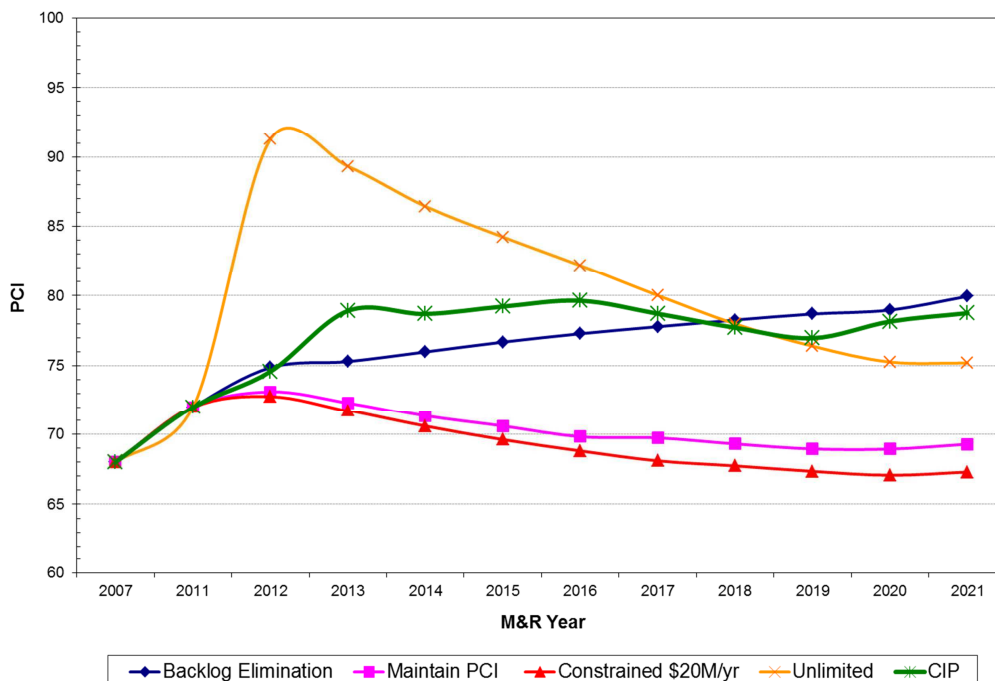
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PMS Data Analysis

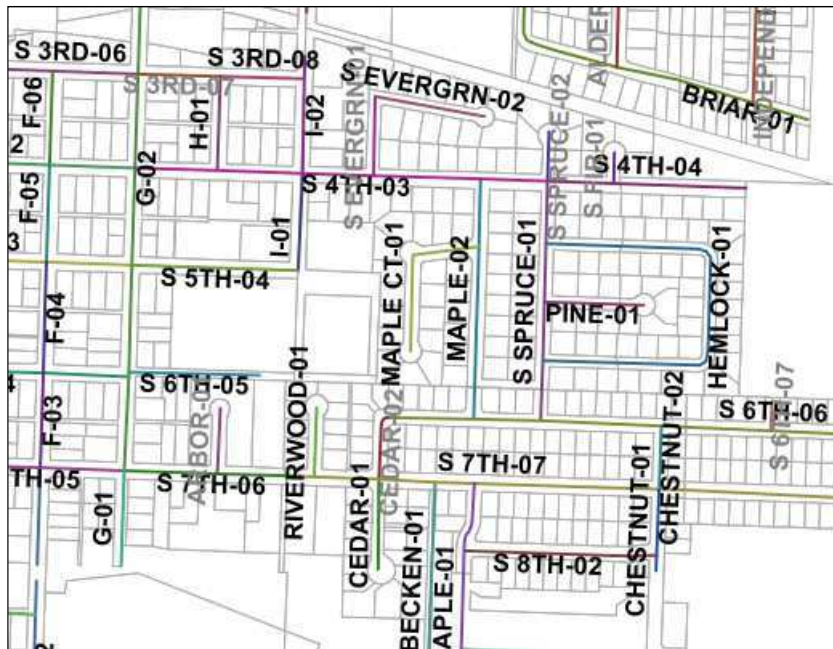
- Compute Current Pavement Condition
- Predict Future Pavement Condition
- Select Feasible Repair Types
- Select Optimal Repair Types & Timing
- Prioritize Repair Projects
- Develop Localized Repair and Preservation Plans
- Develop Multi-Year Capital Improvement Program



Analysis of Budget Scenarios



Prioritized Project Plan



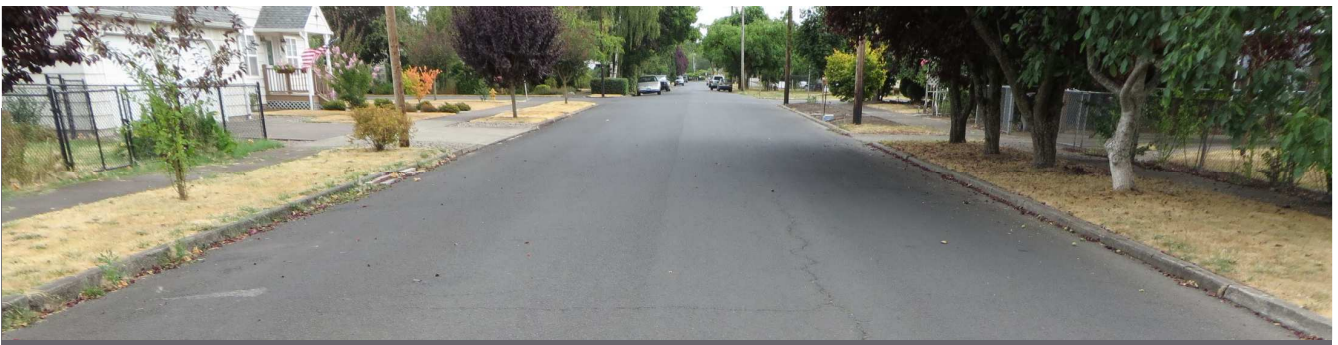
- 2016
- 2017
- 2018
- 2019
- 2020

PAVEMENT SERVICES, INC. 

Prioritized 10-Year M&R Plan

Project	Construction Year	PMP Sections	Total Project Area (sf)	Area Weighted PCI at Construction Year	Total Project Cost (2012 Dollars)	Cost with Escalation
12-01 TW C and RW 28 Deice Mill and OL-Structural	2012	2	246,941	55	\$4,009,122	\$4,009,122
12-02 TW G, TW R Mill and OL-Functional	2012	4	292,879	56	\$2,652,429	\$2,652,429
12-03 TW P Mill and OL-Structural	2012	1	35,821	59	\$581,559	\$581,559
12-04 TW A Mill and OL-Structural	2012	3	114,407	55	\$1,857,414	\$1,857,414
12-05 TL at Ramp AB Mill and Overlay-Functional	2012	2	80,108	66	\$725,490	\$725,490
12-06 B Gates Concrete Pavement Restoration	2012	3	254,453	52	\$4,501,543	\$4,501,543
12-07 RW 15L-33R Mill and OL-Functional	2012	7	501,399	71	\$4,540,869	\$4,540,869
12-08 TW J, K, Q Mill and OL-Structural	2012	14	369,404	64	\$5,997,326	\$5,997,326
13-01 Runway 10-28 RSA Rehab	2013	18	2,222,343	54	\$20,126,425	\$20,629,586
13-02 TWF and TWR (at RW 10) Mill and OL-Functional	2013	3	117,560	62	\$1,064,670	\$1,091,287

PAVEMENT SERVICES, INC. 



Pavement Management for Local Agencies

Thank you!

John Duval, P.E.
john@psipdx.com



PAVEMENT SERVICES, INC. 

MnROAD-NCAT

Pavement Preservation Study

55th Annual
Idaho Asphalt Conference
October 22, 2015



Pavement Preservation

“A program employing a network level, long-term strategy that enhances pavement performance by using an integrated, cost-effective set of practices that **extend pavement life**, improve safety and meet motorist expectations”

- FHWA Pavement Preservation Expert Task Group



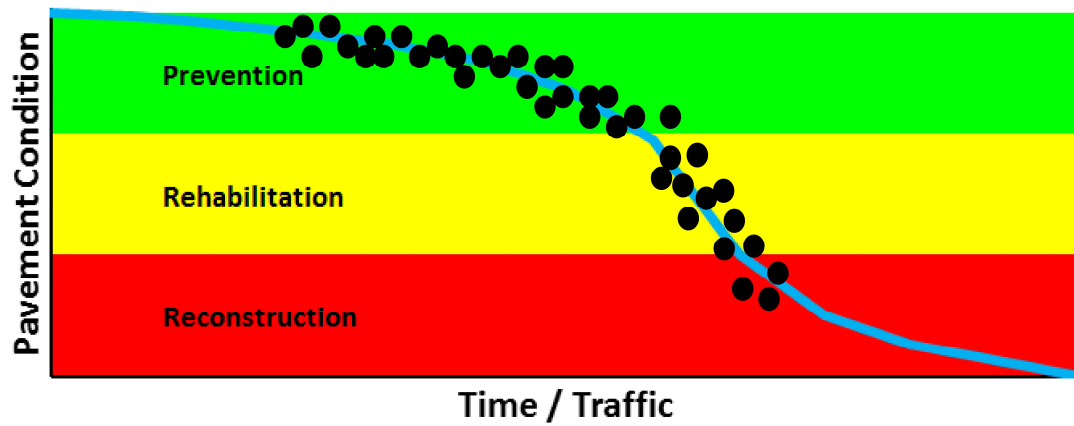
Pavement Preservation Study

Objectives:

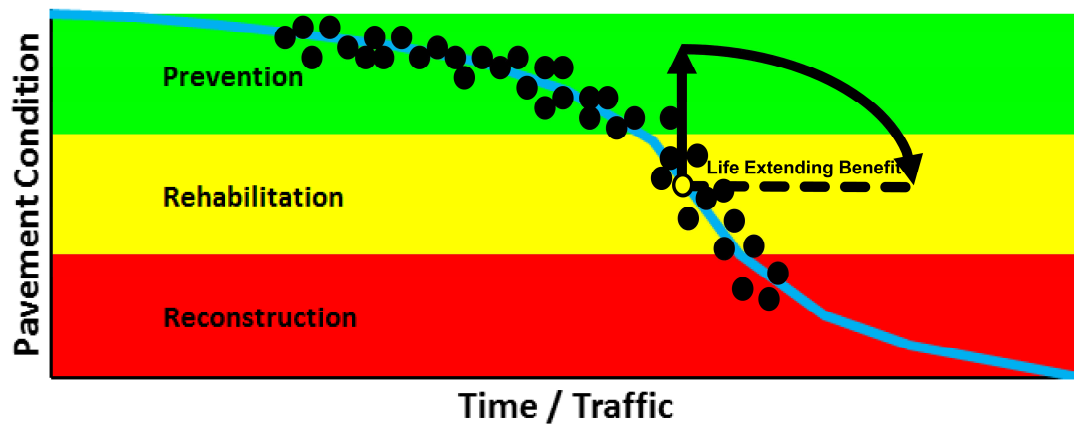
1. Quantify the life extending benefits of study treatments
2. Provide guidance on appropriate inspection and sampling and testing methods for use in construction quality assurance.



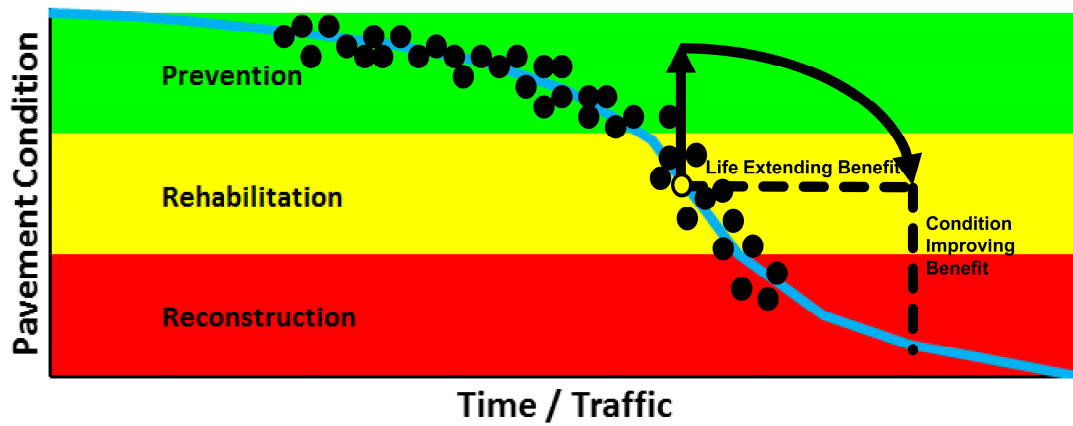
Pavement Preservation



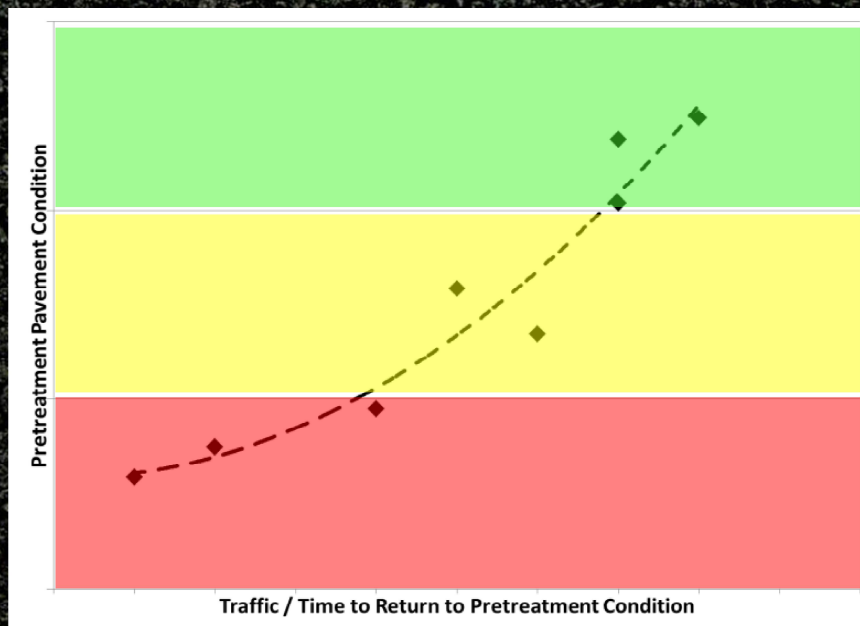
Pavement Preservation



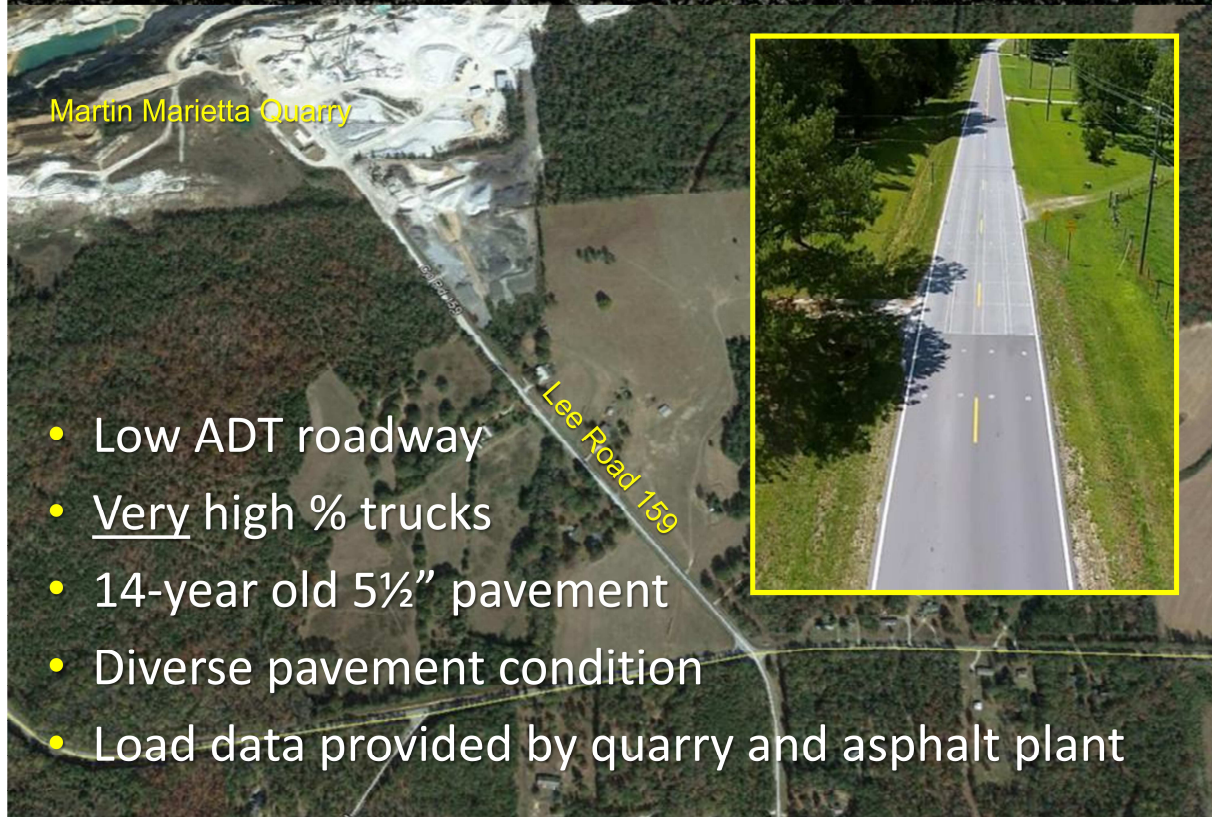
Pavement Preservation



Pavement Preservation



Pavement Preservation on Lee Road 159



- Low ADT roadway
- Very high % trucks
- 14-year old 5½" pavement
- Diverse pavement condition
- Load data provided by quarry and asphalt plant

Pavement Preservation on Lee Road 159

- | | |
|---|--|
| 1. Rejuvenating Fog Seal | 14. Fibermat + Microsurfacing (Cape) |
| 2. Fibermat | 15. Scrub Seal + Microsurfacing (Cape) |
| 3. Control | 16. Scrub Seal |
| 4. Control | 17. Distress Demo Section |
| 5. Crack Seal (CS) | 18. Fibermat + HMA thinlay (HMA Cape) |
| 6. Single Layer Chip Seal | 19. HMA Thinlay (PG 67-22) |
| 7. CS + Single Layer Chip Seal | 20. HMA + 100% Foamed Recycle Inlay |
| 8. Triple Layer Chip Seal | 21. HMA Thinlay (PG 76-22) |
| 9. Double Layer Chip Seal | 22. Ultra Thin Bonded Wearing Course |
| 10. Microsurfacing + Single Chip (Cape) | 23. HMA Thinlay (50% RAP) |
| 11. Microsurfacing | 24. HMA Thinlay (5% PCRAS) |
| 12. CS + Microsurfacing | 25. HMA Thinlay (High Polymer) |
| 13. Double Layer Microsurfacing | |

Pavement Preservation on Lee Road 159

- Rutting, roughness, texture
- Surface friction
- Subgrade moisture contents
- Falling weight deflectometer (FWD)
- Visual and video based cracking measurement



MnROAD-NCAT Partnership



Focusing on 2 National Research Needs

National Pavement Preservation Study

Validation of Cracking Test(s) for Mix Design and QA





Thermal Crack



We all have a stake in **A10B**



National Pavement Preservation Effort

- **Partnership Development**

- Partnership formalized in July 2015
- Build off the strength of NCAT and MnROAD
- States / Academia / Industry involvement
- FP² / National Center for Pavement Preservation

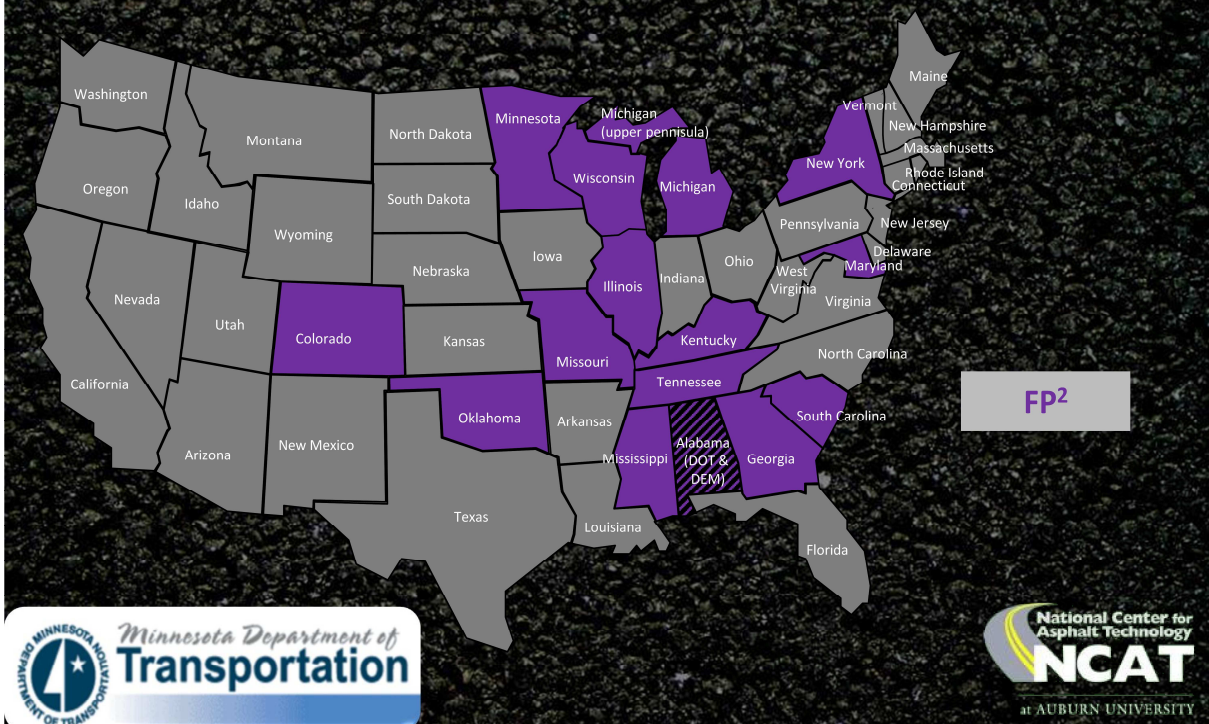


- **Study / Test Sections**

- North (Minnesota) / South (Alabama) Climatic Zones
- Low and High Volume Roads both locations
- Common (Core) Treatments in study
- Provide consistently collected data / analysis



PG 2015 Research Sponsors



2015 Preservation Continuation/Expansion

- Continue monitoring sections on LR 159
- Build new sections on higher ADT roadway in Alabama
- MnROAD to build low and high traffic experiment in 2016 with same core treatments for cold climate.



Higher ADT Off-Track Preservation



- US-280 3 miles to east of Track
- 17,000 ADT, ≈ 9 year old surface
- Westbound outside lane
- Tenth mile sections
- Repeat Lee Road 159 ($\pm$)
- Add CCPR_{F,E}, CIR_{F,E}
- Thin overlays with RAP & RAS



Treatments

- Control Sections
- Surface Treatments
 - Crack Sealing
 - Fog Seal
 - Chip Seals
 - Scrub Seals
 - Microsurfacing
 - Combinations (Cape Seals)
- Thin Overlays (3/4")
 - Dense Graded (4.75 mm)
 - OGFC
 - UTBWC
 - Combinations
- Cold Recycling + 1" overlay
 - Cold-in-place (CIR)
 - Cold Central Plant Recycle (CCPR)



Crack Sealing



Scrub Seal



Fibermat Chip Seal



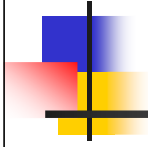
MicroSurfacing



Cold In-Place Recycling



COMPACTION MONITORING SYSTEM FOR ASPHALT PAVEMENTS



Emad Kassem, Tom Scullion, Eyad Masad,
Arif Chowdhury, and Wenting Liu



October 22, 2015.



Motivation

Variability of field density due to unequal coverage and overlapping

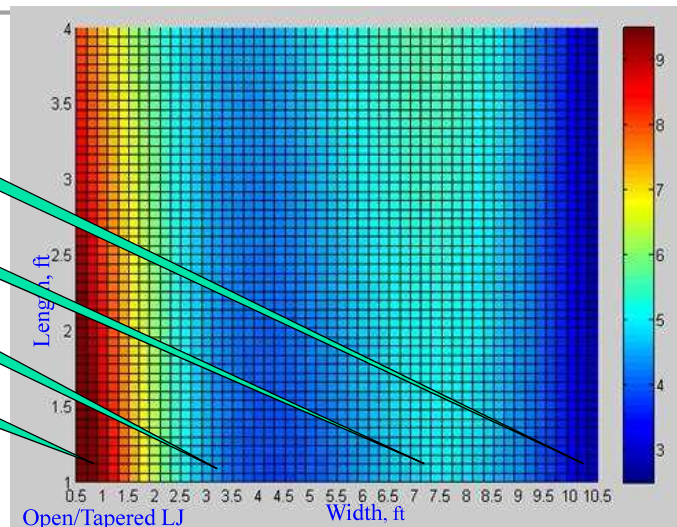
Density has a great effect on the performance

3.0%

5.7%

4.8%

10.0%



Typical Air Void Distribution in a Field Project



Objectives

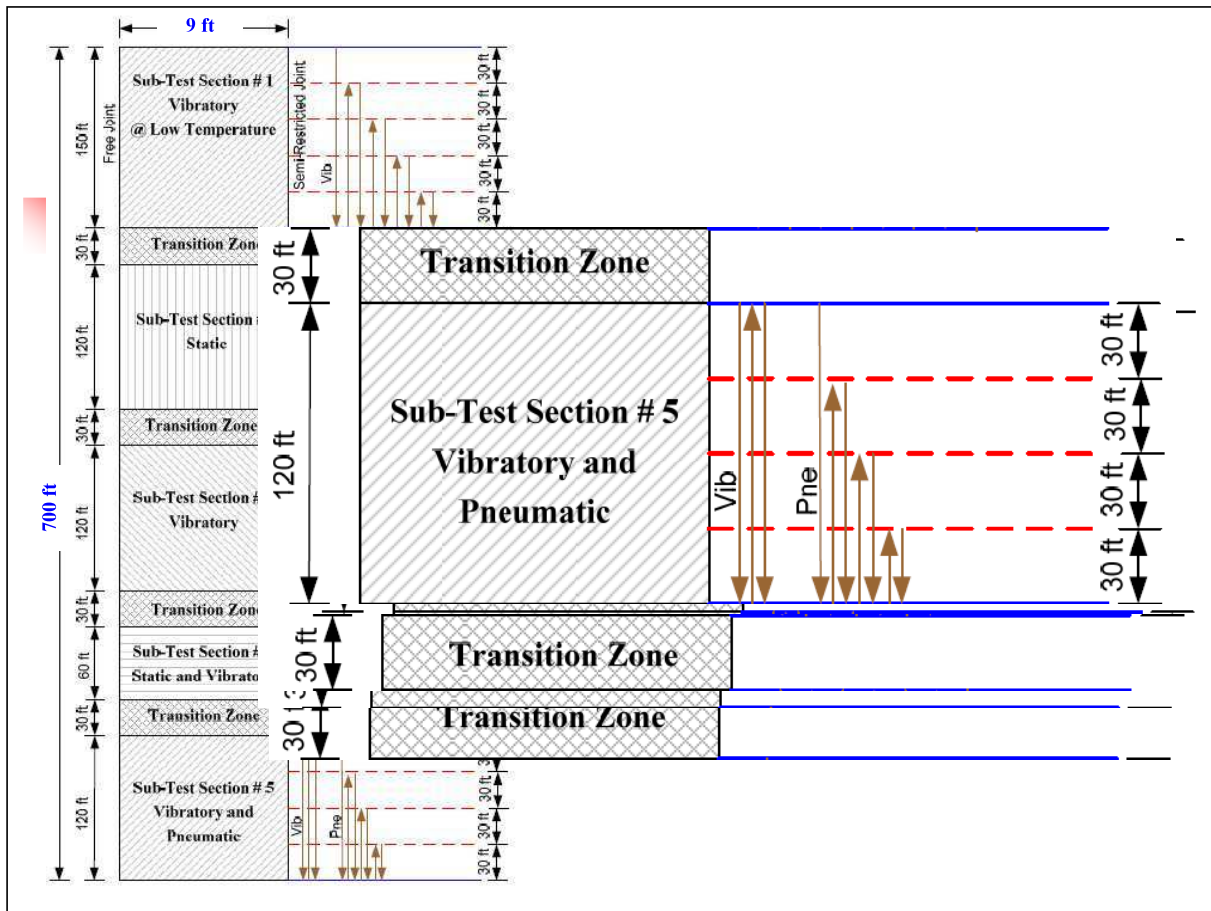
- Study the effect of the following factors on mixture compactability; compaction method, mixture type, support condition, temperature
- Verify the concept of the Compaction Index; as a tool to control uniformity of asphalt pavement compaction
- Study the effect of joint conditions (restricted vs. unrestricted) on the density of the longitudinal joints
- Propose a method for predicting the density of asphalt pavements in the field.

Construct Test Sections

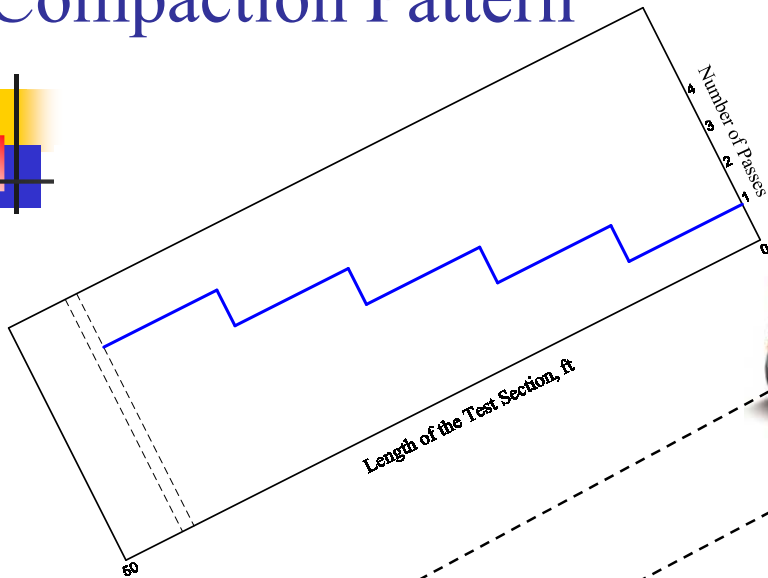


Test Section	Mixture Type	Support
1	2-in Type C PG 76-22, HMA	Concrete Runway
2	2-in Type D PG 64-22, HMA	Concrete Runway
3	2-in Type D PG 64-22, WMA	Concrete Runway
4	2-in Type C PG 76-22, HMA	Asphalt Taxiway
5	2-in Type D PG 64-22, HMA	Asphalt Taxiway

- Compaction methods; static, vibratory, and pneumatic
- Asphalt mixtures; HMA (Type C & D), and WMA (Type D)
- Base conditions; rigid and flexible
- Joint conditions; restricted, un-restricted
- Temperature; designed compaction temp & lower temp.

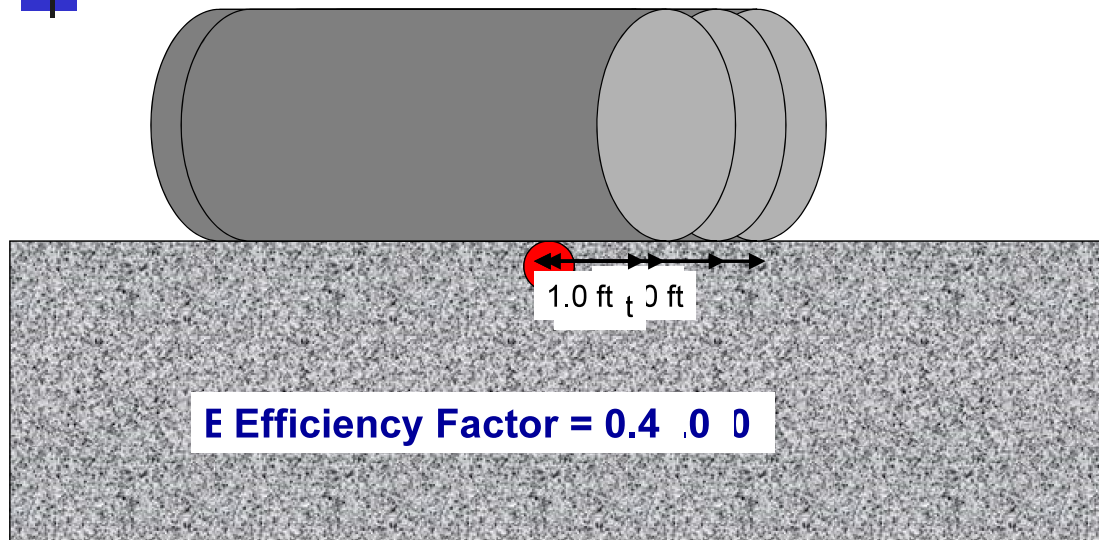


Compaction Pattern



Efficiency Distribution of the Compactive Effort

The center of the roller has better compaction effectiveness than the edge.

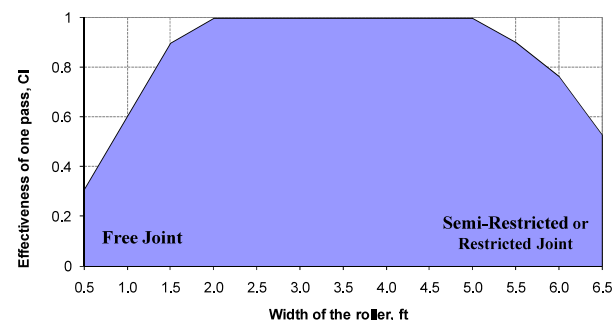


Evaluate the Efficiency Distribution of the Compactive Effort across the Roller Width

■ Compaction Index (CI) = Σ (number of passes * EF of each pass)

R-squared Values

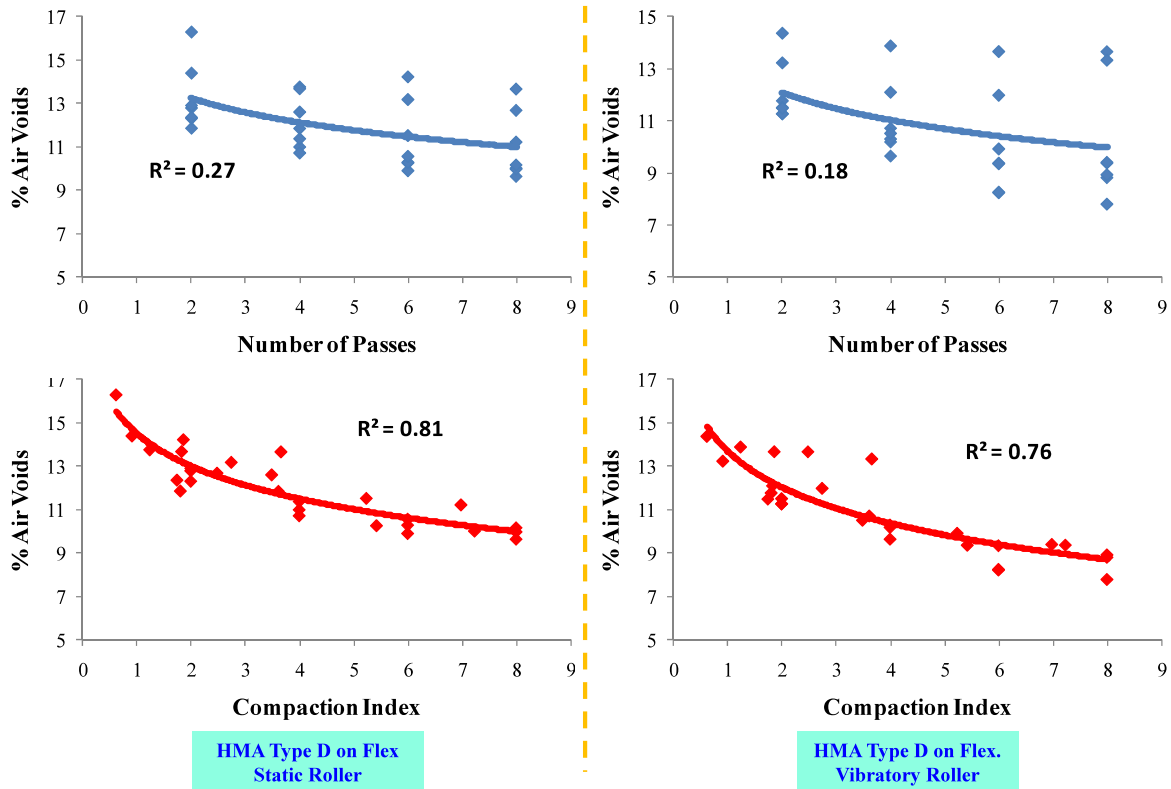
Test Section #	Compaction Method	R-squared	
		%AV vs. N	%AV vs. CI
Type C HMA on Rigid	Static	0.44	0.82
	Vibratory	0.52	0.83
Type D HMA on Rigid	Static	0.60	0.63
	Vibratory	0.68	0.81
	Vibratory*	0.81	0.88
Type D WMA on Rigid	Static	0.87	0.79
	Vibratory	0.89	0.87
	Vibratory*	0.84	0.91
Type C HMA on Flex.	Static	0.64	0.93
	Vibratory	0.57	0.93
	Vibratory*	0.47	0.75
Type D HMA on Flex.	Static	0.27	0.81
	Vibratory	0.18	0.76
	Vibratory*	0.27	0.76



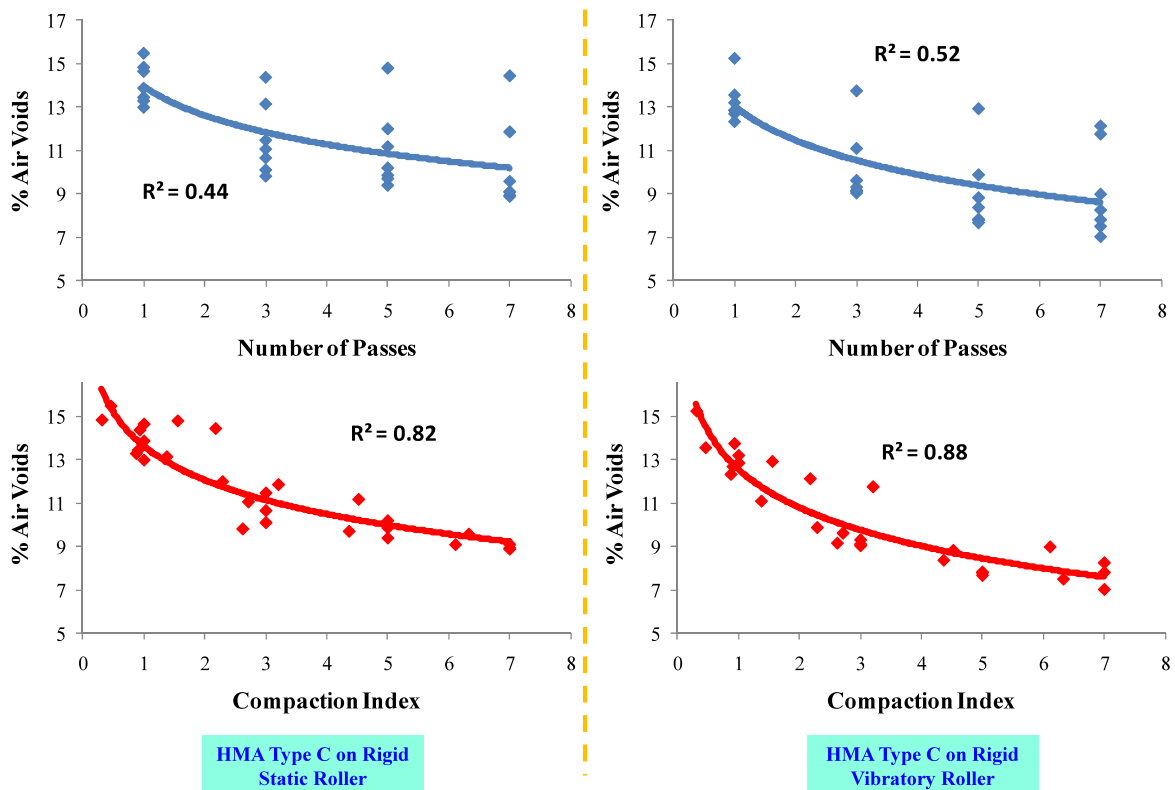
Efficiency Distribution of the Compactive Effort across Roller Width

*These test sections were compacted at lower temperatures

Examples of Correlations



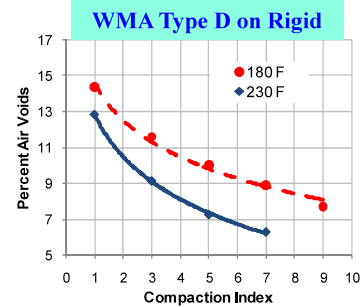
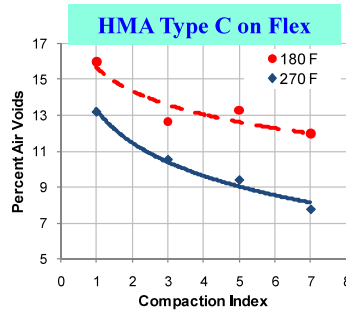
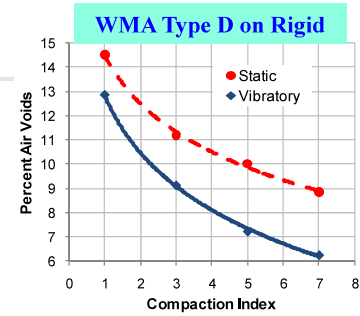
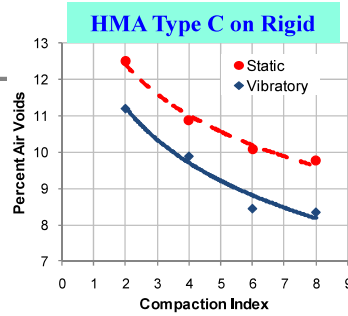
Examples of Correlations



Influence Compaction Method and Temperature

Vibratory rollers applied more compactive effort on the mat than the static rollers

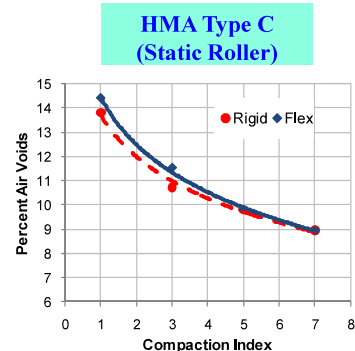
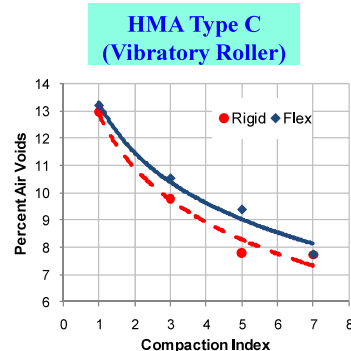
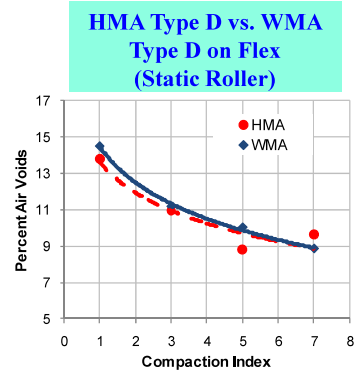
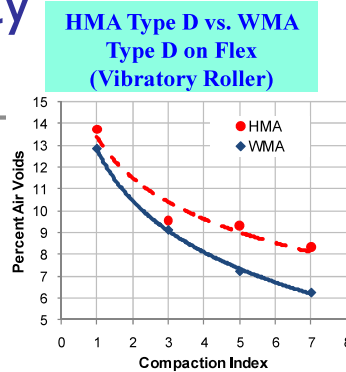
On average, there was 10% increase in the measured percent air voids per 30°F reduction in the compaction temperature



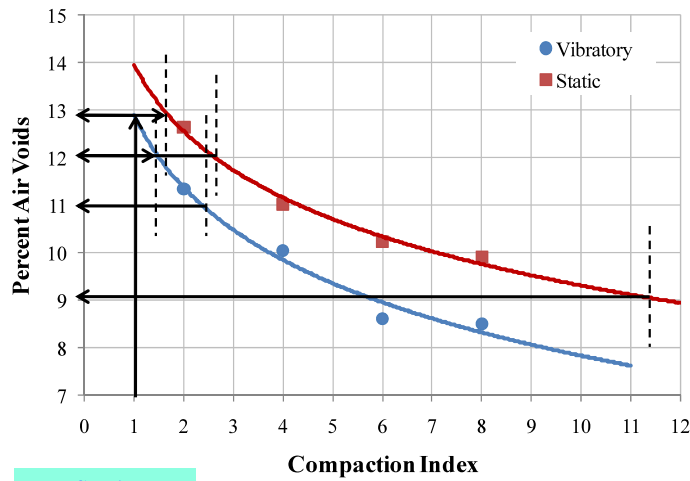
Influence of Mixture Design and Base Type on Density

WMA is easier to compact than the HMA; vibratory rollers

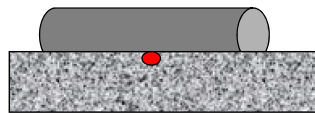
HMA over a rigid base, had slightly higher density than the corresponding mixtures on a flexible base



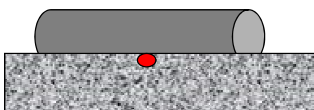
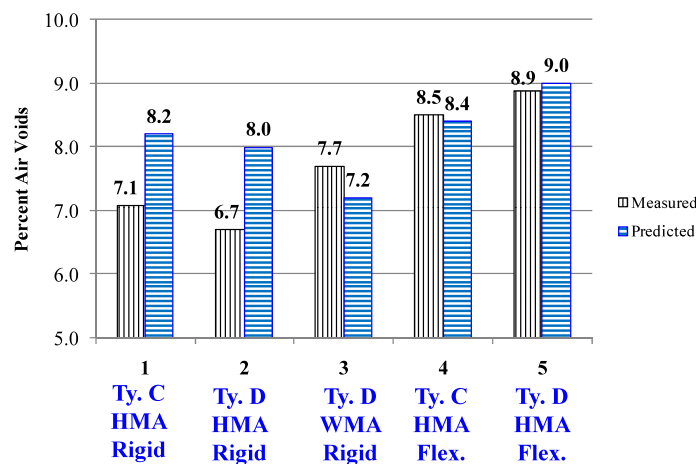
Proposed Method for Prediction of the Density Level in Real-Time



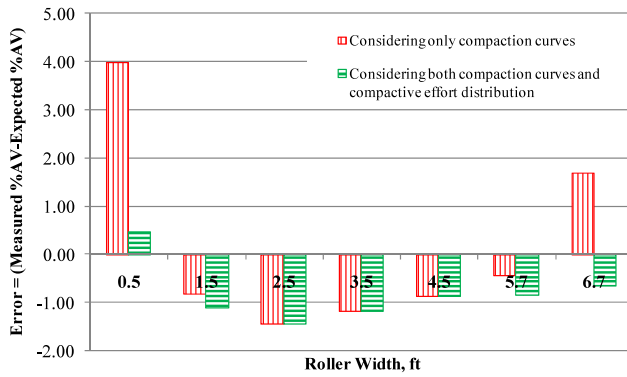
No. of Passes	Compaction Pattern	Predicted %AV	Measured % AV
4	Static	10.5	8.9
5	Vibratory	9.8	
6	Static	9.6	
7	Vibratory	9.2	



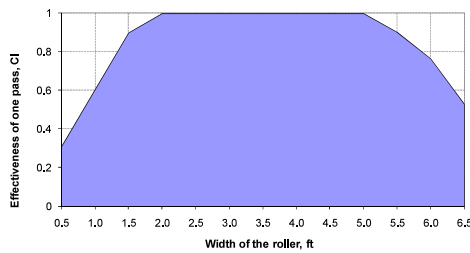
Proposed Method for Prediction of the Density Level in Real-Time



Predicted and Measured Percent Air in the middle of the mat

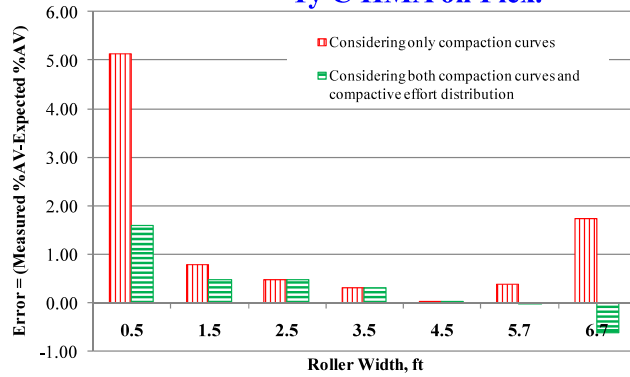


Error in Predicting Density Level for Test Section 1; Ty C HMA on Rigid



Efficiency Distribution

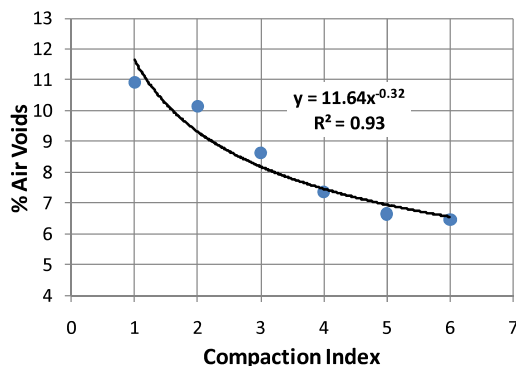
Error in Predicting Density Level for Test Section 4 Ty C HMA on Flex.



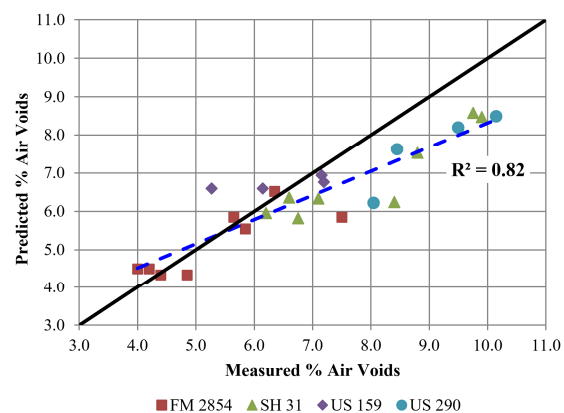
Field Validation

- Good correlation between predicted and measured air voids
- This prediction is based only on one compaction curve (BD); for more accurate prediction, separate compaction curves required

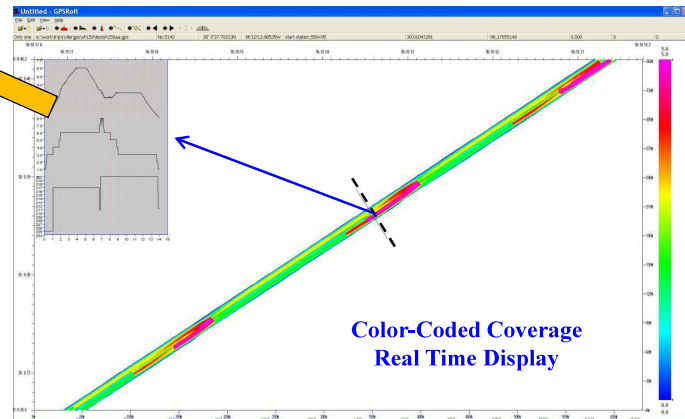
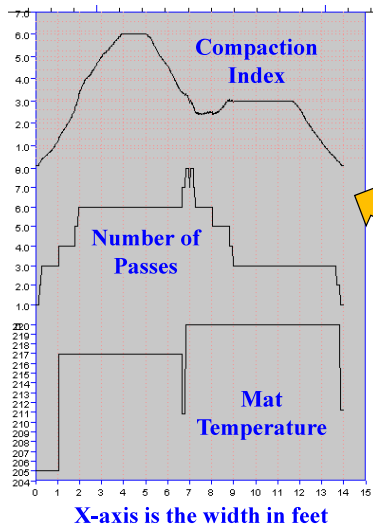
Correlation between predicted and measured % air voids for some field projects



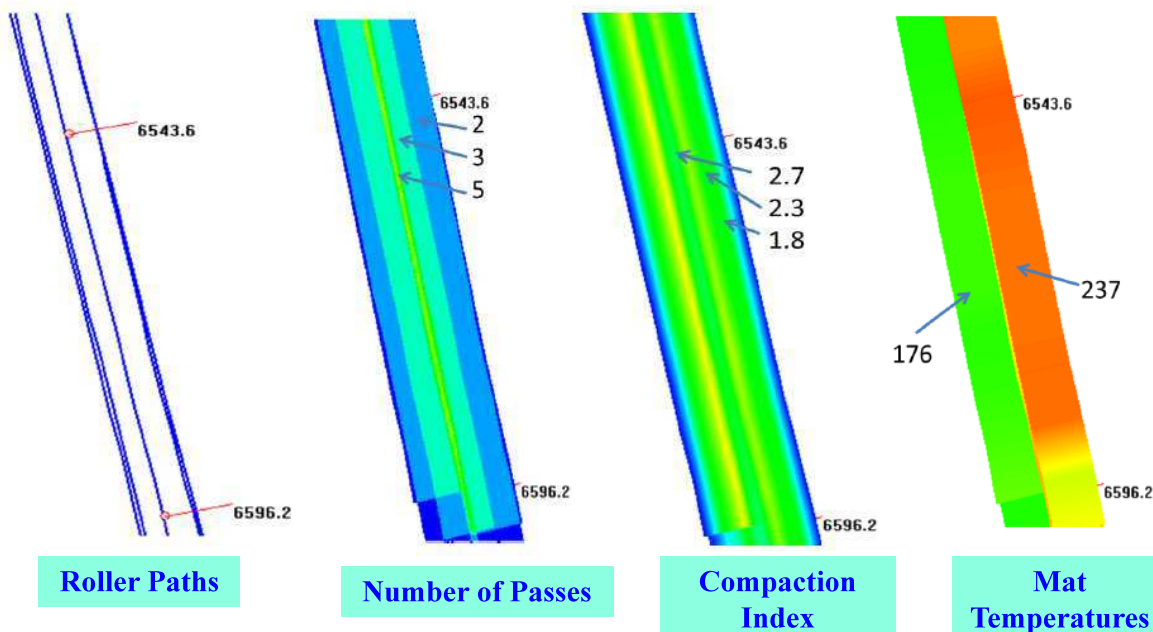
An example of Compaction Curve for BD Roller; SH 31



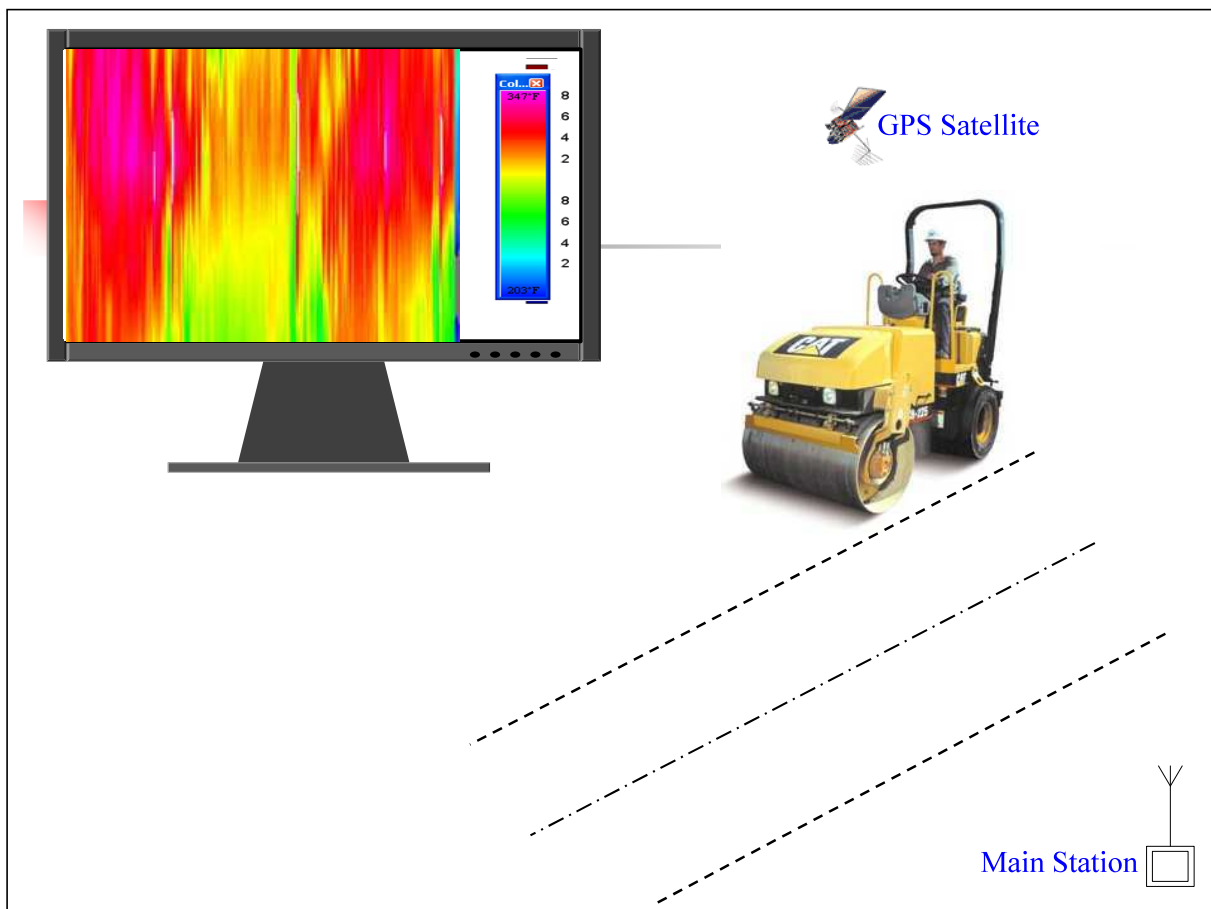
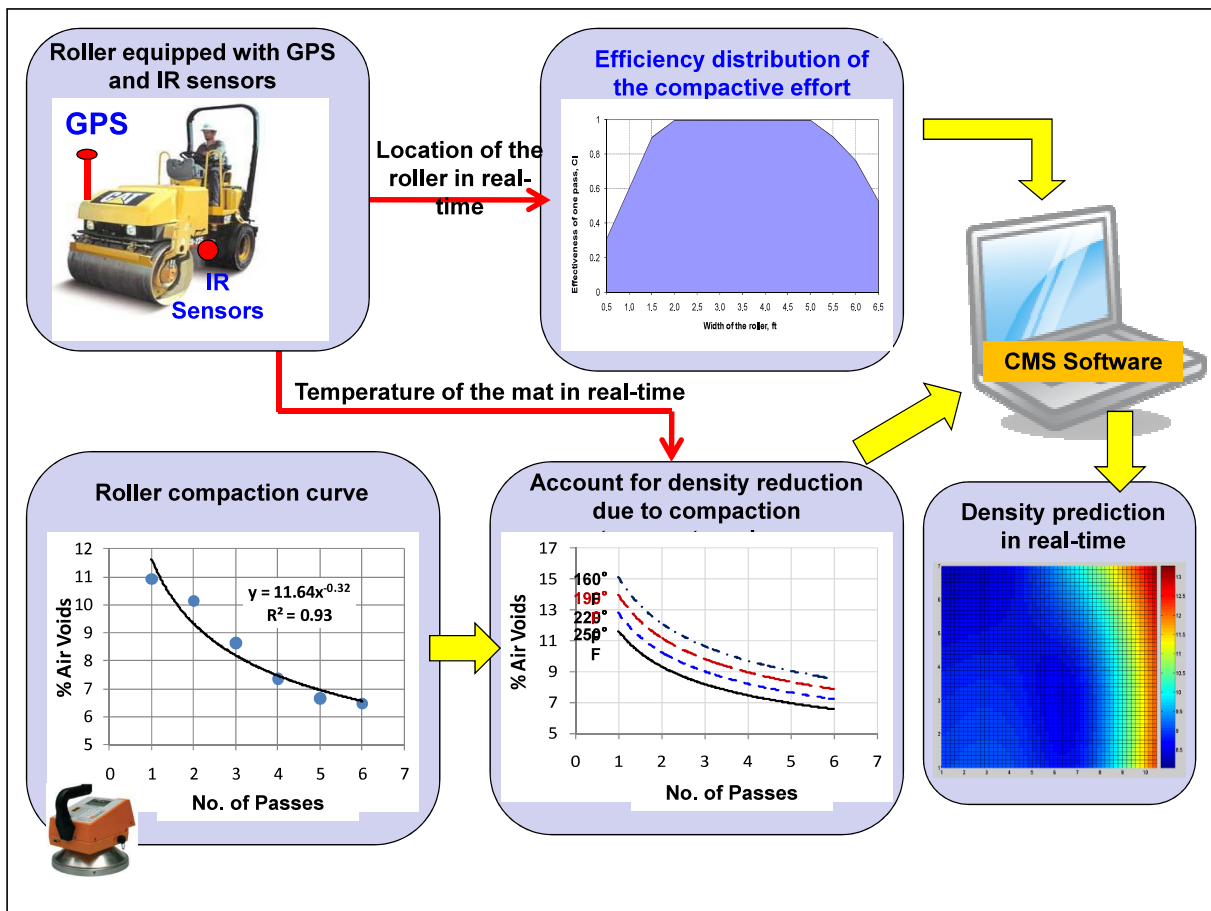
Phase II: Compaction Monitoring System



Phase II: Compaction Monitoring System



Compaction Data from US 87 recorded using CMS





Questions



Performance-based Design Method of Asphalt Mixes that Contain Reclaimed Asphalt Pavement (RAP)

**Haifang Wen, PhD, PE
Kun Zhang, PhD Student
Washington State University**

**Fouad Bayomy, PhD, PE
Ahmed Muftah, PhD Student
University of Idaho**

***Idaho Asphalt Conference
Oct 22, 2015***



Issues related to usage of high RAP

- **Availability**
- **Variability**
- **Cracking potential**
- **Extraction and recovery of RAP binder**
- **Blending mechanism not fully understood**
- **Lack of performance tests or associated cost**
- **.....**

Outline

- **Introduction**
- **Materials and Experiments**
- **Results & Discussion**
- **Conclusions**

3

Introduction



- Aged binder in RAP increased brittleness of mixes, resulting in susceptibility to pavement cracking.
- Softer virgin binder is used based on RAP binder replacement ratio:
 - <17%, no adjustment.
 - 17%~30%, one grade lower.
 - >30%, blending chart is used; complete blending is assumed, which may not be always reasonable.
- Current mix design is based on volumetric properties, not performance-related.

4

Results of PG of Recovered Binder

- **North RAP Binder: PG 75.8-23.6 (PG70-22)**

	PG of Recovered North RAP binder					
	1	2	3	Average	Std	COV
High Temperature	76.9	74.9	75.5	75.8	1.0	1.3%
Low Temperature	-22.7	-24.6	-23.6	-23.6	1.0	4.2%

- **South RAP Binder: PG 85.2-16.8 (PG82-16)**

	PG of Recovered South RAP binder					
	1	2	3	Average	Std	COV
High Temperature	85.3	85.1	85.1	85.2	0.115	0.14%
Low Temperature	-17.0	-16.7	-16.8	-16.8	0.153	0.91%

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Materials and Experiments

- North mixes
 - N0, N17, N30, N50, and NF30
- South mixes
 - S0, S17, S26, S50, and SF26

North Mixes	PG of Virgin Binder	South Mixes	PG of Virgin Binder
N0	58-28 (Target)	S0	70-28 (Target)
N17	58-28	S17	70-28
N30	52-34	S26	64-34
N50	52-34 (40-34*)	S50	58-34 (58-40*)
NF30	52-34	SF26	64-34

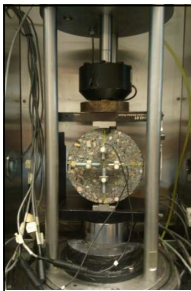
6

Materials and Experiments

- Short-term and long-term aging
- Dynamic modulus test
- Rutting resistance
 - Flow number test
- Fatigue cracking resistance
 - Indirect tensile test (IDT) at 68°F.
 - Bottom-up cracking resistance: fracture work density.
 - Top-down cracking resistance: vertical failure deformation.
- Thermal cracking resistance
 - IDT at 14°F.
 - Fracture work density.



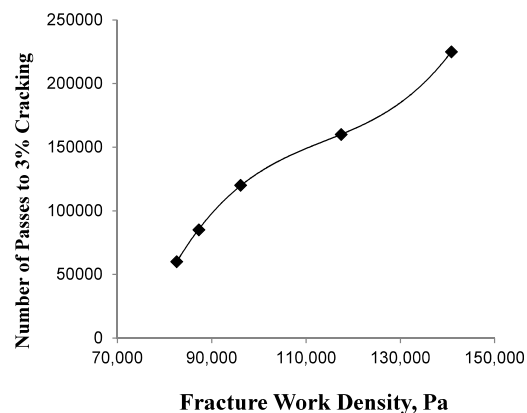
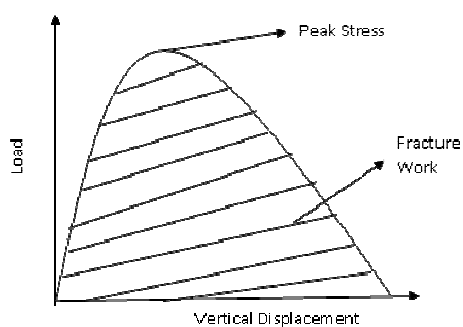
7



Fracture Work Density



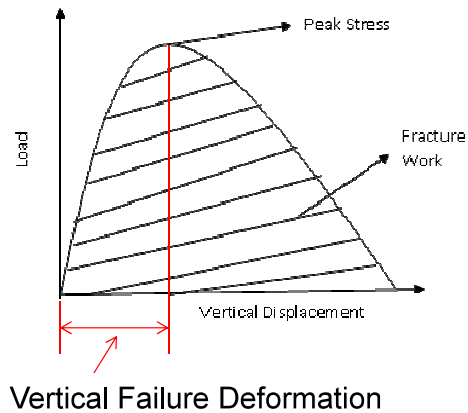
- Bottom-up fatigue cracking - fracture work from Indirect tensile test at 68°F (Wen et al. 2011)



8

Vertical Failure Deformation

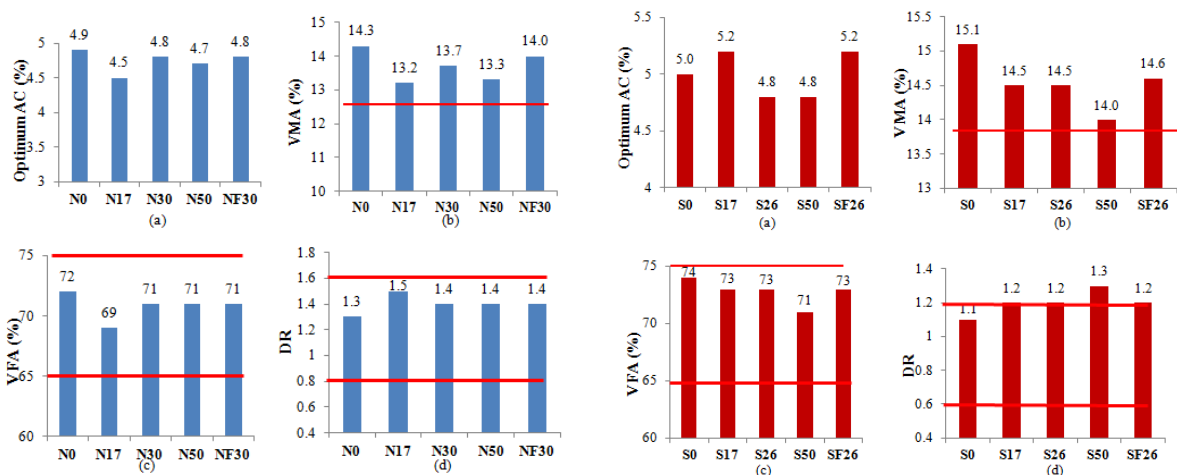
- Top-down cracking – vertical failure deformation (Wen et al. 2015)



9

Results and Discussion

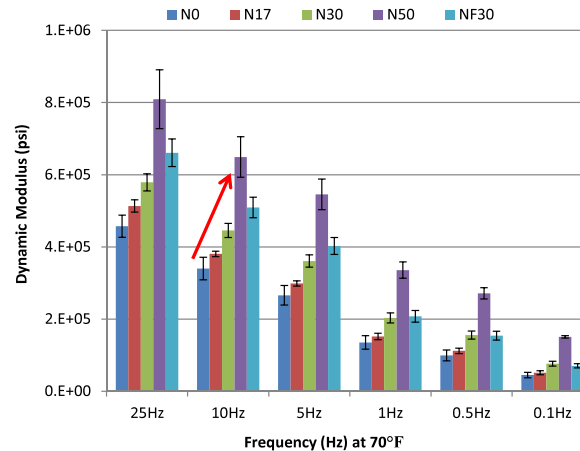
- Mix Design-North mixes (blue) & South mixes (red)**
 - Mixes contain up to 50 percent RAP could be produced and satisfy the specification requirements of volumetrics.
 - However, inclusion of RAP could significantly change the volumetrics of asphalt mixes, which could affect mix performance.



0

Results and Discussion

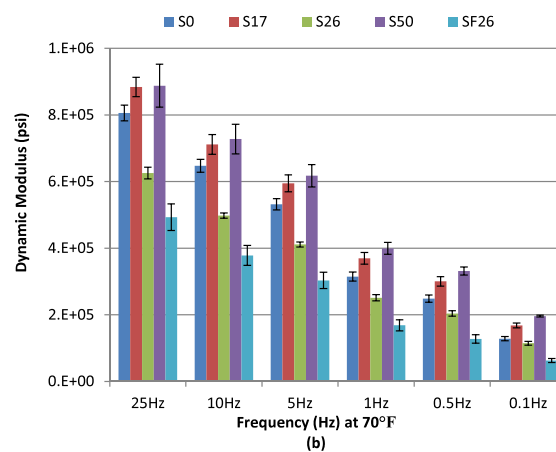
- Dynamic modulus test-North mixes:
 - Binder grade adjustment did not offset the stiffening effects of RAP binder.



11

Results and Discussion

- Dynamic modulus test-South mixes
 - Dynamic modulus values of S0, S17, and S50 mixes are close to each other, and significantly higher than those of S26 and SF26, e.g. at 70°F.

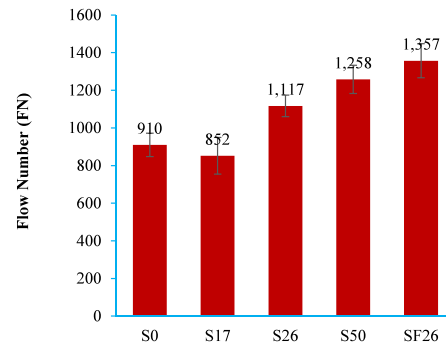
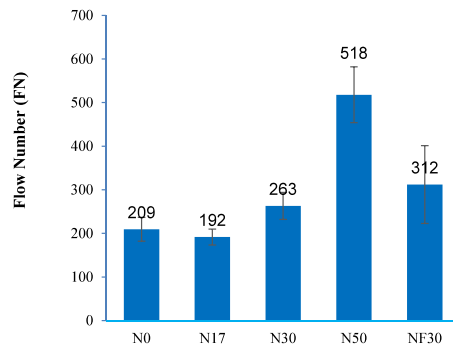


12

Results and Discussion

● Rutting resistance-flow number test

- Mix with low percentage RAP (17% in this study) has similar flow number to control mix.
- Mixes with high RAP (>17%) has increased flow number, with higher resistance to rutting.
- Again, binder grade adjustment did not offset the stiffening effects of RAP binder.

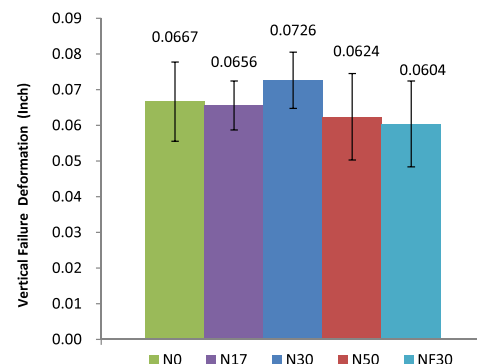
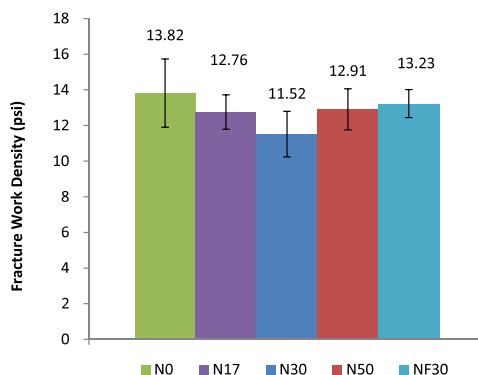


13

Results and Discussion

● Fatigue Cracking Resistance-North mixes

- Target PG of binder is PG58-28.
- Have comparable resistance to bottom-up and top-down fatigue cracking.

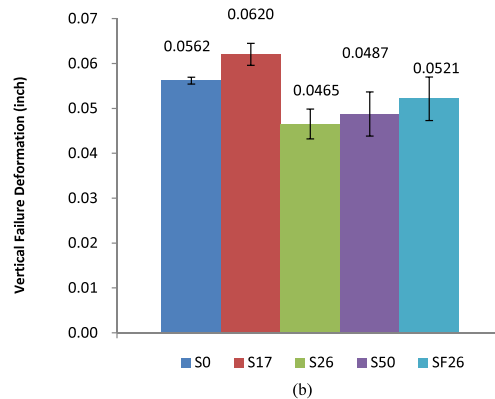
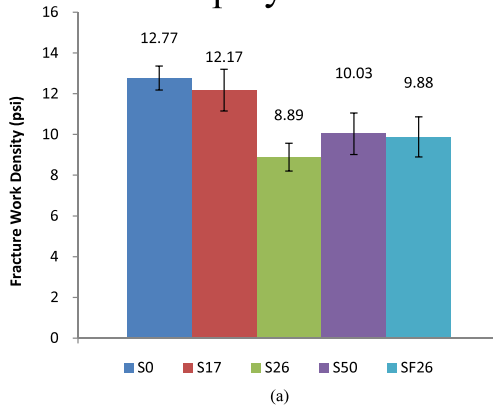


14

Results and Discussion

● Fatigue Cracking Resistance-South mixes

- Target PG of binder is PG70-28.
- S0 and S17 performed identically, and significantly better than S26, S50, and SF26.
- Loss of polymerization?

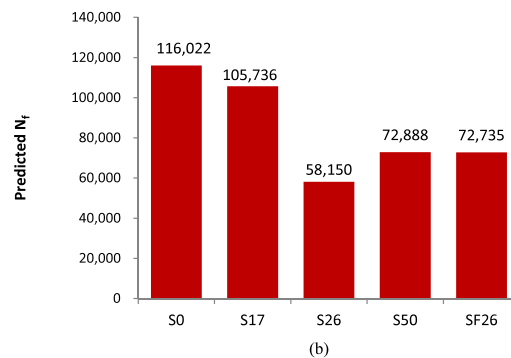
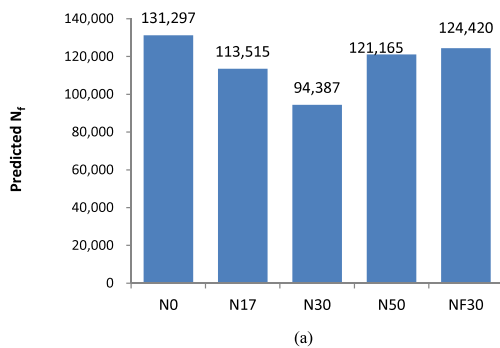
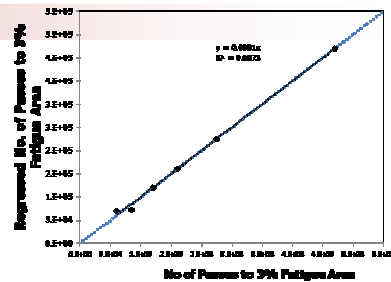


15

Results and Discussion

● Bottom-up cracking fatigue model

$$N_f = 3.75 \times 10^{-5} \left(\frac{1}{\epsilon_t}\right)^{0.147} (FWD)^{1.92} h^{0.135}$$



16

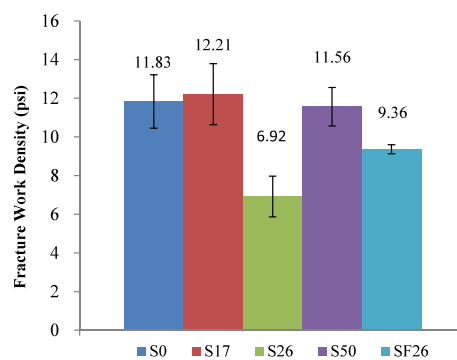
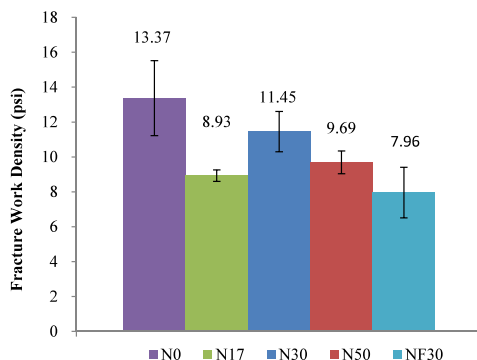
Results and Discussion

- Summary of fatigue cracking resistance
 - Fatigue cracking resistance with low percentage of RAP, e.g. 17%, was comparable to that of control mix.
 - Effects of high percentage RAP (>17%) on fatigue cracking depended on target PG of virgin binder.
 - Low target PG of virgin binder, e.g. PG 58-28: bumping down the grade of virgin binder for high RAP mixes did not affect fatigue resistance, e.g. North mixes.
 - High target PG of virgin binder, e.g. PG 70-28: bumping down the grade of virgin binder for high RAP mixes compromised the fatigue resistance, e.g. South mixes.
 - Recommend to keep the high temperature grade of target binder to avoid elimination or reduction of degree of polymer modification.

17

Results and Discussion

- Low temperature thermal cracking resistance
 - Inclusion of RAP affected thermal cracking performance of asphalt mixes, but was mix-specific.
 - Cracking performance tests shall be considered in mix design.

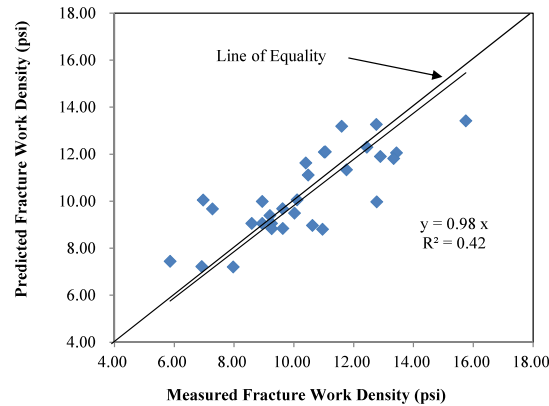


18

Results and Discussion

- Performance-related empirical mix design
 - Based on fracture work at 14°F.
 - Predicted model was moderately effective.

$$FWD_{low} = 9.437 + 0.179P_{RAP} - 5.209AV + 6.690VMA + 1.475PG_{virgin_low} - 0.513PG_{virgin_high}$$



19

Results and Discussion

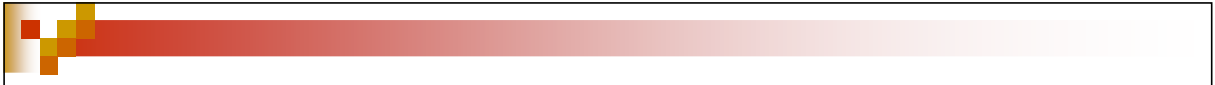
- Procedures of performance-related empirical mix design
 - Selection of low temperature PG of virgin binder for a mix with RAP.
 - (1) Design a control mix without RAP using target PG of virgin binder.
 - (2) Estimate FWD_{low} of the control mix.

$$FWD_{low} = 9.437 + 0.179P_{RAP} - 5.209AV + 6.690VMA + 1.475PG_{virgin_low} - 0.513PG_{virgin_high}$$

- (3) Design a RAP mix to meet volumetrics specification by using target high temperature grade of virgin binder with any low temperature PG.
- $$PG_{virgin_low} = (FWD_{low} - 9.437 - 0.179P_{RAP} + 5.209AV - 6.690VMA + 0.513PG_{virgin_high}) / 1.475$$
 - (4) Determine the low temperature PG of the virgin binder based on above equation.

- Thermal cracking resistance is safeguarded, but binder extraction, recovery, grading of RAP binder, and performance tests of RAP mixes are not needed.

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Conclusions

- Inclusion of RAP could significantly affect volumetrics of asphalt mix.
- Inclusion of RAP could improve rutting resistance, regardless of grade bumping
- Inclusion of low percentage ($<17\%$) of RAP does not affect fatigue cracking resistance, and the effect of inclusion of high percentage ($>17\%$) of RAP on fatigue cracking resistance depended on target PG of binder.
- Inclusion of RAP also affected the thermal cracking performance of asphalt mixes, but was mix-specific.
- A performance-related mix design method was developed to guarantee thermal cracking resistance.

21

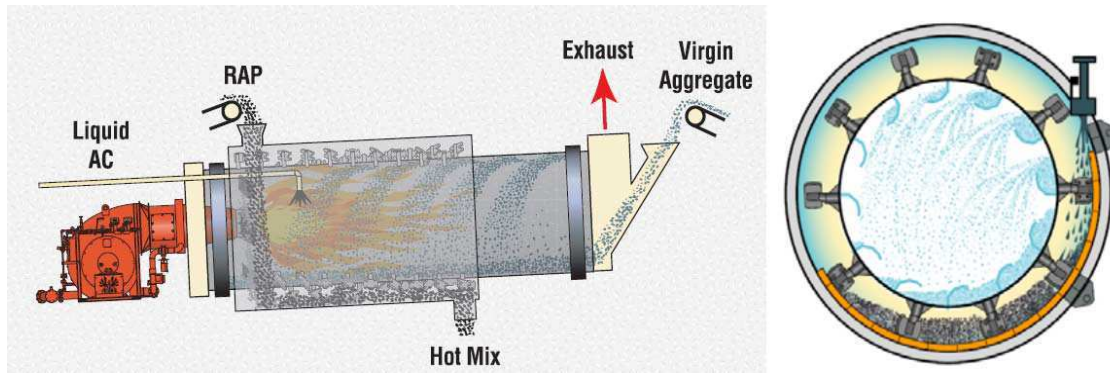


Investigation of Effects of Different Blending Stages on Mix Performance: A WCAT Study

Haifang Wen
Kun Zhang
Washington State University

Investigation of Blending Mechanisms for RAP Binder and Virgin binder

- The production of asphalt mix in asphalt plant greatly affects the blending between RAP binder and virgin binder



(<http://www.astecinc.com/products/drying-mixing/sequential-mixing.html>)

23

Introduction

- Three blending stages between RAP binder and virgin binder during production

- *RAP binder mobilization and transfer to virgin aggregate*



- *Mechanical blending between RAP binder and virgin binder*

- *Diffusion* between RAP binder and virgin binder



(After Rad 2013)

24

Objectives of Study

- Propose a laboratory mixing scheme to distinguish the three blending stages.
- Study the effect of each blending stage on rheological and fracture performance properties of the study mixtures.
- Identify the primary mechanisms of blending of RAP binder and virgin binder.

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Materials and Experiments

- RAP Characterization
 - South Idaho RAP
 - POE RAP

	RAP Aggregate Percent Passing, % Sieve Size (mm)										RAP Binder Content	G _{sb} of RAP Aggregate	True PG of RAP Binder
South Idaho RAP	19.0	12.5	9.5	4.75	2.36	1.18	0.6	0.3	0.15	0.075			
	100	95	88	68	54	43	33	21	14	9.4	4.9%	2.583	85.2-16.8

	RAP Aggregate Percent Passing, % Sieve Size (mm)										RAP Binder Content	G _{sb} of RAP Aggregate	True PG of RAP Binder
POE RAP	19.0	12.5	9.5	4.75	2.36	1.18	0.6	0.3	0.15	0.075			
	100	97	89	63	43	31	23	17	13	8.9	4.4%	2.777	83.8-18.3

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Materials and Experiments

● Mix Design

■ RAP binder replacement ratio: 26%

South Idaho RAP Mixes	Sieve Size (mm)										Specification
	19.0	12.5	9.5	4.75	2.36	1.18	0.6	0.3	0.15	0.075	
Percent Passing, %	100	95	84	62	47	35	26	16	9	5.5	----
Optimum Binder Content, %	4.8										----
Air Voids, %	4.0										4.0
VMA, %	14.5										14 min
VFA, %	73										65-75
Dust-to-Asphalt Ratio	1.2										0.6-1.2
PG of Target Binder	70-28										

POE RAP Mixes	Sieve Size (mm)										Specification
	19.0	12.5	9.5	4.75	2.36	1.18	0.6	0.3	0.15	0.075	
Percent Passing, %	100	93	79	50	33	24	17	13	8	4.8	----
Optimum Binder Content, %	5.1										----
Air Voids, %	4.0										4.0
VMA, %	14.2										14 min
VFA, %	72										65-75
Dust-to-Asphalt Ratio	1.1										0.6-1.6
PG of Target Binder	64-28										

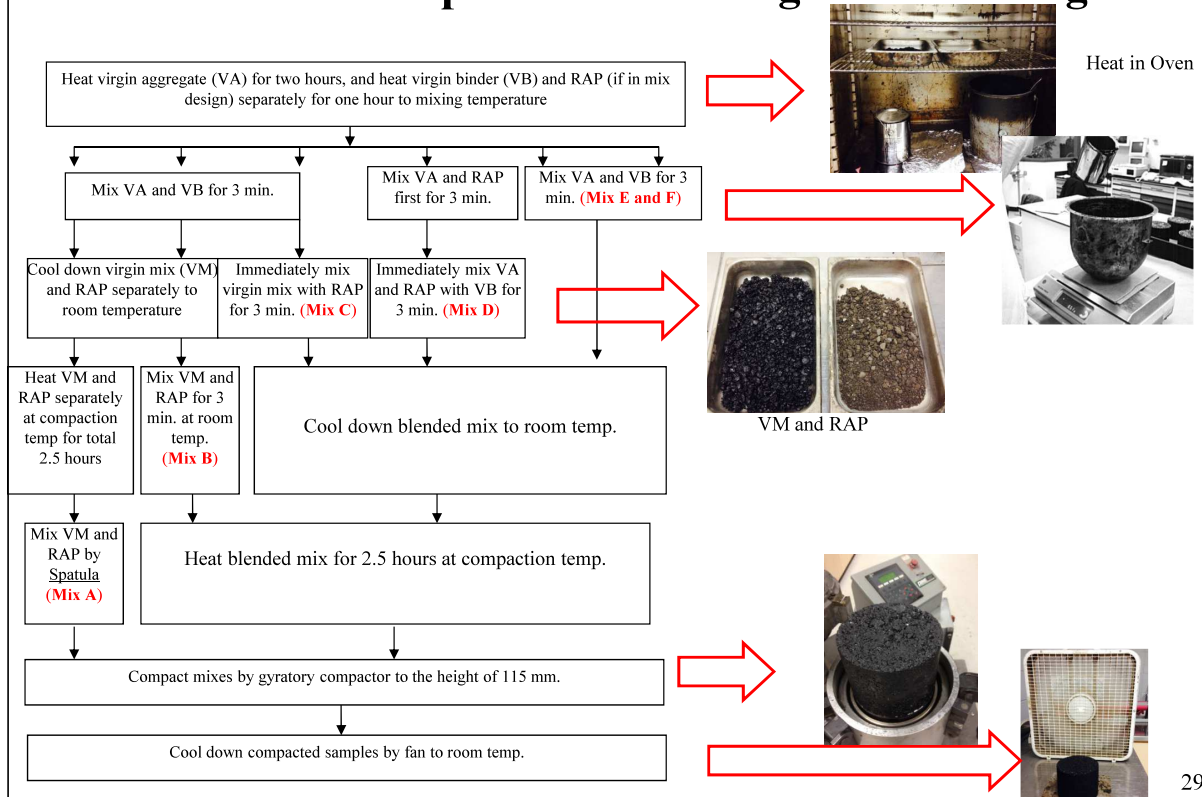
27

Materials and Experiments-Mixing Scheme Design

Mixes	Virgin Binder of South Idaho RAP Mixes	Virgin Binder of POE RAP Mixes	RAP Replacement	Blending Stages
Mix A	PG 64-34	PG 58-34	26%	Minimal Diffusion Only
Mix B	PG 64-34	PG 58-34	26%	Diffusion Only
Mix C	PG 64-34	PG 58-34	26%	Mechanical Blending +Diffusion
Mix D	PG 64-34	PG 58-34	26%	Binder Mobilization +Mechanical Blending +Diffusion
Mix E	PG 64-34	PG 58-34	0%	NA
Mix F (Target Mix)	PG 70-28	PG 64-28	0%	NA

28

Materials and Experiments-Mixing Scheme Design



Materials and Experiments-Mixing Scheme Design

Mixes	Virgin Binder of South Idaho RAP Mixes	Virgin Binder of POE RAP Mixes	RAP Replacement	Blending Stages
Mix A	PG 64-34	PG 58-34	26%	Minimal Diffusion Only
Mix B	PG 64-34	PG 58-34	26%	Diffusion Only
Mix C	PG 64-34	PG 58-34	26%	Mechanical Blending +Diffusion
Mix D	PG 64-34	PG 58-34	26%	Binder Mobilization +Mechanical Blending +Diffusion
Mix E	PG 64-34	PG 58-34	0%	NA
Mix F (Target Mix)	PG 70-28	PG 64-28	0%	NA

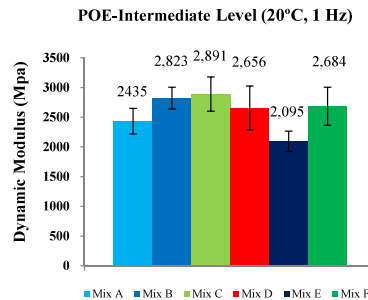
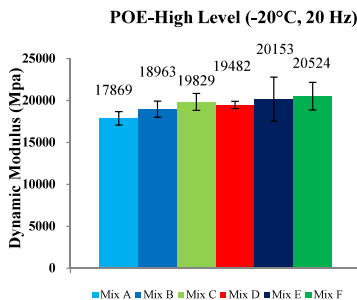
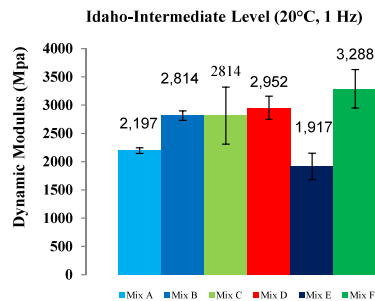
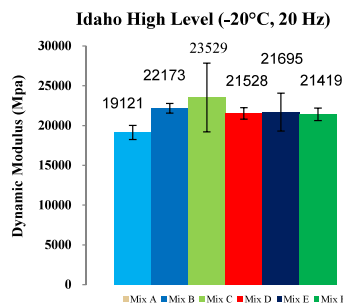
Materials and Experiments



- Make samples
 - 4% air void
 - Short-term and long-term aging
- Rheological performance evaluation
 - Dynamic modulus in indirect tensile (IDT) mode
 - Creep compliance
- Fracture performance evaluation
 - IDT test at 68°F
 - Bottom-up fatigue cracking resistance: fracture work density.
 - Top-down fatigue cracking resistance : vertical failure deformation.
 - IDT test at 14°F
 - Thermal cracking resistance: fracture work density.

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Dynamic Modulus Values at Different Levels

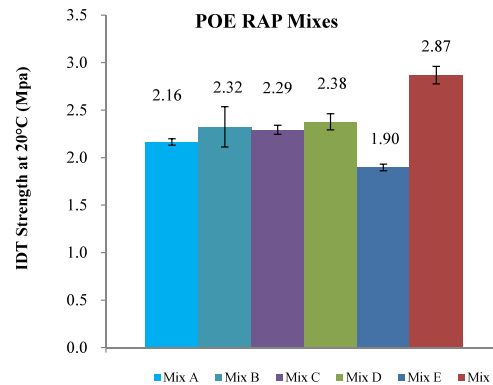
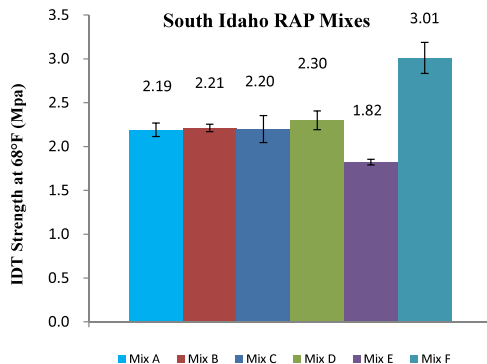


Results and Discussion

● Fracture performance: *IDT test at 68°F*

■ IDT strength at 68°F

- IDT strength of RAP mixes were **higher** than control mix E with the same PG of virgin binder, and **lower** than control mix F with target PG of virgin binder.
- Blended binder in RAP mixes dictated the strength.
- Diffusion is the dominating blending effect between RAP binder and virgin binder.



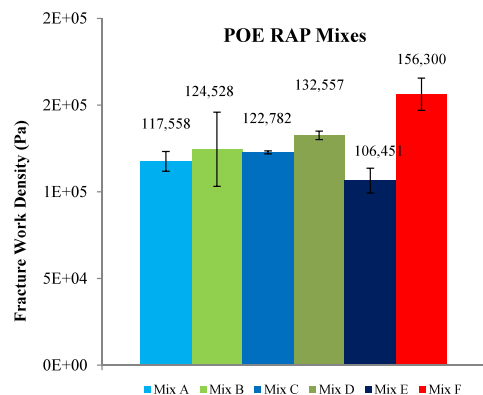
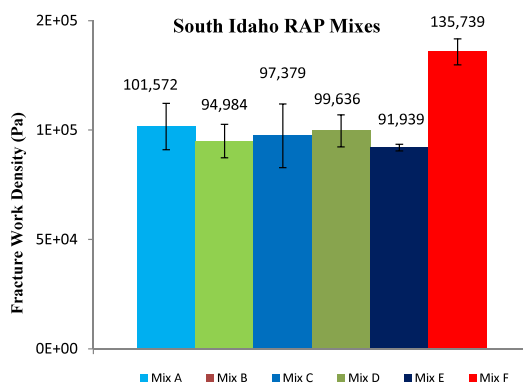
33

Results and Discussion

● Fracture performance: *IDT test at 68°F*

■ Fracture work density-bottom-up fatigue cracking resistance.

- RAP mixes B, C, and D have comparable fracture work density
- Keep high PG of target PG is beneficial



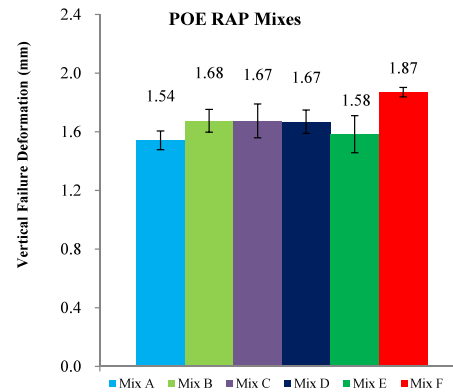
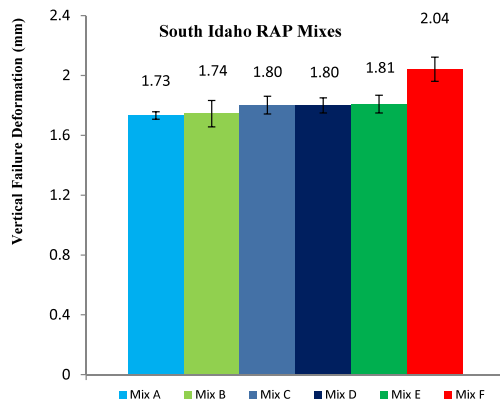
34

Results and Discussion

● Fracture performance: *IDT test at 68°F*

■ Vertical failure deformation-ductility of the mixes

- Values of RAP mixes are close to control mix with same PG of virgin binder
- Relatively soft binder controls the ductility of the mix.
- Keep high PG of target PG is beneficial



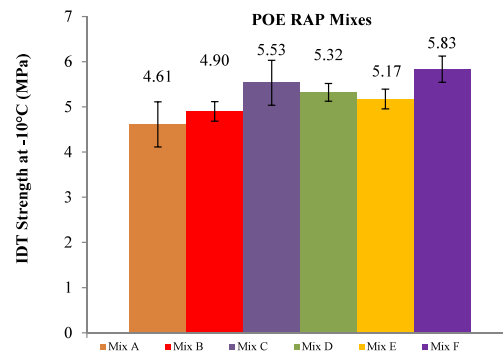
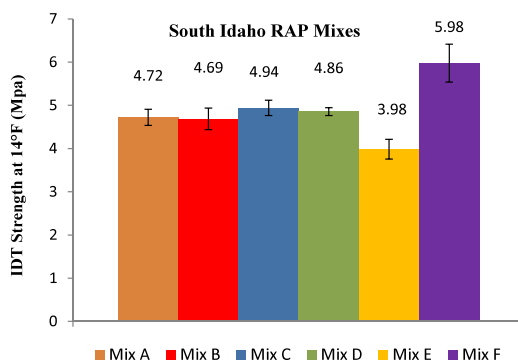
35

Results and Discussion

● Fracture performance: *IDT test at 14°F*

■ IDT strength at 14°F

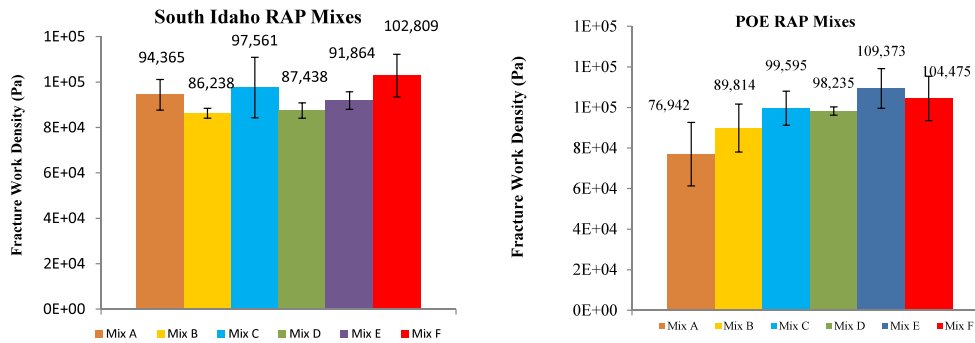
- South Idaho RAP mixes: Same trend as IDT strength of 68°F
- POE RAP mixes: No significant difference between mixes, except Mix A and Mix F. The effect of aggregate properties on low temperature fracture performance is more apparent.
- Diffusion dominates the behavior of RAP mixes compared to RAP binder transfer and mechanical blending.



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Results and Discussion

- Fracture performance: *IDT test at 14°F*
 - No significant difference among mixes



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Conclusions

- Diffusion was the most dominant in affecting rheological and fracture properties of RAP mixes.
- Relatively softer binder controls ductility of the mix, and active blended binder dictates the strength of mixes at intermediate temperature.

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Washington Center for Asphalt Technology (WCAT)



Background

- Established through partnership between
 - Washington State Department of Transportation (WSDOT),
 - Washington Asphalt Paving Association (WAPA), and
 - Washington State University (WSU)
- Funding also contributed by National Science Foundation (NSF)

Board Members

- Tom Baker, State Bridge Engineer, WSDOT
- Jeff Carpenter, State Design Engineer, WSDOT
- Tom Gaetz, Executive Director, WAPA
- Keith Metcalf, Deputy Chief Engineer, WSDOT
- Dave Gent, Technical Director WAPA
- Haifang Wen, WSU, Director

Members



Industry service

- WCAT is AASHTO accredited
 - Binder PG Grading, Extraction and Recovery, MSCR
 - Mix Design and Verification
- Binder Tests
 - RAP Binder Extraction and Recovery
 - Asphalt Content of Compacted Bituminous Mixtures using Ignition Oven or Solvent
 - Dynamic Shear Rheometer
 - Bending Beam Rheometer
 - Rolling Thin Film Oven
 - Pressure Aging Vessel
 - Rotational Viscometer (Brookfield)
 - Multiple Stress Creep and Recovery (MSCR)



Industry service

- Mix performance tests
 - Hamburg Wheel Tracking (APA Jr.)
 - Indirect Tensile Test – fatigue and thermal cracking
 - Dynamic Modulus Test - stiffness
 - Static Creep Test (Flow Time) - rutting
 - Repeated Load Test (Flow Number) – rutting
 - Modified Lottman – moisture damage
 - Studded Tire Machine





Thank you!



Local Highway Technical Assistance Council

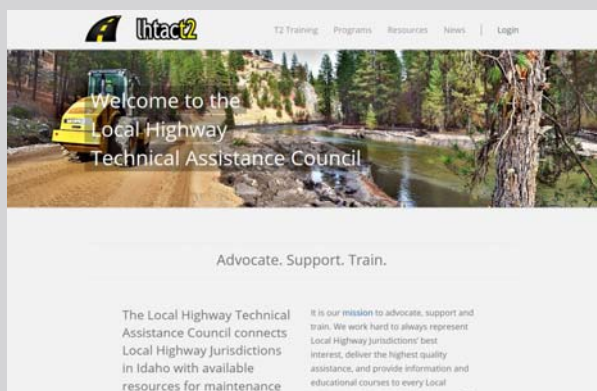
Improving Asphalt Pavement on the Local System

Jeff R. Miles, P.E.
Administrator

October 2015



Local Highway Technical Assistance Council



lhtact2 T2 Training Programs Resources News Login

Welcome to the
Local Highway
Technical Assistance Council

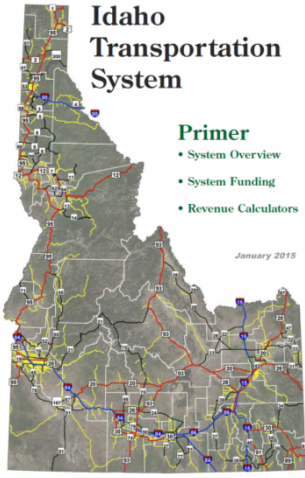
Advocate. Support. Train.

The Local Highway Technical Assistance Council connects Local Highway Jurisdictions in Idaho with available resources for maintenance

It is our mission to advocate, support and train. We work hard to always represent Local Highway Jurisdictions' best interest, deliver the highest quality assistance, and provide information and educational courses to every Local Highway Jurisdiction in Idaho.



Idaho's Local Roadway System



Idaho Transportation System

Primer

- System Overview
- System Funding
- Revenue Calculators

January 2015

Compiled from information provided by the Idaho Transportation Department, the Idaho Tax Commission, and the Local Highway Technical Assistance Council.

Local Transportation System

- Lane Miles (includes unpaved) 63,607
- Bridges > 20 Feet Long..... 2,375
(702 of which are 50+ years of age)
- Square Feet of Local Bridge Deck..... 5.7 million



Local Rural Highways

Overview

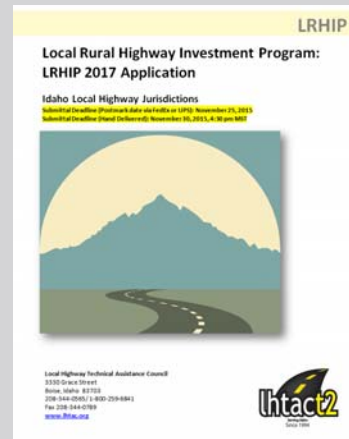




Funding Sources



- LHTAC Grant Program
 - Local Rural Highway Investment Grant (no Federal-aid rules)
- Federal-aid Programs
 - Local Rural
 - Local Urban
 - Safety
 - Federal Lands Access
 - Emergency Relief
- Local Sources
 - Highway Distribution Account
 - New H312 Revenue
 - Local property taxes and levies



The Goal



- Cost Effective, High Quality, Durable



Roadway Condition



- Always consider alternatives to pre-patching and crack filling
 - Recycled Base
 - \$1.00 ~ \$2.00 SY
 - Partial depth reclamation
 - Fiber reinforcement
- Pavement Edge Slope
- 3x Nominal Aggregate size

Asphalt Binder



- For all projects consider commonly available base stock
 - 58-28, 64-22
- Understand Design
 - LTTP Bind
- Anti-Strip
- Warm Mix
 - Evotherm – M
 - LOF 65-00
 - Foaming

		High Temperature, °C				
		52	58	64	70	76
Low Temperature, °C	-16	52-16	58-16	64-16	70-16	76-16
	-22	52-22	58-22	64-22	70-22	76-22
	-28	52-28	58-28	64-28	70-28	76-28
	-34	52-34	58-34	64-34	70-34	76-34
	-40	52-40	58-40	64-40	70-40	76-40

= Crude Oil

= High Quality Crude Oil

= Modifier Required

Mix Design

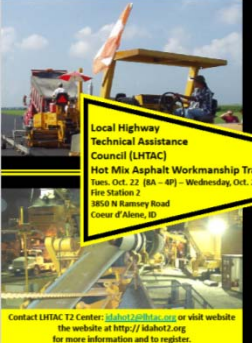


- Consider strategies to lower cost when working in remote or smaller entities
 - Mix design costs vs. available design
 - Time for mix design
 - Existing road condition
 - Good condition
 - Patch existing
 - Crack sealing
 - Recycled base
 - Partial depth reclamation

Workmanship



- Training for inspection and construction staff
 - Through LHTACT2 Center
 - Idaho AGC
- On the job training



Workmanship should be a priority on all FHWA projects. A high level of workmanship can save money in the future for local governments. FHWA Code of Federal Regulations (23 CFR 637) requires that each road building agency ensure that materials and workmanship be covered within the QA program to ensure that the highest quality system will be built. The training will cover current asphalt specifications and LHTAC Best Management Practices (BMP's) of asphalt road building through discussions on:

Teamwork & Safety, Surface Preparation, Delivery, Placement, Compaction, Joint Construction, Segregation Mitigation, and Acceptance Test Strips.

Students will work together with Tim Murphy, MPT as we explore FHWA quality and efficiencies through a review of the mix design, production, process control, PML, and deep exploration of the construction phases (primarily).

The goal of this LHTAC directed training class is to provide up-to-date information for those building hot mix asphalt pavements and to help Idaho local employees become knowledgeable with asphalt paving techniques. The course directly improves efficiency of work being done and assists in making asphalt pavements last longer.

The training is intended for all Idaho employees directly related in the design, contract award, and building and maintaining of asphalt facilities in Idaho. Supervisors, engineers, technicians, consultants, and contractors will benefit by attending this interactive training seminar which will allow for networking as well as ample time for questions and answers.

Local Highway Technical Assistance Council (LHTAC)
Hot Mix Asphalt Workmanship Training
 Tues. Oct. 22 (8A – 4P) – Wednesday, Oct. 23 (8A – 12noon)
 Fire Station 2
 8850 N Ramsey Road
 Coeur d'Alene, ID

Contact LHTAC T2 Center: lhtact2@idahot2.org or visit website the website at <http://idahot2.org> for more information and to register.

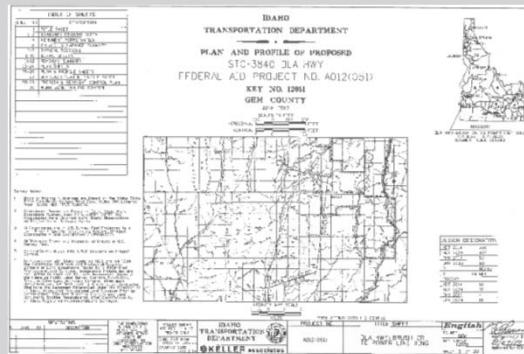
Monthly Review Technology

Local Project



- Ola Highway, Gem County
 - Overlay
 - Limited Recycled Asphalt Base Stabilization
 - Partial Full Depth Reconstruction

1/2" SP-2, PG 64-28
 45% RAP
 0.5 Anti-Strip
 5.3% asphalt
 0.15' single lift
 Compaction temp 326 - 303



Crack Filler Expansion



DEERY 102GL		PRODUCT DATA SHEET
REF. NUMBER: 102GL-1, 102GL-2, 102GL-3		JANUARY 2011
DESCRIPTION: DEERY 102GL is a cold-applied, water-based, emulsified asphalt crack filler. It is designed for use on asphalt and concrete surfaces. The product is available in three grades: 102GL-1 (Standard), 102GL-2 (Heavy Duty), and 102GL-3 (Ultra Heavy Duty). The product is applied using a brush or spray nozzle. The product is designed to fill cracks and provide a durable, long-lasting seal. USE: DEERY 102GL is used to fill cracks in asphalt and concrete surfaces. It is applied in a single coat. The product is designed to fill cracks and provide a durable, long-lasting seal. The product is available in three grades: 102GL-1 (Standard), 102GL-2 (Heavy Duty), and 102GL-3 (Ultra Heavy Duty). The product is applied using a brush or spray nozzle. The product is designed to fill cracks and provide a durable, long-lasting seal. PREPARATION: The surface must be clean, dry, and free of debris. The cracks must be cleaned and free of loose material. The product is applied in a single coat. The product is designed to fill cracks and provide a durable, long-lasting seal. APPLICATION: DEERY 102GL is applied in a single coat. The product is designed to fill cracks and provide a durable, long-lasting seal. The product is available in three grades: 102GL-1 (Standard), 102GL-2 (Heavy Duty), and 102GL-3 (Ultra Heavy Duty). The product is applied using a brush or spray nozzle. The product is designed to fill cracks and provide a durable, long-lasting seal. STORAGE: DEERY 102GL should be stored in a cool, dry place. The product should be kept in its original container. The product is designed to fill cracks and provide a durable, long-lasting seal. SAFETY: DEERY 102GL is a cold-applied, water-based, emulsified asphalt crack filler. It is not flammable. The product is designed to fill cracks and provide a durable, long-lasting seal.		
FOR ADDITIONAL INFORMATION: Contact your local distributor or visit our website at www.deery.com. The product is designed to fill cracks and provide a durable, long-lasting seal.		



Warm Mix Solution



- Acts as an anti-strip
- Lowers compaction temperature between 30 and 60 degrees
- Added approximately \$3.60 per ton
- Heat cost savings



Evotherm® 3G
Warm Mix Asphalt

MWV

Very Successful





Local Project

- Yale Road, Burley HD
 - 2.14 mile reconstruction and realignment

½" SP-2, PG 58-28 WMA
 28% RAP
 0.56 Evotherm
 5.7% asphalt
 0.33' in 2 courses
 Compaction temp 245-253
 Haul 20 miles

The technical drawing is titled "IBAHIO TRANSPORTATION DEPARTMENT PLAN AND PROFILE OF PROPOSED YALE ROAD STAGE 3 FEDERAL AID PROJECT NO. SIC-2837 KEY NO. 1000 CASSIA COUNTY". It includes a map of the project area, a table of stationing, and a table of elevations.

Successful Project



Summary



- When designing local roadway paving consider efficiencies to minimize cost.
- Warm mix will have a positive impact in many cases.
 - Overlays with crack seal
 - Long haul
 - Replace anti-strip
 - Workability

Closeout



Local
Highway
Technical
Assistance
Council

Jeff R. Miles, PE
Administrator

3330 Grace Street
Boise, Idaho 83703

Office: 208.344.0565
Toll Free: 1.800.259.6841
Cell: 208.745.6534
Fax: 208.344.0789
Web: www.lhtac.org
E-mail: jmiles@lhtac.org

Tack Coat Best Practices

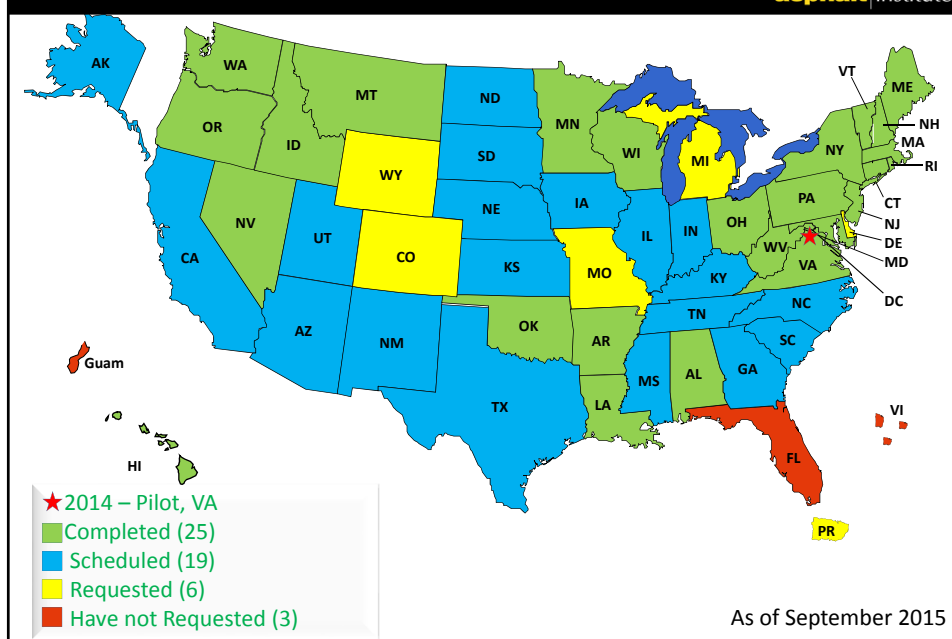
FHWA Cooperative Agreement Subtask



Idaho Asphalt Conference
October 22, 2015



Tack Coat Workshops





Far too frequent practices.



Importance of Tack Coats



- To promote the bond between pavement layers.
- To provide a waterproofing layer.
- To provide a surface for the next layer.
- All layers.

Why do we use Tack Coats?



5

Bonded Demonstration



$\frac{1}{2}$ " Deflection,
60# Load



Unbonded

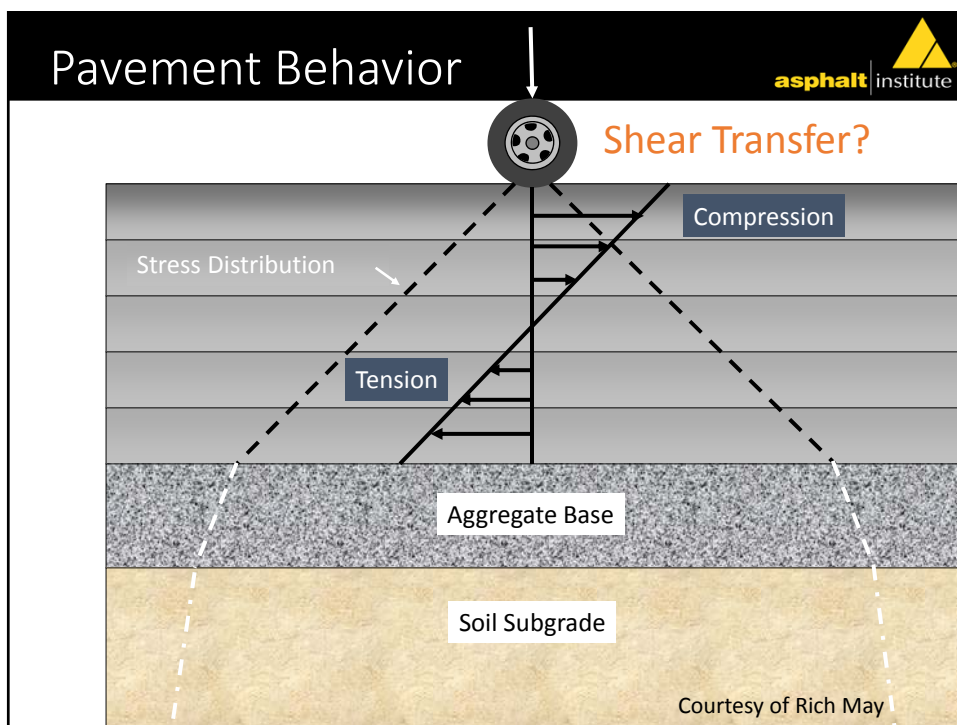
$\frac{1}{4}$ " Deflection,
160# Load

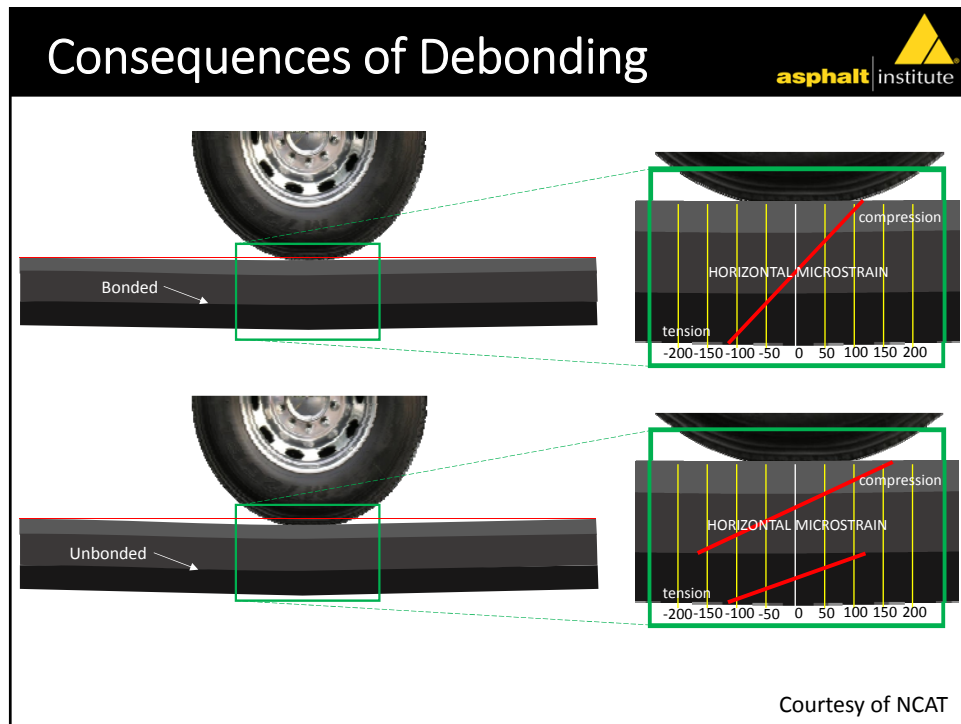


Fully Bonded

Bonded Demonstration Highlights

- Up to 5 sheets (layers)
- 48" x 4" x 11/32"
- 60, 100, or 160 pound loadings
- Various Bonding Configurations
- Two bonded layers had less deflection than five unbonded (60#).
- Five bonded layer deflected half as much as five unbonded with 267% greater loading (60# vs. 160#).





Consequences of Poor



- Layer independence
 - Reduced fatigue life
 - Increased rutting
 - Slippage
 - Shoving
- Compaction difficulty

Direction of traffic?

→



Loss of Fatigue Life Examples



- May and King:
 - 10% bond loss = 50% less fatigue life
- Roffe and Chaignon
 - No bond = 60% loss of life
- Brown and Brunton
 - No Bond = 75% loss of life
 - 30% bond loss = 70% loss of life

8 – 10 years (est.) Interstate Pavement

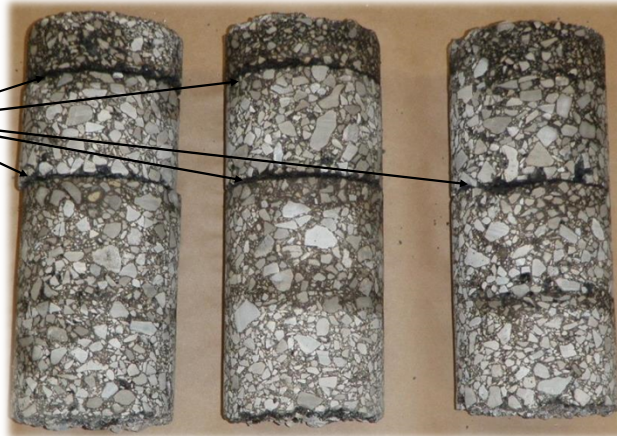


Courtesy of MODOT

Cores Showing Debonding



Bonding
Failures



Courtesy of MODOT

So is it worth it to apply a tack coat?



Cost of Tack Coat

- New or Reconstruction
 - About **0.1-0.2%** of Project Total
 - About **1.0-1.5%** of Pavement Total Cost
- Mill and Overlay
 - About **1.0-2.0%** of Project Total
 - About **1.0-2.5%** of Pavement Total Cost

Estimated Cost of Bond Failure in Only the Top Lift

- Assume no inflation for materials
- Estimated traffic control
- Used project plans for thicknesses
- Used bid tabs for:
 - Milling
 - Material costs
 - Replaced pavement markings

**30-100% of Original
Pavement Costs**

Tack Coat Challenges

- Contractor
 - Application Rate
 - Consistency of Application
 - Tack Coat Pickup or Tracking By Vehicles
 - Traction for Construction Equipment
 - Breaking/Setting Time
- Agency
 - Acceptance
 - Dilution?
 - Application Measurement
 - Bond Quality
 - Tort Claims

Best Practices



- Surfaces need to be clean and dry.
- Uniform application.
- All surfaces are tacked.
- Tack should not be tracked off the road.

Best Practices



- Match application to conditions.
 - Materials
 - Residual rate
- Verify application rate.
- Resist tacking too far ahead of paver.



Distributor Truck Setup



- Liquid temperature
 - Monitor and match to material
- Calibrate distributor truck
 - Spray bar height
 - Spray bar pressure
 - Nozzle angle
 - Nozzle selection
 - Thermometers
 - Volumeter



Calculating field application rates



- There are three primary methods of determining field application rates.
 - Determination by volume.
 - Determination by weight or mass.
 - Determination by direct measurement, ASTM D2995

Critical elements in determining application rates



- Dilution rates are critical in determining final application rates.
- Temperature is important in determining accurate volumetric rates.

Table 13. Temperature - volume corrections for asphalt emulsions ⁽⁶⁾.

°C	°F	M	°C	°F	M	°C	°F	M
10.0	50	1.0025	35.0	95	0.9912	60.0	140	0.9800
10.6	51	1.0022	35.6	96	0.9910	60.6	141	0.9797
11.1	52	1.0020	36.1	97	0.9907	61.1	142	0.9795
11.7	53	1.0017	36.7	98	0.9905	61.7	143	0.9792
12.2	54	1.0015	37.2	99	0.9902	62.2	144	0.9790
12.8	55	1.0012	37.8	100	0.9900	62.8	145	0.9787
13.3	56							0.9785
13.9	57							0.9782
14.4	58							0.9780
15.0	59							0.9777
15.6	60							0.9775
16.1	61	0.9997	41.1	106	0.9885	66.1	151	0.9772
16.7	62	0.9995	41.7	107	0.9882	66.7	152	0.9770
17.2	63	0.9992	42.2	108	0.9880	67.2	153	0.9767
17.8	64	0.9990	42.8	109	0.9877	67.8	154	0.9765
18.3	65	0.9987	43.3	110	0.9875	68.3	155	0.9762
18.9	66	0.9985	43.9	111	0.9872	68.9	156	0.9760
19.4	67	0.9982	44.4	112	0.9870	69.4	157	0.9757
20.0	68	0.9980	45.0	113	0.9867	70.0	158	0.9755
20.6	69	0.9977	45.6	114	0.9865	70.6	159	0.9752
21.1	70	0.9975	46.1	115	0.9862	71.1	160	0.9750

$$\text{Volume}_{@^{\circ}\text{F}} \times M_{\text{value}} = 60^{\circ}\text{F Vol.}$$

$$\text{Volume}_{@^{\circ}\text{C}} \times M_{\text{value}} = 15.6^{\circ}\text{C Vol.}$$

Recommended Application Rates

Surface Type	Residual Rate (gsy)	Appx. Bar Rate Undiluted* (gsy)	Appx. Bar Rate Diluted 1:1* (gsy)
New Asphalt	0.020 – 0.045	0.030 – 0.065	0.060 – 0.130
Existing Asphalt	0.040 – 0.070	0.060 – 0.105	0.120 – 0.210
Milled Surface	0.040 – 0.080	0.060 – 0.120	0.120 – 0.240
Portland Cement Concrete	0.030 – 0.050	0.045 – 0.075	0.090 – 0.150

*Assume emulsion is 33% water and 67% asphalt.

Review and Summary

Areas of Known Agreement



- Layer Bonding is Vital
- Surface Preparation
 - Clean
 - Dry
- Millings Improves Field Performance
 - Shear
 - Cleaning

Areas of Known Agreement



- Application Quality Vital
 - Proper Rate
 - Consistency
- Distributor Truck
 - Setup
 - Calibration/Verification
 - Maintenance
- Tacking of Longitudinal Joints
 - Bonding
 - Confinement
- Excessive Tack is Bad
- Thicker/Stiffer Lifts Less Prone to Slippage



Areas of Known Agreement



- Tack Coat Rate Depends on Surface Condition
 - Fresh
 - Weathered
 - Raveled
 - Milled
- Need for Research
 - Field Performance
 - Field Testing
 - Bond strength
 - Application amount
- Treat Tack as **Separate Pay Item** vs. Incidental Item

Tack Coat Application





 **Free 4-hour workshop
requested through
FHWA divisional offices** 

Questions?

Free webinar:
http://www.asphaltinstitute.org/public/asphalt_academy/webinars/tack-coat-best-practices-webinar-recording.dot

New Technologies in Asphalt Testing

Wade Collins
Vice-President
Pavement Technology Inc.
October 22, 2015

- **Each day**, approximately 1.4 Million tons of HMA are produced in the U.S. (M-F production basis)
 - Equivalent to ~2500 lane miles @ 12' wide and 1.5" thick
 - Distance from New York to Las Vegas



Why is Performance Testing Important?

- Can be used to Evaluate a mix design in the lab and Predict how well it will perform prior to making an investment to place it on the roadway
- Can be used to make the best or most effective use of a situation, opportunity, or resource
- Allows a user to increase understanding of the factors which drive mix performance
- Can be Used to Correlate lab predictions to field results
- Can be used to test Plant Produced Mixes and Cores from the in place compacted mix.
- Provides a performance history of a mix from beginning to end
- Can allow mix designers to look at Life Cycle Cost Analysis versus Initial Cost

Why is Performance Testing Important?-Continued

- "Mixture Economics" can be introduced into the Mix Design Process. Mixes can be designed that cost less without compromising their performance. Ex. Increasing percentage or RAP/RAS
- Improve the Quality of Asphalt Mixes
- Utilized as a Forensic Tool for projects slated for rehabilitation. Information can be used to determine a proper rehabilitation strategy
- Rewards innovative and proactive contractors
- Qualify Aggregate Sources
- Warranty and Design Build Projects
- Conflict resolution between DOT and Producer

New Technologies

- Performance Testing
 - Rutting(AASHTO T340-10)
 - Moisture Susceptibility-Hamburg(AASHTO T324-14)
 - Fatigue
- Real-Time Quality Control
 - Asphalt Plant
 - Aggregate Plant

AASHTO T 340-10 Test Method

- **Test Temperature: Hi-PG Temp(Ex. 64C)**
- **Load 100lbs.**
- **Hose Pressure 100psi**
- **Speed 60 cycles per minute**
- **Test Duration 8,000 cycles (2 ½ hours)**
- **Samples are tested in a dry environment**
- **Gyratory Samples(75mm or Design 115mm samples) are utilized for testing**
- **Field Cores and Slab Specimens can also be tested**

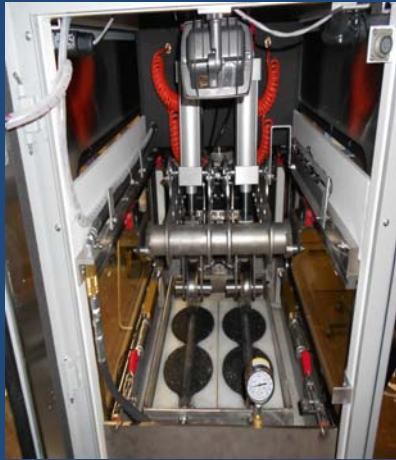
Asphalt Pavement Analyzer(APA)



Asphalt Pavement Analyzer-Junior (APA Jr)



Chamber View of APA Jr Rut Testing



Rutted Beam and Cylindrical Specimens Tested in the APA



Rut Specifications

Arkansas DOT

- Design ESAL's < 3.0, Nmax 115, Ndes 75, PG64-22, LWT: Max 8mm
- Design ESAL's 3.0 – 30.0 Nmax 160, Ndes 100, PG70-22, LWT: Max 5mm
- Design ESAL's > 30.0 Nmax 205, Ndes 125, PG76-22, LWT: Max 5mm
- These LWT results are for any of the type of mix, 9.5, 12.5, 25.0 or 37.5mm

Rut Specifications-Continued

Oregon DOT

- Level 3 (80 gyration) with PG 64-22 or 64-28: 6.0mm max rut
- Level 3 (80 gyration) with PG 70-22 or 70-28: 5.0mm max rut
- Level 4 (100 Gyration) with PG 64-22 or PG 64-28: 5.0mm max rut
- Level 4 (100 Gyration) with PG 70-22 or PG 70-28: 4.0mm max rut

AASHTO T 324-14 (Hamburg Test Method)

- Test Temperature: 50C
- Load 158lbs.
- Speed 50 passes per minute
- Test Duration 20,000 passes (Approx. 7 hours)
- Samples are submerged in water during test
- Gyratory Samples(62+/- 2mm height x 150mm diameter) will need to cut and “Butted Together” inside the molds
- Field Cores and Slab Specimens can also be tested

Chamber View with Hamburg Wheels and Molds



Chamber View with Hamburg
Wheels in Water



Hamburg Test-APA Jr.



Hamburg-Type Cylindrical Samples(Testing Complete)



Hamburg Specifications

California DOT

PG 58	10,000 passes
PG 64	15,000 passes
PG 70	20,000 passes
PG 76 or Higher	25,000 passes

12.5mm Max Allowable Depth

Hamburg Specifications-Continued

Illinois DOT

PG 58 or lower	5,000 passes
PG 64	7,500 passes
PG 70	15,000 passes
PG 76 or Higher	20,000 passes

Max Allowable Depth shall be less than or equal to 12.5mm

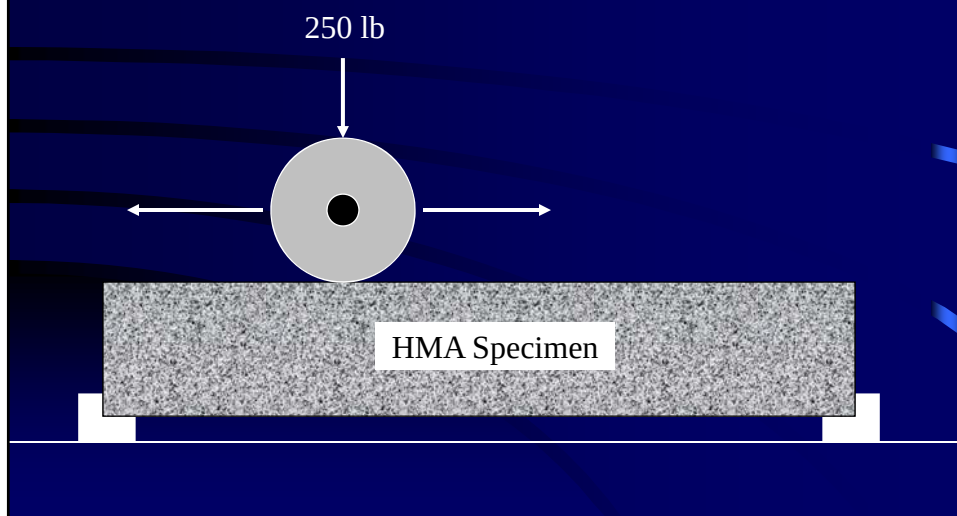
Chamber picture with Solid Steel Wheels(Fatigue Testing)



Asphalt Vibratory Compactor(AVC)



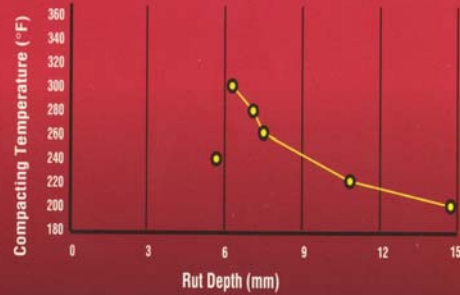
Bending Beam Fatigue Test



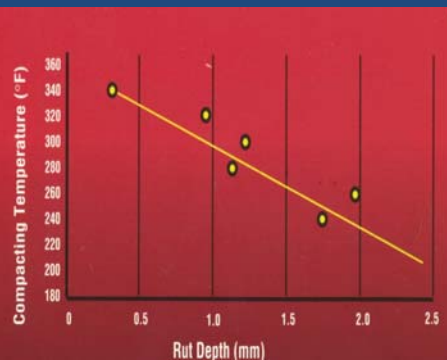
Superpave Beam Properties Tested in APA

Compacted at (°F)	Air Voids (%)		Rutting (mm)	Fatigue (# of Cycles)
	Rut Testing	Fatigue Testing		
300	6.7	6.8	6.38	46,718
290	7.1	7.4	6.26	20,956
280	7.0	7.5	6.06	19,690
260	7.6	8.0	7.47	13,198
240	8.5	8.4	9.50	8,010
220	8.2	8.6	10.72	4,578
200	9.1	9.5	14.84	4,250

9.5mm HMA Rut Susceptibility Tested in APA



12.5mm HMA Rut Susceptibility Tested in APA



Superpave Beam Properties Tested in APA

Compacted at (°F)	Air Voids (%)		Rutting (mm)	Fatigue (# of Cycles)
	Rut Testing	Fatigue Testing		
340	7.4	7.4	0.53	300,000*
330	8.6	7.4	0.88	226,962
320	8.6	8.3	0.89	175,972
300	9.5	9.5	1.13	172,390
280	9.3	10.3	0.91	79,146
260	8.7	9.4	2.00	71,094
240	9.5	9.8	1.55	51,798



PG 64-22

PG 76-22

Fatigue Beam Tested to Failure







Robotic Truck Sampling Device (RTSD)



Benefits of the Robotic Truck Sampling Device (RTSD)

- Safely captures a representative sample along the cross section of the mix
- RTSD can be used to sample asphalt or aggregate
- Sample sizes can be obtained up to 60lbs.
- Sampling time is less than a minute
- Volumetrics are more consistent (Asphalt Content, Gradation, VMA, VFA)
- Adjustments to the plant can be made in a timely manner
- Fewer adjustments have to be made
- Contractors have fewer test result disputes with DOT's.
- Contractors can maximize pay factors by producing mix that is close to the original job mix formula



AUTOMATIC QUALITY CONTROL



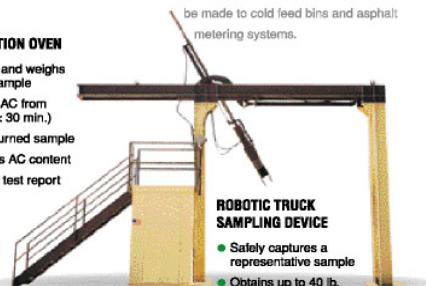
AUTOMATIC GRADATION UNIT

- Grades up to 100 lbs. in 10 mins.
- Computerized sieve analysis
- Automatic Self-Cleaning Cycle
- Frequencies vary with sieve size
- Generates gradation report



FIELD IGNITION OVEN

- Receives and weighs asphalt sample
- Burns off AC from sample (< 30 min.)
- Weighs burned sample
- Calculates AC content
- Produces test report



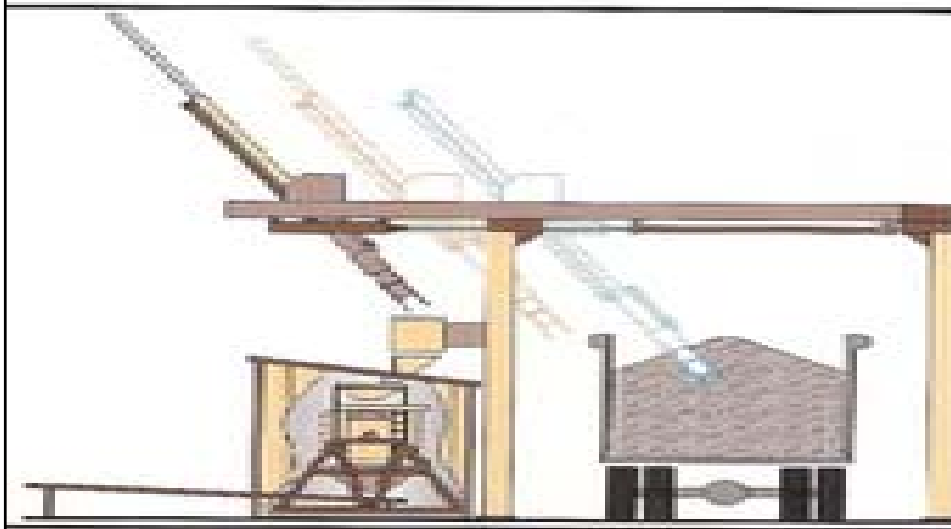
ROBOTIC TRUCK SAMPLING DEVICE

- Safely captures a representative sample
- Obtains up to 40 lb. sample in one plunge
- Helps contractors make adjustments
- Enhances process control

PTI introduces the first Automatic Quality Control (AQC) System for Asphalt Plants. This system allows a contractor to safely capture a representative asphalt sample from a haul vehicle utilizing the Robotic Truck Sampling Device (RTSD). The RTSD deposits the sample into the Field Ignition Oven which burns the sample and calculates the asphalt content. The burned sample is then deposited into the Automatic Gradation Unit (AGU). The AGU shakes the sample and produces a gradation with a test report. These test results go to the control house where adjustments can be made to cold feed bins and asphalt metering systems.

PTI PAVEMENT TECHNOLOGY, INC.
an aetec company
www.pti@pavementtechnology.com
1.888.553.2341 • fax 770.388.0149
PO Box 1196 • Covington, GA 30015

REAL-TIME QUALITY CONTROL SYSTEM ASPHALT PLANT





Real Time Quality Control (RTQC)



REAL-TIME QUALITY CONTROL SYSTEM AGGREGATE PLANT



REAL-TIME QUALITY CONTROL SYSTEM AGGREGATE PLANT



QUESTIONS???????

Evaluation of Fiber-Reinforced Asphalt Pavements – Idaho Case Study

US-30 at Montpelier, Idaho

ITD Project Phase 1 (RP 237) – Lab Evaluation of Materials

Project Team:

UI – Fouad Bayomy (PI), Ahmed Muftah (Grad Student)

WSU – Haifang Wen (Co-PI), Amir Bahadori (Grad Student)

ITD – Dan Harelson and Jesse Barrus

Project Description

US-30, Montpelier SCL to Dingle Rd.

MP 435.281 – 438.501 (3.22 Miles)



Project Description

The project involves

- Milling and overlaying 0.4 ft of the existing roadway and replace by fiber modified HMA in three sections.
- A non modified 4th section is used as control.
- The four sections are approximately equal in length.
- Construction was completed in August 2014 under ITD contract No. 7868

Project Description

Control Mix

- The non-modified Control mix is a Superpave **SP5** using 47% RAP. Mix Design was developed at NCAT, Auburn, AL.
- As per NCAT results, the virgin binder grade is PG70-28, and the RAP binder is PG64-28. The final PG is **PG70-28**

Summary of Mix Design of Control Mix

JMF as provided in NCAT report:

Follows ITD SP5 Superpave mix with 47% RAP

PG70-28

Pb 4.8%

Pb (RAP) = 2.83%

VTM = 4%

VMA = 13.6

VFA = 70.4%

D/b Ratio = 1.1

Project Description

Fiber Modified Mixes

- The fiber-modified sections adopted the same mix design. No change in the mix volumetrics.
- Three types of fibers were provided:
 - Fiber #1 (aramid and polyolefin fibers) – Vendor #1
 - Fiber #2 (wax treated aramid fiber) – Vendor #2
 - Fiber #3 (glass fibers) – Vendor #3

Project Description

Fiber Modified Mixes

- Addition of fibers at the asphalt plant during construction was in accordance with the manufacturers' specifications
- Fiber contents and methods of adding fibers to the mixtures were established and performed by the fibers' vendors

Project Description

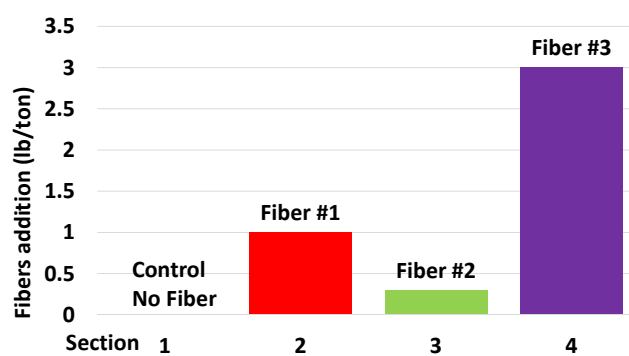
Project Sections

The study included 4 sections, approximately equal in length:

- Section 1 – Unmodified Control section
- Section 2 – Fiber #1 with the rate of 1 lb/ton
- Section 3 – Fiber #2, rate 1/3 lb/ton
- Section 4 – Fiber #3, rate 3 lb/ton



Fiber Quantities /ton



Construction Data	Section 1	Section 2	Section 3	Section 4
	Control	Fiber #1	Fiber #2	Fiber #3
Mix Placed (tons)	4,861.38	4,083.82	4,221.28	4,249.42
Fibers (lbs)	-	4,260.00	1,193.30	13,195.90
Fiber Content lb/ton	-	1.04	0.28	3.11
Fiber Content, %	-	0.052%	0.014%	0.155%

10

Fibers Addition



11



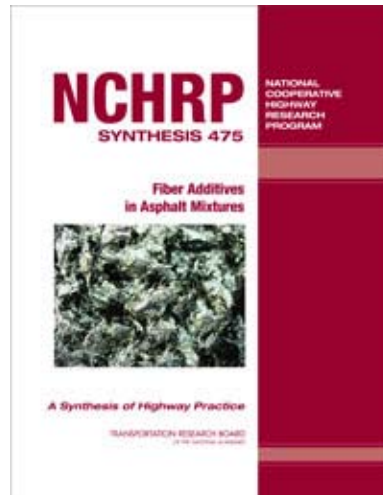


Objectives

- ITD's objective is to rehab the road to address the existing cracking and rutting problems
- The scope of this lab-based phase is limited to material characterization of the placed mixes and to determine whether there are significant changes in mixes' properties upon adding the fibers.
- Field performance monitoring on a yearly basis. At a later stage, the field data collected will be analyzed.

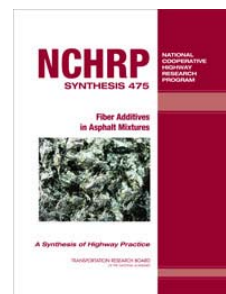
Studies on Fiber-Modified HMA

- NCHRP Synthesis 475 is the most recent synthesis on the use of fibers in asphalt pavements. (released Summer 2015)



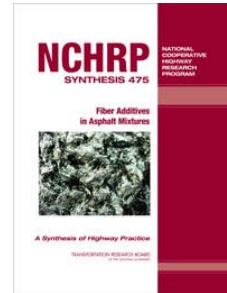
Studies on Fiber-Modified HMA

- **Various Types** of fibers included: cellulose, mineral, synthetic polymer, and glass fibers, as well as some less common fiber types. Recycled fiber materials—such as newsprint, carpet fibers, and recycled tire fibers—have also been used.



Studies on Fiber-Modified HMA

- Effective use of fibers was to reduce binder draindown in gap and open-graded mixes is quite well established, the effects of using fibers for other reasons are less clear.
- Most of the studies on the use of fibers in dense graded mixes indicated fiber content about 0.3% by weight of the mix.



Cases Presented on the NCHRP SYN

CASE 1. AGENCY CONSIDERING USE OF FIBERS



CASE 2. AGENCY WITH VARYING FIBER USAGE



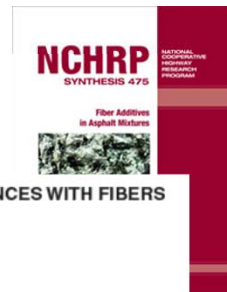
CASE 3. CONTRACTORS' EXPERIENCES WITH FIBERS IN ASPHALT MIXTURES



CASE 4. ONGOING RESEARCH ON FIBERS IN DENSE-GRADED ASPHALT



CASE 5. STATE WITH HIGH FIBER USAGE RESEARCHING OTHER APPLICATIONS



Studies on Fiber-Modified HMA

Ohio Project (in-Progress)

- Project included One type: (aramid and polyolefin) fiber-modified overlays over jointed concrete pavements to address **reflective cracking**
- As per the project contact: *“At this time there is no discernible difference in performance between all sections. The data indicates that the fibers have not reduced reflective cracking severity or extent after 3 years in service. Yearly evaluations will continue to be performed.”*

ITD – UI Project (RP237) Lab Evaluation of Materials

- Properties Types of Fibers Used
- Lab Testing and Results
- Evaluation using ME Software
- Field Performance Evaluation

Fiber #1 (Aramid and Polyolefin)

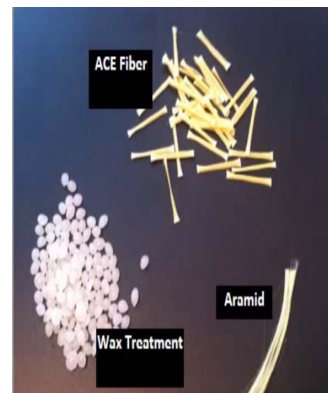
This fiber is a blend of Aramid and Polyolefin fibers. Both fibers have the same length of $\frac{3}{4}$ " (19mm). The specific gravities are 1.44 and 0.91 respectively. The tensile strength of the aramid fibers is up to 400 ksi and decomposition or break down temperature of 800 °F. The Polyolefin Fibers has much lower tensile strength of 70 ksi and break down temperature of 315 °F.



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Fiber #2 (Wax Treated Aramid fibers)

Aramid fibers with $\frac{3}{4}$ " (19 mm) in length, a specific gravity of 1.44 with a tensile strength of 400 ksi. The break down temperature is 800 °F. These fibers are treated with melted wax bath to provide more control of fiber mixing and weighing down the fibers due to its light weight.



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Fiber #3 (Glass Fibers)

- The vendor refers to it as Fiber Glass Type E. The fibers length is $\frac{1}{2}$ " (13mm) and has a specific gravity of 2.7. The tensile strength is 300 ksi. Melting of the fiber glass is relatively high. For this type of fibers, the melting point is 2075°F. Water absorption is less than 1%



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Lab Testing

1. Rutting Resistance:
 - Dynamic Modulus and Flow Number
 - APA
 - HWTT
2. Fatigue Resistance:
 - IDT (Fatigue)
 - Jc
3. Thermal Resistance:
 - IDT (Thermal)

Lab Testing

1. Rutting Resistance:

- Dynamic Modulus and Flow Number
- APA
- HWTT

2. Fatigue Resistance:

- IDT (Fatigue)
- Jc

3. Thermal Resistance:

- IDT (Thermal)

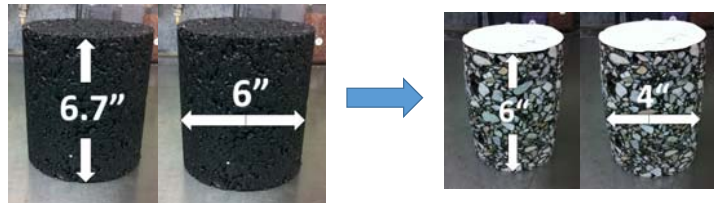
Dynamic Modulus (E^*)

AMPT Test Method (AASHTO T 342-11)

- Sample Preparation for E^*
 - 2-2.5 hours heating the loose mixes to the compaction temperature
 - Compaction
 - Core and cutting with air voids within 6.5%-7.5%
 - Testing temperatures (40 °F, 70 °F, 100 °F, 130 °F)
 - Loading frequencies(0.1Hz, 0.5Hz,1Hz, 5Hz, 10Hz, 25Hz).

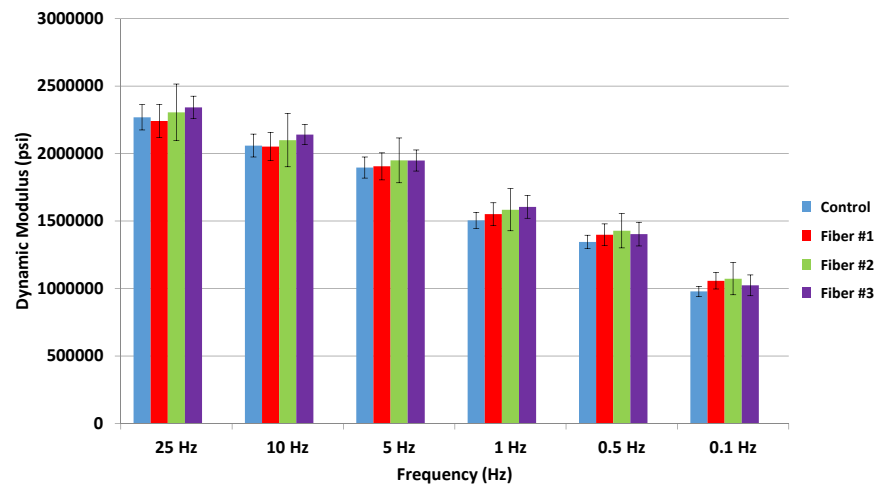
Dynamic Modulus (E^*)

- E^* test using AMPT machine, AASHTO T 342-11



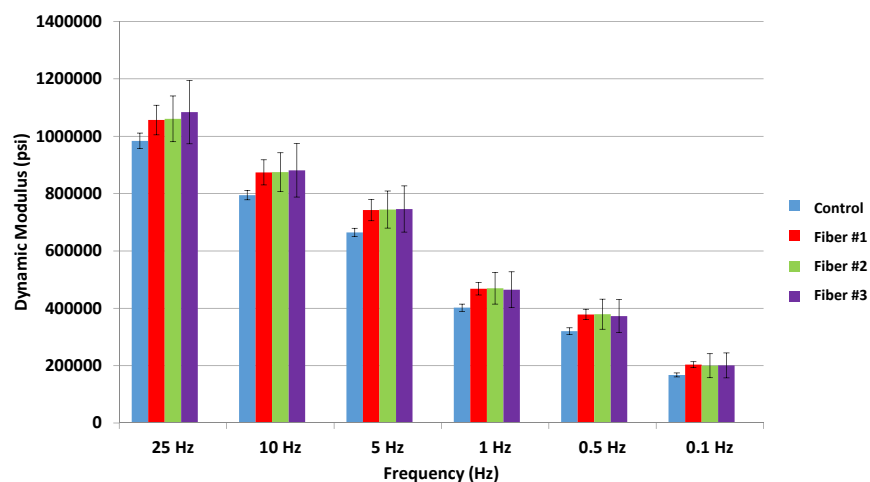
27

Dynamic Modulus Test Results E^* (psi) at 40F



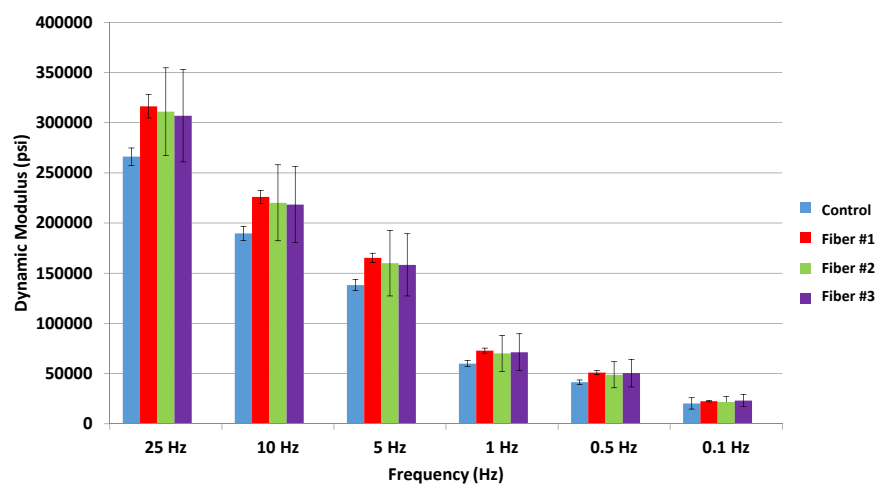
28

Dynamic Modulus Test Results E^* (psi) at 70F



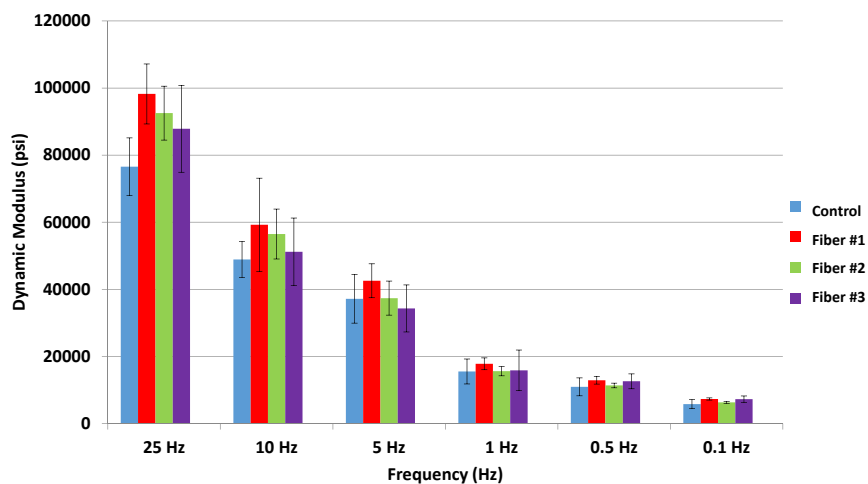
29

Dynamic Modulus Test Results E^* (psi) at 100F



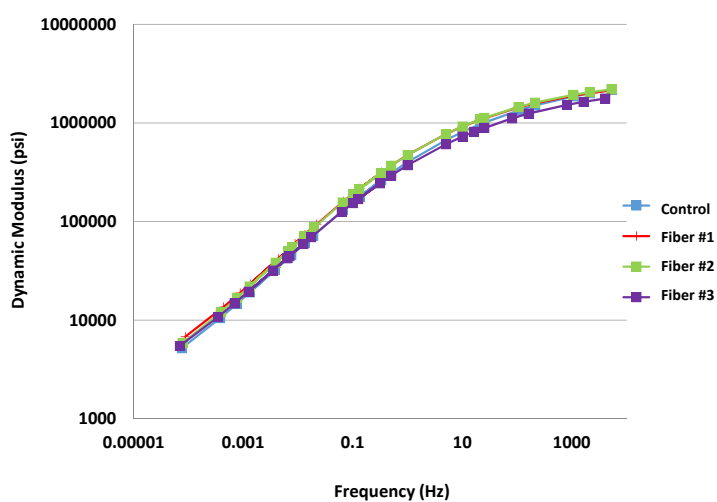
30

Dynamic Modulus Test Results E^* (psi) at 130F



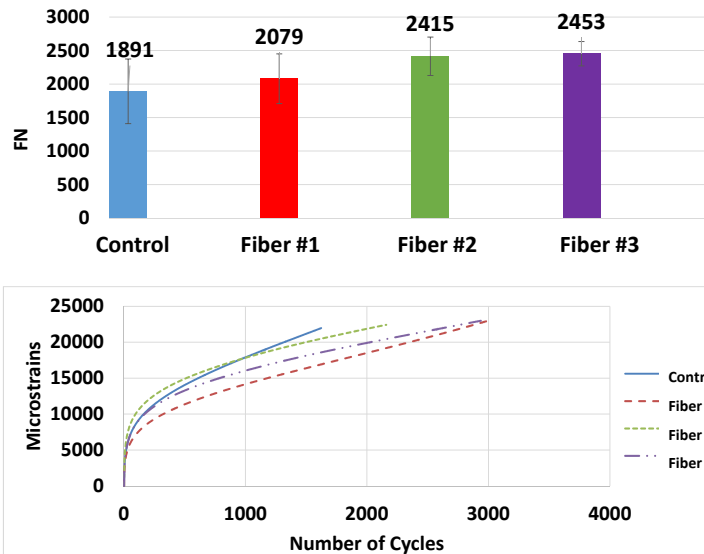
31

Dynamic Modulus Test Results E^* (psi) at 130°F



32

Flow Number Test Results on Non Consolidated Samples



33

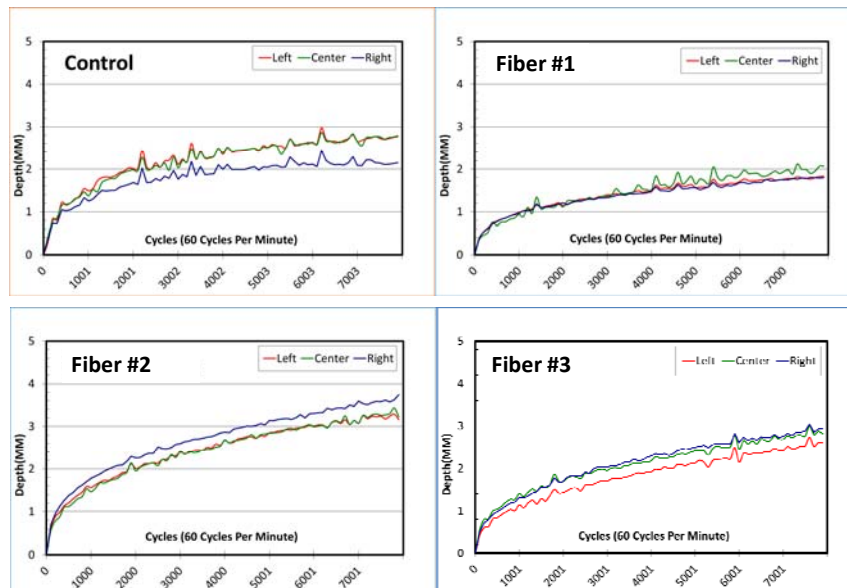
Asphalt Pavement Analyzer (APA)

- The test conducted by Idaho Transportation Department (ITD) in accordance with AASHTO TP 63
- Samples preparation:
 - ✓ Compact the sample to achieve a final air voids of $7 \pm 0.5\%$.
 - ✓ Sample height of 4.53 in (115mm)
 - ✓ The rolling wheel pass was 60 cycles per minutes for a total number of cycles of 8000.





APA Summary of Results

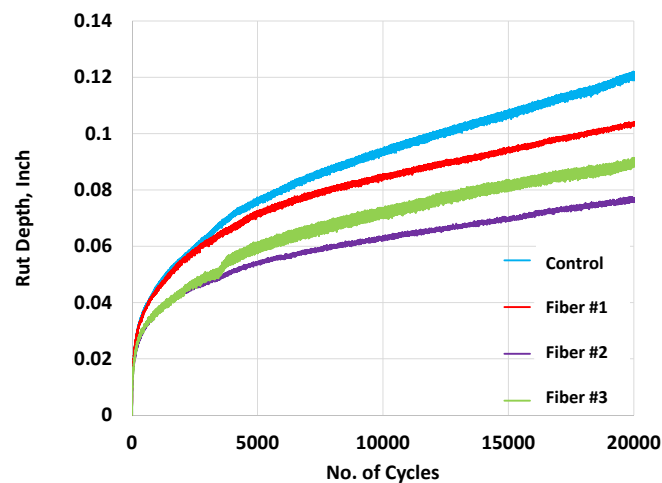


Hamburg Wheel Tracking Test – APA Jr

- The test conducted in accordance with Tex-242-F.
- Samples preparation:
 - ✓ Compact the sample to achieve a final air voids of $7 \pm 0.5\%$.
 - ✓ Sample size of 2.3 ± 0.1 in. in height and 5.9 in. in diameter.
 - ✓ The rolling wheel pass for a total number of cycles of 20,000.



Hamburg Wheel Tracking Test – APA Jr



Lab Testing

1. Rutting Resistance:

- Dynamic Modulus and Flow Number
- APA
- HWTT

2. Fatigue Resistance:

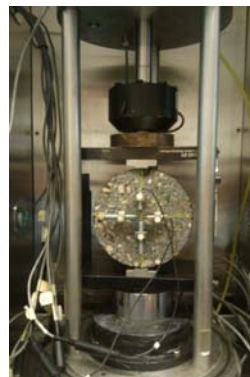
- IDT (Fatigue)
- Jc

3. Thermal Resistance:

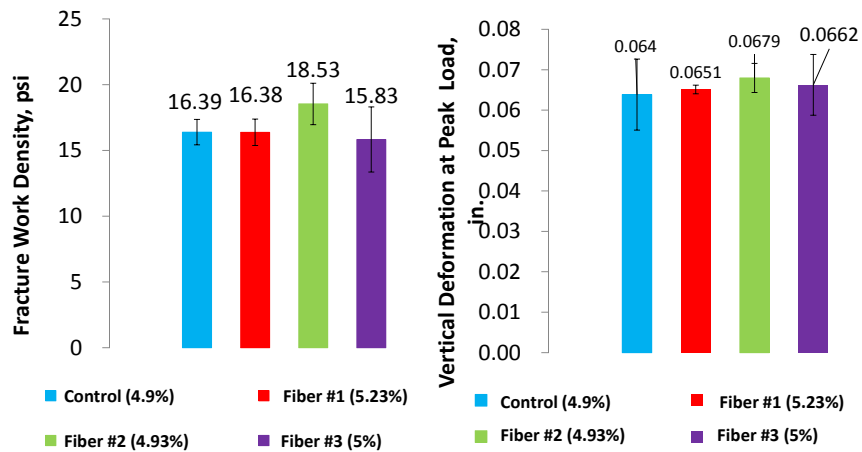
- IDT (Thermal)

Indirect Tension Test:

- The test conducted at 68F.
- Horizontal and Vertical LVDTs to measure the strain.
- Using the Fracture work density to evaluate the sample resistance.
- 3 core samples for each type of mix.



IDT Fracture Test at 68°F



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Fatigue Life Prediction

Bottom-UP Fatigue Life Prediction Model (ALF)

$$N_f = 3.75 \times 10^{-5} \left(\frac{1}{\varepsilon_t} \right)^{0.147} (FWD)^{1.92} h^{0.135} \quad (\text{Wen-2013})$$

Fatigue Life for Different Sections

Mix	N_f
Control	211493
Fiber #1	209702
Fiber #2	267156
Fiber #3	197193

J_c test

- It is a fracture toughness parameter
- It is determined in a Semi Circular Notched Bending Fracture (SCNBF).
- Samples preparation:
 - Compact the sample to achieve a final air voids of 4%.
 - Each sample was sliced into 4-quarter specimens.
 - One of the quarters was left un-notched, the other three quarters were notched to 0.25, 0.5, 0.75 inches.

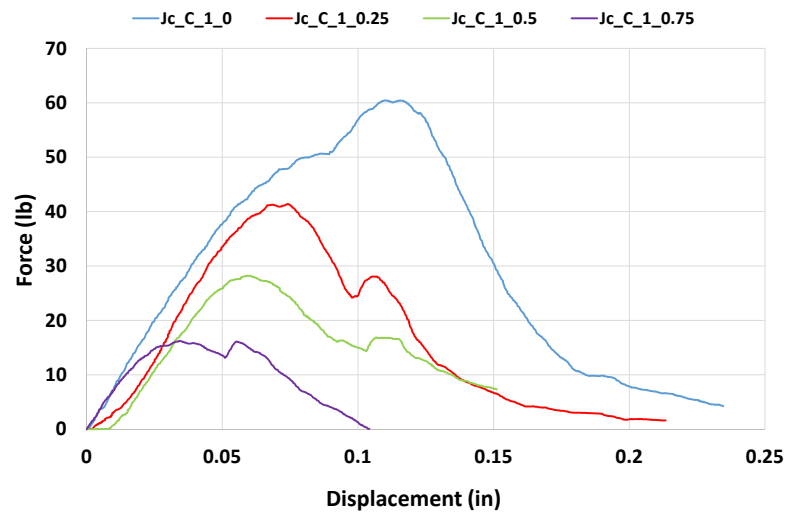


J_c test cont.

- A ramp load with a constant vertical deformation rate of 0.01 in/min. was applied until fracture occurred.
- Draw the relationship between the applied load and the displacement.
- Determine the strain energy (U)
 - which is the area underneath the load-deformation curve divided U by the thickness of the sample.

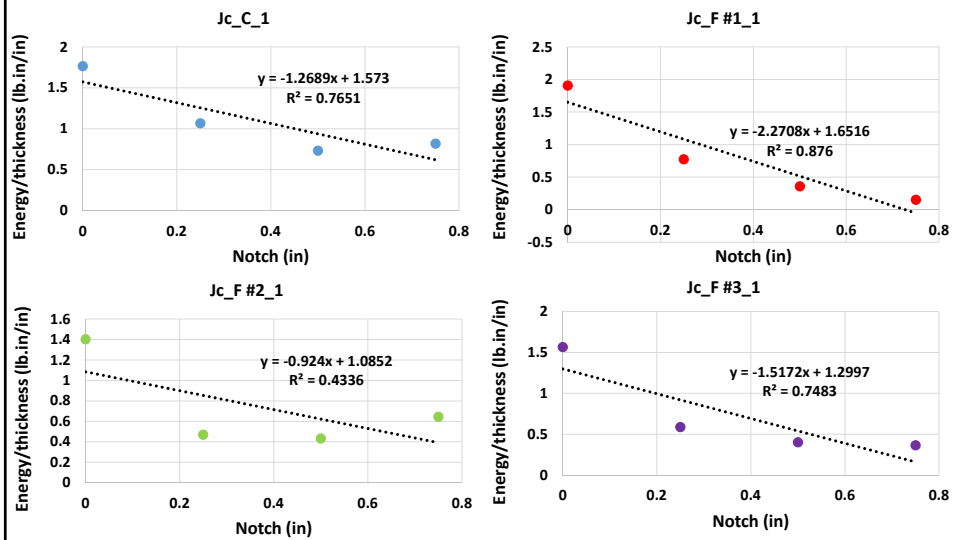


J_c test



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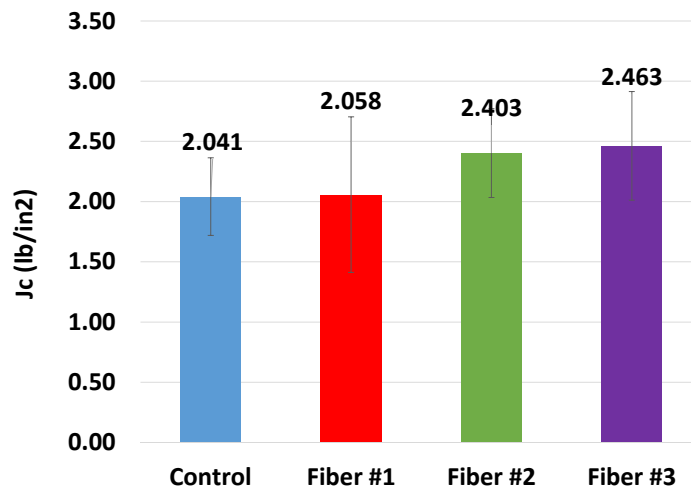
J_c test Results



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J_c test results

Energy under the whole curve



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Lab Testing

1. Rutting Resistance:

- Dynamic Modulus and Flow Number
- APA
- HWTT

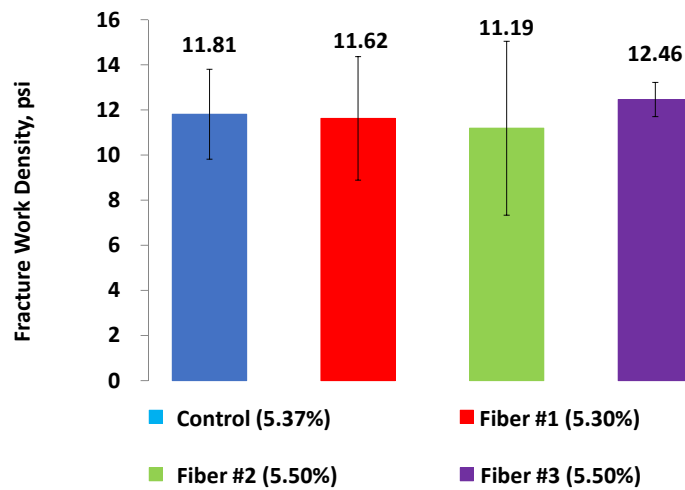
2. Fatigue Resistance:

- IDT (Fatigue)
- J_c

3. Thermal Resistance:

- IDT (Thermal)

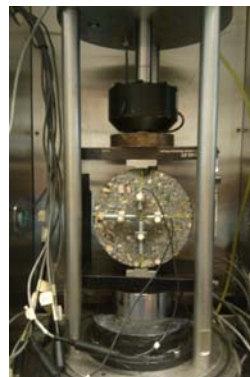
Fracture Work Density at 14°F



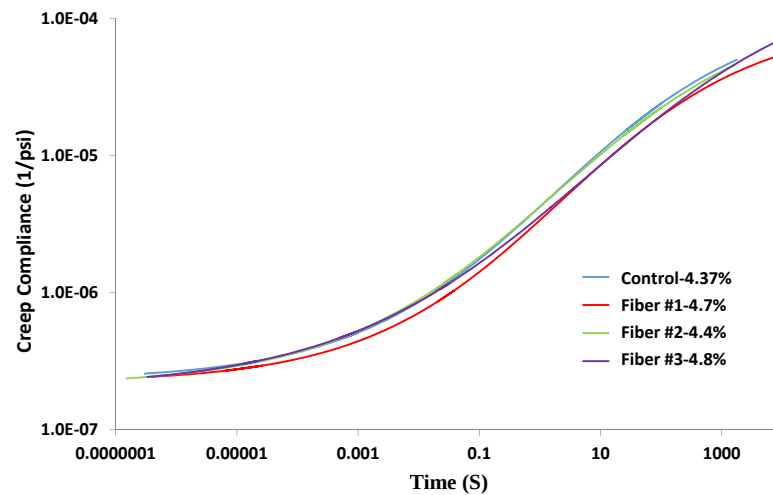
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IDT Creep Compliance

- AASHTO T322-07
- A constant load for 100s for 100s
- Six temperatures (-4, 14, 32, 50, 68, 86 °F)
- Temperatures increasing from low to high
- 3 Samples for each type of mix



Creep Compliance Master Curves at 68° F Reference Temperature



Fiber Content and Distribution of Fibers in the Mix

Lab extraction

X-Ray Tomography

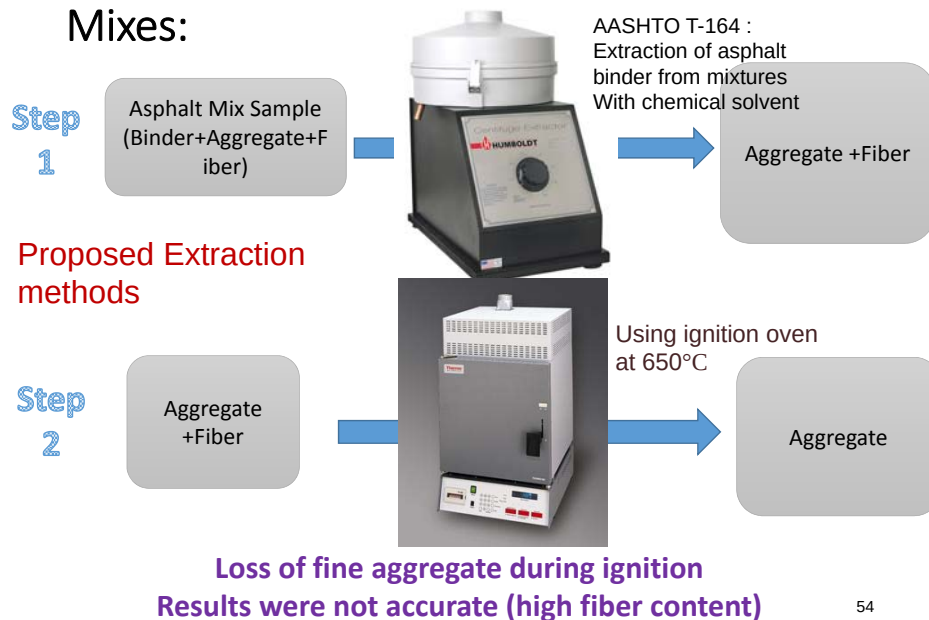
Lab Extraction

A side study done in the lab to determine the actual fiber content in the fiber-modified mixes

- Follow the extraction method as per AASHTO T-164
- Ignition Oven at 650 °C
- Lab modification to separate the fibers by floating

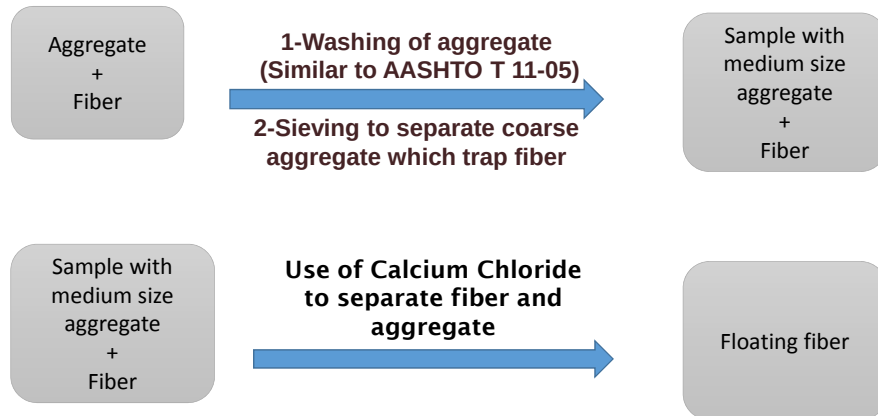
53

Investigation of Fiber Content in Asphalt Mixes:



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❖ **Modification of proposed method (Step 2):**



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Results of Lab Extraction Method:

Fibers #2 (Average of 3 samples)

Asphalt content based on mix weight	4.9%
Target AC	4.8%
Weight of fiber	0.38 g
Fiber content (proposed method)	0.0172%
Fiber content based on mix design	0.015%



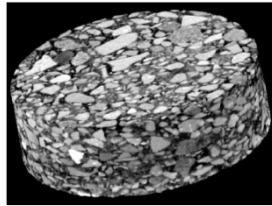
Aggregate +Fiber (Step 1)



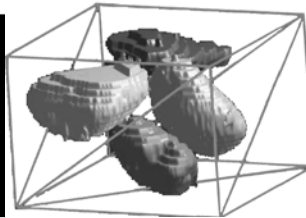
Collected fiber after step 2 ⁵⁶

X-Ray Tomography (in-progress)

- Imaging techniques is efficient approach to characterize the microstructure of the HMA



Gopalakrishnan et al. (2007)



Gopalakrishnan et al. (2007)



Krause et al. (2009)

- X-ray CT has been used to detect the cracks in asphalt mixes

AASHTOWare ME Design input data

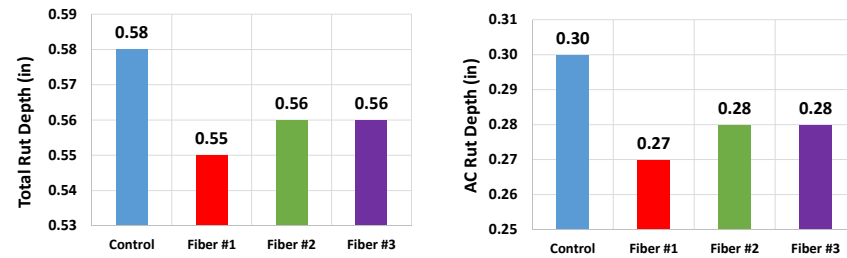
- The pavement structure: 4.8 in. new HMA, 4.8 in. old existing HMA, 7.2 in crushed base, 19.2 in. crushed sub-base.
- Mix class: SP5, $\frac{3}{4}$ NMAS.
- R values = 80 and 60 for base and subgrade.
- AADT, Vehicle class distribution, and adjustment factors provided by ITD.
- Reliability of 90% used.



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AASHTOWare ME Design Analysis

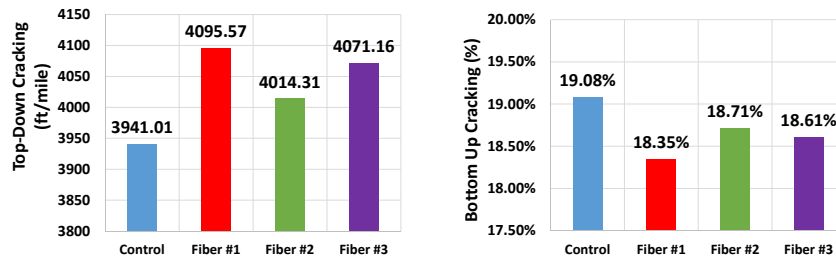
Predicted Rutting



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AASHTOWare ME Design Analysis

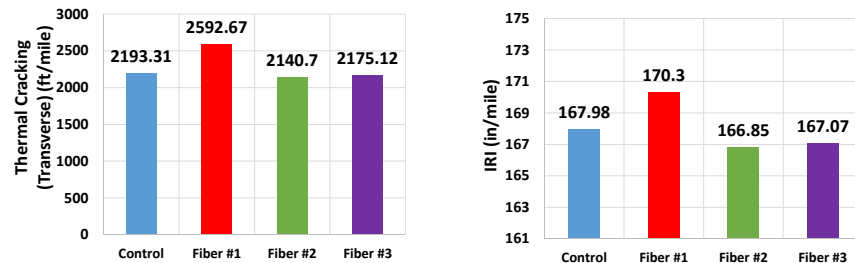
Predicted Fatigue Cracking



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AASHTOWare ME Design Analysis

Predicted Thermal Cracking and IRI

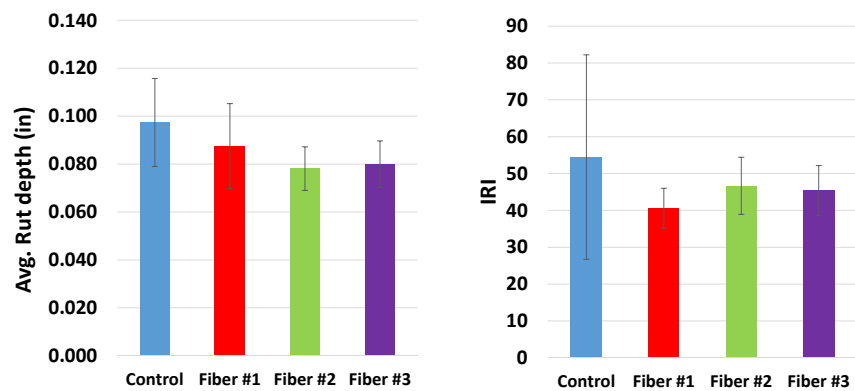


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Summary of Results

- **Lab Evaluation** concluded that there is no significant difference among the performance of the fiber modified mixes. Statistical Analysis of ANCOVA showed **No significant** differences were observed.
- **AASHTOWare ME** Pavement Design software also revealed that mixes perform the same in terms of Rutting resistance, Fatigue cracking resistance, and thermal cracking resistance.

Field Performance of the Constructed Sections (First year)



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Epilog

Inland ASCE Pavement Committee – APAO position paper on use of Aramid Fibers in Asphalt (July 2014)

“We have encouraged local agencies to treat this technology as experimental and to include control sections in all of their projects so differences in performance can be determined. We do not recommend reducing thickness because in our view the research does not justify doing so at this point..”

We Concur with this recommendation.....

Thank you
Questions?





Utilization of Very High RAP Contents

Lessons Learned from the Japan Scan Tour



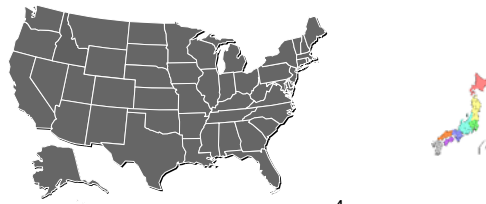
Ryoan-ji Zen Rock Garden Kyoto, Japan

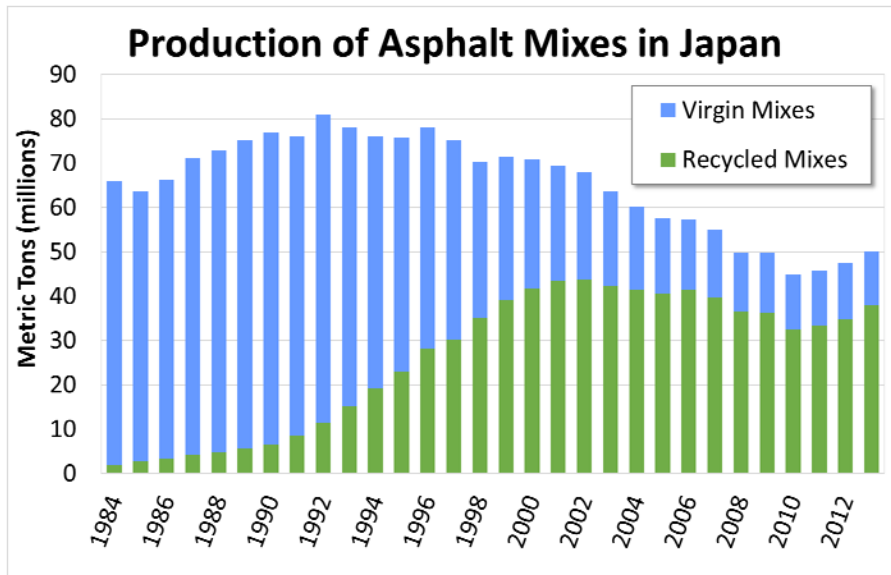
Outline

- Comparisons of Japan and USA
- Motivations to Recycling
- Performance of Recycled Mixes
- RAP Management Practices
- Mix Design Practices
- Plant Operations
- Other Technologies

Comparisons

	U.S.	Japan	%
Land Area	3,806,000 mi ²	145,925 mi ²	3.8%
Population	321 million	128 million	40%
Miles of Paved Roads	2,605,331	791,189	30.4%
No. of Asphalt Plants	~3000	1150	38%
Asphalt Mix Tons/Yr.	350 million	55 million	15.7%



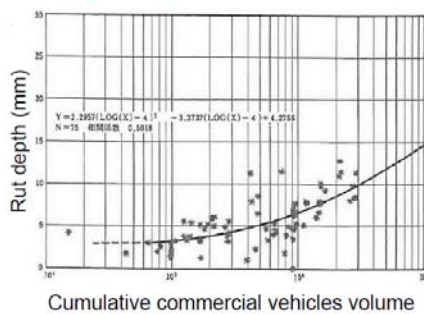


5

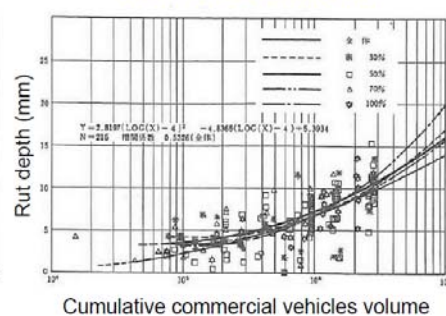
RAP Performance Studies

Conducted by Ministry of Construction from 1982 to 1984

Virgin Asphalt Pavement



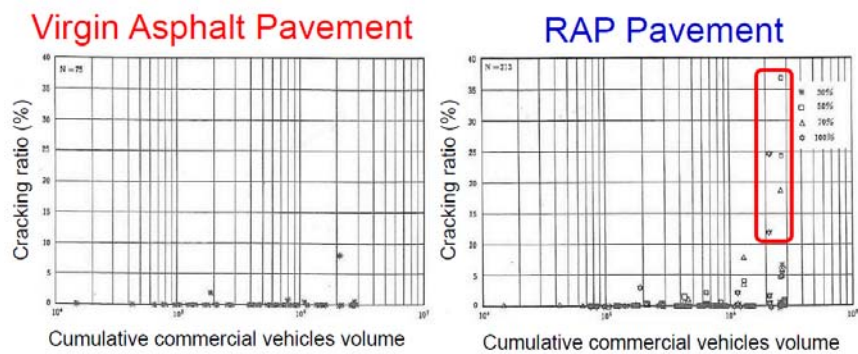
RAP Pavement



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RAP Performance Studies

Conducted by Ministry of Construction from 1982 to 1984



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RAP Management



1. RAP source is not restricted
2. Processing achieves uniformity and low moisture contents
3. RAP is tested for quality standards
4. RAP is fractionated
5. RAP stockpiles are covered⁸

RAP Quality Specifications

Characteristic	Spec. Limit
Min. Asphalt Content	3.8%
Min. Pen. of Recovered AC	20
Max. P ₂₀₀ of Unextracted RAP	5.0%



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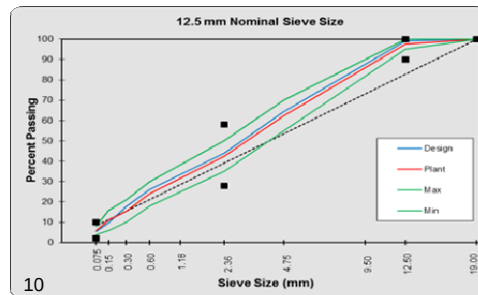
Mix Design Criteria

Parameter	Criteria
Air Voids (%)	3–6
Voids Filled with Asphalt (%)	70–85
Stability (kN)	Traffic ≥1000 vpd ≥7.35 Traffic <1000 vpd ≥4.90
Flow (1/100 cm)	20–40



Typical Surface Mix Gradation

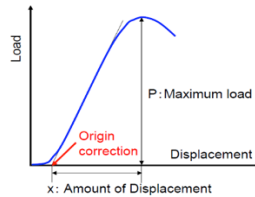
Sieve Size	Design Gradation	Expected Plant Gradation	Specification Gradation Range
19 mm	100	100	100
13.2 mm	99.2	97.5	95–100
4.75 mm	64.4	62.5	55–70
2.36 mm	44.1	42.5	35–50
0.60 mm	26.0	24.0	18–30
0.30 mm	17.7	15.5	10–21
0.15 mm	9.7	11.0	6–16
0.075 mm	5.5	6.0	4–8



IDT “modulus” Performance Test



- Marshall specimen
- 20°C
- load @ 50 mm/min.



$$\text{Indirect tensile modulus (MPa/mm)} = \frac{\sigma_t}{x}$$

$$\text{Indirect tensile strength: } \sigma_t \text{ (MPa)} = \frac{2 \times P}{\pi \times d \times L}$$

x: Amount of displacement
P: Maximum load at break
d: Thickness of the specimen
L: Specimen of diameter

Project Type	IDT Modulus (MPa/mm)
General Use	0.60 - 0.90
Cold and Snowy regions	0.40 – 0.60

Soft Asphalts and Rejuvenators



High Pen. Asphalts

- Penetration-based blending charts



Rejuvenators

- Formulations are Trade Secrets
- Typical dosage rates: 5 to 10% of RAP binder, based on target IDT modulus
- Spec ranges on viscosity, flash point, TFOT viscosity ratio and mass loss.

Asphalt Plants in Japan

- 1150 total plants
- 84% are batch plants
- Plants visited in Tokyo were very sophisticated



Parallel RAP Dryer

- Low moisture content of RAP prior to drying/heating
- RAP dryer at one site was 8 ft. diameter by 33 m long with a capacity of 110 tph
- Exhaust gases thru thermal oxidizer to eliminate smoke
- RAP exit temp. ~330°F
- Hot RAP mixed immediately with rejuvenator and stored for 2-3 hours prior to mixing with virgin materials



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Mixes were produced for us with all virgin materials, 45% RAP and 60% RAP. All of the mixes looked and handled the same.

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Key Takeaways

- Motivation to use high RAP contents in Japan is primarily from a conservation perspective.
- Specifications are fairly simple and include a simple IDT test to avoid brittle mixes.
- RAP dried separately, rejuvenator added and allowed time to condition the RAP.
- Japan has culture of quality, and integrity.
- Limited number of contractors who are willing to heavily invest in sophisticated plants and R&D.





Thank you!

Randy West, PhD, PE
Director

westran@auburn.edu