

60th Idaho Asphalt Conference

October 22, 2020

Morning Session Presiding: Jeff Miles, P.E. Local Highway Technical Assistance Council	
9:15 am	Performance Based Mix Design - HMA Dr. Shane Buchanan, P.E. CRH Americas Materials, Inc., shane.buchanan@na.crh.com
9:55 am	Asphalt Pavement Durability and the Role of Superpave5 Gerry Huber, P.E. Heritage Research Group gerald.huber@hrglab.com
10:35 am	Asphalt Mix Design Using Air Void Regression Steven Hefel, P.E. Wisconsin Dept. of Transportation Steven.Hefel@dot.wi.gov

Afternoon Session Presiding: Emad Kassem, Ph.D., P.E. University of Idaho	
1:00 pm	PaveXpress - A Simplified Pavement Design Tool Trenton Clark, P.E. Virginia Asphalt Association tclark@vaasphalt.com
1:40 pm	NCHRP 9-63: Performance-Related Specification for Emulsified Asphalt Binder Mike Anderson, P.E. The Asphalt Institute MAnderson@AsphaltInstitute.org This presentation is not available. Please contact the speaker
2:20 pm	Pavement Inspection / Pavement Quality Timothy R. Murphy, P.E. Murphy Pavement Technology, Inc. tmurphy@murphypavetech.com This presentation is not available. Please contact the speaker



Virtual via  zoom

Conference Speakers



Fouad Bayomy, PhD, PE
Conference Chair



Jeff Miles, PE
Session Moderator



Shane Buchanan, PhD, PE
Speaker



Gerry Huber, PE
Speaker



Steven Hefel, PE
Speaker



Emad Kassem, PhD, PE
Session Moderator



Trenton Clark, PE
Speaker

Mike Anderson, PE
Speaker



Tim Murphy, PE
Speaker

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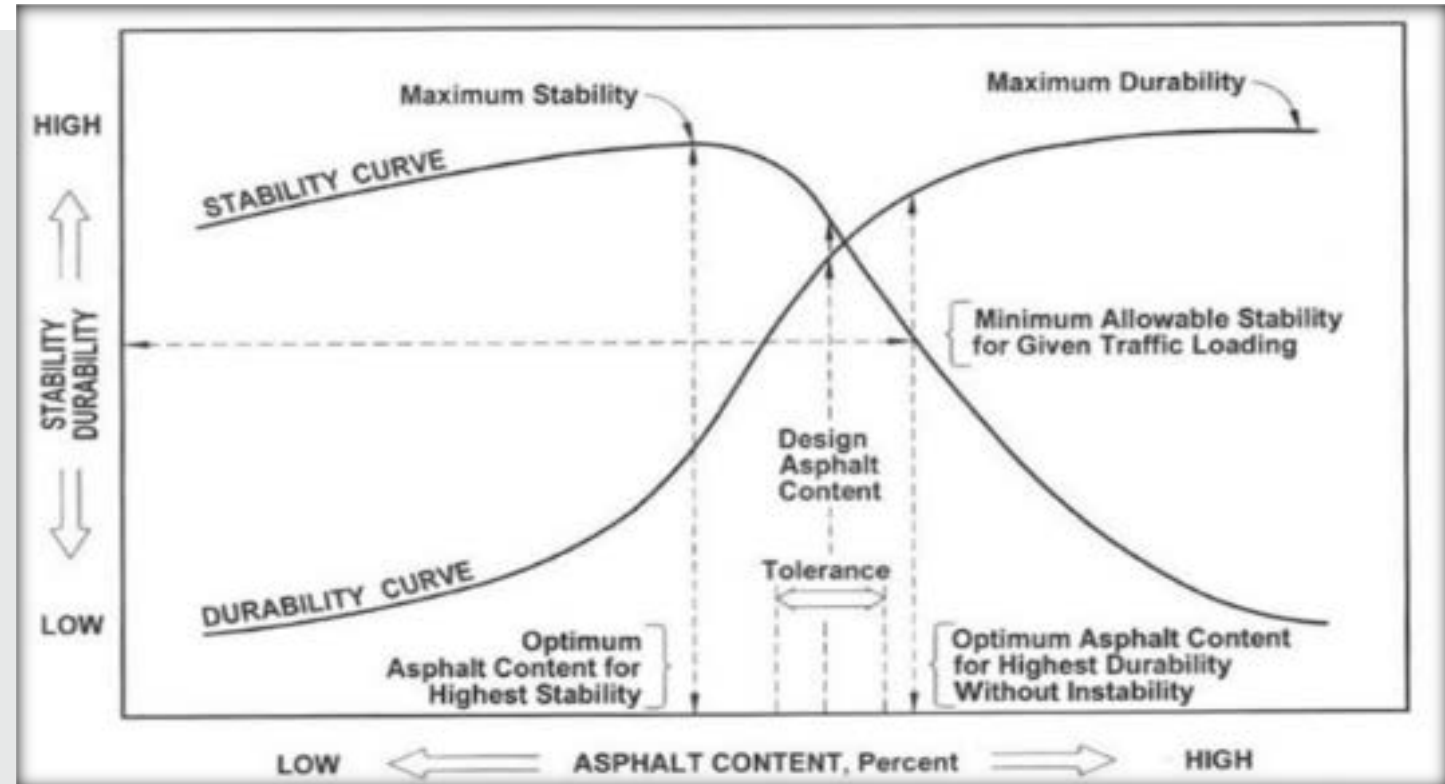


Performance Based Mix Design [Balanced Mix Design (BMD)]



Balanced Mix Design

Mix design based on balancing mix rutting and cracking performance for the desired end use application.



Balanced Mix Design - History

1993: Superpave

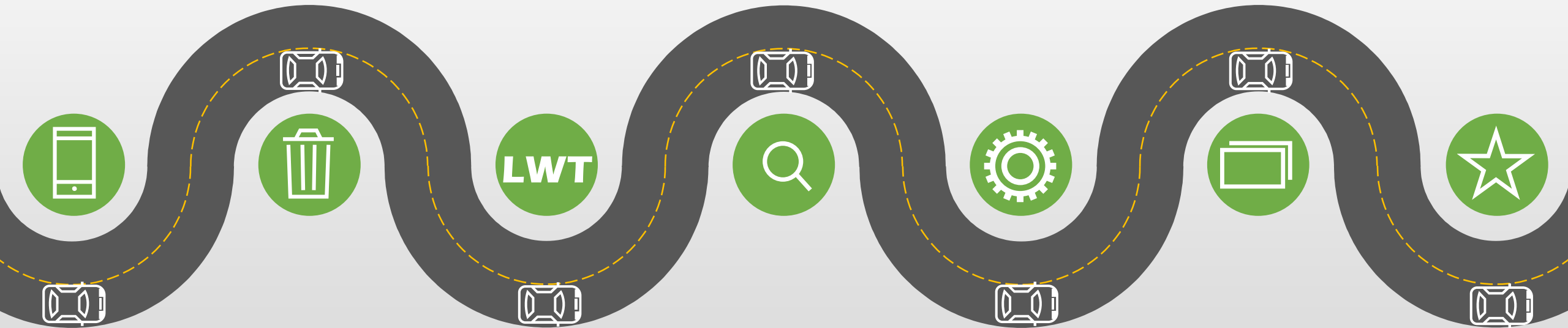
- Level 1 Volumetrics
- Levels 2 and 3 Performance

Late 1990's – Present: Search for “THE” Cracking Test

- IDT, SCB, IFIT, DCT, IDEAL CT, AMPT

2018: NCHRP 20-07/Task 406 Completed by NCAT

- Framework for BMD
- AASHTO Draft Standards for BMD



1920's/40's Previous Mix Design Methods

- 1927: Hveem Stabilometer / Cohesimeter)
- 1943: Marshall (Stability / Flow)

Mid 1990's Loaded Wheel Testers Development/Use

- Georgia LWT
- Asphalt Pavement Analyzer (APA)
- Hamburg

Mid 2010's – Present DOT BMD Specifications

- Louisiana, Illinois, New Jersey, Texas, Oklahoma, Virginia, Wisconsin
- In process: Missouri, Vermont, Utah, Minnesota, Kentucky, Oregon, Tennessee, Indiana, and others.

2019+: Education and Implementation Efforts

- NCAT BMD Regional Workshops
- NCAT BMD Test Track Experiments

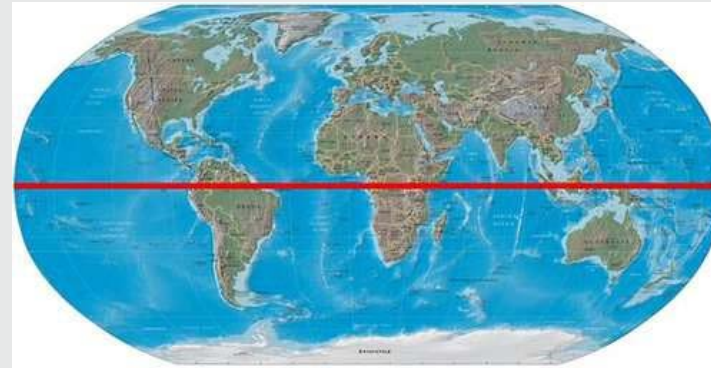
Why Move Forward?

Since Superpave's 1993 Introduction
~ 11,225,000,000 Tons of Mix Produced in U.S.
= 19,548,938 miles @ 12 ft wide 1.5 in thick

- **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
- New York to Las Vegas



- Pave around the earth's equator
~ 782 times.



- Pave to the moon and back!
~ 41 times



The Time is Now to Move Forward!

In Idaho, did you know....

- **Each day**, approximately 11,000 tons of HMA are produced in Idaho (M-F production basis)
- Equivalent to ~20 lane miles @ 12' wide and 1.5" thick



Nampa to Boise

IDAHO	Reported Values		Estimated Values	
	2018	2019	2018	2019
Tons of HMA/WMA Produced	Tons, Millions		Tons, Millions	
Total	1.5	1.5	2.9	2.7
DOT	0.8	0.8	1.5	1.5
Other Agency	0.4	0.3	0.8	0.5
Commercial & Residential	0.3	0.4	0.6	0.7

NAPA: Asphalt Pavement Industry Survey on Recycled Materials and Warm-Mix Asphalt Usage 2019



Why Move Forward?

- **Problems:**

- Volumetrics alone can not adequately evaluate mix variables, such as recycle, warm-mix additives, polymers, rejuvenators, and fibers.

- **Solutions:**

- **Increase understanding** of the factors which drive mix performance
- **Design for performance** and not just to “the spec”.
- **Start thinking** outside of long held “rules and constraints”
- **Innovate!**

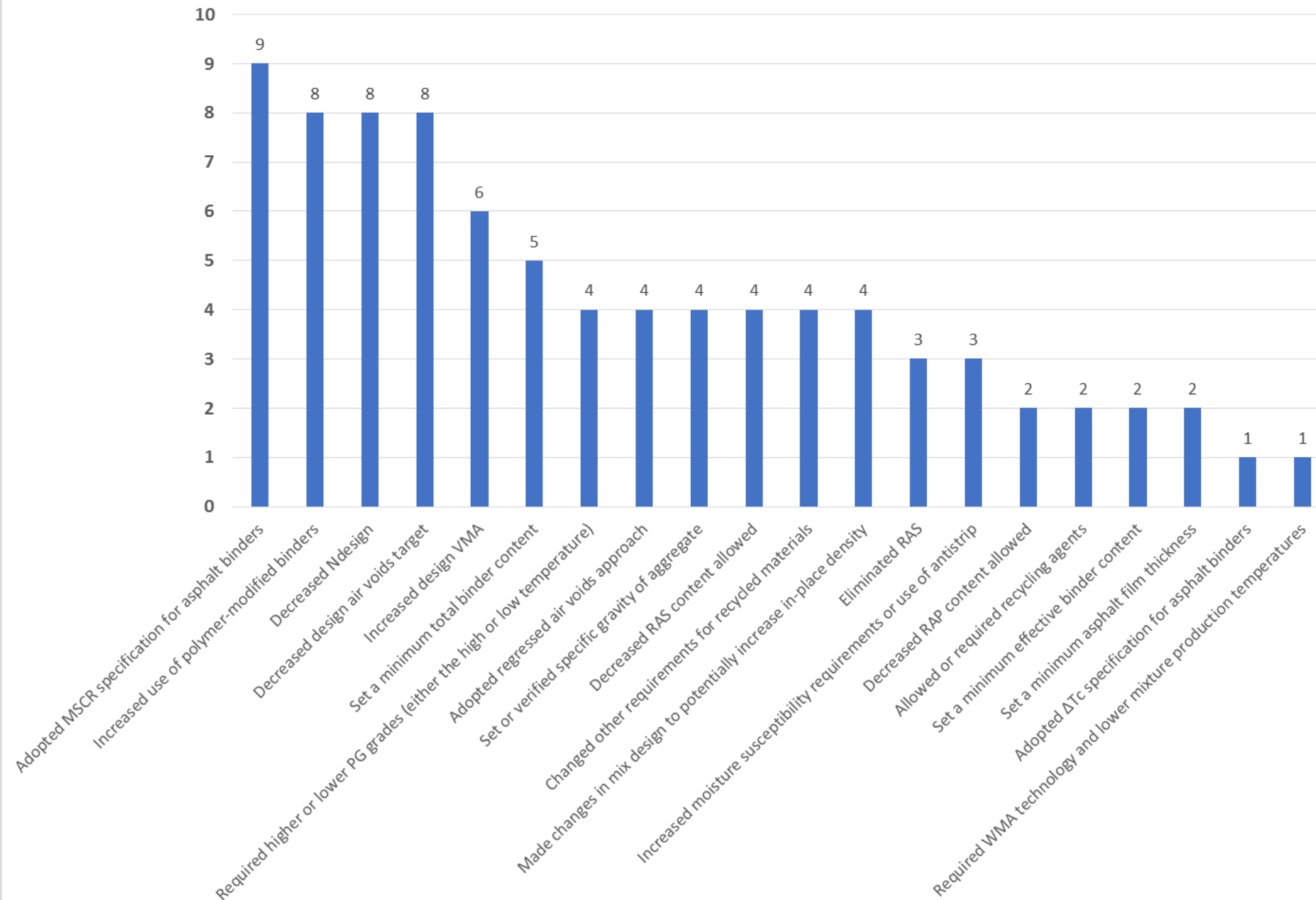


Current Mix Design Specifications

- Most of today's mix design specifications are heavily scripted and follow a “recipe” or standardized approach.
 - Aggregates and grading
 - Volumetrics (Va, VMA, VFA, D/A, etc.)
 - Binder grade and/or minimum %
 - RAP and/or RAS
- While this may work, there are problems
 - What happens when the recipe fails?
 - Specifications have become **convoluted and confounded**
 - ✦ Existing specified items compete against each other
 - ✦ New requirements get added and nothing gets removed
 - “Spec Book Creep”



Agencies Making Specification Changes



All these changes
are being made to
yield a better
performing mixture.
**Question: Why Not
Just Test the Mix?**

Balanced Mix Design Approaches

- Several approaches available.
- **CAUTION:** Adding performance testing to an existing specification without allowances can make for an unachievable, unrealistic outcome.
- Allowances: volumetric property target ranges, thresholds, etc.

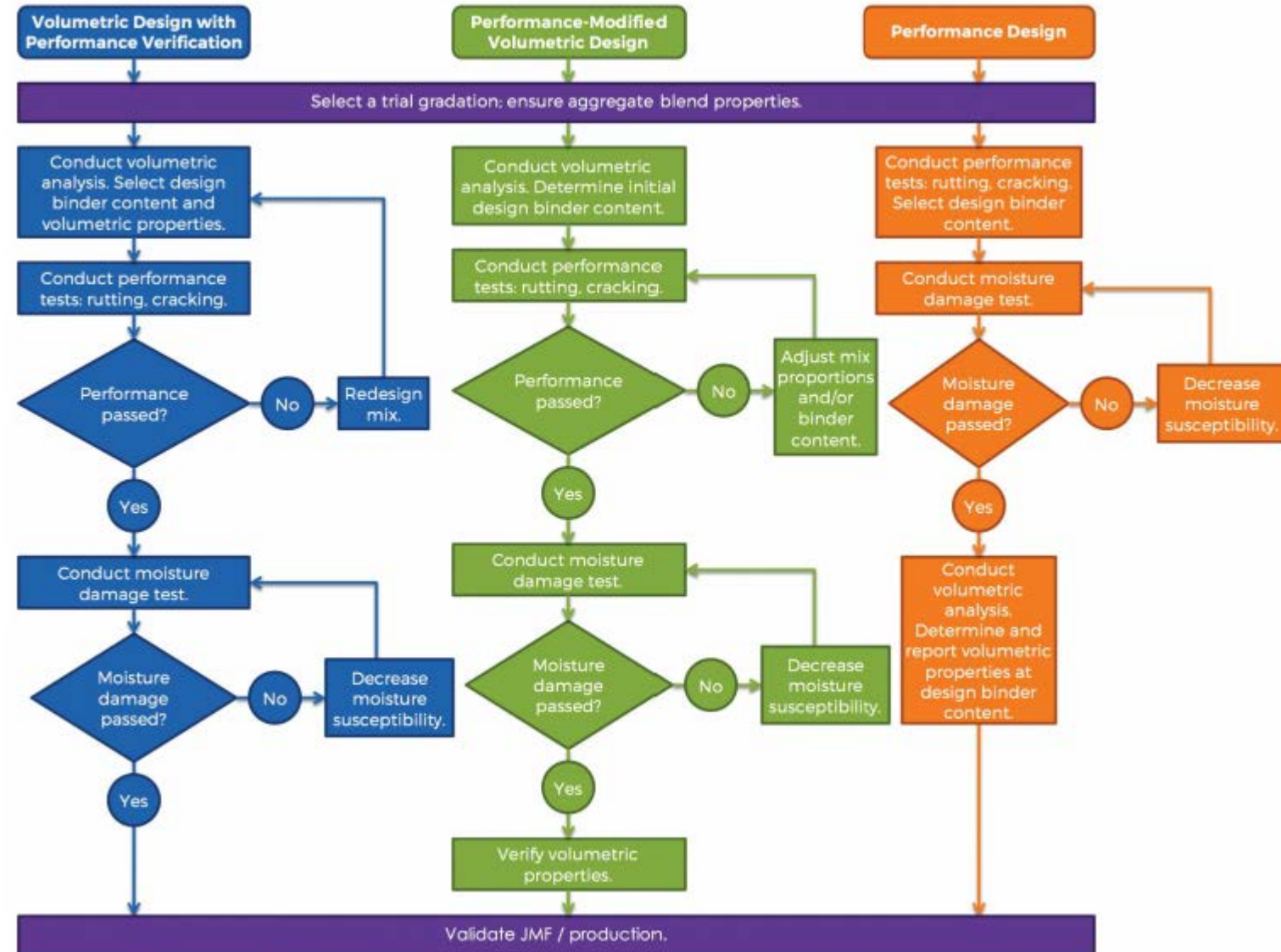
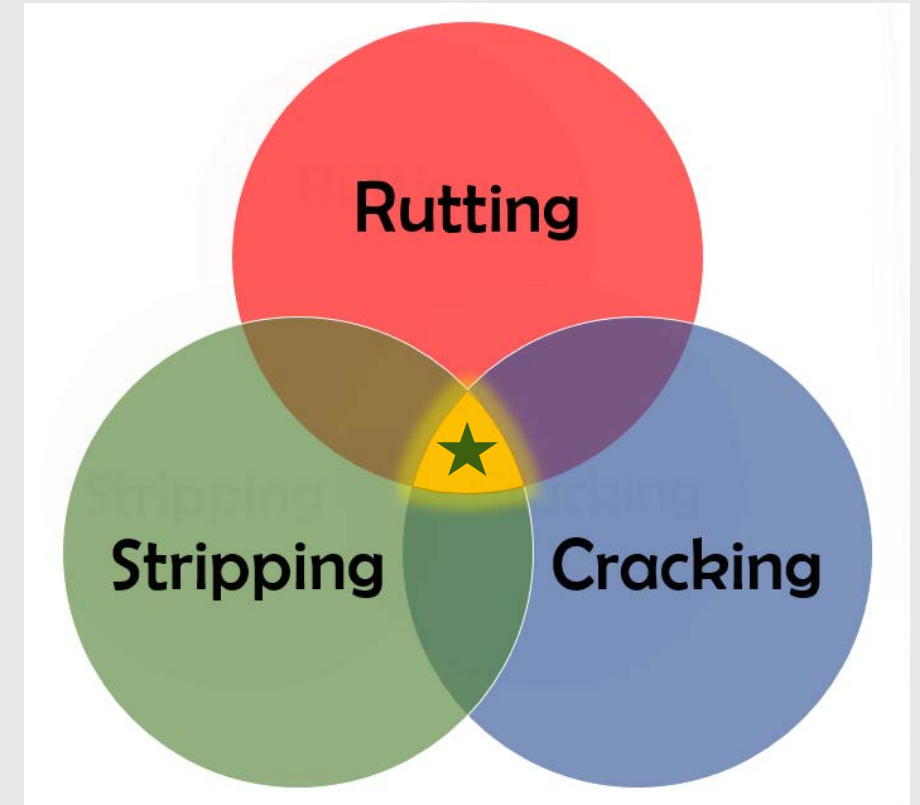
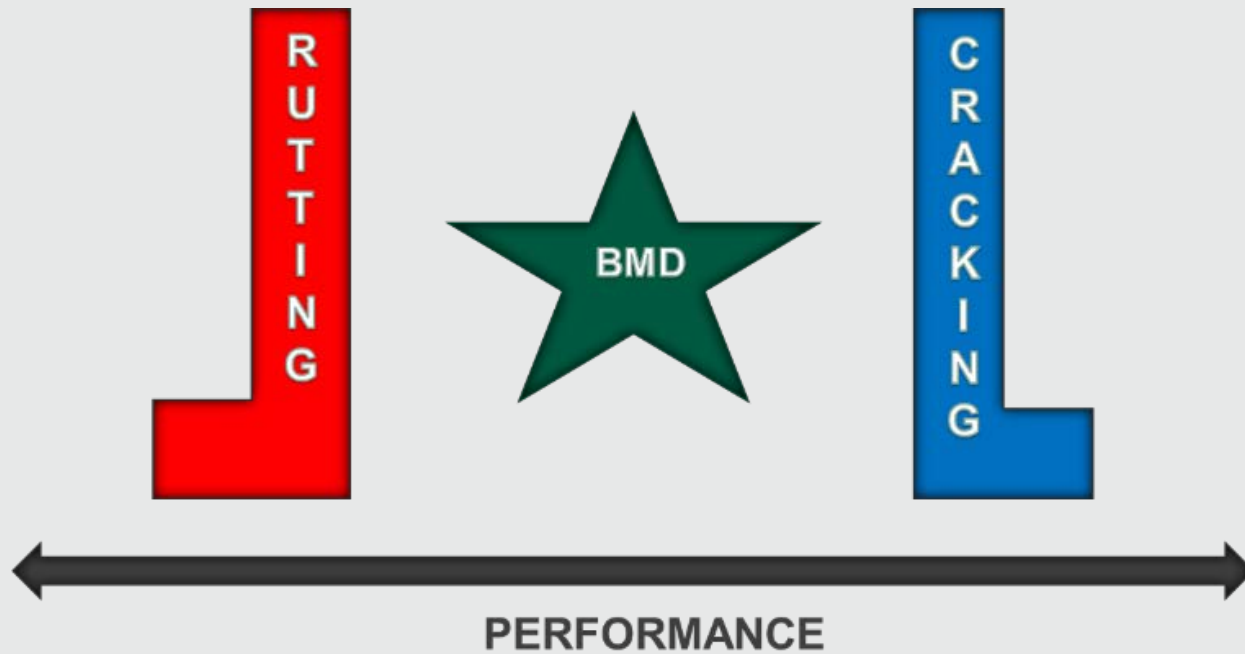


Figure 3-2. Schematic illustration of three BMD approaches.

Performance Tests (Rutting and Cracking) for BMD



Main Pavement Distresses Observed in the Field

Moisture Damage



Permanent Deformation



Fatigue Cracking



Thermal Cracking



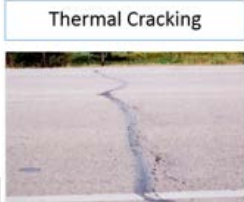
Reflection Cracking



Top-down Cracking



Table 3-12. Commonly used asphalt mixture performance tests.[http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-07\(406\)_Revised_final_report.pdf](http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-07(406)_Revised_final_report.pdf)

Mixture Property	Laboratory Test	Test Standard	Test Parameter(s)	Criteria Available
 Thermal Cracking	Disk-Shaped Compact Tension Test*	ASTM D7313-13	Fracture Energy	Yes
	Indirect Tensile Creep & Strength Test	AASHTO T 322-07	Creep Compliance & Tensile Strength	Yes
	Semi-Circular Bend (SCB) Test*	AASHTO TP 105-13	Fracture Energy	Yes
	Thermal Stress Restrained Specimen Test	BS EN12697-4	Fracture Temperature & Fracture Strength	No
 Reflection Cracking	Disk-Shaped Compact Tension Test*	ASTM D7313-13	Fracture Energy	No
	Texas Overlay Test*	TxDOT Tex-248-F NJDOT B-10	Cycles to Failure & Fracture Properties	Yes
	Illinois Flexibility Index Test	AASHTO TP 124-16	Flexibility Index	Yes
 Fatigue Cracking	Direct Tension Cyclic Fatigue Test	AASHTO TP 107-14	Damage Characteristic Curve & Fatigue Model	No
	Flexural Bending Beam Fatigue Test*	AASHTO T 321 ASTM D7460	Cycles to Failure Fatigue Equation	No
	IDT Fracture Energy Test	N/A	Fracture Energy	No
	Illinois Flexibility Index Test	AASHTO TP 124-16	Flexibility Index	Yes
	SCB at Intermediate Temperature*	LaDOTD TR 330-14 ASTM D8044-16	Strain Energy Release Rate	Yes
	Texas Overlay Test*	TxDOT Tex-248-F	Cycles to Failure Fracture Properties	Yes
 Top-Down Fatigue Cracking	Direct Tension Test	N/A	Fracture Parameters	No
	IDT Energy Ratio Test*	N/A	Dissipated Creep Strain Energy & Energy Ratio	No
	Illinois Flexibility Index Test	AASHTO TP 124-16	Flexibility Index	Yes
 Rutting	Asphalt Pavement Analyzer	AASHTO T 340	Rut Depth	Yes
	Flow Number	AASHTO T 378	Flow Number	Yes
	Hamburg Wheel Tracking Test	AASHTO T 324	Rut Depth	Yes
	Superpave Shear Tester	AASHTO T 320-07	Permanent Shear Strain	No
	Incremental Repeated Load Permanent Deformation	AASHTO TP 116-15	Minimum Strain Rate	Yes
	Hamburg Wheel Tracking Test	AASHTO T 324	Rut Depth & Stripping Inflection Point	Yes
 Moisture Susceptibility	IDT Strength Test	AASHTO T 283	Tensile Strength Ratio & Wet IDT Strength	Yes
	Moisture Induced Stress Tester	ASTM D7870	Changes in G_{mb} & Visual Observations of Stripping	No

Note: * Tests selected at the Cracking Test Workshop in NCHRP Project 09-57 (Zhou et al., 2016)

Rutting Tests



Rutting Tests

- Rutting can be evaluated with several available tests based on the user preference.



Hamburg Wheel Test (HWT)



Asphalt Pavement Analyzer (APA)



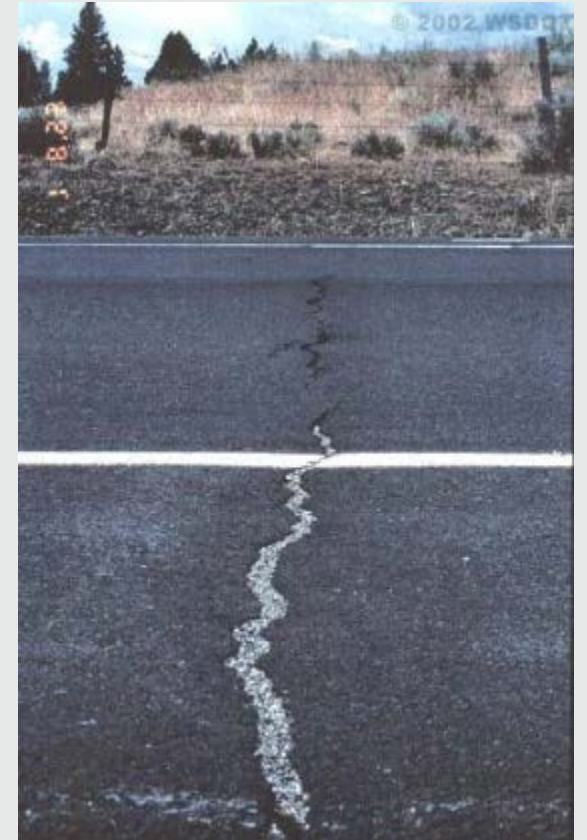
IDT - HT



AMPT Flow Number / Dynamic Modulus

Most commonly used tests. Hamburg gaining popularity due to moisture susceptibility analysis.

Durability Testing (Cracking)



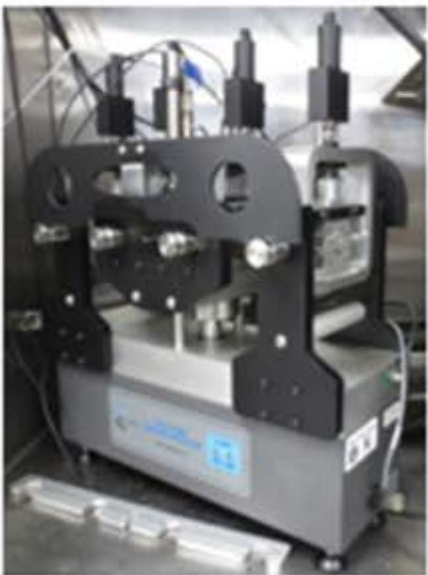
Durability/Cracking Evaluation

- Durability/cracking evaluation is substantially more complicated than stability with aging being one main variable.
- No general consensus the best test(s) or the appropriate failure threshold.
- MANY different tests are available with more being developed.
- Main question is “What is the anticipated mode of distress?”



Fatigue (Bottom Up or Top Down) Related Cracking Tests

Bottom Up



Bending Beam Fatigue

Bottom Up /
Top Down



Texas Overlay Test

Bottom Up

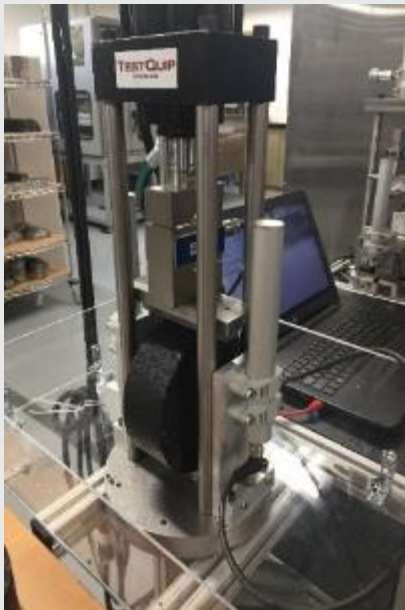


SCB
- LTRC – Jc
- IFIT



Direct Tension Cyclic
Fatigue, S-VECD

Bottom Up /
Top Down



IDEAL CT



Thermal Cracking Tests



IDT Creep
Compliance



TSRST



SCB at Low Temp



Disk Shaped Compact
Tension (DCT)



Reflection (Reflective) Cracking Tests



Disk Shaped Compact Tension (DCT)



Texas Overlay Test



SCB (IFIT)

Leading Tests *Today*



Hamburg Wheel Test (HWT)



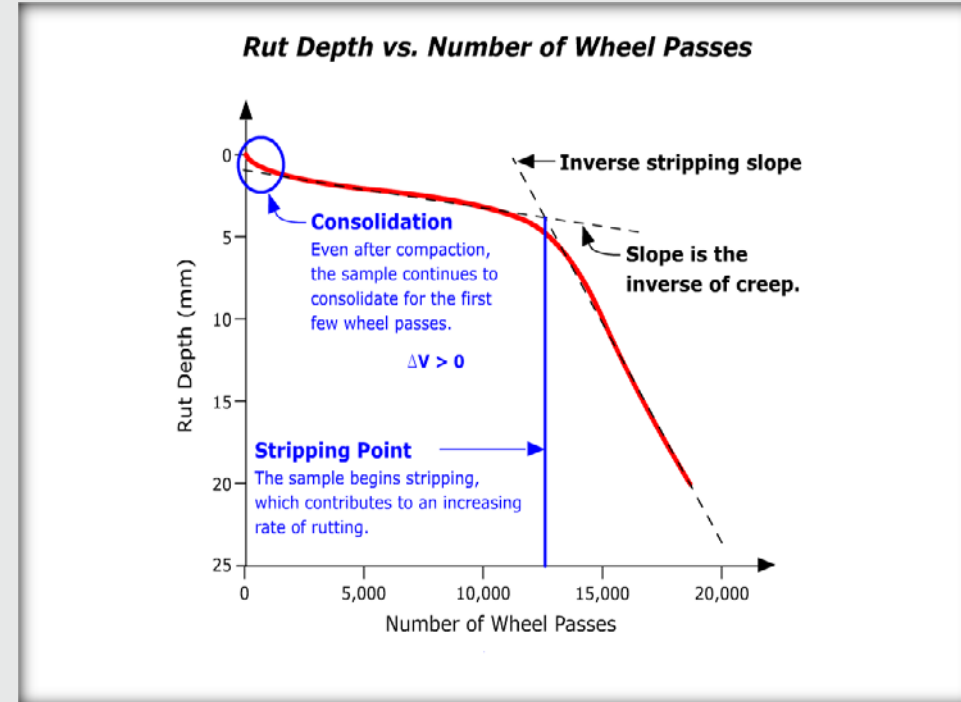
**Illinois Flexibility
Index Test (IFIT)**



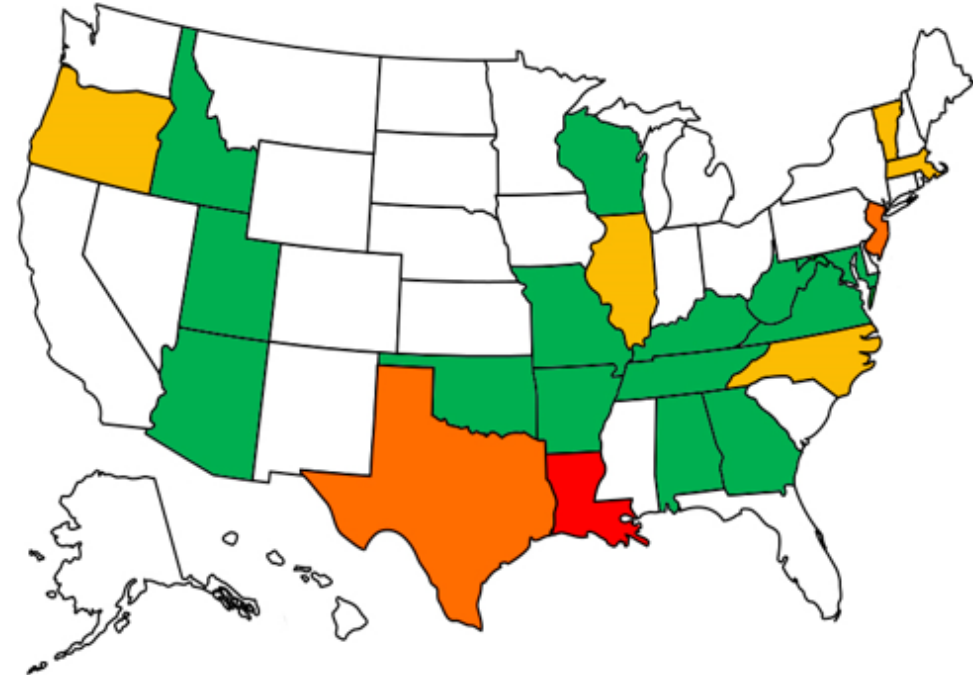
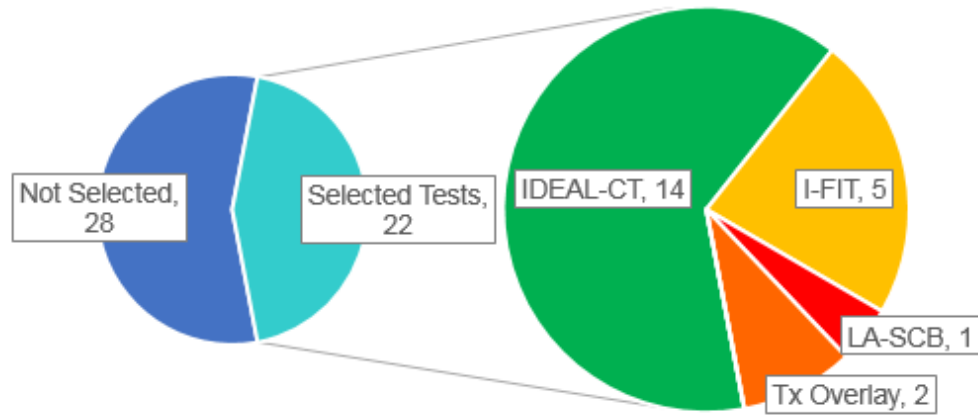
IDEAL CT

Hamburg Wheel Test (HWT)

- AASHTO T324
- Rutting performance combined with moisture susceptibility
- No. of passes (20,000)
- Temperature (~50C)
- Air voids ($7 \pm 0.5\%$)
- Steel Wheel
- Submerged specimen



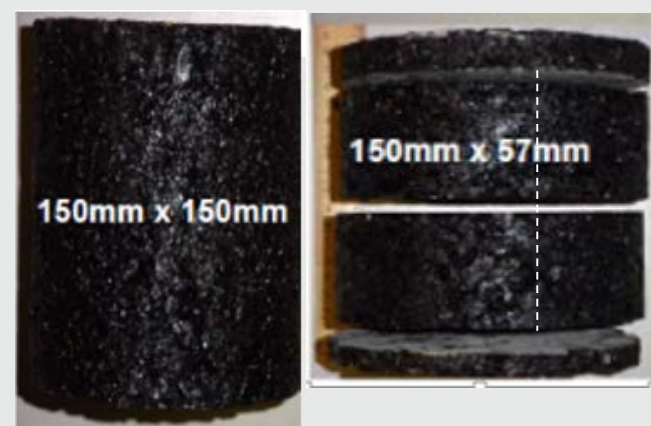
Leading Cracking Tests



- IDEAL-CT
- Illinois Flexibility Index (I-FIT)
- Texas Overlay Test
- Louisiana SCB Test
- Not Selected



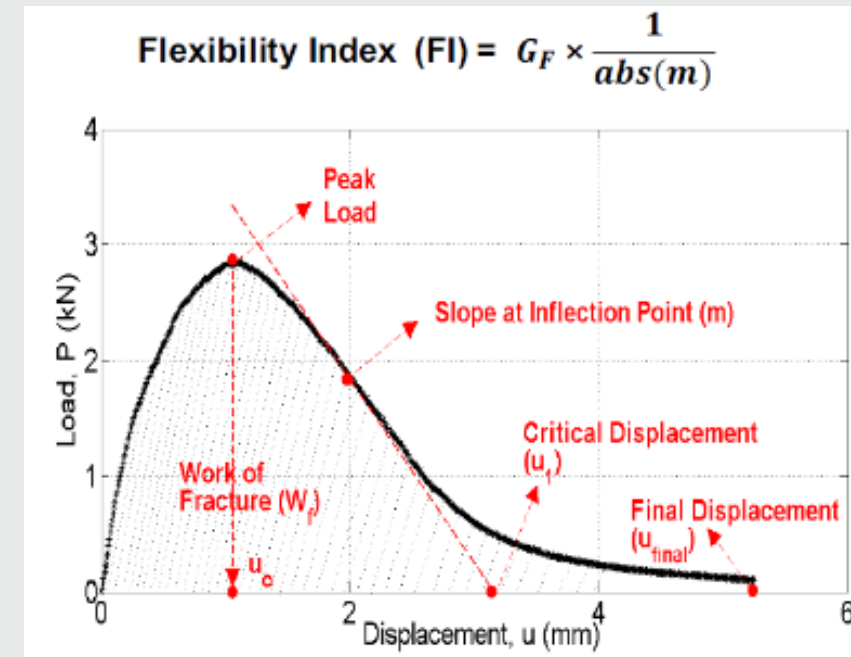
Illinois Flexibility Index Test (I-FIT)



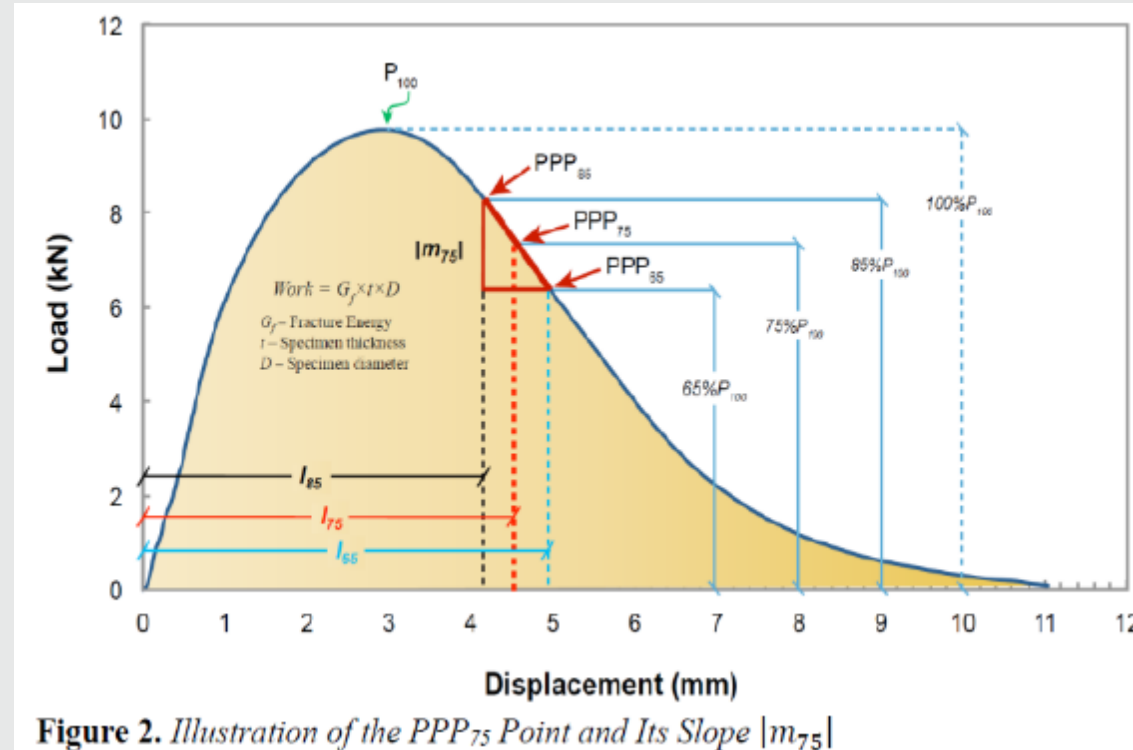
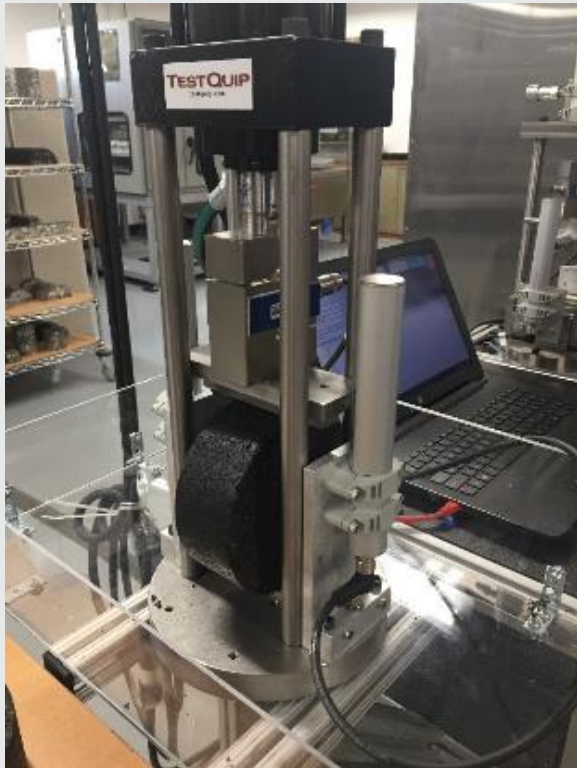
- AASHTO TP 124
- Temperature 25C
- Air voids ($7 \pm 0.5\%$)



Notch



Indirect Tension Asphalt Cracking Test (IDEAL-CT)



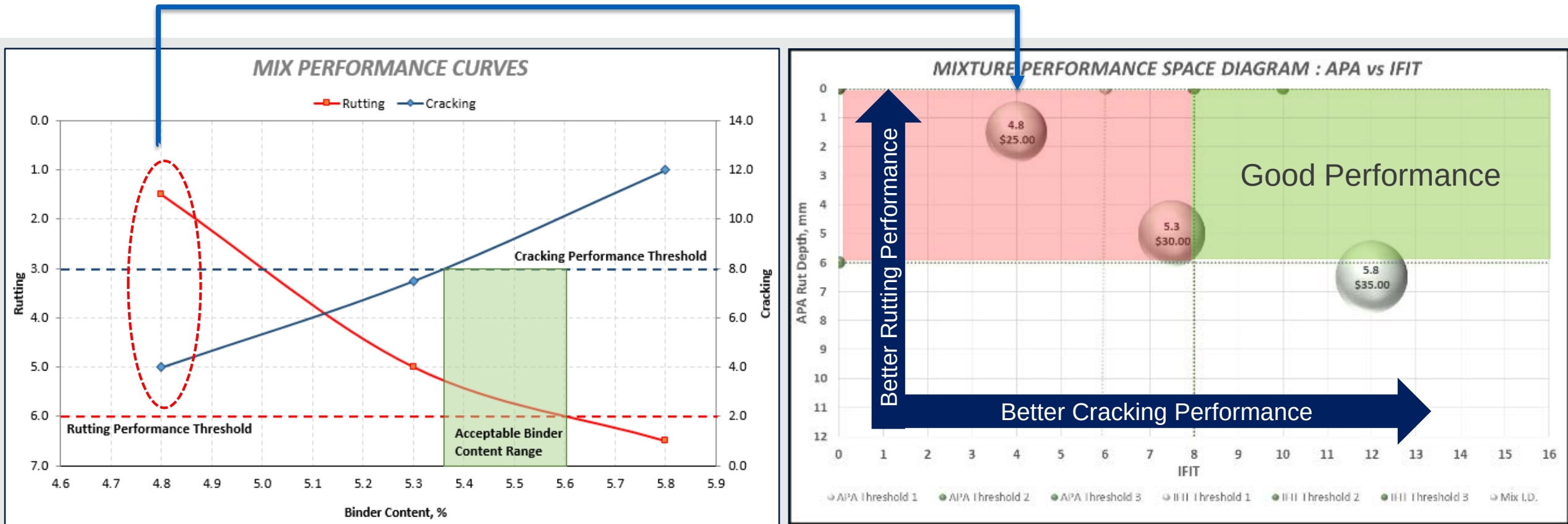
- ASTM D8225
- Similar to IFIT
- Faster, easier to test.
- 62 mm height, uncut specimen



Indirect Tension Asphalt Cracking Test (IDEAL-CT)
NCHRP IDEA Project 195: Development of an
IDEAL Cracking Test for Asphalt Mix Design,
Quality Control and Quality Assurance

$$CT_{Index} = \frac{G_f}{|m_{75}|} \times \left(\frac{l_{75}}{D} \right)$$

Total Mixture Performance



What are the States Doing?



Illinois Balanced Mix Design



- Phased implementation
 - 26 Pilot projects 2016/2017
 - All Interstate projects 2019
 - **Full implementation 2020**



Hamburg

+



IFIT

(1) Hamburg Wheel Test Criteria. The maximum allowable rut depth shall be 0.5 in. (12.5 mm). The minimum number of wheel passes at the 0.5 in. (12.5 mm) rut depth criteria shall be based on the high temperature binder grade of the mix as specified in the mix requirements table of the plans.

Illinois Modified AASHTO T 324 Requirements ^{1/}

PG Grade	Number of Passes
PG 58-xx (or lower)	5,000
PG 64-xx	7,500
PG 70-xx	15,000
PG 76-xx (or higher)	20,000

(3) I-FIT Flexibility Index (FI) Criteria^{1/}. The minimum allowable FI shall be as follows:

Minimum Flexibility Index (FI)	
HMA	8.0
SMA	8.0

Louisiana Balanced Mix Design



- Louisiana DOT implemented BMD in the 2016 Standard Specifications for **all DOT projects.**



Hamburg

+



Louisiana SCB

Table 502-6¹
Asphalt Concrete General Criteria

Nominal Max., Size Agg.	0.5 inch (12.5 mm)			0.75 inch (19 mm)			1.0 inch (25 mm)			1.5 inch (37.5 mm)	SMA	
Type of Mix	Incidental Paving ^{2,9}	Wearing Course		Wearing Course	Binder Course		Binder Course	Base Course ⁹	ATB ^{8,9}	Base Course ⁹	Wearing	
Level ³	A	1	2	2	1	2	1	2	1	1	2	
LWT, max. rut-design, mm @ # passes, @ 50°C	10 @ 10,000	10 @ 20,000	6 @ 20,000	6 @ 20,000	10 @ 20,000	6 @ 20,000	10 @ 20,000	6 @ 20,000	12 @ 20,000	10 @ 10,000	12 @ 20,000	6 @ 20,000
Dust/Effective Asphalt Ratio, %		0.6 – 1.6										
SCB, min, Jc, KJ/m2 @ 25°C	All mix design level 1 must meet minimum 0.5 Jc , All mix design level 2 must meet minimum 0.6 Jc.											

- Hamburg research began prior to 2000*
- SCB research began in 2004*





New Jersey Balanced Mix Design

- NJDOT High RAP Design incorporates BMD



Asphalt Pavement Analyzer (APA)

+



Texas Overlay Tester

Table 902.13.03-2 Performance Testing Requirements for HMA HIGH RAP Design				
	Requirement			
	Surface Course		Intermediate and Base Course	
Test	PG 64-22	PG 64E-22	PG 64-22	PG 64E-22
APA @ 8,000 loading cycles (AASHTO T 340)	≤ 7 mm	≤ 4 mm	≤ 7 mm	≤ 4 mm
Overlay Tester (NJDOT B-10)	≥ 200 cycles	≥ 275 cycles	≥ 100 cycles	≥ 150 cycles



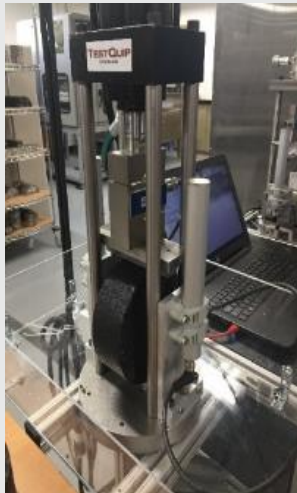
Virginia Balanced Mix Design



- New (April 2019) **Special Provision for High Reclaimed Asphalt Pavement (RAP) Content Surface Mixes Designed Using Performance Criteria**



Asphalt Pavement Analyzer (APA)



IDEAL CT



Cantabro

Test	Procedure	Specimens	Criteria
AASHTO T340 – Method of Test for Determining Rutting Susceptibility of HMA Using the Asphalt Pavement Analyzer (APA)	8,000 passes @ 64°C	2 replicates of 2 pills (APA Jr) - Gyratory pill: 150 mm dia., 75 ± 2 mm ht. - Compact to 7±0.5% air voids <u>Lab produced mix</u>: condition loose mix for 2 hours at the design compaction temperature prior to compacting <u>Plant produced mix</u>: Minimize any cooling of and bring specimens to the compaction temperature and compact immediately.	Rutting ≤ 8.0mm
AASHTO TP 108-14 (2018). Standard Method of Test for Determining the Abrasion Loss of Asphalt Mixture Specimens (Cantabro)	300 rotations 30-33 rot/min	3 replicates - Gyratory pill: 150 mm dia., 115 ± 5 mm ht. - Compact to N_{design}, report air voids <u>Lab-produced mix</u> – condition loose mix for 2 hours at the design compaction temperature prior to compacting	Mass loss ≤ 7.5%
ASTMXX- Determination of Cracking Tolerance Index of Asphalt Mixture Using the Indirect Tensile Cracking Test at Intermediate Temperature (CT _{ind} a.k.a. "Ideal CT")	- Condition specimens 25±1°C for 2±0.5 hr - load Apply load using load-line displacement control at rate of 50 mm/minute, record load to peak and through failure; analyze.	3 replicates - Gyratory pill- 150mm dia., 62 ± 2mm ht. - Compact to 7±0.5% air voids <u>Lab-produced mix</u> – condition loose mix for 4 hours at the design compaction temperature prior to compacting	CT _{index} ≥ 70

Texas DOT Balanced Mix Design



Special Specification 344

Superpave Mixtures - Balanced Mix Design



1. DESCRIPTION

Construct a hot-mix asphalt (HMA) pavement layer composed of a compacted, Superpave (SP) mixture of aggregate and asphalt binder mixed hot in a mixing plant utilizing a Balanced Mix Design (BMD) approach.



Hamburg

+



Texas Overlay Tester

Table 11A
Hamburg Wheel Test Requirements

High-Temperature Binder Grade	Test Method	Minimum # of Passes @ 12.5 mm ¹ Rut Depth, Tested @ 50°C
PG 64 or lower	Tex-242-F	10,000 ²
PG 70		15,000 ³
PG 76 or higher		20,000

1. When the rut depth at the required minimum number of passes is less than 3 mm, the Engineer may require the Contractor to lower the Ndesign level to no less than 35 gyrations.
2. May be decreased to no less than 5,000 passes when shown on the plans.
3. May be decreased to no less than 10,000 passes when shown on the plans.

Table 11B
Overlay Test Requirements

Mixture Property	Test Method	Surface Mixtures	Intermediate and Base Mixtures
Critical Fracture Energy (CFE), ¹ in.-lb/in. ² , Min	Tex-248-F	1.0	1.0
Crack Progression Rate (CPR), ¹ Max		0.45	0.55

1. If the requirement is not met, the Engineer may approve the mix if the average number of cycles is ≥ 300 cycles.

Oklahoma DOT Balanced Mix Design



OKLAHOMA DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION
FOR
BALANCED MIX DESIGN REQUIREMENTS

These Special Provisions amend and where in conflict, supersede applicable sections of the 2009 Standard Specifications for Highway Construction, English and Metric and applicable Special Provisions.

NOTE: It is the intent of this special provision to allow the contractor/producer the option to design and produce HMA/WMA meeting Balanced Mix Design (BMD) requirements that does not necessarily meet the requirements of 2009 Standard Specifications and current Special Provisions. In addition, during production, JMF tolerances of 2009 Standard Specifications and current Special Provisions will be applied. An open communication should be established during the HMA/WMA design process between the contractor/producer and ODOT Materials Division Bituminous Branch to facilitate the approval process. The final HMA/WMA design will be at the discretion of the ODOT Bituminous Branch Manager.



Hamburg

+



IFIT

Table 708:11a Hamburg Rut Test Requirements ^{a, b}	
Binder Grade	Minimum Number of Passes to 12.50 mm Rut Depth, Tested at 122 °F (50C)
PG 64	10,000
PG 70	15,000
PG 76	20,000

Table 708:8 Mix Design Properties of Laboratory Molded Specimens						
Property	Superpave			SMA	PFC	RBL
	PG64	PG70	PG76	PG76	PG76	PG64
Cantabro	Report Only					
I-FIT	≥ 8.0	≥ 8.0	≥ 8.0	---	---	---

Notes:

Hamburg + IFIT @ 7% voids, Cantabro @ 4%
Short term aging used (R30)



Vermont AOT Balanced Mix Design

(Under Development)



Hamburg

+



IFIT

(a) **Hamburg Wheel Tracker (HWT) Criteria.** The maximum allowable rut depth at 20,000 passes shall be based on the mix type specified in Table 1 below.

TABLE 1 - DESIGN CRITERIA FOR HWT TEST

Hamburg Wheel Tracking (HWT) Test Properties	Mix Type and Nominal Maximum Aggregate Size (inches)		
	Type IIS (3/4)	Type IIIS (1/2)	Type IVS (3/8)
Rut depth in mm (inches)	12.5 (0.50)	12.5 (0.50)	10.0 (0.40)
Stripping Inflection Point (SIP)	≥ 15,000 passes		
Test Method	AASHTO T 324		
Test Temperature in °C (°F)	45 ± 1.0 (113 ± 1.8)		

(b) **Illinois Flexibility Index Test (I-FIT) Criteria.** I-FIT testing to measure the cracking susceptibility of the mix design shall be completed in accordance with AASHTO TP 124. The minimum allowable Flexibility Index (FI) for each mix type shall be as specified in Table 2 below.

TABLE 2 - DESIGN CRITERIA FOR I-FIT TEST

Mix Type and Nominal Maximum Aggregate Size (inches)	Minimum Flexibility Index (FI)
Type IIS (3/4)	10.0
Type IIIS (1/2)	10.0
Type IVS (3/8)	10.0

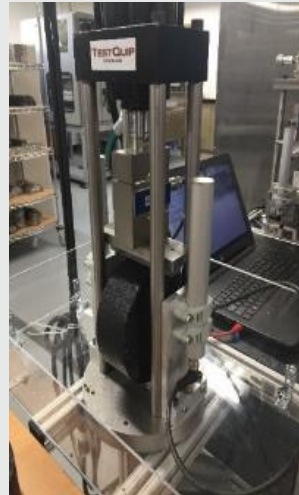
Kentucky TC Balanced Mix Design (Under Development)



- Special Note
 - Hamburg
 - IDEAL CT (KYCT Index)



Hamburg



IDEAL CT

3.3 Hamburg Testing. Perform the rut resistance analysis (Hamburg) in accordance to AASTHO T-324, not to exceed 20,000 passes for all bituminous mixtures during the **mix design** phase and **production**. For mix design approvals, submit Hamburg results on the Department MixPack. For Class 4 mixtures, submit ingredient materials to the Division of Materials for informational verification.

3.3.1 Hamburg Testing Frequency. Perform testing and analysis **per lot of material**. The plant produced bituminous material sampled for the Hamburg test does not have to be obtained at the same time as the acceptance and KYCT sample. If the Hamburg test sample is not obtained at the same time as the KYCT sample, determine the Maximum Specific Gravity of the KYCT sample in accordance with AASTHO T-209 coinciding with the Hamburg specimens.

3.2 KYCT Testing. Perform crack resistance analysis (KYCT) in accordance with the current Kentucky Method for KYCT Index Testing during the **mix design** phase and during the **plant production** of all **surface mixtures**. For mix design approvals, submit KYCT results on the Department MixPack. For Class 4 mixtures, submit ingredient materials to the Division of Materials for informational verification.

3.2.1 KYCT Frequency. Obtain an adequate sample of hot mix asphalt to insure the acceptance testing, gradation, and KYCT gyratory samples can be fabricated and is representative of the bituminous mixture. Acceptance specimens shall be fabricated first, then immediately after, fabricate the KYCT samples with the gyratory compactor in accordance with Section 2.4 of this Special Note. Analysis of the KYCT specimens and gradation will be required **one per subplot** produced from the same asphalt material and at the same time as the acceptance specimen is sampled and tested.

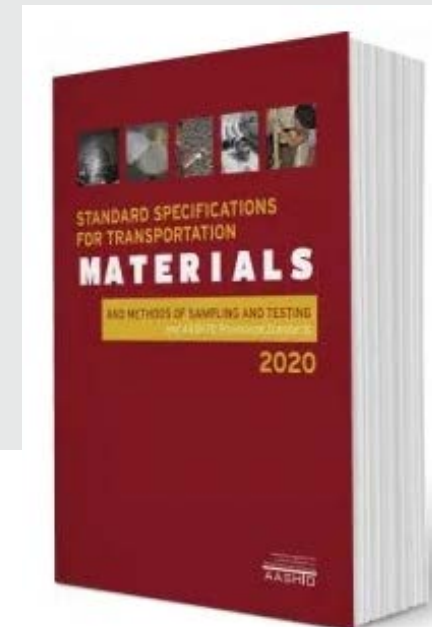
Data Collection first, Threshold Setting afterwards!

BMD Momentum



New Published AASHTO Standards in 2020!

- **PP 105 – Balanced Design of Asphalt Mixtures (standard practice document)**
 - Serves as a framework for balanced design of asphalt mixtures that governs the development of an asphalt mixture job mix formula based on mixture volumetric properties, performance-based/related test results, or both.
 - May also be used to provide a preliminary selection of mix parameters as a starting point for performance prediction analyses.
- **MP 46 – Balanced Mix Design (standard specification document)**
 - Specifies minimum performance testing requirements for balanced design of asphalt mixtures.



1. PROJECT: [Investigation of Balanced Mixture Design for New York State Asphalt Mixtures](#)

☐ Center for Advanced Infrastructure and Transportation, \$80000, 2019, Active

2. PROJECT: [Balanced Mixture Design Implementation Support](#)

☐ Wisconsin Department of Transportation, \$150000, 2019, Active

3. PROJECT: [Impact of Production Variability on Balanced Mix Design in Virginia](#)

☐ Virginia Department of Transportation, \$362921, 2019, Active

4. PROJECT: [Framework of Asphalt Balanced Mix Design \(BMD\) for New England Transportation Agencies](#)

☐ Maine Department of Transportation, 2019, Active

5. PROJECT: [Use of the IDEAL-CT Test for Pavement Cracking to Achieve a Balanced Asphalt Mix Design](#)

☐ Mountain-Plains Consortium, \$174000, 2019, Active

6. PROJECT: [Development of a Balanced Mix Design \(BMD\) Procedure for Tennessee Asphalt Mixtures](#)

☐ Tennessee Department of Transportation, \$179,925.00, 2018, Active

7. PROJECT: [Development of a Balanced Mix Design Method in Oregon](#)

☐ Oregon Department of Transportation, \$85000, 2017, Active

8. PROJECT: [2305 - Implement Balanced Asphalt Mix Design in Oklahoma](#)

☐ Oklahoma Department of Transportation, \$111332, 2017, Completed

9. PROJECT: [Support for Balanced Asphalt Mixture Design Specification Development in Missouri](#)

☐ Missouri Department of Transportation, \$283609, 2017, Active

10. PROJECT: [Develop Guidelines and Design Program for Hot-Mix Asphalts Containing RAP, RAS, and Other Additives through a Balanced Mix-Design Process](#)

☐ Texas Department of Transportation, \$523750, 2016, Active

11. PROJECT: [Balanced Mix Design for Asphalt Mixtures: High RAP Field Trials](#)

☐ Virginia Department of Transportation, \$304843, 2019, Active

12. PROJECT: [Feasibility and Implementation of Balanced Mix Design in Nebraska](#)

☐ Nebraska Department of Transportation, \$119942, 2018, Active

13. PROJECT: [SPR-4114: Performance Balanced Mix Design for Indiana's Asphalt Pavements](#)

☐ Indiana Department of Transportation, \$242591, 2017, Completed

14. PROJECT: [TRC1802 - Performance-Based Asphalt Mixture Design \(PBD\) for Arkansas](#)

☐ Arkansas Department of Transportation, \$5354,263, 2017, Active



What are Some Steps to Prepare for BMD?



1. Remember, it's still aggregate, asphalt, and air!
2. Be aware of what's happening
3. Participate in conferences/meetings to learn more
4. Understand the impact of BMD on asphalt binder demand, recycle potential / availability
5. Evaluate your readiness (e.g., capabilities / needs). Do you need to more people, training, equipment?
6. Act to increase readiness
7. Establish baseline (test your mixes to see where you are at)
8. Optimize mixes (performance + economics)
9. Embrace the opportunity!
- 10. Be the leader!**



“By failing to prepare, you are preparing to fail.”

- Ben Franklin

Will a BMD Have a Higher Binder Content?



- Depends...
 - How is the current “recipe” specification established?
 - Are your mixes currently “dry”?
 - What part of the state do you operate?
 - Varying aggregate gravities w/ current specifications yield “different” mixes.
- **Evaluate your mixes now and find out!**
 - For initial evaluation, use IFIT w/ 8 or IDEAL CT w/ 70



Will BMD Mixes Cost More to Produce?



- Depends...
 - What is your **current performance** relative to a BMD requirement?
 - What's the overall provided opportunity to **innovate**?
 - Recycle
 - Aggregates
 - Grading
 - Additives



What Do I See Happening!

- Most states will move toward a version of BMD within the next 3 years.
- Vast number of tests will be consolidated down into probably 4 to 5 test.
- Regional type approach may be used (similar tests and perhaps thresholds).
- Mix designs opened up to allow for alternate volumetrics / materials provided performance is achieved.
- Production testing conducted via mix design and/or surrogate tests (quicker) to ensure design = JMF.
- **Mix performance will be increased.**

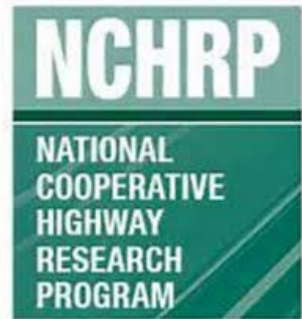


More Information



Training Course:

<http://www.eng.auburn.edu/research/centers/ncat/education/training/industry/balanced-mix.html>



Task 406 Development of a Framework for BMD

[http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-07\(406\)_Revised_final_report.pdf](http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-07(406)_Revised_final_report.pdf)

Thank You

Shane Buchanan
Asphalt Performance Manager
CRH Americas Materials
205-873-3316
shane.buchanan@na.crh.com

<http://www.pennyauctionwatch.com/>



Idaho Asphalt Pavement Conference



Asphalt Pavement Durability The Role of Superpave5

Gerry Huber
Heritage Research Group
October 22, 2020



Why is it?



*That roads start off
looking like this?*



And end up
looking like this



First of All

*Let's Talk About
Asphalt*

How Does Asphalt Work?



Magnets



How does asphalt age?



+



=



Film Thickness?

- Purdue University

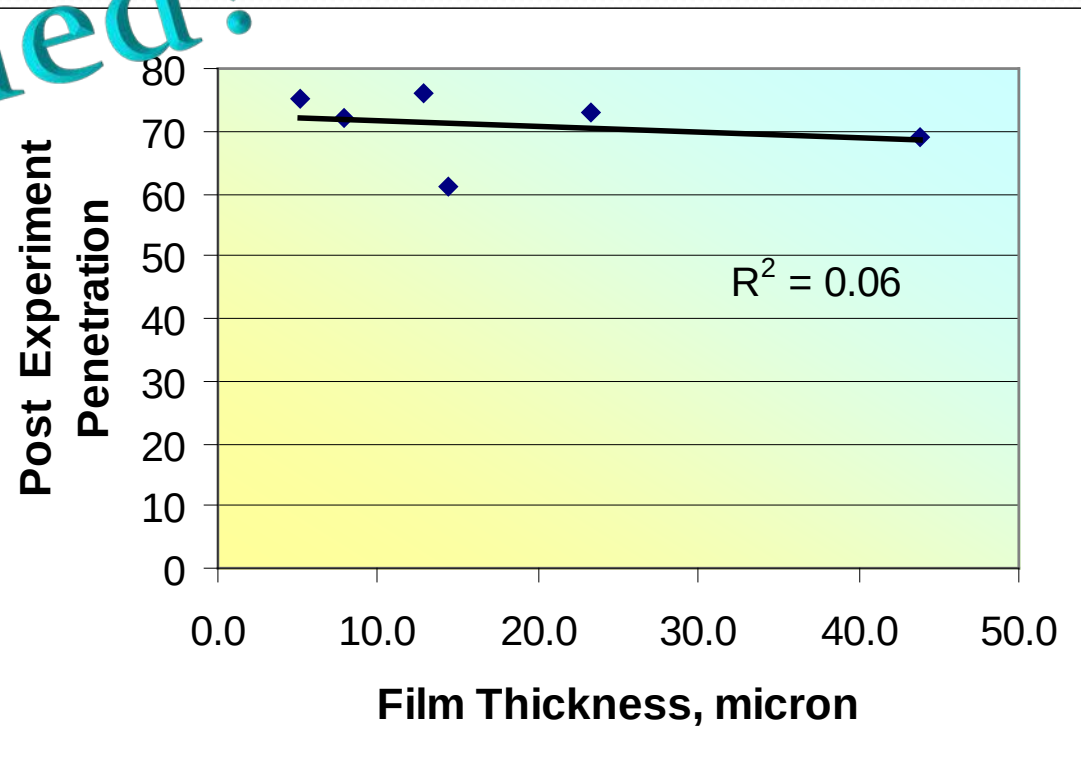
- Open-Graded mixes

- Air voids

- 21.0 to 35.0%

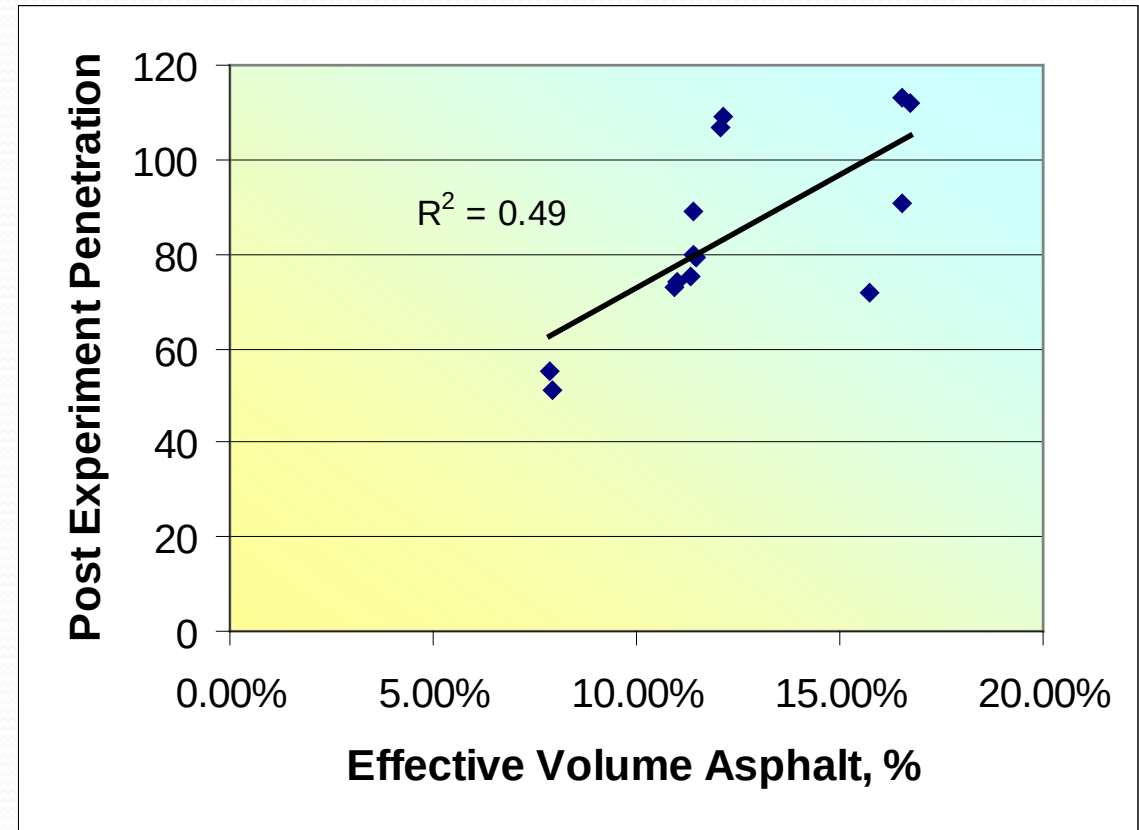
- Film Thickness

- 5.1 to 43.9 μm



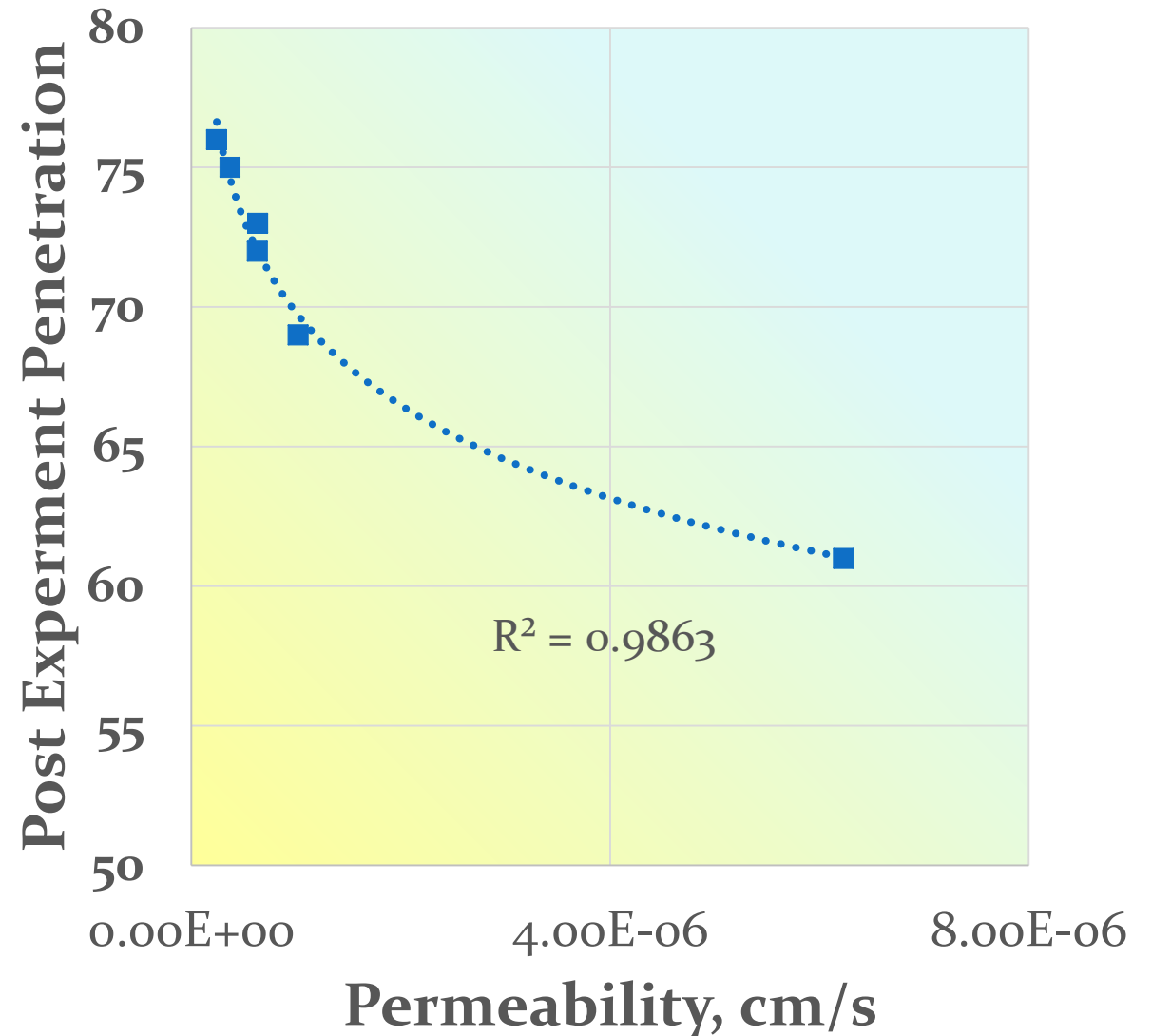
Effective Volume Asphalt?

- Shows medium strength relationship with penetration after aging.



Permeability

- Correlation of asphalt aging to mixture permeability
 - Different film thickness
 - Different asphalt contents
 - Different air voids

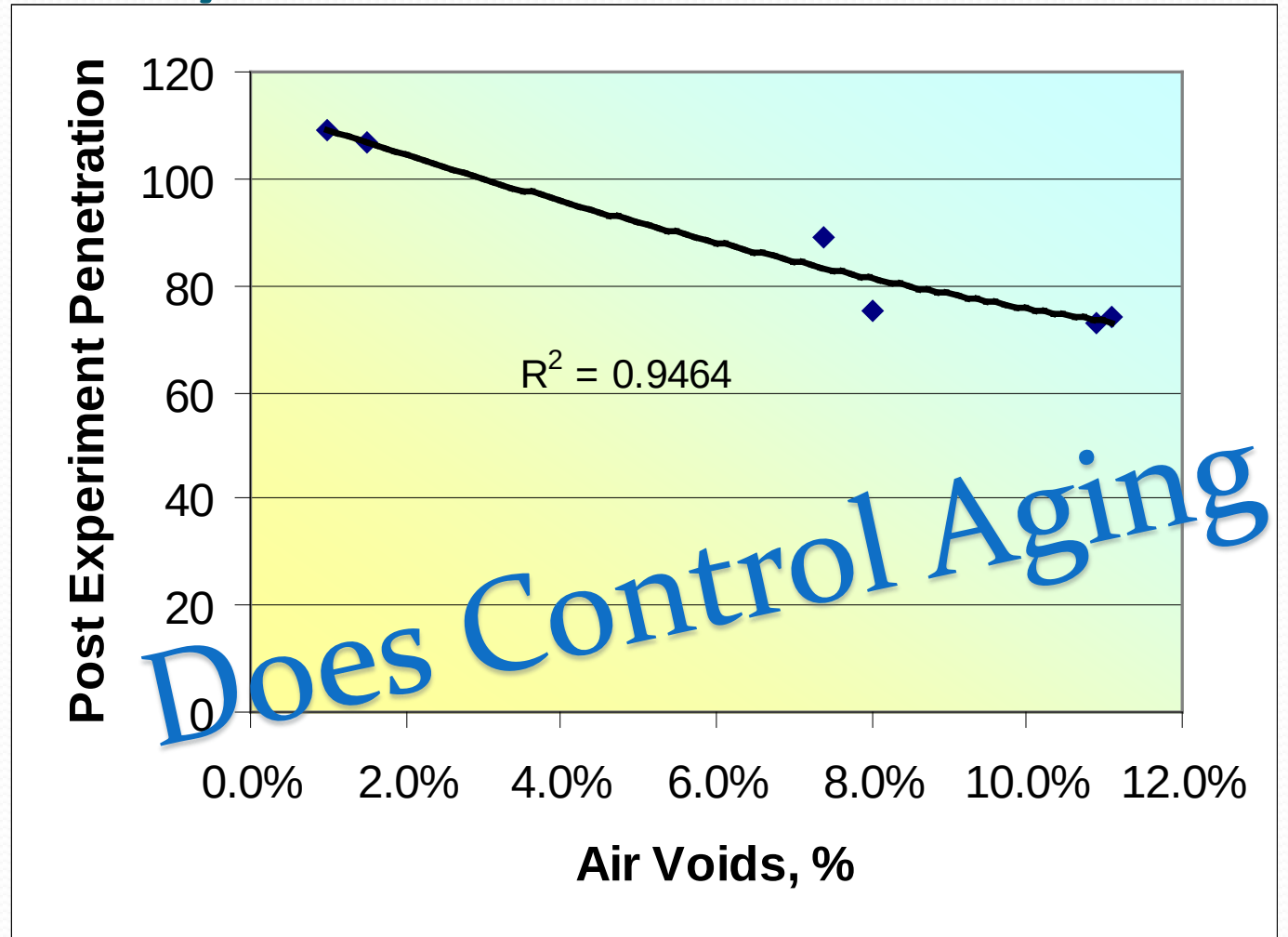


Purdue Research Paper 1976-19

Air Voids (in-place)

- Purdue University
 - Dense-graded mix
 - 5.5% asphalt
 - Vary compaction
 - Air voids
 - 1.0% to 11.1%

Purdue Research Paper 1976-19



Field Example



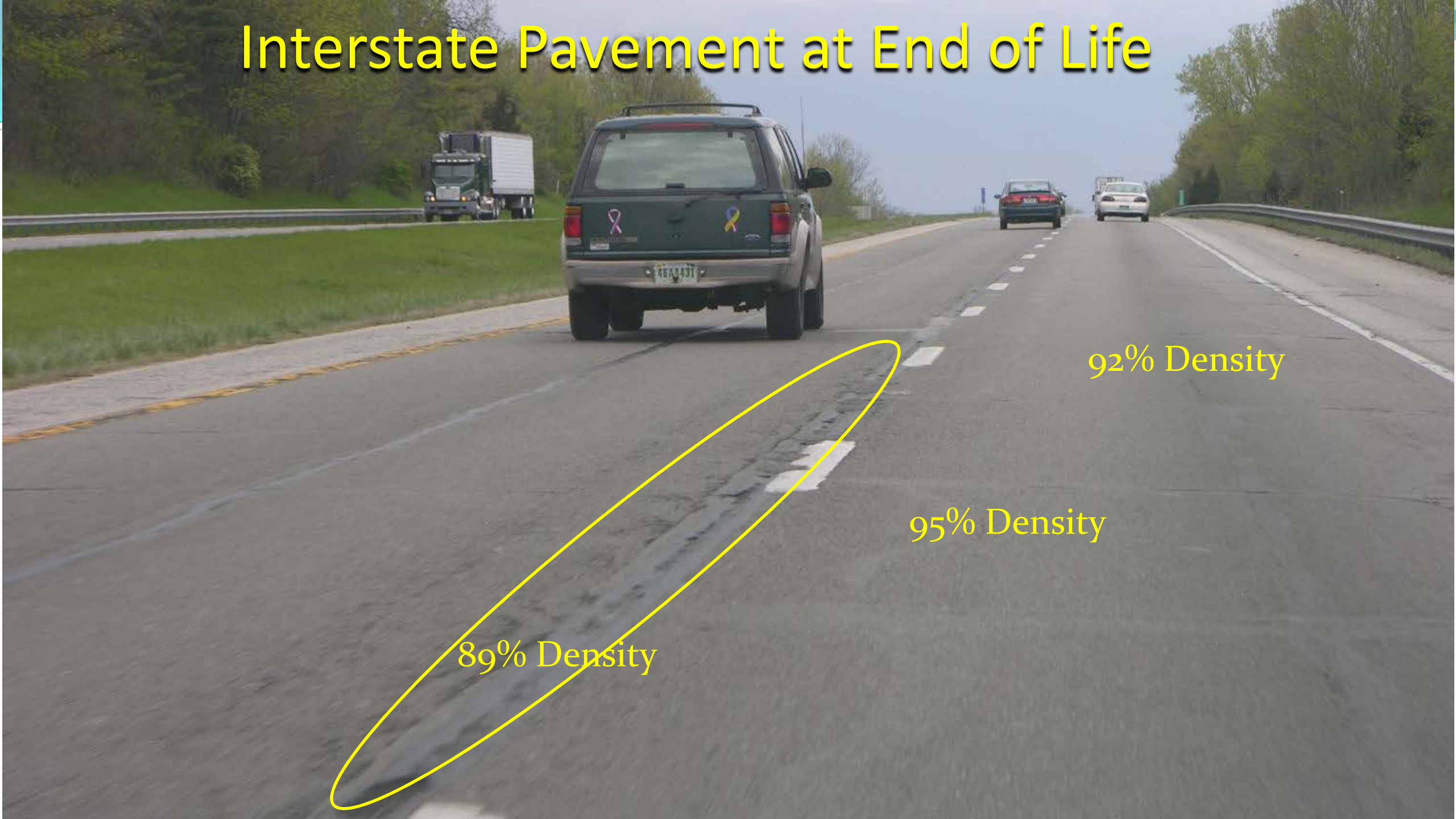




No Crack

Crack

Interstate Pavement at End of Life



92% Density

95% Density

89% Density

Superpave 5 Concept

- Mix Design
5% air voids



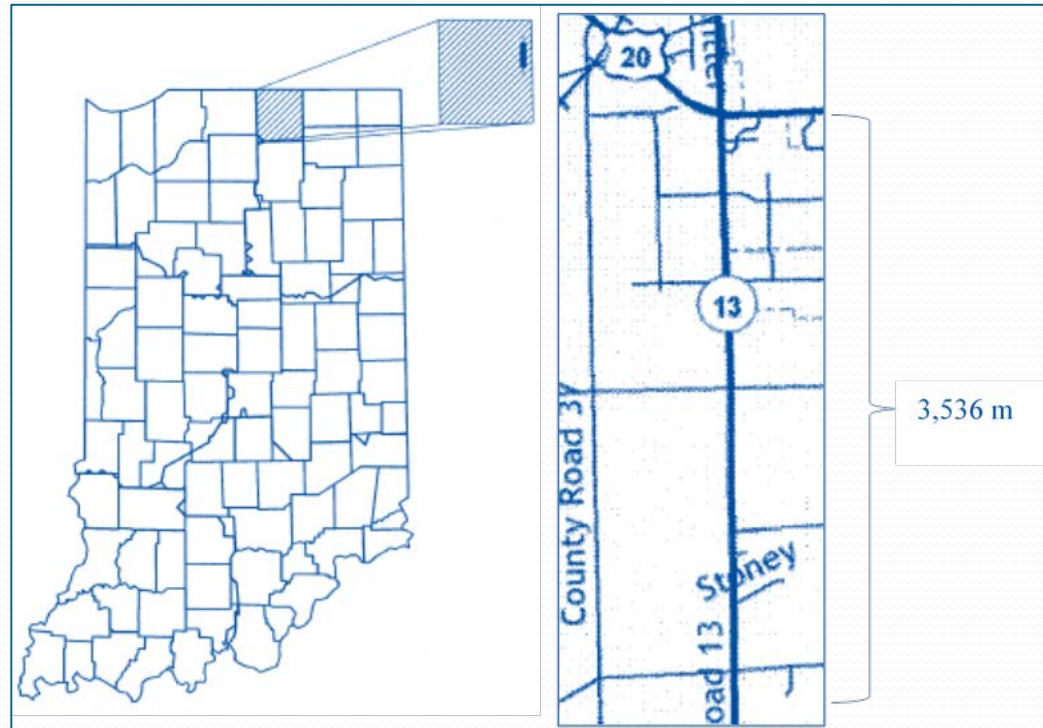
- Field
Compaction
95% Gmm



SR 13, Middlebury, Indiana

- 2013 Trial Project
 - 13,400 AADT
 - 19% heavy trucks

First
Project





Counter-Flow Drum Mix
Plant



Superpave4



Tack Coat



Material Transfer



Same Rolling Train

Superpave5 Compaction

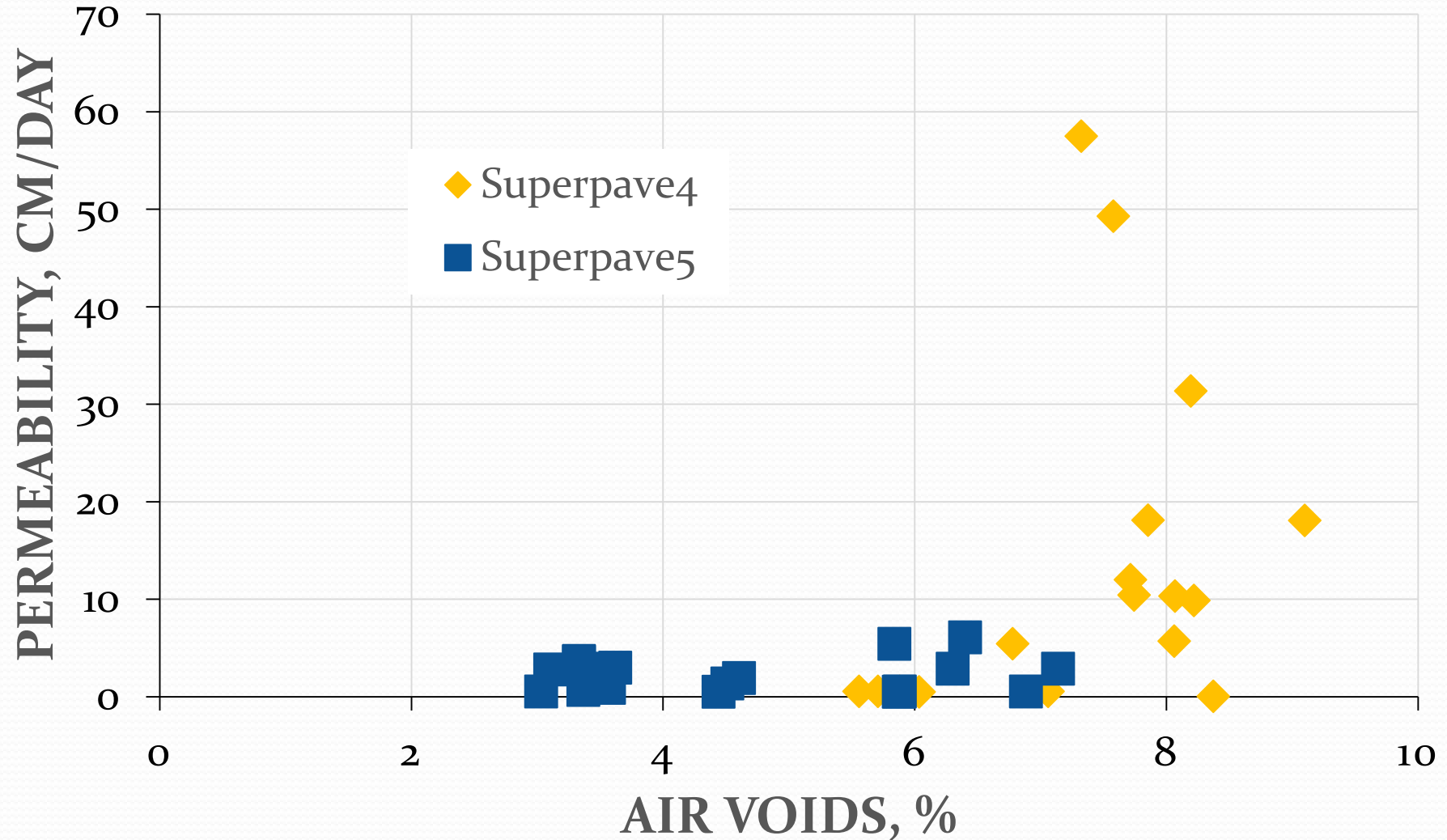
Mix Construction Properties

	Superpave4			Superpave5		
	Design	QC	QA	Design	QC	QA
Asphalt, %	5.1	5.1	5.0	5.4	5.5	5.2
Air Voids, %	4.0	3.5	4.1	5.0	4.5	4.0
Density, %Gmm	-	-	91.6	-	94.7	96.9

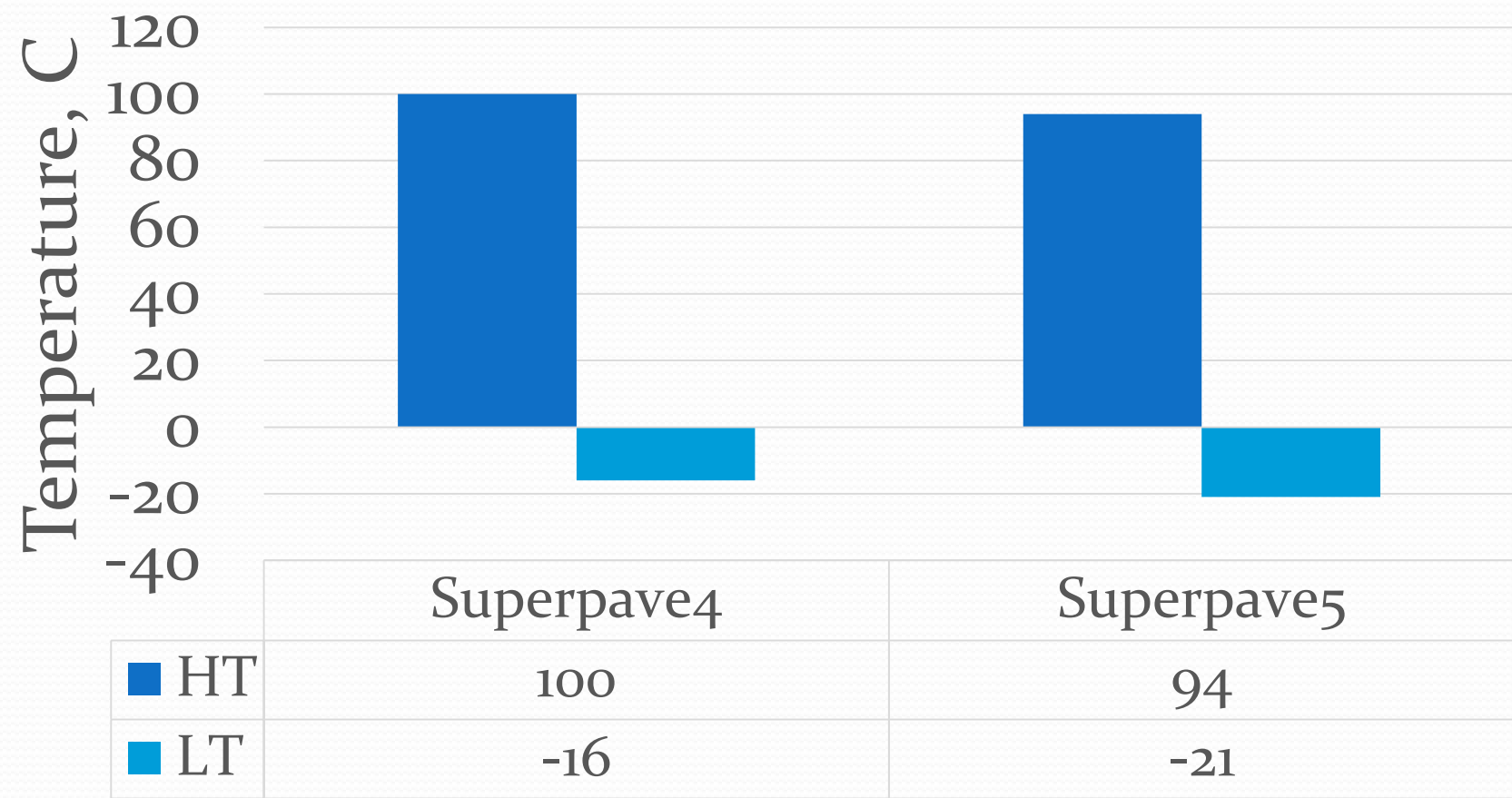


Cores Taken 2018

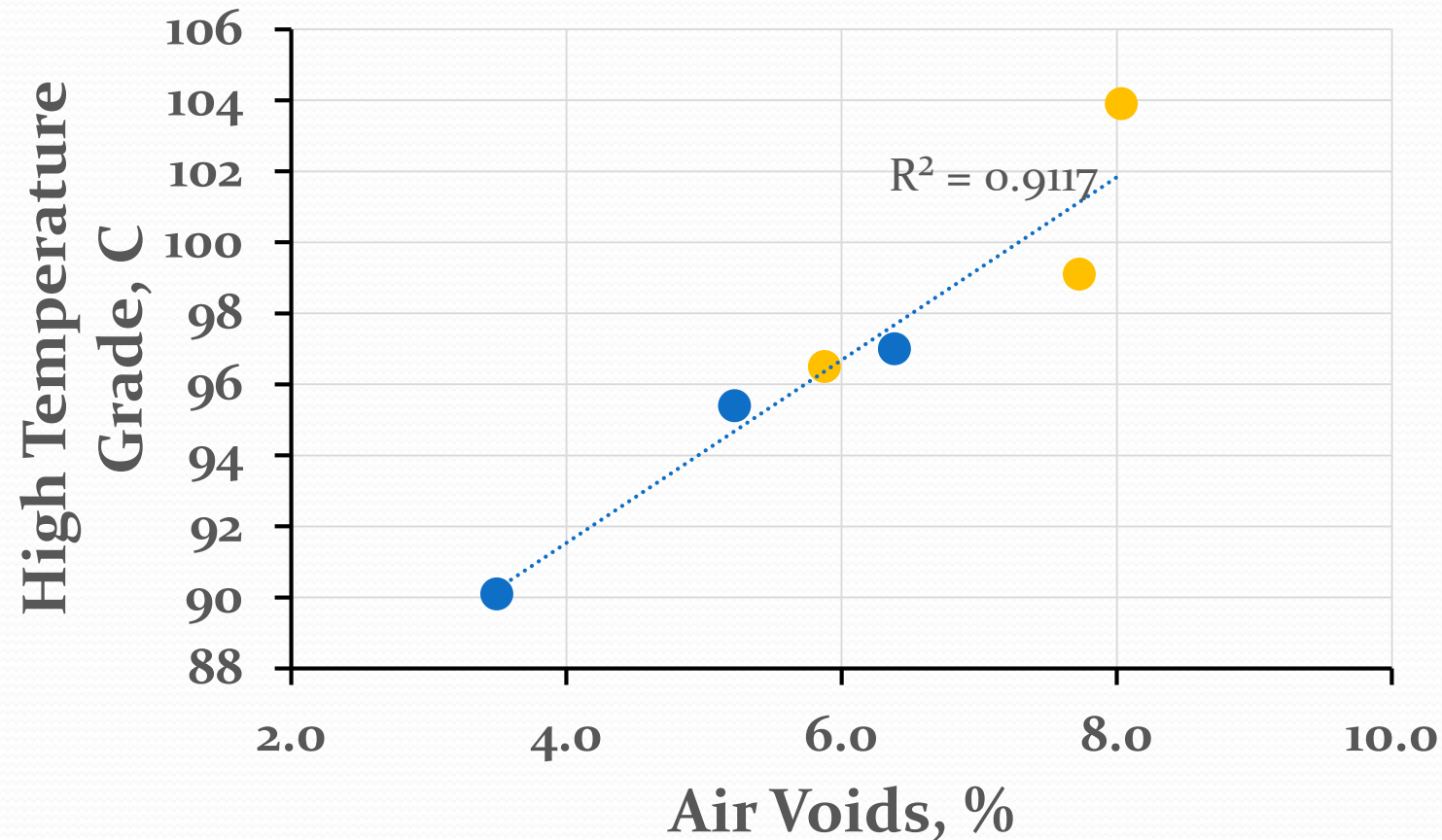
Permeability



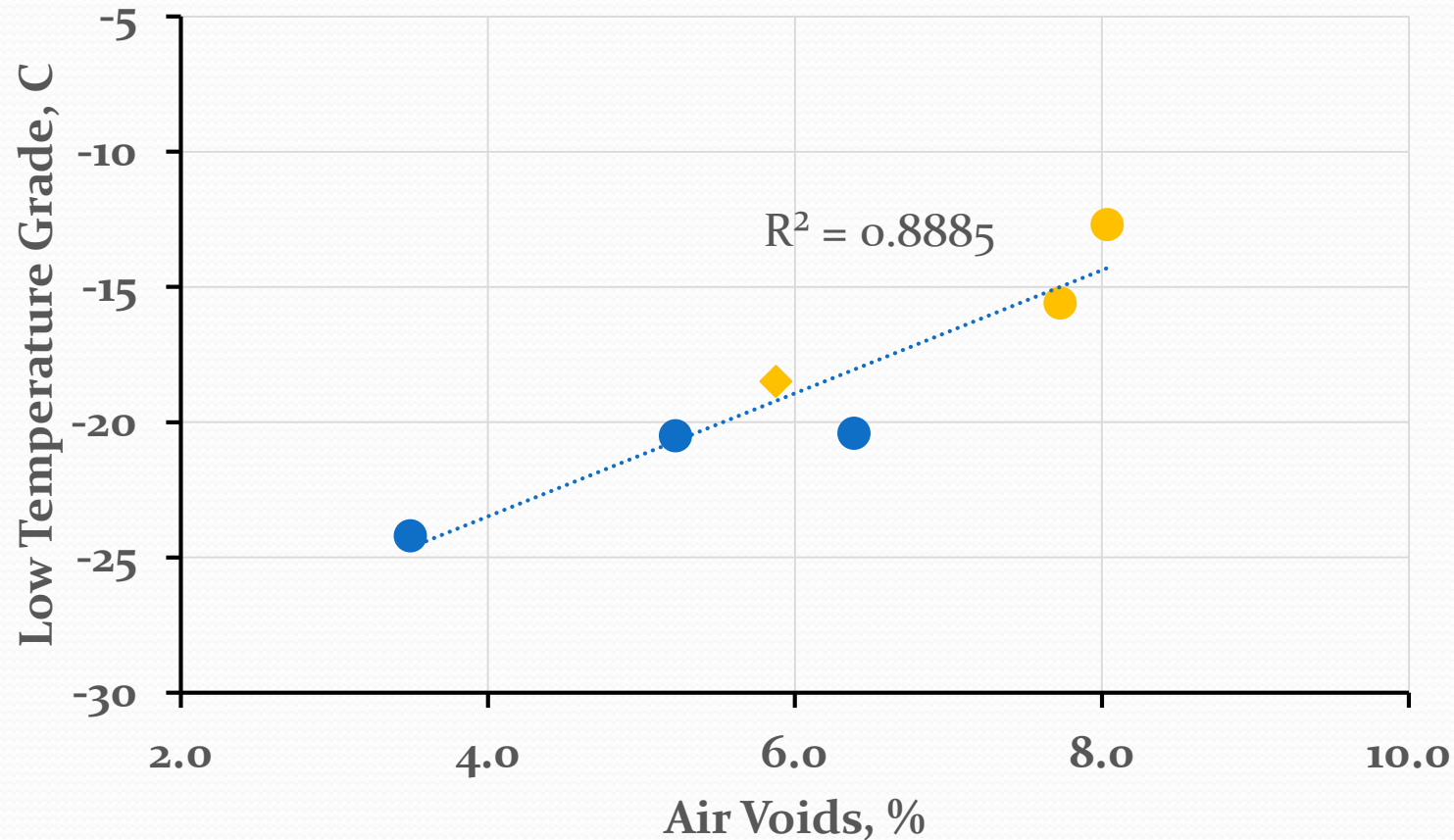
Asphalt Binder Grade



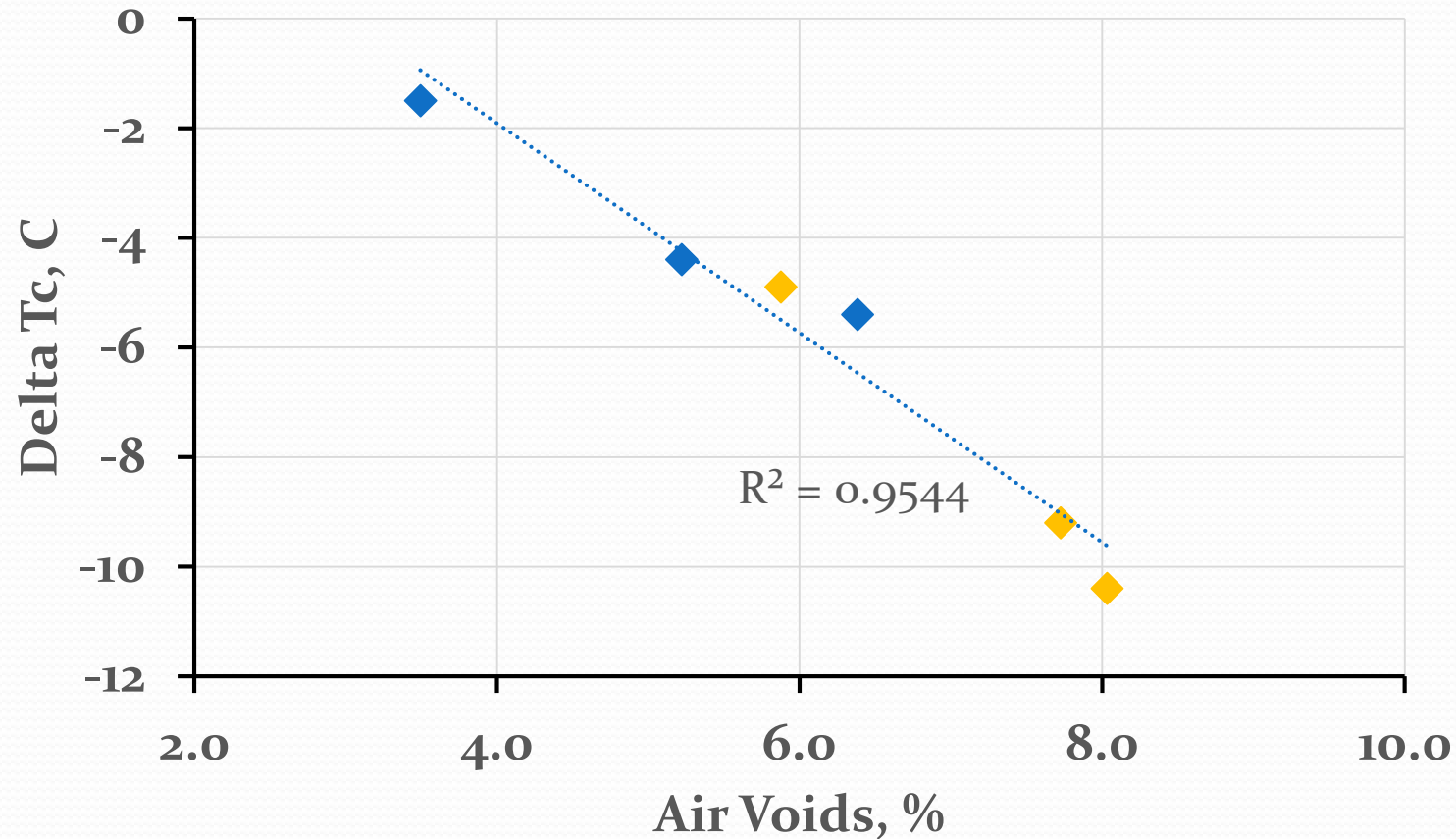
Correlation PG High Temp to In-Place Air Voids



Correlation PG Low Temp to In-Place Air Voids



Correlation Delta Tc to In-Place Air Voids



Specification Revisions

- Air Voids at $N_{\text{des}} = 5.0\%$
- Design Gyration
 - $100 \rightarrow 50$
 - $75 \rightarrow 30$
- Density LSL = 93.0%

INDOT Implementation

- 10 pilot projects in 2018
- Allowed by “opt-in” basis for 2019
- Effective for all mixes in 2020

Superpave5 Density (2019)

- Superpave4
 - Average = 93.19%
 - 899 sublots
- Superpave5
 - Average = 94.53%
 - 1000 sublots

Superpave5 Air Voids (2019)

- Superpave4
 - 3.91⁰%
 - 899 sublots
- Superpave5
 - 4.71⁰%
 - 1000 sublots

What does it all mean?

- Asphalt Binder Aging
 - Most strongly related to permeability
- Superpave5
 - Increase in-place density
 - Reduce in-place permeability
 - No increase in cost

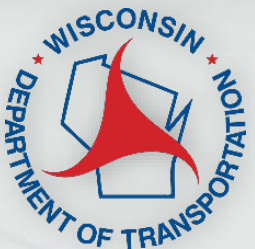
Thank You!

Air Void Regression

Steve Hefel
WisDOT HMA Supervisor

Idaho Asphalt Conference

October 22, 2020



Problem

- Fatigue cracking
- Wheel path cracking
- Raveling



Inadequate Binder In The Mix

- Since the inception of Superpave mixtures, Wisconsin has seen binder content in mixes decrease

Items To Address And A Possible Solution

Need to put our thinking caps on

- Raise VMA
- Better monitor aggregate specific gravities
- Test Actual Binder Content
- Effective binder content
- Air Void Regression



Raise VMA

- Add 0.5% to most surface mixes
 - For 12.5mm mixes, [1] 14.5 for LT and MT mixes.
 - For 9.5mm mixes, [2] 15.5 for LT and MT mixes

Aggregate Specific Gravities

- Contractor determined gravities are used
- Now verifying gravities with department samples
- Agg sources are verified more often, 1-3 years instead of 5



Asphalt Binder Content Determination

• Previous

- AC by calculation.
- AC by nuclear gauge reading, optional.
- AC by inventory, optional.



• Current

- AC by ignition oven according to AASHTO T308 (CMM 836.6.3.6),
- by chemical extraction according to AASHTO T-164 method A or B; or
- by automated extraction according to ASTM D8159 as modified in CMM 836.6.3.1.



Effective Binder Content

- Started to be used by one region
- Requires many mix designs to be replaced with new designs or
- Would take years to fully implement

Not chosen to use statewide

Air Void Regression (AVR)

The Best Solution

- WisDOT AVR process, benefits, concerns
- Wisconsin Highway Research Program (WHRP) Research completed by NCAT
- WisDOT Performance Testing Data

Air Void Regression

- Design at the typical 4.0% air voids
- Meet all criteria for 4.0%
 - Gyrations, VMA, Dust to Binder, Percent Binder Replacement, etc
- Use the design points to determine binder content at 3.0%
- Use the 3.0% volumetric properties.

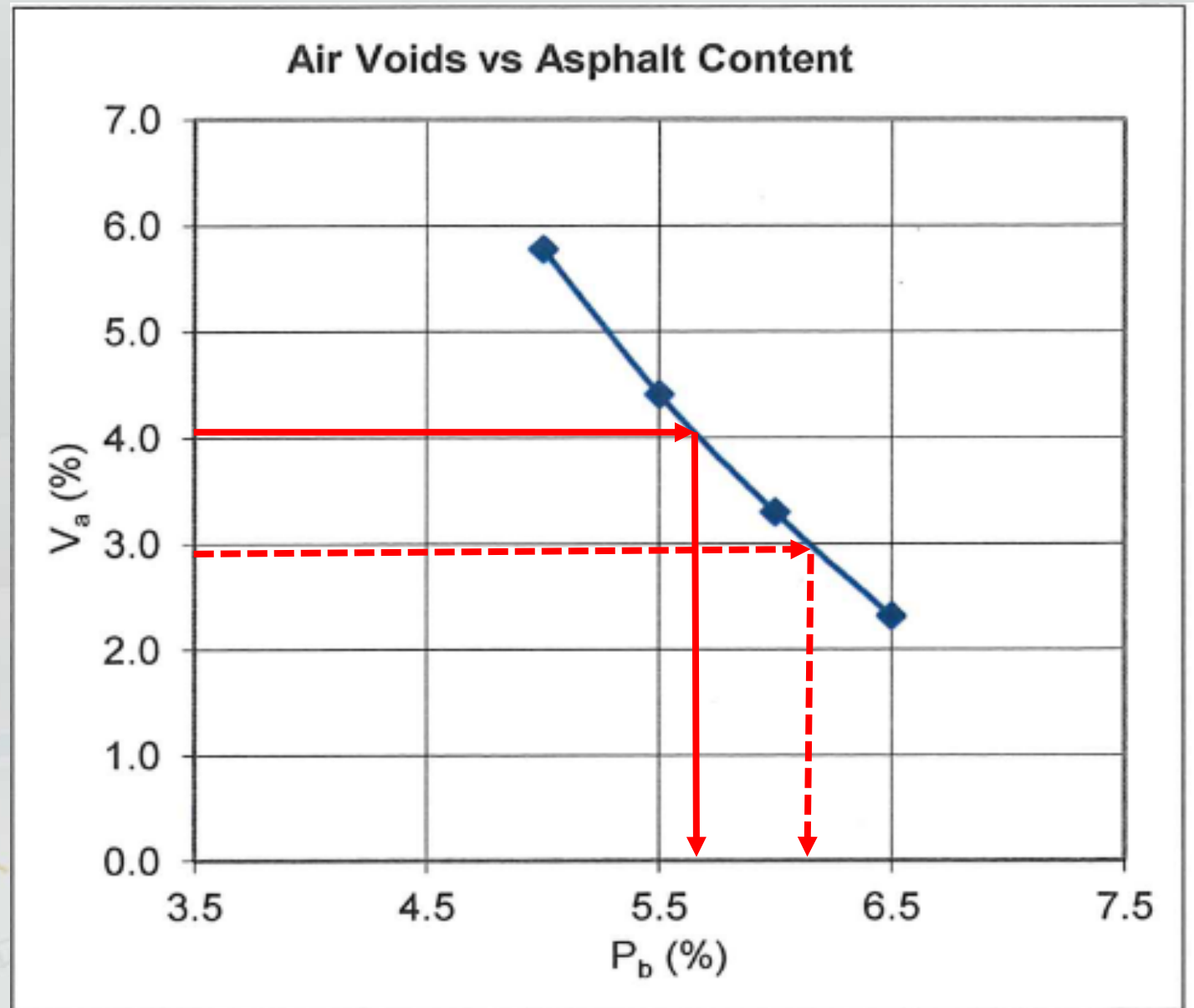
Existing 4.0% air void designs can be used as well as new ones

No mass redesigns are needed

Air Void Regression

Original 4.0 Optimum
%AC = ~ 5.7

Regressed 3.0 Optimum
%AC = ~ 6.1



Volumetric Properties at 3.0%

- Binder content, % (Pb).
- Maximum specific gravity (Gmm).
- Bulk specific gravity (Gmb).
- Air voids, % (Va).
- VMA (voids of the mineral aggregate), %.
- VFB (voids filled with binder) also called VFA (voids filled with asphalt), %.
- TSR (tensile strength ratio).
- TSR Compaction Effort (N = "x").

Benefits

- Increased virgin binder added, 0.3 to 0.4%
- Increased durability, increased asphalt film thickness
- Increased in place density/decreased permeability
- Improved workability- easier paving
- No change to existing 4.0% designs except computing 3.0% volumetrics

Concerns

- Cost
 - Increase of \$1 to \$2 per ton
- Stability
 - WisDOT is confident in the dense graded aggregate structure
 - Reduced LT mESALS from below 2 mESALS to below 1 mESALS

Research, WHRP by NCAT

- Wisconsin Highway Research Program project 16-06
- Regressing Air Voids for Balanced HMA Mix Design
- Evaluate 6 common mix designs in Wisconsin regressed to lower air voids

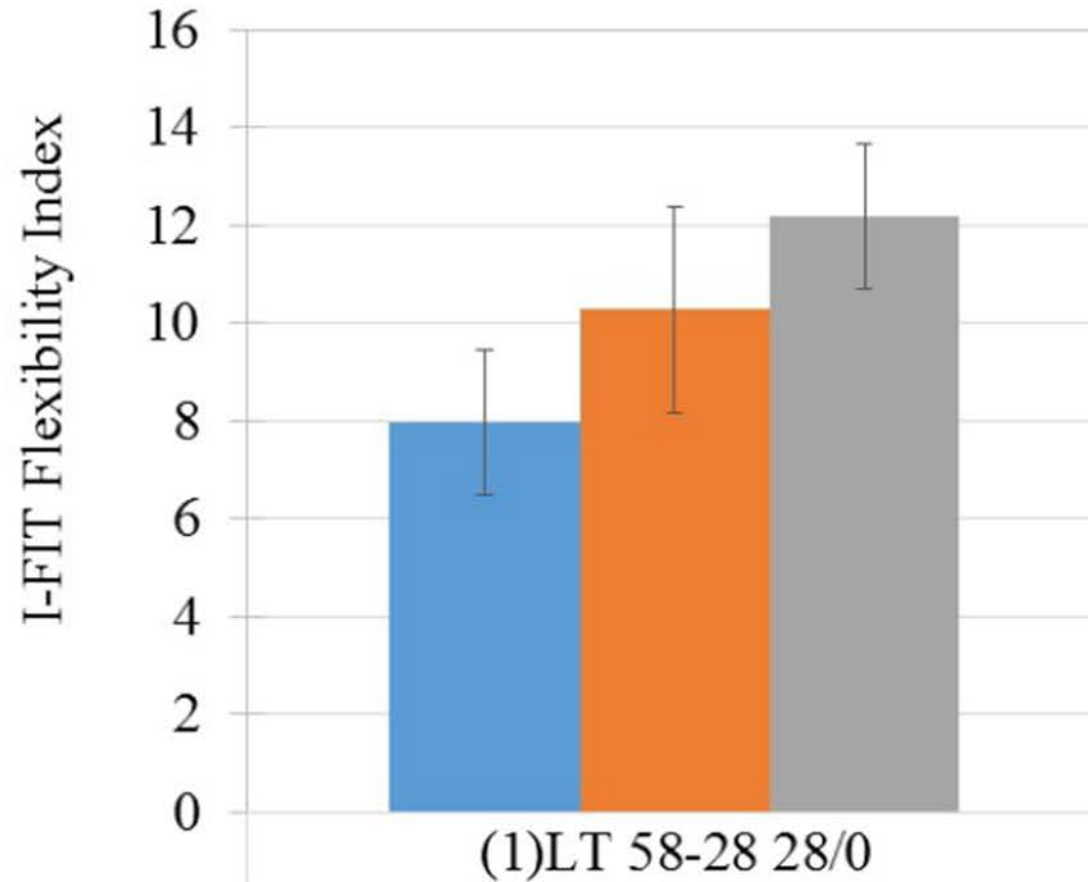
Research Report

<https://wisconsindot.gov/documents2/research/0092-16-06-final-report.pdf>

Research Brief

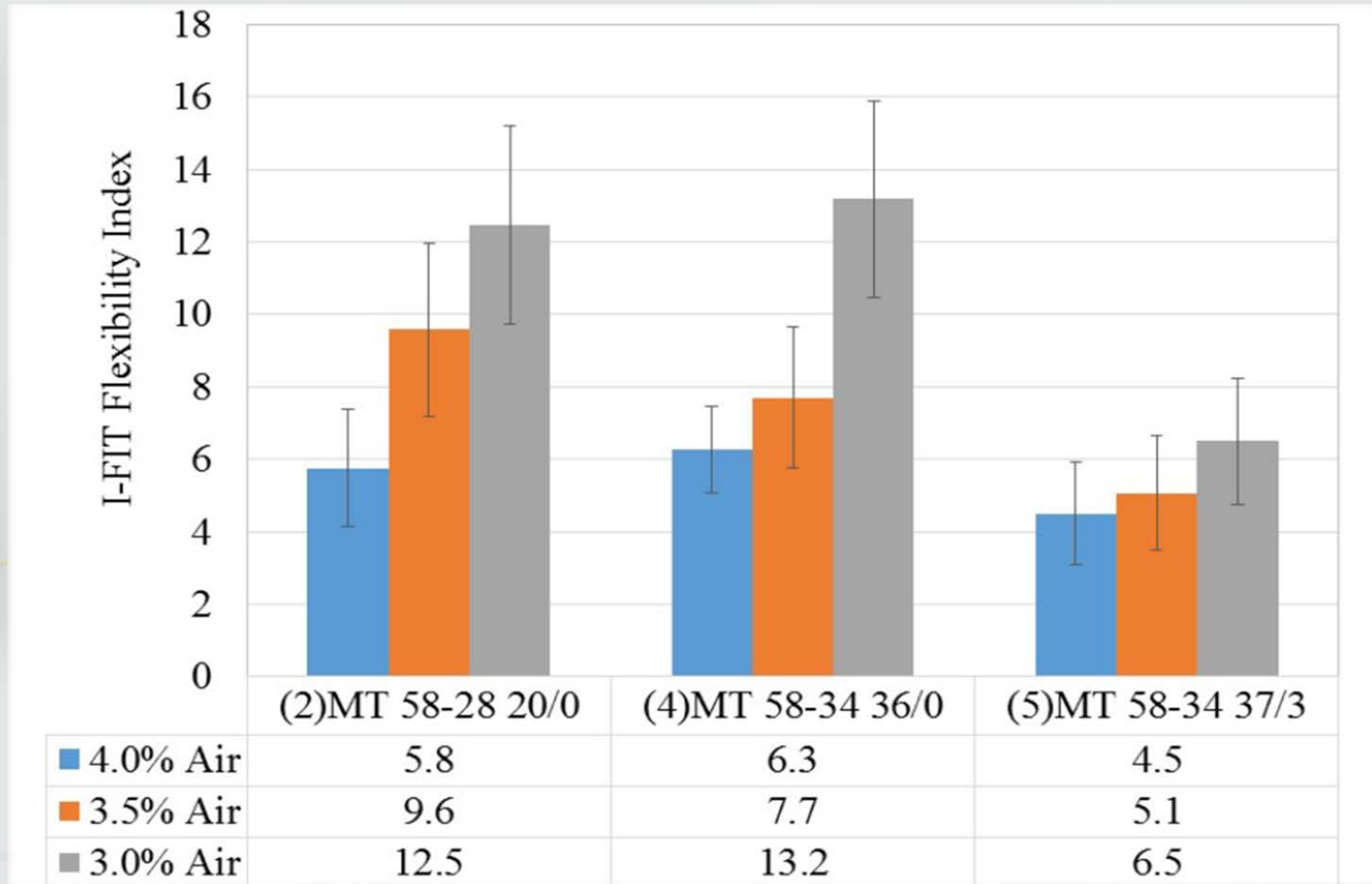
<https://wisconsindot.gov/documents2/research/0092-16-06-research-brief.pdf>

Flexibility Index for LT mix

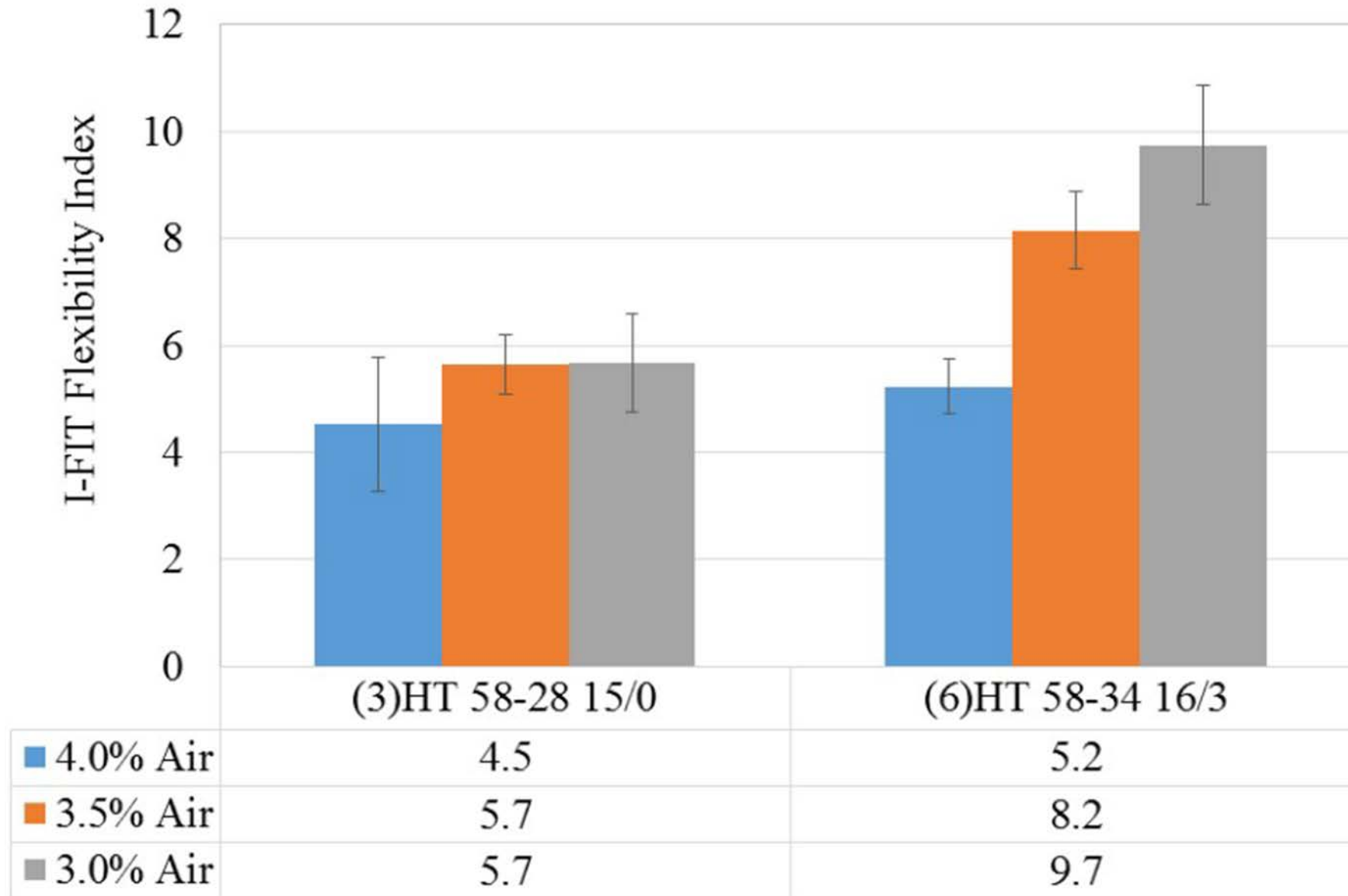


■ 4.0% Air	8.0
■ 3.5% Air	10.3
■ 3.0% Air	12.2

Flexibility Index for MT mixes



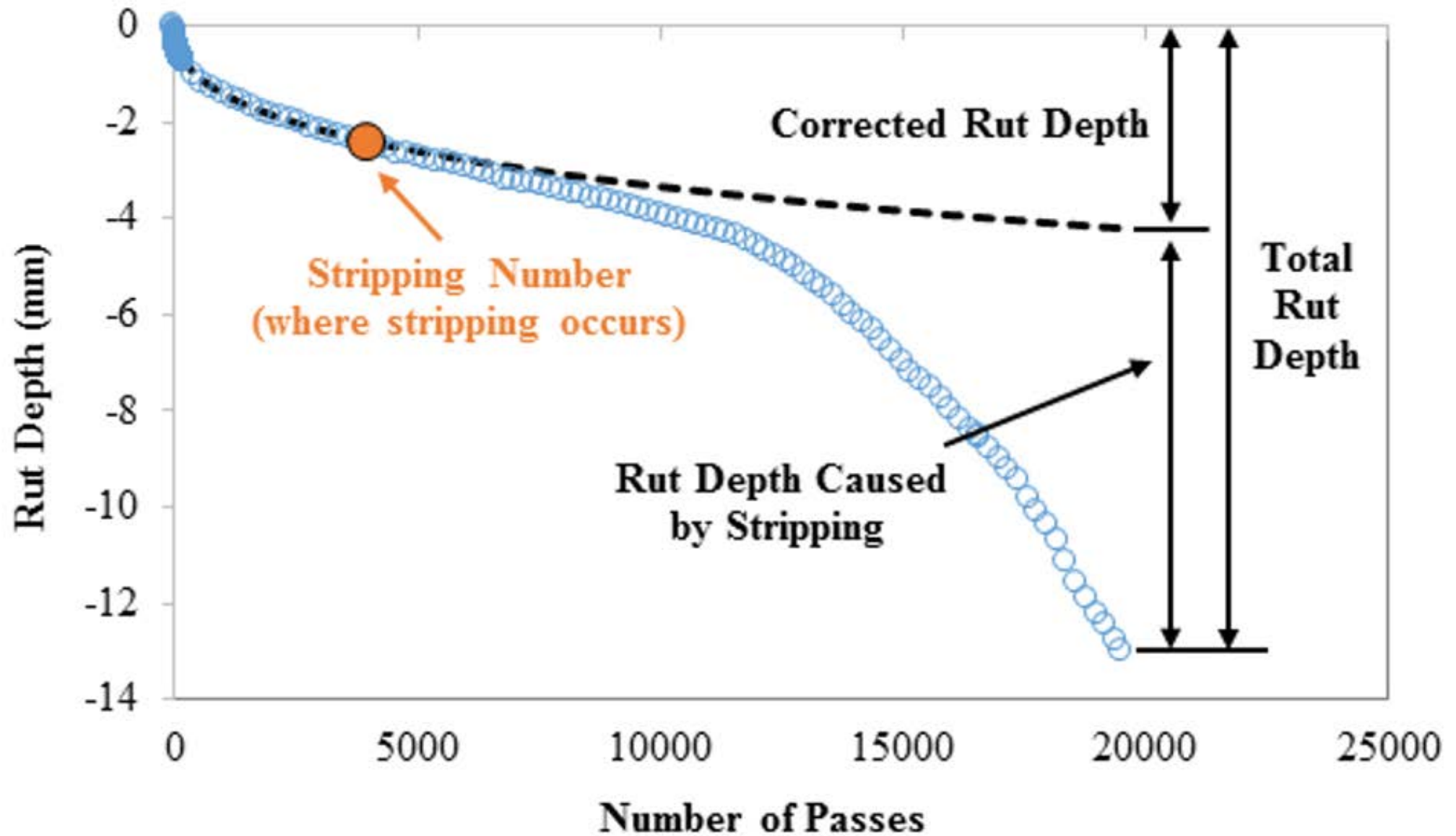
Flexibility Index for HT mixes



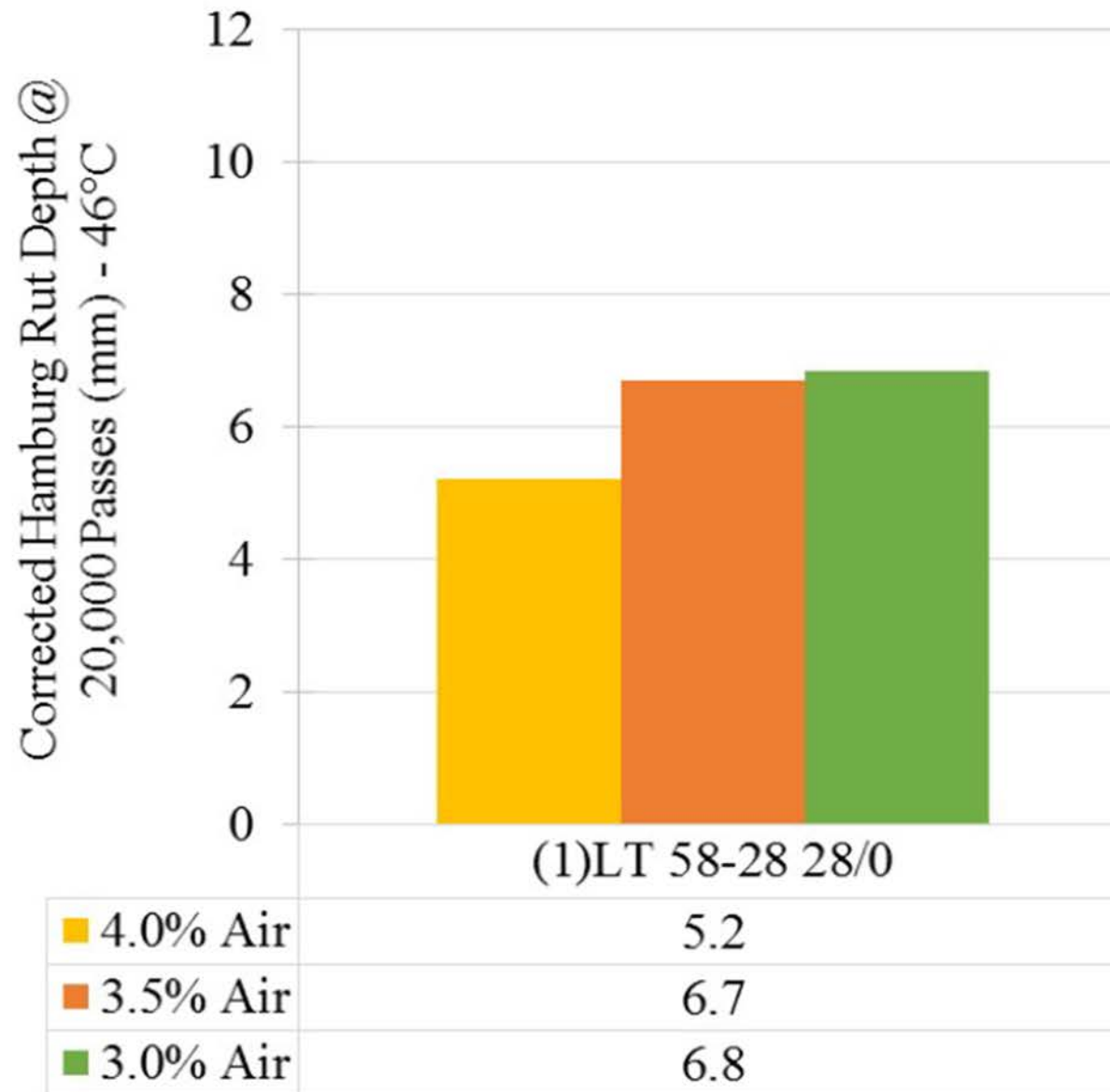
16-06 Hamburg Wheel Testing Corrected Rut Depth

- Corrected Rut Depth and Stripping Number are determined from Hamburg Wheel Data to separate the effects of rutting and stripping
- Fan Yin formerly at TTI now at NCAT promotes this method

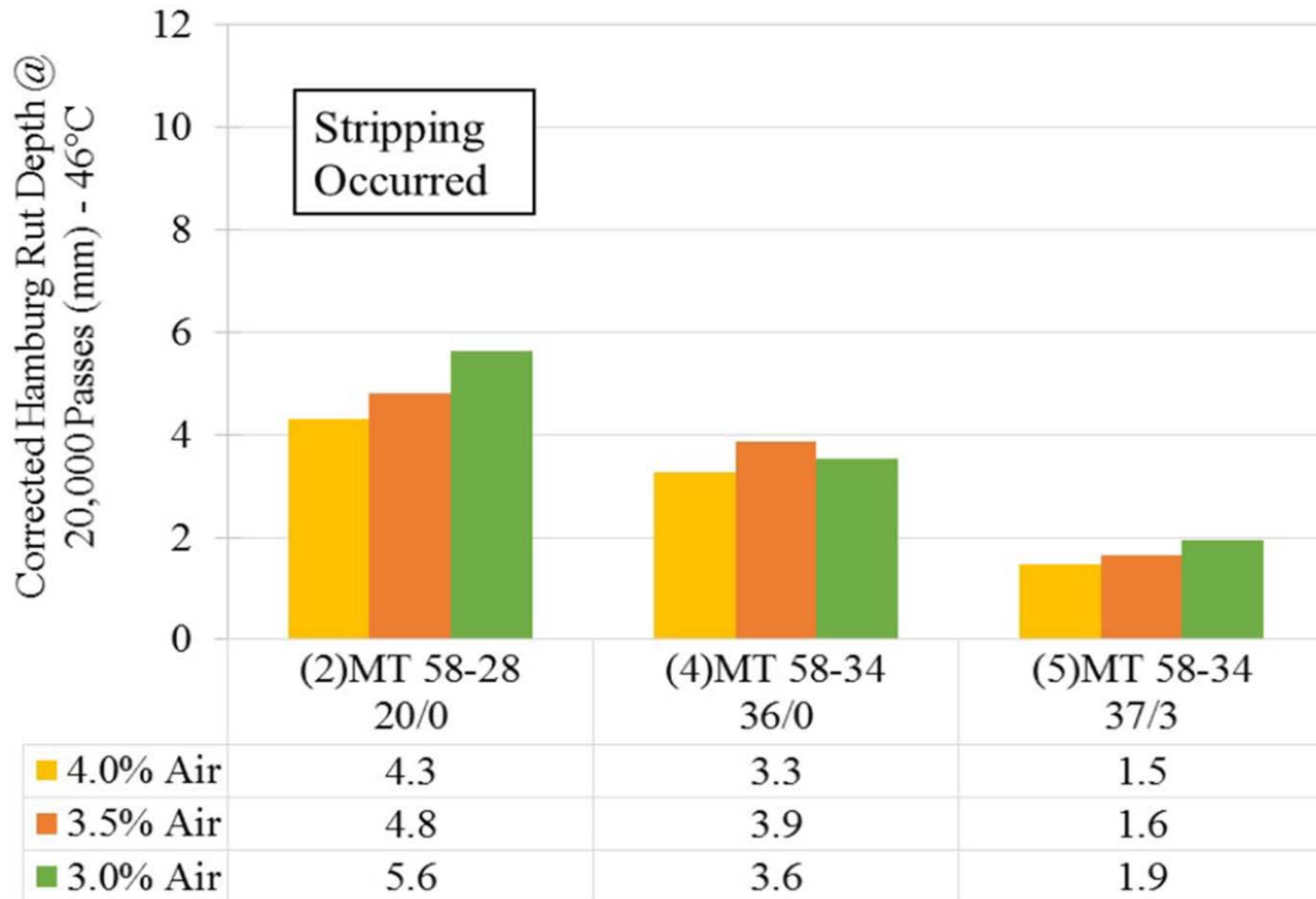
- Corrected rut depth (CRD) (Yin et al., 2014 – TRR 2446)



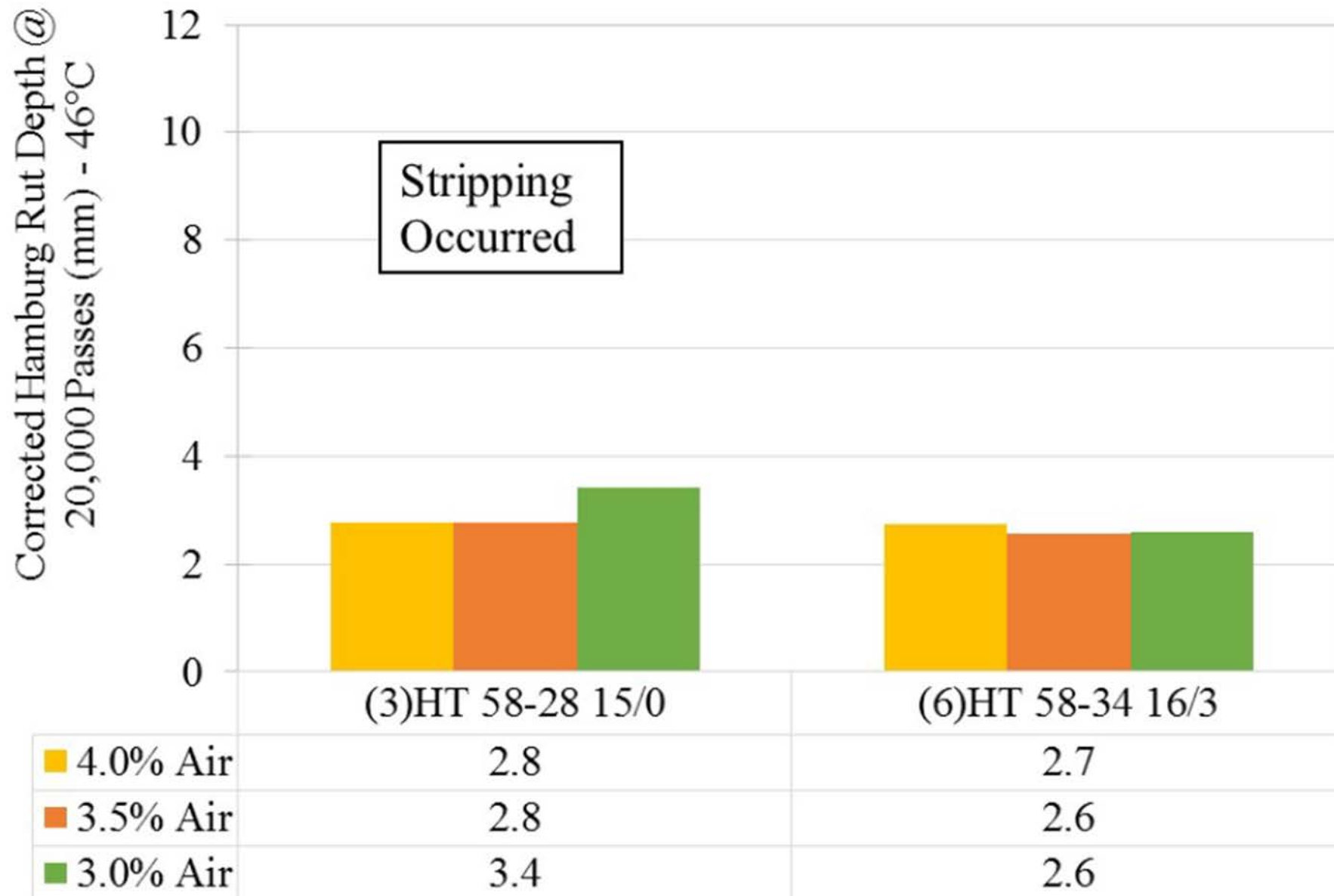
Corrected Rut Depth for LT mix



Corrected Rut Depth for MT mixes



Corrected Rut Depth for HT mixes



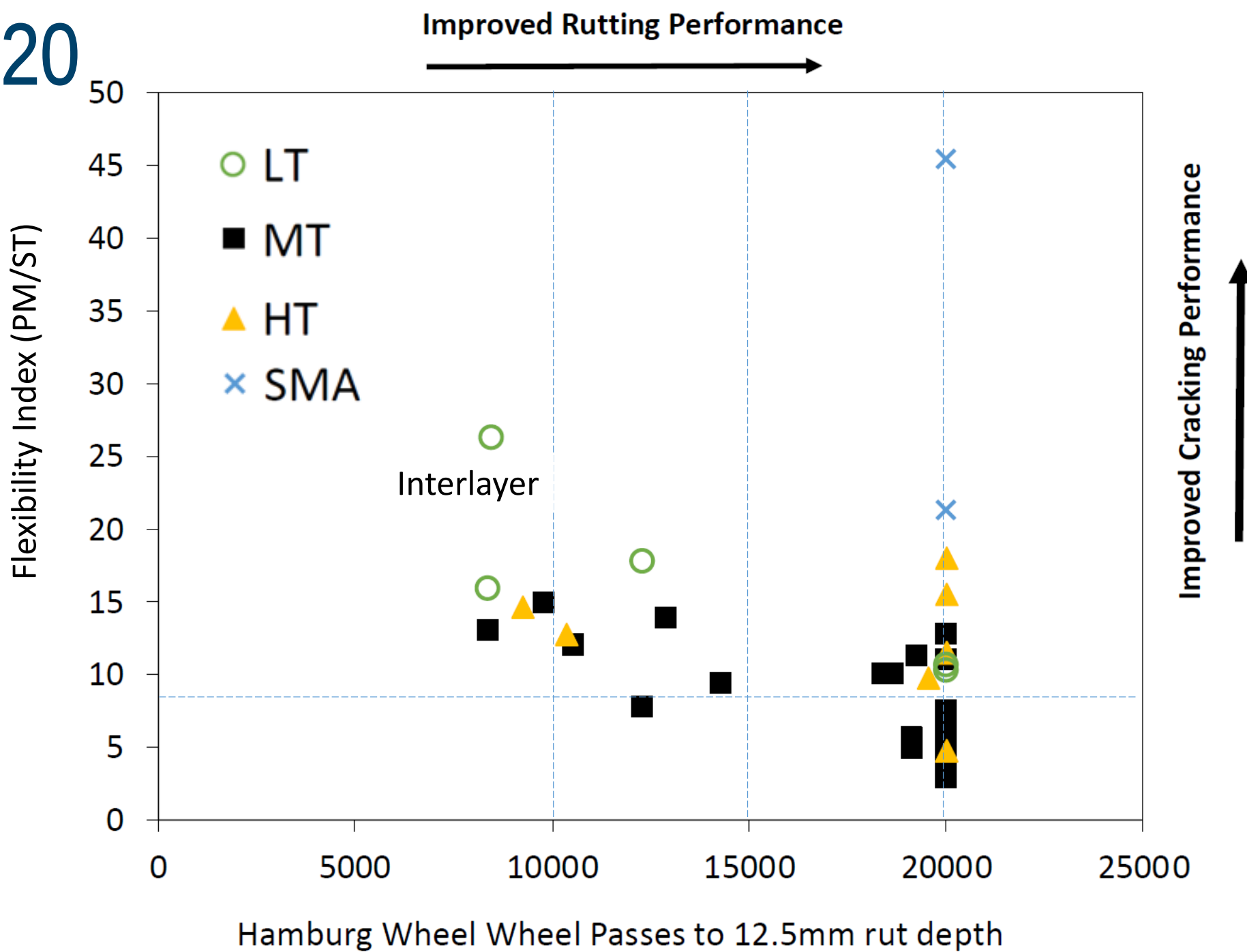
16-06 Conclusions

- “based on the I-FIT FI results, the regressed air voids approach to mix design will have a significant, positive impact on the cracking resistance of the mixtures”
- “designing Wisconsin asphalt mixtures with the air voids regressed to 3.0 percent is not likely to cause any problems with increased rutting susceptibility”
- “Results from this project indicate that the regressed air voids approach can improve cracking resistance without compromising the deformation resistance of asphalt mixes”

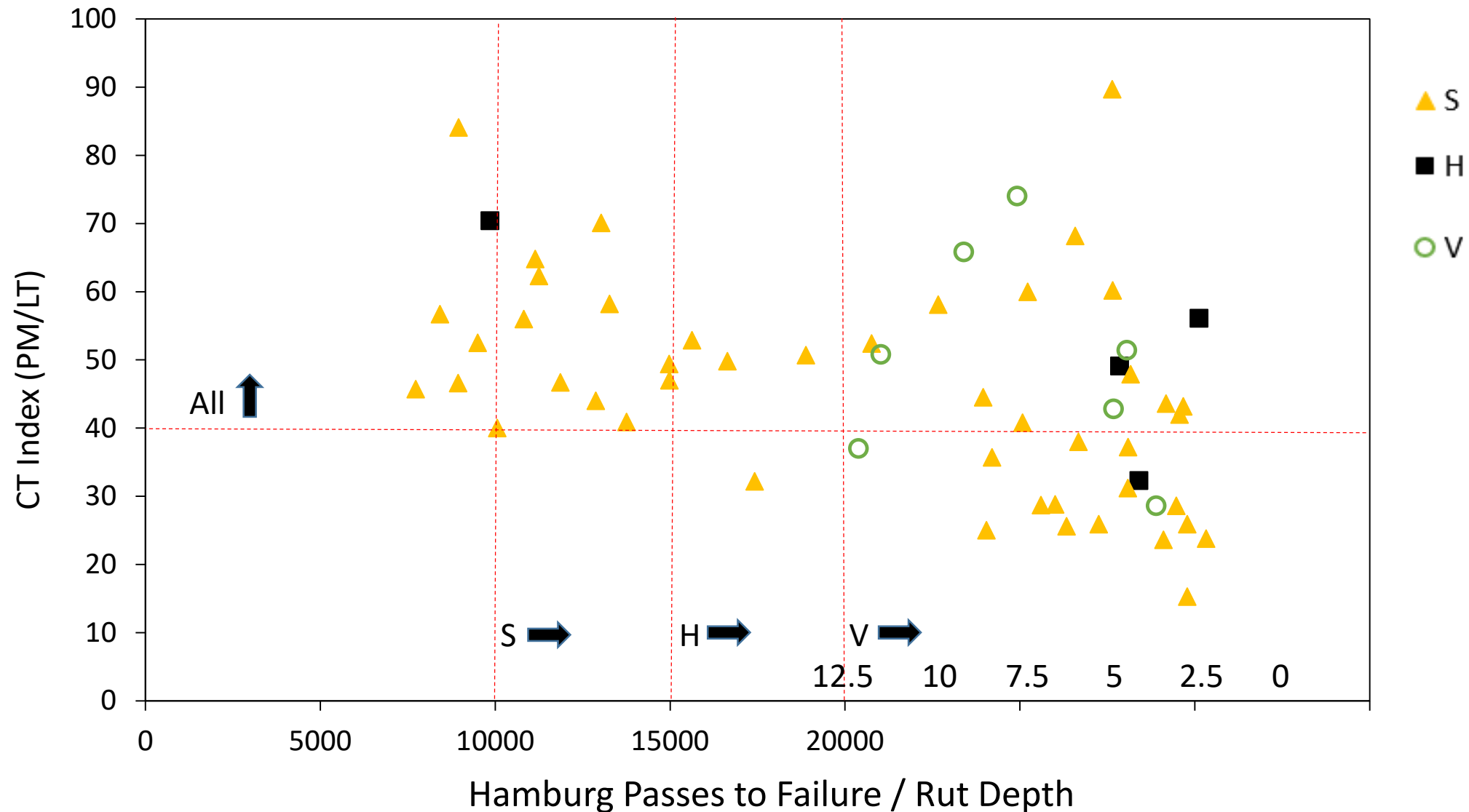
Research, WisDOT data

- Performance Testing on Pre-2020 AVR mixes (I-FIT)
- Performance Testing on 2020 AVR mixes (IDEAL-CT)

Pre-2020



Performance Testing on 2020 AVR mixes



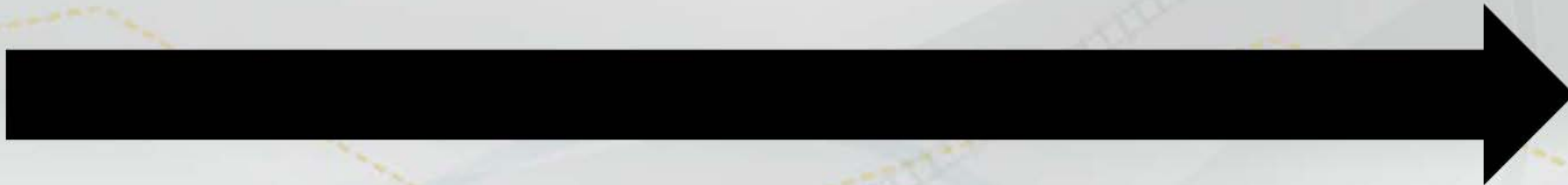
Summary

- Even with AVR, WisDOT mixes are stable
- AVR provides additional cracking resistance (along with other benefits)

“Performance testing completed in this research indicates 3.0% regressed air voids will improve pavement life in Wisconsin.”

– Steve Hefel, WisDOT

Air Void Regression



Increased asphalt binder → increased cracking resistance

Questions?

Steve Hefel, P.E.

HMA Supervisor
Bureau of Technical Services
Wisconsin Department of Transportation
608-246-7934

Steven.Hefel@dot.wi.gov



PaveXpress – A Simplified Pavement Design Tool!

Trenton M. Clark, P.E.

President – Virginia Asphalt Association

October 22, 2020

1:00 pm MDT

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PaveXpress – A Simplified Pavement Engineering Tool!

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Who Do You Work For?

1. Local Government Agency
2. A/E/C Firm
3. Idaho DOT
4. FHWA
5. Contractor
6. Other



Sli.do Code 81078

What Is Your Knowledge of Pavement Engineering?

1. I am regularly performing pavement designs and analysis
2. I am familiar with the pavement design and analysis process, but rarely do it
3. I know very little or nothing about pavement design and analysis, but want to learn more
4. None and I am being forced to listen to a guy from Virginia that I can barely understand due to his accent.

Basics of Pavement Engineering

Pavement Design

Pavement Analysis

Economic Analysis

Pavement Management

Recalibration Procedures For The Structural Asphalt Layer Coefficient In The 1993 AASHTO Pavement Design Guide

NCAT Report 14-08

DOWNLOAD



AASHTO 93/98 Design

The Design tool uses the empirical AASHTO93 and AASHTO98 equations to design flexible and rigid pavements respectively, including new structures and rehabilitation.



Life-Cycle Cost Analysis (LCCA)

The LCCA tool estimates and compares costs of alternative pavement designs throughout their design life, including both direct (agency) and indirect (user) costs.



Agency Cost

The Agency Cost calculator quickly estimates direct costs implied by a pavement's materials and geometry.



PerRoad

PerRoad supports Perpetual Pavement philosophy and determines pavement design using mechanistic-empirical (ME) concepts.

History of PaveXpress

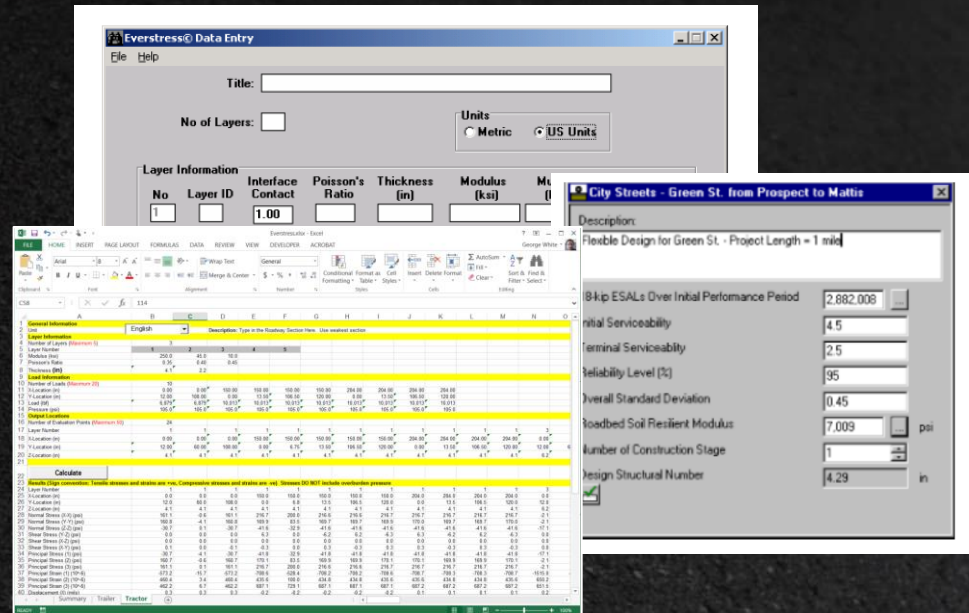
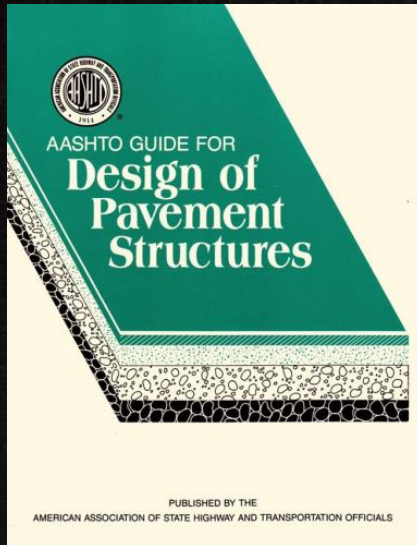
What Is PaveXpress?

A free, online tool to help you create and evaluate pavement designs and overlays using key engineering inputs, based on the empirical and mechanistic-empirical pavement design processes

- ✓ **Free** — no cost to use
- ✓ **Accessible** — via the web and mobile
- ✓ **Standards Based** - AASHTO and/or industry standard practices
- ✓ **User-friendly** — streamlined UI/UX
- ✓ **Collaborative** - share, save, and print
- ✓ **Interactive** — help and resources



Don't we already have tools for this?



Pavement ME is generally used for high volume roads, and a gap exists for easy to use tools for local and lower volume roads

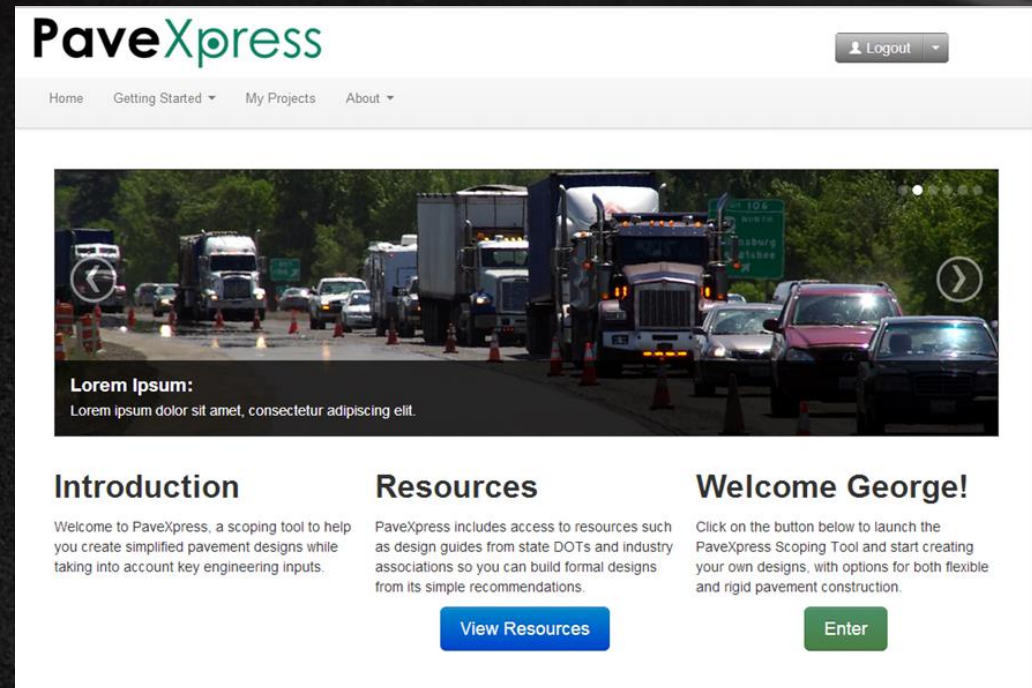
Asphalt.

AMERICA RIDES ON US



The Evolution of PaveXpress

- Version 1.0
 - New Asphalt Pavement Designs
 - New Concrete Pavement Designs
 - Parking Lot Design and Guidance



New Construction – Asphalt



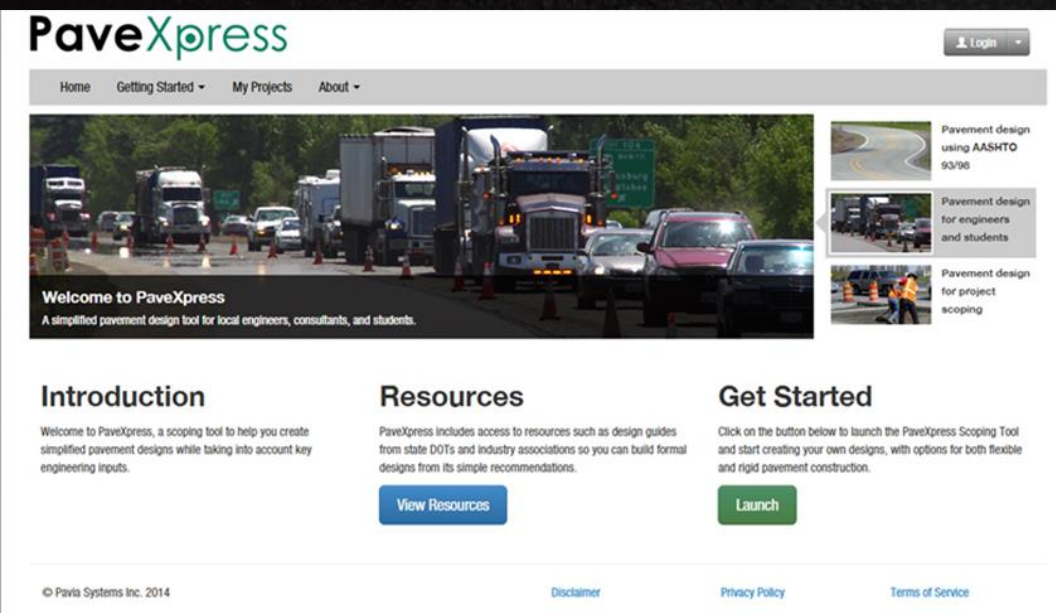
Asphalt.

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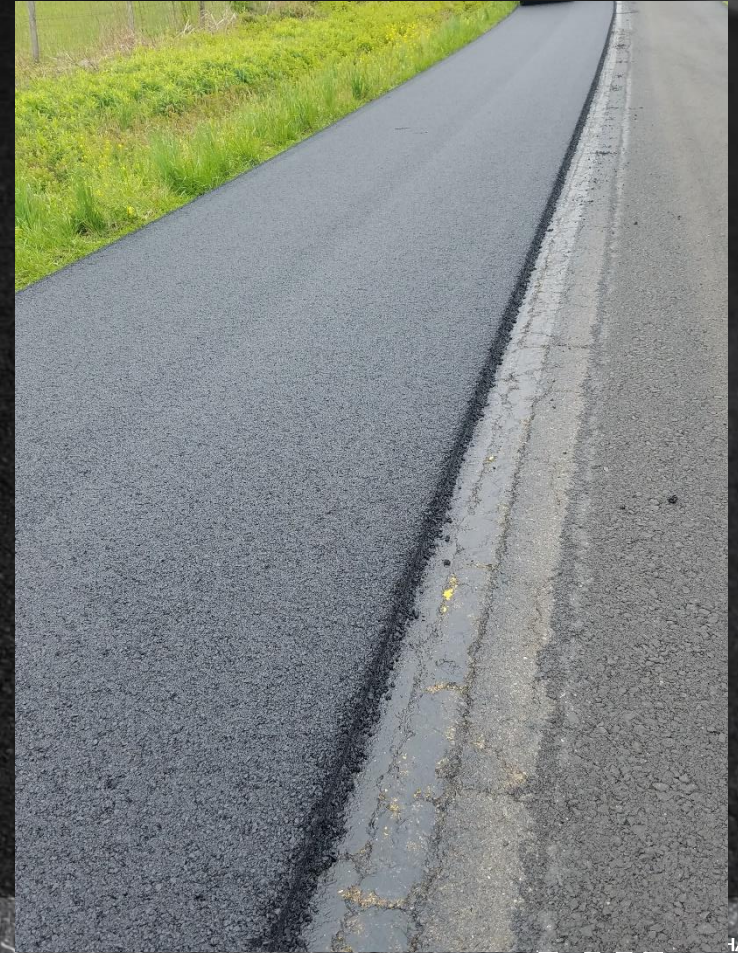


The Evolution of PaveXpress

- Version 2.0
 - Rehabilitation and Overlay Design with AC for Flexible Pavements
- Version 3.0
 - Structural Porous Asphalt Pavement



Parking Lots and Overlays



Asphalt.

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Additional Modules

- Simple Cost Estimating
- Mechanistic Pavement Analysis with EverStress
- LCCA with FHWA's *RealCost*
- PavementInstruct

PAVEXpress Statistics

Sessions

97,716

% of Total: 100.00% (97,716)



Users

56,002

% of Total: 100.00% (56,002)



Avg. Session Duration



00:04:31

Avg for View: 00:04:31 (0.00%)



% New Sessions

56.82%

Avg for View: 56.82% (0.00%)



Pages / Session

2.30

Avg for View: 2.30 (0.00%)



Pageviews

224,394

% of Total: 100.00% (224,394)



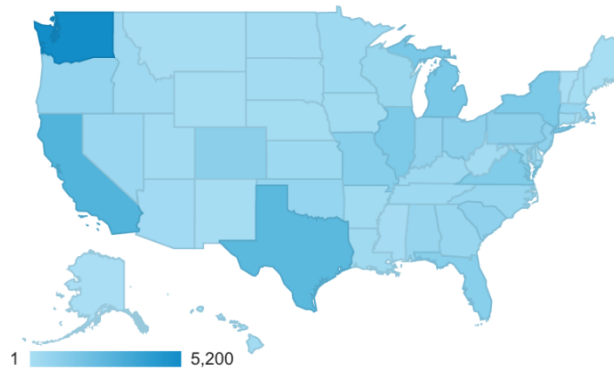
Unique Pageviews

131,996

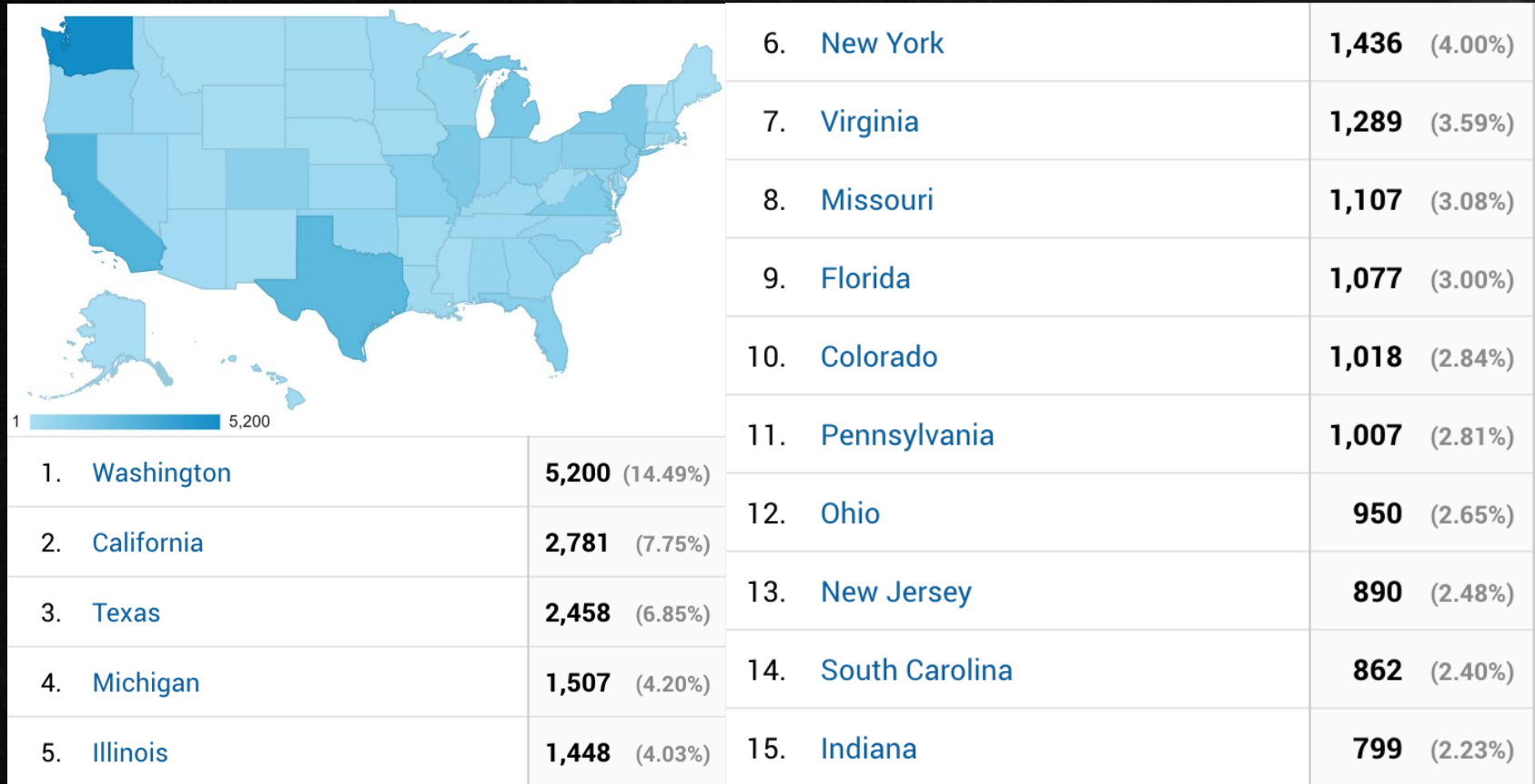
% of Total: 100.00% (131,996)



Users



States with heaviest usage



User Survey

- 2018 Survey of PaveXpress Users
- Three Common Requests for Enhancements
 - Metric Capability
 - Simplified LCCA for Agencies
 - Mechanistic-Empirical Pavement Design Methodology (i.e., PerRoad)

Metric Capability

- Implemented in 2020
- Allows user to toggle between units
- Beneficial for non-US markets

What Is LCCA?

- “an engineering economic analysis tool that allows transportation officials to quantify the differential costs of alternative investment options for a given project.”
 - FHWA

Source: <https://www.fhwa.dot.gov/infrastructure/asstmgmt/lcca.cfm>

Two Approaches to LCCA

Real Cost

- Includes deterministic and probabilistic modeling
- Incorporates user costs
- Considers impacts of work zones
- Data input intensive

Simplified Agency

- Deterministic modeling
- Focuses on agency costs

LCCA Overview in PaveXpress

Activities

- New Construction
- Reconstruction
- Rehabilitation
- Resurfacing
- Corrective Maintenance
- Preventive Maintenance



M-E Pavement Design

- Based on PerRoad
- Uses engineering properties of materials
- Focuses on bottom up cracking and subgrade rutting



Let's walk through PaveXpress together

PAVEXpress

PRODUCTS ▾ LEARNING CENTER ▾ RESOURCES ▾

LAUNCH

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Takeaways

- PaveXpress uses 1993/1998 AASHTO and PerRoad for Designs
- AC Overlays can be designed using current distress and structural condition
- Pavement thickness is influenced by traffic loadings, subgrade strength and material properties
- Users can modify LCCA scenarios and unit costs

QUESTIONS

Asphalt.

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