Maximizing Pavement Life

64th Annual NJ Asphalt Paving Conference
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Asphalt Institute

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Outline

- Distress Identification and Causes
- Thickness Design
- Mix Type and Lift Thickness
- Binder Selection
- Effect of Recycled Binders
- Mix Design
- Prep for Paving
- Minimizing Segregation
- Laydown Operations
- Importance of Density
- Pavement Preservation

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Dealing with Pavement Distress

- Distress Identification is Critical
- Design to Eliminate Distress
- Rehabilitation depends on both the Type and Severity of Distress
- Proper Routine Maintenance Minimizes Future Problems and Reduces Costs

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Asphalt Pavement Distress

General Types

- Cracking
- Distortions
- Disintegration

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Types of Cracking

- Longitudinal
- Transverse
- Reflective
- Edge
- Block
- Alligator
- Slippage

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Distortions

- Rutting
- Corrugations
- Depressions
- Disintegration

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Distress Categories (Causes)

- Load Related
- Environmental
- Other Design / Construction Related
  - Poor Drainage
  - Material Deficiencies
  - Construction-related Deficiencies
  - Insufficient Design

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There maybe multiple causes …

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Pavement Thickness Design

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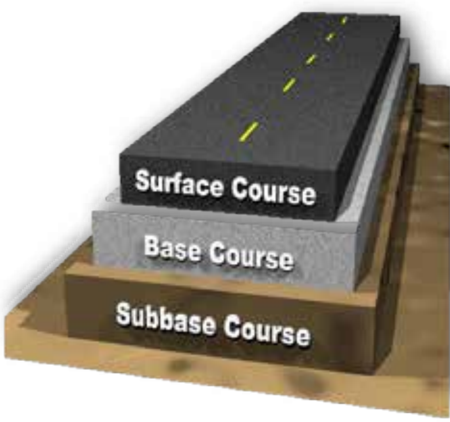
MEPDG *(AASHTO 2000)*



AASHTO has been developing MEPDG for high volume roads, but a gap has developed for local roads and lower volume roads.

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Pavement Design

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What Is PaveXpress?

A free, online tool to help you create and evaluate pavement designs and overlays using key engineering inputs, based on the AASHTO 1993 and 1998 supplement pavement design process.

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

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PaveXpressdesign.com

TRAINING LESSONS

- Session 1 – PAVEXpress Overview
- Session 2 – New Pavement Designs with 1993 and 1998 AASHTO
- Session 3 – Overlay Design
- Session 4 – Mechanistic-Empirical Pavement Design and Evaluation
- Session 5 – Introduction to Mechanistic-Empirical Design with PerRoad
- Session 6 – PerRoad Design
- Session 7 – Porous Pavement Design with PAVEXpress
- Session 8 – Initial Costing and LCCA Functions

The Asphalt Pavement Alliance collaborated with Pavia to create a stand alone website which continues to add additional features for industry use.

PaveInstruct.com developed tutorials to educate PaveXpress users

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Limitations*

- The equations were developed based on the specific pavement materials and roadbed soil present at the AASHO Road Test.
- The equations were developed based on the environment at the AASHO Road Test only.
- The equations are based on an accelerated two-year testing period rather than a longer, more typical 20+ year pavement life. Therefore, environmental factors were difficult if not impossible to extrapolate out to a longer period.
- The loads used to develop the equations were operating vehicles with identical axle loads and configurations, as opposed to mixed traffic.

*Courtesy of Pavement Interactive

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Perpetual Pavement Design Software

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Video – First 6 min

PerRoad and PerRoadXpress use the mechanistic-empirical design philosophy. The program couples layered elastic analysis with a statistical analysis procedure (Monte Carlo simulation) to estimate stresses and strains within a pavement. In order to predict the strains which would prove detrimental for fatigue cracking or structural rutting.

www.asphaltroads.org/perpetual-pavement

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What does a P. P. look like?

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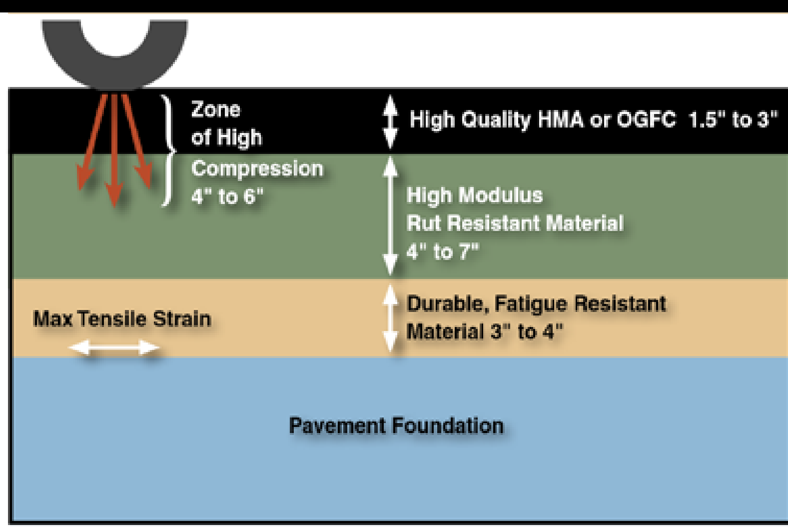

Many pavements are constructed just short of PP thickness without knowing.

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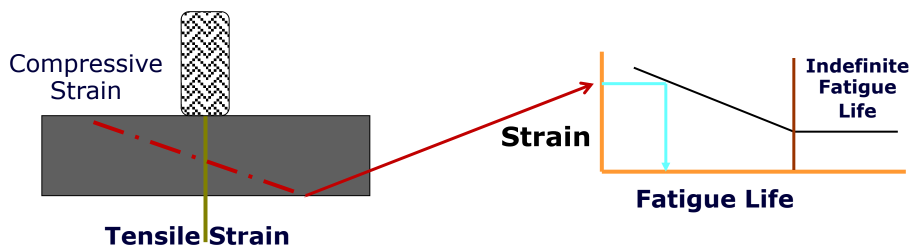
Perpetual Pavement

Traditional thin section, high modulus mix

» Thin Asphalt Pavement = **Higher Strain**

» Higher Strain = **Shorter Fatigue Life**



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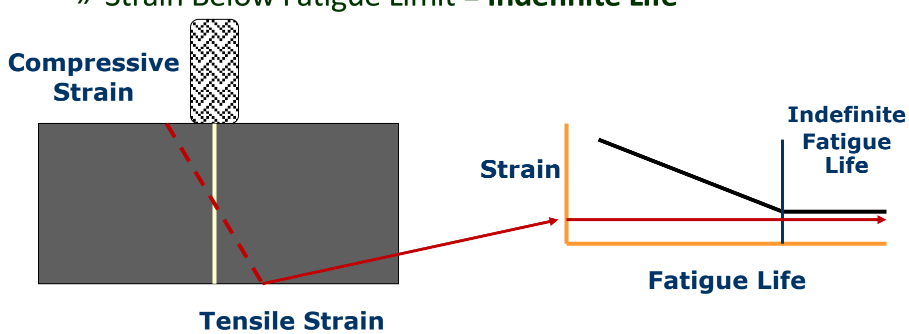
Perpetual Pavement

Fatigue Resistant Asphalt Thickness

» Minimize Tensile Strain with Pavement Thickness

» Thicker Asphalt Pavement = **Lower Strain**

» Strain Below Fatigue Limit = **Indefinite Life**



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Perpetual Pavement

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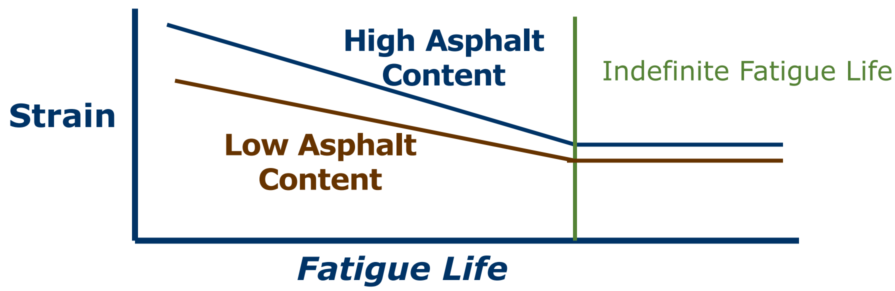
Fatigue Resistant Asphalt Mixture

» High Effective Asphalt Content Mixes = **Greater Strain Capability**

» Modified Binders = **Greater Strain Capability**



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Lift Thickness and Mix Type

So you designed an 8.43" thick asphalt pavement. Now what?

What are you going to lay, and how thick are you going to lay it?

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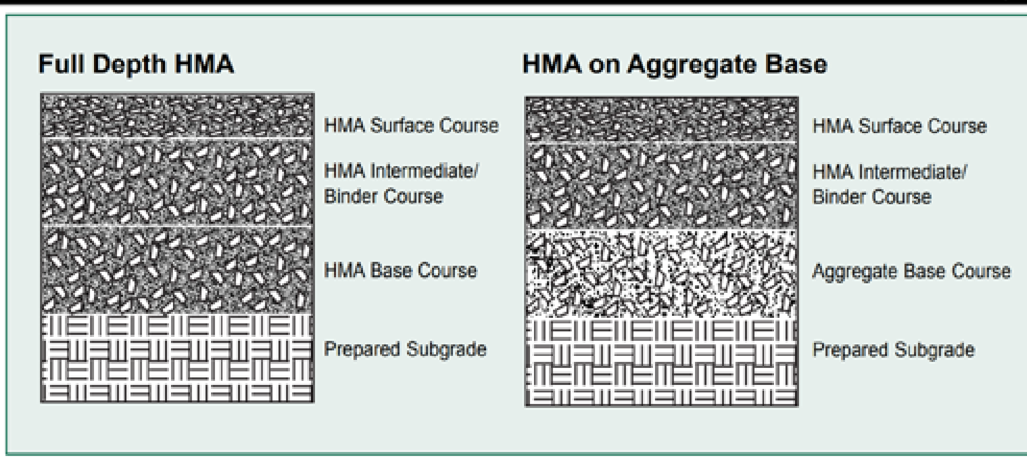
Pavement Layers



There are no AASHTO / ASTM methods or specifications for mixture types or lift configurations

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Aggregate Size Definitions

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Nominal Maximum Aggregate Size

- One size larger than the first sieve to retain (cumulative) more than 10%

Maximum Aggregate Size

- One size larger than nominal maximum size

Both definitions are based on the standard ASTM sieve nest

Sieve, mm (US)	Retained, %	Cumulative Retained, %	Passing, %
37.5 (1.5")	0	0	100
25.0 (1.0")	0	0	100
19.0 (3/4")	0	0	100
12.5 (1/2")	0	0	100
9.5 (3/8")	5	5	95
4.75 (#4)	22	27	73
2.36 (#8)	21	48	52
1.18 (#16)	13	61	39
.600 (#30)	12	73	27
.300 (#50)	11	84	16
.150 (#100)	4	88	12
0.075 (#200)	7	95	5.0
Pan	5.0	100	

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Mixture Aggregate Sizes

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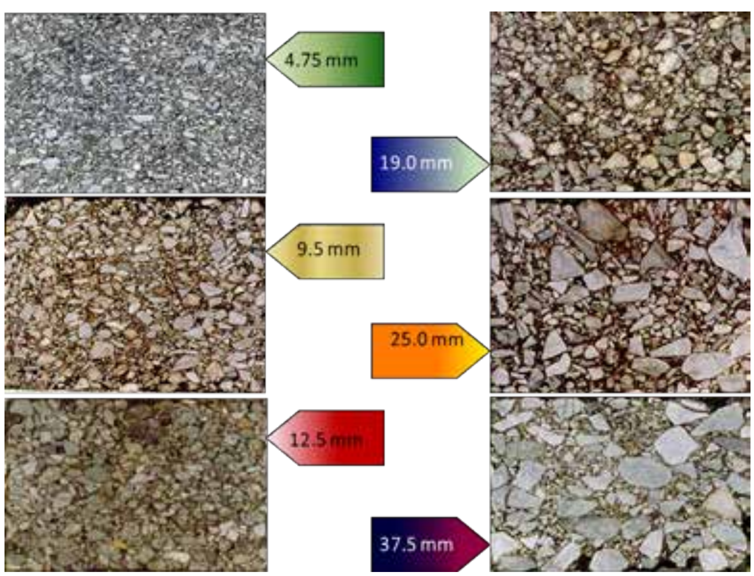

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Aggregate Size vs. Strength

Mixture Facts:

- Larger Aggregate Size ≠ Increased Strength
- Higher coarse aggregate = lower asphalt content
- Finer aggregate mixtures are less permeable, more compactible and more durable

Mixture Strength is determined by:

- Aggregate shape, strength and texture
- Proper binder type and quantity
- Field placement and compaction

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Superpave Size Designations

Superpave Designation	Nom Max Size, mm	Max Size, mm
37.5 mm	37.5	50.0
25.0 mm	25.0	37.5
19.0 mm	19.0	25.0
12.5 mm	12.5	19.0
9.5 mm	9.5	12.5

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Compacted Lift Thickness

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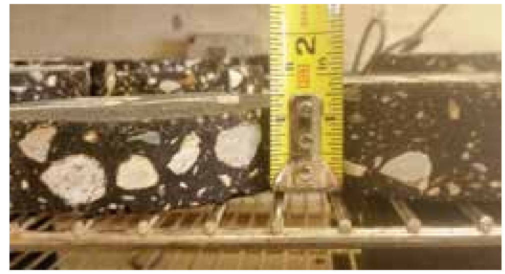
NMAS grading is different than older "Topsize" Grading



Old Rule of Thumb - Minimum lift thickness = 2x Topsize

NMAS - Minimum compacted thickness
✓4 times nominal aggregate size
✓3 times nominal aggregate size for fine graded mixtures

- Thicker lifts are easier to compact
- Cool slower, providing longer compaction time

Minimum -----------NOT MAXIMUM !

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SGC Density vs. Lift Thickness

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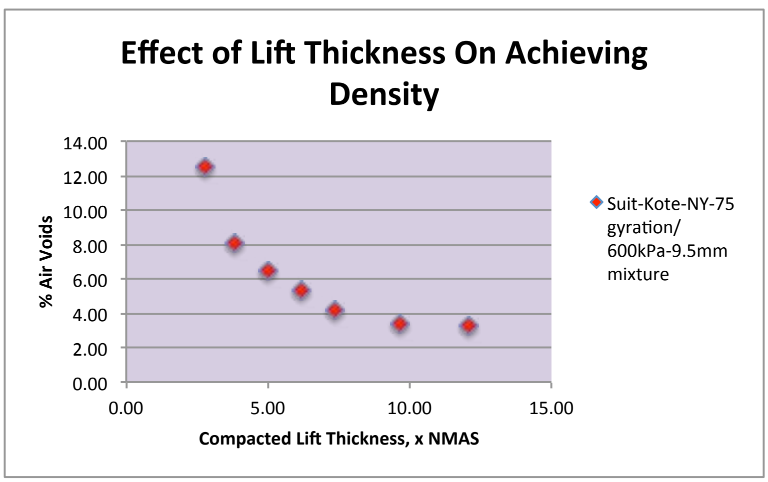

9.5 mm crushed gravel @ 75 gyrations

Thicker Lifts Are Easier To Compact

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Superpave Asphalt Binder Specification

Grading System Based on Climate

PG 64-22

- **Performance Grade**
- **Max pavement design temp**
- **Min pavement design temp**

AASHTO M320

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Calculated Pavement Temperatures
Topeka, KS

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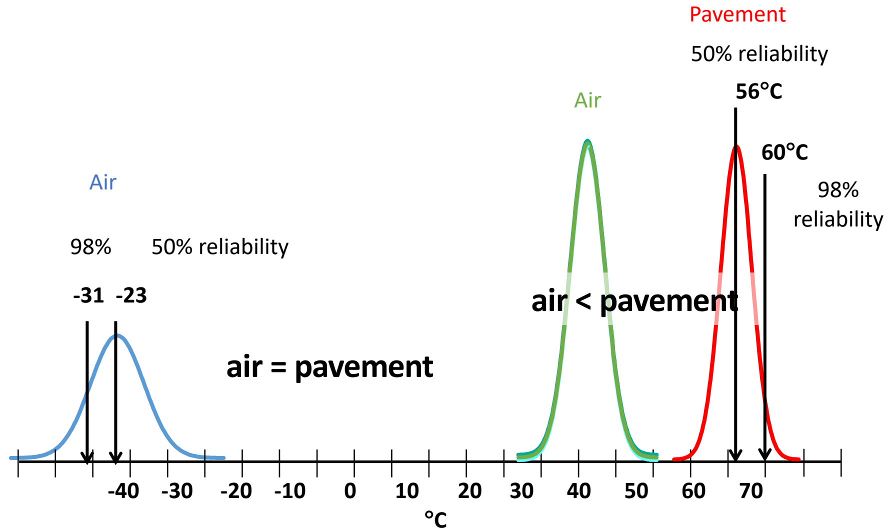

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PG Binder Selection - Topeka, KS

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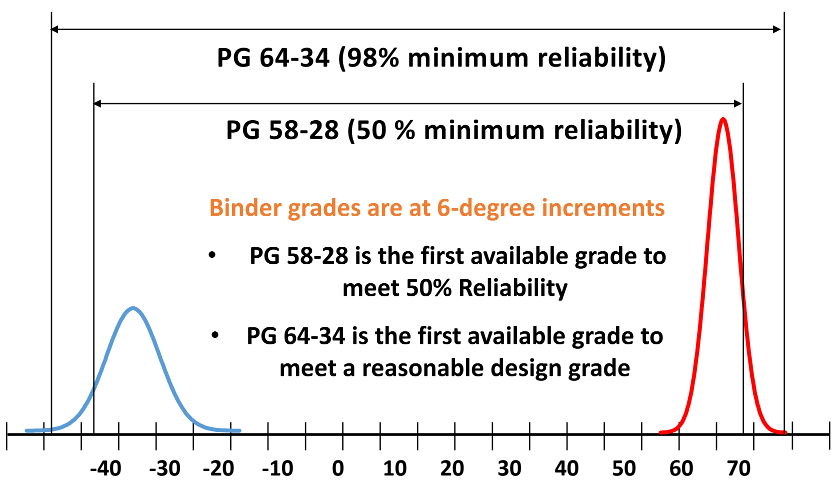

Binder grades are at 6-degree increments

- **PG 58-28 is the first available grade to meet 50% Reliability**
- **PG 64-34 is the first available grade to meet a reasonable design grade**

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Effect of Loading Rate on Binder Selection Using AASHTO M320 Specification

Example:

- Toll road
  PG 64-22 ← 90 kph (55 MPH)
- Toll booth
  PG 70-22 ← Slow
- Weigh stations
  PG 76-22 ← Stopping

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Superpave Asphalt Binder Specification

Grading System Based on Climate

PG 64E-22

- Performance Grade
- Max pavement design temp
- Traffic Level
- Min pavement design temp

AASHTO M332

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LTPP Studies

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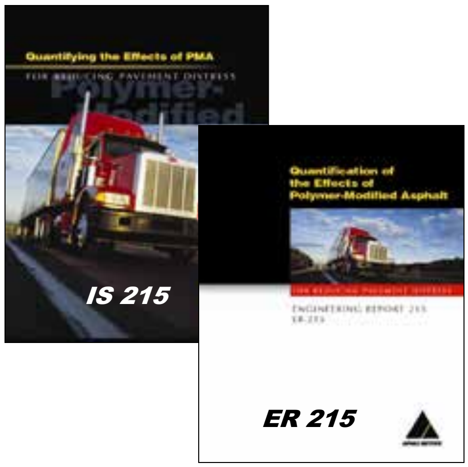
Quantifying the Effects of PMA for Reducing Pavement Distress



This study (published in Feb 2005) used national field data to determine enhanced service life of pavements containing polymer modified binders versus conventional binders. The data is from a variety of climates and traffic volumes within North America.

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IS-215 Data

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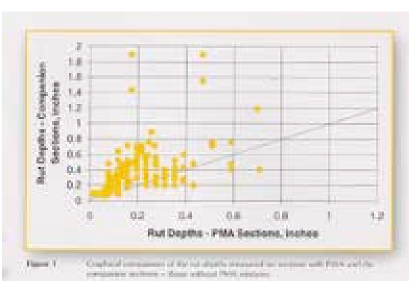

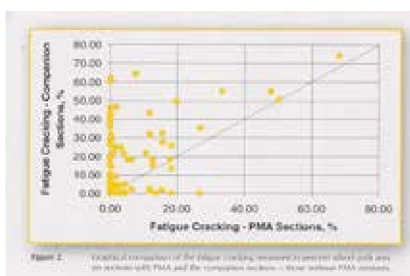

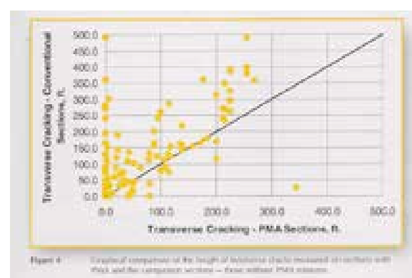

Polymer modified asphalt sections had reduced rutting, reduced fatigue cracking, and reduced transverse cracking compared to unmodified asphalt sections

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Recycled Binders

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The Elephant In The Room

An obvious problem or risk no one wants to discuss, or a condition of groupthink no one wants to challenge

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NCHRP 9-12 Recommendations

RAP mixtures should be able to perform at least as well as virgin mixes.

ACTION	RAP
No Change in Binder Grade	15% or less
One Grade Lower	16 - 25%
Use Blending Charts	>25%

Adopted in AASHTO M323

Superpave Volumetric Mix Design

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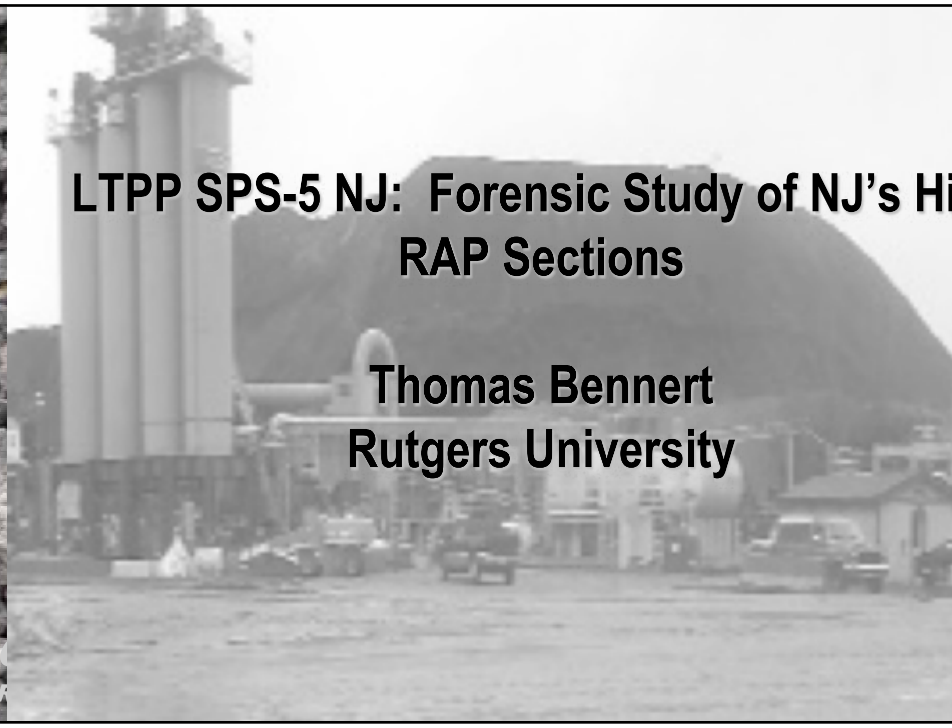

LTPP SPS-5 NJ: Forensic Study of NJ's High RAP Sections

Thomas Bennert
Rutgers University

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LTPP SPS-5: RAP vs. Virgin

- Four comparison pairs per project (location)
  - 2" overlay, no mill
  - 2" overlay with mill
  - 5" overlay, no mill
  - 5" overlay with mill
- Five performance measurements (annual)
  - Rutting, mm
  - IRI, m/km
  - Fatigue cracking, m^2
  - Transverse cracking, # per section
  - Longitudinal cracking, m

CAIT
RUTGERS
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What Happened in NJ?

- NJ LTPP 30% RAP sections designed using softer binder
  - Control: 0% RAP, AC-20
  - 30% RAP used AC-10
- NJ LTPP SPS-5 sections ready for rehab (milled out) in 2010
- Convinced NJDOT to provide funding for analysis of sections

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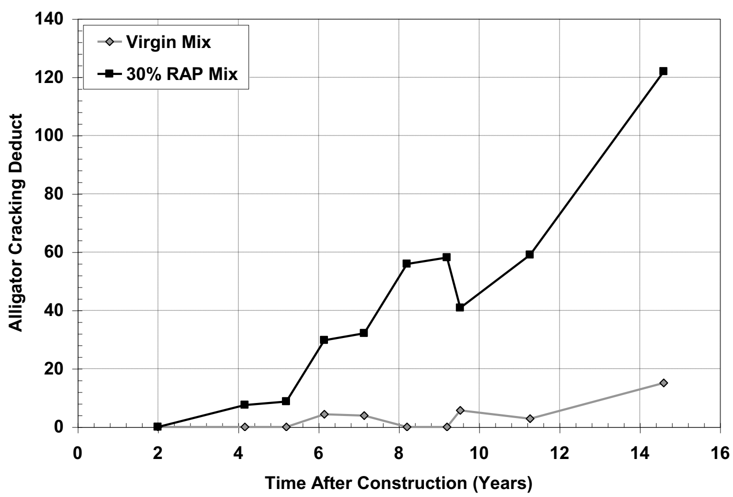
NJ SPS-5 Cracking – 2 Inch Overlay Section (Milled)



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RUTGERS

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Acknowledgement

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Acknowledgement

WHRP
Wisconsin Highway Research Program

WISCONSIN DEPARTMENT OF TRANSPORTATION

- Project 0092-14-06 Critical Factors Affecting Asphalt Durability
  - Evaluate changes to the composition of asphalt mixtures that WisDOT should consider to improve durability
    - Resistance to load associated cracking
    - Resistance to aging

http://wisconsindot.gov/documents2/research/14-06-revised-final-report.pdf

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Improving Load Associated Cracking

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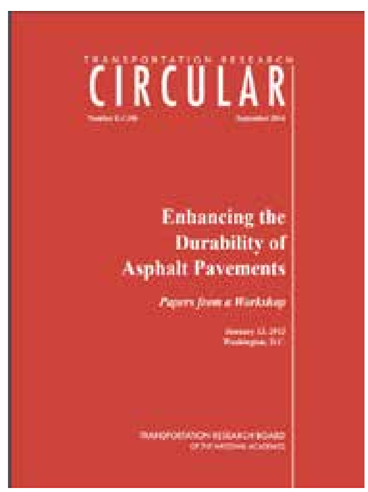
- Increase Effective Volume of Binder
- Use Polymer Modification
- Use Softer Grade of Binder
- Place Limits on Recycled Binder Effectiveness



http://onlinepubs.trb.org/onlinepubs/circulars/ec186.pdf

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Illinois SCB (Flexibility Index)

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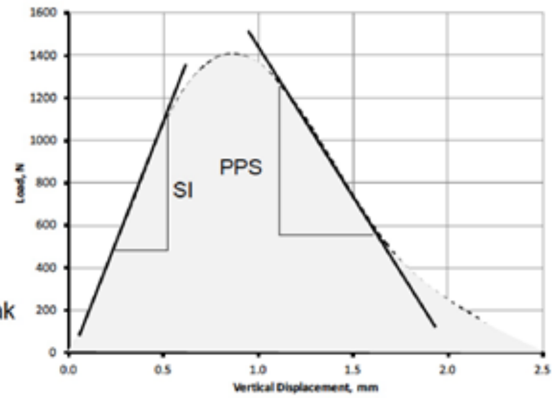
Illinois SCB (Flexibility Index)



SI = Stiffness Index
Slope @ 50% of Peak Load
AI=Aging Index
=SI_{LTOA}/SI_{STOA}

FI = Energy/Post Peak Slope
Resistance to cracking increases with increasing FI

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Example Design Specification

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Effective RAP Binder Ratio	Minimum Design VBE, vol %							
	58-28 S	58-28 H	58-28 V	58-28 E	58-34 S	58-34 H	58-34 V	58-34 E
0.00	10.0	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**
>0.00 ≤0.05	10.4	10.2	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**
>0.05 ≤0.10	10.7	10.5	10.1	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**
>0.10 ≤0.15	11.1	10.9	10.4	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**
>0.15 ≤0.20	11.5	11.3	10.8	10.2	10.1	**10.0**	**10.0**	**10.0**
>0.20 ≤0.25	11.9	11.7	11.2	10.6	10.4	10.2	**10.0**	**10.0**
>0.25 ≤0.30	12.2	12.0	11.5	11.0	10.8	10.6	10.1	**10.0**
>0.30 ≤0.35	Low Temperature Grade Controls				11.2	11.0	10.5	**10.0**
>0.35 ≤0.40					11.5	11.3	10.9	10.3
>0.40 ≤0.45					11.9	11.7	11.2	10.6
>0.45 ≤0.50					12.3	12.1	11.6	11.0

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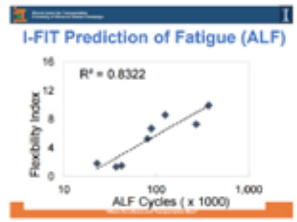
Effect of Recycled Binder

Effect of Recycled Binder No Grade Change

VBE	Low Grade	RBR	FI	% of Control Life
10.5	-28	0.00	6.5	100
10.5	-28	0.05	6.0	92
10.5	-28	0.10	5.5	84
10.5	-28	0.15	5.0	77
10.5	-28	0.20	4.5	69
10.5	-28	0.25	4.0	61
10.5	-28	0.30	3.5	53



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Materials Selection

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Aggregate

- Makes up 93 to 96% of the mixture weight
- Acts as the skeleton of the pavement mixture
  - Skid resistance
  - Stability
  - Workability

Asphalt Binder

- Makes up 4 to 7% of the mixture weight
- Acts as the "glue" or "muscle" of the mix
  - Flexibility
  - Durability

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Mix Design is a balancing act

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Smooth, Quiet Ride

Good Strength & Stability

No Rutting

No Shoving

No Flushing

Durable

No Cracking

No Raveling

How?

- Materials Selection
- Volumetric design

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Phase Diagram

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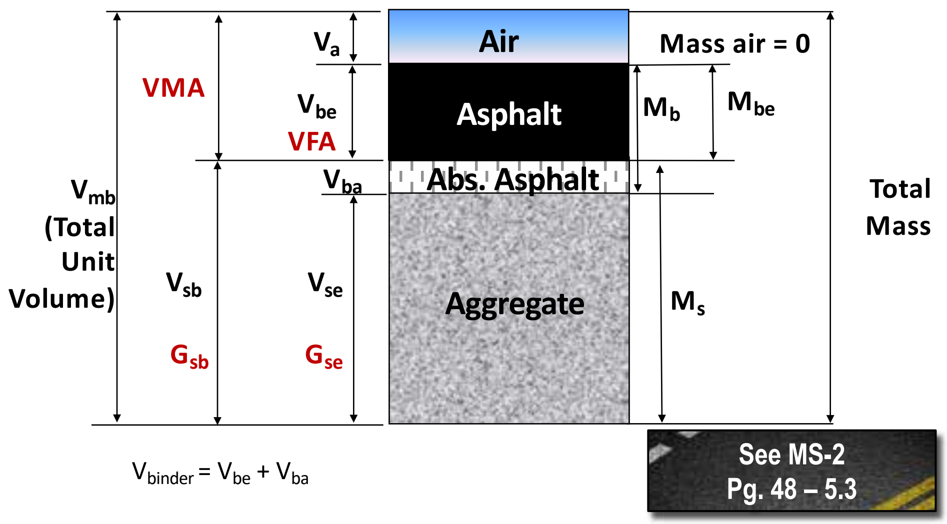
Analyzed by VOLUME

Measured by MASS



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Balanced Mix Design

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"Asphalt mix design using performance tests on appropriately conditioned specimens that address multiple modes of distress taking into consideration mix aging, traffic, climate and location within the pavement structure."

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What Is a Balanced Mix Design

- Balanced mix design is simply design a mix to "balance" the rutting and cracking resistance
- We do this by varying the asphalt content (increase) as we do in volumetric design trials and perform:
  - Rutting: Hamburg Wheel Tracker, APA, or AMPT Flow Number
  - Cracking: DC(T), SCB-iFit, Ideal CT, Overlay Test, or beam fatigue


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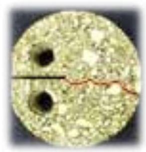

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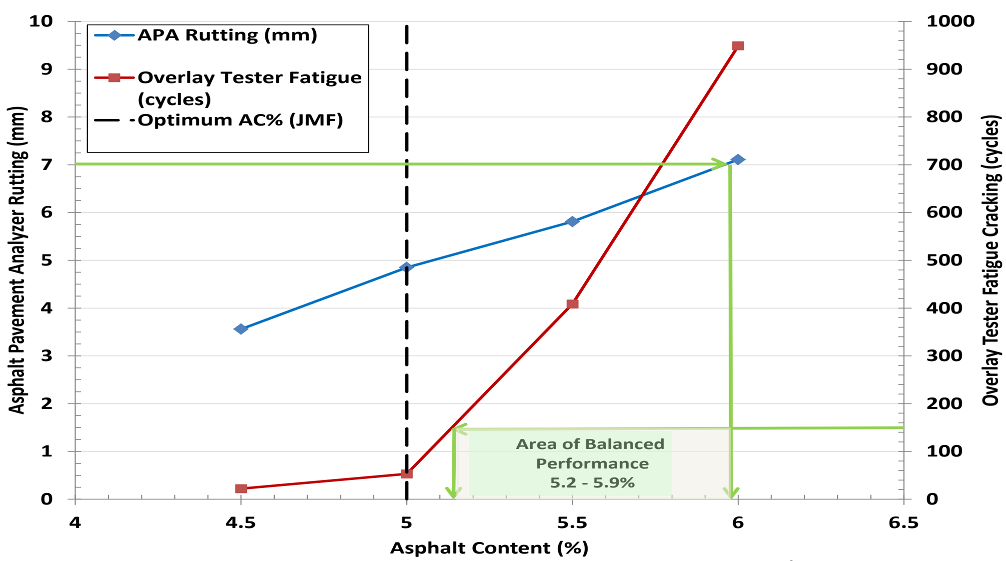
New Jersey Balanced Design



Courtesy of Tom Bennert

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Preparation For Paving Laydown Operations

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Surface Preparation

The most common surfaces overlaid with HMA or WMA include:

- Subgrade
- Granular Base Course (Aggregate Base)
- Existing Asphalt Pavement
- Existing PC Concrete Pavement

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Preparing to Overlay Existing HMA

Preparing an existing asphalt surface may be as simple as sweeping (*multiple passes may be necessary*) the existing surface and applying tack coat

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Preparing to Overlay Existing HMA

Or it may involve one or more of the following:

- Patching
- Cleaning and filling cracks
- Placing a leveling course
- Milling the surface

Failed areas MUST be cleaned, repaired and brought into good structural condition before overlaying.

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Patch It!

- Make sure to get at least 1 foot into the sound pavement when you mark the patch for removal
- Use good straight lines that are cut with vertical faces
- Remove all loose material
- Tack base and all vertical surfaces
- Patches must be strong enough to become a part of the permanent structure or they *will* be back!

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Importance of Tack Coats

Why do we use Tack Coats?

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Importance of Tack Coats

- **To promote the bond between pavement layers.**
  - To prevent slippage between pavement layers.
  - Vital for structural performance of the pavement.
  - All layers working together.
  - Apply along all transverse and longitudinal vertical surfaces.

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Best Practices

- Surfaces need to be clean and dry
- Uniform application
- Tack all surfaces
  - Horizontal
  - Vertical

Road Cleaning Equipment, Showing Broom and Blower Mounted on a Fordson Tractor. The Blower Removes the Dust that has not been Entirely Swept Off by the Broom.

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Common Tack Coat Questions

- **What is the Optimal Application Rate?**
  - Surface Type
  - Surface Condition
- **Workshop Recommended Ranges**

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.

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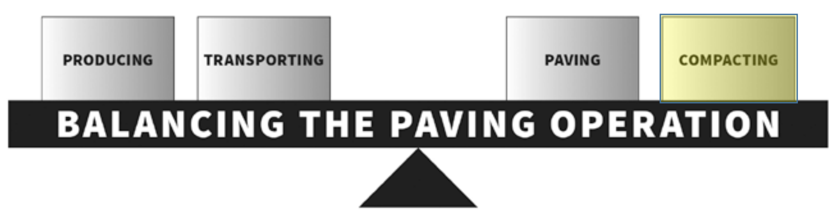

What is a balanced paving operation?

The synchronized balance of the four phases of asphalt paving to provide continuous paving operations. The four phases are mixture production, mixture hauling, paving operations, and compaction.

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Truck-End Segregation

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Truck-end segregation is caused by segregation in the truck transferred through the paver.

Make sure the trucks are being loaded in multiple drops!

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Loading the Hopper

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Break the load before opening the tailgate.
Move the mix in a mass - no trickling!

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Do not let the hopper run dry!

Maintain a full Hopper

Dump paver wings
only when necessary

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Material Transfer Vehicle (MTV)

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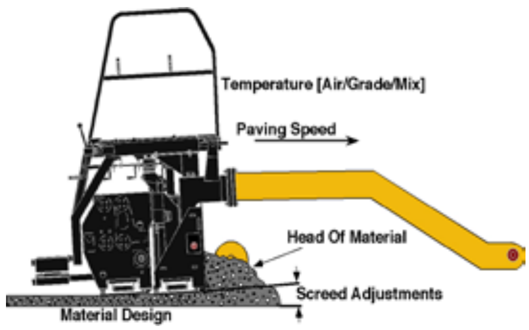
Understanding the Paver



Factors Affecting the Screed

- Paving speed
- Head of material
- Screed adjustments
- Mix design
- Mix temperature
- Air temperature
- Grade temperature

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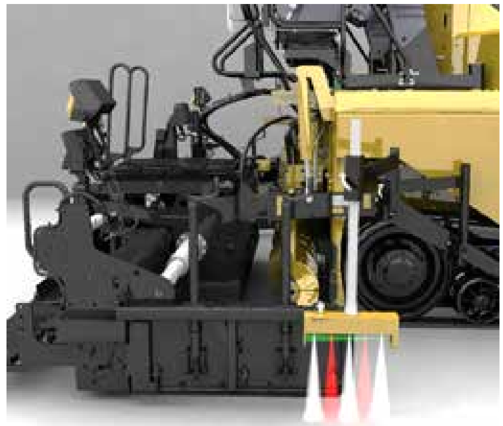
Joint Matcher

Joint Match



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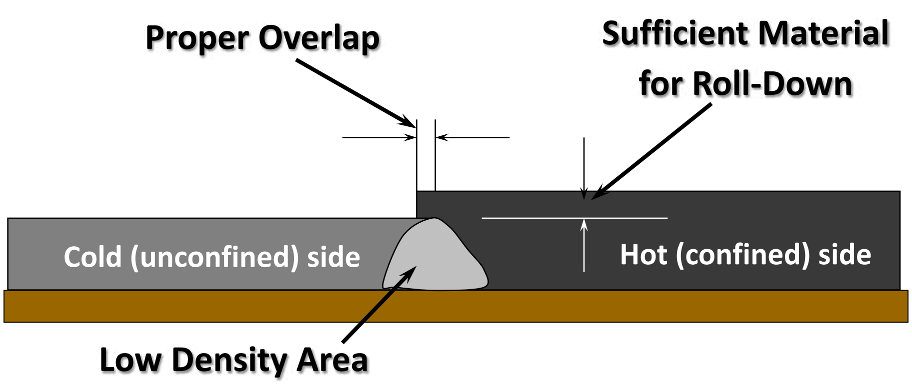
We Know Unsupported Edge Will Have Lower Density



Please note **Cold side** and **Hot side**, as they are terms used throughout this Workshop.

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The Best Longitudinal Joint: *Echelon Paving*

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First Pass Must Be Straight!

string-line should be used to assure first pass is straight

Stringline for reference, and/or Skip Paint, Guide for following

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VRAM

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Density vs. Loss of Pavement Service Life

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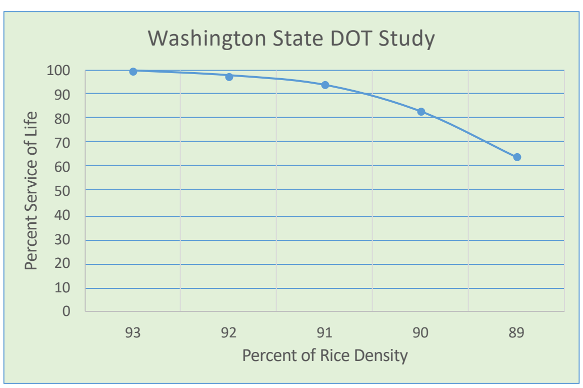
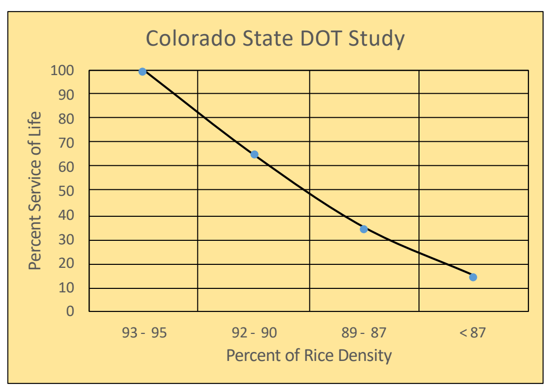


Thicker Pavements TRR 1217, 1989



Typical Pavements CDOT 2013-4, 2013

For both thicker and thinner, reduced in-place density at the time of construction results in significant loss of Service Life!

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NCAT Report 16-02 (2016)

Literature Review on connecting in-place density to performance

- 5 studies cited for fatigue life
- 7 studies cited for rutting
- "A **1% decrease in air voids** was estimated to improve the fatigue performance of asphalt pavements between 8.2 and 43.8%, to improve the rutting resistance by 7.3 to 66.3%, and to **extend the service life by conservatively 10%**."

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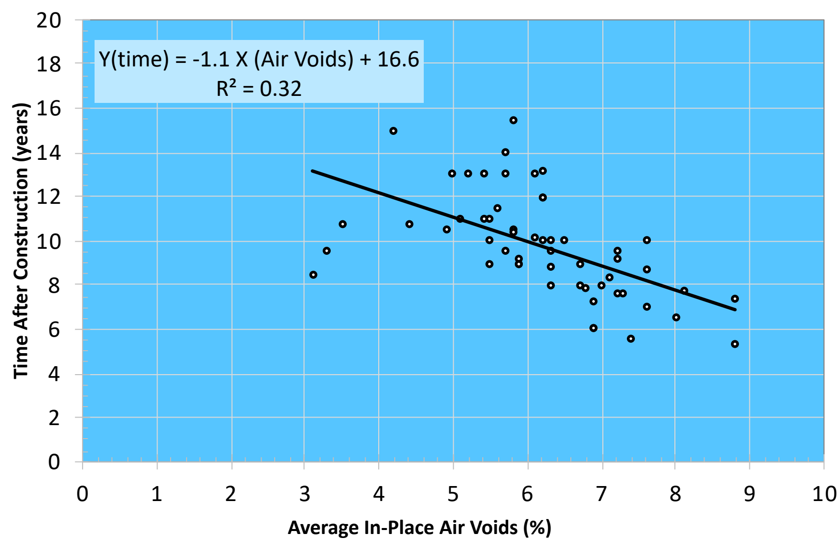
Research from New Jersey



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Pavement Preservation

- Pavement preservation techniques are cost-effective and environmentally sustainable strategies designed to extend the life of existing pavements before they deteriorate substantially.
- Pavement preservation methods prolong pavement life, avoiding high future costs of reconstruction or rehabilitation through the expenditure of lesser amounts of money at critical points in a pavement's life.
- **roadresource.org**

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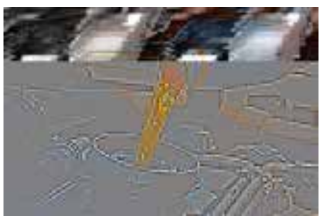
"The right treatment on the right pavement at the the right time"

- Different pavement preservation treatments
- What distress does each treatment address
- When should each treatment be used (expected performance)
- Methods to optimize roadway network



"As with changing the oil in a car, the earlier the preventative maintenance of asphalt pavements, the longer they will last without needing serious repair."

- Tom Wood, Research Project Engineer, MNDOT Office of Materials and Road Research

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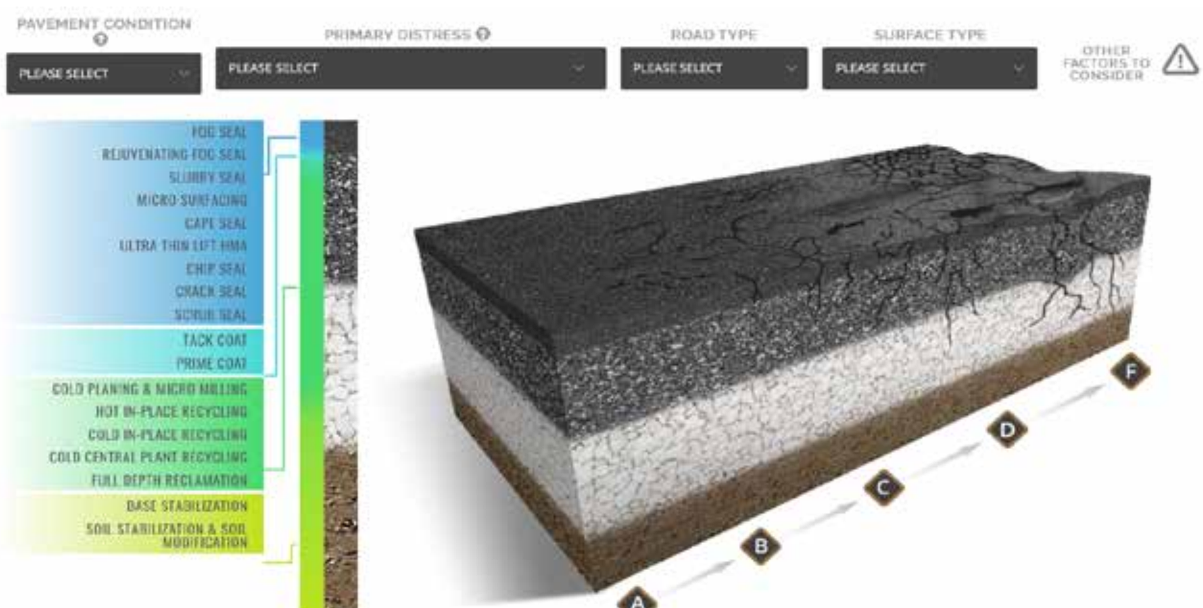
Exploring by Pavement Criteria



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Exploring by Pavement Photos

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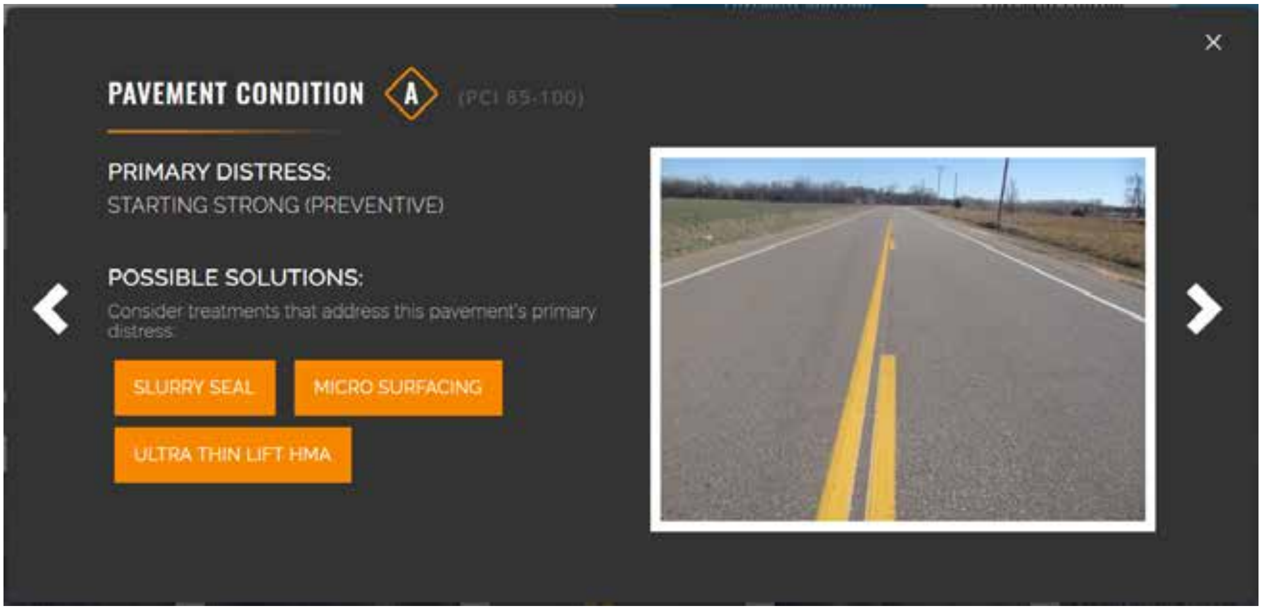

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Maximizing Pavement Life

- Pavement Design
- Materials Selection
- Construction Practices
- Pavement Preservation

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Thanks!

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