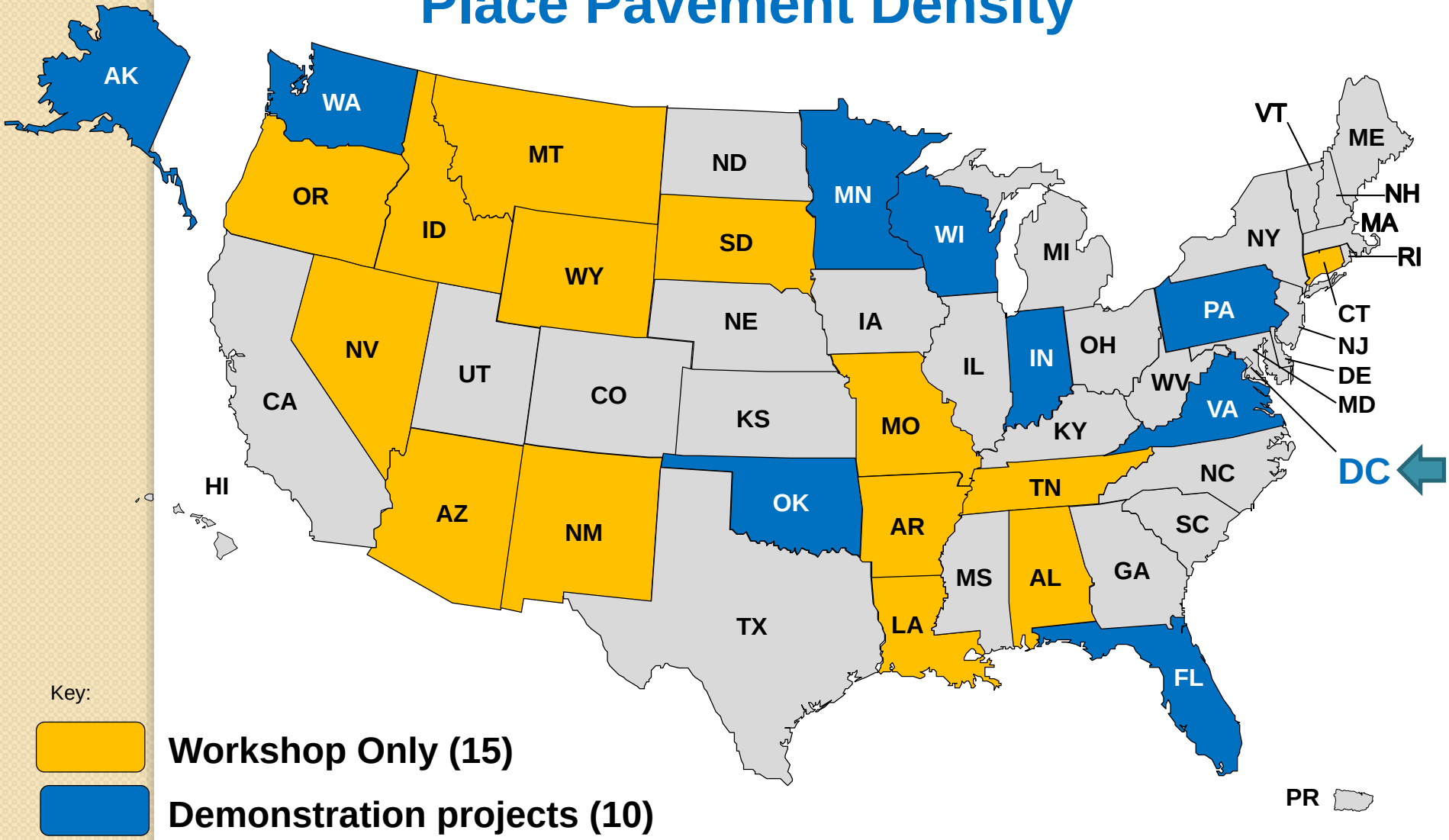
Enhanced Durability Through Increased In-Place Pavement Density

FHWA and Asphalt Institute
Workshop

Enhanced Durability of Asphalt Pavements through Increased In-Place Pavement Density



Evolution of Traffic

- Interstate highways - 1956
- AASHO Road Test - 1958-62
  - still widely used for pavement design
  - legal truck load - 73,280 lbs.
- Legal load limit to 80,000 lbs. - 1982
  - 10% load increase
  - 40-50% greater stress to pavement
- Radial tires, higher contact pressure
- FAST Act raising load limit to 120,000 lbs. (in select locations)

Led to Rutting in 1980s

Which led to…Superpave

- Fixed the rutting problem
- Gyratory compaction lowered binder contents
- Add in higher and higher recycled materials?

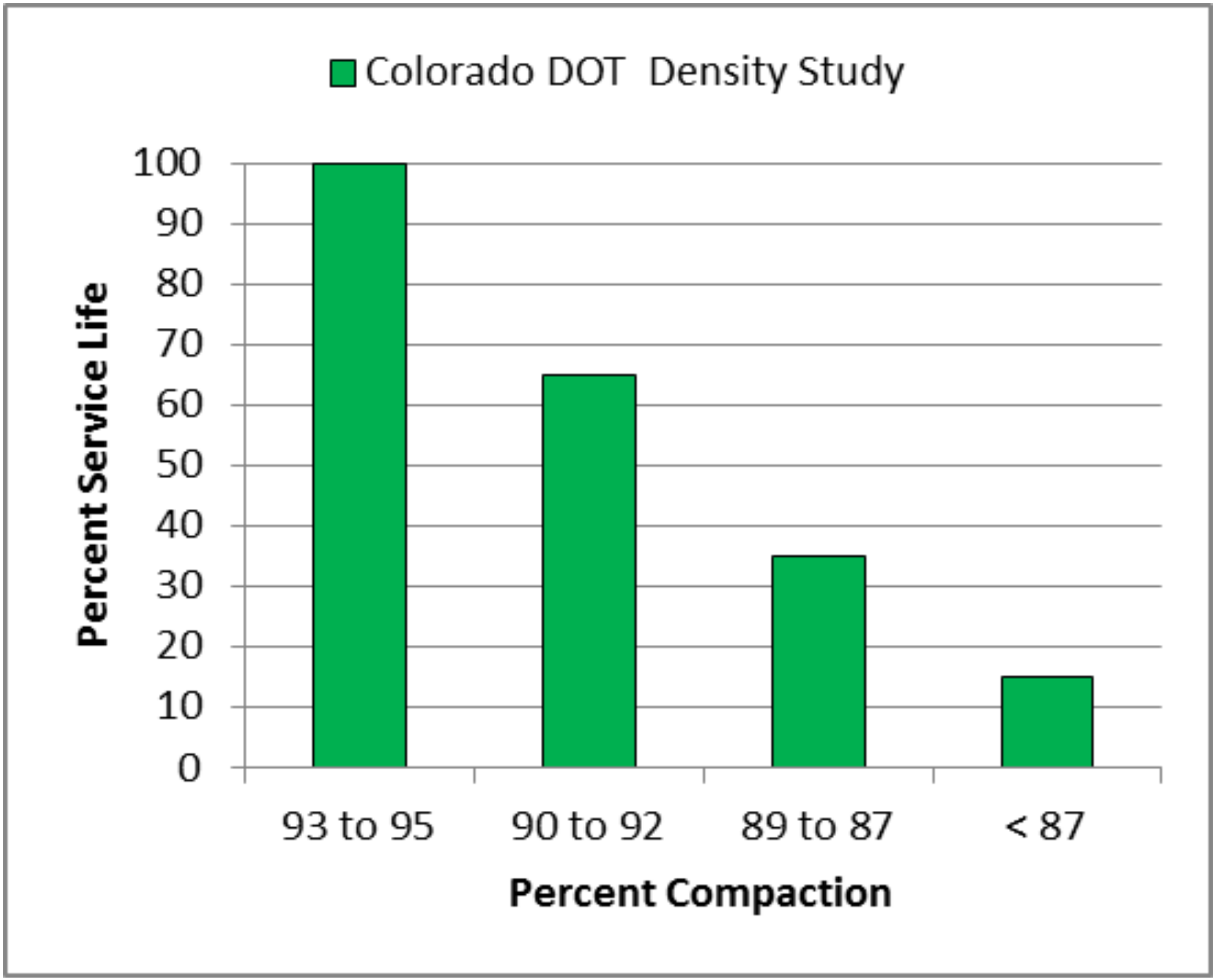
Improved Compaction = Improved Performance

A BAD mix with GOOD density out-performed a GOOD mix with POOR density for ride and rutting.

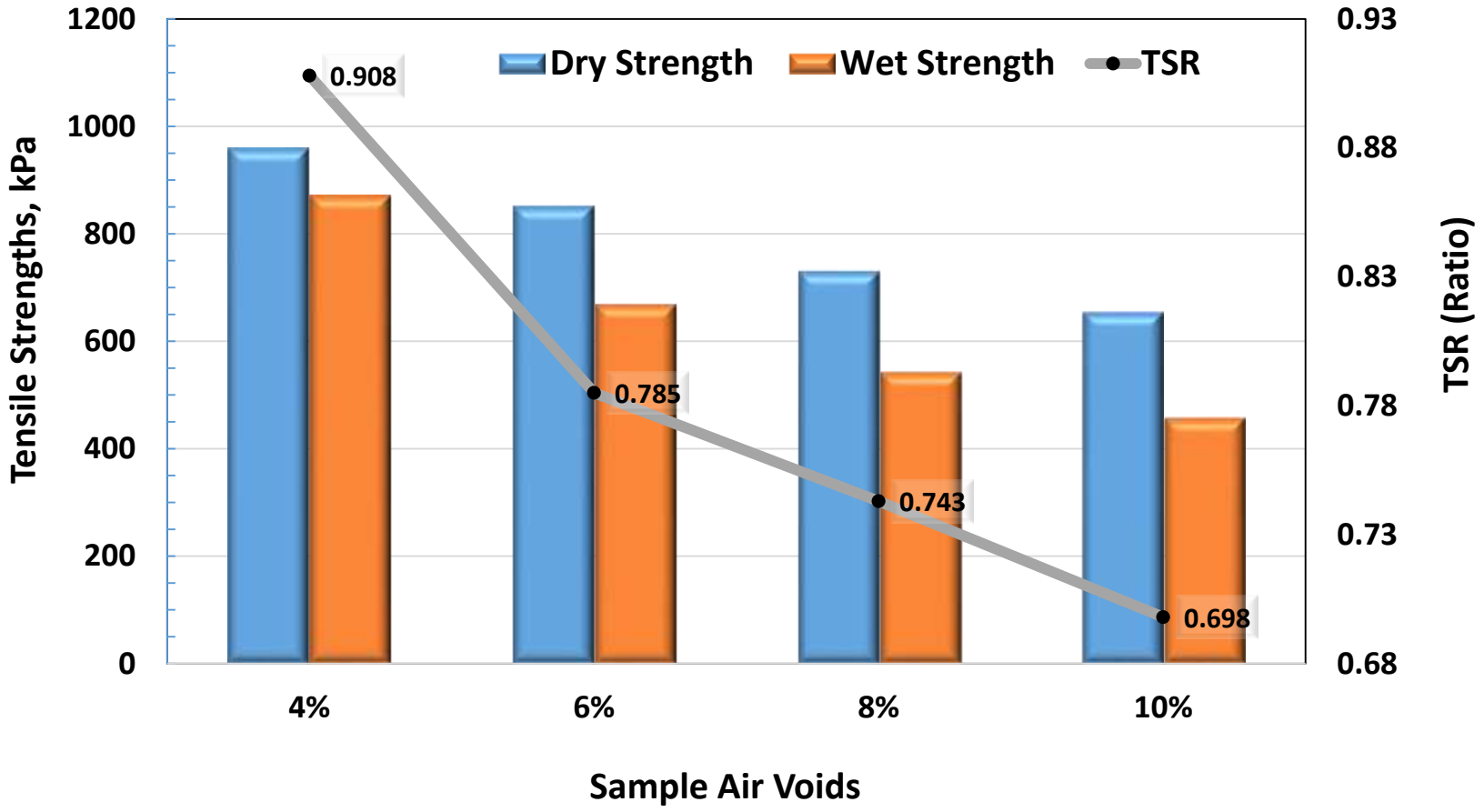
WesTrack Experiment

Effect of In-Place Voids on Life

Colorado DOT Study



Tensile Strength & Moisture Susceptibility vs. Air Voids
AASHTO T 283



FHWA Performance Based Mix Design

	Fatigue Cracking	Rutting
Design Air Voids For every 1% increase	40% increase	22% decrease
Design VMA For every 1% increase	73% decrease	32% increase
Compaction Density For every 1% lower in-place Air Voids	19% decrease	10% decrease

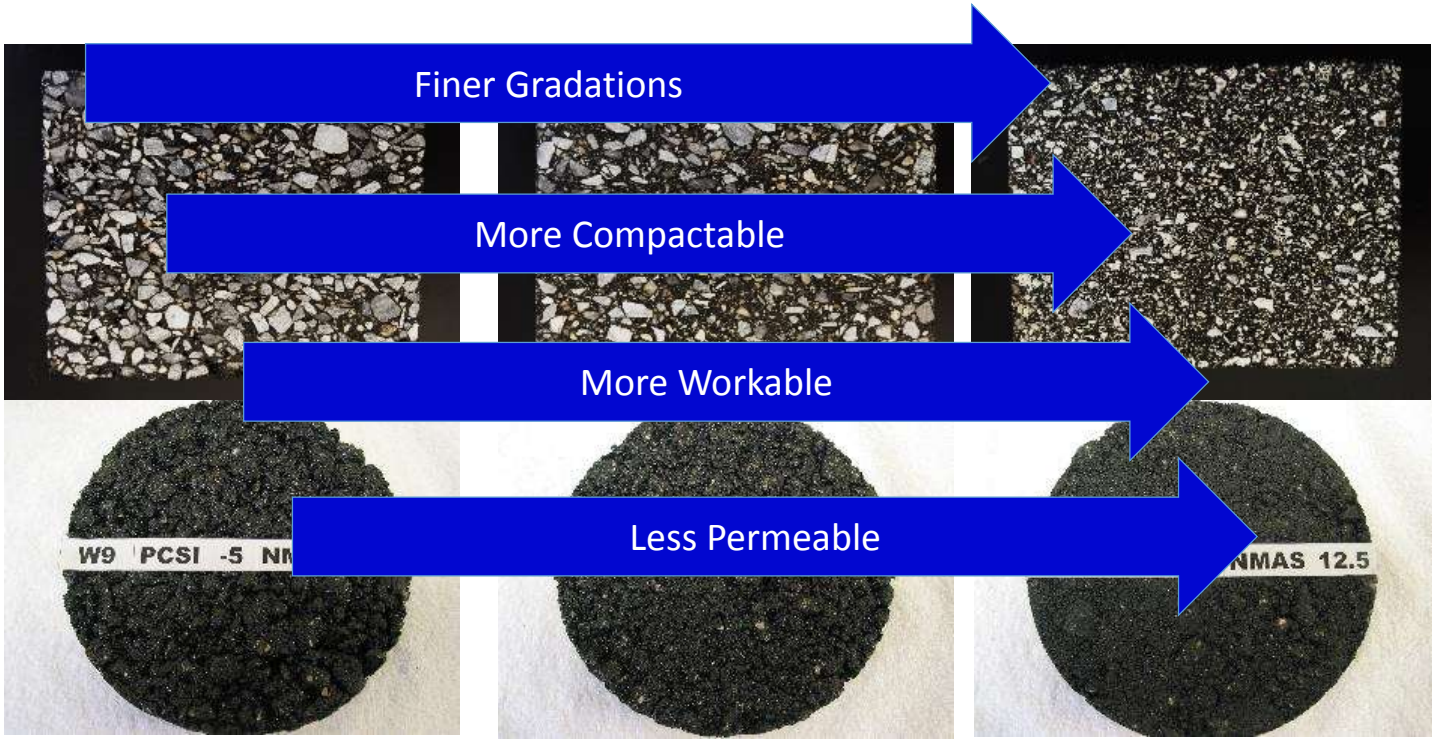
Courtesy of Nelson Gibson

Increasing Density Improved Both!

NCAT Report 16-02 (2016)

"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%**."

Choosing a Gradation



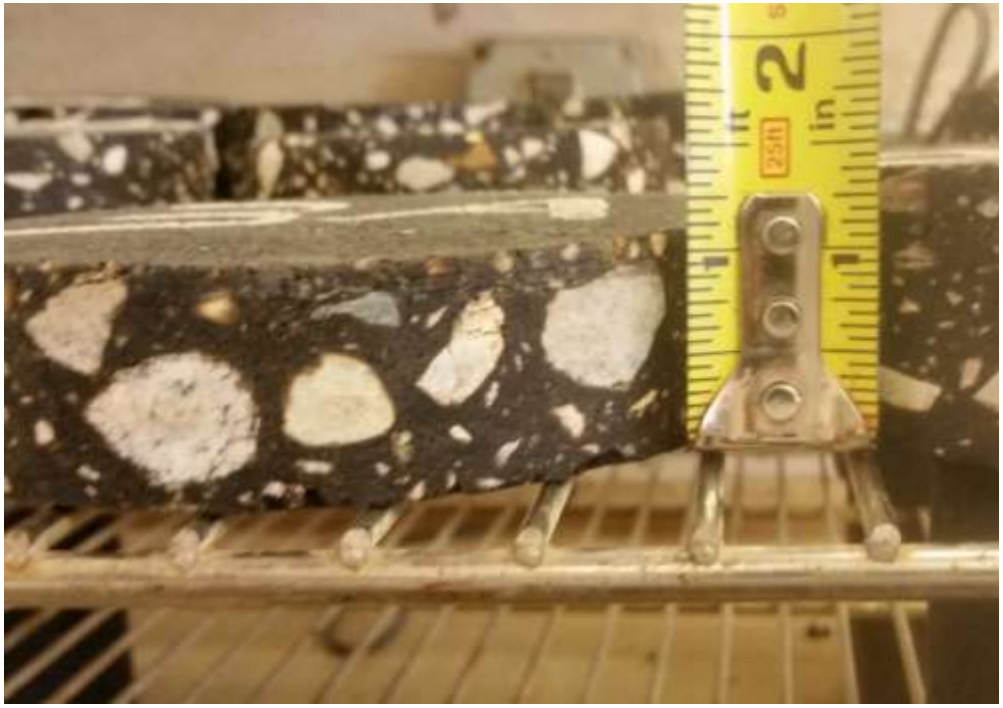
Requires better aggregate
Higher binder contents

Courtesy of NCAT

Reduce Permeability

Design to a **minimum** lift thickness

- ≥ 3X NMAS on fine graded mixtures
- ≥ 4X NMAS on coarse graded mixtures



Do not neglect future pavement preservation

Balance the Mix Design

Smooth Quiet Ride
Skid Resistance

Strength/
Stability

Rut Resistance

Shoving

Flushing
Resistant

Durability

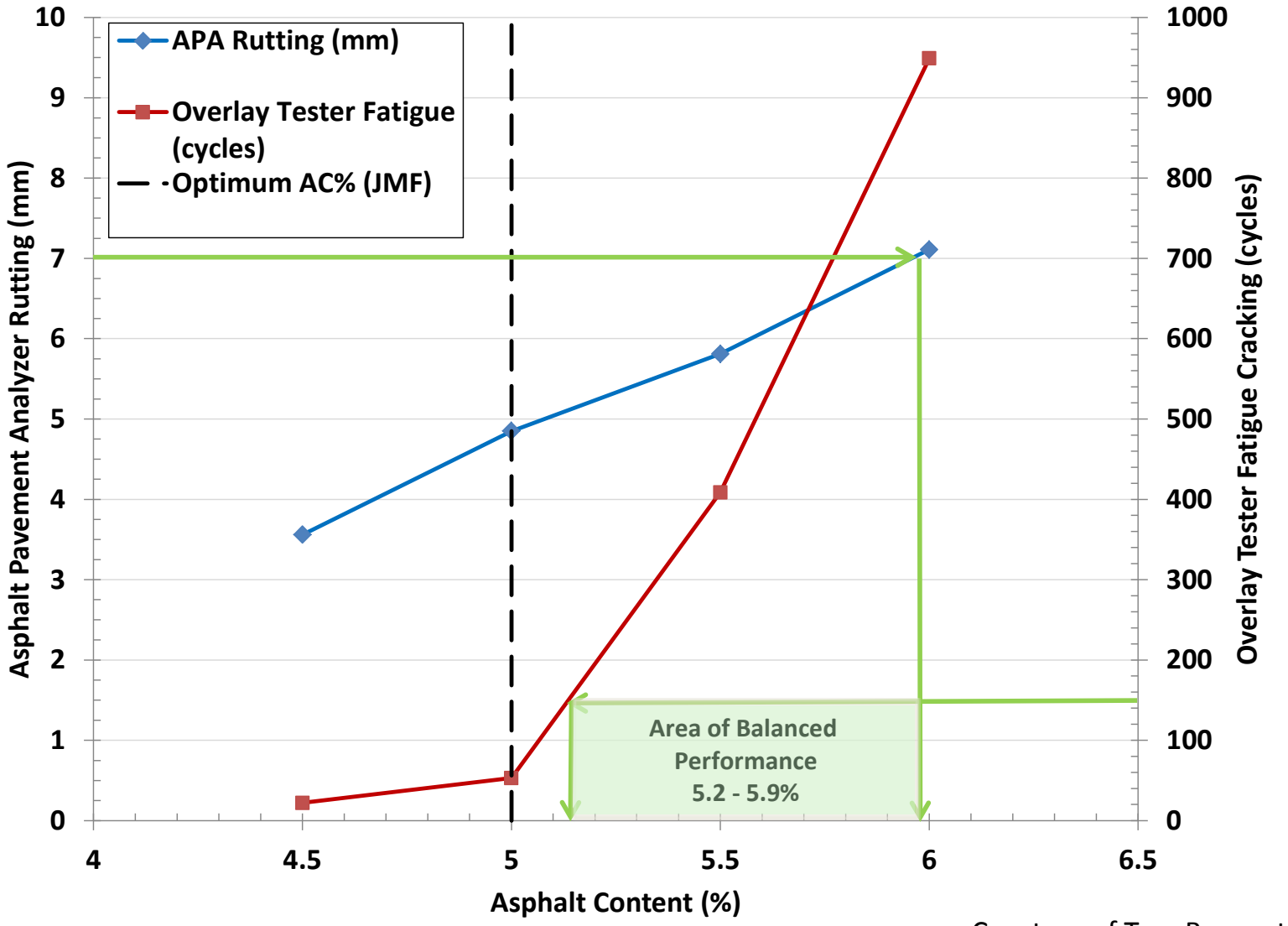
Crack
Resistance

Raveling

Permeability

DON'T ATTACK ONE HALF AT THE EXPENSE OF THE OTHER HALF!!

Future Balanced Design Concept



Courtesy of Tom Bennert

Superpave 5 – Purdue Research

- Design at 5% air voids and compact to 5% voids in field (95% G_{mm})
- Lower design gyration to increase in-place density
  - No change in rutting resistance
  - No change in stiffness
  - Improve pavement life
    - Reduced aging
- Maintained Volume of Eff. Binder (V_{be})
  - Increased VMA by 1%

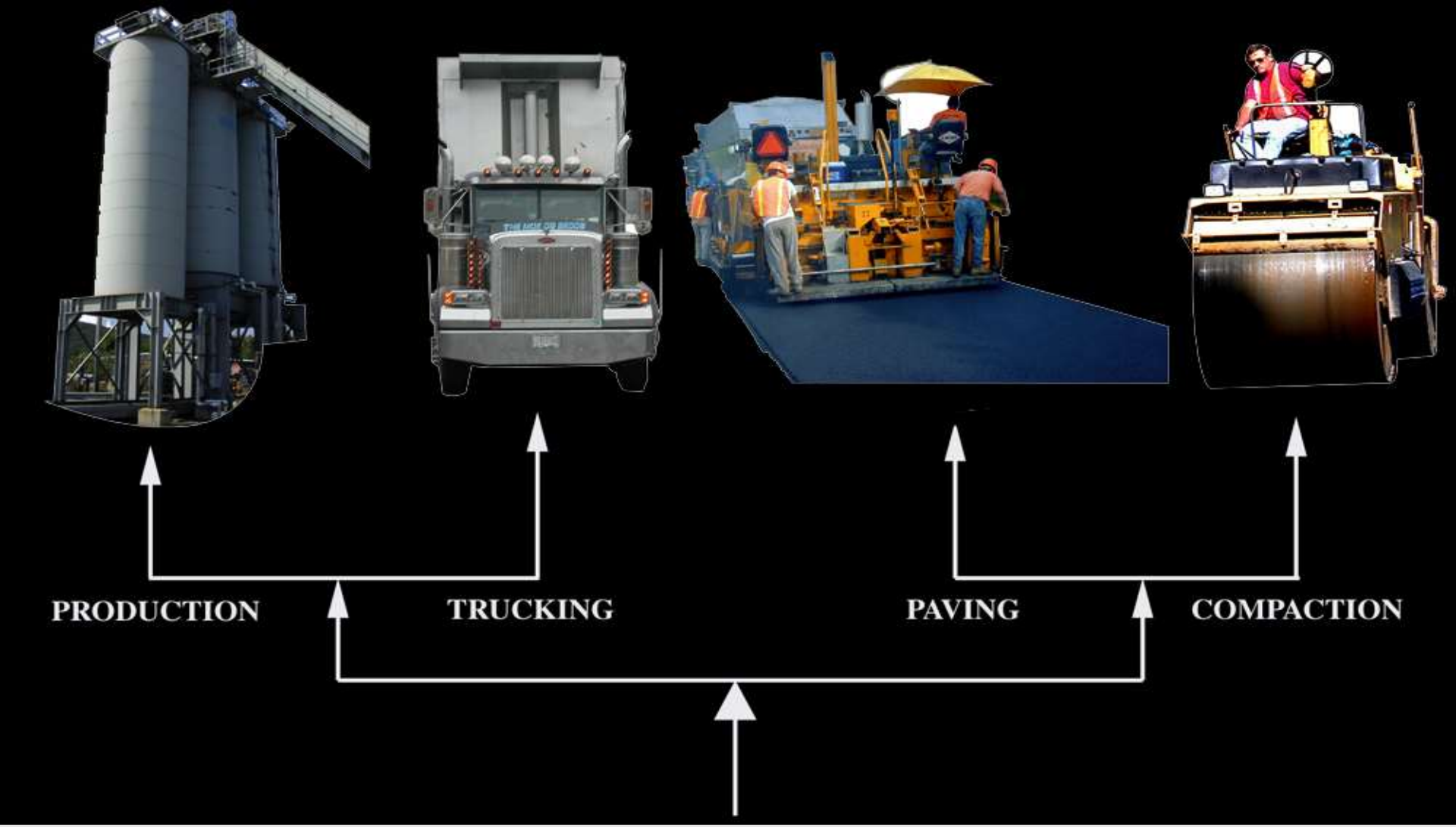
Courtesy of Gerald Huber

Lab Screening

- Flow Number (rutting evaluation)
  - N100/4/7 840 cycles
  - N30/5/5 1180 cycles ↑
- Stiffness
  - N100/4/7 2,072 MPa
  - N30/5/5 2,645 Mpa ↑

Note: gradations had to be altered to maintain Effective Asphalt Contents

Courtesy of Gerald Huber



Balancing the Paving Operation

Use Best Construction Practices

Uniform Paving Train Operation

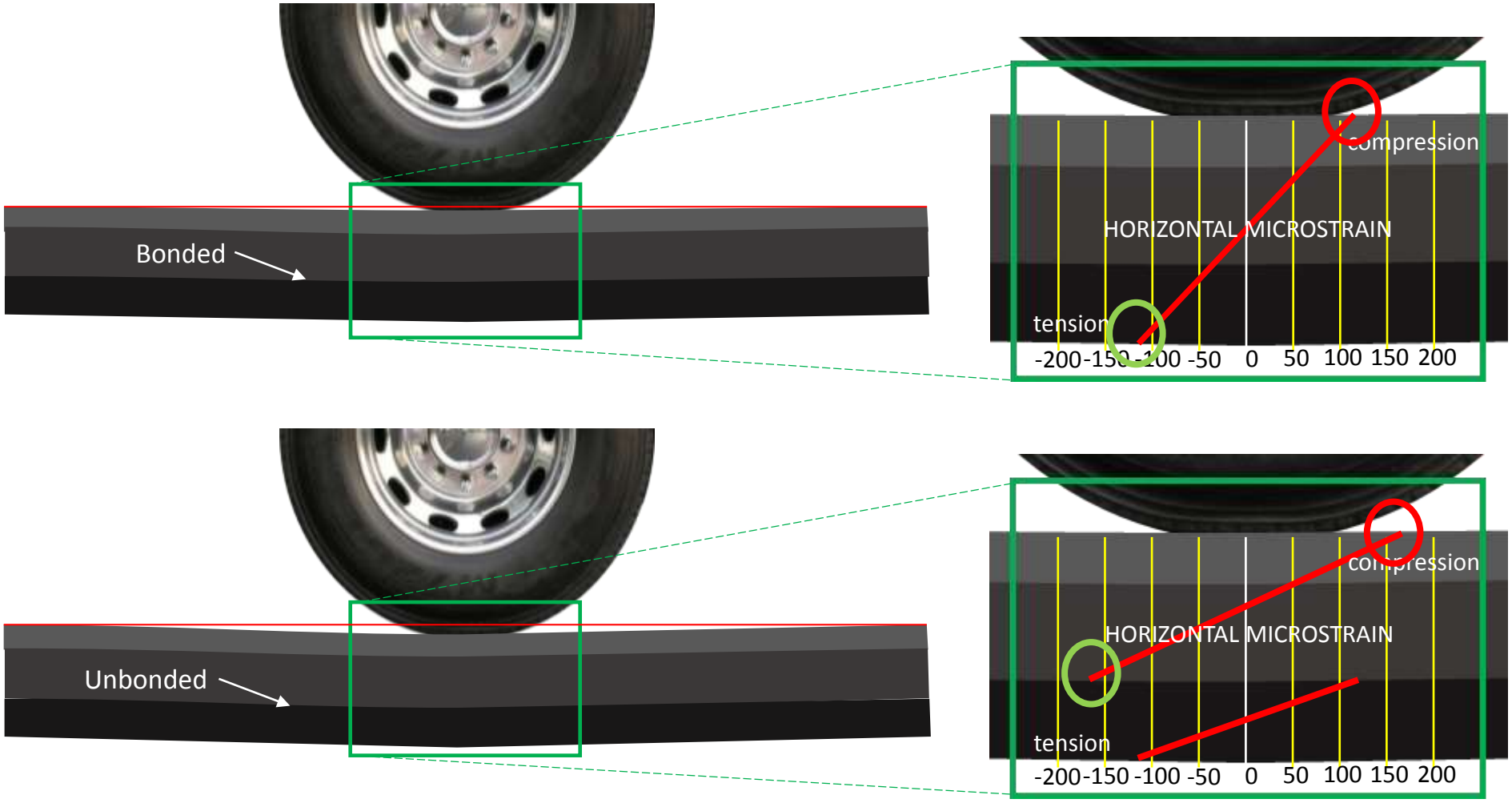
- Determine plant production rate
- Plan for sufficient, timed mix delivery
- Establish a constant paver speed
- Assure ample rollers are available
  - Keep water trucks up to the rollers

Successful Tack Coat

The Ultimate Goal:

Uniform, complete, and adequate coverage

Consequences of Debonding



Courtesy of NCAT

Proper Tack Coat Application

- Specify and monitor adequate tack coat application
  - Allow the use of alternate materials
    - Low Tracking tack
    - Modified materials
    - Paving grade binders

A well compacted pavement section will not perform if it is not properly bonded!!

Successful Longitudinal Joints

asphalt institute

Notched Wedge

Butt

PA: How Did it Work?

In-place Density Summary, Reported by PA DOT

Year	# Lots	Avg. Roadway Density, %TMD	Avg. Joint Density, %TMD	
2007	18	93.9	**87.8**	begin measuring at Jt.
2008	43	94.1	**88.9**	method spec
2009	29	94.1	**89.2**	method spec
2010	No data, transition to PWL spec			
2011	137	94.1	**91.0**	PWL, LSL 89%
2012	162	94.0	**91.6**	PWL, LSL 89%
2013	167	93.9	**91.4**	PWL, LSL 89%
2014	316	94.1	**92.3**	PWL, LSL 90%
2015	493		**92.6**	PWL, LSL 90%

PA: Annual Statewide Totals on Incentives/Disincentives for Joint Density

Year	Incentive Payments	Disincentive Payments
2011	$268K	$99K
2012	$489K	$63K
2013	$588K	$25K
2014	$1,002K	$127K

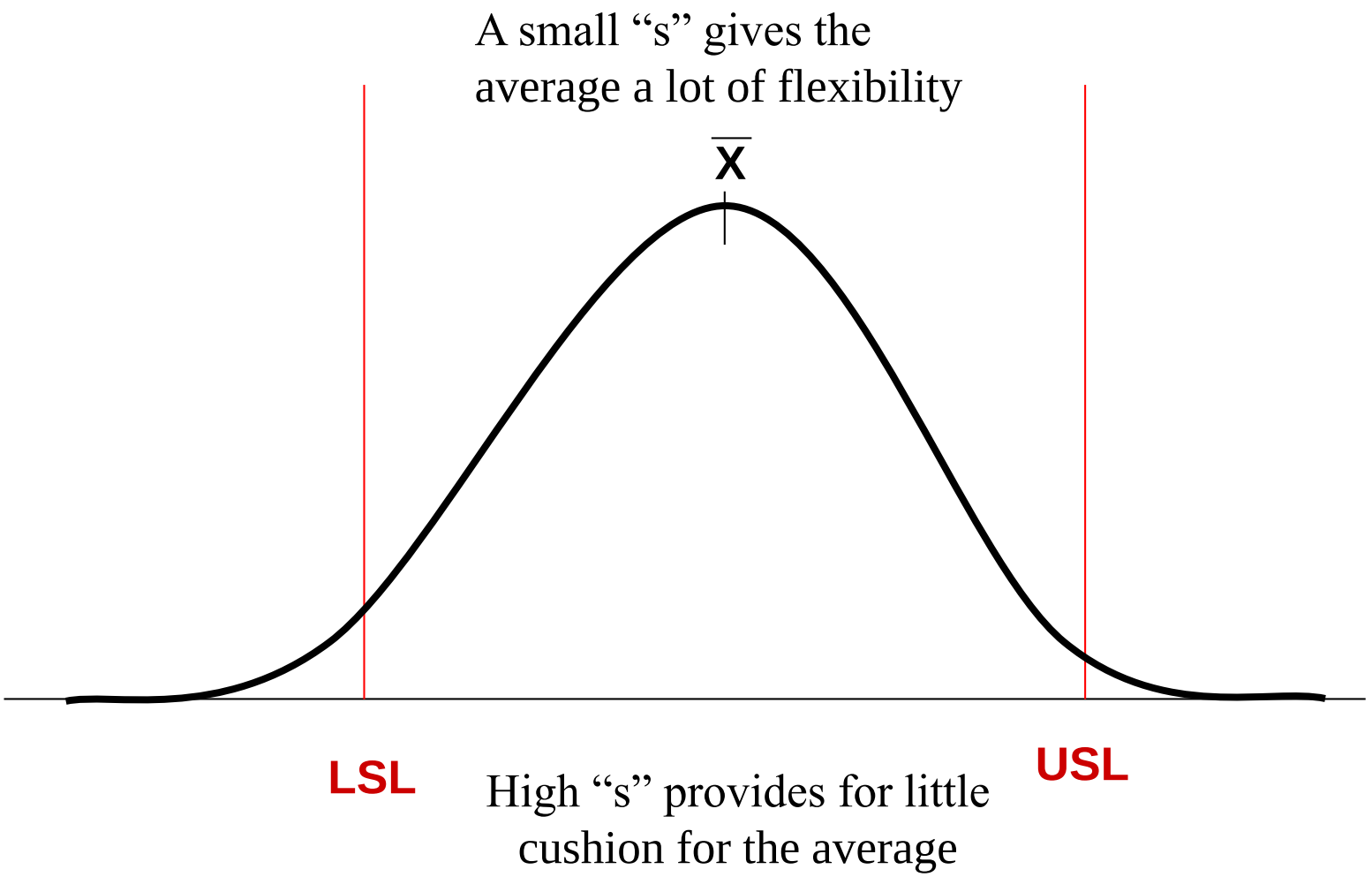
Note: MI and CT have averaged over 91.5%, and AK over 92.0% density at the joint over recent construction seasons

Improve Longitudinal Joints

Permeable Longitudinal Joints will:

- Cause safety concerns
- Necessitate premature maintenance
- Contribute to delamination
- Severely impact the life cycle performance
- Joint density no less than 2% mat density requirement

Uniformity is the key!



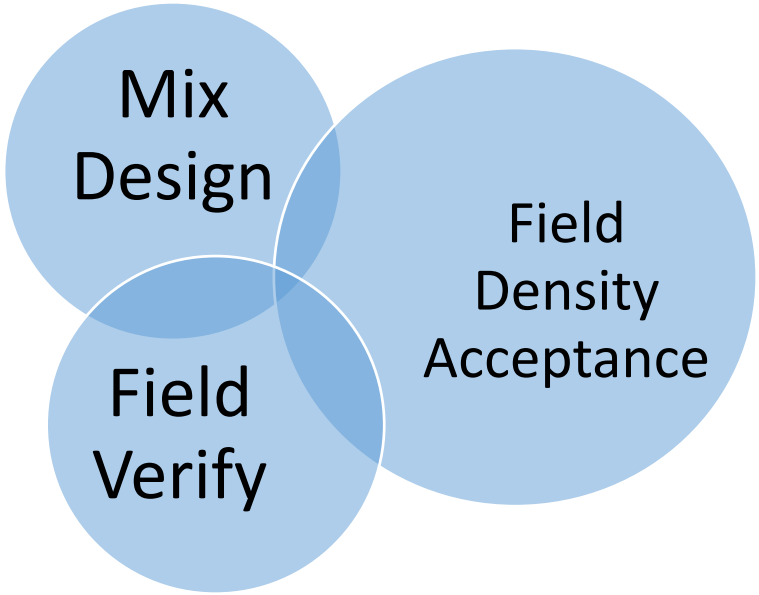
Uniformity comes from balancing plant/delivery/paver/compaction!

Premise:

- ✓ Compaction is essential for long-term pavement performance
- ✓ There are many compaction enhancements currently in use
- ✓ Compaction goals can be improved

FHWA Demonstration Project Field Project Results

- 8 of 10 projects to date
- Three Key Lessons:
  1. Follow best practices
  2. Inter-relationship between:
  3. Higher density is achievable



Processes and Technologies

- **None are Found on All of the Projects**
- Processes:
  - Altered Rolling Pattern
    - Additional Roller Passes
    - Altered Roller Spacing
    - Added Rollers to Compaction Process
  - Modified Mix Design
    - Increased Asphalt Content
- Technology
  - Intelligent Compaction
  - Ground Penetrating Radar

Preliminary Results

- Process Changes
  - Altered Roller Patterns
    - Increased Density
    - **0.3-1.9% ↑**
  - Modified Mix Design
    - Increased Density
    - **1.2% ↑**
- Technology
  - No Preliminary Results Available

Maximizing Our R.O.I.

- Infrastructure loads continue to rise
- Budget availability continues to fall
- Increased pavement life can be economically achieved
- Research conservatively shows that a 10% increase in pavement life can be achieved by increasing compaction by 1%.

What would a 3% increase in compaction do for our industry?

Specify Increased Compaction

- Shoot for 94% TMD
  - Regularly achieved on airfields throughout the country.
- Use Percent Within Limit specifications
  - A 92% LSL demands 93 – 94% compaction target
  - Use a one sided test – LSL only
  - Consider high side outlier testing
- Assure Density is achieved on the road
  - Consider Cores for acceptance
  - Require adequate gauge calibration
  - Regularly determine G_{mm} on plant produced mix
- Pay for increased compaction – 5% Bonus

Use Best Construction Practices

Promote Innovation

- Encourage / require Intelligent Compaction
- Use WMA – compaction aid
- SHRP2 – IR
- Consider alternative rollers
  - Pneumatic
  - Vibratory Pneumatic
  - Oscillatory
  - ?

Bottom Line

Increased compaction = Increased Performance

Better "Return on Investment" for the taxpayers

More Successful Pavements = More Tonnage for the HMA Industry !!!

Thank you for your time!!!