



Enhanced Durability Through Increased In-Place Pavement Density

FHWA and Asphalt Institute
Workshop
2016 - 2017

For CAPRI, March 7, 2023
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Asphalt Institute



High priority for FHWA Pavements Office in 2016

- Premise: Big improvement to performance with minimal cost/ effort by using existing technologies and best practices to achieve better compaction
- AI: develop full-day workshop and deliver to States
- NCAT: Lit Review on how in-place density relates to performance (NCAT Report 16-02)
- 10 field demo projects in 2016 (Phase 1) to improve density. 19 additional demo projects in subsequent years.
 - Randy to discuss 29 demo projects in collective sense



1. Intelligent Compaction
 2. Best Practices for Longitudinal Joints
 3. Tack Coat Best Practices
 4. Enhanced Durability Through Increased In-Place Pavement Density
- Requested, hosted, advertised by state agency
 - Instructors typically met with agency and industry reps. the day prior
 - Owners, contractors, consultants attended workshop
 - Entire team: design, QC/QA, field ops, lab techs, etc.
 - Attendance high overall (no fee)
 - Limited only by room size
 - Cost to deliver workshop thru co-op agreement

The Federal Highway Administration (FHWA) and Asphalt Institute presented an Enhanced Durability through Increased In-Place Pavement Density Workshop to ten states as shown below. This one-day workshop offered owners and contractors the opportunity to learn about the dramatic durability increases that can be realized from relatively small increases in in-place densities. This workshop provided the most current information on how to achieve consistently high densities and the resulting economic benefits.



Research has conservatively indicated that a 1% increase in density at the time of construction can result in a 10% increase in service life. Using these values, life cycle cost analysis indicates that an 8.8% savings can be expected.

Additional Information

- [Enhanced Durability through Increased In-Place Pavement Density Workshop Slides \(2017\)](#)
- [Tack Coat Information](#)
- [Longitudinal Joint Information](#)
- [NCAT Report 16-02: Enhanced Compaction to Improve Durability and Extend Pavement Service Life: A Literature Review](#)
- [Fall 2016 ASPHALT Magazine article on Durability](#)

Engineering Menu

[Overview](#)

[Asphalt Design, Construction & Maintenance](#)

[Asphalt Thickness Design Software](#)

[Frequently Asked Questions \(FAQs\)](#)

[Glossary of Terms](#)

[Roofing](#)

[Specification Databases](#)

[Sustainability](#)

[Technical Documents](#)

Topics during “High D” Workshop

- Definitions: air voids, density, compaction, durability, etc.
- Link density to pavement durability
- How mix design affects compaction and durability
- Factors affecting compaction
- Compactive forces and rollers
- Best practices for roller operations
- Getting good density at longitudinal joints
- Importance of tack coats and best practices
- Specifications, measurement, payment
- Improving compaction with technology (IC, IR-Bar, Safety Edge)

Over 350 ppt slides

A Few Select Slides from Workshop

With my additional notes (red text and in italics)

Importance of Compaction



“Compaction is the single most important factor that affects pavement performance in terms of durability, fatigue life, resistance to deformation, strength and moisture damage.” – C. S. Hughes, NCHRP Synthesis 152, *Compaction of Asphalt Pavement*, (1989)



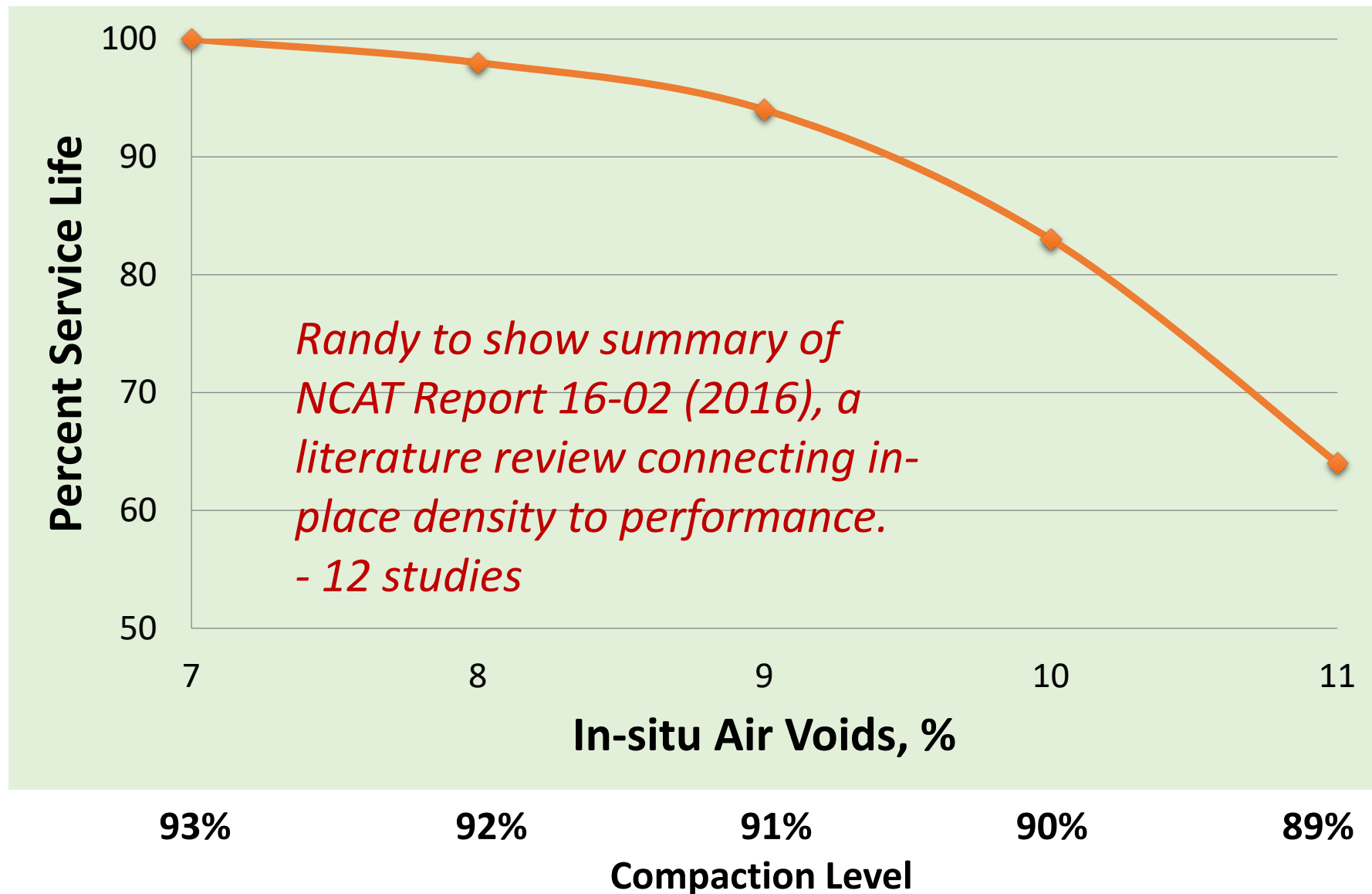
“The amount of air voids in an asphalt mixture is probably the single most important factor that affects performance throughout the life of an asphalt pavement. The voids are primarily controlled by asphalt content, compactive effort during construction, and additional compaction under traffic.” – E. R. Brown, NCAT Report No. 90-03, *Density of Asphalt Concrete—How Much is Needed?* (1990)

- Industry concerned with durability
 - Premature cracking and raveling
 - Need for more binder in the mix
- Many State agencies looking for ways to improve durability
 - Minimum binder contents
 - Optimize mix designs
 - Balanced Mix Design (balance rutting and cracking)

Improved compaction has typically not been considered

Effect of In-Place Voids on Life

Washington State DOT Study



A red water truck is driving away from the camera on a road, spraying water onto the pavement. The road surface is wet and reflective. To the left is a steep, rocky embankment. In the background, there are green trees and distant mountains under a clear sky. The text "...and then there's permeability" is overlaid at the top of the image.

...and then there's permeability

**Permeability at the
Longitudinal joint**

Photo: Wes McNett

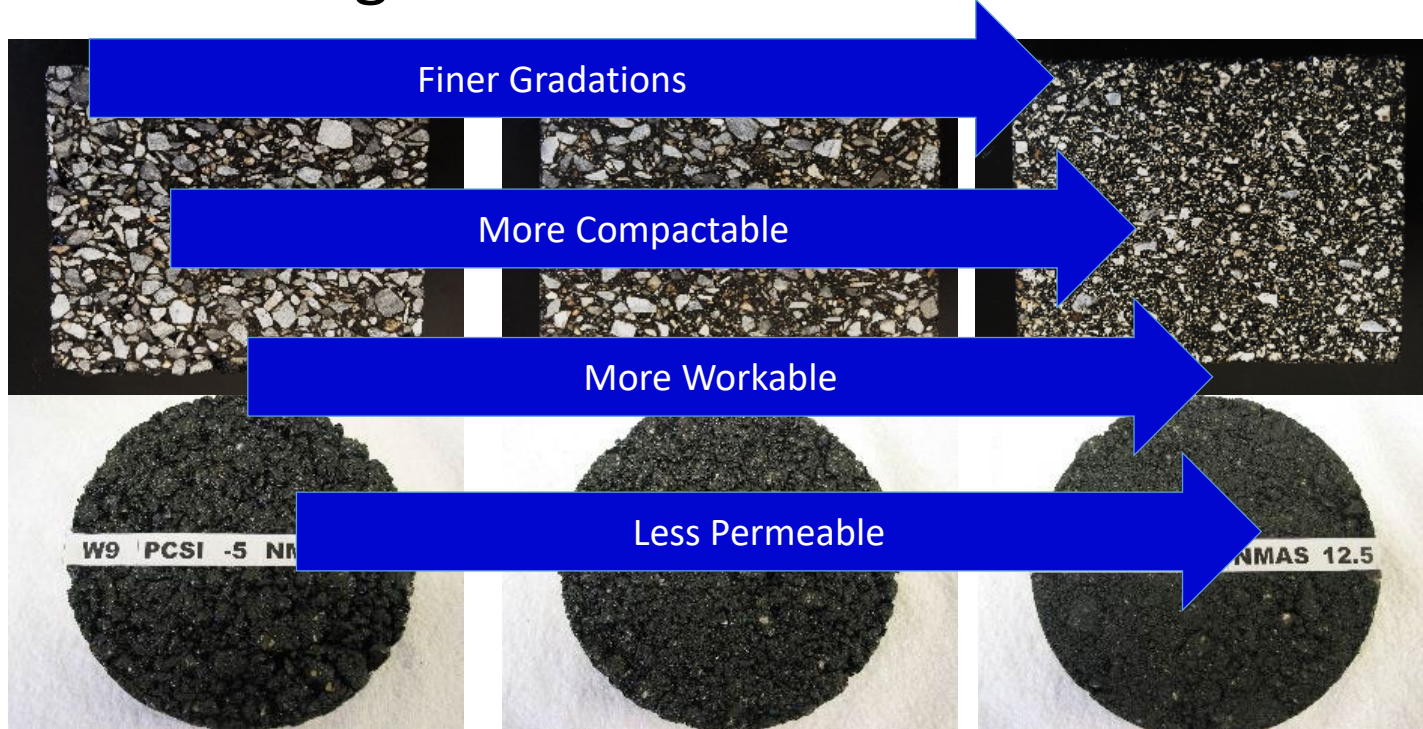


**Permeability can be
Catastrophic**



Choosing a Gradation

Requires better aggregate
Higher binder contents



*Randy to show relationship between air voids,
permeability, and NMA5 from NCAT Report 03-02*

Reduce Permeability

Design to a **minimum** lift thickness

- $\geq 3X$ NMAS on fine graded mixtures
- $\geq 4X$ NMAS on coarse graded mixtures



Do not neglect future pavement preservation

Balance the Mix Design

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

Smooth Quiet Ride, Skid Resistance



Strength/
Stability

Rut Resistance

Shoving

Flushing
Resistant

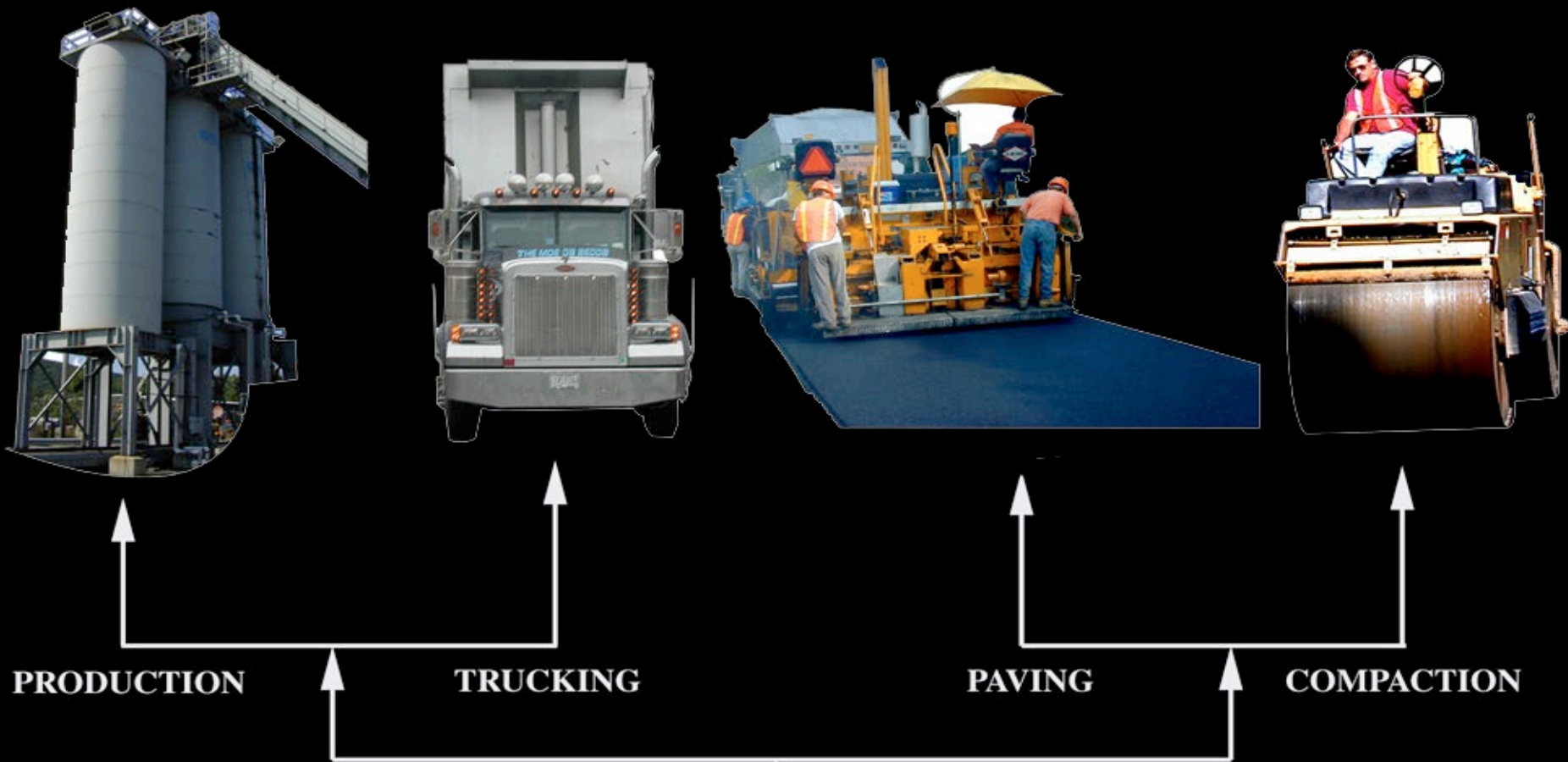
Durability

Crack
Resistance

Raveling

Permeability

High D Workshop explained concepts of BMD and Superpave 5

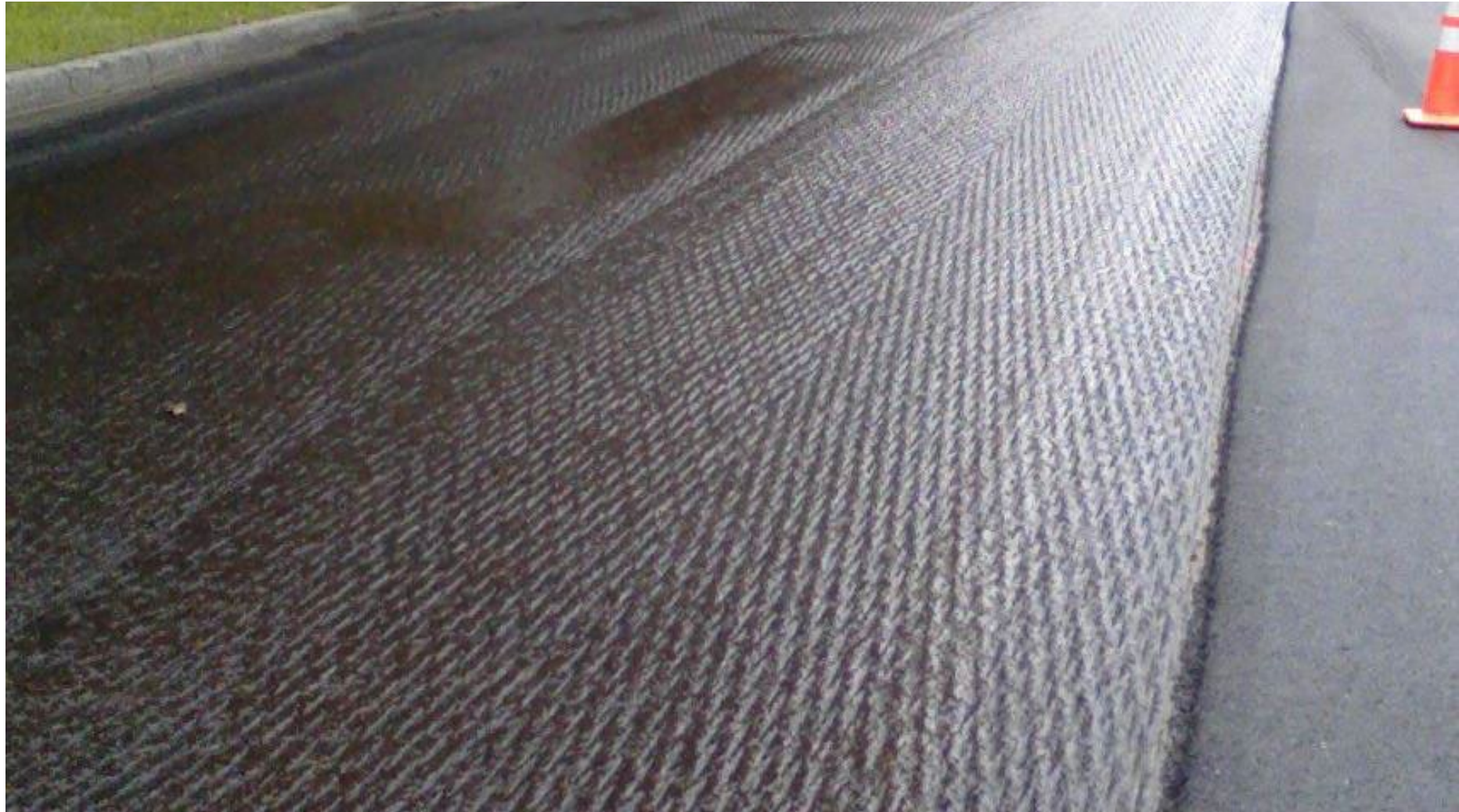


Balancing the Paving Operation

Successful Tack Coat

The Ultimate Goal:

Uniform, complete, and adequate coverage

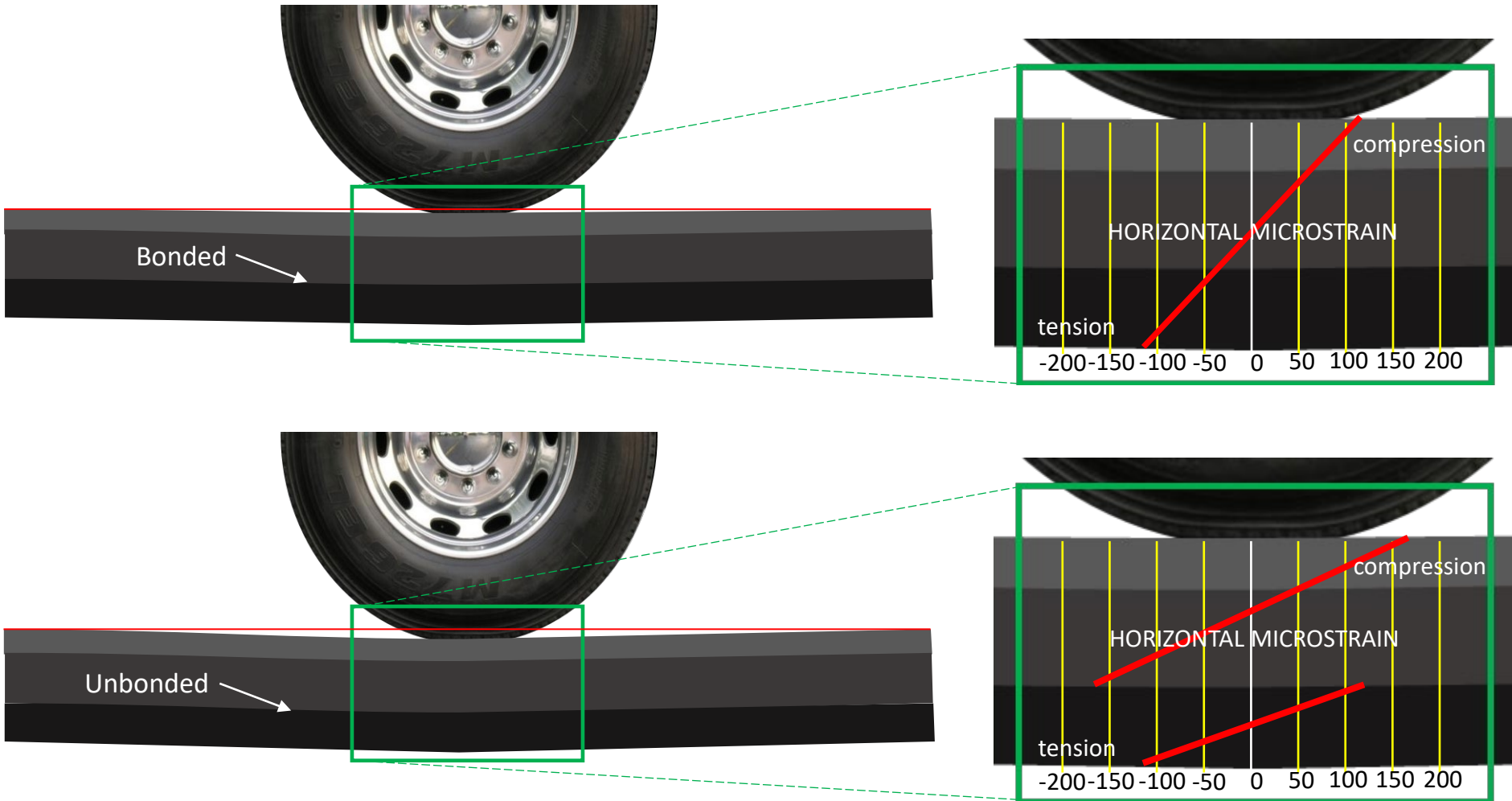




Far too frequent practices...



Increased Stress Due to Debonding



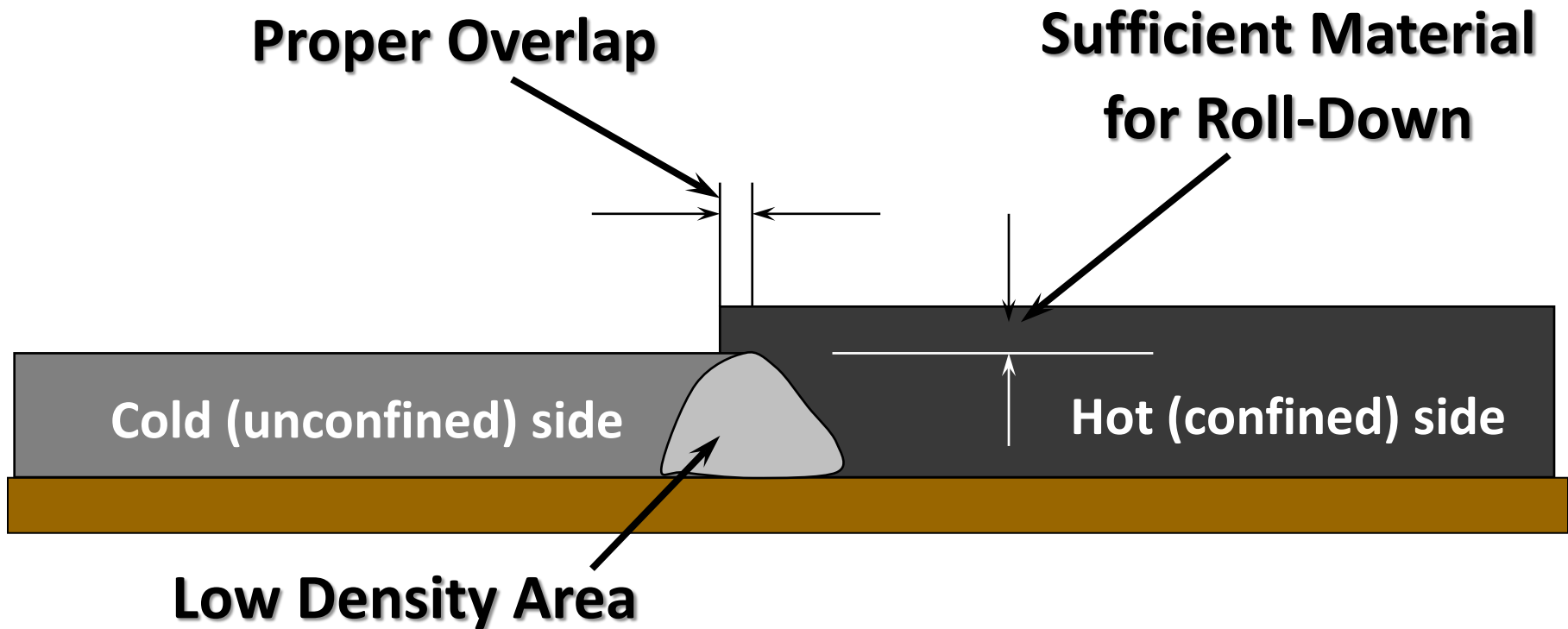
Proper Tack Coat Application

- Specify and monitor adequate tack coat application
 - Control dilution of emulsion
 - Separate pay item?
 - Alternate materials
 - Low Tracking tack
 - Modified materials
 - Paving grade binders



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

Longitudinal joints is topic for tomorrow



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

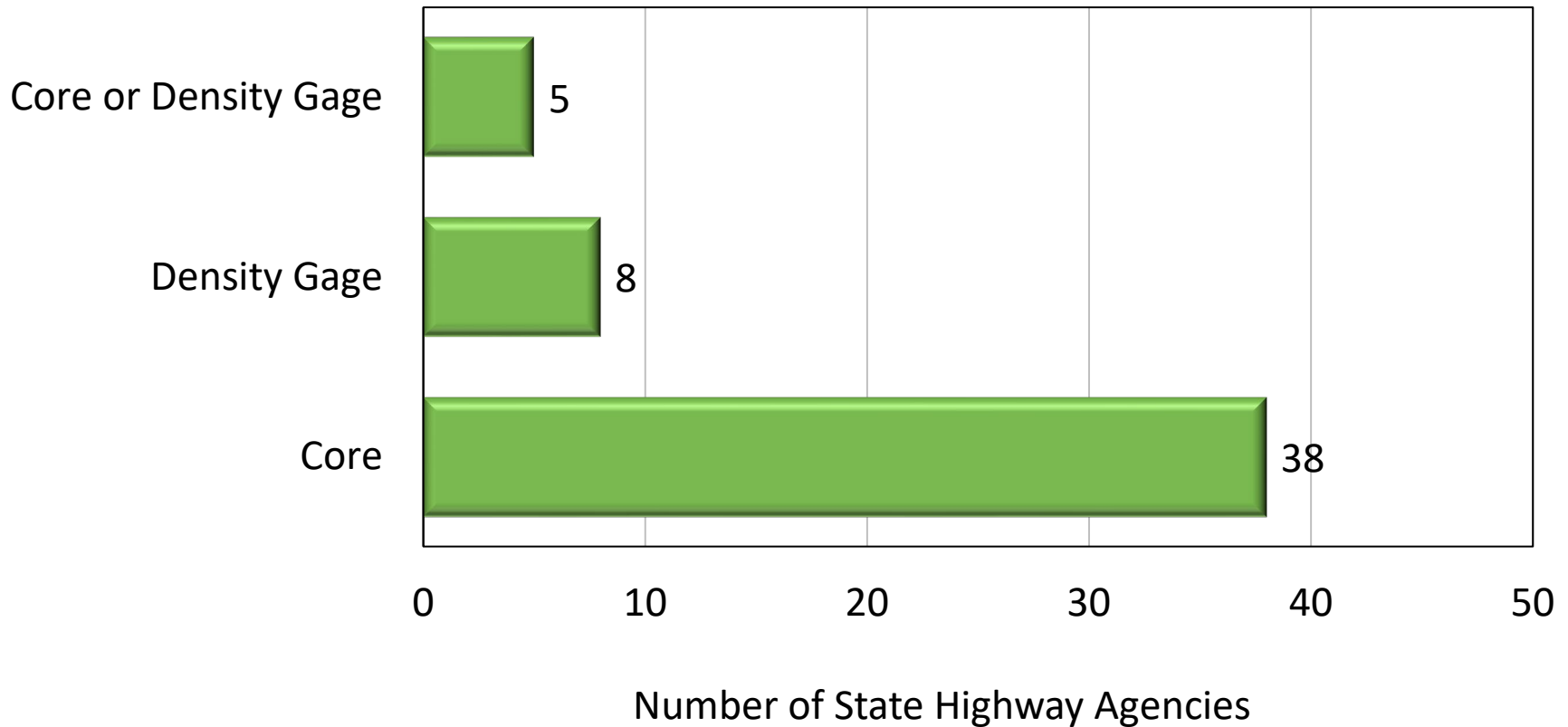
State Highway Agency (SHA) Density Specification Mining

FHWA Co-op Task 2.15 State Density Maps
2017

Percent of what?

Field Density Measurement

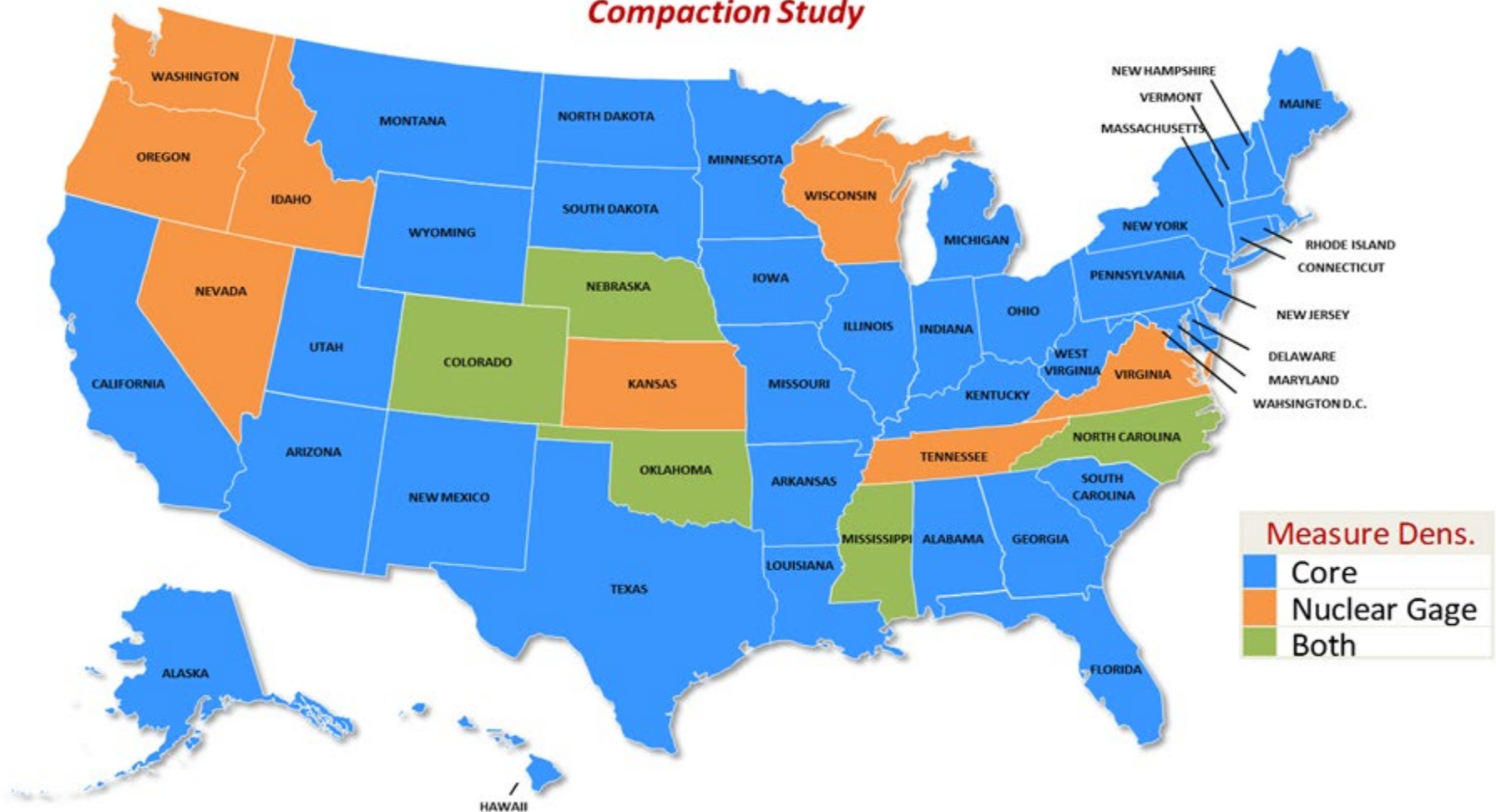
Acceptance Methods Used to Measure Density



Field Density Measurement

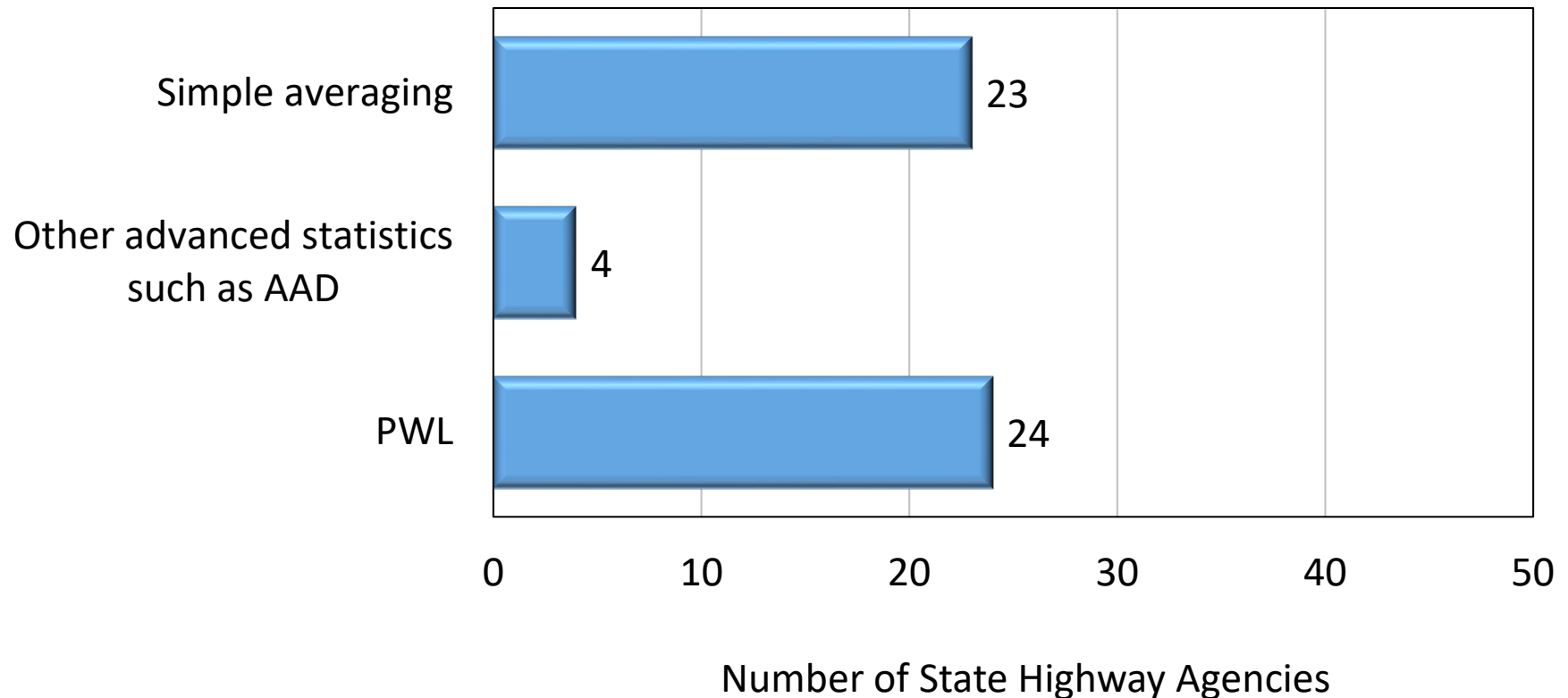
Method Used to Measure In-Place Density

Compaction Study



How Is Acceptance Determined

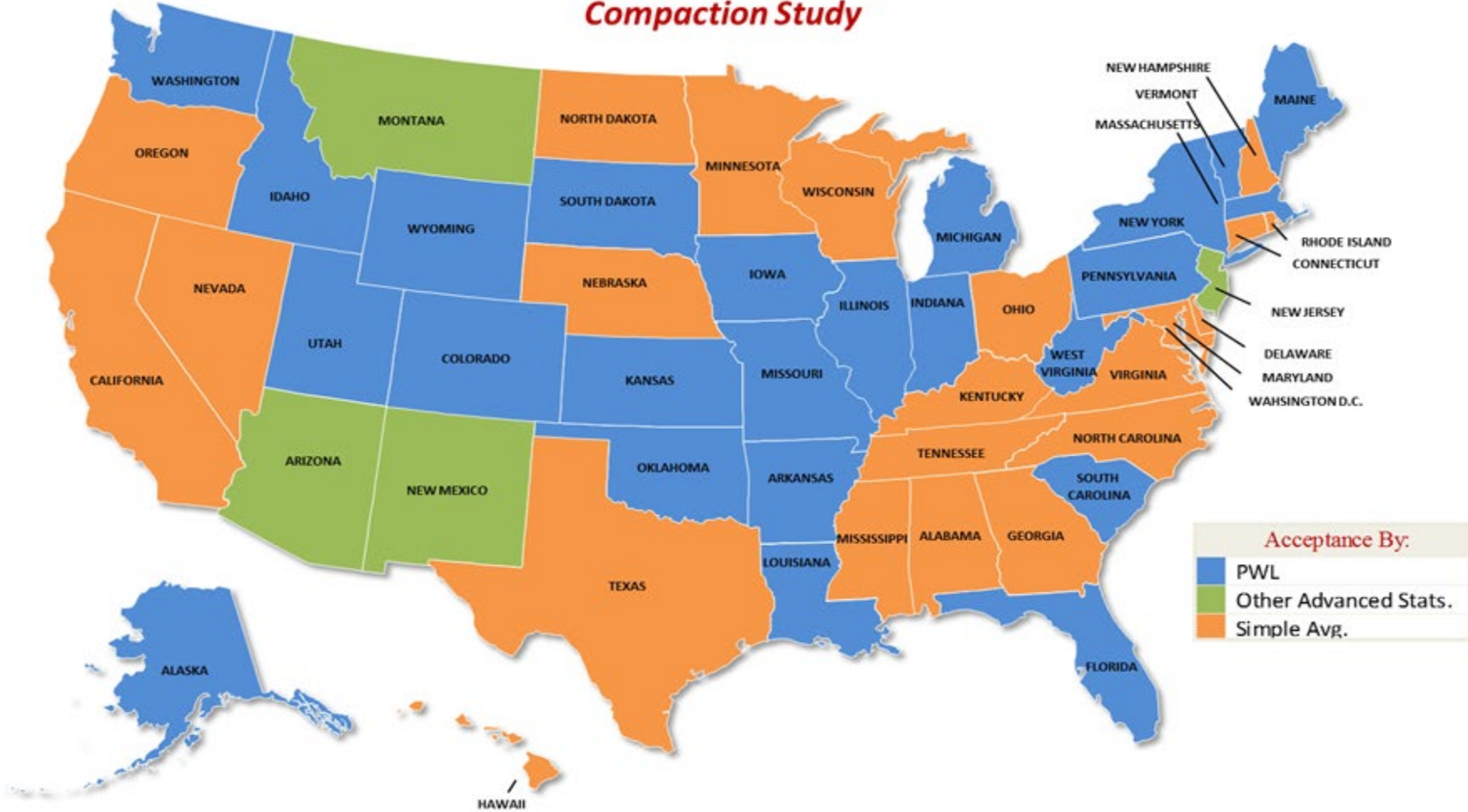
How Is Acceptance Determined?



PWL or Simple Average

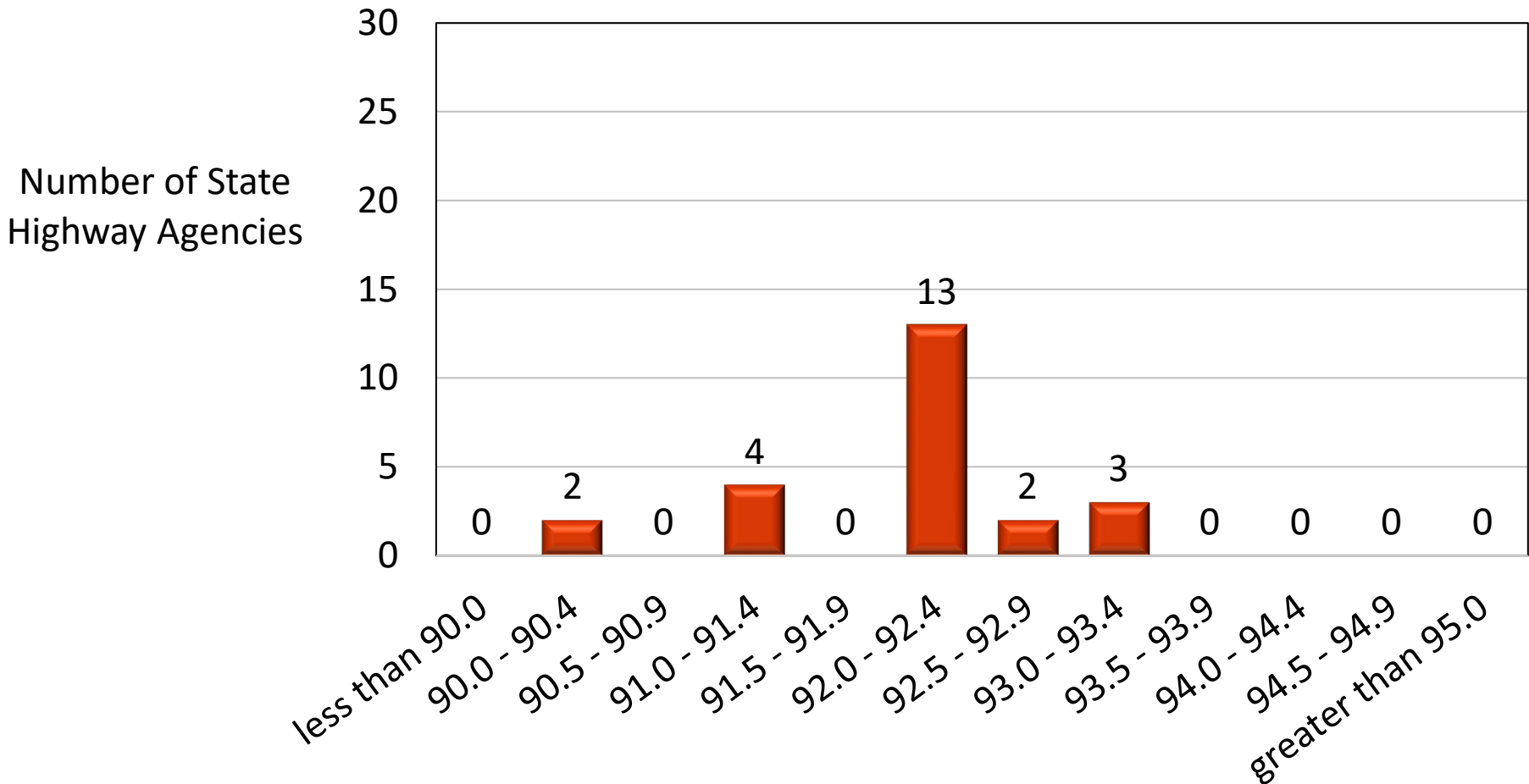
Acceptance Determination

Compaction Study



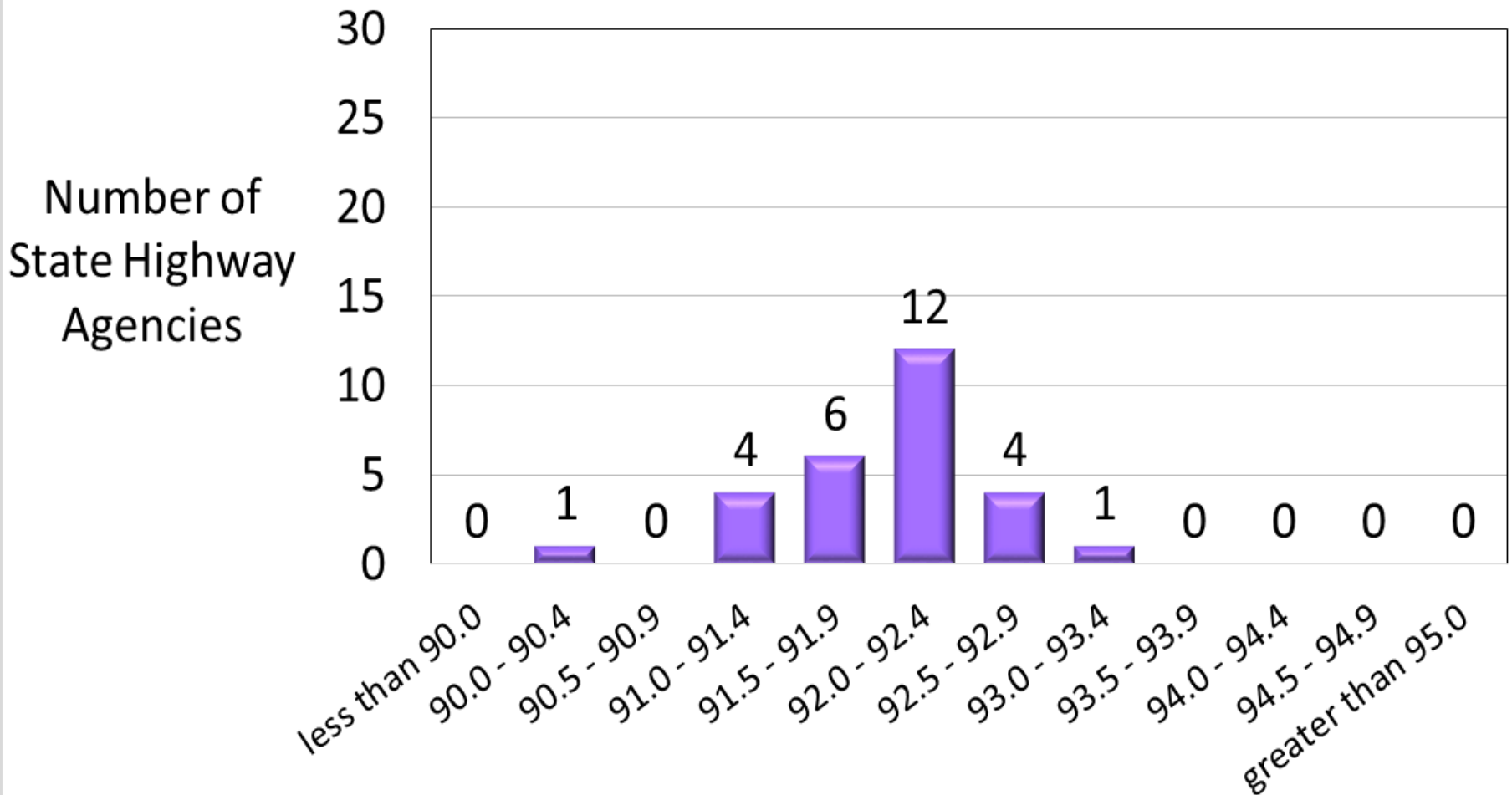
For Simple Avg. States

Lowest Specification Density for 100% Pay - Simple Average -



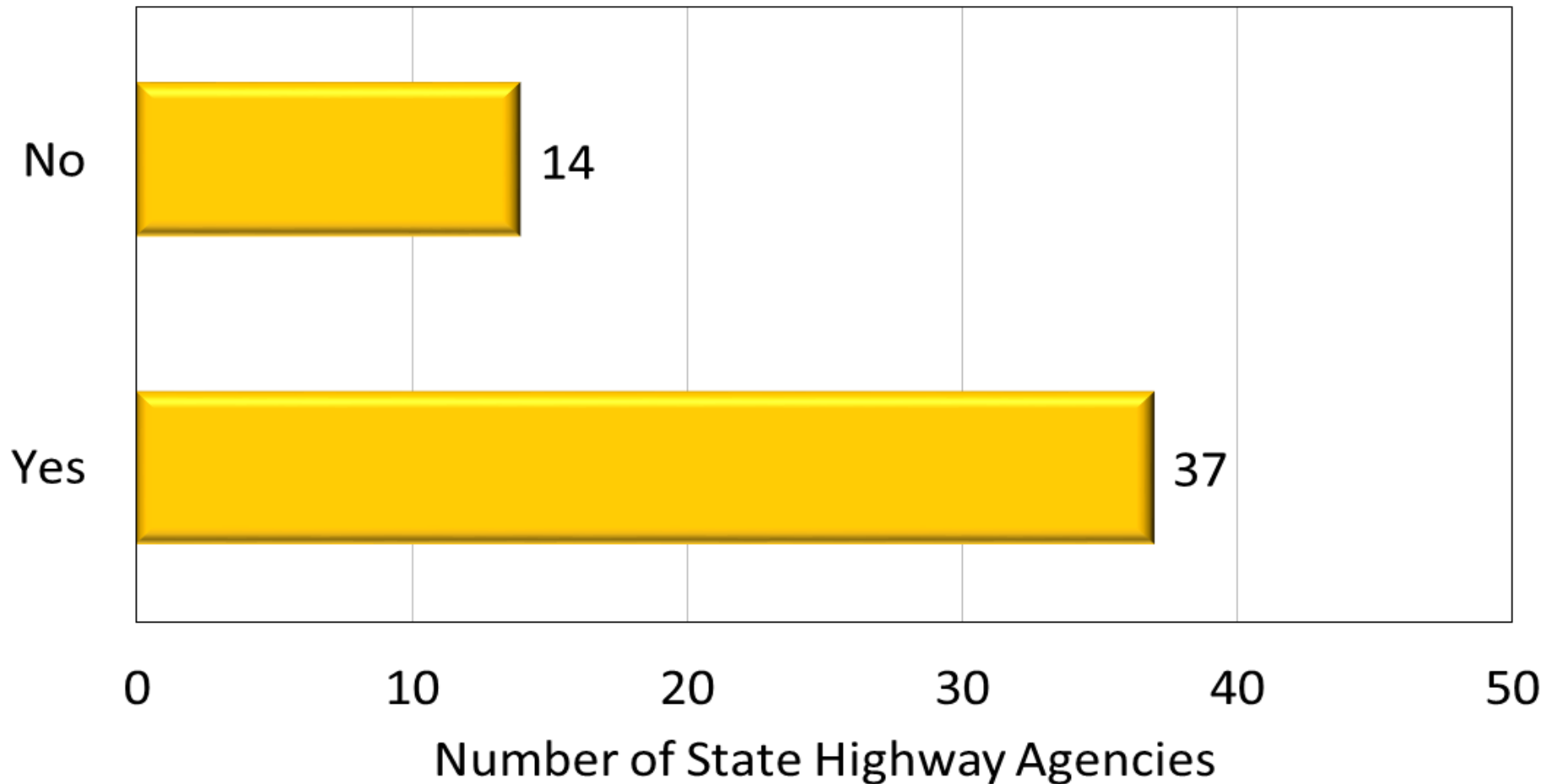
For PWL States

PWL Lower Limit for 100% Pay - PWL -



Compaction Incentive

Is There an Incentive (bonus) for Compaction?





Bottom Line:

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