State Highway Agency (SHA) Density Specification Data Mining

FHWA Co-op Task 2.15 State Density Maps

Background

Goals of data mining – how to SHA's specify mat density:

- **Methods** of measure
  - Cores, gage, roller pattern
- **Baseline** measure
  - Max. Theoretical Gravity (G_{mm}), lab bulk sample (Gmb), control strip
- **Sampling**
  - Lot/sublot size and how averaged
- **Spec type**
  - PWL, other advanced statistics, simple average
- Specification **limits**
- Is there a compaction **incentive**?

The Process

- Asphalt Institute Regional Engineers gathered information from latest SHA specifications and direct agency contacts
- Data was sent to Phil Blankenship, AI Sr. Research Engineer to compile and review
- Data was reviewed with specs as much as possible
  - Since some specs leave some interpretation, there may be some mistakes.
- What we looked at:
  - Focus was on a high-level review of specifications to gather density requirements for SHA highest level compaction standard (interstate / primary route pavements)

The Process

- Sampling size refers to sublot since it is the most frequent sampling
  - Lot sizes were captured too
- Density limits were on acceptance of samples or QA
  - How low before pay is reduced below 100%?
- Minimum density acceptance
  - Some SHA's specify a minimum or lowest density for 100% acceptance based on a simple average
  - Others referenced PLW or advanced statistics
    - If only PWL, the lower limit of the PWL was assumed to be lowest level for 100% acceptance.
    - When specifying PWL the minimum is usually about 1-1.5% about the lowest specified value.

Arizona Example

Compaction Acceptance:

The compaction **lot pay factor** shall be the compaction pay factor determined as set forth in Subsection 417-7.05(B).

Twenty paired cores taken per lot, with ten tested (Gmb) and ten saved (in case of dispute; tested by an independent lab, selected by the DOT).

Target Value (TV) for compaction is Pa = 7.0% (in-place Air Voids). **UL is 9.0%** *(or 91% of G_{mm})* and LL is 4.0%. (LL changed to 3.5%).

The Engineer will determine the Total Percent within Limits (PT) for compaction in accordance with Subsection 406-9(I) and Table 406-1 to determine the compaction pay factor.

PT Determination:

The PT is calculated by statistics; using UL and LL, to determine a **two-sided "PWL"** (see Subsection 109.11).

Pay Factors:

If PT is 100, then Contractor gets +$1.00 per ton pay factor. (this is a bonus)

If PT is 89 or less there is a sliding scale pay reduction (for compaction down to -$3.00 per ton).

If PT is less than 50, rejection per Subsection 417-9(E). [Max negative pay for compaction is $5.]

[These have changed to different dollar figures].

The Good, Bad and Ugly

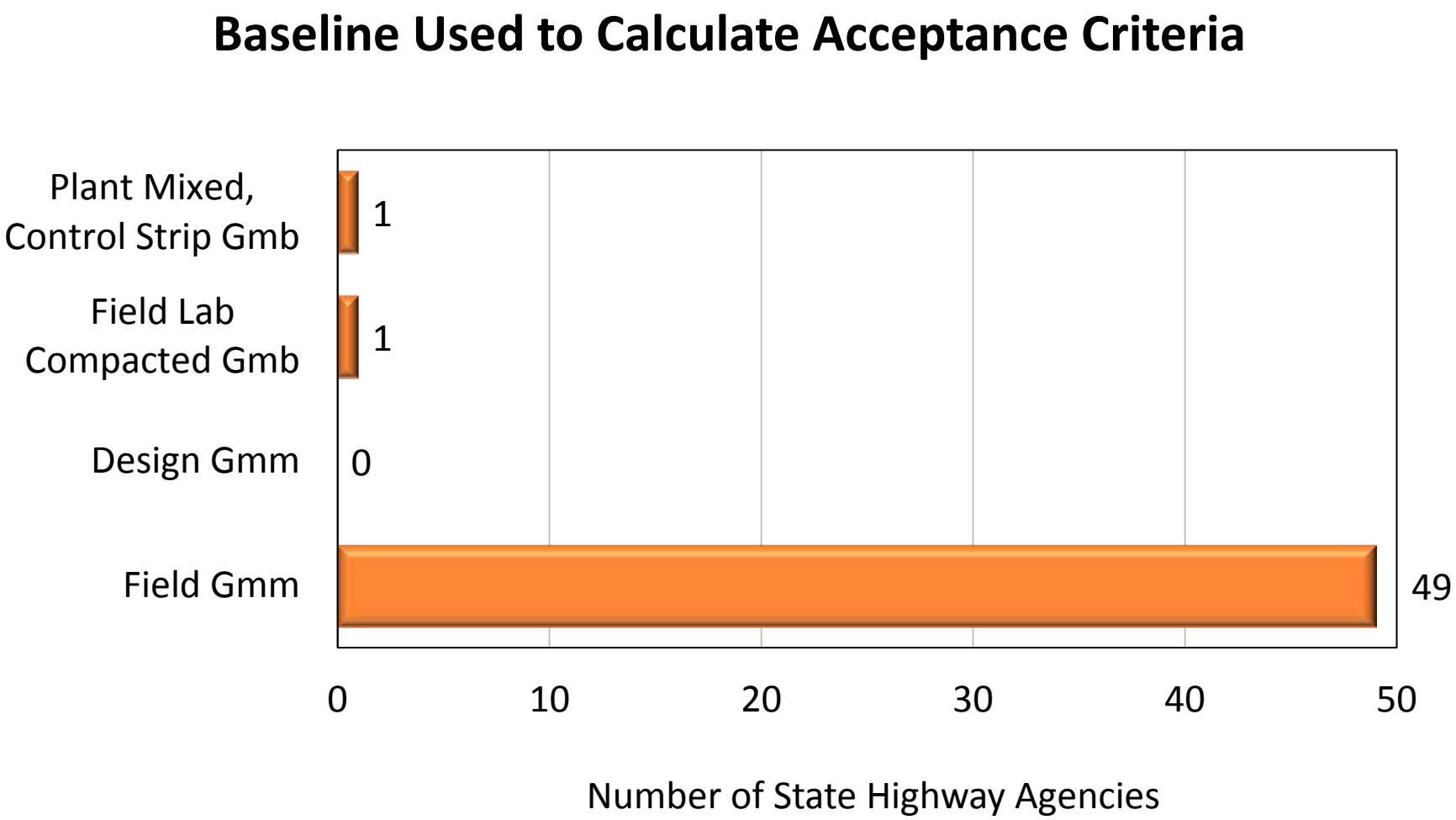
- Critical information was usually difficult to interpret or find. Seems to be known or understood locally.
  - *"**460.3.3.2 Pavement Density Determination.** The engineer will determine the target maximum density using department procedures described in CMM 8-15. The engineer will determine density as soon as practicable after compaction and before placement of subsequent layers or before opening to traffic…"*
    - The additional documents are not always easy to access. I created an account on one site and then it was going to cost to download.
  - Some specs had the critical information of Gmm, lots, density spread over many pages or books.
  - Some did not address when the Gmm is measured
    - It is probably assumed to be daily

The Good, Bad and Ugly

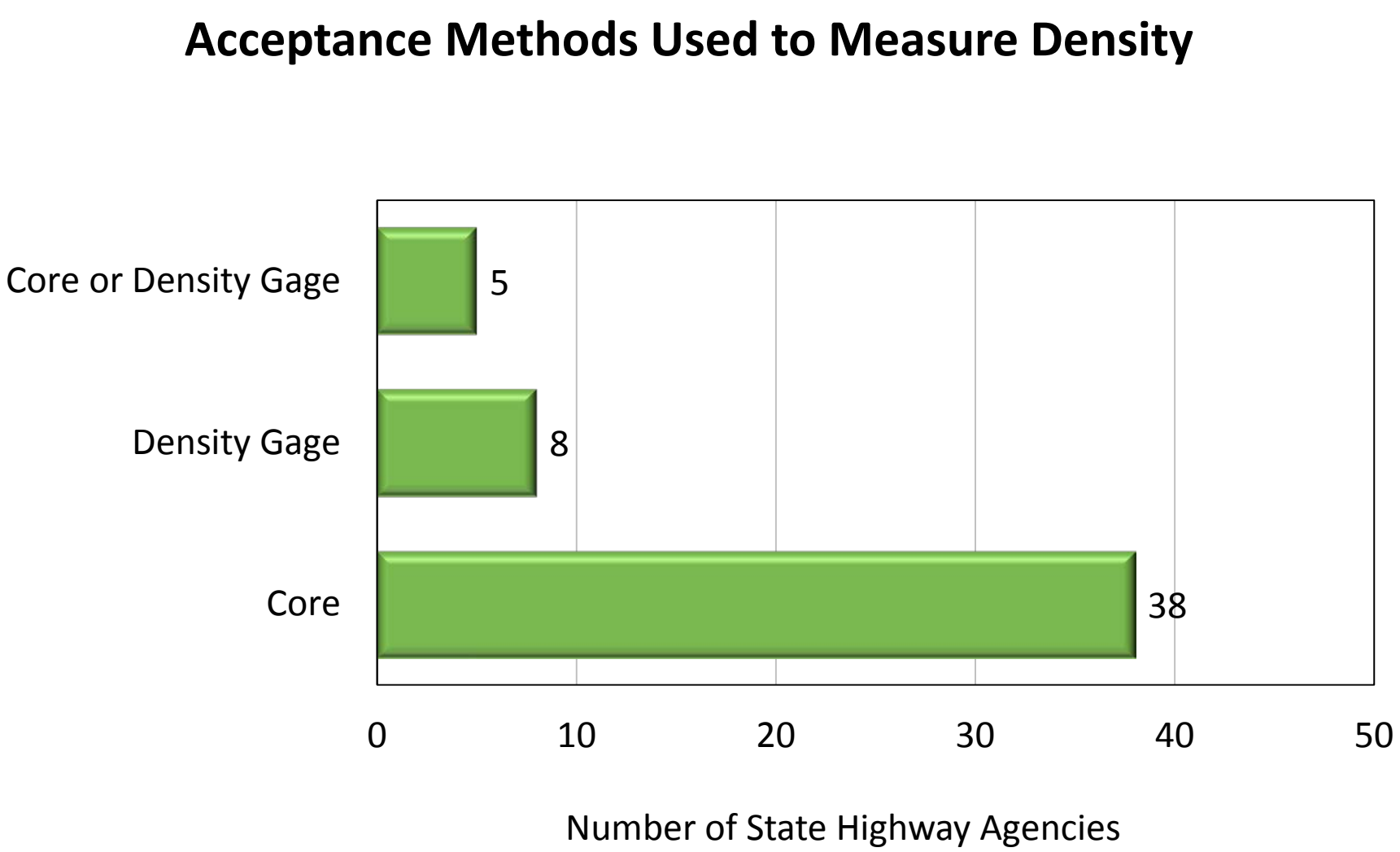
- EASY and to the POINT
  - *"Five randomly selected cores (4" min./ 6" max. diameter), from the travel lane, will be tested to determine density compliance and acceptance. One core shall be taken from each sublot. The Bulk Specific Gravity (G_{mb}) of the cores shall be determined as stated above and the average calculated. The maximum theoretical gravity (G_{mm}) from acceptance testing for that shift's production will be averaged and the percent density will be determined for compliance by dividing the G_{mb} average by the Gmm average."*
    - Most everything you need about density in one paragraph!

Travel Lane Density		
% Gmm		% Pay
Min	Max	
99.1	100	90
98.1	99	94
97.1	98	98
96.1	97	100
95.1	96	101
94.1	95	102
93.1	94	101
92.1	93	100
91.1	92	98
90.1	91	94

Baseline for Density Acceptance



Density Acceptance Methods



Density Acceptance Methods

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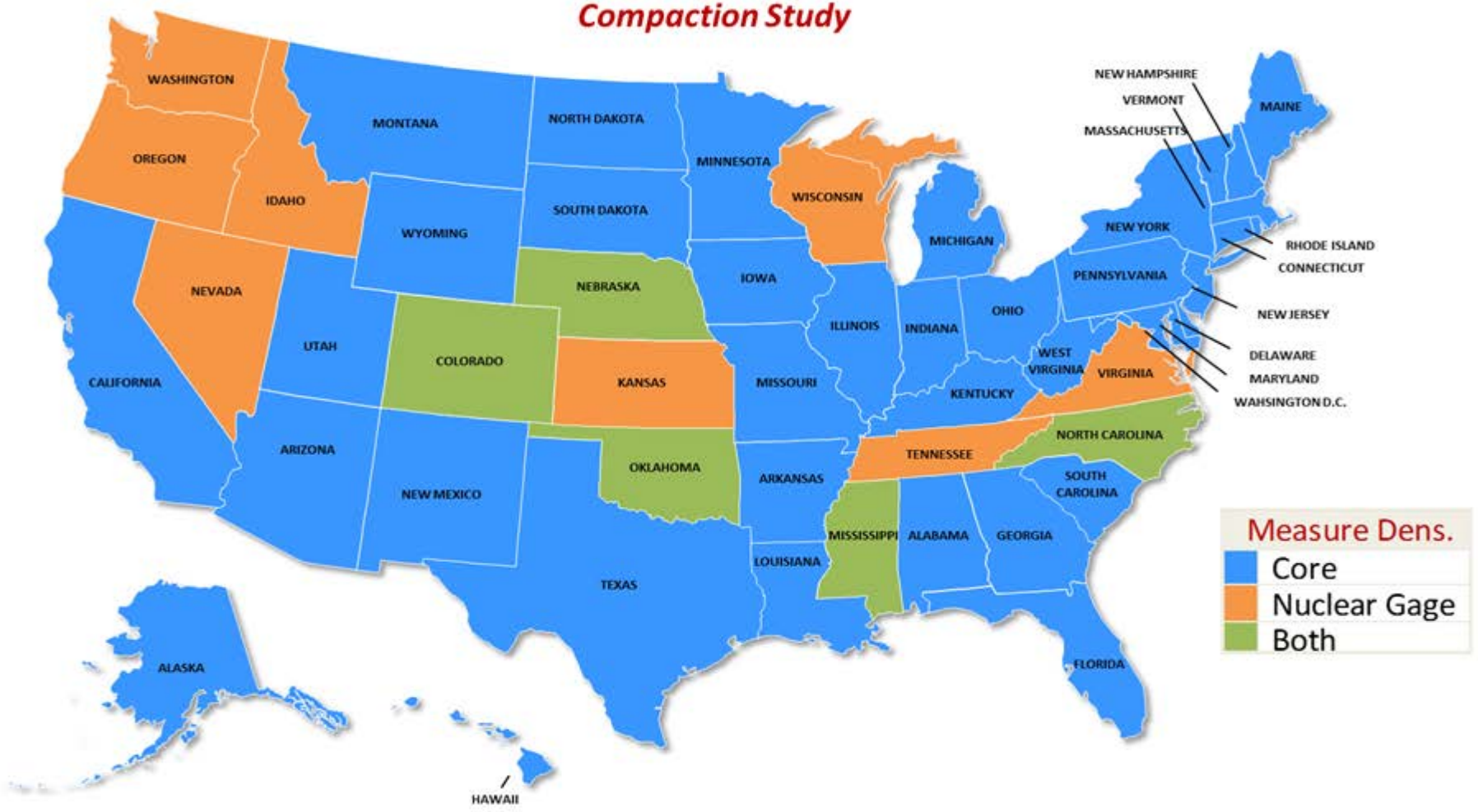
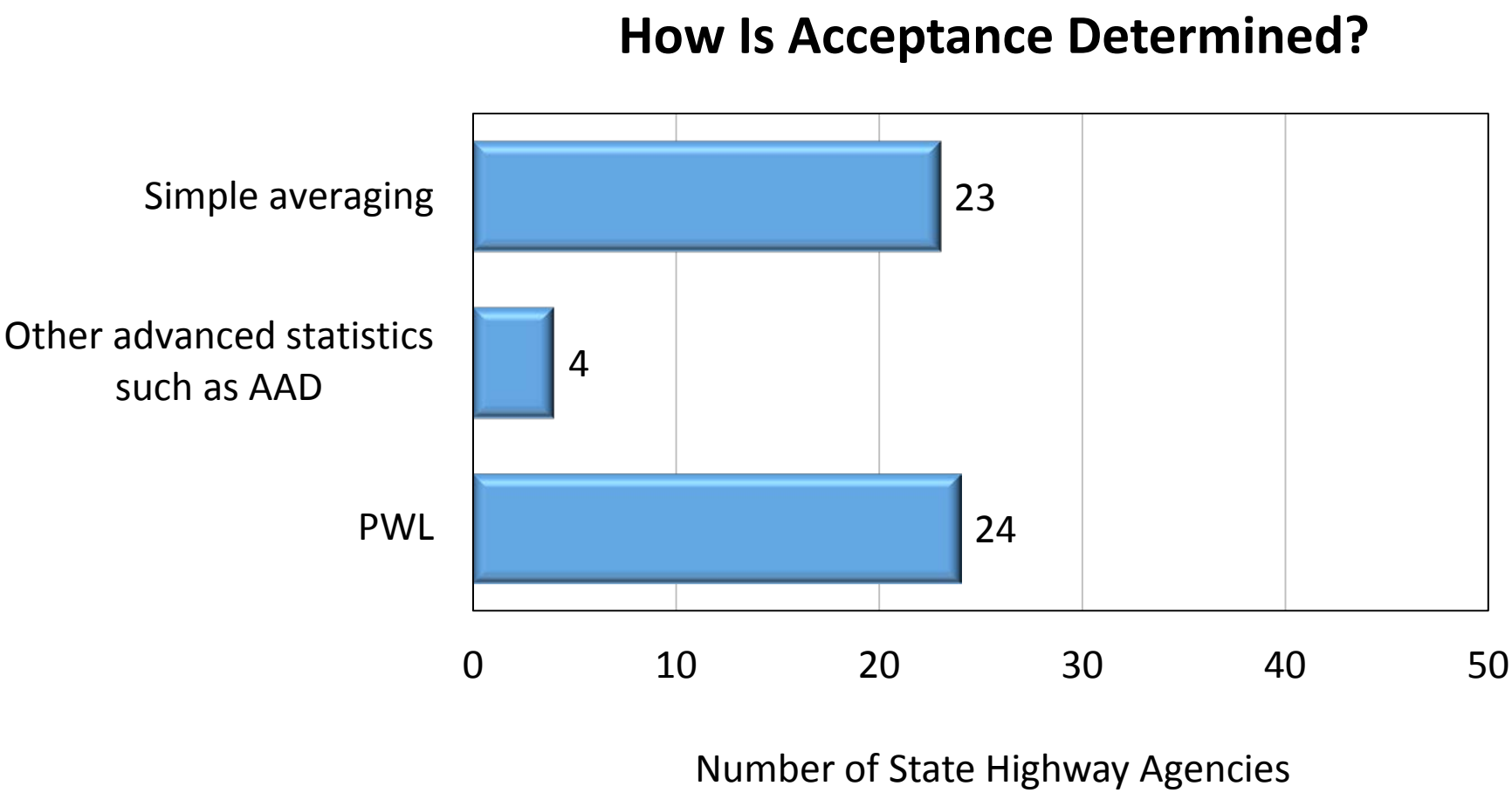
Method Used to Measure In-Place Density

Compaction Study



Data: SHA Specifications. Source: Asphalt Institute-FHWA Co-op

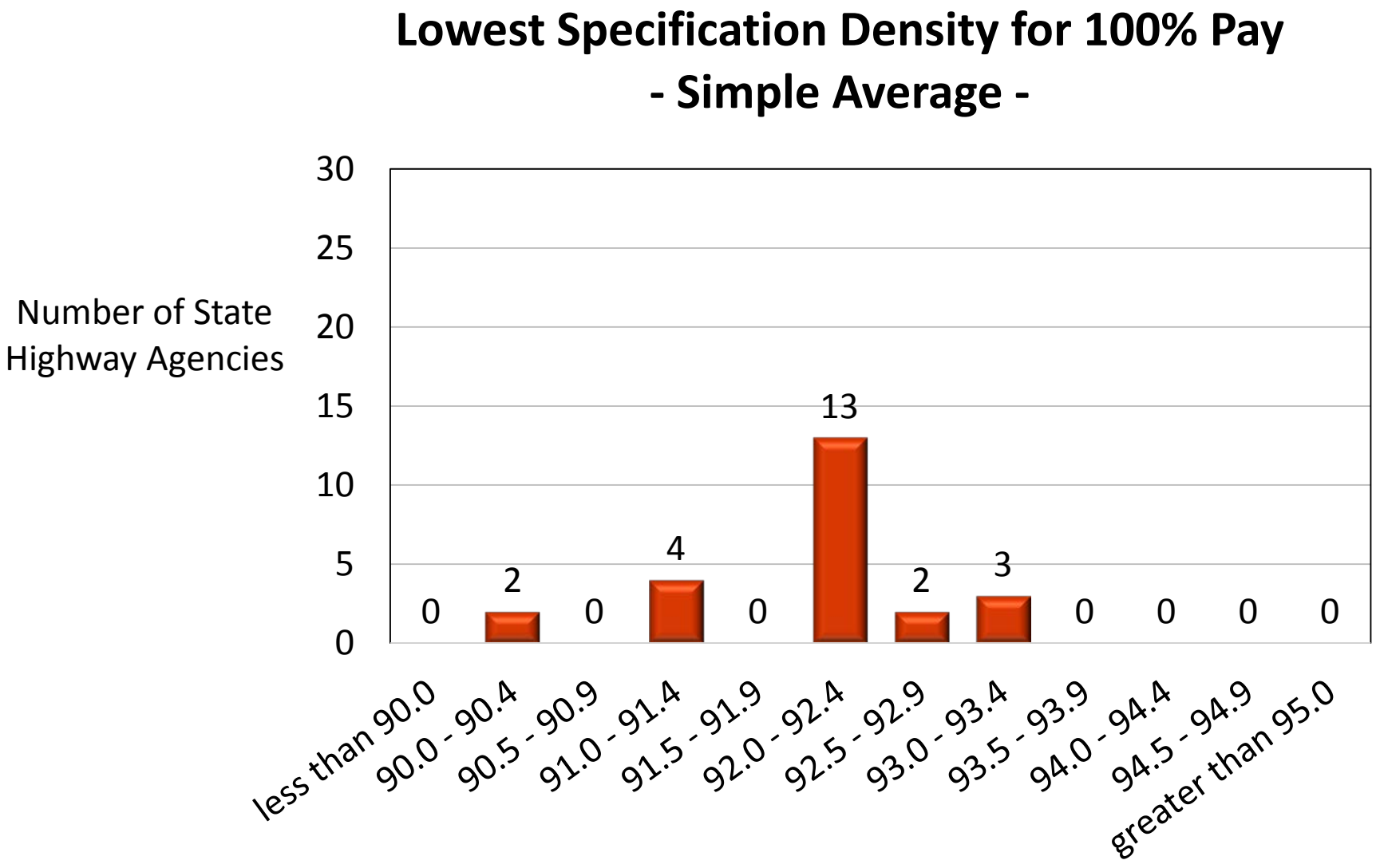
How Is Acceptance Determined



PWL or Simple Average

Data: SHA Specifications. Source: Asphalt Institute-FHWA Co-op

Lowest Specification Density
Simple Average



PWL Specs

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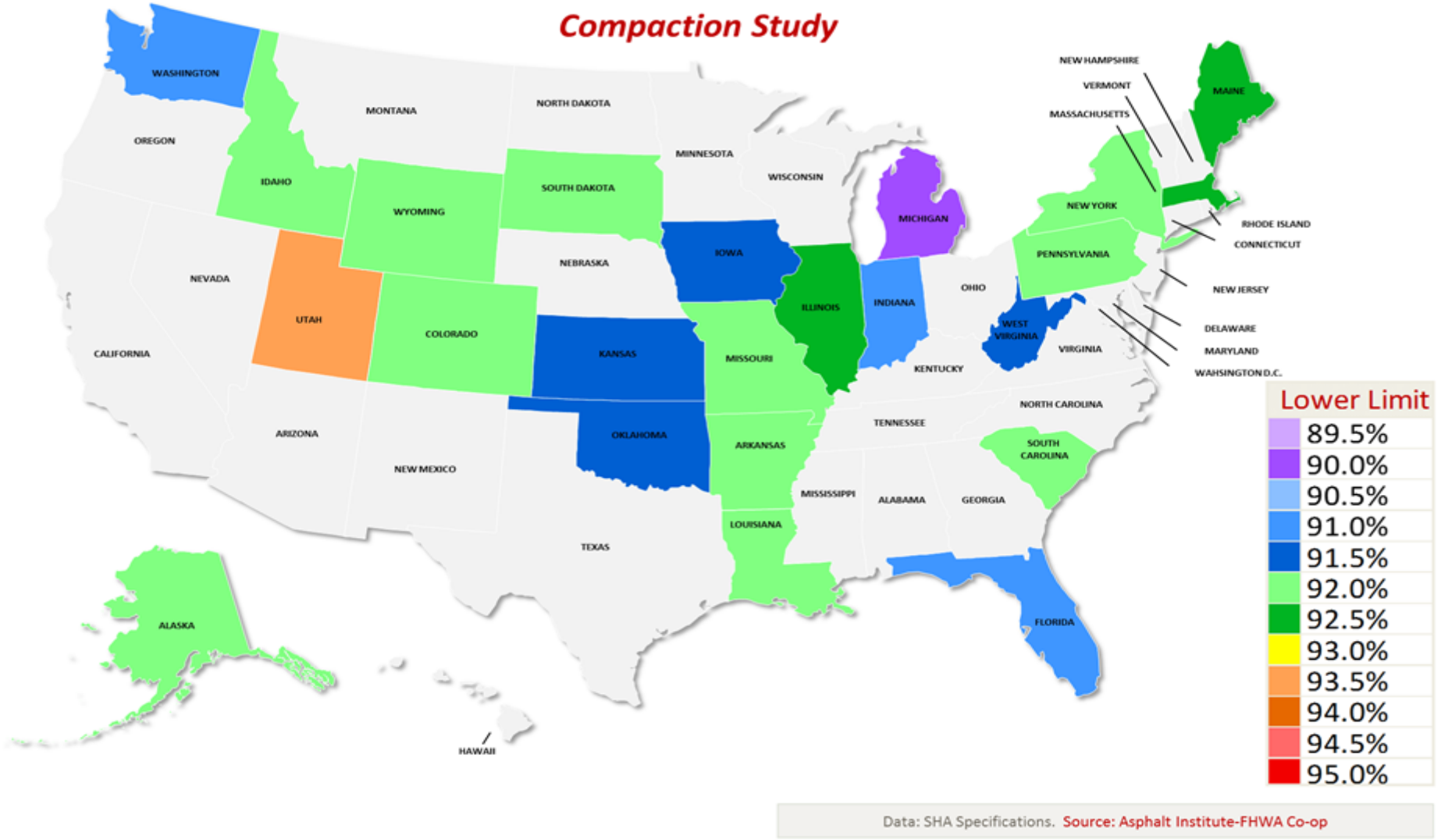
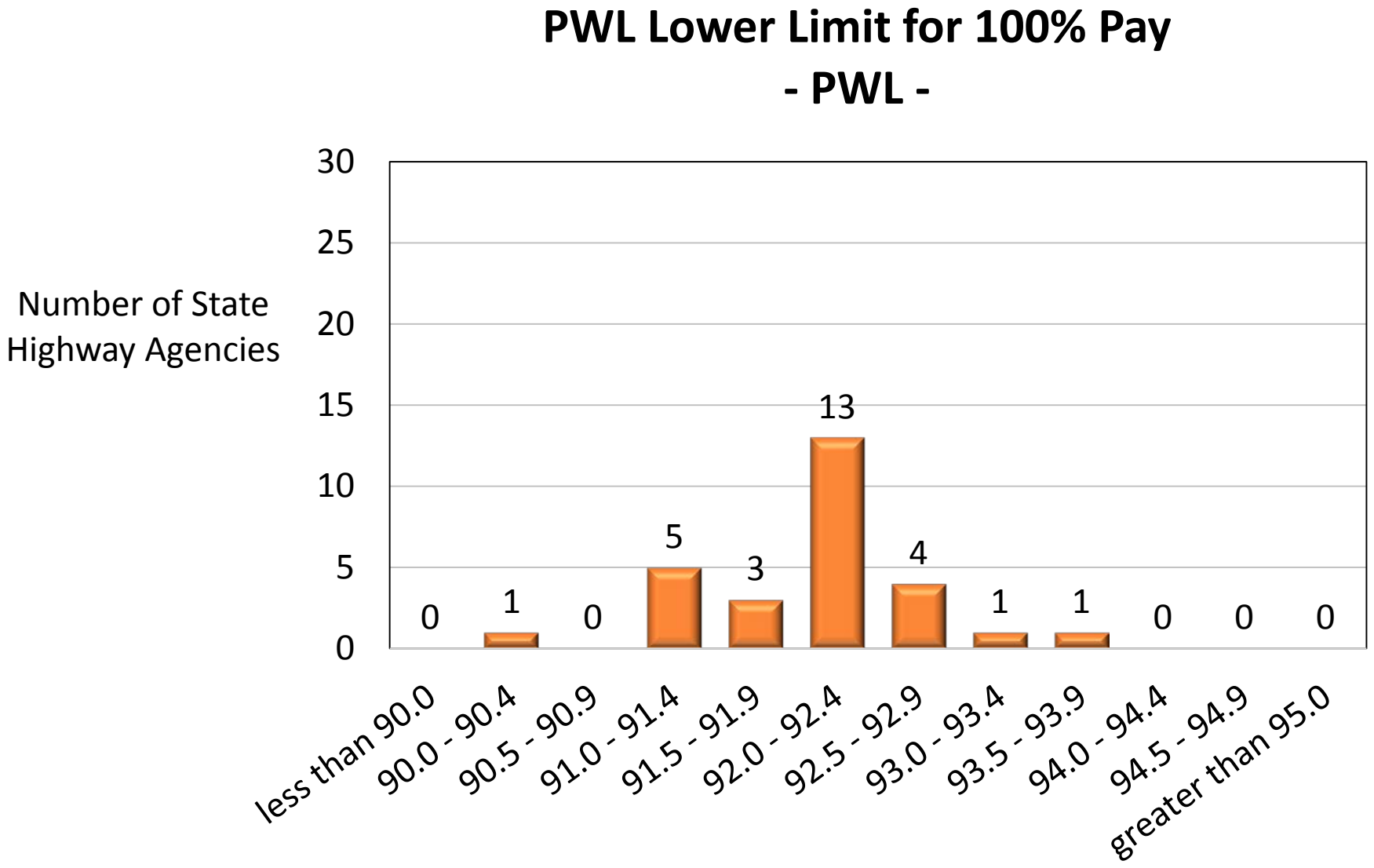
Lowest Specification Density by PWL (Lower Limit)



Data: SHA Specifications. Source: Asphalt Institute-FHWA Co-op

Lowest Specification Density

PWL



Simple Average Specs

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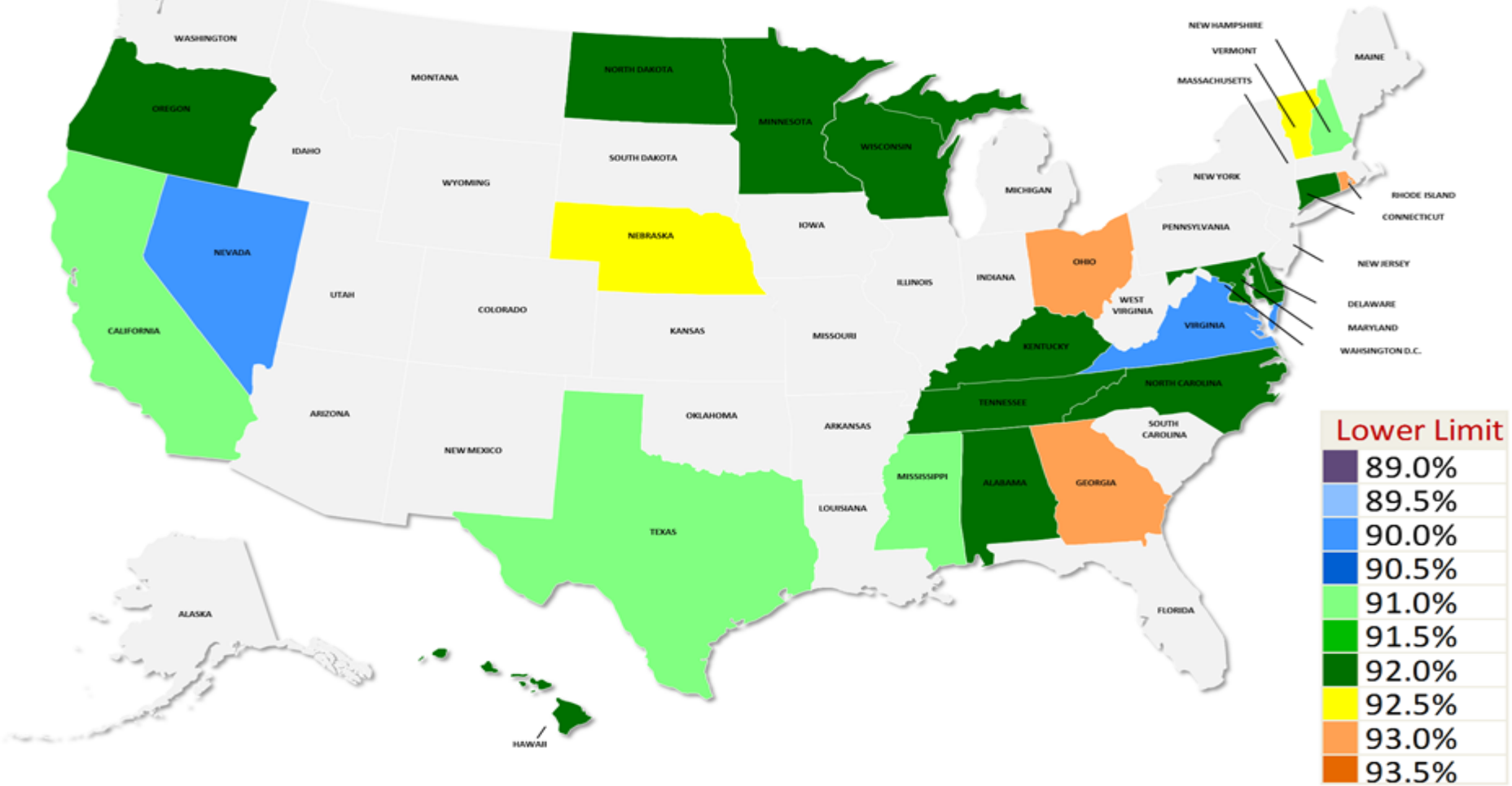
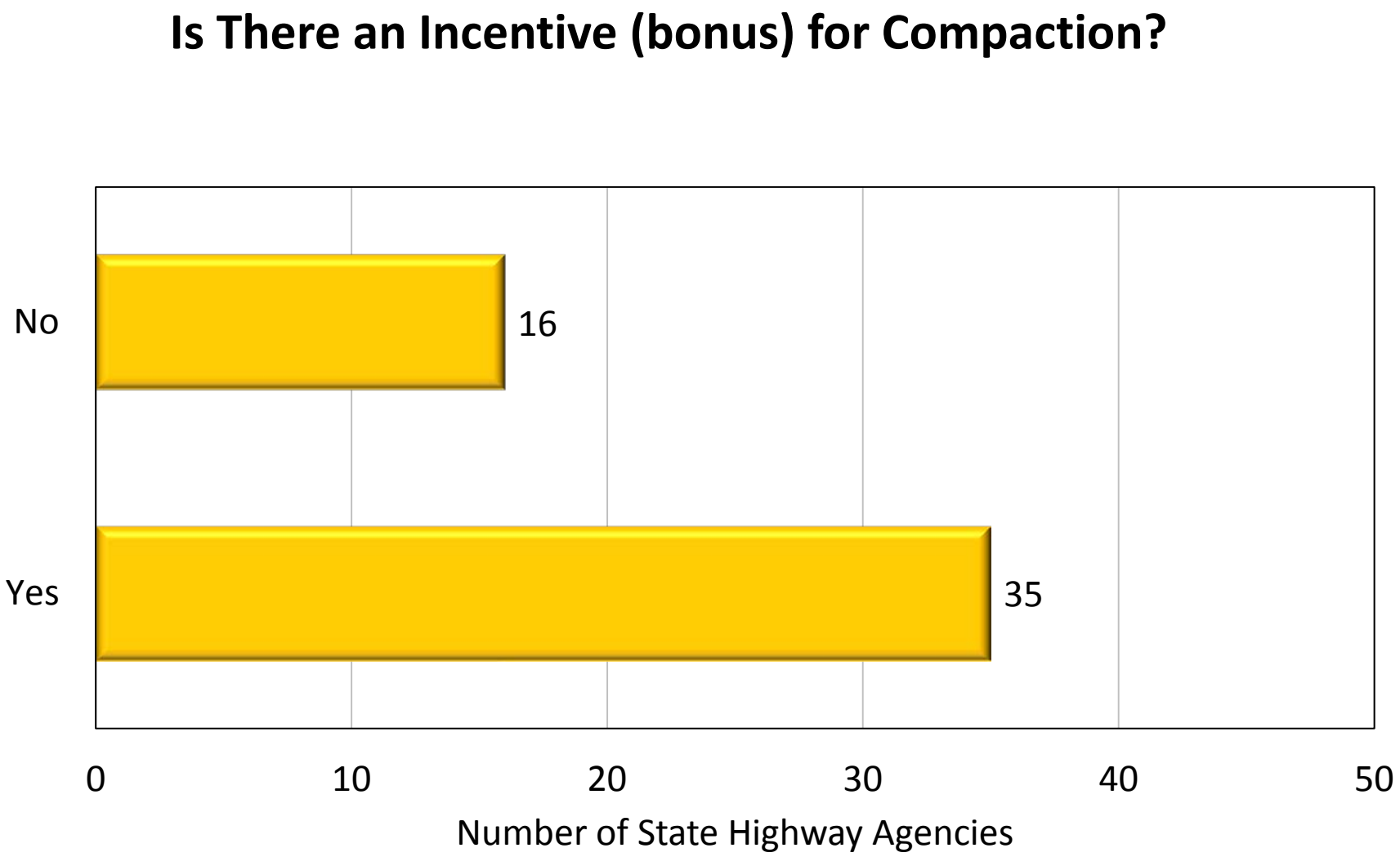
Lowest Specification Density by Simple Average (Lower Limit)

Compaction Study



Data: SHA Specifications. Source: Asphalt Institute-FHWA Co-op

Compaction Incentive



Compaction Incentive

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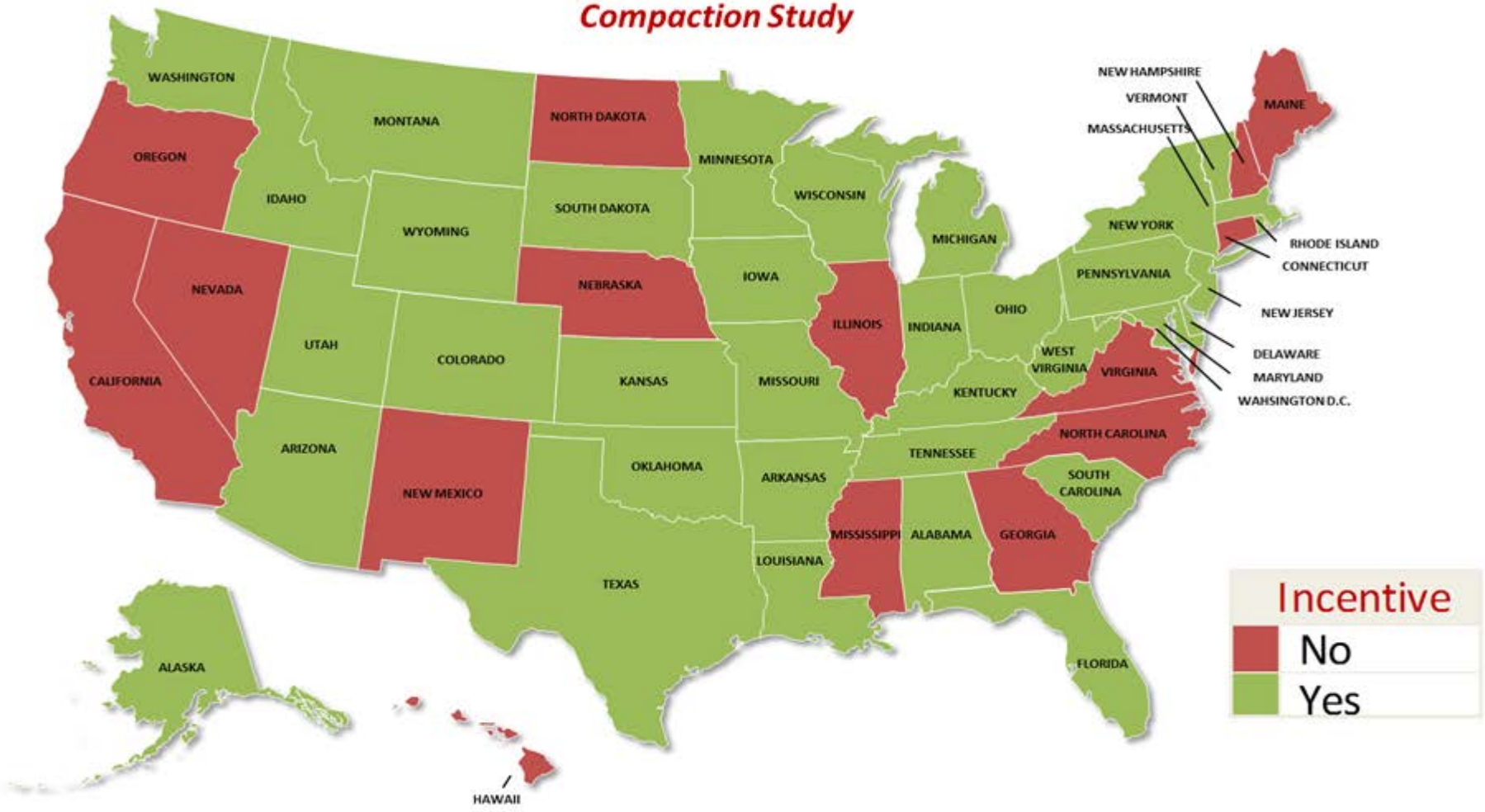
Incentive (Bonus) for Compaction

Compaction Study



Data: SHA Specifications. Source: Asphalt Institute-FHWA Co-op

How Much?

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Maximum Incentive (%) for Compaction

Compaction Study

Data: SHA Specifications. Source: Asphalt Institute-FHWA Co-op

Broad Observations

- G_{mm} is the majority acceptance of the density baseline
- Cores are the majority for acceptance of pavement density
- About an equal split of states who use PWL and Simple Average method for acceptance
  - PLW seems to have scare that goes along with it...can I really understand this?
- 92% of Gmm is the majority target for states using a simple average
  - Same is true for PWL states but realize that PWL minimum is not a “real minimum”. The target minimum is about 1-1.5% above.
- Most states offer a compaction incentive

Broad Observations

- Most who do **not** offer an incentive are the Simple Average states
  - 13 out of 16 non-incentive states are Simple Average.
- Neighboring states tend to match specs and incentives
- Some specification were very difficult to understand.
  - What is the baseline measure from? Field or lab
  - How often is G_{mm} measured? Average, daily
  - Information was spread over several specification sections or multiple inspector books.
- Usually 2-3 levels of compaction including roller pattern and non-inspection.
  - We reported the highest level only

Broad Observations

- Some base specifications allow lower densities
  - Superpave memo from ~1994 recommended to use 1 less gyration level to allow for more compaction for layers <4” from the surface
- Several specifications allow for > 4% air voids design (~4.3 to 4.5%) or field adjustments up to 5% air voids.
  - Making field density at 3-4x NMAS even more difficult to achieve