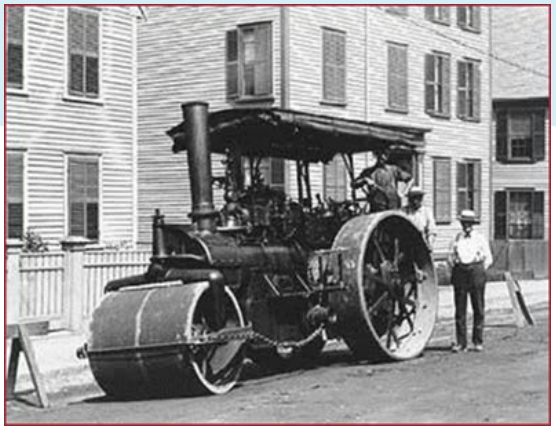


Enhanced Durability Through Increased Density

FEBRUARY 8, 2017

MID-ATLANTIC QUALITY ASSURANCE WORKSHOP

FHWA

MATERIALS AND QUALITY ASSURANCE TEAM

Overall Objective

Ultimately,

achieving the in-place asphalt pavement density that results in the highest asphalt pavement performance.

Compaction is Important

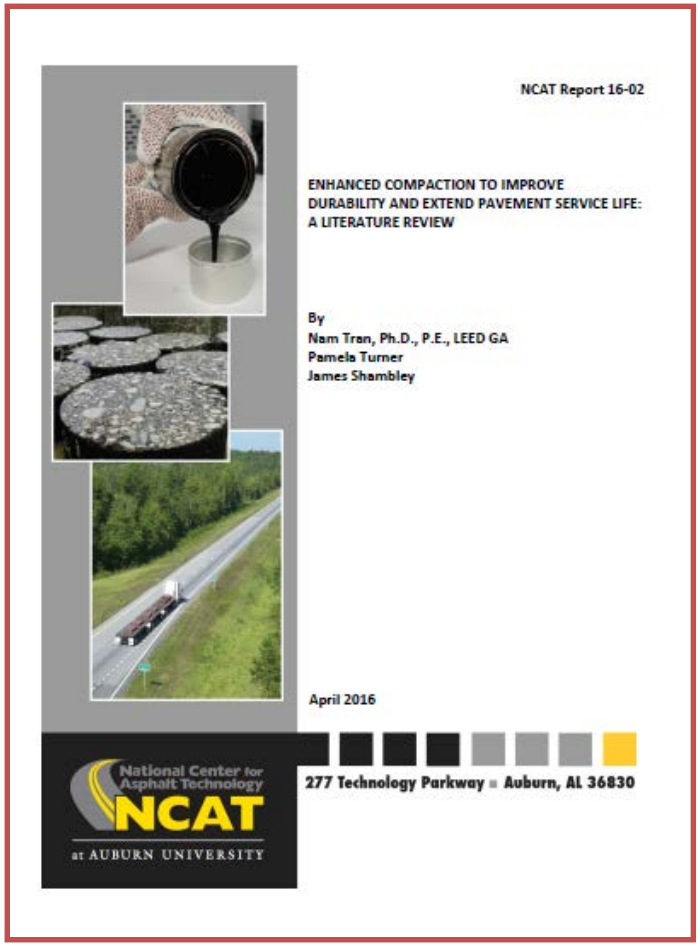
- Hughes, C.S., "Compaction of Asphalt Pavement." NCHRP Synthesis 152, Washington, D.C., 1989.
  - Compaction is the **single most important factor** that affects pavement performance in terms of durability, fatigue life, resistance to deformation, strength and moisture damage.
- Geller, M. Synthesis 152
  - "Compaction is the **most economical** alternative for achieving an increase in the life expectancy of new and rehabilitated pavement."

- Brown, E.R., "Density of Asphalt Concrete – How Much is Needed?" NCAT Report 90-03. 1990.
  - "The amount of 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."

NCAT Report 16-02 (2016)

"A **1% decrease in air voids** was estimated to:

- <u>improve fatigue</u> performance by 8.2 and 43.8%
- <u>improve the rutting</u> resistance by 7.3 to 66.3%
- **<u>extend the service life</u> by conservatively 10%**."


NCAT Report 16-02

ENHANCED COMPACTION TO IMPROVE DURABILITY AND EXTEND PAVEMENT SERVICE LIFE: A LITERATURE REVIEW

By
Nam Tran, Ph.D., P.E., LEED GA
Pamela Turner
James Shambley

April 2016

National Center for Asphalt Technology
NCAT
at AUBURN UNIVERSITY

277 Technology Parkway ▪ Auburn, AL 36830

http://eng.auburn.edu/research/centers/ncat/files/technical-reports/rep16-02.pdf

Reasons for Compaction

Cracking

- To improve fatigue cracking resistance
- To improve thermal cracking resistance

Rutting

- To minimize prevent further consolidation
- To provide shear strength and resistance to rutting

Moisture Damage

- To ensure the mixture is waterproof (impermeable)

Aging

- To minimize oxidation of the asphalt binder

Compaction is important, but not a cure-all remedy

Compaction Workshop

FHWA & Asphalt Institute (AI)

- Feedback Very Positive
  - Formal training
  - Comprehensive:
    - Mix design to
    - Finish roller to
    - Measurement and Acceptance
  - Back to the basics focus
  - Learned new topics and reinforced others

- Workshops to Date
  - 10 locations
  - > 450 participants

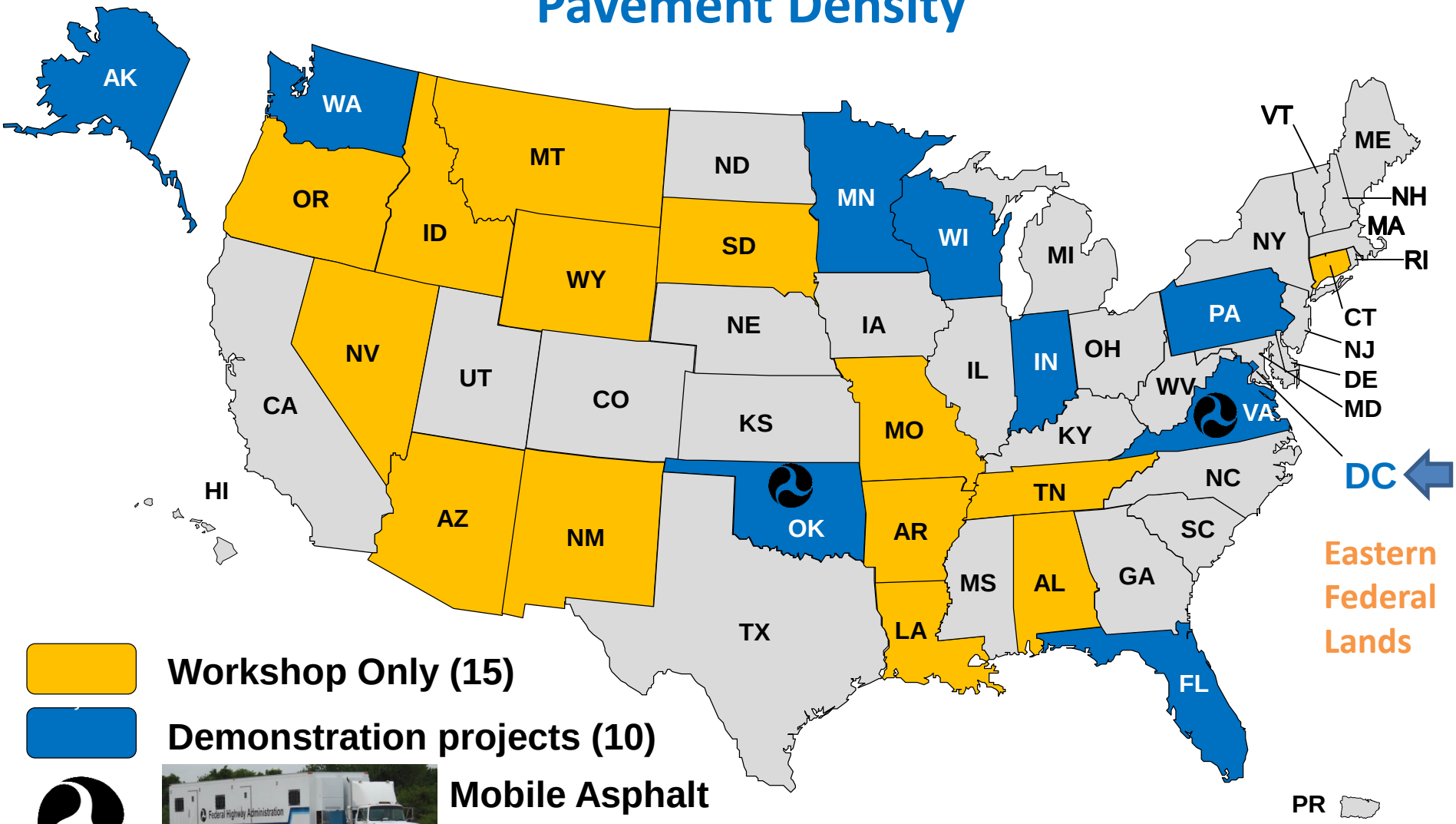
Field Demonstration Projects

FHWA & National Center for Asphalt Technology (NCAT)

NCAT Provided

- Pre-paving meeting attendance and advice
- On-site technical advice

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



Workshop Only (15)

Demonstration projects (10)

Mobile Asphalt Testing Trailer (2)

Achieving Increased In-place Density

1. % Density Requirement
2. Optimum Asphalt Content
3. Consistency
4. Best Practices

State #1

	Location	Mode	Passes	Equipment
	Delivery	MTV		Roadtec SB-2500
Control	Breakdown	Static	10	CAT CB54
		Static	10	CAT CB54

State #1

Experiment	Contractor's Compactive Effort
Test Section 1	**Added 1 to 2 vibratory passes**
Test Section 2	**Added pneumatic** - CAT CW34

State #1

Experiment	Density Results (%)	Change
Control	93.5	---
Test Section 1	93.2	Not significant
Test Section 2	95.4	+ 1.9

Average of 10 core densities each / Reference is G_{mm}

- 2 static rollers achieved full incentive
- Using vibratory mode resulted in no change in % density
- Adding pneumatic increased % density

State #2

	Location	Mode	Passes	Equipment
	Delivery			End Dumps
Control	Breakdown	Vibratory	8	BW 161 AD-5 (10 ton)
	Finish	Static	7	BW 138 AD-5 (4 ton)
Test Section	Breakdown	Vibratory	10	Same

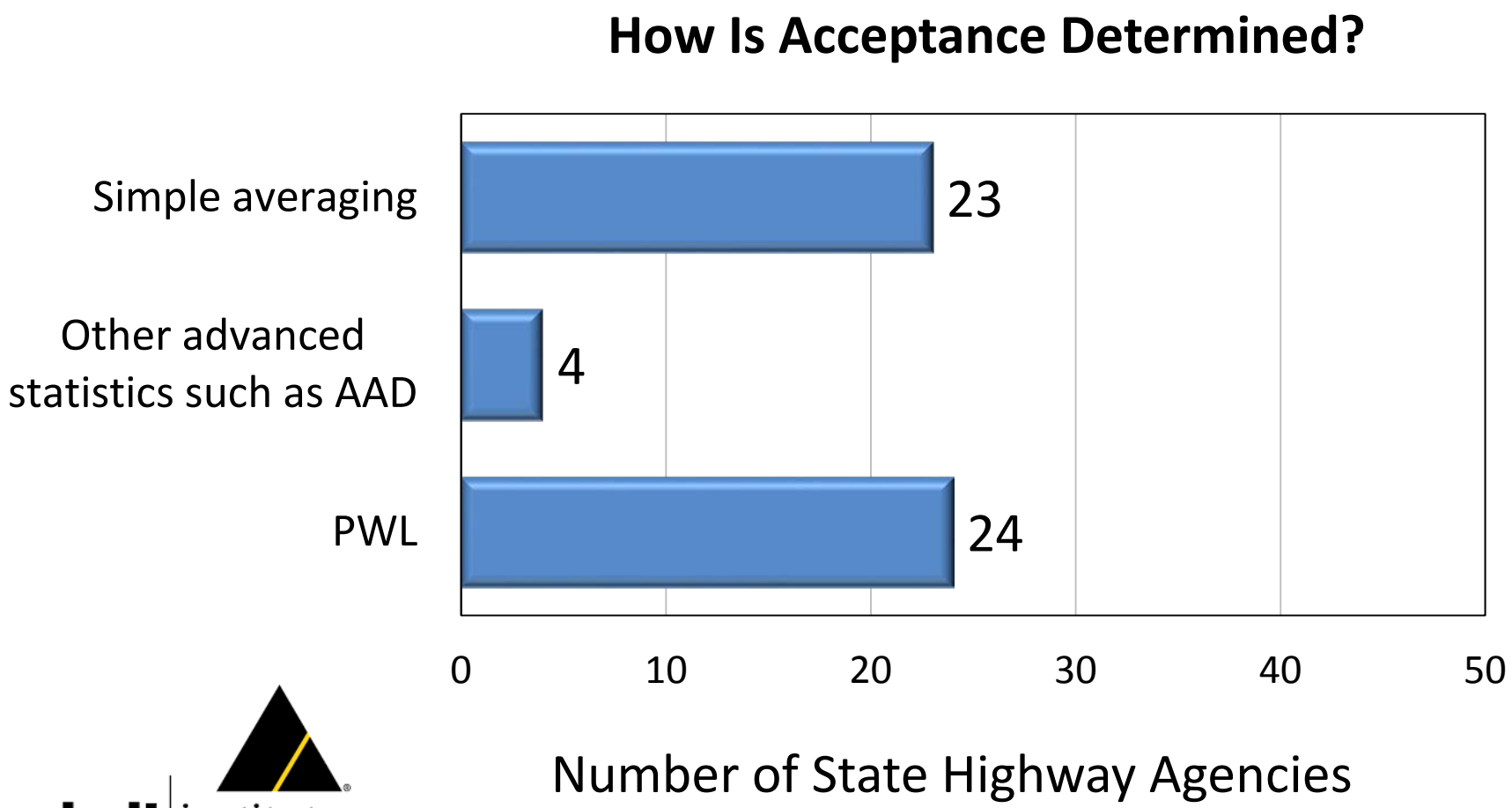
State #2

Experiment	Density Results (%)	Change
Control	91.7	---
Test Section	92.5	≈ + 1

Average of 6 cores each / Reference is G_{mm}

- Only 1 compaction roller needed to meet specification
- Adding 2 passes increased % density

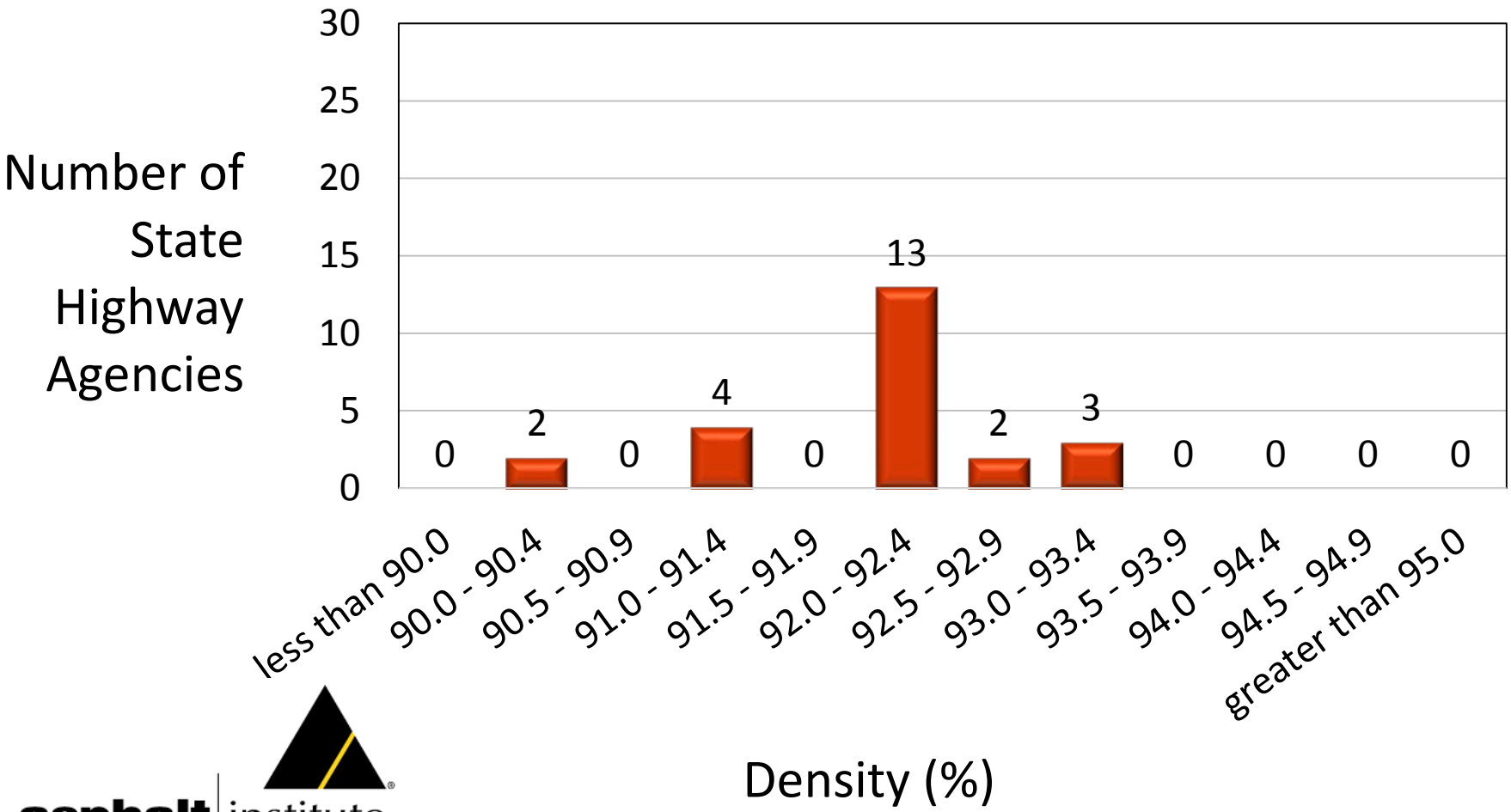
How Is Acceptance Determined



asphalt institute

2016

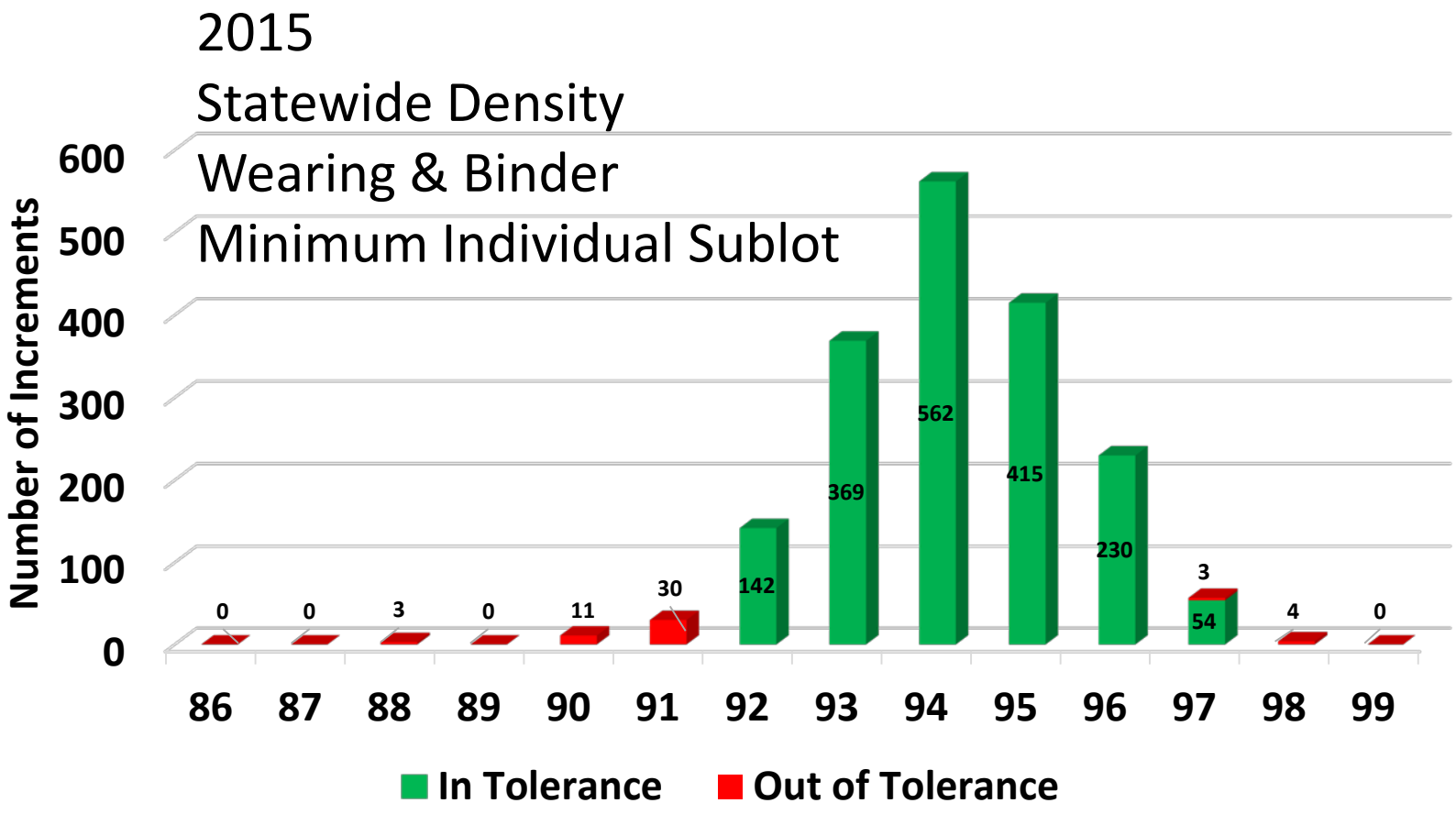
Minimum Lot Average



asphalt institute

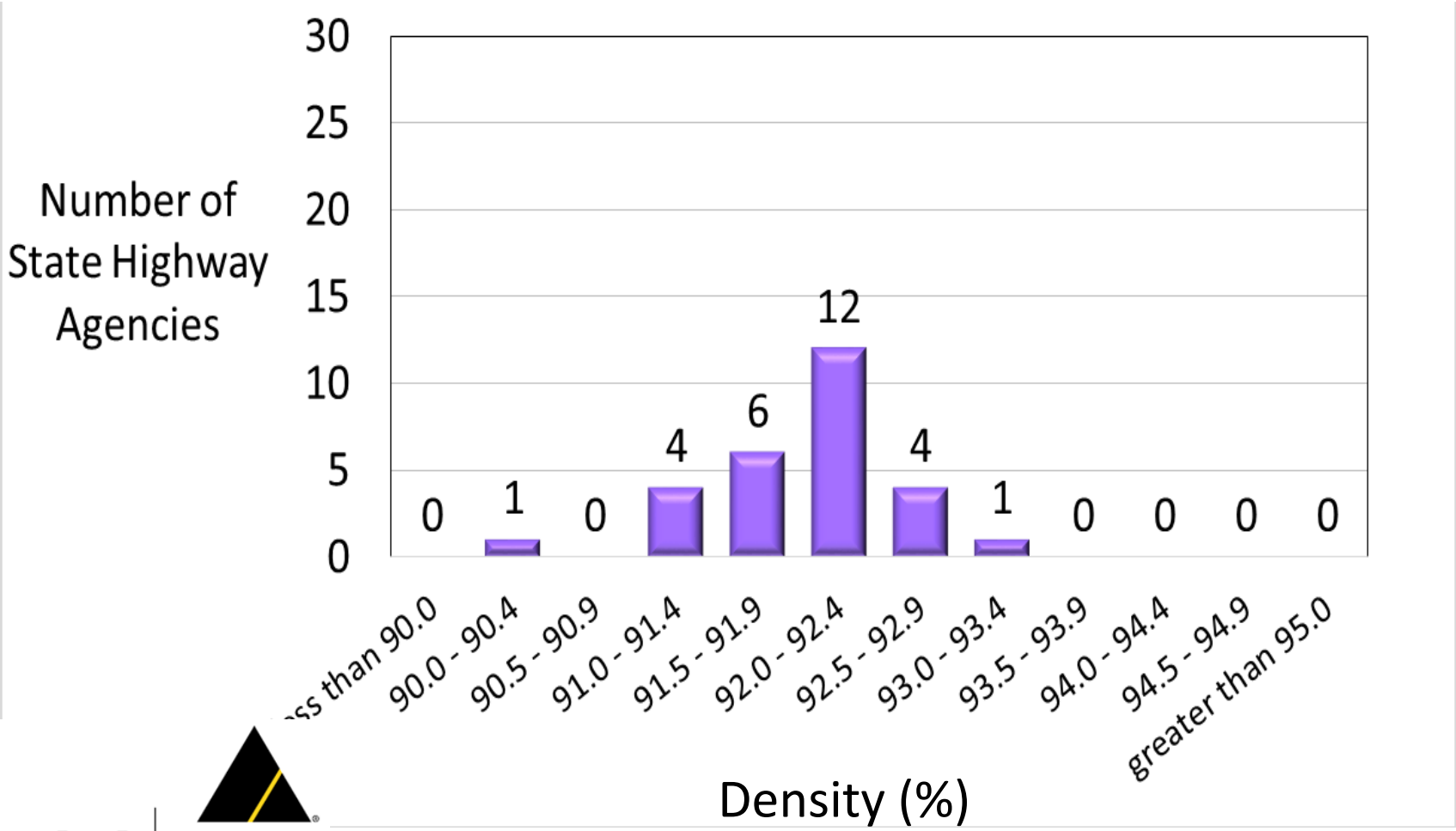
2016

PennDOT Case Study



pennsylvania
DEPARTMENT OF TRANSPORTATION

PWL: Lower Specification Limit

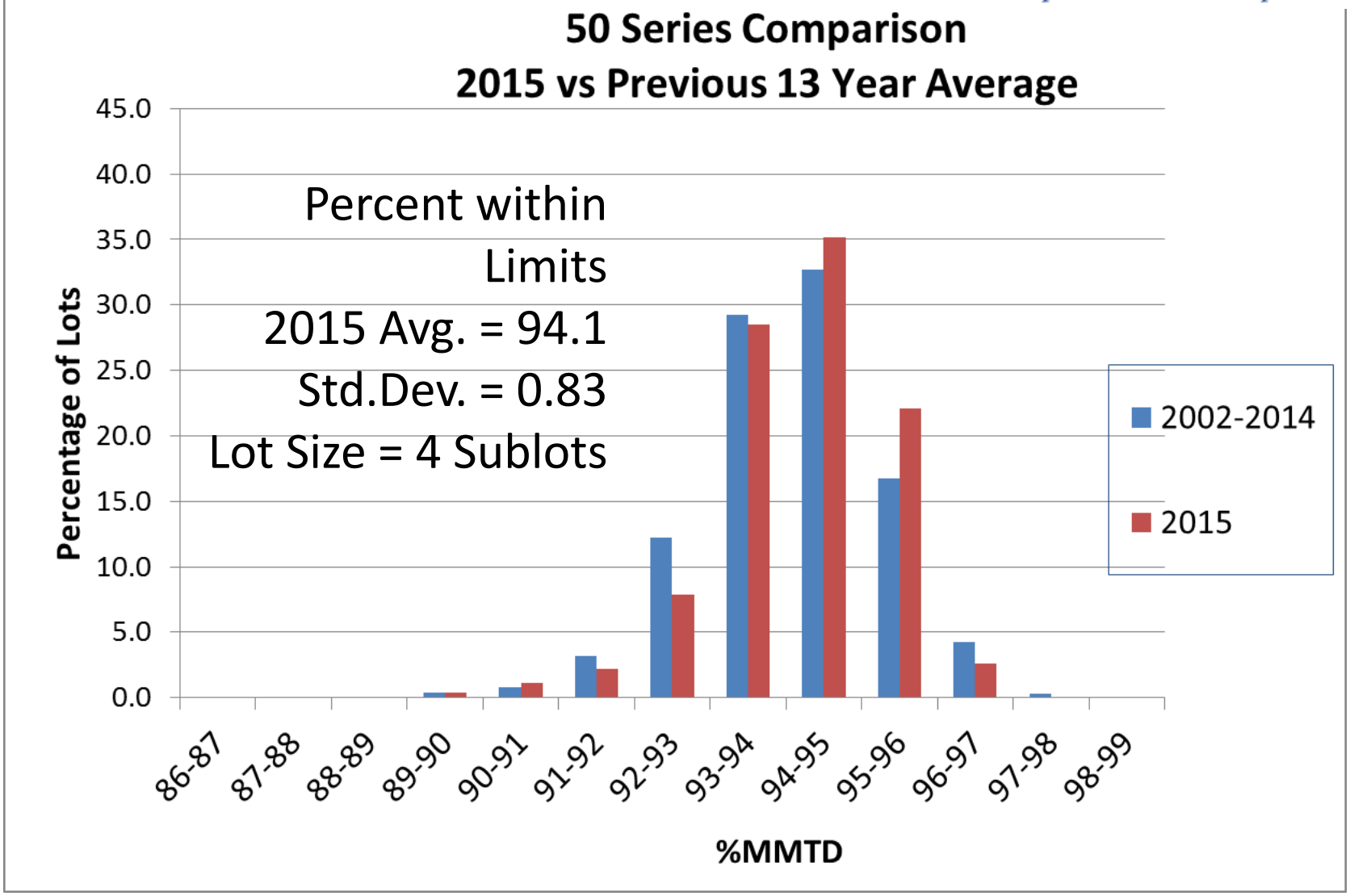


asphalt institute

2016

NYSDOT Case Study

New York State
Department of Transportation



Achieving Increased In-place Density

1. % Density Requirement
2. Optimum Asphalt Content
3. Consistency
4. Best Practices

State #3

	Location	Mode	Passes	Equipment
	Delivery	Bottom Dumps		Cedar Rapids MS2
Control	Breakdown	Vibratory	7	Dynapac CC 624
		Vibratory	7	Dynapac CC 624
	Intermediate	Pneumatic	7	CAT CW35
		Pneumatic	7	Hamm GRW18

State #3

Experiment	Contractor's Compactive Effort
Test Section 1	**Added 1 vibratory roller** – Hamm HD130 (5 total rollers)
Test Section 2	**Added 0.3% asphalt** (5 total rollers)

State #3

Experiment	Density Results (%)	Change
Control	92.9	---
Test Section 1	92.9	No change
Test Section 2	94.1	+ 1.2

Average of 8 core densities each / Reference is G_{mm}

- 4 compaction rollers needed to meet specification
- 1 additional roller did not change % density
- Mix design adjustment resulted in % density increase
- Added new technology: IC, IR, and RDM

State #4

	Location	Mode	Passes	Equipment
	Delivery	MTV		Weiler E2850
Control	Breakdown	Vibratory	5	Dynapac CC 624 HF
		Vibratory	5	Volvo DV 140B
	Intermediate	Pneumatic	11	Hamm GRW280

State #4

Experiment	Contractor's Compactive Effort
Test Section 1	**Added 1 vibratory roller** – Dynapac CC 524 HF (4 rollers)
Test Section 2	**Added 0.3% asphalt** (4 rollers)

State #4

Experiment	Density Results (%)	Change
Control	93.5	---
Test Section 1	95.0	+ 1.5
Test Section 2	95.4	+ 1.9

Average of 12 nuclear gauge readings each / Reference is G_{mm}

- Control achieved maximum incentive
- Additional roller and mix design adjustment resulted in % density increase

Selecting Optimum with Superpave

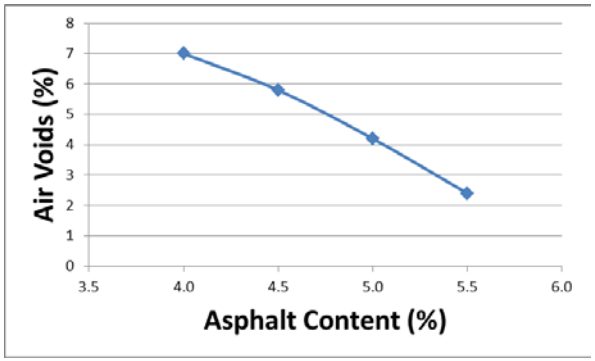
What Changes Were Made to AASHTO Standards?

- Gyrations
- Air Voids
- Voids in the Mineral Aggregate (VMA)
- Is There Additional Criteria?

American Association of State Highway and Transportation Officials
AASHTO
The Voice of Transportation

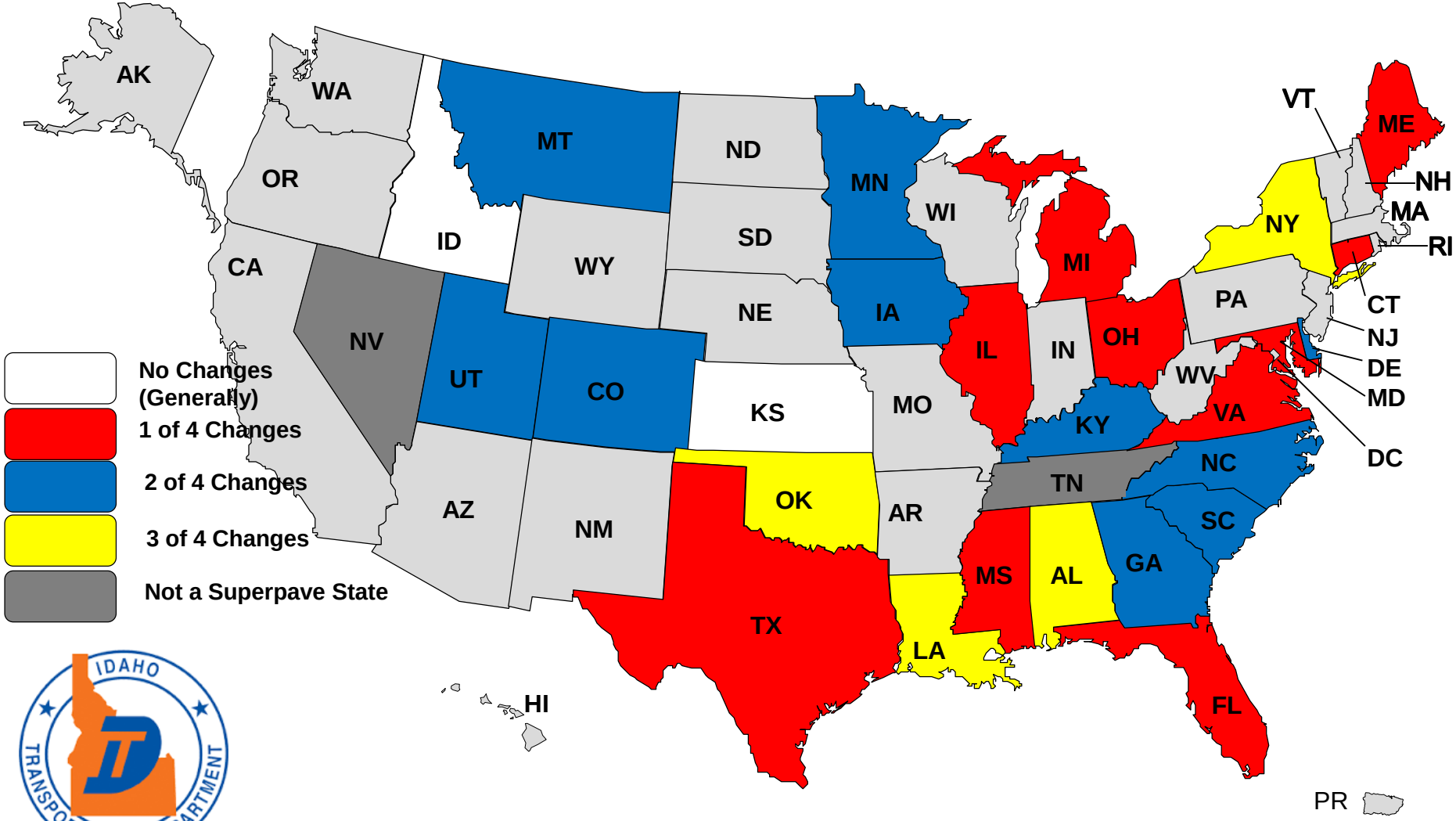
Asphalt Mixture Adjustments

State	Adjustments	Additional Asphalt
3	⇩ Gyrations (Regression)	0.3%
4	⇩ Air Voids (Regression) ⇧ VMA	0.3%
9	⇩ Gyrations ⇧ Air Voids ⇧ VMA	≈ 0.3%

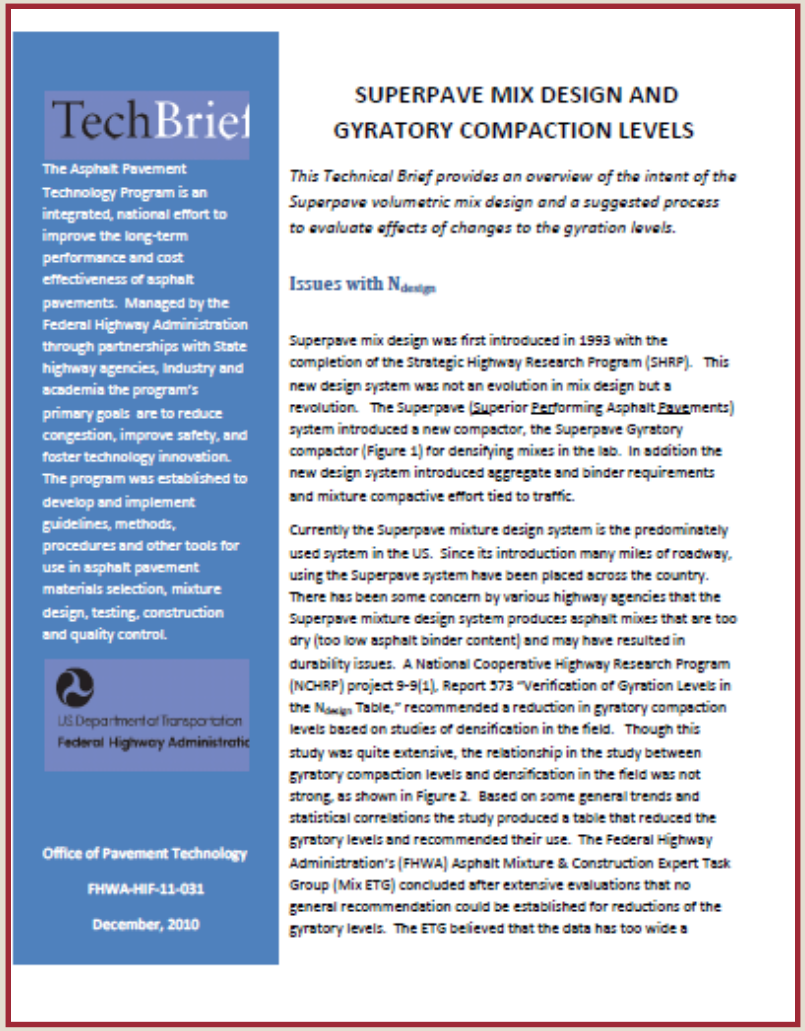


Combination of Changes

54% (14 of 26) Made 2 or More Changes



FHWA Tech Brief



TechBrief

The Asphalt Pavement Technology Program is an integrated, national effort to improve the long-term performance and cost effectiveness of asphalt pavements. Managed by the Federal Highway Administration through partnerships with State highway agencies, industry and academia the program's primary goals are to reduce congestion, improve safety, and foster technology innovation. The program was established to develop and implement guidelines, methods, procedures and other tools for use in asphalt pavement materials selection, mixture design, testing, construction and quality control.

US Department of Transportation
Federal Highway Administratio

Office of Pavement Technology

FHWA-HIF-11-031

December, 2010

SUPERPAVE MIX DESIGN AND GYRATORY COMPACTION LEVELS

This Technical Brief provides an overview of the intent of the Superpave volumetric mix design and a suggested process to evaluate effects of changes to the gyration levels.

Issues with N_{design}

Superpave mix design was first introduced in 1993 with the completion of the Strategic Highway Research Program (SHRP). This new design system was not an evolution in mix design but a revolution. The Superpave (Superior Performing Asphalt Pavements) system introduced a new compactor, the Superpave Gyratory compactor (Figure 1) for densifying mixes in the lab. In addition the new design system introduced aggregate and binder requirements and mixture compactive effort tied to traffic.

Currently the Superpave mixture design system is the predominately used system in the US. Since its introduction many miles of roadway, using the Superpave system have been placed across the country. There has been some concern by various highway agencies that the Superpave mixture design system produces asphalt mixes that are too dry (too low asphalt binder content) and may have resulted in durability issues. A National Cooperative Highway Research Program (NCHRP) project 9-9(1), Report 573 "Verification of Gyration Levels in the N_{design} Table," recommended a reduction in gyratory compaction levels based on studies of densification in the field. Though this study was quite extensive, the relationship in the study between gyratory compaction levels and densification in the field was not strong, as shown in Figure 2. Based on some general trends and statistical correlations the study produced a table that reduced the gyratory levels and recommended their use. The Federal Highway Administration's (FHWA) Asphalt Mixture & Construction Expert Task Group (Mix ETG) concluded after extensive evaluations that no general recommendation could be established for reductions of the gyratory levels. The ETG believed that the data has too wide a

Title: Superpave Mix Design and Gyratory Compaction Levels

Purpose: Evaluate Effects of Changes to Gyratory Levels

Achieving Increased In-place Density

1. % Density Requirement
2. Optimum Asphalt Content
3. Consistency
4. Best Practices

State #5

	Construction Information
Delivery	MTV: Roadtec SB-1500
Control	Current minimum sublot specification
Test Section	New PWL specification

State #5

	Location	Mode	Passes	Equipment
Test Section	Breakdown	Vibratory	5	CAT CB 54B
		Vibratory	5	Sakai WS800
		Vibratory	5	CAT CB 54B
	Joints	Vibratory	5	??

State #5

Experiment	Density Results (%)	Change	Pay Factor	Std. Dev. (* Statewide)
Statewide Avg.	93.6	---	---	---
Control	94.4	---	0.97	1.55*
Test Section 1	96.1	+1.7	1.04	0.95*

Average of 5 cores each / Reference is G_{mm}

- Implementing PWL specification

State #6

	Location	Mode	Passes	Equipment
	Delivery	MTV		Weiler E2850
Control	Breakdown	Vibratory	9	CAT CB 68B
	Intermediate	Pneumatic	17	Dynapac CP30
Test Section	**Decrease roller spacing**			Same

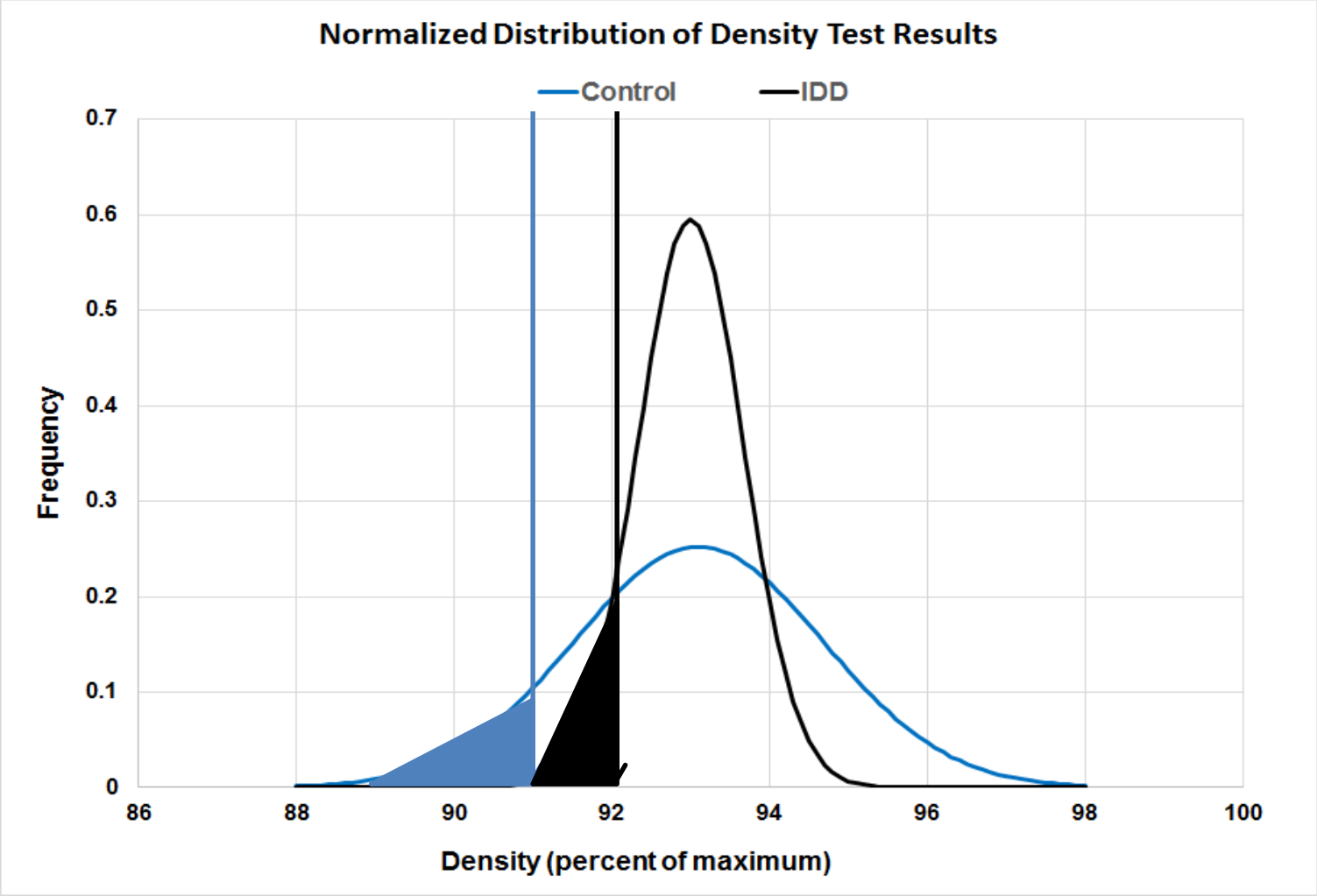
State #6

Experiment	Density Results (%)	n	LSL	PWL
Control	93.1	77	**91.0**	90.3
Test Section	93.0	11	**92.0**	93.3

Standard deviation changes from 1.58 to 0.67 from individual tests
Reference is G_{mm}

- Additional effort by contractor was minimal
- Uniformity improvements showed LSL could be 1% higher

Percent Within Limits



Consistency is Important

Standard Deviation

- State #6
  - Nuclear from individual tests
  - Control: S.D. = 1.58
  - Test Section: S.D. = **0.67**
- PennDOT Statewide
  - Cores with lot size = 5 sublots
  - Old Spec: S.D. = 1.58
  - New Spec: S.D. = **0.98**
- NYSDOT PWL Statewide
  - Cores with lot size = 4 sublots
  - 2007: S.D. = 0.92
  - 2015: S.D. = **0.83**

Achieving Increased In-place Density

1. % Density Requirement
2. Optimum Asphalt Content
3. Consistency
4. Best Practices

State #7

	Location	Mode	Passes	Equipment
	Delivery	MTV		IR MC 330
Control	Breakdown	Vibratory Static	2 3	CAT CB 64B
	Intermediate	Static	5	Hamm HD+ 90

State #7

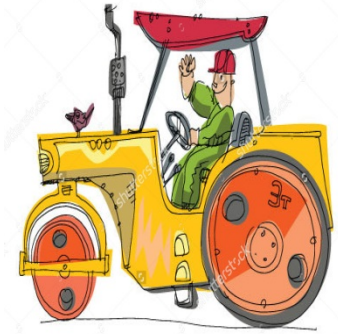
	Location	Mode	Passes	Equipment
Test Section #1	Breakdown	Vibratory Static	2 1	CAT CB 64B
	Intermediate	Static Oscillatory	1 2	Hamm HD+ 90
Test Section #2	Breakdown	Vibratory	3	CAT CB 64B
	Intermediate	Static Oscillatory	1 2	Hamm HD+ 90

State #7

Experiment	Density Results (%)	Change
Control	92.2	---
Test Section 1	92.0	Not significant
Test Section 2	92.0	Not significant

Average of 10 cores each / Reference is G_{mm}

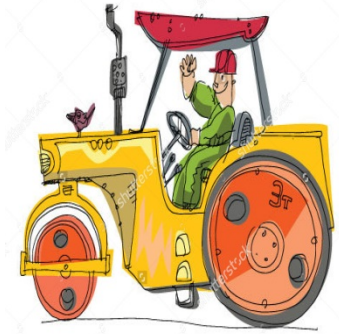
- % density increase was not significant
- % density results exceeded current specification



Field Compactive Effort Control Sections

State ID	Total		Vibratory		Pneumatic		Echelon		Focus Area
	Rollers	Passes	Rollers	Passes	Rollers	Passes	Brkdn.	Inter.	
2	1	8	1	8	0	0	No	No	More passes
7	2	10	1	2	0	0	No	No	Oscillation
9	2	14	2	10	0	0	Yes	No	More AC
8	2	18	2	18	0*	0	No	No	New Technology
1	2	20	0	0	0*	0	Yes	No	Pneumatic
5	4	20	4	20	0*	0	Yes	No	Std. Dev.
4	3	21	2	10	1	11	Yes	No	More AC
3	4	24	2	12	2	12	Yes	Yes	More AC and New Technology
6	2	26	1	9	1	14	No	No	Std. Dev.

* Polymer Modified Asphalt



% Density Test Sections

State ID	Total		Specification	Require-ment	Incentive / Disincentive	Field Density (% G_{mm})	Breakdown Roller
	Rollers	Passes					
7	2	6	% Control Strip	98.0	D	92.1	No echelon
2	1	10	Min. Sublot	92.0	D	92.5	No echelon
9	2	14	PWL	91.0	I / D	95.4	Echelon
8	2	18	PWL	92.0	I / D	95.6	No echelon
5	4	20	PWL	92.0	I / D	96.1	Echelon
4	3	23	Min. Lot Avg.	91.5	D	95.3	Echelon
3	4	24	Min. Lot Avg.	92.0	I / D	94.1	Echelon
6	2	26	PWL	91.0	I / D	93.0	No echelon
1	2	30	PWL	91.8	I / D	93.2	Echelon / No vibratory

PWL = Percent within Limits

Achieving Increased In-place Density

1. % Density Requirement
2. Optimum Asphalt Content
3. Consistency
4. Best Practices

Next Steps

- SHAs' summary reports on 10 projects
  - Potential follow-up on field performance
- FHWA's best practices communication
  - Summary document
  - Tech Brief
  - Additional workshops (funding dependent)
- Extend field experiment
  - Dependent of funding
  - Dependent on state interest

Thank you

QUESTIONS / COMMENTS:

TIM ASCHENBRENER, P.E.

FHWA

SENIOR ASPHALT PAVEMENT ENGINEER

MATERIALS AND QUALITY ASSURANCE TEAM

OFFICE OF ASSET MANAGEMENT, PAVEMENTS AND CONSTRUCTION

LAKEWOOD, COLORADO

(720) 963-3247

TIMOTHY.ASCHENBRENER@DOT.GOV