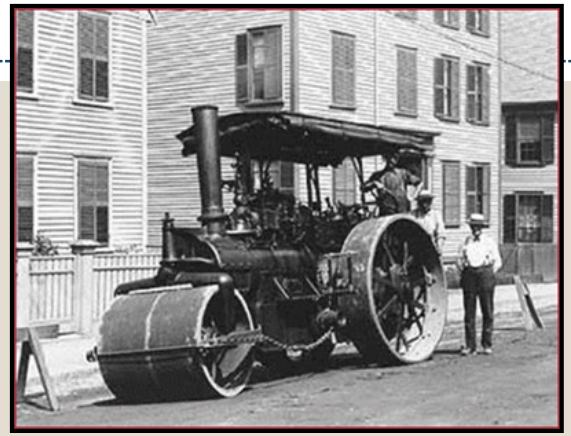
FHWA's Demonstration Project for Enhanced Durability Through Increased Density



Courtesy Asphalt Institute

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FHWA

U.S. Department of Transportation
Federal Highway Administration

Disclaimer

- FHWA does not endorse any one particular entity and that any entity's name or mention of any proprietary product does not indicate FHWA endorsement and is merely shared for information exchange purposes only.

Abbreviations & Acronyms

- AAD = absolute average deviation
- Avg. = average
- AVR = air void reduction
- Δ = delta = change
- DP = demonstration project
- G_{mm} = maximum specific gravity of mixture
- Int. = interstate
- L.F. = linear foot
- LJS = longitudinal joint sealant
- NCAT = National Center for Asphalt Technology
- NMAS = nominal maximum aggregate size
- PWL = percent within limits
- SHA = state highway administration
- Std. Dev. = standard deviation
- t/NMAS = thickness to NMAS
- VMA = percent voids in the mineral aggregate
- WMA = warm mix asphalt

Achieving Increased In-place Density

1. **Density is Important**
2. Gold Medal Examples
3. Density Demonstration Projects
4. Agency Specification Changes

Reasons for Obtaining Density

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

FHWA photo

Moisture Damage

- To ensure the mixture is waterproof (impermeable)

Aging

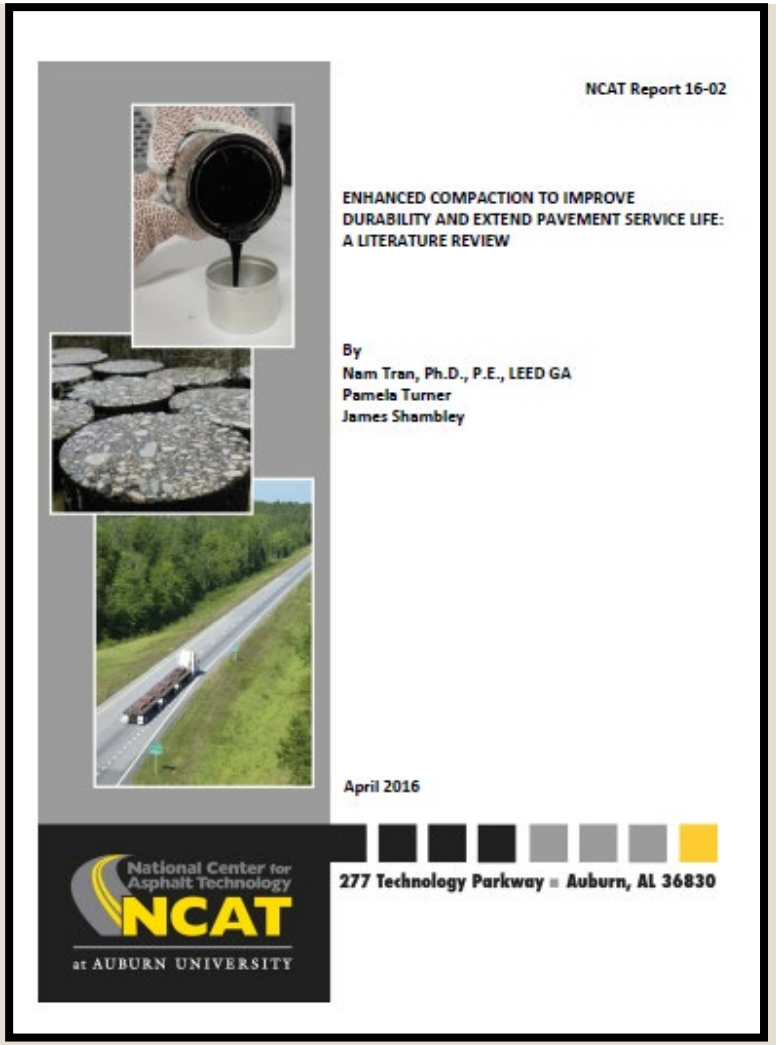
- To minimize oxidation of the asphalt binder

Density is important, but not a cure-all

National Center for Asphalt Technology (NCAT) Report 16-02 (2016) (Funded by FHWA)

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

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



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

Achieving Increased In-place Density

1. Density is Important
2. **Gold Medal Examples**
3. Density Demonstration Projects
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Some "Gold Medal" Density (% G_{mm}) Specifications Purpose

- Identify density (% G_{mm}) specifications that are success stories.
- Considering the Olympics, these success stories are considered "gold medal" examples.

Image Pixabay

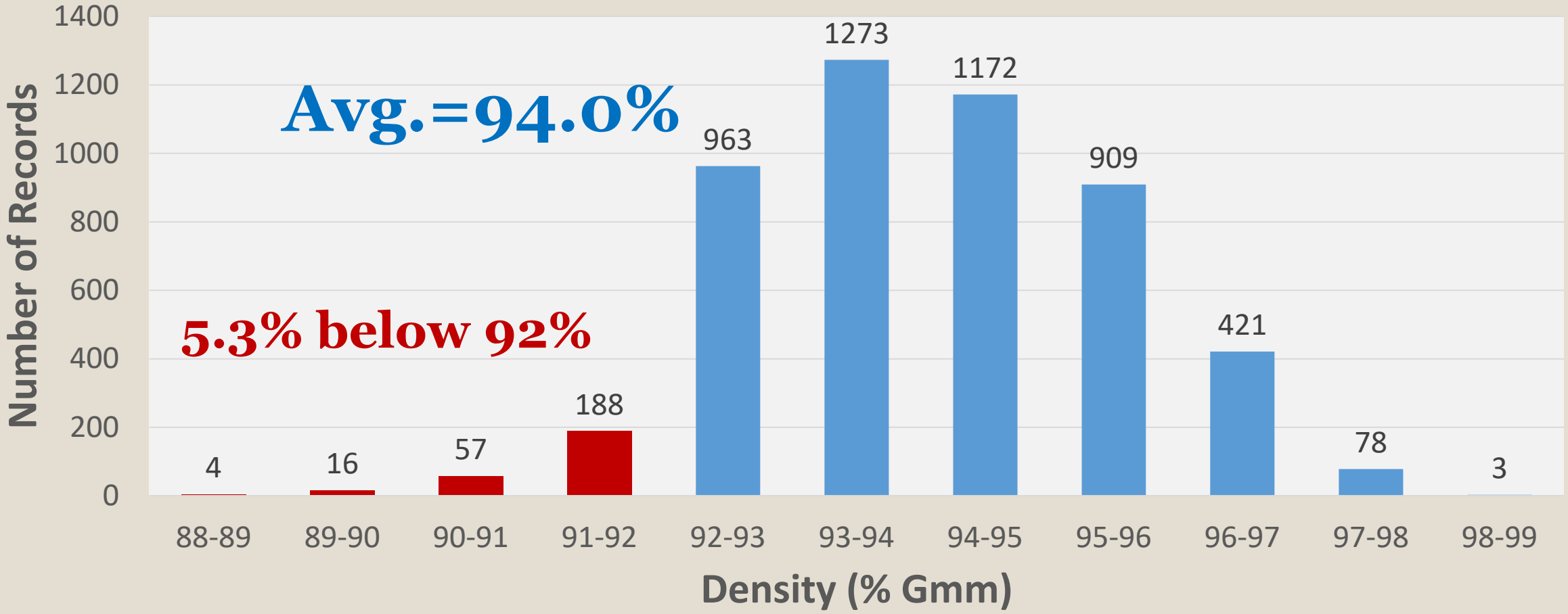
Note: There are likely more. Contact me if you think you have one.

Some “Gold Medal” Density (%G_{mm}) Specifications

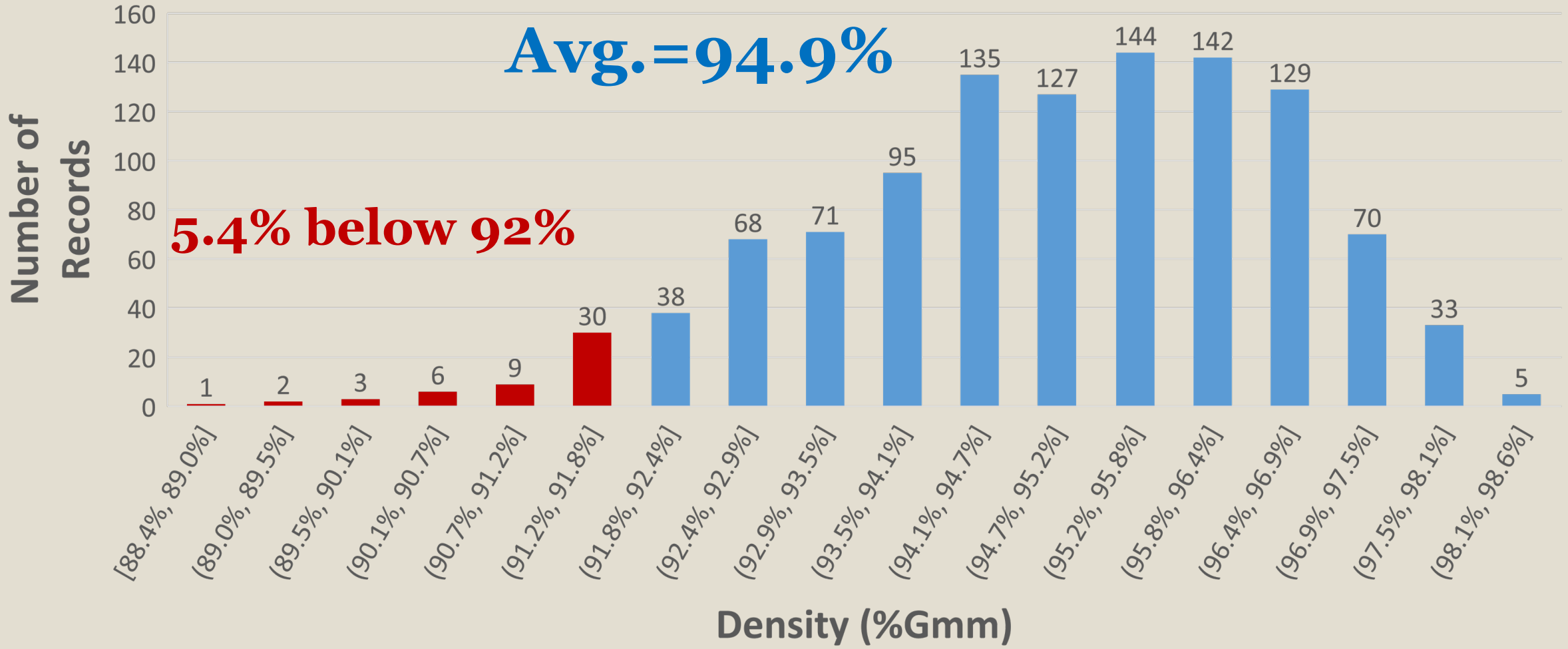
- Alaska DOT&PF
- Indiana DOT
- Maine DOT
- Maryland DOT SHA
- Michigan DOT
- Missouri DOT
- Montana DOT
- New Jersey DOT
- New York State DOT
- Pennsylvania DOT
- Puerto Rico HTA
- Tennessee DOT

Note: There are likely more. Contact me if you think you have one.

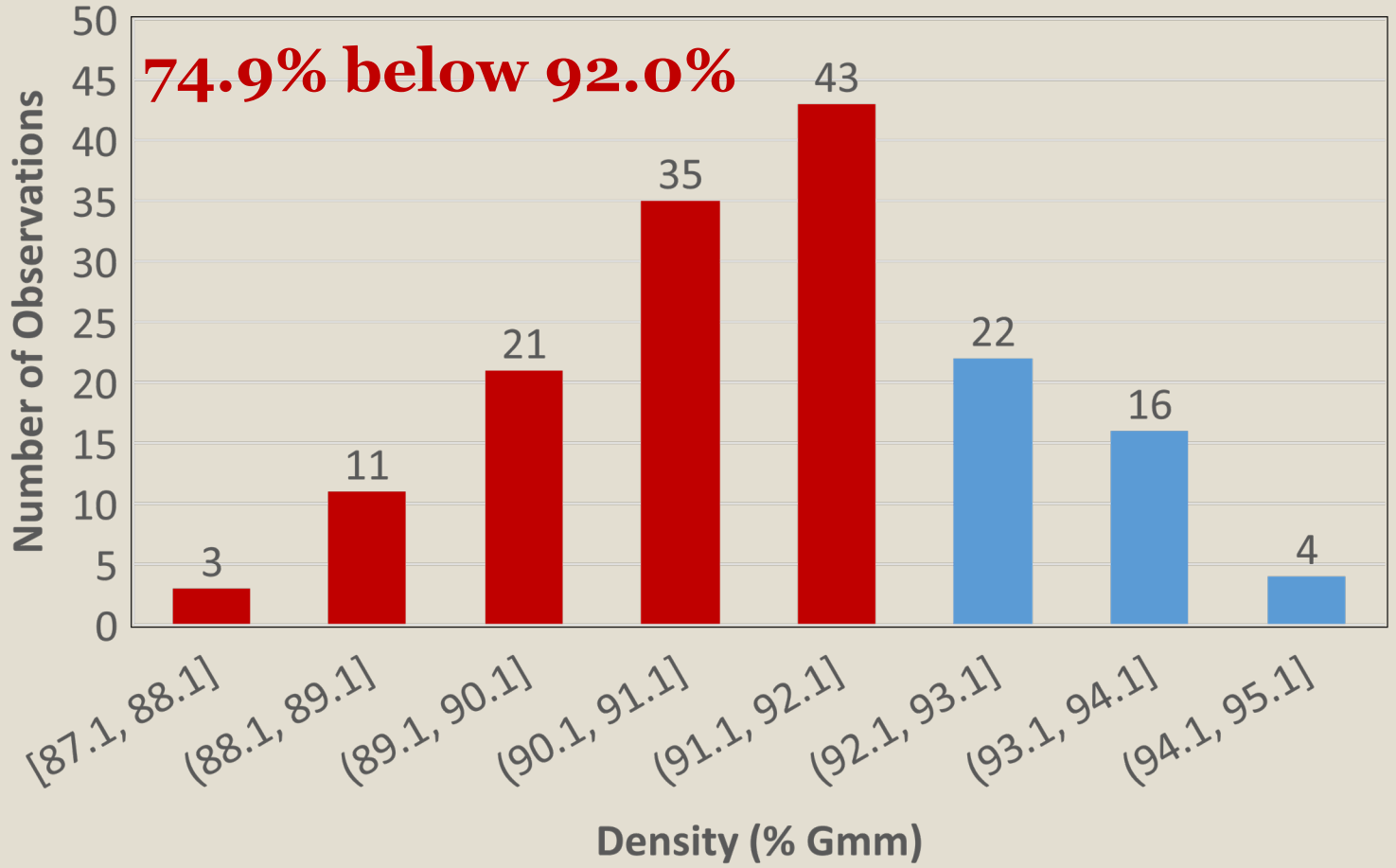
Maryland DOT SHA
Statewide Results 2017



New Jersey DOT
Statewide Results from 2018



A Project Example



FHWA photo

After 1 Year

"Gold Medal" Density (%G_{mm}) Specifications
Specification / Criteria / Results

	MD	MT	TN
Type of Specification	Lot Avg. & Ind. Sublot	Lot Avg. & Range	Lot Avg.
Limits (% G_{mm})	92.0 to 97.0	93.0 to 100.0	92.0 to 97.0
Incentive for Only Density	5.0%	8.0% (AC sep.)	2.0%
Max. Incent. (% G_{mm})	94.0	94.0 to 95.0	94.0
Avg. (% G_{mm})	94.0	94.3	93.9
Std. Dev. of Lots	1.03	N/A	N/A
< 92% G_{mm}	5.3%	6.6%	11.0%

"Gold Medal" Density (%G_{mm}) Specifications
Specification / Criteria / Results

	AK	IN	ME	MI	NJ	MO	NY	PA	PRHTA
Type of Specification	PWL	PWL	PWL	PWL	PD	PWL	PWL	PWL	PWL
Limits (% G_{mm})	93.0 to 100.0	93.0 to 100.0	92.5 to 97.5	92.5 to 100.0	92.0 to 98.0	92.0 to 97.0	92.0 to 97.0	92.0 to 98.0	92.0 to 99.0
Incentive for Only Density	5.0%	1.75%	2.5%	2.0%	4.0%	1.25%	5.0%	2.0%	2.5%
Max. Incent. (% G_{mm})	≈96.0		≈93.5	≈94.5		≈94.5	≈94.0	≈94.0	≈94.0
Avg. (% G_{mm})	94.9	93.9	94.5	94.4	94.9	93.7	94.2	94.4	94.6
Std. Dev. of Lots	1.76		1.20	1.03			1.01	1.46	
< 92% G_{mm}	5.6%	8.4%	5.8%	5.5%	5.4%	5.0%	5.0%	3.1%	3.6%

Gold Medal Density (% G_{mm}) Specifications
Specification/Criteria/Results

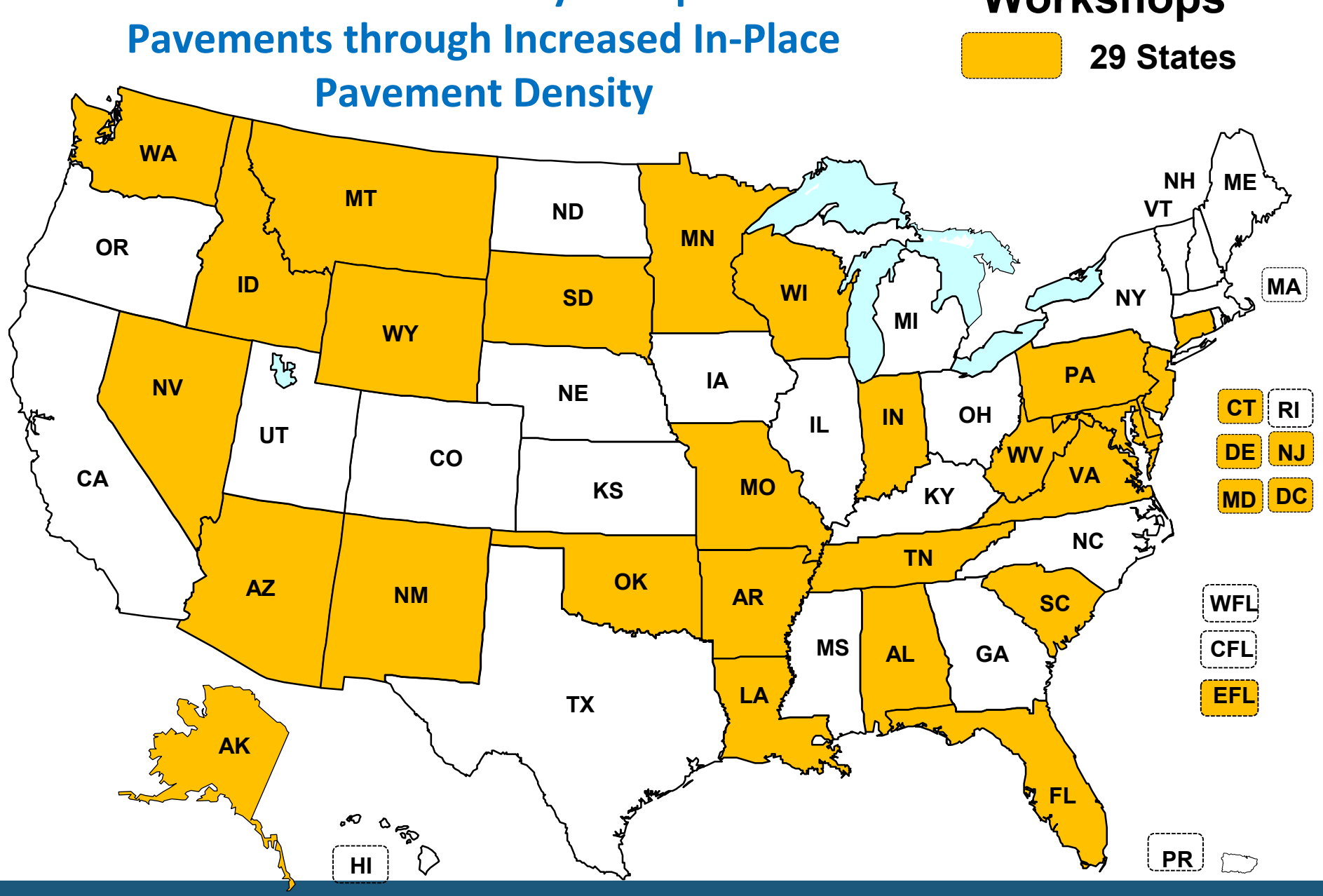
Longitudinal Joint

	AK	IN	ME	MI	MT	NY	PA	TN
Type of Specification	Lot Avg.	Method	PWL	Lot Avg.	Lot Avg.	Under Development	PWL	Lot Avg.
Limits (% G_{mm})	>91.0	Long. Joint Sealant (LJS) and fog seal	>91.0	>90.5	>91.0 >92.0 for incentive		>90.0	>91.0
Incentive for Only Joint Density	$1.50 per L.F. (≈6.25%)		2.0%	$1.00 per L.F. (≈4.0%)	$4.50 per L.F.		$5000 per Lot (≈2.5%)	1.25%

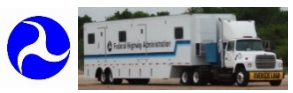
Achieving Increased In-place Density

1. Density is Important
2. Gold Medal Examples
3. **Density Demonstration Projects**
4. Agency Specification Changes

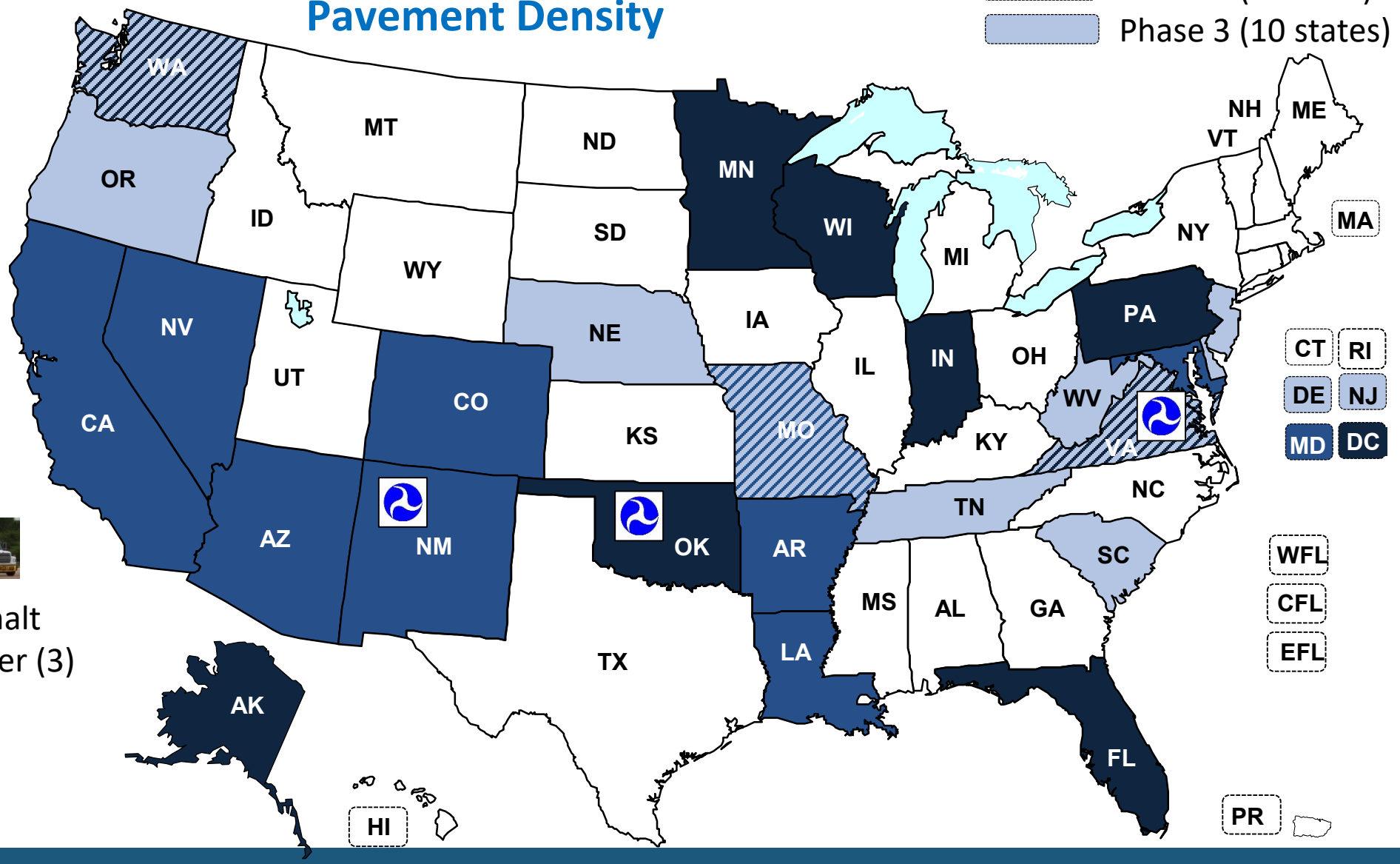
Enhanced Durability of Asphalt Pavements through Increased In-Place Pavement Density



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



Mobile Asphalt Testing Trailer (3)



Demonstration Project Status

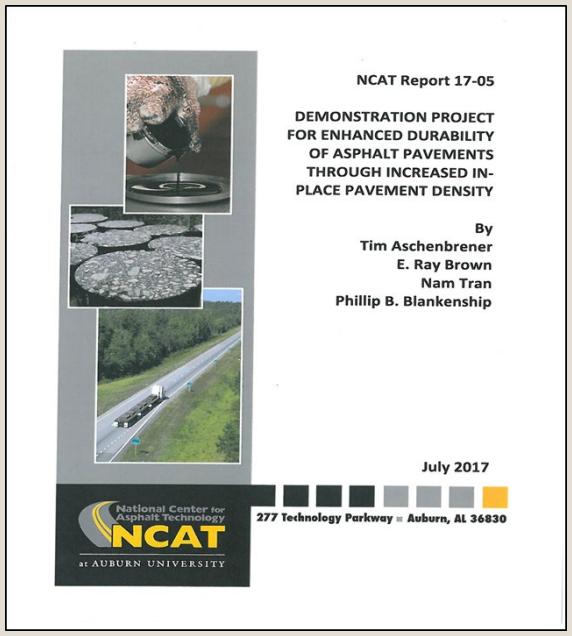
Phase	Year	States	Constructed	State Reports Completed	FHWA Summary Report	Additional Information
1	2016	10	10	10	July 2017	Literature Review
2	2017-2018	8	8 (2 re-do's)	7	July 2019	Gold Medal Specifications
3	2018-2019	11	11	10		Contractor Techniques & SHA Changes

Updated: December 1, 2019

Summary Reports

Phase 1

- NCAT Report 17-05
- July 2017



Report Phase 1:

- http://eng.auburn.edu/research/centers/ncat/files/technical-reports/rep17-05.pdf

Report Phase 2:

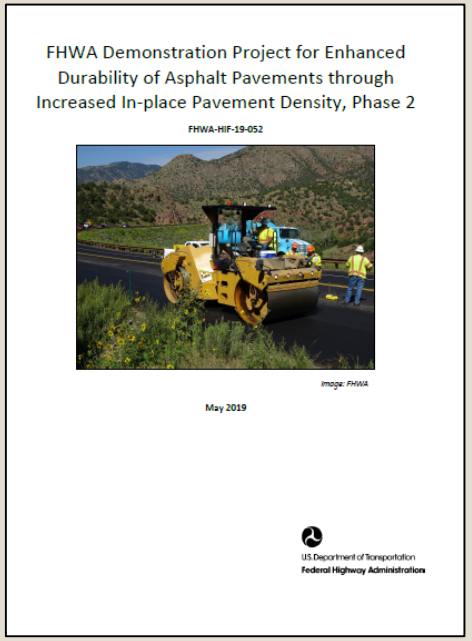
- https://www.fhwa.dot.gov/pavement/asphalt/pubs/hif19052.pdf

FHWA density website:

- https://www.fhwa.dot.gov/pavement/asphalt/density/index.cfm

Phase 2

- FHWA Report HIF-19-052
- NCAT Report 19-02
- July 2019



Number of Experimental Sections

	Number To Date
SHAs	26
Demonstration Projects	29
Control Sections	35
Test Sections	86
Experimental Sections	121

Each demonstration project had an average of 4.2 experimental sections.

Can We Achieve Increased In-place Density?

YES!

- Test sections had increased density (% Gmm):
- 17 of 28 demonstration projects achieved ≥ 1.0% increase
- 22 of 28 demonstration projects achieved ≥ 94.0% Gmm
- 23 of 28 had either/or

Of 26 states, will there be changes?

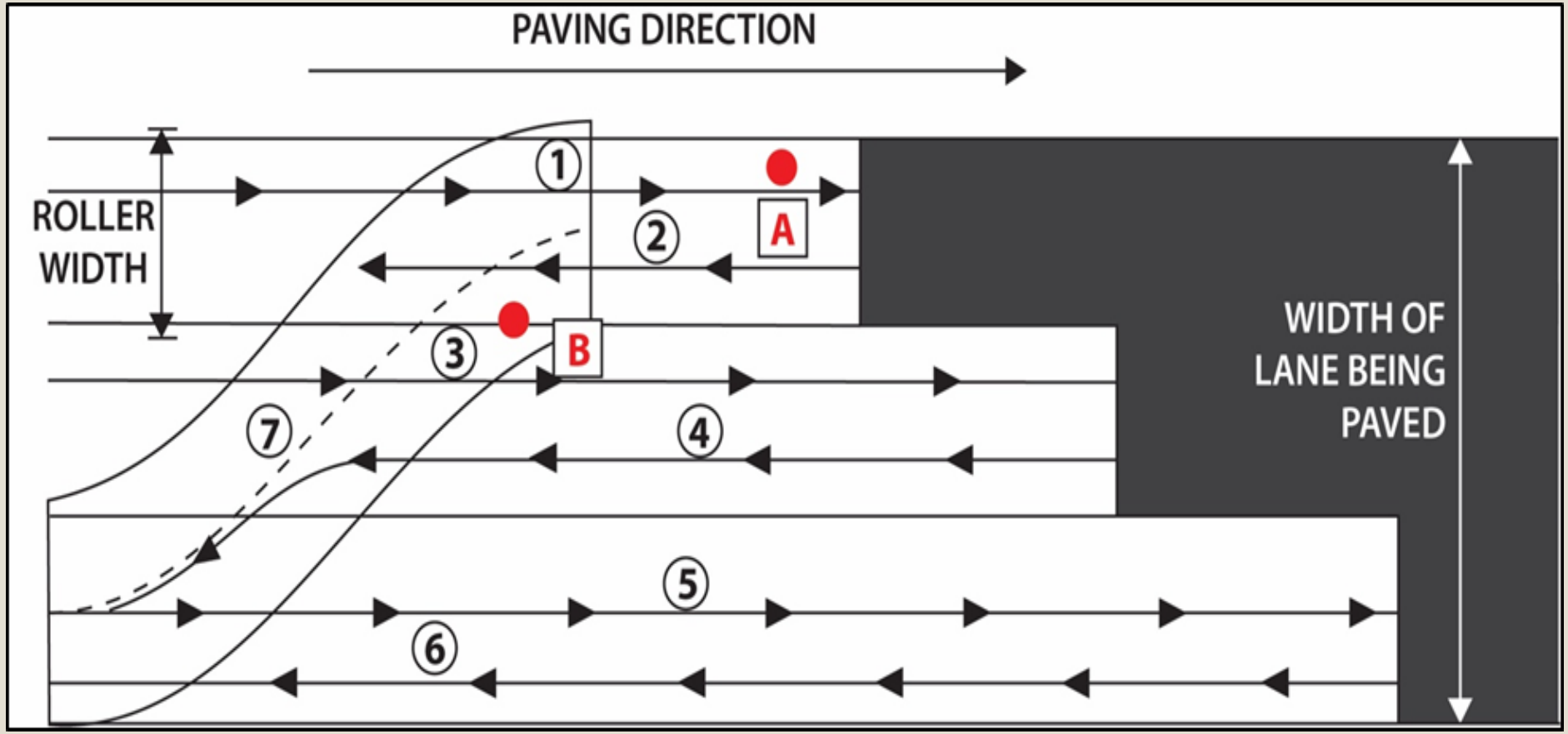
- 24 of 26 states are changing specifications

What Changes Were Made to Increase Density?

- Contractor Changes
  - More passes / more rollers / type / location
    - "Roll until you meet density requirements"
    - Some were using 1 roller
    - Pneumatic / Oscillation / Combination
    - Echelon
- Agency Changes
  - Adjusting optimum asphalt content
  - Larger t/NMAS
  - Smaller NMAS
  - Innovative materials / techniques

Courtesy Miguel Montoya

Defining Passes



Point	Passes
A	2
B	5
This Study	7

Contractor Changes
Overall Passes

28 Demonstration Projects (DP)

Passes	No. of DP	% of DP
< 15	9	32%
15 to 20	9	32%
>20	10	36%

No. of rollers ranged from:
1 to 5
Passes ranged from:
9 to 33

18 Demonstration Projects (DP)

Added Passes (Avg.)	Increased Density (% G_{mm}) (Avg.)
6.4	1.2%

Contractor Changes
Roller Type and Position

Roller Type / Position (No. of DP)	Test Sections	Increased Density (% G_{mm}) (Avg.)
Breakdown in Echelon (10)	26	Very effective
Pneumatic (11)	22	Varied
Oscillation (7)	11	Varied
Vibratory Pneumatic (2)	2	+2.2%
Combination Roller (1)	2	+2.0%
Tighter / Consistent Pattern (2)	2	S.D. cut in half

Courtesy Miguel Montoya

3 Photos Courtesy NCAT

Agency Changes
NMAS and t/NMAS

NMAS (mm)	Demonstration Projects
9.5	8
12.5	20
19.0	6

t/NMAS	Demonstration Projects
< 3.0	2
3.0 to 3.9	6
4.0 to 4.9	20
≥ 5.0	5

4 SHAs had test sections with 9.5 mm NMAS

Agency Changes
t / NMAS

4 Demonstration Projects
5 Test Sections

	t / NMAS			Increased Density (% G_{mm}) (Avg.)
	Control	Test	Δ	
P2-S5	4.0	3.5	0.5	(>94.0)
P3-S8	2.5	3.0	0.5	0.0
P1-S3	3.0	4.0	1.0	0.0
P1-S4	3.5	4.7	1.2	+1.2
P3-S8	2.5	4.0	1.5	+1.0

Agency Changes
Adjusting Optimum Asphalt Content

Demonstration Project	Control Section Density (%Gmm)	Asphalt Added	Test Section Density (%Gmm)	Change in Density (%Gmm)
P1-S3	92.9	0.3	93.5	+0.6
P1-S4	93.5	0.3	94.6	+1.1
P1-S5	92.5	0.3	95.2	+2.7
P2-S2	92.2	0.2	94.5	+2.3
	95.6	0.2	95.9	+0.3
P2-S4	95.8	0.2	96.5	+0.7
	95.7	0.2	97.1	+1.4
P2-S5	92.0	0.7	95.0	+3.0
	92.0	0.1	93.7	+1.7
P2-S7	92.8	0.2	94.5	+1.7
P3-S2	92.6	0.2	94.9	+2.3
	92.6	0.6	95.8	+3.2
P3-S3	91.3	0.5	90.7	-0.6
P3-S4	TBD			
P3-S6	94.5	0.2	95.1	+0.6
P3-S7	91.9	0.2	91.9	0.0
Average		0.29		+1.4

12 Demonstration Projects
16 Test Sections

Avg. Increased Asphalt Content
= 0.3%

Avg. Increased Density (%G_{mm})
= 1.4%

Keys to Adjusting Optimum Asphalt Content

- Mixture design (e.g., gyrations / air voids / VMA / others)
- Performance testing (e.g., rutting, cracking, moisture damage)
- Acceptance
- In-place density requirement

- These are all related:
  - Consider systematic changes

Agency and Contractor Changes
New Technologies

- **Warm Mix Asphalt (5 Demonstration Projects)**
  - At lower production temperatures
    - 2 projects: no change in density
  - At normal production temperatures
    - 1 project: 3.0% increase in density (92.2 to 95.2%)
    - 1 project: no change in density, but 2 fewer passes per roller
    - 3 projects: no change in density, but already >94%

Achieving Increased In-place Density

1. Density is Important
2. Gold Medal Examples
3. Density Demonstration Projects
4. **Agency Specification Changes**

Agency Specification Changes (1 of 4)

- Primary Density Specification (3)
  - Used more often
  - Improved secondary density specification
- Quality Measure (5)
  - Mathematical tools that are used to quantify the level of quality of an individual quality characteristic
    - PWL
    - Lot average
    - AAD
- Specification Limit (14)
  - Upper limit
  - Lower limit

(#) – Number of States making changes or in the process

Agency Specification Changes (2 of 4)

- Acceptance Plan
  - Process for evaluating the acceptability of a lot of material
  - Standard Deviation (7)
  - Lot / Sublot Size (2)
  - Incentive / Disincentive (7)
  - Quality Characteristics (1)

(#) – Number of States making changes or in the process

Agency Specification Changes (3 of 4)

- Quality Control of Aggregates (1)
- t / NMAS (3)
- Longitudinal Joint Density (4)
- Testing Methodologies (2)

(#) – Number of States making changes or in the process

Agency Specification Changes (4 of 4)

- Mix Design: Increasing Asphalt (14)
- Mix Design: Performance Testing (10)
- New Technology (5)

(#) – Number of States making changes or in the process

State 4:
Cost / Benefit of Best Practices

- Benefit of 1% Density Increase
  10 percent of $60 / ton mix = $$$$$$

- Cost of 1 Percent Density Increase
  Additional rollers ≤ $
  Additional binder ≤ $$
  (AVR to 3%)
  WMA Additive ≤ $
  9.5mm vs. 12.5mm ≈ $$

Image: Pixabay; text added

Key Findings

- Level of field compactive effort varies greatly
- No extraordinary field compactive effort needed
  - Specification (quality measure, limits, incentives, etc.)
  - Smaller NMAS
  - Larger t/NMAS
  - Adequate binder content
- All Together:
  - Mixture design with appropriate asphalt content
  - Performance testing
  - Acceptance
  - In-place density

Next Steps

- Field experiment – Phase 3 Report
  - Final review
- FHWA's best practices communication
  - 4 Tech Briefs
  - Focused visits in 2020
  - Additional workshops (funding dependent)

Image: Pixabay

Thank you

QUESTIONS / COMMENTS:

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