FHWA's Demonstration Project for Enhanced Durability Through Increased Density

Phase 2 and Where Do We Go from Here

Courtesy Asphalt Institute

TIM ASCHENBRENER, P.E.
SENIOR ASPHALT PAVEMENT ENGINEER
PAVEMENT MATERIALS TEAM
OFFICE OF PRECONSTRUCTION, CONSTRUCTION AND PAVEMENTS
FHWA

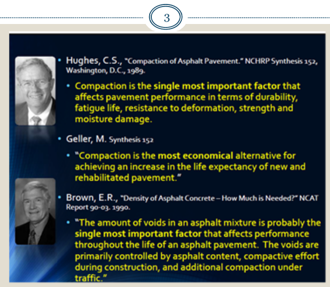
Achieving Increased In-place Density

2

1. **Density is Important**
2. Gold Medal Examples
3. Density Demonstration Projects

Density Is Important

3



From an FHWA document

Reasons for Obtaining Density

4

FHWA photo

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

Density is important, but not a cure-all

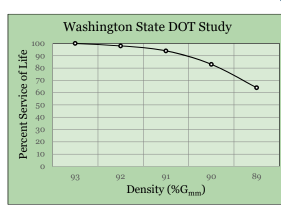
National Center for Asphalt Technology (NCAT) Report 16-02 (2016) (Funded by FHWA)

5

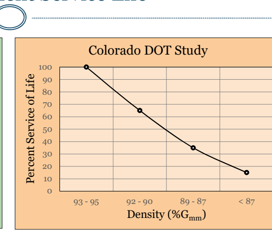
"A **1% decrease in air voids** was estimated to:
- **improve fatigue** performance by 8.2 and 43.8%
- **improve the rutting** resistance by 7.3 to 66.3%
- **extend the service life** by conservatively 10%"

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

How Much Density (%G_{mm}) is Enough? Loss of Pavement Service Life



Thicker Pavements TRR 1217, 1989

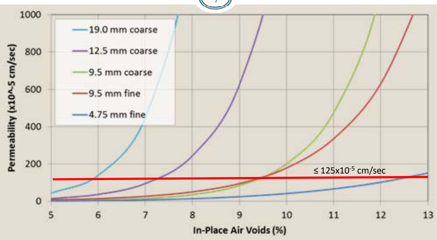


Typical Pavements CDOT 2013-4, 2013

Reduced in-place density at the time of construction results in significant loss of service life!

How Much Density (%G_{mm}) is Enough? NCAT Permeability Study

7



Finer NMAS mixes generally less permeable at equivalent air void levels!

From NCAT Report 03-02

Achieving Increased In-place Density

8

1. Density is Important
2. **Gold Medal Examples**
3. Density Demonstration Projects

Some "Gold Medal" Density (% G_{mm}) Specifications Purpose

9

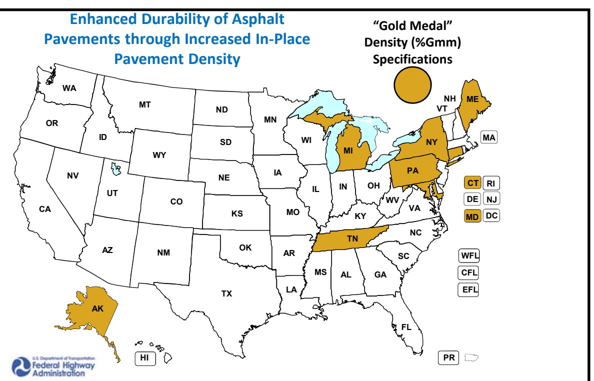
- Identify density (% G_{mm}) specifications that are success stories.
- Since this is an Olympic year, these success stories are considered "gold medal" examples.

Image Pixabay

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

- Alaska DOT&PF
- Maine DOT
- Maryland DOT SHA
- Michigan DOT
- New York State DOT
- Pennsylvania DOT
- Tennessee DOT

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



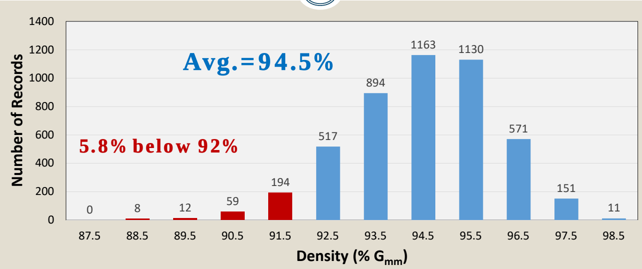
Gold Medal Density (% G_{mm}) Specifications Project Information

12

	State D	AK	ME	MD	MI	NY	PA	TN
Year(s) of Data Analyzed	2016	2015	2013 to 2017	2017	2015	2017	2017	2015 to 2017
Mix Type	Type C	Type II 19mm & Superpave 12.5 mm	9.5, 12.5 and 19 mm	Dense Graded	9.5, 12.5 and 19 mm	Series 50 9.5, 12.5 and 19 mm	High level wearing surface 9.5, 12.5 & 19mm	D-mix (3/8" NMAS)
Type of Projects	N/A	Interstate and principal arterial	All mainline projects		All projects> 5,000 tons	Full or partially controlled roadways		Interstate and SR Freeways
Acceptance Testing	Agency only	Agency only	Agency only	Contractor validated by agency	Agency only	Agency only	Agency only	Agency only

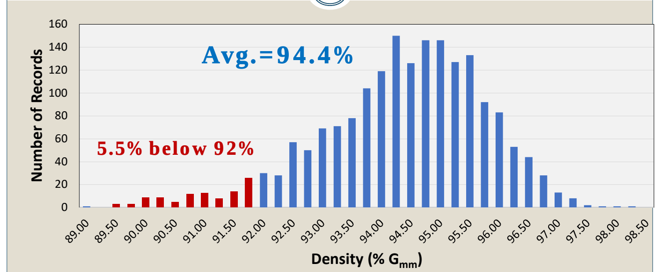
Maine DOT
Statewide Results 2013 to 2017

13



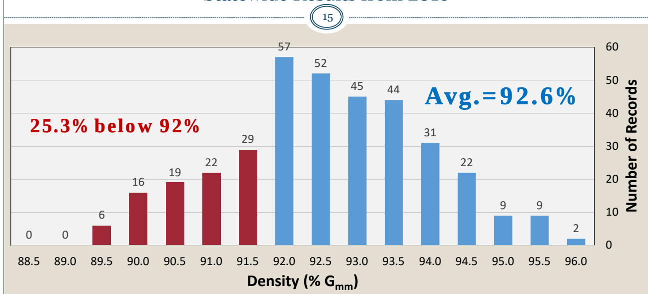
Michigan DOT
Statewide Results from 2015

14



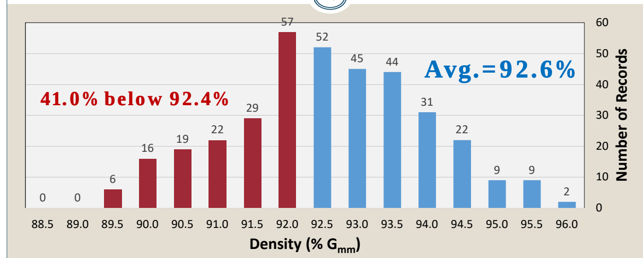
State D
Statewide Results from 2016

15



State D
Statewide Results from 2016

16



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

17

	State D	AK	ME	MD	MI	NY	PA	TN
Type of Specification		PWL	PWL		PWL	PWL	PWL	
Limits (% G_{mm})		93.0 to 100.0	92.5 to 97.5		92.5 to 100.0	92.0 to 97.0	92.0 to 98.0	
Incentive for Only Density		5.0%	2.5%		2.0%	5.0%	2.0%	
Max. Incent. (% G_{mm})		≈96.0	≈93.5		≈94.5	≈94.0	≈94.0	
Avg. (% G_{mm})		94.9	94.5		94.4	94.2	94.4	
Std. Dev. of Lots		1.76	1.20		1.03	1.01	1.46	
< 92% G_{mm}		5.6%	5.8%		5.5%	5.0%	3.1%	

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

18

	State D	AK	ME	MD	MI	NY	PA	TN
Type of Specification		PWL	PWL		PWL	PWL	PWL	Lot Avg.
Limits (% G_{mm})		93.0 to 100.0	92.5 to 97.5		92.5 to 100.0	92.0 to 97.0	92.0 to 98.0	92.0 to 97.0
Incentive for Only Density		5.0%	2.5%		2.0%	5.0%	2.0%	2.0%
Max. Incent. (% G_{mm})		≈96.0	≈93.5		≈94.5	≈94.0	≈94.0	94.0
Avg. (% G_{mm})		94.9	94.5		94.4	94.2	94.4	93.9
Std. Dev. of Lots		1.76	1.20		1.03	1.01	1.46	N/A
< 92% G_{mm}		5.6%	5.8%		5.5%	5.0%	3.1%	11.0%

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

19

	State D	AK	ME	MD	MI	NY	PA	TN
Type of Specification		PWL	PWL	Lot Avg. & Ind. Sublot	PWL	PWL	PWL	Lot Avg.
Limits (% G_{mm})		93.0 to 100.0	92.5 to 97.5	92.0 to 97.0	92.5 to 100.0	92.0 to 97.0	92.0 to 98.0	92.0 to 97.0
Incentive for Only Density		5.0%	2.5%	5.0%	2.0%	5.0%	2.0%	2.0%
Max. Incent. (% G_{mm})		≈96.0	≈93.5	94.0	≈94.5	≈94.0	≈94.0	94.0
Avg. (% G_{mm})		94.9	94.5	94.0	94.4	94.2	94.4	93.9
Std. Dev. of Lots		1.76	1.20	1.03	1.03	1.01	1.46	N/A
< 92% G_{mm}		5.6%	5.8%	5.3%	5.5%	5.0%	3.1%	11.0%

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

20

	State D	AK	ME	MD	MI	NY	PA	TN
Type of Specification	Lot Avg.	PWL	PWL	Lot Avg. & Ind. Sublot	PWL	PWL	PWL	Lot Avg.
Limits (% G_{mm})	91.5 to 95.0	93.0 to 100.0	92.5 to 97.5	92.0 to 97.0	92.5 to 100.0	92.0 to 97.0	92.0 to 98.0	92.0 to 97.0
Incentive for Only Density	1.5%	5.0%	2.5%	5.0%	2.0%	5.0%	2.0%	2.0%
Max. Incent. (% G_{mm})	92.75	≈96.0	≈93.5	94.0	≈94.5	≈94.0	≈94.0	94.0
Avg. (% G_{mm})	92.6	94.9	94.5	94.0	94.4	94.2	94.4	93.9
Std. Dev. of Lots	N/A	1.76	1.20	1.03	1.03	1.01	1.46	N/A
< 92% G_{mm}	25.3%	5.6%	5.8%	5.3%	5.5%	5.0%	3.1%	11.0%

Gold Medal Density (% G_{mm}) Specifications
Testing and Frequency

21

	State D	AK	ME	MD	MI	NY	PA	TN
Lot Size (tons)	2,000	5,000	4,500	Day's production	5,000	1,000	2,500	1,000
Sublots per Lot	8	10	6	5 min.	5	4	5	5
Frequency (tons)	250	500	750	500 max.	1000	250	500	200
Measuring G_{mb}	6-in. cores 1 per sublot	6-in. cores 1 per sublot	6-in. cores 1 per sublot	4 or 6-in. cores 2 per sublot	6-in. cores 1 per sublot	6-in cores 1 per sublot	6-in cores 1 per sublot	4 or 6-in. cores 1 per sublot
Measuring G_{mm}	Avg. of 5 tests: every 500 tons	Individual test: 1 per lot	Individual test: 1 per sublot	Individual test: Daily value	Individual test: 1 per sublot	Ind. test: 1 per lot	Individual test: Daily value	Daily Avg.: 2 tests per day

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

22

Longitudinal Joint

	State D	AK	ME	MD	MI	NY	PA	TN
Type of Specification	None	Lot Avg.	PWL	None	Lot Avg.	Under Development	PWL	Lot Avg.
Limits (% G_{mm})	---	>91.0	>91.0	---	>90.5	---	>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%)	---	$5000 per Lot (≈2.5%)	1.25%

Achieving Increased In-place Density

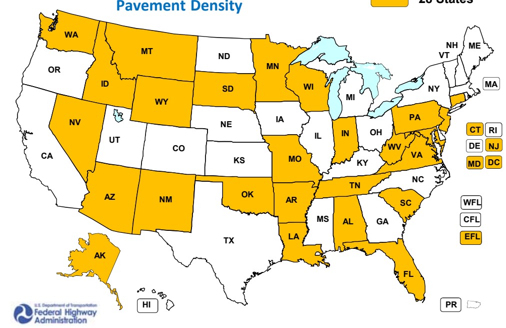
23

1. Density is Important
2. Gold Medal Examples
3. **Density Demonstration Projects**

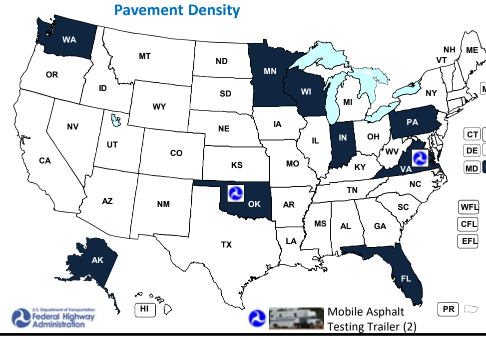
Enhanced Durability of Asphalt Pavements through Increased In-Place Pavement Density

Workshops

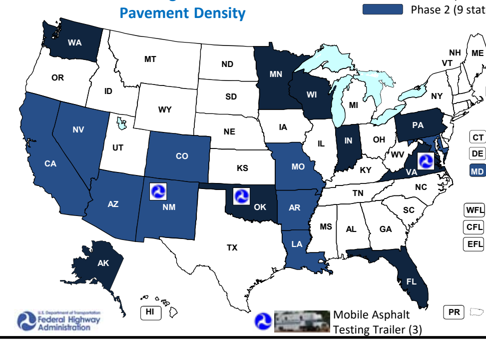
28 States



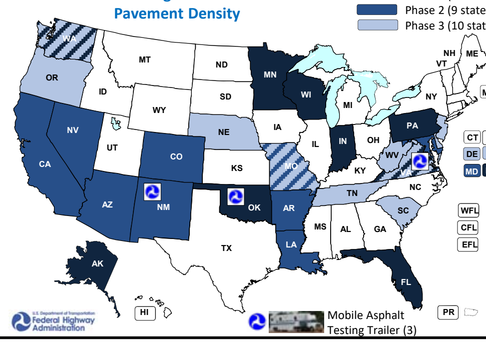
Enhanced Durability of Asphalt Pavements through Increased In-Place Pavement Density



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



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



Demonstration Project Status

28

Phase	Year	States	Constructed	State Reports	Summary Report
1	2016	10	10	10	July 2017
2	2017-2018	9	8 (2 re-do's)	2	
3	2018	10	10	0	

Updated: Nov. 1, 2018

Field Compactive Effort Control Sections

29

State ID	Total		Vibratory		Pneumatic		Echelon		Focus Area
	Rollers	Passes	Rollers	Passes	Rollers	Passes	Brkdn.	Inter.	
2	1	7	1	7	0	0	No	No	More passes
9	2	16	1	3	0	0	No	No	Oscillation
6	2	14	2	10	0	0	Yes	No	More AC
7	3	15	3	12	0*	0	Yes	No	Std. Dev.
5	3	15	2	10	1	5	Yes	No	More AC
10	2	18	2	18	0*	0	No	No	New Tech.
1	2	18	0	0	0*	0	Yes	No	Pneumatic
4	3	21	2	10	1	11	Yes	No	More AC
3	4	24	2	10	2	14	Yes	Yes	More AC and New Tech.
8	2	24	1	8	1	15	No	No	Std. Dev.

* Polymer Modified Asphalt

Density (%G_{mm}) Test Sections

30

State ID	Total		Breakdown Roller	Field Density (% G_{mm})	Δ from control	Specification	Require-ment	Incentive/ Disincentive
	Rollers	Passes						
2	1	9	No echelon	91.8	+ 0.8	Min. Sublot	92.0	D
9	2	12	No echelon	92.0	- 0.2	% Control Strip	98.0	D
6	2	14	Echelon	95.4	+ 2.1	PWL	91.0	I/D
5	3	15	Echelon	95.2	+ 2.7	PWL	92.0	I/D
7	3	15	Echelon	96.1	+ 1.7	PWL	92.0	I/D
10	2	18	No echelon	95.7	+ 0.1	PWL	92.0	I/D
8	2	24	No echelon	93.0	+ 1.0	PWL	91.0	I/D
4	4	26	Echelon	95.4	+ 1.9	Min. Lot Avg.	91.5	D
1	3	27	Echelon / No vibratory	95.4	+ 1.9	PWL	91.8	I/D
3	5	29	Echelon	94.1	+ 1.2	Min. Lot Avg.	92.0	I/D

Can We Achieve Increased In-place Density?

31

YES!

- Test sections had increased density (% Gmm):
- 8 of 10 States achieved > 1.0% increase
- 7 of 10 States achieved > 94.0% Gmm
- 6 of 10 States achieved > 95.0% Gmm

- Will there be changes?
- 8 of 10 States are changing specifications

Agency Changes (1 of 2)

32

- Measuring density (1)
- Reference density (1)
- Density of pavement to meet requirements (4)
  - Some at 90 to 91% Gmm
  - Others at 94% Gmm
- Type of specification (2)
  - 22 states use minimum lot average
  - 25 states use PWL
    - Impacts contractors' target and consistency
- Consistency (2)
  - Standard deviations <1.00 were achievable

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

Agency Changes (2 of 2)

33

- Incentives (3)
  - 37 states have incentives: range from 1 to 10%; average 2.9%
- Mixture design changes (5)
  - Many states changing Superpave to get more asphalt
  - Must also look at density specification
- New technologies (2)
  - Did not help improve density, but were a good trouble-shooting tool

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

Contractor Changes

34

- More passes
  - "Roll until you meet density requirements"
- More rollers
  - Some were using 1 roller
- Type of rollers
  - Pneumatic / Oscillation
- Location of rollers
  - Echelon
- General best practices
  - Temperature / spacing / screed

Courtesy Miguel Montoya

State 4: Cost / Benefit of Best Practices

35

- Benefit of 1 Percent Density Increase
  10 percent of $60 / ton mix = $$$$$$
- Cost of 1 Percent Density Increase
  Additional rollers ≤ $
  AVR to 3% W/binder ≤ $$
  WMA Additive ≤ $
  9.5mm vs. 12.5mm ≈ $$

Image: Pixabay; text added

Summary Document Phase 1

36

NCAT Report 17-05:
"Demonstration Project for Enhanced Durability of Asphalt Pavements through Increased In-place Pavement Density"
July 2017

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

Next Steps

37

- Field experiment – Phase 2
  - 8 of 9 states completed construction
  - 2 of 9 states completed reports
- Field experiment – Phase 3
  - 10 of 10 states completed construction
  - 0 of 10 states completed reports
- FHWA's best practices communication
  - Summary documents: Phases 2 and 3
  - Tech Brief
  - Additional workshops
    - Funding dependent

Image: Pixabay

Thank you

QUESTIONS / COMMENTS:

TIM ASCHENBRENER, P.E.
FHWA
SENIOR ASPHALT PAVEMENT ENGINEER
PAVEMENT MATERIALS TEAM
OFFICE OF PRECONSTRUCTION, CONSTRUCTION AND PAVEMENTS
LAKEWOOD, COLORADO

(720) 963-3247
TIMOTHY.ASCHENBRENER@DOT.GOV

Image Pixabay