Enhanced Durability Through Increased Density

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CORPUS CHRISTI, TEXAS

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Overall Objective

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

Our Visit

1. The Importance of % Density
2. FHWA – AI Compaction Workshop
3. Field Demonstration Projects
4. Wrap Up

Compaction is Important

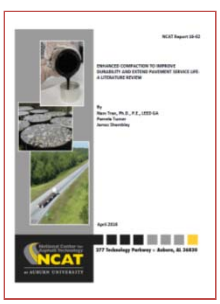
- Hughes, C.S., "Compaction of Asphalt Pavement." NCHRP Synthesis 152, Washington, D.C., 1989.
  - Compaction is the **single most important factor** that affects pavement performance in terms of durability, fatigue life, resistance to deformation, strength and moisture damage.
- Geller, M. Synthesis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

9

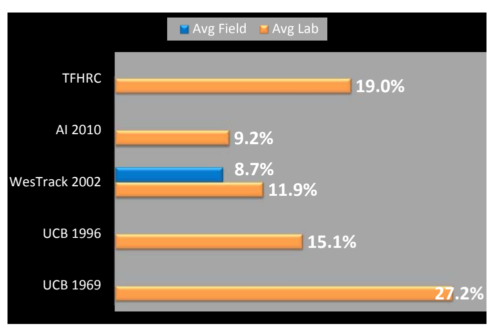
NCAT Report 16-02 (2016)

"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%."

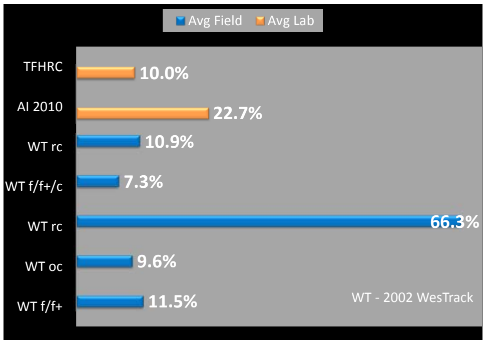


http://eng.auburn.edu/research/centers/ncat/files/technical-reports/rep16-02.pdf

Average Increase in Fatigue Life for 1% Decrease in Air Voids



Average Decrease in Rut Depth for 1% Decrease in Air Voids



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

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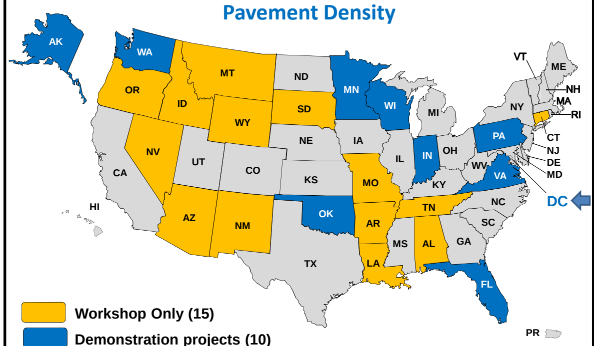
Enhanced Durability of Asphalt Pavements through Increased In-Place Pavement Density



Workshop Outline

1. Introduction
2. Mixture Factors Effecting Compaction
3. Compaction Best Practices
4. Other Best Practices
5. Measurement & Payment
6. New Technologies
7. Wrap Up

11

Workshop

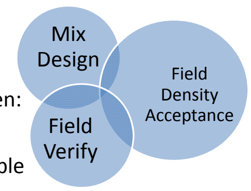
- Feedback Very Positive
  - Formal training
  - Comprehensive:
    - Mix design to
    - Finish roller to
    - Measurement and Acceptance
  - Back to the basics focus
  - Learned new topics and reinforced others
- Workshops to Date
  - 10 locations
  - > 450 participants

Our Visit

1. The Importance of Density
2. FHWA – AI Compaction Workshop
3. **Field Demonstration Projects**
4. Wrap Up

FHWA Demonstration Project Field Project Results

- 8 of 10 projects to date
- Three Key Lessons:
  1. Follow best practices
  2. Inter-relationship between:
  3. Higher density is achievable



U.S. Department of Transportation
Federal Highway Administration

State #1

Experiment	Contractor's Compactive Effort
Control	2 static rollers in echelon (≈10 passes each)
Test Section 1	Added 1 to 2 vibratory passes
Test Section 2	3 rollers – added pneumatic

State #1

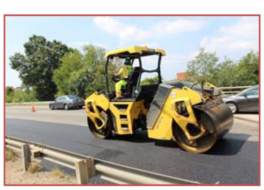
Experiment	Density Results (%)	Change
Control	93.5	---
Test Section 1	93.2	Not significant
Test Section 2	95.4	+ 1.9

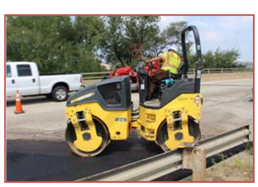
Average of 10 core densities each / Reference is G_{mm}

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

State #2

Experiment	Contractor's Compactive Effort
Control	10-ton vibratory roller (8 passes) 4-ton vibratory roller (7 passes)
Test Section	10-ton vibratory roller (10 passes) 4-ton vibratory roller (7 passes)





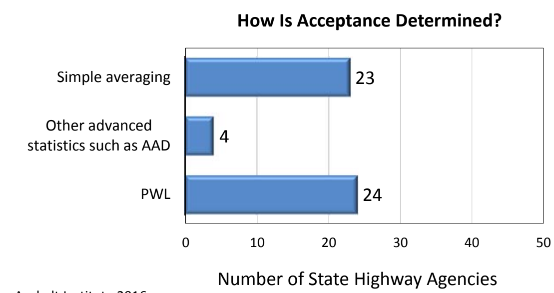
State #2

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

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

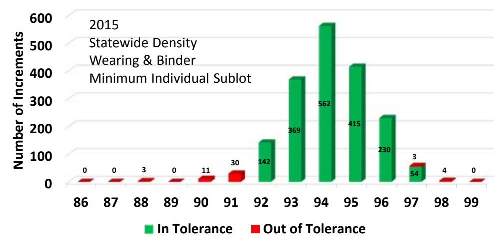
- Only 1 compaction roller needed to meet specification
- Adding 2 passes increased % density

How Is Acceptance Determined



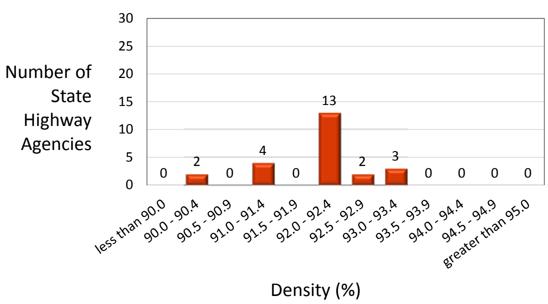
Asphalt Institute 2016

PennDOT Case Study



pennsylvania
DEPARTMENT OF TRANSPORTATION

Minimum Lot Average



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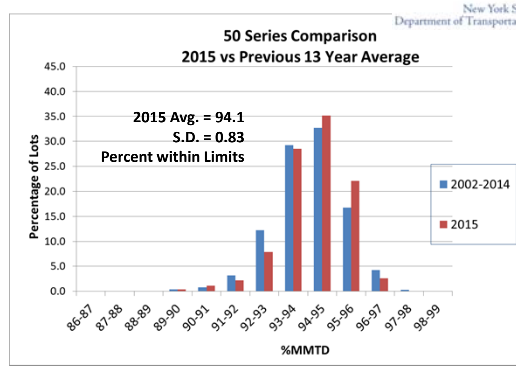
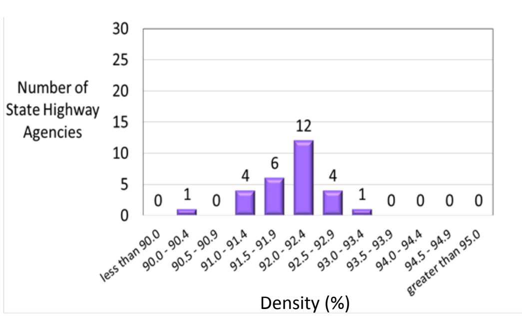
NYSDOT Case Study

New York State
Department of Transportation



PWL: Lower Specification Limit



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State #3

Experiment	Contractor's Compactive Effort
Control	4 rollers - 2 vibratory in echelon (5 to 7 passes each) - 2 pneumatic in echelon (5 to 7 passes each)
Test Section 1	5 rollers – **added 1 vibratory roller**
Test Section 2	5 rollers – **added 0.3% asphalt**

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

State #4

Experiment	Contractor's Compactive Effort
Control	2 vibratory rollers in echelon (5 passes each) 1 pneumatic roller (11 passes)
Test Section 1	Added 1 vibratory roller
Test Section 2	4 rollers Added 0.3% asphalt

State #4

Experiment	Density Results (%)	Change
Control	94.1	---
Test Section 1	94.4	+ 0.3
Test Section 2	95.3	+ 1.2

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

- Control achieved maximum incentive
- Additional roller did not change % density
- Mix design adjustment resulted in % density increase

Selecting Optimum with Superpave

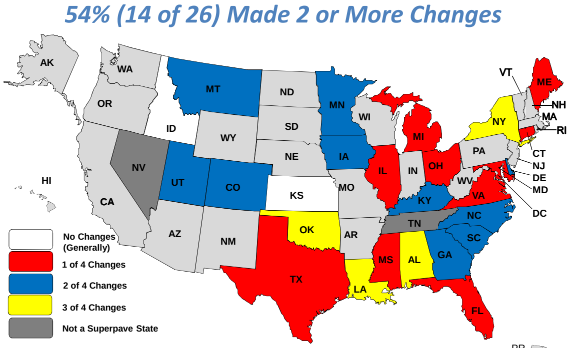
What Changes Were Made to AASHTO Standards?

- 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

Combination of Changes

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



State #5

Experiment	Contractor's Compactive Effort
Control	???
Test Section 1	4 rollers – 3 vibratory rollers in echelon 1 vibratory on joint (4 vibratory & 1 static pass)

State #5

Experiment	Density Results (%)	Change
Statewide Avg.	93.6	---
Control	94.4	---
Test Section 1	96.1	+1.7

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

- Implementing PWL specification
- Control and test section both obtained maximum incentive

State #6

Experiment	Contractor's Compactive Effort
Control	1 vibratory roller (9 passes) 1 pneumatic roller (14 to 18 passes) 1 finish roller (passes)
Test Section	Same rollers and passes **Decreased roller spacing** Increased pneumatic weight by 3 tons

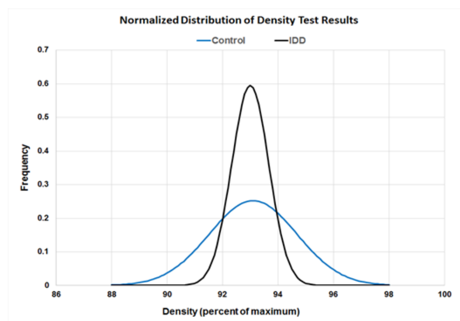
State #6

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

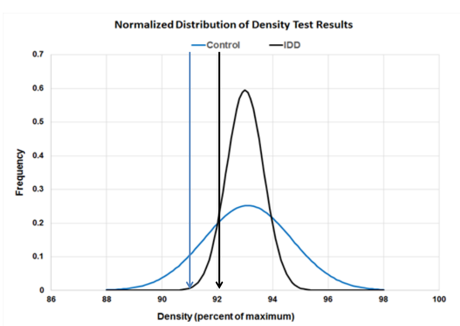
Standard deviation changes from 1.58 to 0.67 / Reference is G_{mm}

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

Percent Within Limits



Percent Within Limits



FHWA Demonstration Project Field Project Results

- 8 of 10 projects to date
- Key Lessons:
  1. Follow best practices
     - 6 of 8 increased density from control
     - 4 of 8 had equipment issues
  2. Inter-relationship between:
     - Mix design / Field mix verification / Density specification
     - 2 of 8 had “dry” mixtures
  3. Higher density is achievable:
     - Optimistically: higher density with best practices only (8 of 8)
     - Pessimistically: higher density with additional roller (4 of 8)

Our Visit

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Next Steps

- Summary report on 10 projects' construction
  - Potential follow-up on field performance
- Best practices communication
  - Summary document
  - Tech Brief
  - Additional training workshops (funding dependent)
- Potential to extend field experiment with more states
  - Dependent of funding
  - Dependent on state interest

38

Thank you

QUESTIONS / COMMENTS:

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