Dispute Resolution
National Pavement Preservation Conference

October 13, 2016
Marriott Hotel
Nashville, TN

Jon Epps
Texas A&M Transportation Institute
Texas A&M University
Outline

- **Introduction**
- Key Activities & Measurements
- Variability
- Sampling Variability
- Testing Variability
- Materials/Construction Variability
- Summary
Introduction

• Pavement Preservation Alternatives
• Common Disputes
• Resolution
Pavement Preservation Alternatives

- Fog Seal
- Slurry Seal/Micro-Surfacing
- Chip Seal
- Thin Asphalt Mixture Overlay
Common Disputes

- QC/QA Test Results (Comparisons)
- Job Mix Formula (Approval/Changes)
- Change Materials (Aggregates/Binders)
- Performance (Premature Distress)
Resolution

- Address Likely Issues Prior to Construction
- Public Agency/Contractor/Material Supplier
  - Resolve Recurring Issues
  - Pre-construction Meeting
  - Specifications – Address Dispute Resolution
  - Meetings/Information Exchange
- Performance Warranty
- Third Party
- Legal
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Key Activities & Measurement

Pre-Construction

Construction

Post-Construction
Pre-Construction

- Mixture Design
  - Aggregate Properties
  - Binder Properties
  - Additive Properties
  - Mixture Properties
  - Proportions (Job Mix Formula)
  - Verification

- Equipment Calibration
- Laboratory Accreditation
- Personnel Certification
Construction

• Process Control Tests
• Quality Control Tests
• Quality Assurance Tests
• Independent Assurance Tests
• Certifications
• Inspection
• Quality Management System
Post-Construction

- Measurement & Payment
- Final Acceptance
- Performance (Warranty)
Post Construction Performance

Project Selection
  • Type Severity, Extent of Distress
  • Thickness Design
  • Traffic
  • Constraints

Pre-Construction

Construction
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60 Asphalt Binder Contents

- Frequency

- 4.3 %: 4
- 4.5 %: 9
- 4.7 %: 14
- 4.9 %: 12
- 5.1 %: 2

- National Pavement Preservation Conference 2016
Statistical Representation of Variability

- Mean – \( \bar{x} \)
- Standard Deviation – \( s \)
- Coefficient of Variation – \( \frac{s}{\bar{x}} \)
QC/QA and Variability

Variability = variability + variability + variability

(QC/QA) (sampling) (test method) (mat./const.)

$S^2_{QC/QA} = S^2_s + S^2_t + S^2_{m/c}$
Sources of Variability

• Sampling - random variation in sampling methods or procedures
• Testing - random variation in testing performance and equipment
• Material - random natural variation
• Construction - variation inherent in production and construction methods

Sampling + testing variability = about 50% of the variation in test results
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## Effect of Number of Samples and Associated Risk

<table>
<thead>
<tr>
<th>Number of Samples (n)</th>
<th>Contractor’s Risk (α)</th>
<th>Owner’s Risk (β)</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>0%</td>
<td>84%</td>
</tr>
<tr>
<td>1</td>
<td>5%</td>
<td>50%</td>
</tr>
<tr>
<td>4</td>
<td>0%</td>
<td>16%</td>
</tr>
<tr>
<td>4</td>
<td>5%</td>
<td>2.5%</td>
</tr>
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</table>
Stratified Random Sampling

Sublot 1
Sublot 2
Sublot 3
Sublot 4

Sta 100
Sta 110
Sta 120
Sta 130
Sta 140
Point of Sampling

• Asphalt
  – Plant Tank or Middle 1/3 of Truck Load
  – Bleed off & Discard Prior to Sampling
  – Sample & Seal
Point of Sampling

- **Asphalt Content**
  - Loose Plant, Truck, Mat (entire lift), Windrow, or Paver (auger) Samples, Cores

- **Aggregate Gradation**
  - Coldfeeds or hot bins
  - Extracted from HMA (loose samples or cores)

- **Lab Compacted Volumetrics**
  - Loose Plant, Truck, Mat (entire lift), Windrow, or Paver (auger) Samples
Effect of Sampling Location on Gradation Variability

![Graph showing the effect of sampling location on gradation variability.](image)

- **Sieve Size:** 3/4", 1/2", 3/8", #4, #8, #16, #30, #50, #100, #200
- **Categories:** Coldfeeds (n=45), Loose HMA (n=45), Cores (n=46)

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**Standard Deviations**

- **Sieve Size:** 3/4", 1/2", 3/8", #4, #8, #16, #30, #50, #100, #200

**Legend:**
- Coldfeeds (n=45)
- Loose HMA (n=45)
- Cores (n=46)
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Within Laboratory Precision - (Single Operator Precision)

<table>
<thead>
<tr>
<th>Designations</th>
<th>Description</th>
<th>Single Operator Precision</th>
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<tr>
<td></td>
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<td>Standard Deviation (1S)</td>
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<td></td>
<td>AASHTO</td>
</tr>
<tr>
<td>T228</td>
<td>D70</td>
<td>Asphalt Cement Specific Gravity</td>
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<tr>
<td>T85</td>
<td>C127</td>
<td>Coarse Aggregate Specific Gravity</td>
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<tr>
<td>T84</td>
<td>C128</td>
<td>Fine Aggregate Specific Gravity</td>
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<tr>
<td>T166</td>
<td>D2726</td>
<td>Bulk Specific Gravity of Compacted Bituminous Specimens</td>
</tr>
<tr>
<td>T209</td>
<td>D2041</td>
<td>Theoretical Maximum Specific Gravity of Bituminous Mixture</td>
</tr>
</tbody>
</table>

* - “Duplicate specific gravity results by same operator should not be considered suspect unless differ more than 0.02.”

( ) - supplemental procedure for mixtures containing porous aggregate conditions ("dryback procedure").
**Within Laboratory Precision - (Single Operator Precision)**

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<th>Single Operator Precision</th>
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<tr>
<td></td>
<td></td>
<td>Standard Deviation (1S)</td>
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<tr>
<td>AASHTO Method</td>
<td></td>
<td>AASHTO</td>
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<tr>
<td>T228</td>
<td>Asphalt Cement Specific Gravity</td>
<td>0.0008</td>
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<tr>
<td>T85</td>
<td>Coarse Aggregate Specific Gravity</td>
<td>0.009</td>
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<tr>
<td>T84</td>
<td>Fine Aggregate Specific Gravity</td>
<td>0.011</td>
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<tr>
<td>T166</td>
<td>Bulk Specific Gravity of Compacted Bituminous Specimens</td>
<td>*</td>
</tr>
<tr>
<td>T209</td>
<td>Theoretical Maximum Specific Gravity of Bituminous Mixture</td>
<td>0.0040 (0.0064)</td>
</tr>
</tbody>
</table>

* - “Duplicate specific gravity results by same operator should not be considered suspect unless differ more than 0.02.”
( ) - supplemental procedure for mixtures containing porous aggregate conditions (“dryback procedure”).
**Duplicate specific gravity results by the same operator should not be considered suspect unless they differ more than 0.02.**

( ) - supplemental procedure for mixtures containing porous aggregate conditions ("dryback procedure").
Monte Carlo Simulation

%AV = 100 \times \frac{G_{mm} - G_{mb}}{G_{mm}}

G_{mm} and G_{mb} = inputs
%AV = output

G_{mm} Distribution
Same G_{mm} Distribution
G_{mb} Distribution

%AV Distribution
Summary and Conclusions

- “Acceptable” Variability Associated with the Measurement of the Properties Required to Determine HMA Volumetrics can Have a Significant Impact on Calculated Volumetric Properties
Summary and Conclusions

• Within Laboratory Test Method Variability May Lead to Differences in AV and VMA of 1.0±% for Any Given Mix Design

• These Differences Translate into Potential Differences of 0.7% in Optimum Asphalt Content Selection
Summary and Conclusions

- Between Laboratory Test Method Variability May Lead to Differences in AV and VMA of over 2.0% for Any Given Mix Design

- These Differences Translate into Potential Differences of Over 1.0% in Optimum Asphalt Content Selection
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- Material - random natural variation
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## Typical Variability

<table>
<thead>
<tr>
<th>Property</th>
<th>Standard Deviation(s)</th>
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<tbody>
<tr>
<td>Asphalt Content, %</td>
<td>0.25</td>
</tr>
<tr>
<td>% pass 4.75 mm, %</td>
<td>3.0</td>
</tr>
<tr>
<td>% pass 2.36 mm to 0.15 mm, %</td>
<td>2.0</td>
</tr>
<tr>
<td>% pass 0.075 mm, %</td>
<td>0.7</td>
</tr>
<tr>
<td>Air Voids, %</td>
<td>1.0</td>
</tr>
<tr>
<td>VMA, %</td>
<td>1.5</td>
</tr>
<tr>
<td>VFA, %</td>
<td>5.0</td>
</tr>
</tbody>
</table>
Why Understand Testing Variability

• Provide quality product to our customer
• Remain in business
• Establish specification limits
• Predict pay factors
Percent within Limits

<table>
<thead>
<tr>
<th>Target Value</th>
<th>5.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limits</td>
<td>± 0.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lot</th>
<th>X</th>
<th>s</th>
<th>PWL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.0</td>
<td>0.20</td>
<td>96</td>
</tr>
<tr>
<td>2</td>
<td>4.8</td>
<td>0.20</td>
<td>84</td>
</tr>
</tbody>
</table>

Asphalt Binder Content:
- Lot 1: 5.0
- Lot 2: 4.8

Lower limit: 4.2
Upper limits: 5.4
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Fog Seal

• Asphalt Quality
  – Transverse
  – Longitudinal

• Variability of Surface
Slurry Seal/Micro-Surface

- Mix Design
- Mix Properties (Pre-Construction/Construction)
- Individual Material Properties
- Individual Mixture Quantities
  - Binder
  - Aggregate
  - Additives
- Quantities Placed
  - Transverse
  - Longitudinal
Chip Seal

• Design
• Individual Material Properties
• Quantity Placed (Aggregate/Asphalt)
  – Transverse
  – Longitudinal
Asphalt Mixture

• Mix Design
• Mix Properties
• Individual Material Properties
• Individual Mixture Quantities
• Quantity Placed
Resolution

• Solve Recurring Issues prior to Construction
  – Sample Location
  – Test Variability
  – Reasonableness of Specification
• Pre-Construction Meeting
• Specification – Clear Method for Solving Disputes
• Public Agency/Contractor/Material Supplier Meetings
• Partial Pay
• Performance Warranty
• Arbitration
• Legal
Remember...

• Time is Money
• Remove & Replace – Costly
• Owner Must Be Satisfied
Questions?