NCHRP Project 20-07 / Task 400

Effect of Elevation on Rolling Thin Film Oven Aging of Asphalt Binder

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Advanced Asphalt Technologies, LLC
Lots of Help

- Dave Anderson
- Jim Rosenberger
- Gayle King
- John Malusky
- Shauna Teclemariam
- Volunteer Labs
- Binder Suppliers
Outline

• Review Objectives
• Review Approach
• Review Findings of Statistical Analysis
• Effect of Conditioning Time of Properties of RTFOT Residue
• Present Final Experimental Design
• Update Status
Objectives

• Confirm or refute previous studies showing an elevation effect in properties of RTFOT residue

And if there is an effect and it is of engineering significance then…

• Improve the AASHTO T 240 procedure to minimize differences in physical properties of RTFOT residue obtained at different elevations.
Approach

• Perform statistical and engineering analysis of available data:
  – Western Cooperative Testing Group
  – AASHTO Resource Proficiency Samples

• Select method to minimize elevation effect

• Design, execute, and analyze an experiment to confirm viability of the selected method

• Prepare documentation
  – Recommended modifications to AASHTO T 240 with commentary
  – Report with data files
Statistical Analysis

- **Western Cooperative Testing Group**
  - 11 binders, 1 neat, 10 modified
  - 40 labs, 1 replicate
  - 441 observations
  - 12 to 6,720 ft elevation range (uniform distribution)

- **AASHTO Resource**
  - 4 binders, 2 neat, 2 modified
  - 213 labs, 2 replicates
  - 1700 observations
  - 0 to 6,295 ft elevation range (68 % below 1,000 ft)
Statistical Analysis

• Properties
  – Original G*/sinδ
  – RTFOT G*/sinδ
  – Aging Index
  – $J_{nr3.2}$
  – $R_{3.2}$
  – Mass Change
AASHTO Resource 235/236

Graphs showing the relationship between elevation (1000 ft) and various parameters:
- $G'\sin\delta$, kPa
- $J_{NR}$, 1/kPa
- Mass Change, %
- $\%R$, %
# Summary of Statistically Significant Effects

<table>
<thead>
<tr>
<th>Data Set</th>
<th>Binder</th>
<th>Type*</th>
<th>RTFOT G*/sinδ, kPa/1,000 ft</th>
<th>Aging Index</th>
<th>Mass Change, %/1,000 ft</th>
<th>Jnr, kPa⁻¹/1,000 ft</th>
<th>%R, %/1,000 ft</th>
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* N denotes neat binder, P denotes polymer modified binder
Engineering Significance of Elevation Effect: $G^*/\sin\delta$
What Are the Options?

- Modify RTFOT to condition at a constant pressure
- Relate elevation effect to other measured binder properties
- Vary RTFOT temperature with elevation
- Vary RTFOT time with elevation
Effect of Conditioning Time on RTFOT Residue Properties

- $G^*/\sin\delta$, kPa
- $J_{NR-1}$/kPa
- Mass Change, %
- % R, %
# Experimental Estimate of Additional RTFOT Conditioning Time

<table>
<thead>
<tr>
<th>Binder</th>
<th>$\Delta G^*/\sin \delta$, kPa/min</th>
<th>$\Delta G^*/\sin \delta$, kPa/1,000 ft</th>
<th>Additional Conditioning Time, min/1,000 ft</th>
<th>$\Delta J_{NR}$, kPa⁻¹/min</th>
<th>$\Delta J_{NR}$, kPa⁻¹/1,000 ft</th>
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Average = 1.9 min/1000 ft
Theoretical Estimate of Additional RTFOT Conditioning Time

Carbonyl formation rate model

\[ r_{CA} = A p^\alpha e^{\left(\frac{-E}{RT}\right)} \]

where:
- \( r_{CA} \) = carbonyl formation rate
- \( p \) = oxygen pressure
- \( T \) = temperature
- \( R \) = universal gas constant
- \( A, \alpha, \) and \( E \) are binder dependent fitting constants

Theoretical Estimate of Additional RTFOT Conditioning Time

- Assume rheological properties depend on total amount of carbonyl formed

\[
(r_{CA})_0 t_0 = (r_{CA})_h t_h
\]

\[
t_h = t_0 \left( \frac{p_0}{p_h} \right)^\alpha
\]
## Theoretical Estimate of Additional RTFOT Conditioning Time

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Experiment Design

- Elevation, ft
- RTFOT Conditioning Time, min

- Lab Testing
- Expected
Experimental Design

- 24 Labs
  - 181 ft to 7124 ft

- 8 Binders

<table>
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<th>Binder</th>
<th>Type</th>
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Experimental Design

• Each lab will condition each binder at two times based on elevation
  – 2 bottles for mass change at lab
  – 2 bottles returned to AAT for rheological testing
  – 8 RTFOT runs per laboratory

• Analysis
  – T 240 mass change
  – T 315 G*/sinδ
  – T 350 J_{nr3.2}, and R_{3.2}
Status

• Binders have been received
• Containers have been received
• Currently breaking down binders for shipment
• Expect an e-mail from me to verify shipping address and laboratory elevation
• Expect to ship binders in October