Impacts of Ignition Furnace Correction Factors in Quality Assurance

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• Unless noted otherwise, FHWA is the source for all images in this presentation.
Acknowledgements

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- Dennis Dvorak from FHWA-Resource Center
Abbreviations and Acronyms

- AASHTO – American Association of State Highway and Transportation Officials
- CF – Correction factor
- JMF – Job mix formula
- LCP – Light capital pavement
- NMAS – Nominal maximum aggregate size
- PWL – percent within limits
- UTB – Ultra-thin bonded
Why do you care?

What are you going to get out of this?

Give context for the **significant impact of errors** in correction factors for ignition furnaces

- Impacts accurate and fair **acceptance** by agencies
- Impacts **quality control** assessments by contractors
- Impacts proper and fair payment for asphalt mixtures
Why do you care?

What are you going to get out of this?

Topics for discussion:
- Background
  - AASHTO T 308
  - MaineDOT practice
- Results
  - All CF
  - CF comparisons
  - Impact on QA
    - Simulations
    - Real Lot data
Background
AASHTO T 308 – Ignition Furnace

- Used by most agencies and contractors to determine asphalt content
- Correction factor key to adjust for aggregate burn off and breakdown at high temperatures

Entity preparing ignition furnace correction factors
(Source: NCHRP 09-56)
AASHTO T 308 – Correction Factors

• “A1.1. Asphalt binder content results may be affected by the type of aggregate in the mixture and the ignition furnace. Therefore, asphalt binder and aggregate correction factors must be established by testing a set of correction specimens for each job mix formula (JMF) mix design. Correction factor(s) must be determined before any acceptance testing is completed and repeated each time a change in the mix ingredients or design occurs. Any changes greater than 5 percent in stockpiled aggregate proportions should require a new correction factor.”

• NCHRP 09-56 Variability of Ignition Furnace Correction Factors
  • “Although not recommended in the AASHTO T 308 standard, sharing correction factors between different furnaces should not be a significant problem when low correction factor aggregates (of 0.1% or less) are used. For higher mass loss aggregates (1.0% and larger), sharing correction factors should not be allowed. As the CF increases from 0.1% to 1.0%, the errors caused by sharing CFs will certainly increase.”
Background: Acceptance Sampling Practice

Sampling from the paver hopper onsite

Secured by agency personnel.

Transported by contractor to one of two MaineDOT labs

Lab #1 (Central Lab)
Lab #2 (Regional Lab)
Background: Correction Factor Practice

- Correction factor generated by MaineDOT for each ‘base’ JMF for each oven per AASHTO T 308
  - ‘Base’ considered to be aggregate and RAP skeleton and binder aim – can vary binder grade, additives, etc.
- Lab batches two samples for design using component aggregate, virgin binder content, and RAP
  - Actual binder mass added is recorded and used.
- One sample is split into four AASHTO T308 tests and correction factor generated from average of four samples
- Second sample is shipped to second lab for their potential use in dispute process – split and tested a similar way in another oven.
Unique Data Analysis Opportunity

- Database containing the following:
  - Mix design
  - Date correction factor performed
  - Laboratory
  - Oven ID
  - Correction factor

- Opportunity to:
  - Analyze distribution of correction factors
  - Compare CF between labs and oven generated using same process

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<th>REF ID</th>
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Unique Data Analysis Opportunity

### This study:

<table>
<thead>
<tr>
<th>Mix Design</th>
<th>Same</th>
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<tr>
<td>CF generation procedure</td>
<td>Same</td>
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<tr>
<td>Oven manufacturer</td>
<td>Same</td>
</tr>
<tr>
<td>Staff training</td>
<td>Same</td>
</tr>
<tr>
<td>Oven</td>
<td>Different</td>
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<tr>
<td>Laboratory</td>
<td>Different</td>
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</tbody>
</table>

### Real life:

<table>
<thead>
<tr>
<th>Mix Design</th>
<th>Same</th>
</tr>
</thead>
<tbody>
<tr>
<td>CF generation procedure</td>
<td>Different</td>
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<tr>
<td>Oven manufacturer</td>
<td>Different</td>
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<tr>
<td>Staff training</td>
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<tr>
<td>Laboratory</td>
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</tr>
</tbody>
</table>

This is a best-case scenario for CF differences....
Results
Correction Factor Distribution

- 2018-2022
- Typical factors between 0.3% – 0.5%
- Clear difference between LCP and UTB
  - Impact of recycled materials, aggregate types, and fines
Correction Factor Distribution

- 2018-2022
- No clear impact of NMAS
Correction Factor Comparisons

- 75 comparisons between different furnaces for the same mixture design.
- 13 from the same lab / 62 from different labs
- Absolute differences
Difference in CF – Cumulative Distribution

- Avg. Difference = 0.10
- Median Difference = 0.07
- 75th percentile = 0.14

- Different labs saw the highest differences
Background: MaineDOT PWL Acceptance

- MaineDOT uses PWL and AASHTO pay equation (90 PWL = 1.0 pay)
- Agency-only results
- Asphalt content equals 25% of composite payfactor
- Typical lot (6 sublots) of 4500 tons at $100/ton used for cost analysis
- Asphalt content tolerance of 0.4% from mix design aim as LSL and USL

QA Impacts based upon three CF error values:
- 0.07 (Median)
- 0.10 (Average)
- 0.14 (75th percentile)
Scenarios to Simulate CF Impact

Run for positive bias and negative bias, positive shown only as example

Scenario 1:
Lot on aim with typical standard deviation (90 PWL).

Scenario 2:
Lot average 0.1% higher than target with tighter standard deviation to achieve 90 PWL.

Scenario 3:
Lot average 0.2% higher than target with tighter standard deviation to achieve 90 PWL.

Scenario 4:
Lot average 0.3% higher than target with tighter standard deviation to achieve 90 PWL.

Scenario 5:
Lot average 0.1% high with typical standard deviation.

Scenario 6:
Lot average 0.2% high with typical standard deviation.

Scenario 7:
Lot average 0.3% high with typical standard deviation.
Scenarios to Simulate CF Impact

Run for positive bias and negative bias, positive shown only as example

Scenario 1:
Lot on aim with typical standard deviation to achieve 90 PWL.

Scenario 2:
Lot average 0.1% higher than target with tighter standard deviation to achieve 90 PWL.

Scenario 3:
Lot average 0.2% higher than target with tighter standard deviation to achieve 90 PWL.

Scenario 4:
Lot average 0.3% higher than target with tighter standard deviation to achieve 90 PWL.

Scenario 5:
Lot average 0.3% higher than target with typical standard deviation.

Scenario 6:
Lot average 0.3% higher than target with typical standard deviation.

Scenario 7:
Lot average 0.3% high with typical standard deviation.

Scenarios 1-4 = Starting PWL held constant at 90 with different averages

Scenarios 5-7 = Lot standard deviation held constant with different averages
## PWL Error (Positive Bias)
- Assumes no adjustment by the contractor to Acceptance results as that cannot be simulated
- Significant effects, especially when the original average value is off the stated aim

<table>
<thead>
<tr>
<th>Change in CF</th>
<th>ΔPWL Based Per Condition</th>
<th>Scenarios 1-4</th>
<th>Scenarios 5-7</th>
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<tr>
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<td>Average Lot Asphalt Content</td>
<td>On Aim</td>
<td>Aim + 0.1%</td>
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<tr>
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<td>-1.8</td>
<td>-7.5</td>
<td>-11.8</td>
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<tr>
<td>+0.07</td>
<td>-1.8</td>
<td>4.5</td>
<td>7.8</td>
</tr>
<tr>
<td>-0.10</td>
<td>-3.6</td>
<td>-12.5</td>
<td>-19.9</td>
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<tr>
<td>+0.10</td>
<td>-3.6</td>
<td>4.9</td>
<td>9.8</td>
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<tr>
<td>-0.14</td>
<td>-7.1</td>
<td>-16.5</td>
<td>-26.4</td>
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<tr>
<td>+0.14</td>
<td>-7.1</td>
<td>4.2</td>
<td>10.1</td>
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</table>
### ΔPayment (Positive Bias)

- Assumes no adjustment by the contractor to Acceptance results as that cannot be simulated
- 1% = $4500 in scenario

<table>
<thead>
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<th>Change in Overall Lot Payment Per Condition</th>
<th>Scenarios 1-4</th>
<th>Scenarios 5-7</th>
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<tbody>
<tr>
<td></td>
<td>Average Lot Asphalt Content</td>
<td>Average Lot Asphalt Content</td>
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<tr>
<td></td>
<td>On Aim</td>
<td>Aim + 0.1%</td>
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<tr>
<td>Change in CF</td>
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<tr>
<td>+0.07</td>
<td>-0.2%</td>
<td>-1.0%</td>
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<tr>
<td>-0.07</td>
<td>-0.2%</td>
<td>0.6%</td>
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<tr>
<td>+0.10</td>
<td>-0.5%</td>
<td>-1.6%</td>
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<tr>
<td>-0.10</td>
<td>-0.5%</td>
<td>0.6%</td>
</tr>
<tr>
<td>+0.14</td>
<td>-0.9%</td>
<td>-2.1%</td>
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<tr>
<td>-0.14</td>
<td>-0.9%</td>
<td>0.5%</td>
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</table>
Actual Lot Analysis

- Three major designs evaluated with larger CF differences – 32 total lots
  - Design A (9.5mm Fine-Graded w/ RAP) – CF difference = 0.30
  - Design B (12.5 mm Coarse-Graded w/RAP) – CF difference = 0.37
  - Design C (12.5 mm Coarse-Graded w/RAP) – CF difference = 0.43

<table>
<thead>
<tr>
<th>Design</th>
<th>Average Original PWL</th>
<th>Average Altered PWL (subtract error)</th>
<th>Average Altered PWL (add error)</th>
<th>Average PWL Error</th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>70.6</td>
<td>66.9</td>
<td>43.0</td>
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<td>B</td>
<td>93.1</td>
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<td>C</td>
<td>65.8</td>
<td>45.8</td>
<td>48.1</td>
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</tbody>
</table>
Findings

- Effect of mixture type evident in CF’s for MaineDOT mixtures
- Bias observed between CF generated for different ovens if the same design
  - Range in values for Maine aggregates (0.07 – 0.14 range)
  - Differences smaller than observed than in national studies (typically with higher loss and absorptive aggregates)
- Differences in CF can cause significant impacts to Acceptance and Quality Control functions if accurate CF not generated
  - Observed in statistical acceptance program depending on the conditions
  - Effect can be made worse when production is off the aim
Thank you for your attention!

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