Outline

• Motivation
• Tests
• Participation
• Preliminary Analysis and Observations

Overview and Motivation

• Help collect data on mixture performance tests that are being considered as part of Balanced Mix Design implementation efforts
  » Understanding Test Variability
    » Within Lab
    » Between Lab
• Help test users gain experience and confidence in their ability to perform these tests
Cracking Tests Offered

- Illinois Flexibility Index Test (I-FIT)  
  ▸ AASHTO TP124-18
- IDEAL-CT  
  ▸ now ASTM D8225-19
- Overlay Tester  
  ▸ Tex-248-F

Rutting Tests Offered

- Hamburg Wheel-Tracking  
  ▸ AASHTO T324-17
- Asphalt Pavement Analyzer (APA)  
  ▸ AASHTO T340-10

Mixture Information

- 9.5 mm NMAS
- PG 64-22 Base Binder (unmodified)
- 30% RAP
- No RAS or Rejuvenator
- BMD Design
Background

- Advertisement sent out in Summer 2018
- 200 Buckets (!) sampled for the Round Robin
  - Mix Sampled from a Stockpile that had been passed through a Material Transfer Vehicle
- Plant Mix sent to participating labs
  - Q1 2019
- Requested an Excel Summary file for each lab per test in addition to the raw data
- Labs provided with detailed fabrication and testing instructions

Phase I

- All specimen fabrication performed in participating labs
  - Loose Mix Provided
  - Testing complete
  - Data summary report sent to participating labs
    - ‘Blind’ for participants
    - Lab 1, Lab 2, etc...

Participation – Phase I

<table>
<thead>
<tr>
<th>Test ID</th>
<th>Agreed to Participate</th>
<th>Data Received (as of Nov '19)</th>
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<tbody>
<tr>
<td>Hamburg</td>
<td>36</td>
<td>32</td>
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<td>23</td>
<td>19</td>
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Preliminary Analysis – Phase I

- Populate one database per test
- Tests
  - Hamburg, I-FIT, IDEAL-CT, APA
- Descriptive Statistics
  - Within and Between Labs
  - Coefficient of Variation (CV)
- Outlier Analysis
- Within Lab Repeatability
- Observations

Example Data Collection Form

Hamburg Data Analysis

- 2 replicates per laboratory
  - Two Wheel Tracks
  - Rut Depth at 10,000 passes
    - Common Failure Threshold – Unmodified Binder
  - Rut Depth at 20,000 passes
    - Test Termination
### Hamburg Rut Depth – 10,000 passes

- **Statistics**
  - N = 32
  - Mean = 3.05
  - St Dev = 0.67
  - Min = 1.97
  - Q1 = 2.62
  - Median = 2.87
  - Q3 = 3.28
  - Max = 5.01

- *CV does not include outliers*

### Hamburg Rut Depth – 20,000 passes

- **Statistics**
  - N = 32
  - Mean = 3.91
  - St Dev = 1.42
  - Min = 2.53
  - Q1 = 3.10
  - Median = 3.38
  - Q3 = 4.01
  - Max = 8.42

- *CV does not include outliers*

### APA – Data Analysis

- A full set of replicates requested per lab
  - Either 4 or 6 depending on the model of APA
- Requested both Manual (caliper) and Automated rut depths be reported
  - 9 labs reported Automated, 5 reported Manual
  - Automated data shown
APA – Summary Statistics

Statistics
- N = 9
- Mean = 2.91
- SD = 0.75
- Min = 2.20
- Q1 = 2.30
- Median = 2.81
- Q3 = 3.23
- Max = 4.55

APA – Data Analysis

- Within Lab Coefficient of Variation
  - Around 15%
- Between Lab Coefficient of Variation
  - Around 26% (automated rut depths)

I-FIT and IDEAL-CT

- I-FIT
  - 8 replicates requested per lab
  - Some sent more, some less
- IDEAL-CT
  - 5 replicates requested per lab
  - ASTM E178-16a used to identify outliers within each set
  - 90% confidence
I-FIT Data Analysis – Phase I

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<th>Lab ID</th>
<th>Flu (%)</th>
<th>Flexibility Index</th>
<th>Va (%)</th>
<th>Flexibility Index</th>
<th>Average</th>
<th>Average St Dev</th>
<th>CV (%)</th>
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<td>5.23</td>
<td>36.9</td>
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</tbody>
</table>

Example high CV dataset

- No defined outlier
- Average = 2.01
- St. Dev. = 1.53
- CV (%) = 76.1

Statistics

- N = 19
- Mean = 4.35
- StDev = 2.34
- Min = 0.75
- Q1 = 2.78
- Median = 4.41
- Q3 = 5.24
- Max = 11.52
I-FIT Data Analysis – Phase I

- Within lab repeatability
  - Average of all CV (Within Lab) – 38.3%
  - Note: Three labs with very high CV (above 70%)
    - When you exclude these three labs from the average, the average CV is 29.4%
  - NCAT Experience
    - CV for non-trimmed mean data sets
      - In the 20 to 30% range
- Between lab repeatability
  - Minus Outlier Lab
    - CV = 41.0%

Illinois Dept. of Transportation – I-FIT Round Robin Studies

- Proposed Precision Statements from IDOT
  - Single-Operator Precision – The single-operator coefficient of variation of flexibility index has been found to be 27.1%. Therefore, results of two properly conducted tests by the same operator on the same material are not expected to differ from each other by more than 75.9% of their average.
  - Multi-laboratory Precision – The multi-laboratory coefficient of variation of flexibility index has been found to be 34.1%. Therefore, results of two properly conducted tests by two different laboratories on specimens of the same material are not expected to differ from each other by more than 95.5% of their average.

IDEAL-CT Data Analysis – Phase I

<table>
<thead>
<tr>
<th>Lab ID</th>
<th>Replicates</th>
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<th>FE (J/m²)</th>
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<td>12,496</td>
<td>100.6</td>
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</tbody>
</table>
### IDEAL-CT – Summary Statistics – Phase I

- **Statistics**
  - \( N = 14 \)
  - \( \text{Mean} = 109.8 \)
  - \( \text{St Dev} = 36.6 \)
  - \( \text{Min} = 36.5 \)
  - \( \text{Q1} = 84.3 \)
  - \( \text{Median} = 108.0 \)
  - \( \text{Q3} = 130.5 \)
  - \( \text{Max} = 188.0 \)

### IDEAL-CT Data Analysis – Phase I

- **Within lab repeatability**
  - Average CV of 13 labs = 17.8%
  - NCAT Experience is this value has been around 20%

- **Between lab repeatability**
  - Average = 109.8
  - St Dev of Means = 36.6
  - CV (%) = 33.3

### Phase II – Prepared Samples

- With remaining mix, send prepared samples to the participating labs
  - I-FIT and IDEAL-CT
- Help assess the impact of specimen fabrication on test variability
Phase II – Prepared Samples

- Large volume of specimens made in the NCAT lab
  - Buckets homogenized using a quartermaster
  - Mix split into individual specimens and stored in sealed plastic bags
  - Specimens prepared by the same operator using the same oven and the same gyratory compactor
  - Each lab received a set of specimens with close to the same spread and average of air voids

IDEAL-CT – Phase I vs. Phase II

![Boxplot of CT Index](image)

<table>
<thead>
<tr>
<th>Phase</th>
<th>CV</th>
<th>N</th>
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<tbody>
<tr>
<td>Phase I</td>
<td>33.3%</td>
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<tr>
<td>Phase II</td>
<td>11.1%</td>
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</table>

I-FIT – Phase I vs. Phase II

![Boxplot of FI %](image)

<table>
<thead>
<tr>
<th>Phase</th>
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</thead>
<tbody>
<tr>
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<td>Phase II</td>
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</table>

*CV does not include outliers
Observations – Phase I vs. II

- Specimen preparation had a major impact on the variability of the IDEAL-CT results
- Specimen preparation had an effect on the I-FIT variability, but not to the degree of the IDEAL-CT
  - Mixture selected for this study had above average within-lab variability in the I-FIT test

Future Work

- Phase II summary reports to participating labs
- Final report – All Tests and Phases
- Investigation into other factors
  - Machine Effects
  - Precision statement analysis
- Additional mixes in the future?
  - You need more than one mix type for good precision statements...

THANKS!