NCAT Mixture Performance Testing Round Robin

Adam J. Taylor, P.E.

NCAT

SEAUPG 2019

Outline

- Motivation
- Tests
- Participation
- Preliminary Analysis and Observations

NCAT 2

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

NCAT 3

Cracking Tests Offered

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

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Rutting Tests Offered

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

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Mixture Information

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

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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

Test ID	Agreed to Participate	Data Received (as of Nov '19)
Hamburg	36	32
I-FIT	23	19
IDEAL-CT	15	14
APA	12	10
OT	6	1

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

Boxplot of Rut Depth - 10,000 passes

Outlier

CV = 18.1%

*CV does not include outliers

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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

Boxplot of Rut Depth - 20,000 passes

Outlier

CV = 17.5%

*CV does not include outliers

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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

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APA – Summary Statistics

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

Boxplot of Auto Rut

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APA – Data Analysis

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

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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

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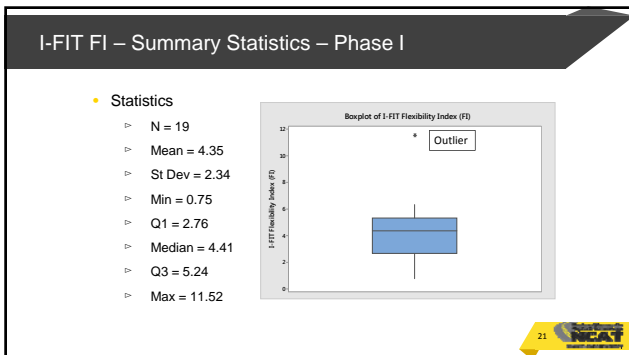
I-FIT Data Analysis – Phase I

Lab ID	Replicates	V (%) Average	Flexibility Index Average	St Dev	CV (%)
1	7	7.0	0.97	0.56	57.8
2	7	6.8	0.75	0.73	98.2
3	8	6.8	2.01	1.53	76.1
4	8	7.0	5.24	0.96	18.3
5	16	6.9	2.76	1.07	38.6
6	8	7.0	5.71	1.58	27.6
7	8	7.1	4.29	1.27	29.6
8	8	7.1	4.89	0.95	19.4
9	7	7.3	2.86	2.09	73.2
10	30	7.1	11.52	3.21	27.8
11	8	6.9	4.41	0.60	13.7
12	8	7.2	5.45	1.32	24.2
13	8	6.9	4.19	1.87	44.7
14	8	6.9	4.66	1.06	22.9
15	10	7.2	2.39	1.25	52.4
16	8	6.8	4.73	1.07	22.7
17	8	6.9	4.29	0.91	21.3
18	5	7.3	6.33	1.31	20.7
19	8	7.0	5.23	0.66	36.9

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I-FIT Data Analysis – Phase I

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

FI
0.45
1.11
0.58
0.83
2.47
3.65
2.42
4.60

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I-FIT FI – Summary Statistics – Phase I

- Statistics
  - N = 19
  - Mean = 4.35
  - St Dev = 2.34
  - Min = 0.75
  - Q1 = 2.76
  - Median = 4.41
  - Q3 = 5.24
  - Max = 11.52

Boxplot of I-FIT Flexibility Index (FI)

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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%

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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.
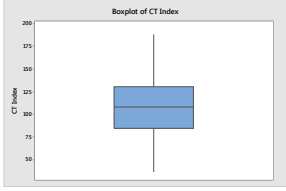
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IDEAL-CT Data Analysis – Phase I

		Va (%)	FE (J/m²)	CT Index		
Lab ID	Replicates	Average	Average	Average	St Dev.	CV (%)
1	5	7.1	12,273	117.5	22.5	19.1
2	5	7.0	11,954	82.5	13.9	16.9
3	5	7.0	13,370	113.7	29.5	26.0
4	5	6.9	6,176	36.5	13.0	35.6
5	12	7.0	11,960	100.6	15.1	15.0
6	5	7.0	12,683	97.4	13.9	14.3
7	5	6.9	12,496	144.1	22.4	15.5
8	5	7.1	12,412	74.7	12.9	17.2
9	5	7.0	12,452	126.0	23.0	18.2
10	5	7.0	12,265	84.9	14.7	17.3
11	5	6.9	11,471	102.2	15.3	14.9
12	5	7.0	14,937	188.0	25.2	13.4
13	5	6.8	10,539	122.1	13.7	11.2
14	5	7.1	13,475	146.6	21.0	14.3

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IDEAL-CT – Summary Statistics – Phase I

- Statistics
  - N = 14
  - Mean = 109.8
  - St Dev = 36.6
  - Min = 36.5
  - Q1 = 84.3
  - Median = 108.0
  - Q3 = 130.5
  - Max = 188.0

Boxplot of CT Index

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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

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Phase II – Prepared Samples

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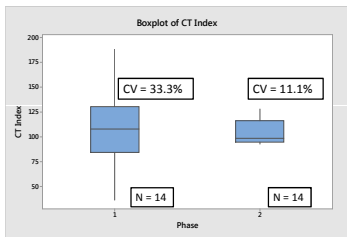- Help assess the impact of specimen fabrication on test variability
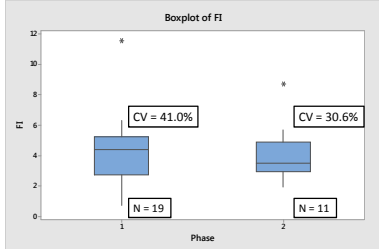
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Phase II – Prepared Samples

- 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

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IDEAL-CT – Phase I vs. Phase II

Boxplot of CT Index

CV = 33.3%   CV = 11.1%

N = 14   N = 14

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I-FIT – Phase I vs. Phase II

Boxplot of FI

CV = 41.0%   CV = 30.6%

N = 19   N = 11

*CV does not include outliers

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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!

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