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Northeast Balanced Mix Design Working Group:
Overview and Round Robin Results

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Northeast Balanced Mix Design Working Group

Mission Statement:

The Northeast Balanced Mixture Design Working Group is dedicated to advancing durable, sustainable, and resilient asphalt mixtures through the collaborative development of balanced mixture design in the Northeast region. Our mission is to foster collaboration, knowledge-sharing, and best practices among professionals in the asphalt materials community for responsible implementation of balanced mix design.

Northeast Balanced Mix Design Working Group

Objectives:

1. **Promote Standardization:** Advocate for the establishment of standardized BMD protocols and specifications (where appropriate) that can be more uniformly applied across the Northeast, providing clarity and consistency for industry practitioners.
2. **Collaborate with Stakeholders:** Forge partnerships with academia, industry associations, and material suppliers to create a collaborative network focused on the effective integration of BMD in construction projects in the Northeast region.
3. **Facilitate Knowledge Exchange:** Create platforms for the exchange of knowledge and experiences among states, fostering a community-driven approach to overcoming implementation challenges and optimizing BMD applications.

Through these efforts, the Northeast Balanced Mixture Design Working Group seeks to accelerate the integration of BMD into mainstream construction practices, ultimately contributing to the creation of infrastructure that not only meets the highest standards of performance but also aligns with the principles of sustainability and resilience.

Northeast Balanced Mix Design Working Group

Members:

Each agency participating in the Northeast Balanced Mix Design Working Group shall provide a member to serve on the group. Members shall be expected to attend group meetings when able and actively participate in activities to represent their agency. FHWA shall serve as a liaison and coordinator of the group.

Agency	Role	Name
FHWA	Liaison / Coordinator	Derek Nener-Plante
MaineDOT	Member	Casey Nash
NHDOT	Member	Joe Blair
VTrans	Member	Aaron Schwartz
MassDOT	Member	Maggie Jasper
RIDOT	Member	Michael Byrne
CTDOT	Member	David Howley
NYDOT	Member	TBD
NJDOT	Member	Mark Gillece
PennDOT	Member	Jay Sengoz
Quebec	Member	Felix Doucet

NE BMD Working Group: 2024 Activity

- Creation of group, mission, and objectives on 1/1/2024
- Survey of agency practices for specimen fabrication
- Initial IDEAL-CT round robin focused on specimen fabrication
- Database metadata creation

Questions / State	VT	NH (NHDOT intends to use BMD for the mix design acceptance phase, only. However, if performance testing is eventually performed on plant-produced mixtures we envision conducting as follows.)	NJ	CT	ME	MA
Where are field-produced mixtures sampled?	*Truck at plant*	*Truck at plant*	*Truck at plant*	*At paver site.*	*Typically from paver; occasionally from truck*	*At the plant out of truck*
What sample container is used for field produced mixture samples?	*Cardboard boxes*	*NHDOT envisions 5 gal. metal buckets*	*5-gallon metal buckets*	*New cardboard box.*	*Cardboard box*	*Samples cardboard boxes sometimes lined with wax paper.*
Are field-produced mixtures cooled to room temperature before compaction or not?	*Yes. Samples transported to central lab and reheated later for testing.*	*NHDOT envisions this would occur due to travel time to the Main Lab*	*No.*	*Yes*	*Yes*	*Depends on whether they are fabriacted at the plant or at the central lab.*
Are there any additional aging conditioning applied to the mixture before compaction (AASHTO R30)?	*No.*	*NHDOT does not anticipate intentionally doing additional aging*	*No.*	*No.*	*No.*	*No, just heat to compaction temperature.*
a. What size pans are used for mixture conditioning?	*N/A*	*N/A*	*N/A*	*N/A*	*12"x20" and 11"x17"(Used for bulks)*	*Varies*
b. What thickness (approximately) of mixture is placed in the pans?	*N/A*	*N/A*	*N/A*	*N/A*	*25-50mm*	*Shoot for 25-50mm.*
c. Is mixture sample temperature monitored during conditioning? If so how often	*N/A*	*N/A*	*N/A*	*N/A*	*No*	*N/A*
d. If conditioning is applied is there any stirring of the mixture performed?	*N/A*	*N/A*	*N/A*	*N/A*	*Mixture is stirred halfway through conditioning (60 ±5 minutes).*	*N/A*
Is a uniform compaction temperature applied for all field-produced mixtures? What is the temperature if so?	*No. Compaction temoerature is specific to designs and PGAB supplier.*	*As specified on the bill of lading for compaction temperature*	*No. It's mixture specific.*	*No, temperature is mix/binder specific and factoring WMA applicable.*	*150°C*	*No use mix design compaction temperature.*
What are the conditions for heating the mixture up to compaction temperature? Is this controlled uniformly or every mixture and specimen?	*Loose mix box samples are initially reheated to ensure separation of particles per AASHTO T 209 at a temperature of 110 ± 5°C prior to splitting into pan(s). Once split into pan(s), the samples are then brought up to the mixture's compaction temperature. Time largely dependent on sample size and mixture type.*	*NHDOT anticipates trying to minimize aging but there will be avoidable heating to handle sample mix from buckets to compaction*	*N/A*	*Initial heating is done with sample in cardboard box until it can be split into pans. Oven set to one temperature. Controlled uniformly for each mixture and sample.*	*Mixture is heated in oven at 150 ±3°C for at least 2 hours*	*Mixture is heated at compaction temperature until it reaches set temperature.*

2024 NE BMD IDEAL-CT ILS

- Objective:
  - To evaluate the impact of different specimen reheating and fabrication procedures on CT_{index} variability between Northeast agency testing laboratories.
- Impact:
  - Will provide a measure of the potential gains to be realized (in reduced variability between labs) if a uniform specimen reheating and fabrication procedure was to be developed and implemented.

2024 NE BMD IDEAL-CT ILS

- Labs Participating
  - VT, NJ, ME, MA, CT, NH, PA, MATC, CAP Lab
  - All labs have load frame from the same manufacturer except for labs 5 & 6
- 9.5 mm mixture from VA

Phase 1 – Section 1 & 2

Section 1

- Test the mix for G_{mb}, G_{mm}, asphalt content, and gradation per typical methods.

Section 2

- Reheat, fabricate, and test five specimens for IDEAL-CT testing per typical laboratory practice.

Phase 2 – Section 3

Day 1

- Reheating, splitting, and compaction must be complete on this day.
- End Result: Five specimens that meet air void content of 7.0 ± 0.5% and specimen size of 150 ± 2 mm diameter and 62 ± 1 mm thickness.

Day 2

- Must be day immediately after reheating, splitting, and compaction.
- End Result: Five CT_{index} values and all corresponding data.

Items Standardized:

- Reheating and compaction temperature = 150°C
- Time for reheating = 3 hours ± 15 min
- Theoretical maximum gravity for air voids, *Gmm* = 2.696
- Pans cannot be cooled after splitting – immediately into oven for compaction
- Achieving compaction temperature – 150°C for 1 hour ± 15 min
- IDEAL-CT testing 18-24 hours after compaction

Phase 2 – Section 4

Day 1

- Reheating, splitting, and the start of aging must be complete on this day.
- End Result: At least five pans split out to proper mass and into an oven for aging.

Day 2

- Must be day immediately after reheating and splitting.
- End Result: Five specimens that meet air void content of 7.0 ± 0.5% and specimen size of 150 ± 2 mm diameter and 62 ± 1 mm thickness.

Day 3

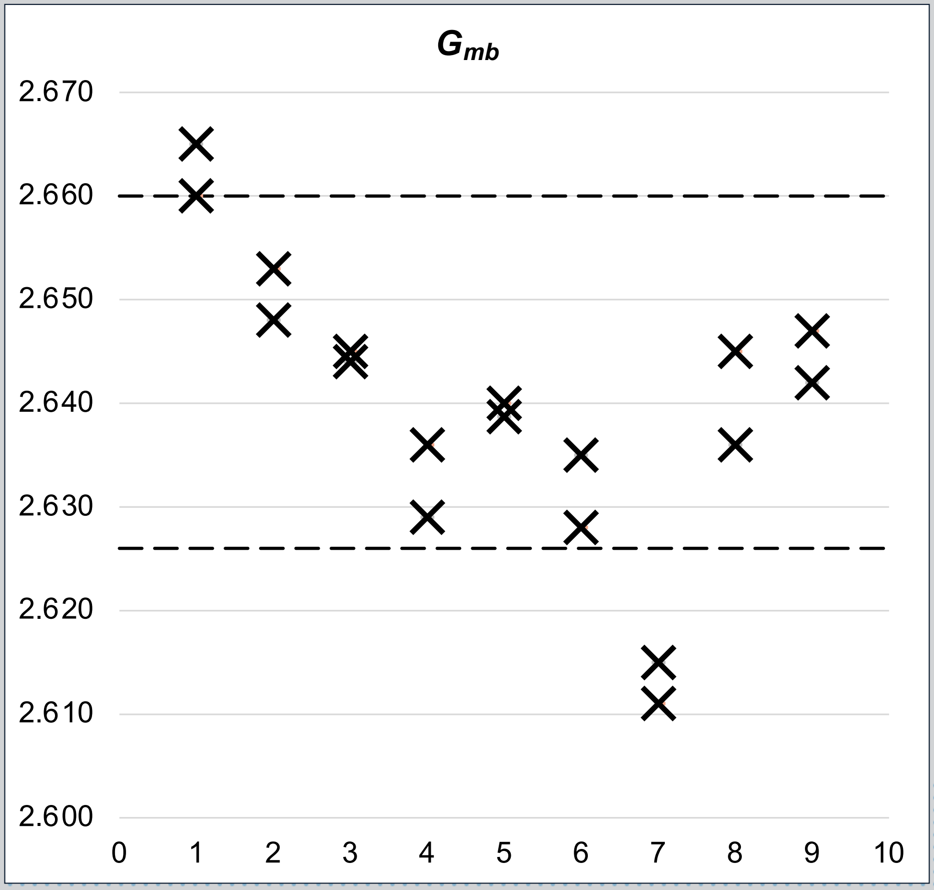
- Must be day immediately after compaction.
- End Result: Five CT_{index} values and all corresponding data.

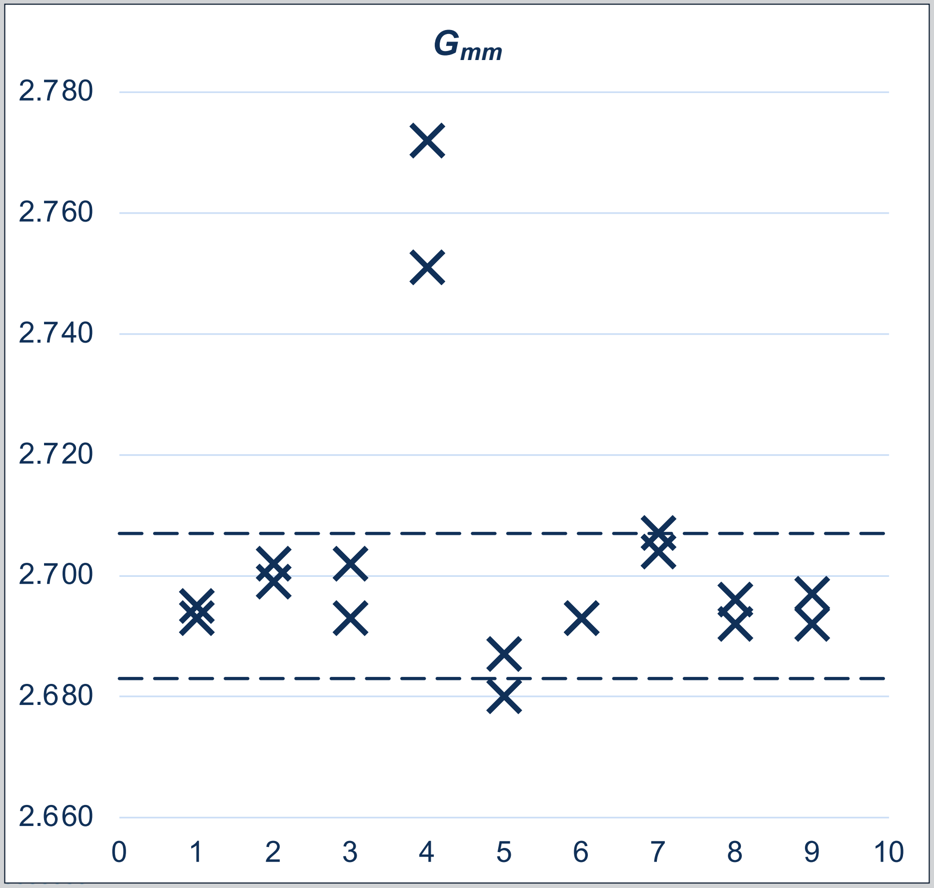
Items Standardized:

- Reheating and compaction temperature = 150°C
- Time for reheating = 3 hours ± 15 min
- Theoretical maximum gravity for air voids, *Gmm* = 2.696
- Pans cannot be cooled after splitting – immediately into oven aging
- Aging conducted immediately after splitting - 110°C for 20 hours ± 30 min
- Achieving compaction temperature – 150°C for 1 hour ± 15 min
- IDEAL-CT testing 18-24 hours after compaction

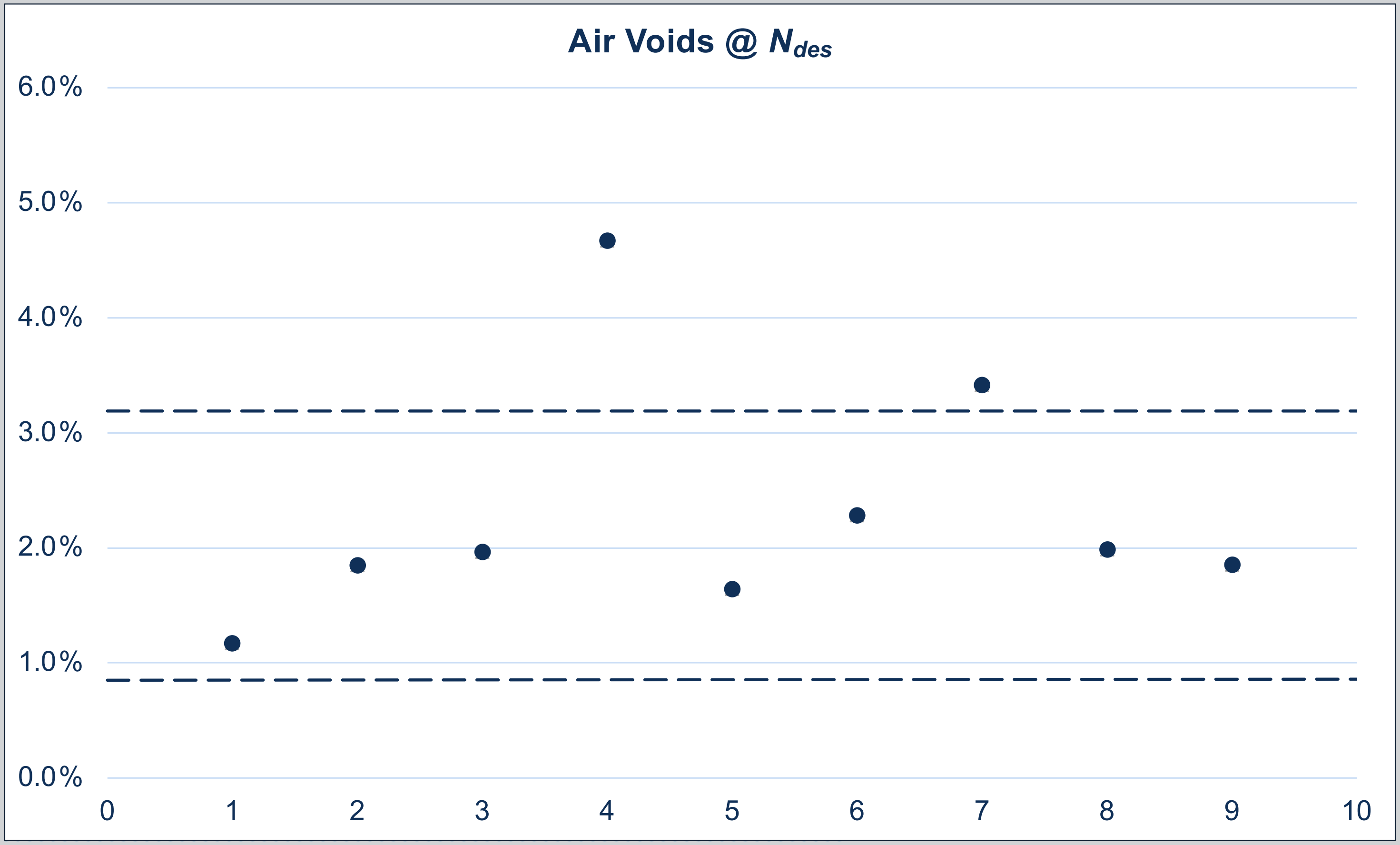
Lab #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Gmm1	2.695	2.699	2.693	2.772	2.687	2.693	2.707	2.696	2.697
Gmm2	2.693	2.702	2.702	2.751	2.680	2.693	2.704	2.692	2.692
Gmm	**2.694**	**2.701**	**2.698**	**2.762**	**2.684**	**2.693**	**2.706**	**2.694**	**2.695**
Gmb1	2.660	2.653	2.645	2.636	2.640	2.628	2.611	2.645	2.647
Gmb2	2.665	2.648	2.644	2.629	2.639	2.635	2.615	2.636	2.642
Gmb	**2.663**	**2.651**	**2.645**	**2.633**	**2.639**	**2.632**	**2.613**	**2.641**	**2.645**
Pb	5.7	5.6	5.6	5.5	5.7	5.7	5.4	5.6	5.8
Air Voids	**1.17%**	**1.85%**	**1.96%**	**4.67%**	**1.65%**	**2.28%**	**3.42%**	**1.99%**	**1.86%**
1/2"	100.0	99.3	99.7	98.4	100.0	99.2	100.0	99.6	99.0
3/8"	93.8	92.2	91.9	90.6	95.0	90.6	91.6	92.6	91.3
1/4"		72.8	73.8		76.0			74.2	
No. 4	67.1	63.8	63.3	61.9	67.0	61.1	62.1	63.4	61.7
No. 8	42.0	39.1	40.2	39.1	42.0	38.2	38.8	39.4	38.9
No. 16	27.2	26.2	26.6	25.2	27.0	25.0	25.3	25.9	25.1
No. 30	20.8	19.7	20.2	18.9	20.0	18.8	19.2	19.5	18.8
No. 50	15.8	15.1	15.3	14.3	16.0	14.2	14.6	14.9	14.2
No. 100	11.9	11.0	11.5	10.6	12.0	10.4	10.7	10.8	10.4
No. 200	8.5	7.8	8.0	7.4	8.5	7.2	7.5	7.6	7.1
Shake Time (min)	10.0	8.0	5.0	8.0	7.0	8.0	7.5	10.0	7.0

Section 1 - Standard Testing





Section 1 - Standard Testing



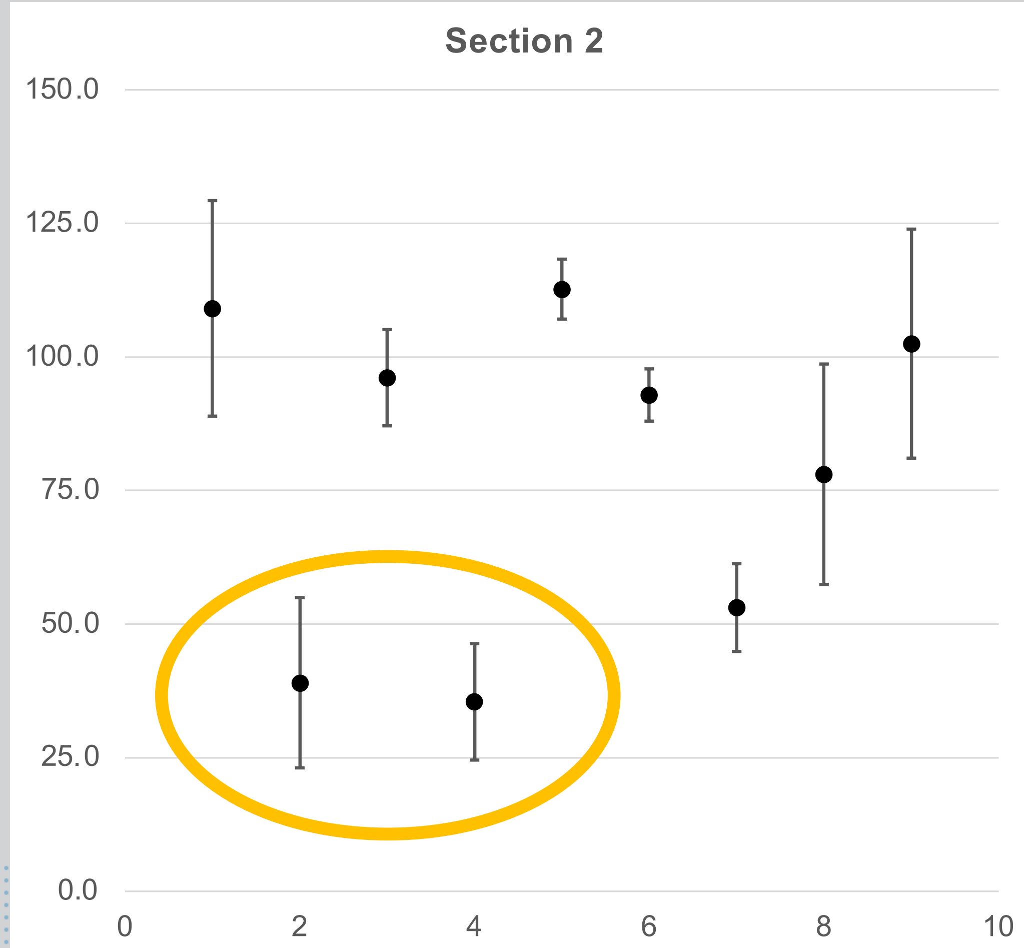
Section 1 - Standard Testing

Lab #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
CT1	108.9	63.6	103.4	49.5	112.1	99.2	47.8	81.8	118.6
CT2	130.8	39.2	101.0	32.1	118.1	91.5	59.6	93.8	130.9
CT3	84.6	35.3	98.5	26.6	118.2	95.9	64.2	53.0	91.2
CT4	94.0	38.0	80.6	44.2	110.1	86.3	46.8	100.8	92.7
CT5	127.2	19.1	97.1	24.9	105.0	91.6	47.1	60.9	79.1
AVG CT	**109.1**	**39.0**	**96.1**	**35.5**	**112.7**	**92.9**	**53.1**	**78.1**	**102.5**
ST DEV CT	**20.2**	**15.9**	**9.0**	**10.9**	**5.6**	**4.9**	**8.2**	**20.6**	**21.4**
COV CT	**18.5%**	**40.8%**	**9.4%**	**30.7%**	**5.0%**	**5.3%**	**15.5%**	**26.4%**	**20.9%**

Section 2 – IDEAL-CT Reheated (No Guidance)

Lab #	1	2	3	4	5	6	7	8	9
CT1	108.9	63.6	103.4	49.5	112.1	99.2	47.8	81.8	118.6
CT2	130.8	39.2	101.0	32.1	118.1	91.5	59.6	93.8	130.9
CT3	84.6	35.3	98.5	26.6	118.2	95.9	64.2	53.0	91.2
CT4	94.0	38.0	80.6	44.2	110.1	86.3	46.8	100.8	92.7
CT5	127.2	19.1	97.1	24.9	105.0	91.6	47.1	60.9	79.1
AVG CT	**109.1**	**39.0**	**96.1**	**35.5**	**112.7**	**92.9**	**53.1**	**78.1**	**102.5**
ST DEV CT	**20.2**	**15.9**	**9.0**	**10.9**	**5.6**	**4.9**	**8.2**	**20.6**	**21.4**
COV CT	**18.5%**	**40.8%**	**9.4%**	**30.7%**	**5.0%**	**5.3%**	**15.5%**	**26.4%**	**20.9%**

Overall Population (*n = 45*)
Mean = 79.9
Standard deviation = 31.5



Section 2 – IDEAL-CT Reheated (No Guidance)

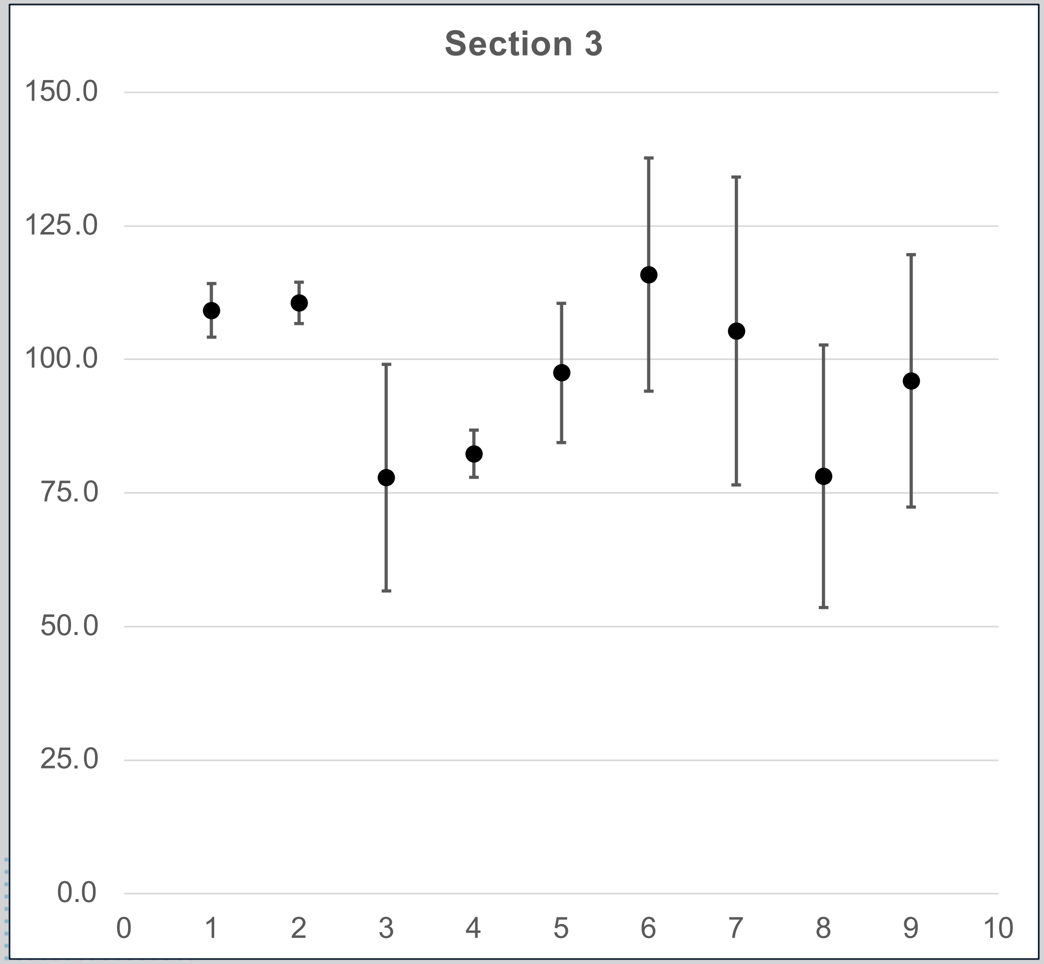
Lab #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
CT1	107.0	106.8	112.1	78.5	116.4	147.4	79.4	71.4	73.6
CT2	111.0	117.0	84.2	84.1	103.4	128.7	134.8	90.9	126.2
CT3	117.0	108.5	62.2	77.9	91.1	100.8	99.6	114.3	96.1
CT4	104.0	110.4	61.3	88.7	82.1	94.4	136.0	59.4	111.9
CT5	107.0	110.3	69.6	82.6	94.4	108.3	76.9	54.7	72.2
AVG CT	**109.2**	**110.6**	**77.9**	**82.4**	**97.5**	**115.9**	**105.3**	**78.1**	**96.0**
ST DEV CT	**5.0**	**3.9**	**21.2**	**4.4**	**13.0**	**21.8**	**28.8**	**24.6**	**23.6**
COV CT	**4.6%**	**3.5%**	**27.2%**	**5.4%**	**13.4%**	**18.8%**	**27.4%**	**31.5%**	**24.6%**

Section 3 – IDEAL-CT Reheated (with Guidance)

Section 3 – IDEAL-CT Reheated (with Guidance)

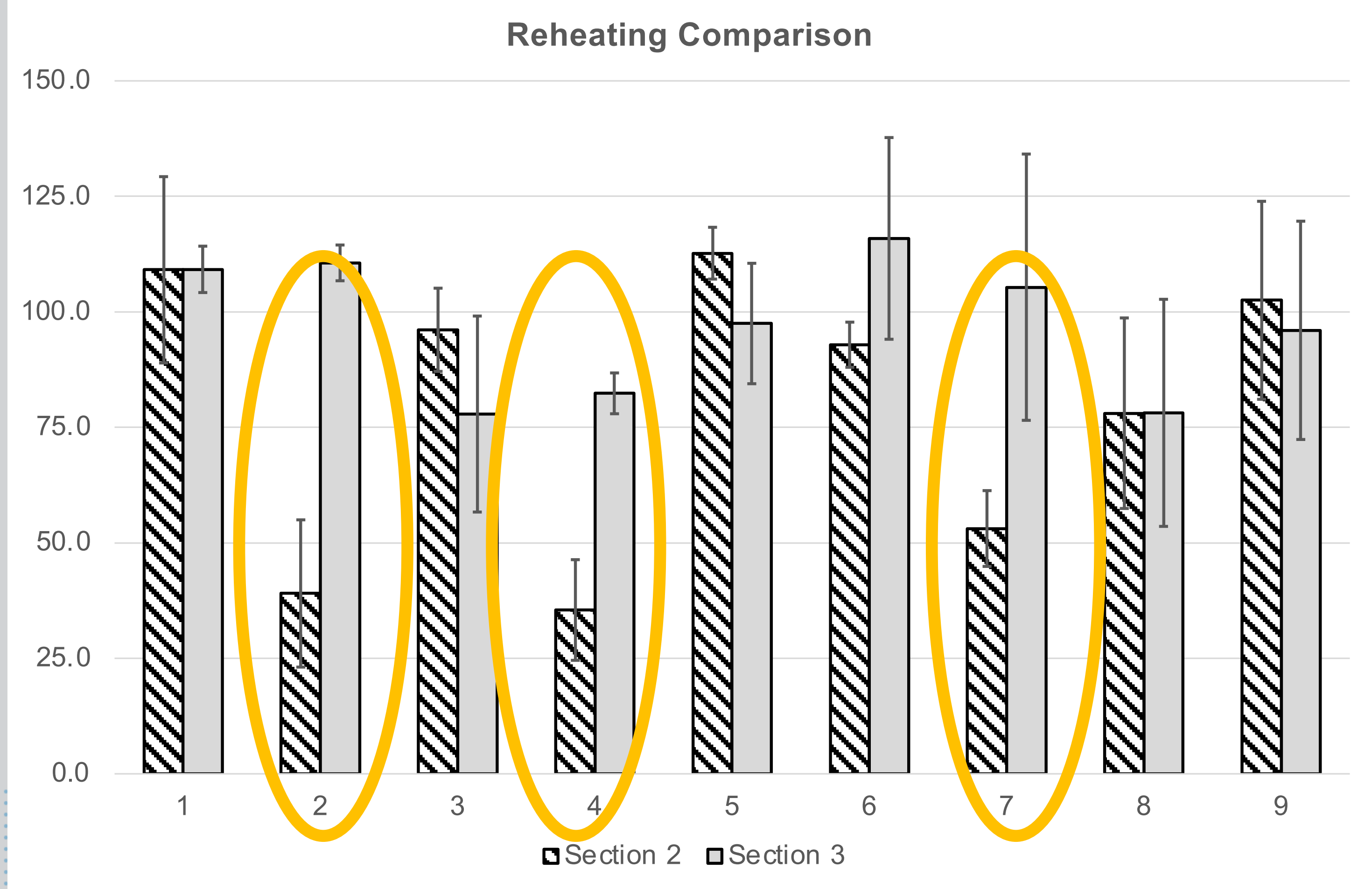
Lab #	1	2	3	4	5	6	7	8	9
CT1	107.0	106.8	112.1	78.5	116.4	147.4	79.4	71.4	73.6
CT2	111.0	117.0	84.2	84.1	103.4	128.7	134.8	90.9	126.2
CT3	117.0	108.5	62.2	77.9	91.1	100.8	99.6	114.3	96.1
CT4	104.0	110.4	61.3	88.7	82.1	94.4	136.0	59.4	111.9
CT5	107.0	110.3	69.6	82.6	94.4	108.3	76.9	54.7	72.2
AVG CT	**109.2**	**110.6**	**77.9**	**82.4**	**97.5**	**115.9**	**105.3**	**78.1**	**96.0**
ST DEV CT	**5.0**	**3.9**	**21.2**	**4.4**	**13.0**	**21.8**	**28.8**	**24.6**	**23.6**
COV CT	**4.6%**	**3.5%**	**27.2%**	**5.4%**	**13.4%**	**18.8%**	**27.4%**	**31.5%**	**24.6%**

Overall Population (*n = 45)*
Mean = 97.0
Standard deviation = 21.9



Observations:

- *Clear difference between Sections for Labs, 2, 4, & 7*
- *Some labs reduced within-lab variability – others increased within-lab variability*



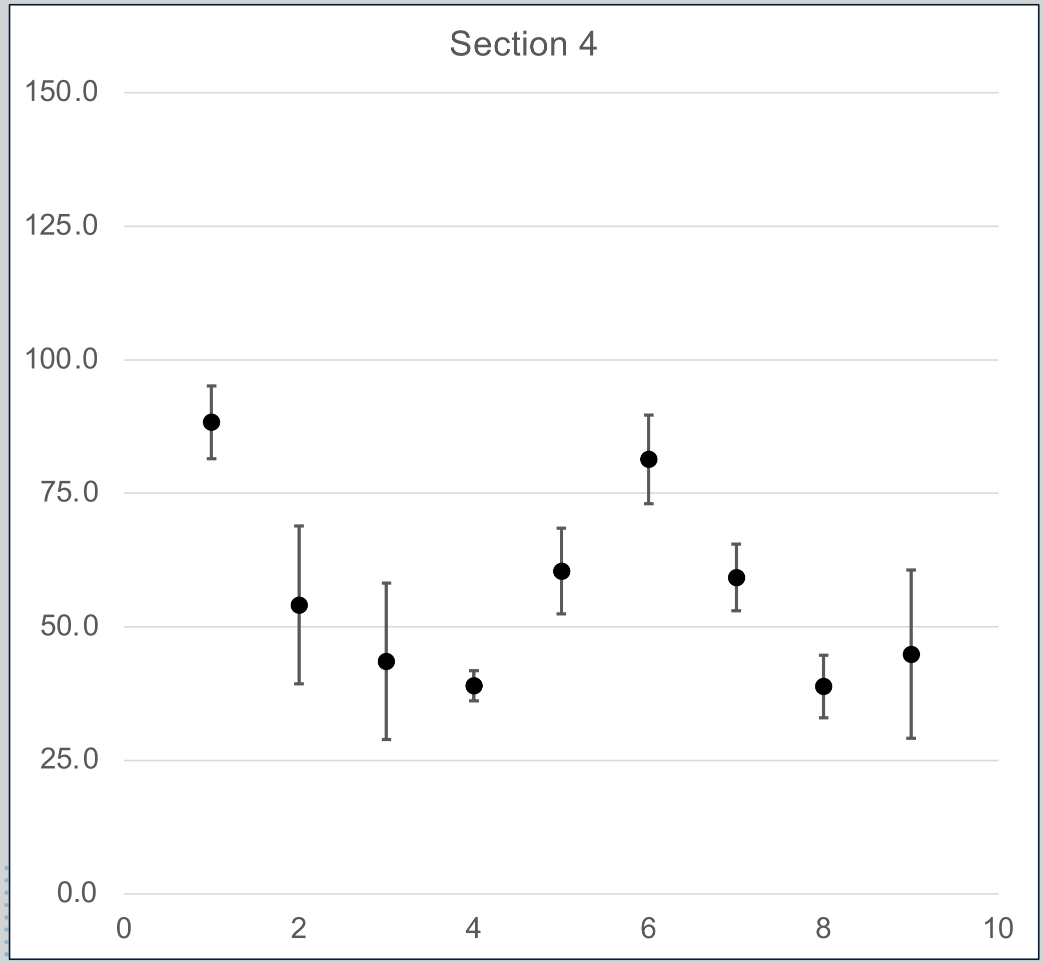
Section 2 vs. Section 3

Lab #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
CT1	89.2	75.6	67.1	40.0	58.4	81.1	54.9	38.2	38.1
CT2	86.3	54.1	37.1	34.0	53.8	74.6	56.2	37.8	71.9
CT3	99.5	48.0	36.4	39.4	60.2	94.3	65.2	47.8	36.2
CT4	81.9	35.1	47.5	40.6	55.7	73.6	66.7	31.4	33
CT5	84.5	57.7	29.6	40.8	74.1	83.1	53.2	38.9	45.2
AVG CT	**88.3**	**54.1**	**43.5**	**39.0**	**60.4**	**81.3**	**59.2**	**38.8**	**44.9**
ST DEV CT	**6.8**	**14.8**	**14.6**	**2.8**	**8.0**	**8.3**	**6.2**	**5.9**	**15.8**
COV CT	**7.7%**	**27.3%**	**33.6%**	**7.3%**	**13.3%**	**10.2%**	**10.5%**	**15.1%**	**35.1%**

Section 4 – IDEAL-CT w/Aging (with Guidance)

Lab #	1	2	3	4	5	6	7	8	9
CT1	89.2	75.6	67.1	40.0	58.4	81.1	54.9	38.2	38.1
CT2	86.3	54.1	37.1	34.0	53.8	74.6	56.2	37.8	71.9
CT3	99.5	48.0	36.4	39.4	60.2	94.3	65.2	47.8	36.2
CT4	81.9	35.1	47.5	40.6	55.7	73.6	66.7	31.4	33
CT5	84.5	57.7	29.6	40.8	74.1	83.1	53.2	38.9	45.2
AVG CT	**88.3**	**54.1**	**43.5**	**39.0**	**60.4**	**81.3**	**59.2**	**38.8**	**44.9**
ST DEV CT	**6.8**	**14.8**	**14.6**	**2.8**	**8.0**	**8.3**	**6.2**	**5.9**	**15.8**
COV CT	**7.7%**	**27.3%**	**33.6%**	**7.3%**	**13.3%**	**10.2%**	**10.5%**	**15.1%**	**35.1%**

Overall Population (*n = 45)*
Mean = 56.6
Standard deviation = 19.5



Section 4 – IDEAL-CT w/Aging (with Guidance)

Observations:

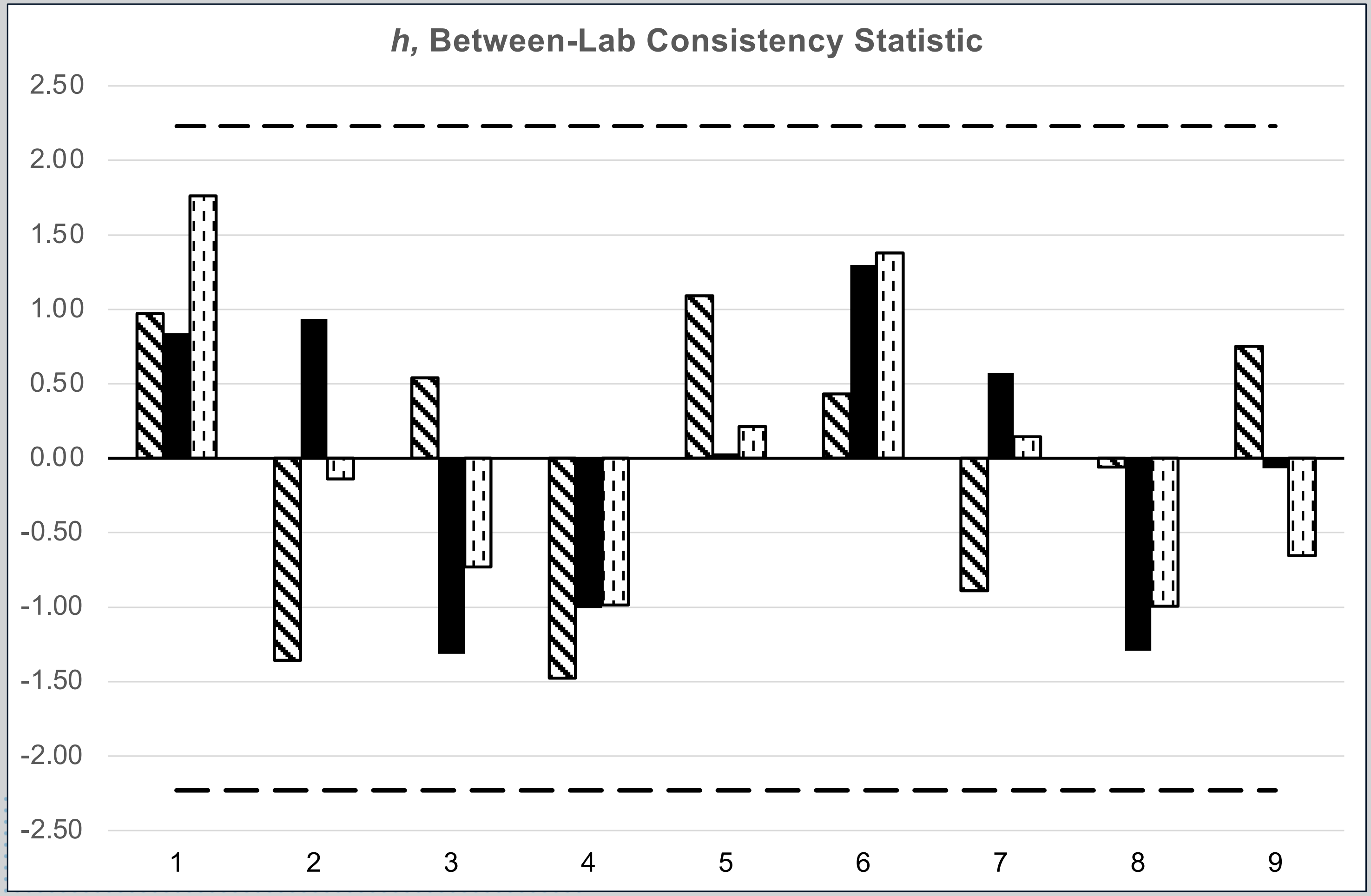
- Conducted ILS analysis per ASTM E691
- *r = R for Section 3 due to excellent agreement between labs*
- *Outlier analysis conducted per lab per Section and overall – none identified*

Value / Section	Section 2 *Reheating – No Guidance*	Section 3 *Reheating – With Guidance*	Section 4 *Aged – With Guidance*
r *Repeatability*	40.34 (50.5%)	52.4 (54.0%)	28.6 (50.6%)
R Reproducibility	52.2 (65.3%)	52.4 (54.0%)	34.1 (60.2%)

ILS Statistics & Analysis

Observations:

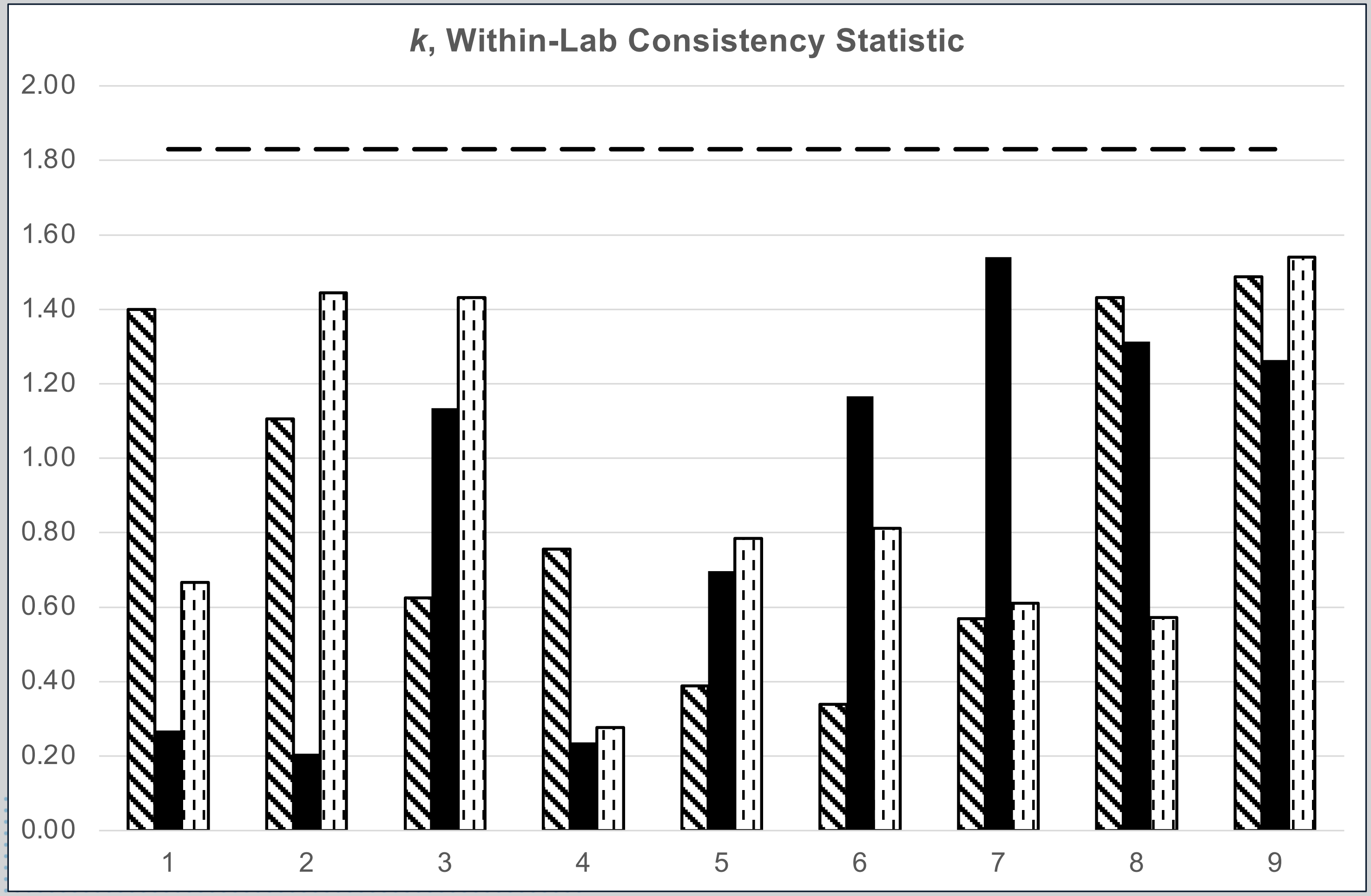
- *h = between-lab consistency statistic*
- *All labs below the threshold for potential issues for all Sections*



ILS Statistics & Analysis

Observations:

- *k = within-consistency statistic*
- *All labs below the threshold for potential issues for all Sections*
- *Those approaching threshold for all sections bear further investigation*



ILS Statistics & Analysis

Lab #	1	2	3	4	5	6	7	8	9
AAF 1 *Section 2 to Section 4*	0.81	1.39	0.45	1.10	0.54	0.88	1.12	0.50	0.44
AAF 2 *Section 3 to Section 4*	0.81	0.49	0.56	0.47	0.62	0.70	0.56	0.50	0.47

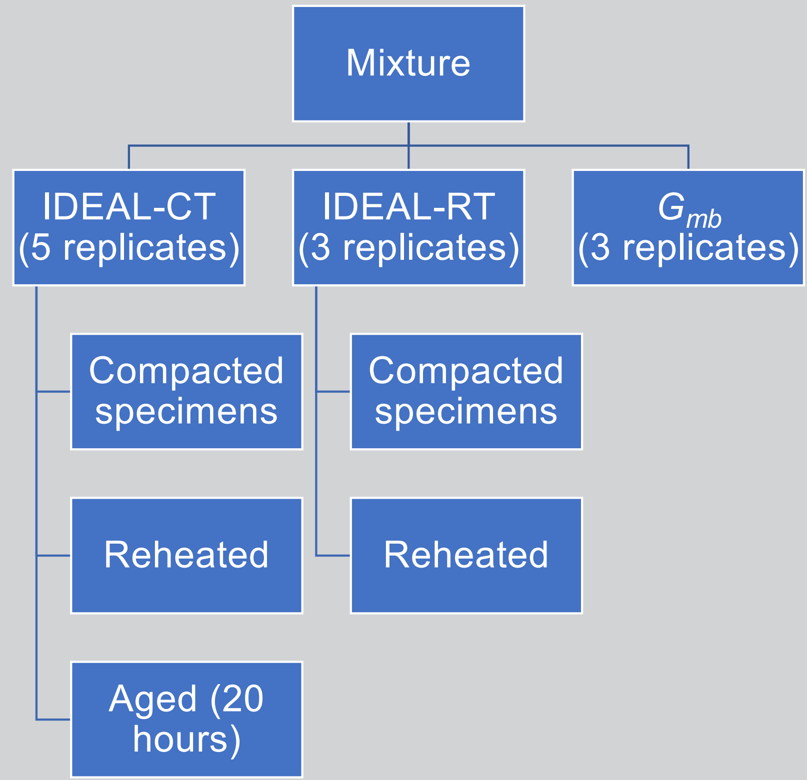
Other Analysis: Aging Adjustment Factors (AAF)

Observations

- Volumetrics matter for lab consistency
  - Differences in typical specific gravity testing can impact BMD results
  - Further volumetric round robin in the northeast bears investigation
- Existing reheating procedures are very open to different practice (multiple reheating, impact of G_{mm}, etc.)
- Providing specific reheating guidance has a clear positive impact on between-lab variability of IDEAL-CT
  - Some unfamiliarity with the procedure may have led to fewer gains on repeatability
- Aging does not appear to significantly reduce variability
- IDEAL-CT has a significant variability that needs to be addressed for responsible implementation

What's Next for NE BMD Working Group

- 2024/2025 BMD round robin
  - Multiple plant-produced mixtures
- Development of regional guidance for reheating?
- Potential for coordinated effort on BMD validation (see next slide)
- What else?



2024 NE BMD – Validation Idea

- Pool state resources to produce a wider validation experiment
- Each state to use 1 project for validation site paved in 2025
  - At least 3+ sections of different surface mixtures plus a control
    - Focus on material changes to net BMD differences (PG binder grade, RAP content, asphalt content, etc.)
  - Attempt to complete through contract modification and contractor option
  - Each section is extensively sampled and tested to be repeated among multiple StateDOT labs
  - Include multiple BMD tests and aging conditions, sharing data between states
- Would result in several sections in multiple states that could be analyzed as a group
- Look for outside assistance in performance monitoring?

Questions?

Thank you for your attention!

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