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Managing Mix Performance With BMD

Stacey Diefenderfer, Ph.D., P.E.
Virginia Transportation Research Council
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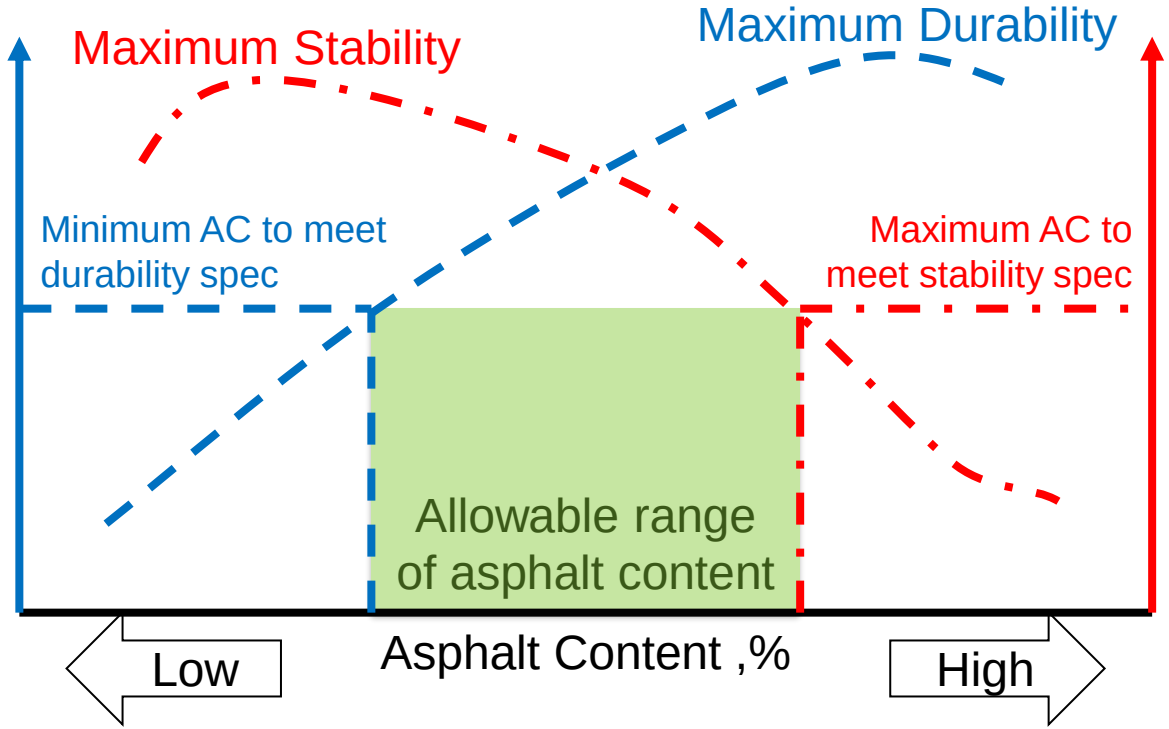
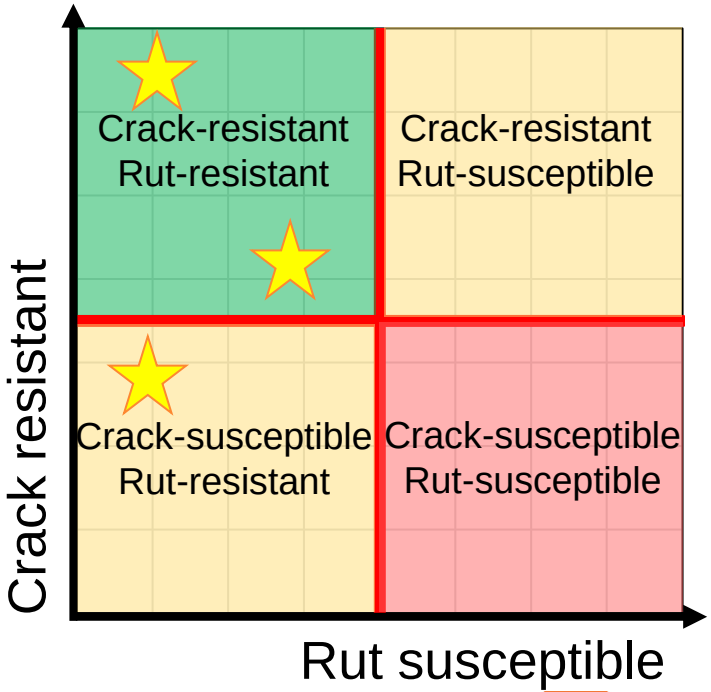
VDOT 2024 BMD Criteria

Distress	Test	Limit
Cracking	IDT-CT (reheat)	70 (min)
	IDT-CT (non-reheat)	95 (min)
Rutting	APA rut test	8mm (max)
	IDT-HT (wet)	report only 100kPa (min)
Durability	Cantabro	7.5% (max)
Moisture	Tensile Strength Ratio	80% (min)

What is a Balanced Mix?





BMD for Specific Traffic & Structure

- Identify distress of concern
- Match mix performance requirements to conditions

  - Minimal traffic, average loading – aging, top-down cracking
  - Heavy traffic, heavy loading – rutting, fatigue cracking
  - Thin pavements – fatigue cracking
  - Thick pavements – top-down cracking
  - Intersections – rutting, shoving

Designing a Balanced Mix

- Start with good aggregate structure
  - Communicate with quarry – be aware of changes/variability
  - Bailey Method - develop, evaluate, & adjust aggregate blend
  - Evaluate gradation curves for sensitivity of volumetrics changes in JMF
- Know your binder source and quality
  - Same PG ≠ same performance in BMD
  - Crude source & refining process impact binder quality
  - Can be differences in same PG among suppliers

Designing a Balanced Mix (2)

- Know your RAP
  - Binder content & grade
  - Gradation – do you / can you fractionate
  - Accurate $G_{sb\text{-}RAP}$

Balancing an Unbalanced Mix

- Where is mix lacking?
  - Durability / cracking resistance
  - Rutting resistance
  - Moisture susceptibility
- Can mix be balanced?
  - How close to / far from performance thresholds
  - How close to volumetric thresholds
  - How sensitive is the mix to changes
    - Gradation
    - Binder content

General Practices

- Use systematic process for changes
  - One change at a time
- Bailey method - impact of aggregate properties on Pbe
  - Aggregate shape
  - Aggregate surface texture
  - Aggregate packing or structure
- Compare plant gradations to cold feed gradations
  - P200 & aggregate breakdown are important

General Practices

- Emphasize VMA
  - Exceeding minimum VMA is beneficial, but do not unreasonably exceed minimum VMA
- Adjustments causing significant impact on volumetrics may have significant impact on one performance test & little/no impact on another performance test

Balancing for Rutting Resistance

- Restrict Pbe
- Increase the binder grade
  - recycled materials
  - polymer modification
- Reduce the VMA by trying other gradations
- Reduce or remove dust &/or natural sand
- Increase aggregate angularity of sand sized materials
- Evaluate impact of dust particle size

Balancing for Durability/Cracking Resistance

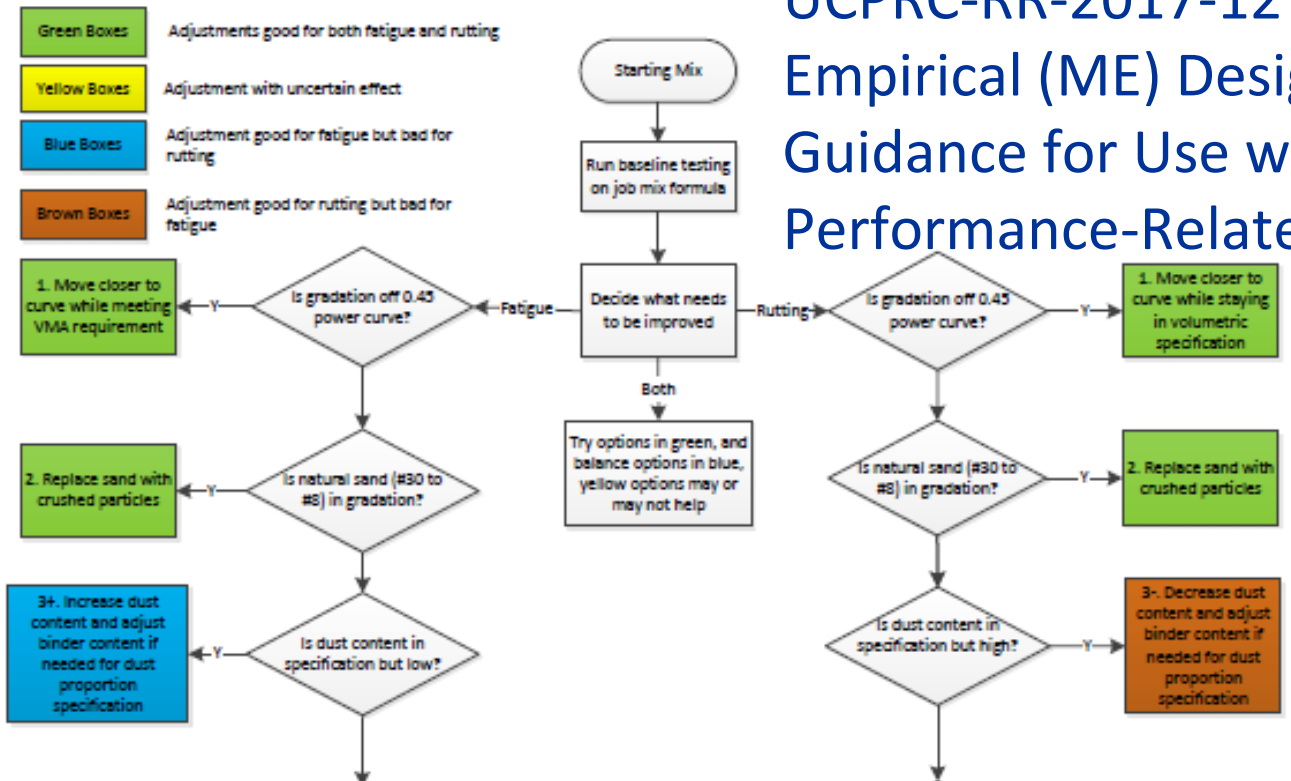
- Adjustments are mix type dependent
  - No one answer or mix adjustment for all cases
- Add more binder
  - Volume of binder is governing factor in load-related cracking
  - If cannot add binder due to low air voids, may need to use washed aggregates during production or different aggregate
- Increase VMA
  - target 0.5 - 1.0% higher than minimum
- Increase VFA

Balancing for Durability/Cracking Resistance (2)

- Reduce air voids
- Manage binder stiffness
  - Look at RAP/RAS content & impact on virgin binder PG
  - Increased RAP → may need softer binder or recycling agent
- Change binder source
- Adjust dust to binder ratio
  - P200 needs to be clean
  - Sieves #4 & #8 not that important
- Change aggregate type or sand being used

Resource - Procedure

http://www.ucprc.ucdavis.edu/PDF/UCPRC-RR-2017-12.pdf

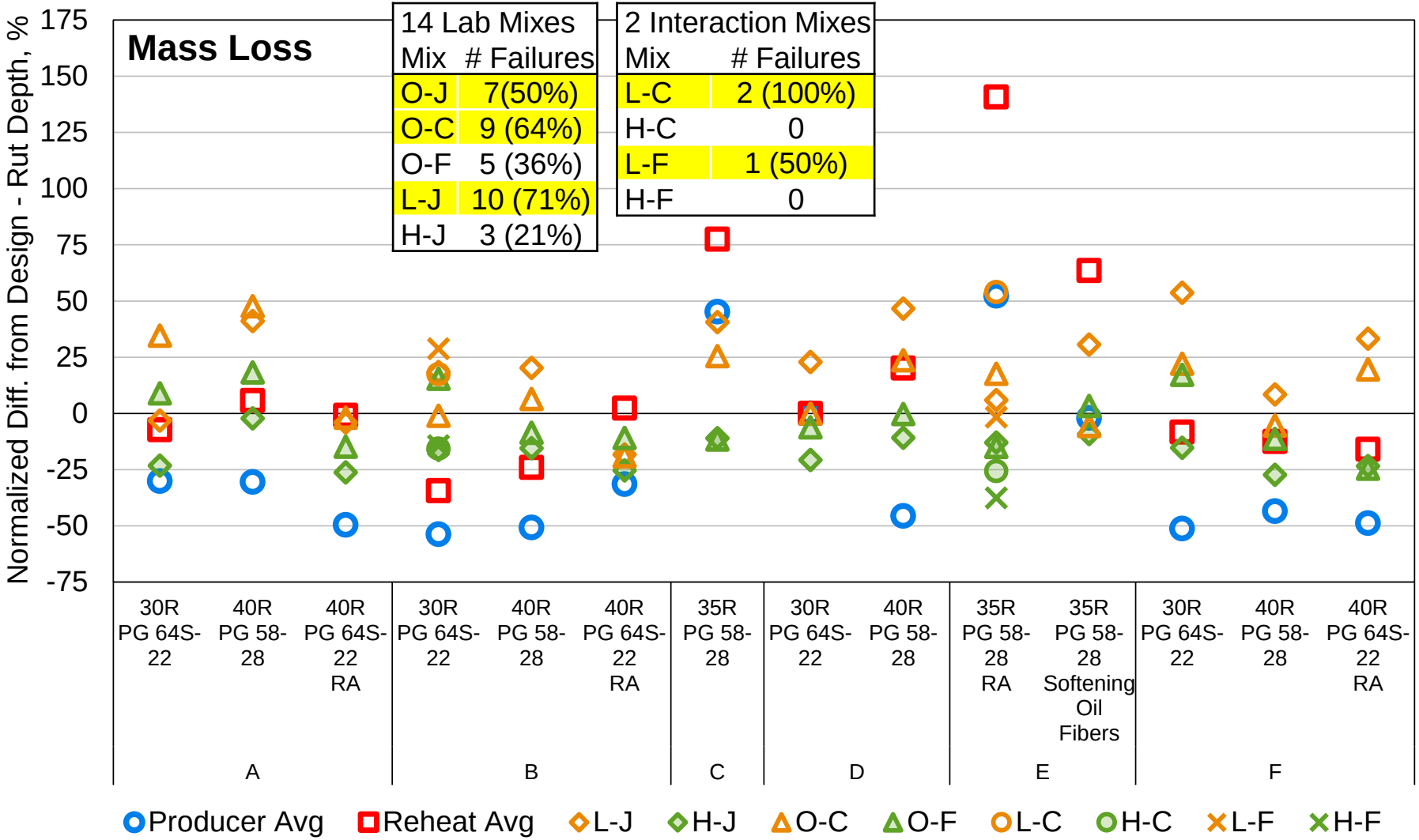


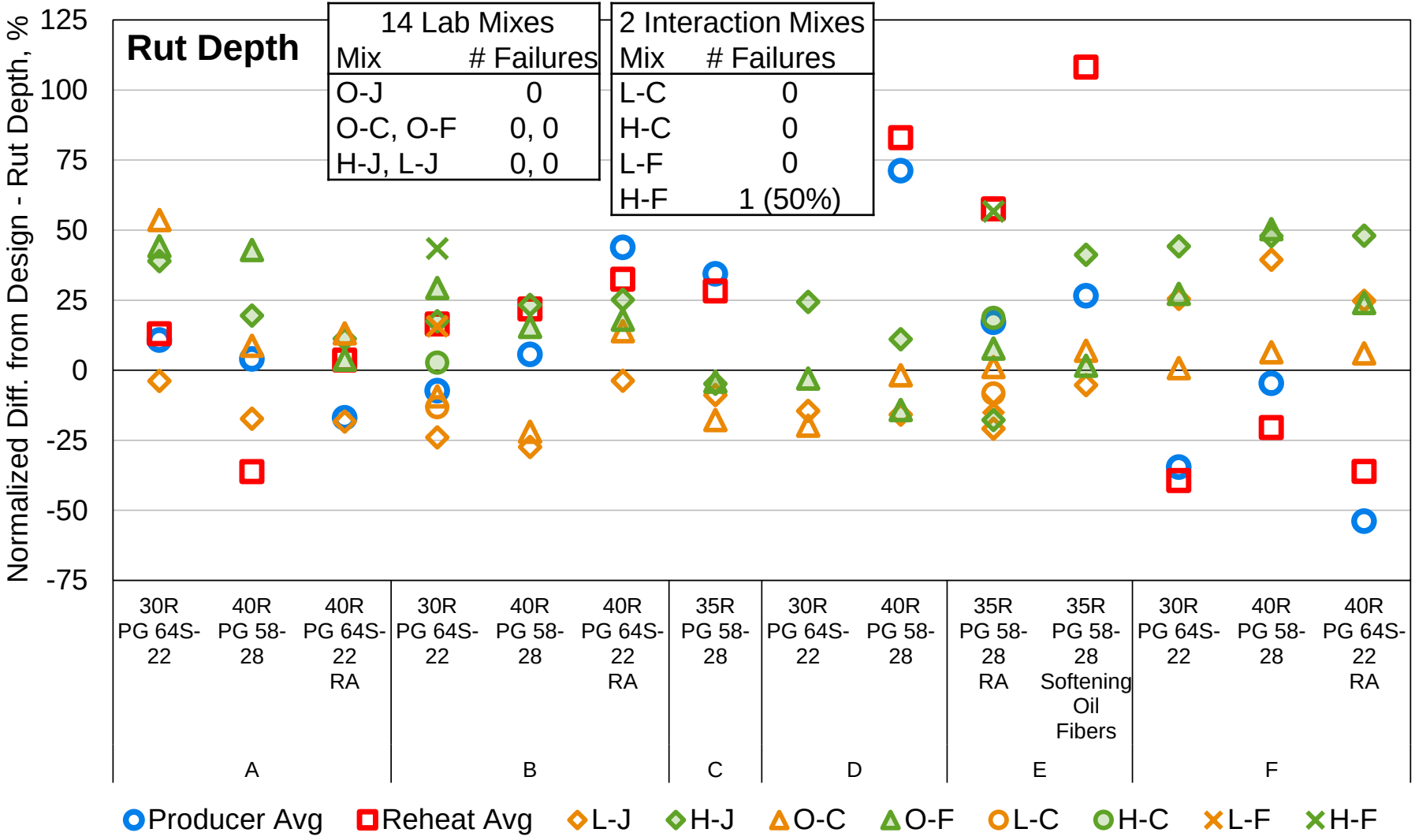
UCPRC-RR-2017-12 Mechanistic-Empirical (ME) Design: Mix Design Guidance for Use with Asphalt Concrete Performance-Related Specifications

- Page 9 Figure 2.1

Challenges During Production

- Variability
  - Changes in stockpile materials
  - Binder source changes
  - Plant variability
  - Load-out procedure
  - Sampling practice
  - Test specimen fabrication
  - Test variability


Mass Loss
14 Lab Mixes
Mix # Failures
O-J 7(50%)
O-C 9 (64%)
O-F 5 (36%)
L-J 10 (71%)
H-J 3 (21%)
2 Interaction Mixes
Mix # Failures
L-C 2 (100%)
H-C 0
L-F 1 (50%)
H-F 0
Normalized Diff. from Design - Rut Depth, %
175
150
125
100
75
50
25
0
-25
-50
-75
30R PG 64S-22
40R PG 58-28
40R PG 64S-22 RA
30R PG 64S-22
40R PG 58-28
40R PG 64S-22 RA
35R PG 58-28
30R PG 64S-22
40R PG 58-28
35R PG 58-28 RA
35R PG 58-28 Softening Oil Fibers
30R PG 64S-22
40R PG 58-28
40R PG 64S-22 RA
A
B
C
D
E
F
Producer Avg
Reheat Avg
L-J
H-J
O-C
O-F
L-C
H-C
L-F
H-F


Rut Depth
14 Lab Mixes
Mix # Failures
O-J 0
O-C, O-F 0, 0
H-J, L-J 0, 0
2 Interaction Mixes
Mix # Failures
L-C 0
H-C 0
L-F 0
H-F 1 (50%)
Normalized Diff. from Design - Rut Depth, %
125
100
75
50
25
0
-25
-50
-75
30R PG 64S-22
40R PG 58-28
40R PG 64S-22 RA
30R PG 64S-22
40R PG 58-28
40R PG 64S-22 RA
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O-C
O-F
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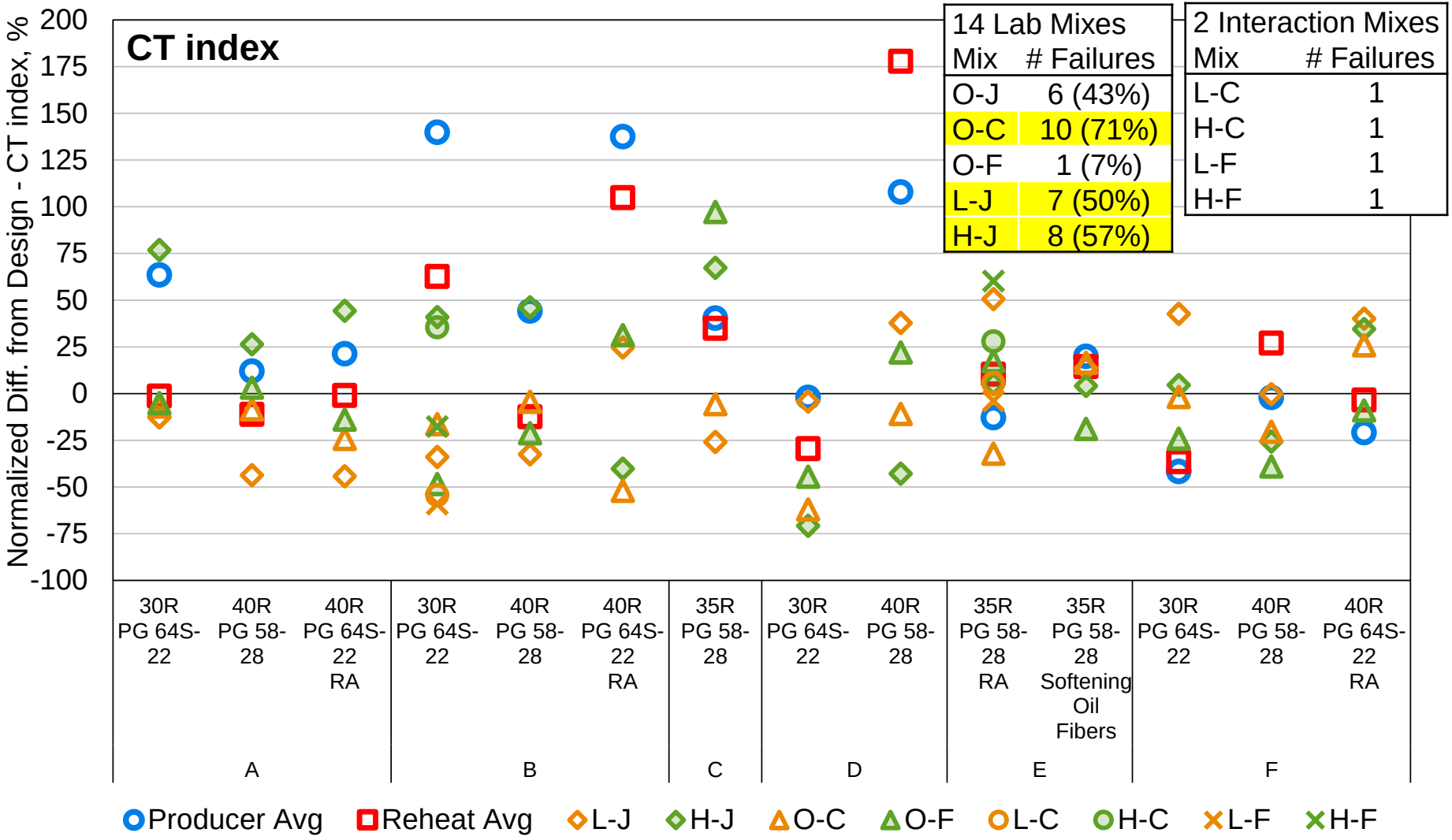
H-C
L-F
H-F

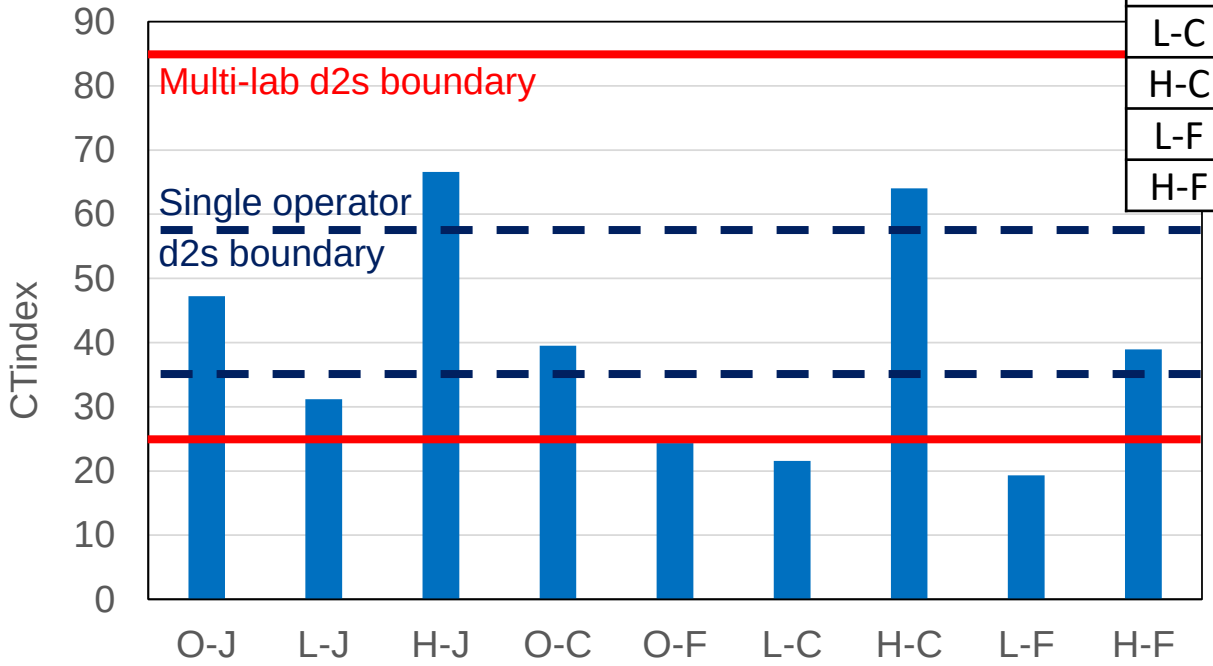

CT index
Normalized Diff. from Design - CT index, %
200
175
150
125
100
75
50
25
0
-25
-50
-75
-100
14 Lab Mixes
Mix # Failures
O-J 6 (43%)
O-C 10 (71%)
O-F 1 (7%)
L-J 7 (50%)
H-J 8 (57%)
2 Interaction Mixes
Mix # Failures
L-C 1
H-C 1
L-F 1
H-F 1
30R PG 64S-22
40R PG 58-28
40R PG 64S-22 RA
30R PG 64S-22
40R PG 58-28
40R PG 64S-22 RA
35R PG 58-28
30R PG 64S-22
40R PG 58-28
35R PG 58-28 RA
35R PG 58-28 Softening Oil Fibers
30R PG 64S-22
40R PG 58-28
40R PG 64S-22 RA
A
B
C
D
E
F
Producer Avg
Reheat Avg
L-J
H-J
O-C
O-F
L-C
H-C
L-F
H-F

CTindex Variability

Design CTindex < Threshold + Single-operator d2s

- increases risk of failure during production

Mix	Number (%) of 14 Mixes Exceeding d2s Boundaries	
	Single Operator	Multi-laboratory
L-J	11 (78.6%)	1 (7.1%)
H-J	9 (64.3%)	1 (7.1%)
O-C	2 (14.3%)	0 (0.0%)
O-F	3 (21.4%)	0 (0.0%)
L-C	1 (50.0%)	1 (50.0%)
H-C	2 (100%)	0 (0.0%)
L-F	2 (100%)	1 (50.0%)
H-F	0 (0.0%)	0 (0.0%)



Other Resources

- Balanced Mix Design (BMD) Resource Guide
  - https://www.asphaltpavement.org/expertise/engineering/resources/bmd-resource-guide

- NCAT Balanced Mix Design Resources
  - https://www.eng.auburn.edu/research/centers/ncat/education/bmd.html

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Thank you!

stacey.diefenderfer@vdot.virginia.gov