Air Void Regression

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Problem

- Fatigue cracking
- Wheel path cracking
- Raveling

Inadequate Binder In The Mix

- Since the inception of Superpave mixtures, Wisconsin has seen binder content in mixes decrease

Items To Address And A Possible Solution

Need to put our thinking caps on

- Raise VMA
- Better monitor aggregate specific gravities
- Test Actual Binder Content
- Effective binder content
- Air Void Regression

Raise VMA

- Add 0.5% to most surface mixes
  - For 12.5mm mixes, *[1]* 14.5 for LT and MT mixes.
  - For 9.5mm mixes, *[2]* 15.5 for LT and MT mixes

Aggregate Specific Gravities

- Contractor determined gravities are used
- Now verifying gravities with department samples
- Agg sources are verified more often, 1-3 years instead of 5

Asphalt Binder Content Determination

- Previous
  - AC by calculation.
  - AC by nuclear gauge reading, optional.
  - AC by inventory, optional.

- Current
  - AC by ignition oven according to AASHTO T308 (CMM 836.6.3.6),
  - by chemical extraction according to AASHTO T-164 method A or B; or
  - by automated extraction according to ASTM D8159 as modified in CMM 836.6.3.1.

Effective Binder Content

- Started to be used by one region
- Requires many mix designs to be replaced with new designs or
- Would take years to fully implement

Not chosen to use statewide

Air Void Regression (AVR)

The Best Solution

- WisDOT AVR process, benefits, concerns
- Wisconsin Highway Research Program (WHRP) Research completed by NCAT
- WisDOT Performance Testing Data

Air Void Regression

- Design at the typical 4.0% air voids
- Meet all criteria for 4.0%
  - Gyratations, VMA, Dust to Binder, Percent Binder Replacement, etc
- Use the design points to determine binder content at 3.0%
- Use the 3.0% volumetric properties.

Existing 4.0% air void designs can be used as well as new ones

No mass redesigns are needed

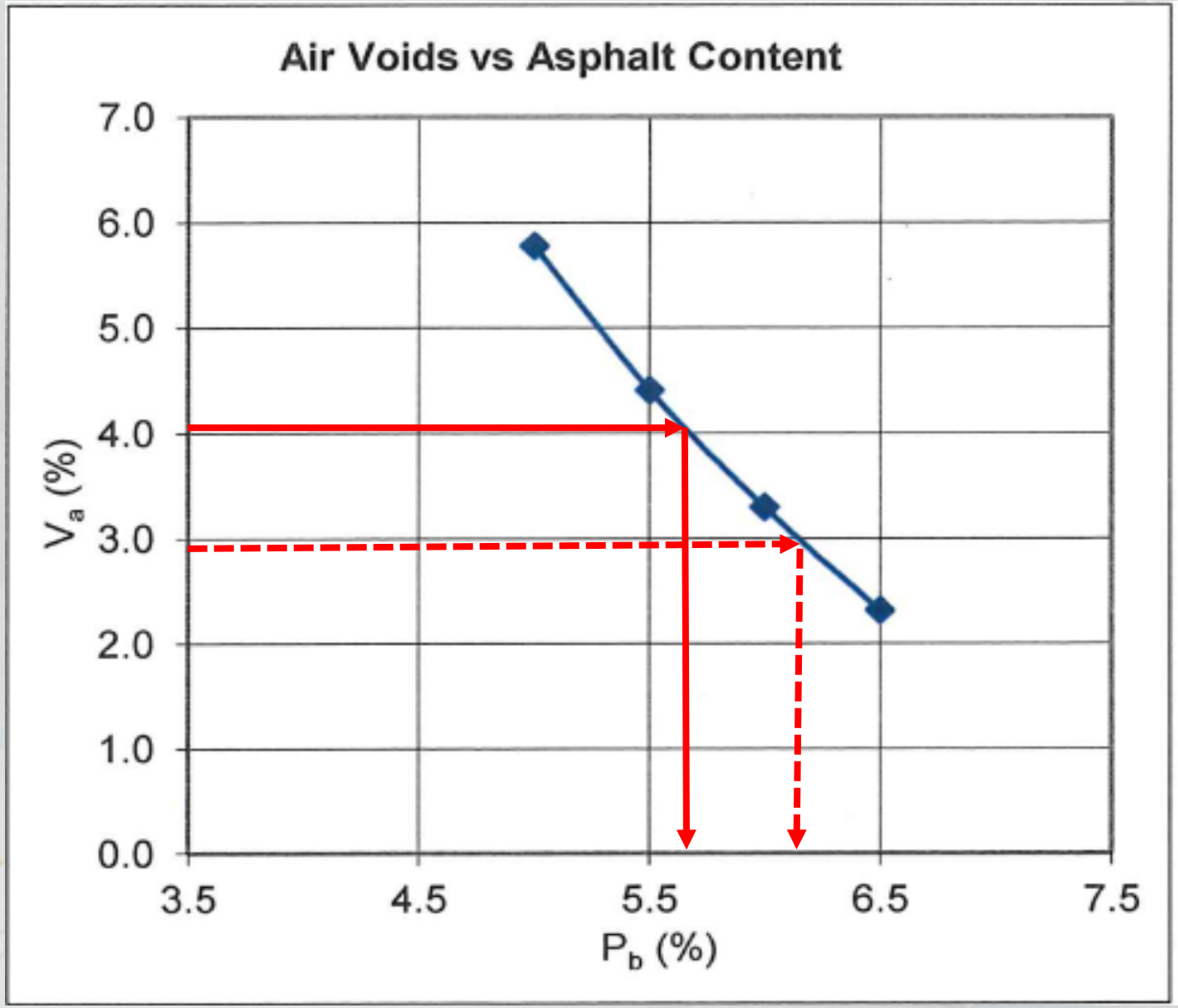
Air Void Regression

Original 4.0 Optimum

%AC = ~ 5.7

Regressed 3.0 Optimum

%AC = ~ 6.1



Volumetric Properties at 3.0%

- Binder content, % (Pb).
- Maximum specific gravity (Gmm).
- Bulk specific gravity (Gmb).
- Air voids, % (Va).
- VMA (voids of the mineral aggregate), %.
- VFB (voids filled with binder) also called VFA (voids filled with asphalt), %.
- TSR (tensile strength ratio).
- TSR Compaction Effort (N = "x").

Benefits

- Increased virgin binder added, 0.3 to 0.4%
- Increased durability, increased asphalt film thickness
- Increased in place density/decreased permeability
- Improved workability- easier paving
- No change to existing 4.0% designs except computing 3.0% volumetrics

Concerns

- Cost
  - Increase of $1 to $2 per ton
- Stability
  - WisDOT is confident in the dense graded aggregate structure
  - Reduced LT mESALS from below 2 mESALS to below 1 mESALS

Research, WHRP by NCAT

- Wisconsin Highway Research Program project 16-06
- Regressing Air Voids for Balanced HMA Mix Design
- Evaluate 6 common mix designs in Wisconsin regressed to lower air voids

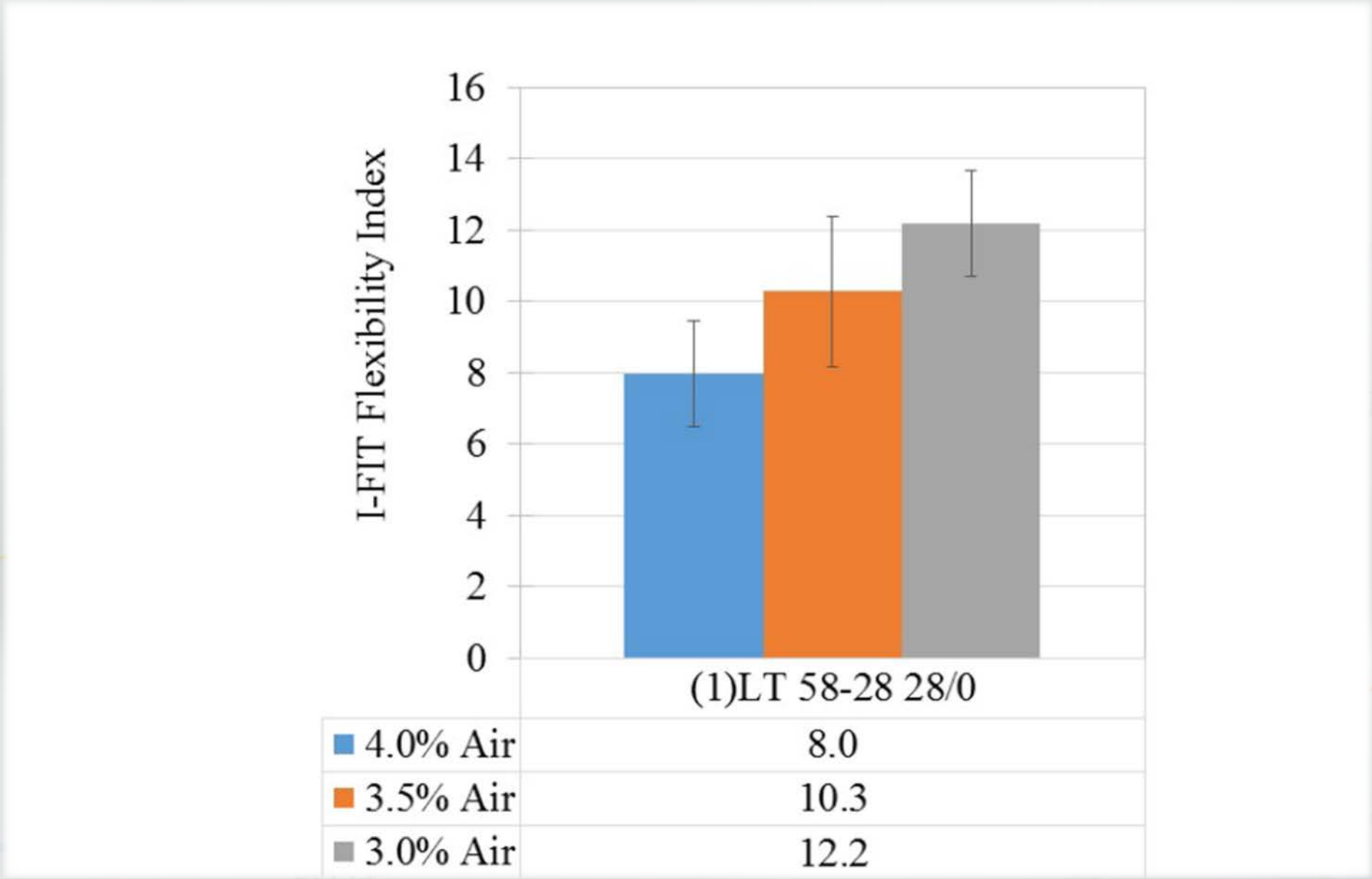
Research Report

https://wisconsindot.gov/documents2/research/0092-16-06-final-report.pdf

Research Brief

https://wisconsindot.gov/documents2/research/0092-16-06-research-brief.pdf

Flexibility Index for LT mix



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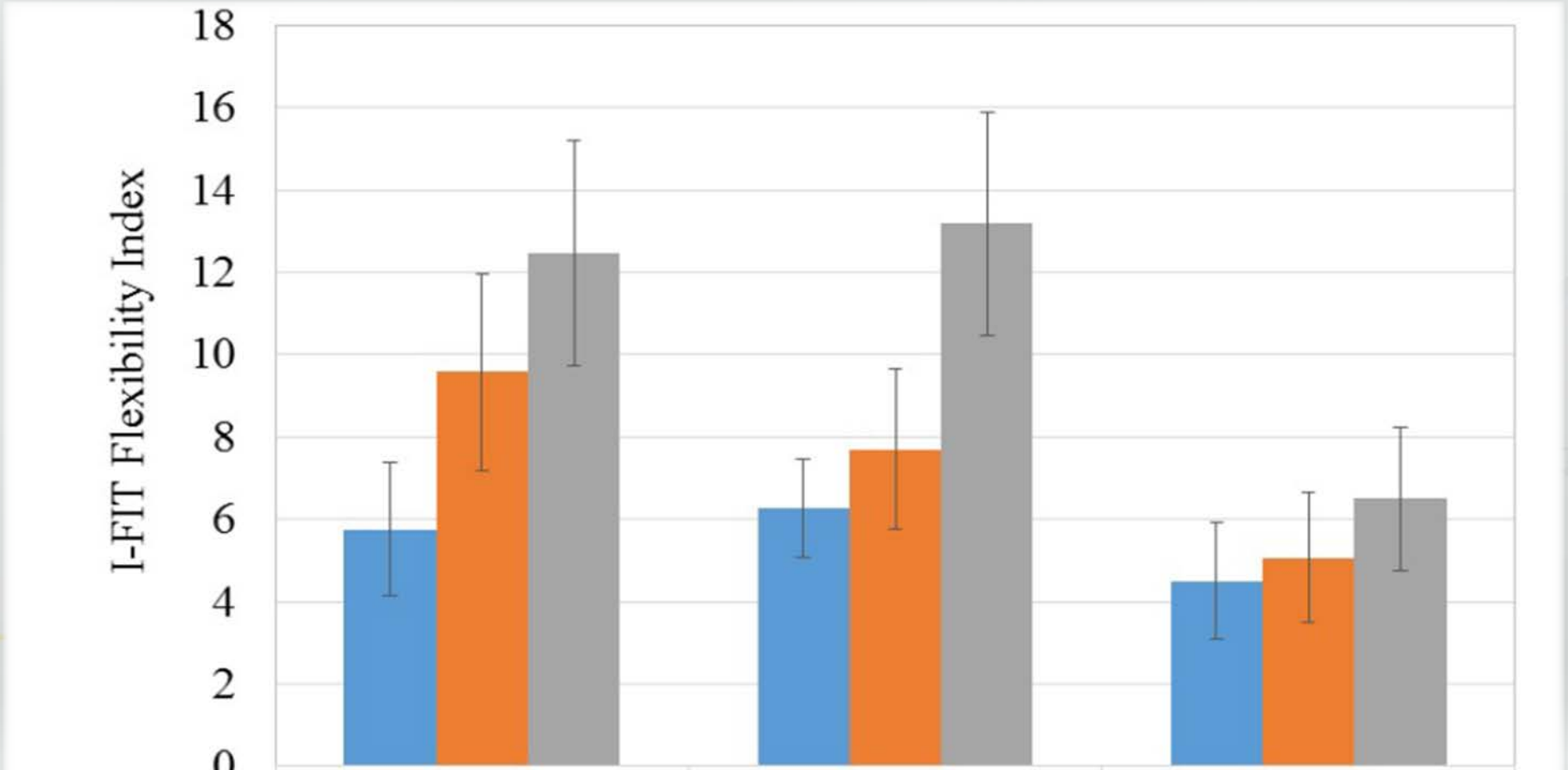
Flexibility Index for MT mixes



	(2)MT 58-28 20/0	(4)MT 58-34 36/0	(5)MT 58-34 37/3
4.0% Air	5.8	6.3	4.5
3.5% Air	9.6	7.7	5.1
3.0% Air	12.5	13.2	6.5

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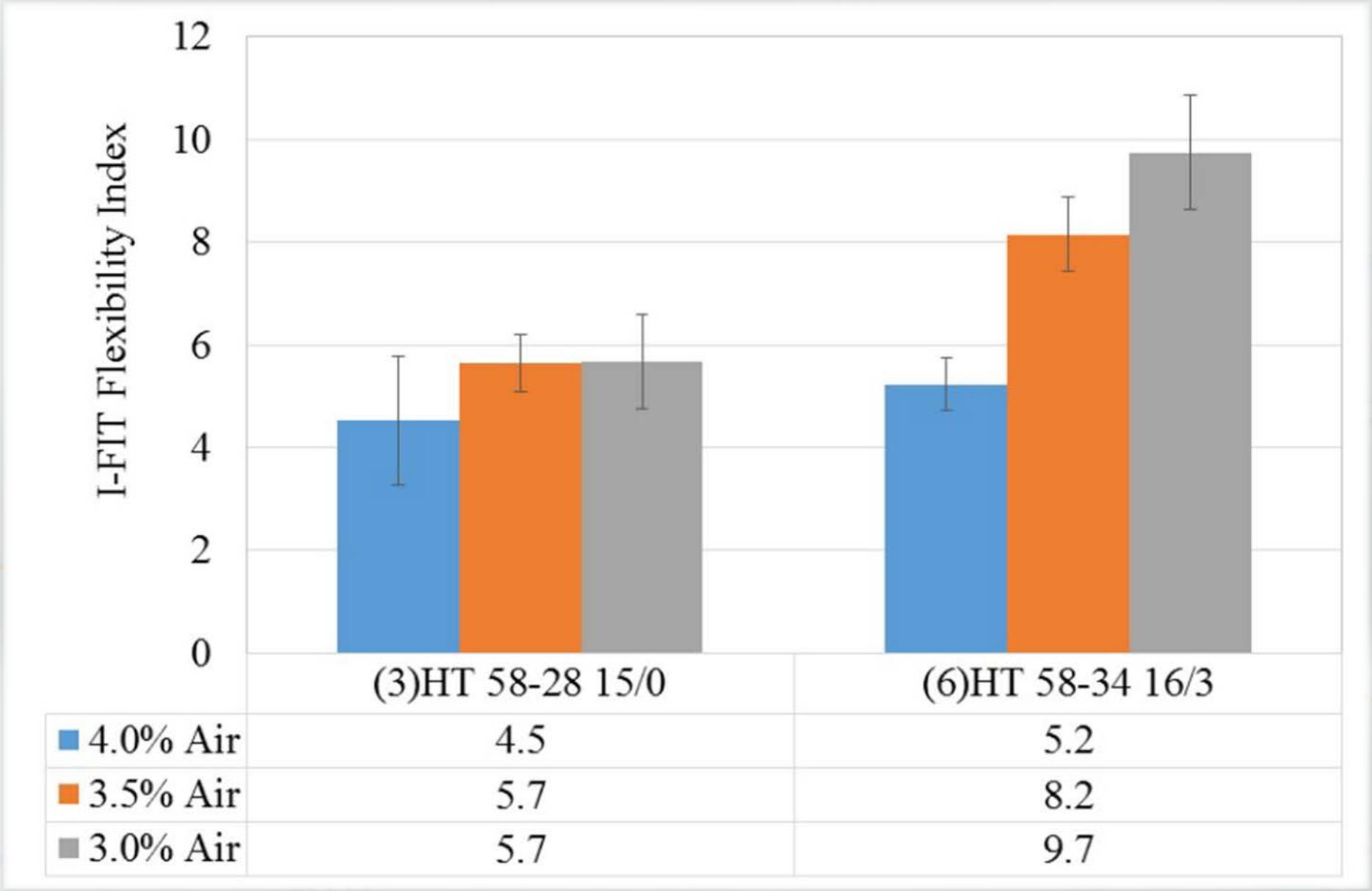
Flexibility Index for HT mixes



	(3)HT 58-28 15/0	(6)HT 58-34 16/3
4.0% Air	4.5	5.2
3.5% Air	5.7	8.2
3.0% Air	5.7	9.7

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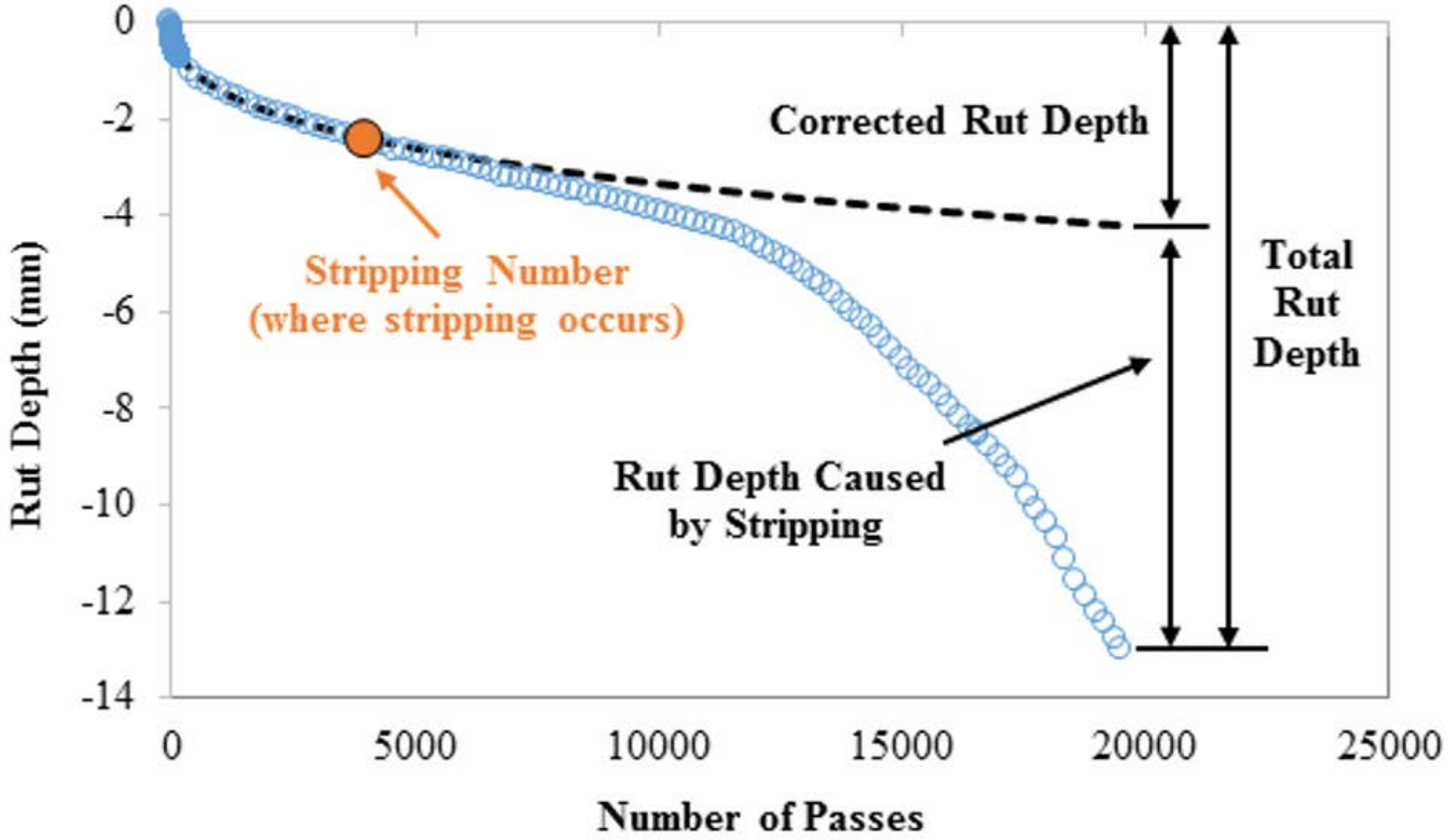
16-06 Hamburg Wheel Testing Corrected Rut Depth

- Corrected Rut Depth and Stripping Number are determined from Hamburg Wheel Data to separate the effects of rutting and stripping
- Fan Yin formerly at TTI now at NCAT promotes this method

- Corrected rut depth (CRD) (Yin et al., 2014 – TRR 2446)



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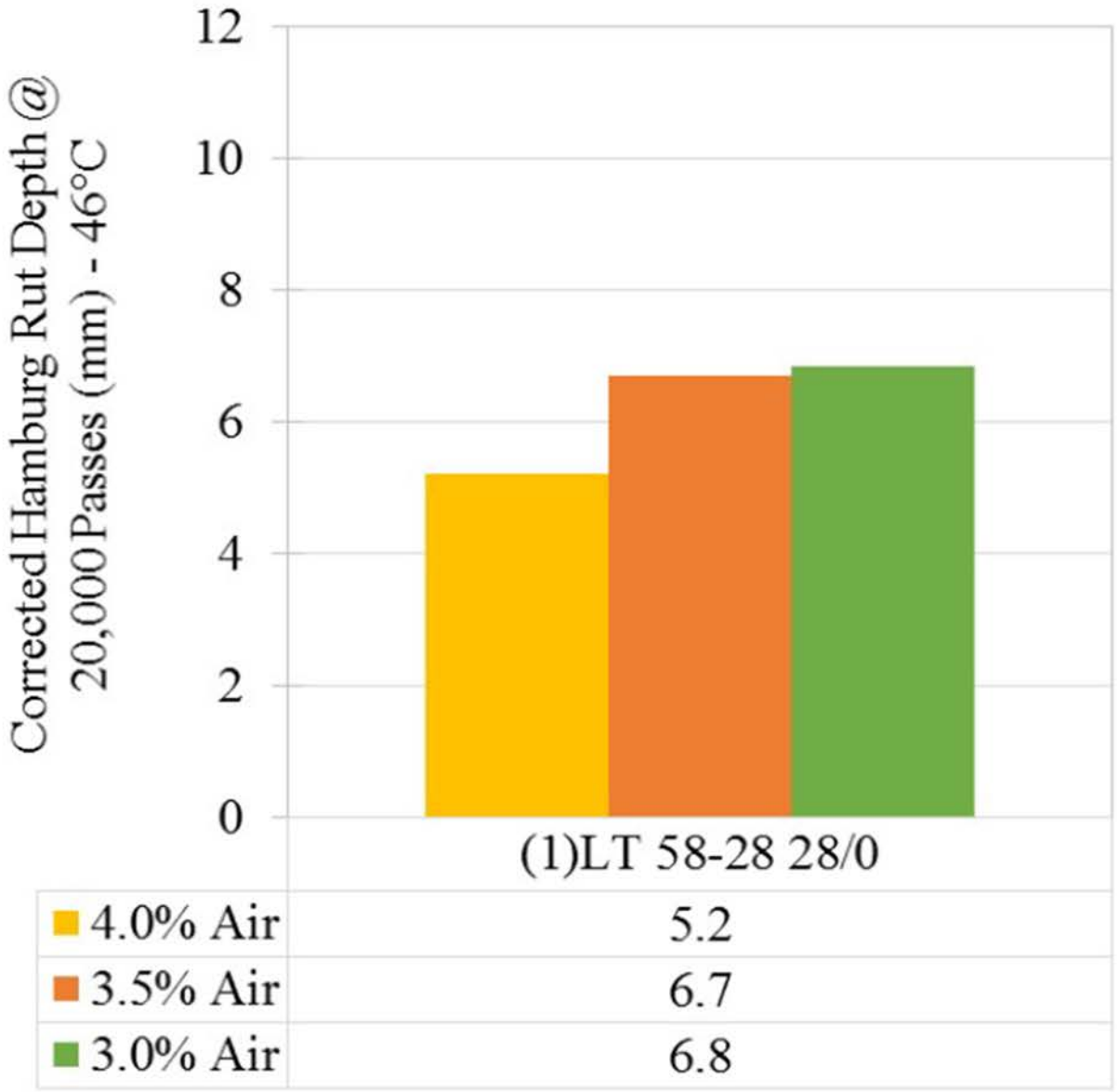
Corrected Rut Depth for LT mix



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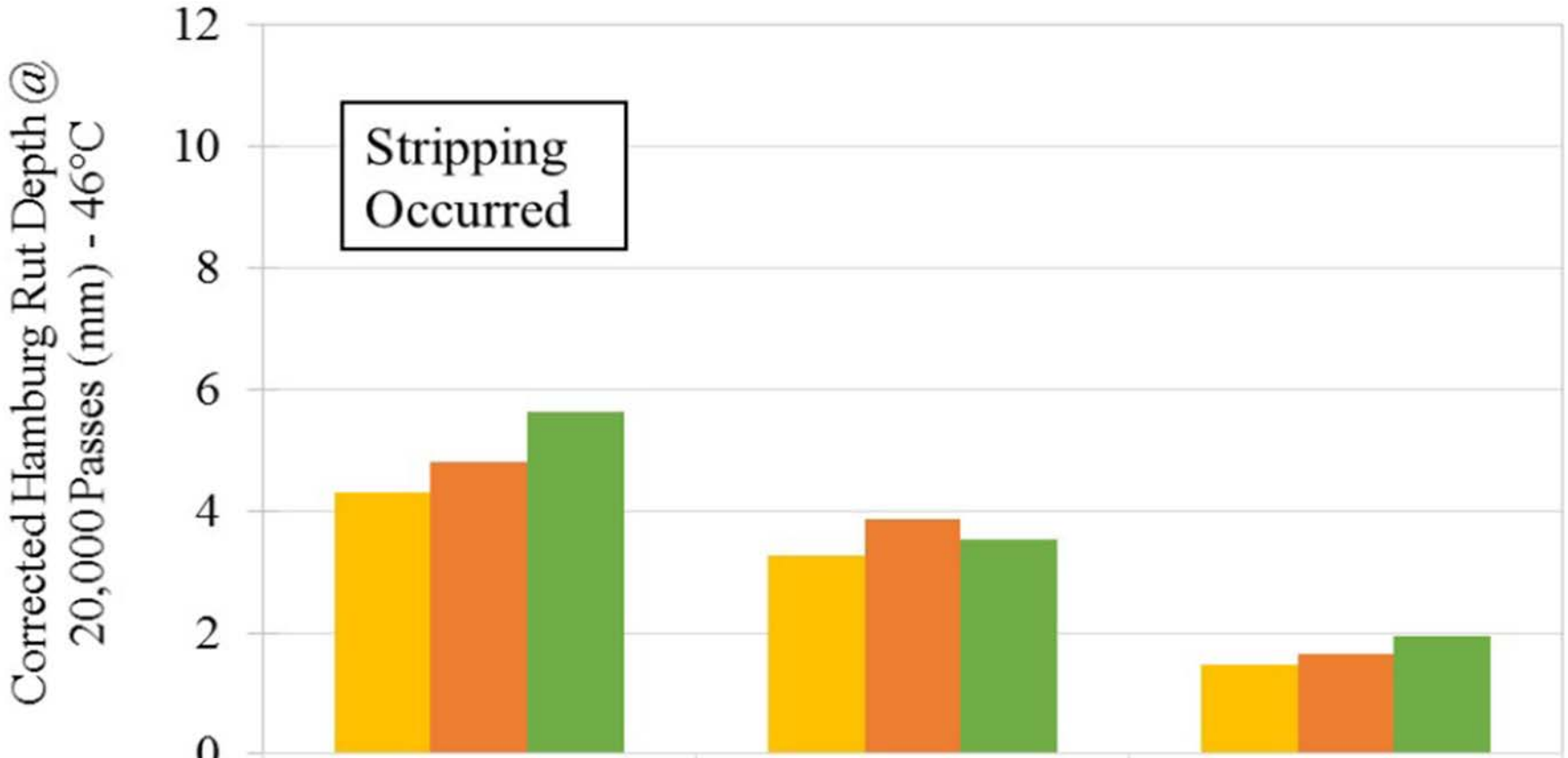
Corrected Rut Depth for MT mixes



	(2)MT 58-28 20/0	(4)MT 58-34 36/0	(5)MT 58-34 37/3
4.0% Air	4.3	3.3	1.5
3.5% Air	4.8	3.9	1.6
3.0% Air	5.6	3.6	1.9

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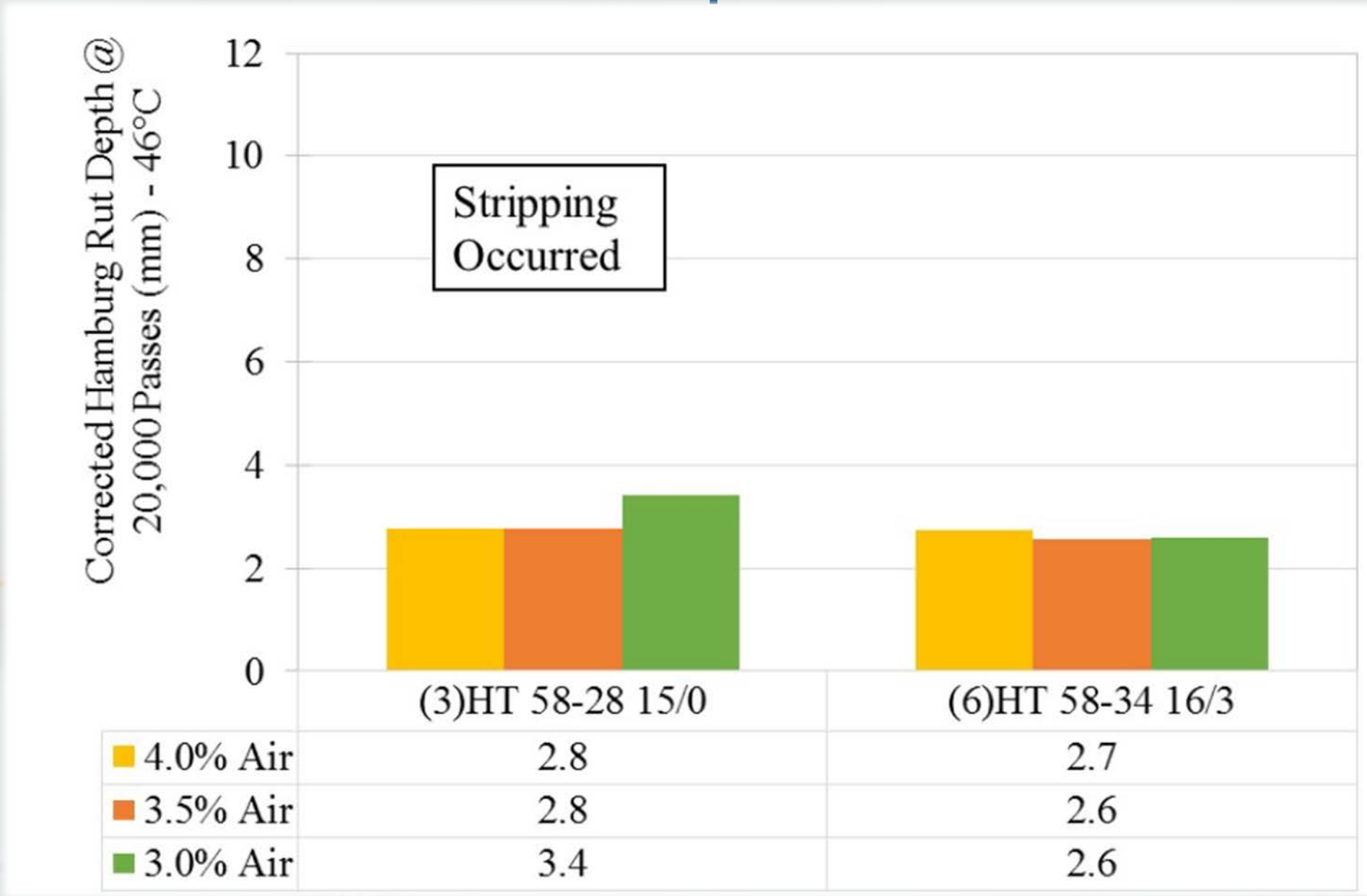
Corrected Rut Depth for HT mixes



	(3)HT 58-28 15/0	(6)HT 58-34 16/3
4.0% Air	2.8	2.7
3.5% Air	2.8	2.6
3.0% Air	3.4	2.6

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16-06 Conclusions

- “based on the I-FIT FI results, the regressed air voids approach to mix design will have a significant, positive impact on the cracking resistance of the mixtures”
- “designing Wisconsin asphalt mixtures with the air voids regressed to 3.0 percent is not likely to cause any problems with increased rutting susceptibility”
- “Results from this project indicate that the regressed air voids approach can improve cracking resistance without compromising the deformation resistance of asphalt mixes”

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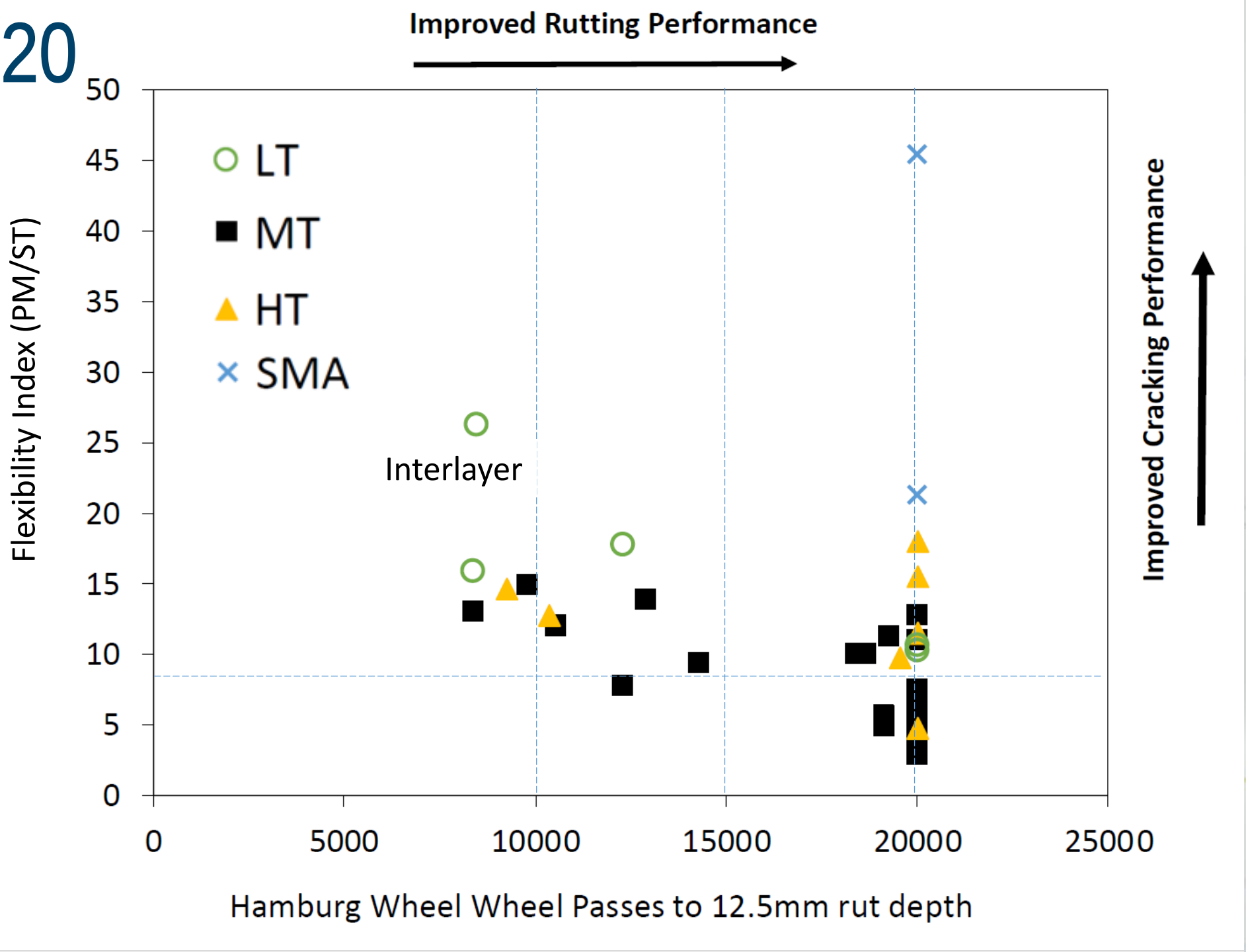
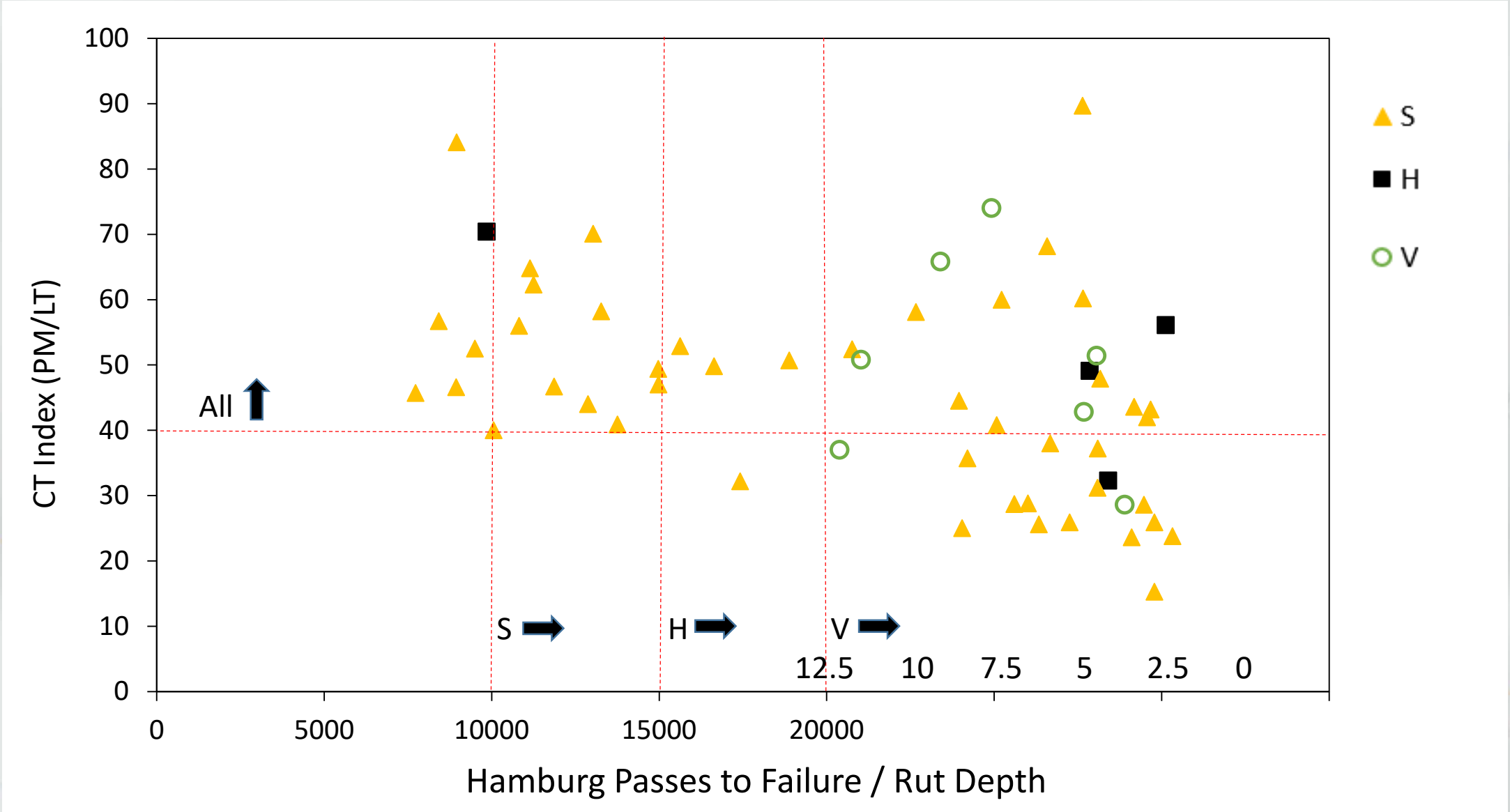
Research, WisDOT data

- Performance Testing on Pre-2020 AVR mixes (I-FIT)
- Performance Testing on 2020 AVR mixes (IDEAL-CT)

Pre-2020


Improved Rutting Performance
Flexibility Index (PM/ST)
Improved Cracking Performance
LT
MT
HT
SMA
Interlayer
0
5
10
15
20
25
30
35
40
45
50
0
5000
10000
15000
20000
25000
Hamburg Wheel Wheel Passes to 12.5mm rut depth

Performance Testing on 2020 AVR mixes



Summary

- Even with AVR, WisDOT mixes are stable
- AVR provides additional cracking resistance (along with other benefits)

"Performance testing completed in this research indicates 3.0% regressed air voids will improve pavement life in Wisconsin."

– Steve Hefel, WisDOT

Air Void Regression

Increased asphalt binder → increased cracking resistance

Questions?

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