Advantages of Chemical WMA in BMD

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Trey Wurst, P.E.

Adam Schaefer

Agenda

- Brief History of WMA
- Better Binder Performance
- Improved Mix Performance
- WMA Application - Compaction
- Pavement Designed to Perform

PURIFY. PROTECT. ENHANCE.

History of WMA

2002
- NAPA led study tour to Europe

2004
- WMA demonstration at World of Asphalt
- First field trials in FL and NC

2005
- WMA TWG formed
- First WMA on NCAT Test Track
- Field trials in FL, IN, MD, NH, OH, TX and Canada

2007
- FHWA/AASHTO European Scan Tour
- NCHRP 9-43 on WMA Mix Design initiated

2008
- WMA trials in 32 states
- 1st International WMA Conference

2009
- Full-Depth WMA Test Sections at NCAT
- NCHRP 9-47 on Eng. Props, emissions, field performance completed

2010
- WMA trials in 45 states / 10 Canadian Providences
- Over 20 WMA technologies in the US

2011
- NCHRP 9-43 completed
- 2nd International WMA Conference

2013
- NCHRP 9-49 on WMA Moisture Susceptibility completed

2014
- NCHRP 9-47A on WMA Properties and Performance completed

2015
- NCHRP 9-53 on Foamed Asphalt completed

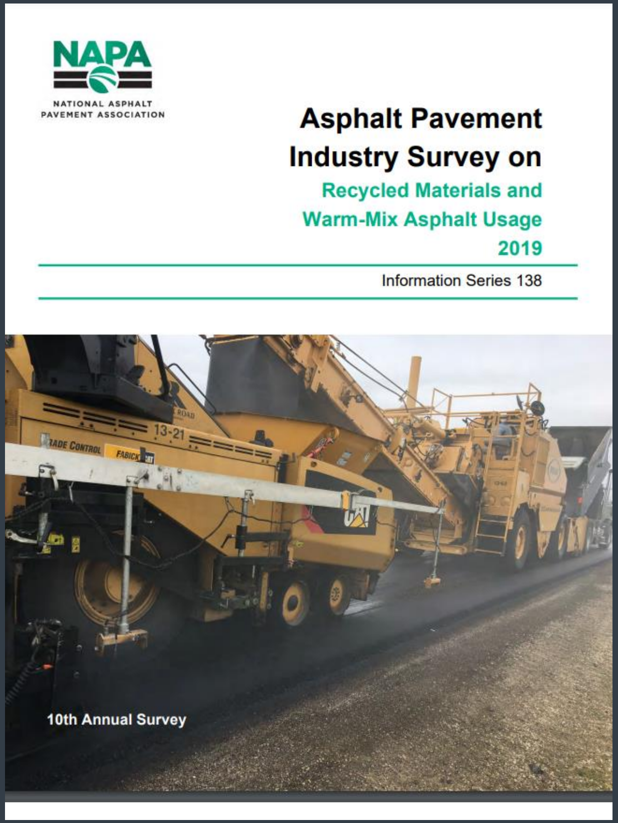
2016
- NCHRP 9-49A on Long-Term Field Performance completed

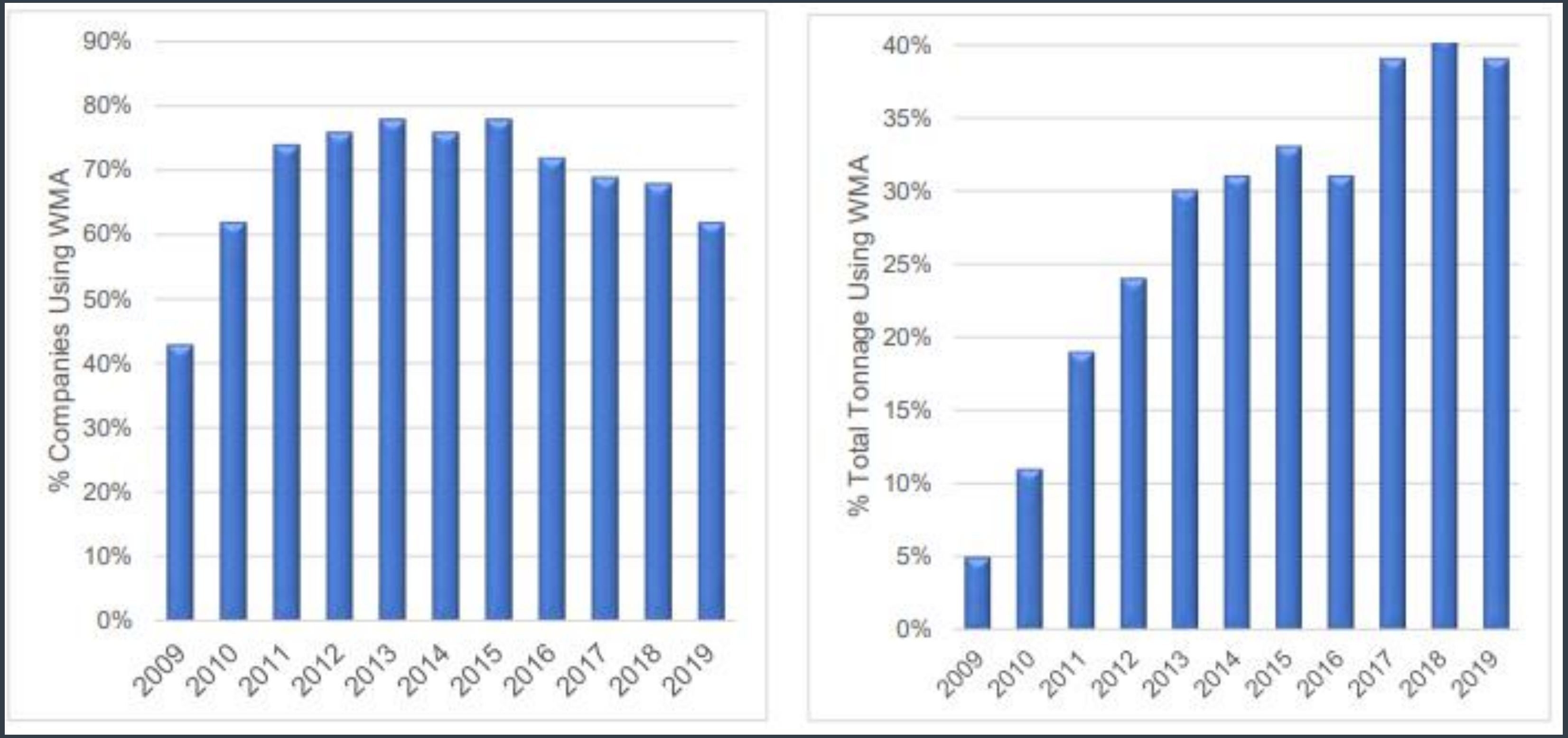
2018
- NCHRP 9-55 on RAS + WMA completed

2020
- NCHRP 9-61 on binder aging to accurately reflect mix aging to be completed

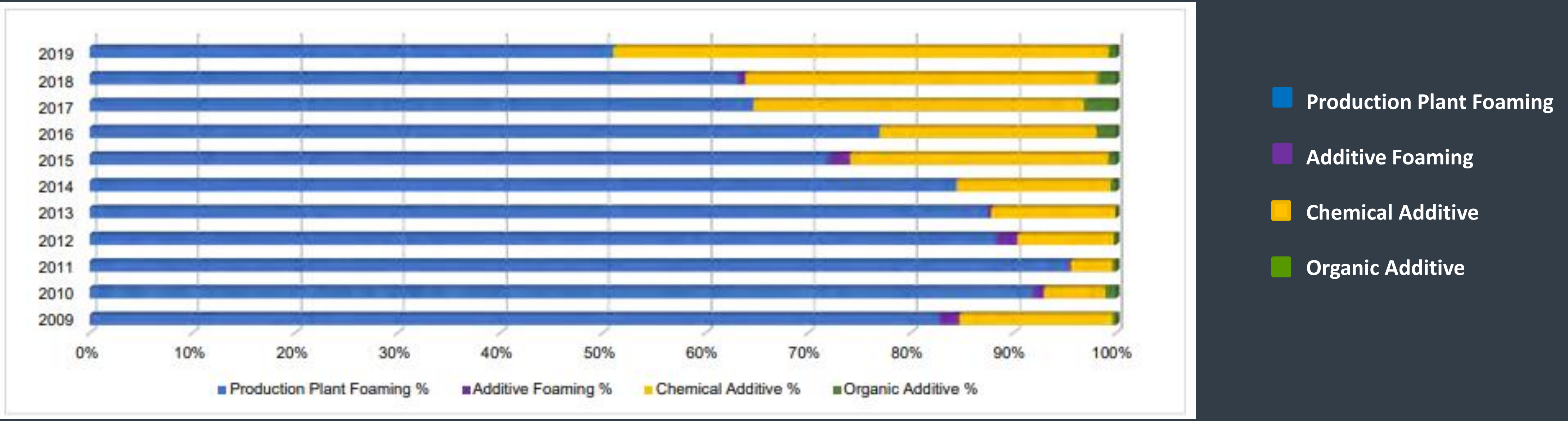
NAPA's WMA Usage Surveys

- The National Asphalt Paving Association (NAPA) has conducted a systematic survey of asphalt mixture producers across the United States to quantify the use of recycled materials and the production of WMA from 2009 until 2019.





NAPA Survey on WMA Usage



WMA Technology	% Production										
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Production Plant Foaming	83.0	92.0	95.4	88.3	87.0	84.5	72.0	76.9	64.7	63.2	51.0
Additive Foaming	2.0	1.0	0.2	2.0	0.3	0.0	2.1	0.0	0.0	0.7	0.0
Chemical Additive	15.0	6.0	4.1	9.4	12.1	15.0	25.2	21.1	32.2	34.3	48.3
Organic Additive	0.3	1.0	0.3	0.2	0.0	0.5	0.7	1.9	3.1	1.8	0.7

Graphs are from NAPA's "Asphalt Pavement Industry Survey on Recycled Materials and Warm-Mix Asphalt Usage: 2019"

LESS BINDER OXIDATION

COLD WEATHER PAVING

FIBER-FREE SMA

MIX TYPES:
OGFC
PMB
GTR …

MAT DENSITY

MORE UNIFORM

SEGREGATION =

LESS THERMAL

HIGHER RECYCLED MATERIAL CONTENT

LONGER HAUL DISTANCES

BETTER COMPACTION DENSITY = BONUS PAY

LIME REPLACEMENT

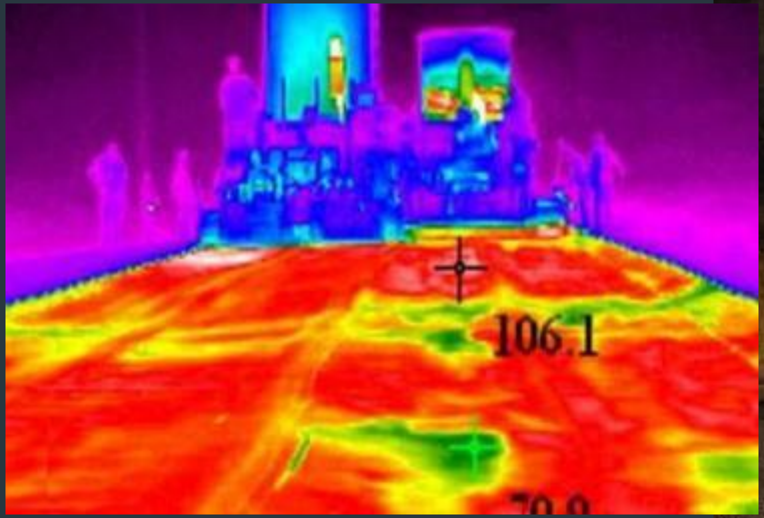
REDUCED AGGREGATE ABSORPTION

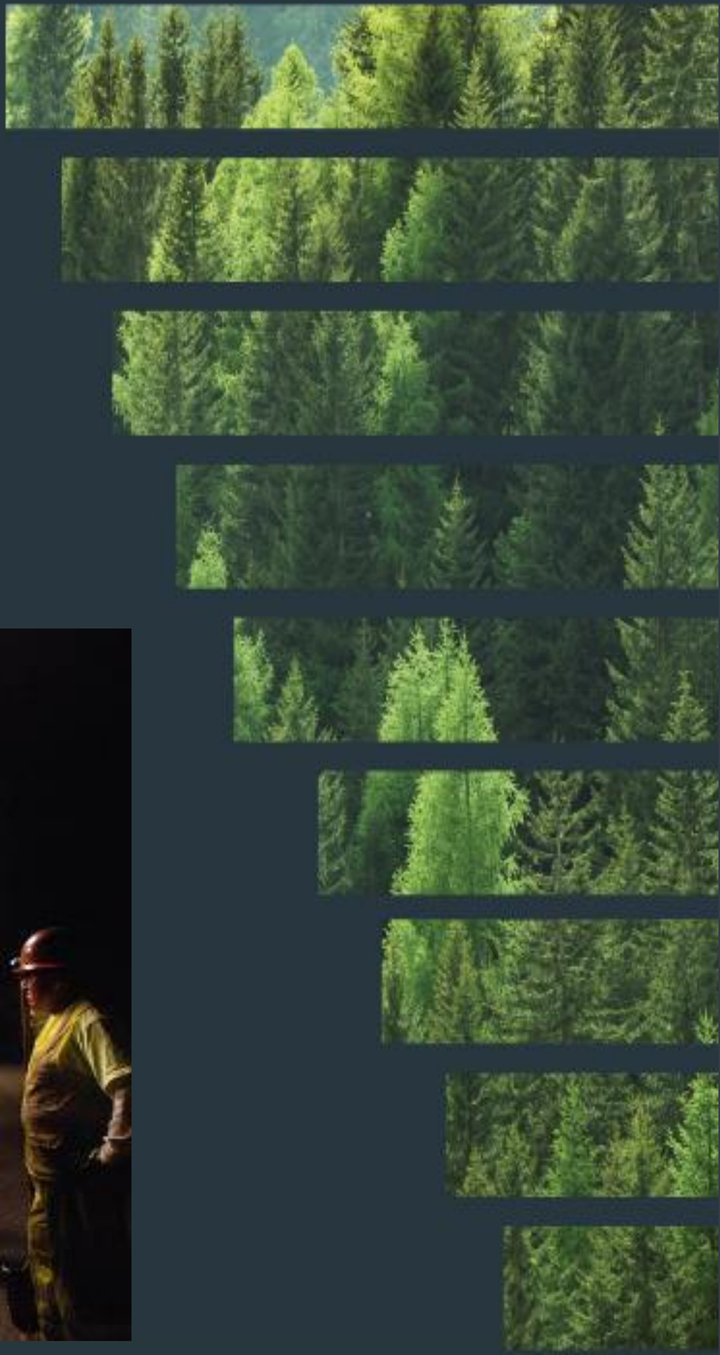
Ingevity "Three Pillars Approach" to WMA

Binder Analysis

Mixture Performance

Pavement Design





What Influences Binder Aging?

Short-Term "Spurt" Aging

Process dependent
Controllable

In-Service Aging

Environmental dependent
Predictive

How Our Industry Lab Ages Binder

Short-term Aging
Rolling Thin Film Oven

In-service Aging
Pressure Aging Vessel

PG 64 -22

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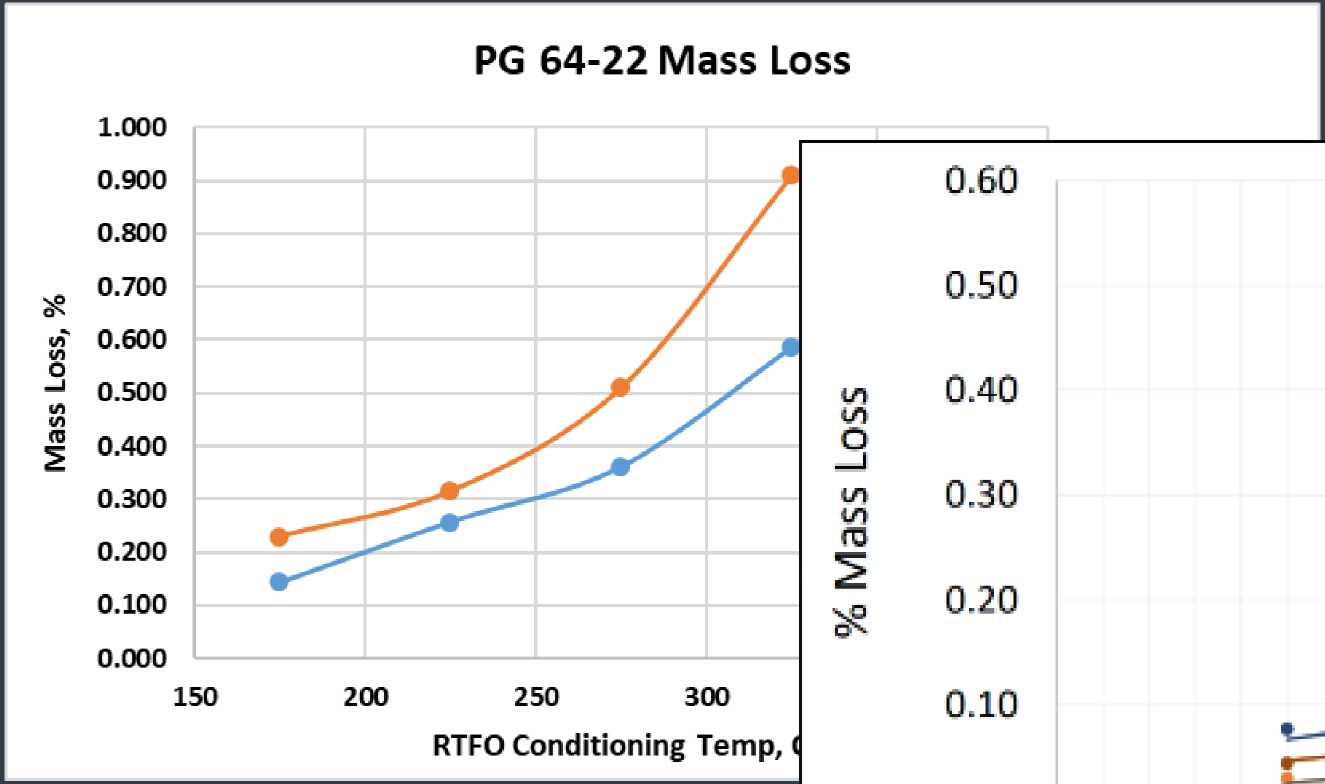
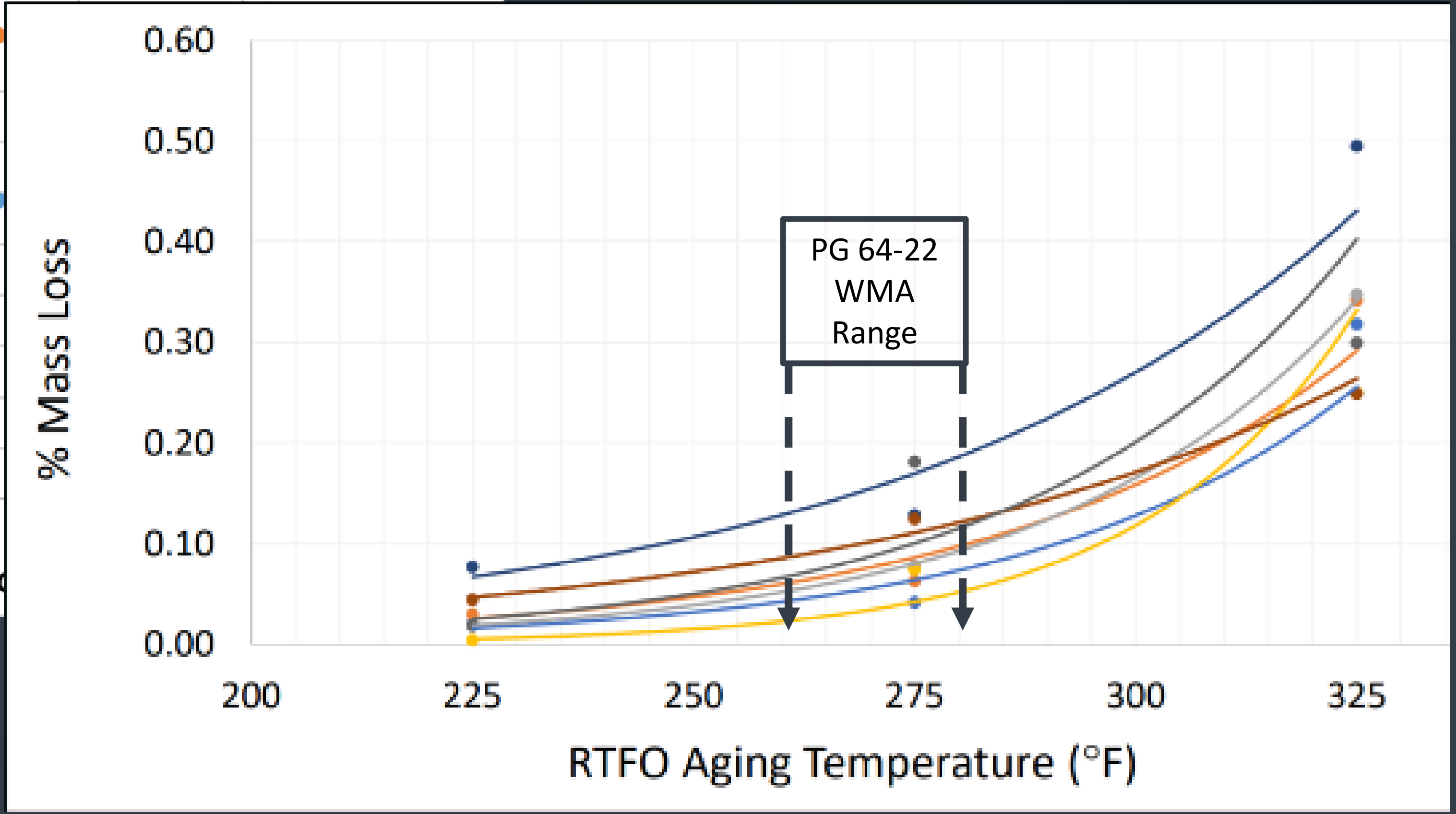
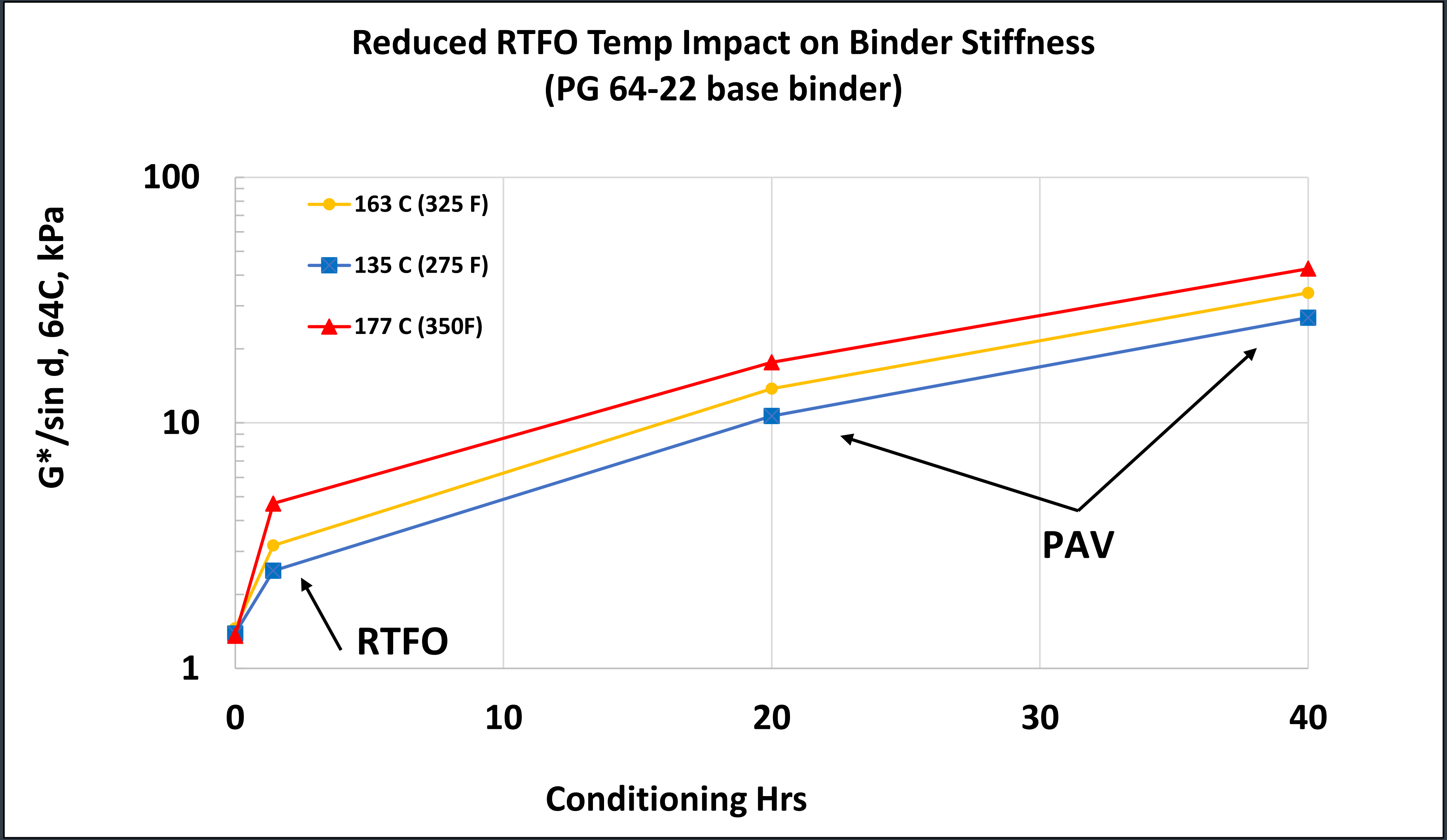
Binder Mass Loss vs RTFO Temperatures



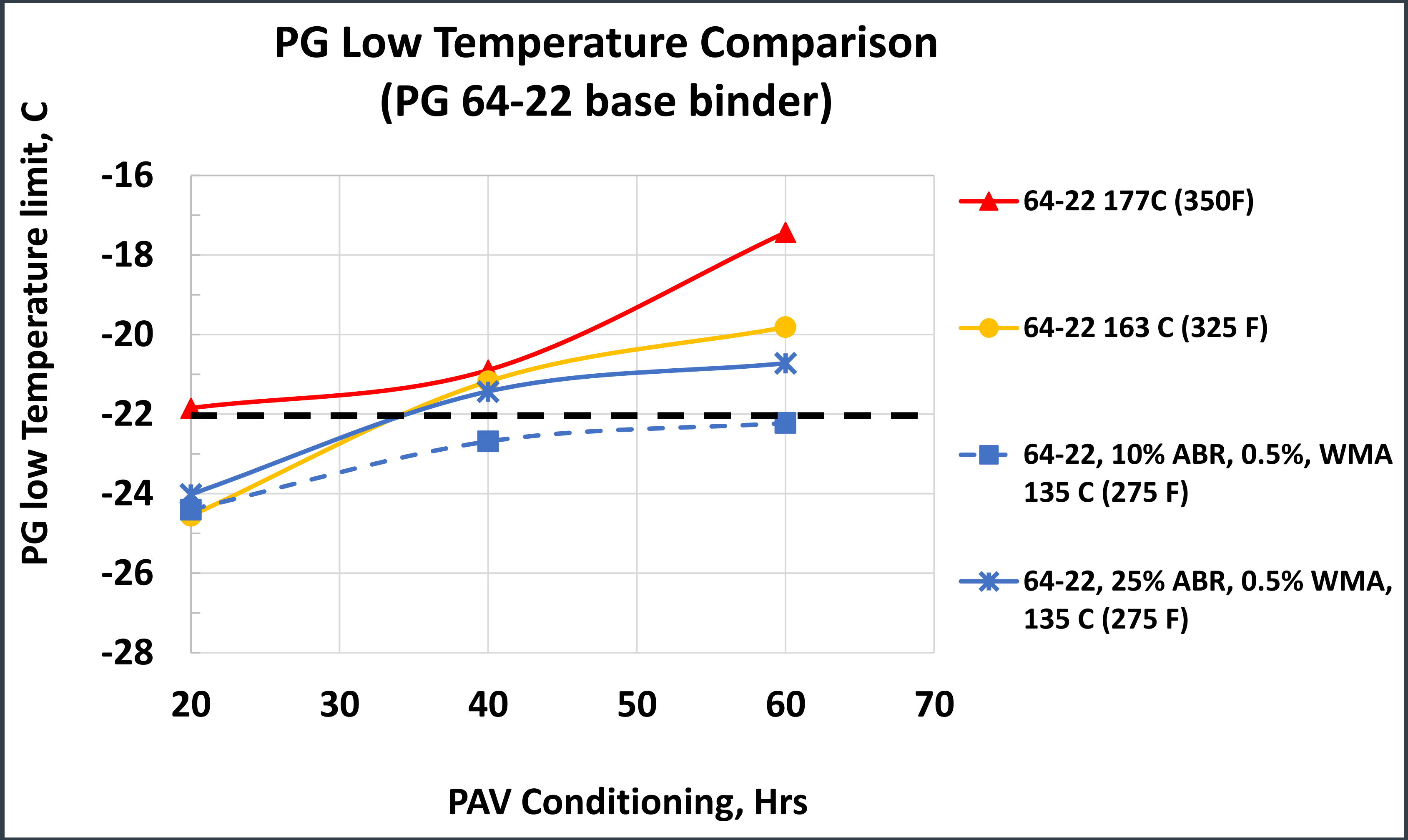


Binder Stiffness vs RTFO Temperatures



PG Low Temp After Extended Aging

- 20 Hr PAV is common aging limit for PG specifications
- PG 64-22 RTFO 350F is out of spec after 20 Hr PAV
- Reducing RTFO 50F still meets spec after 60 Hrs



5yrs	10yrs	15yrs

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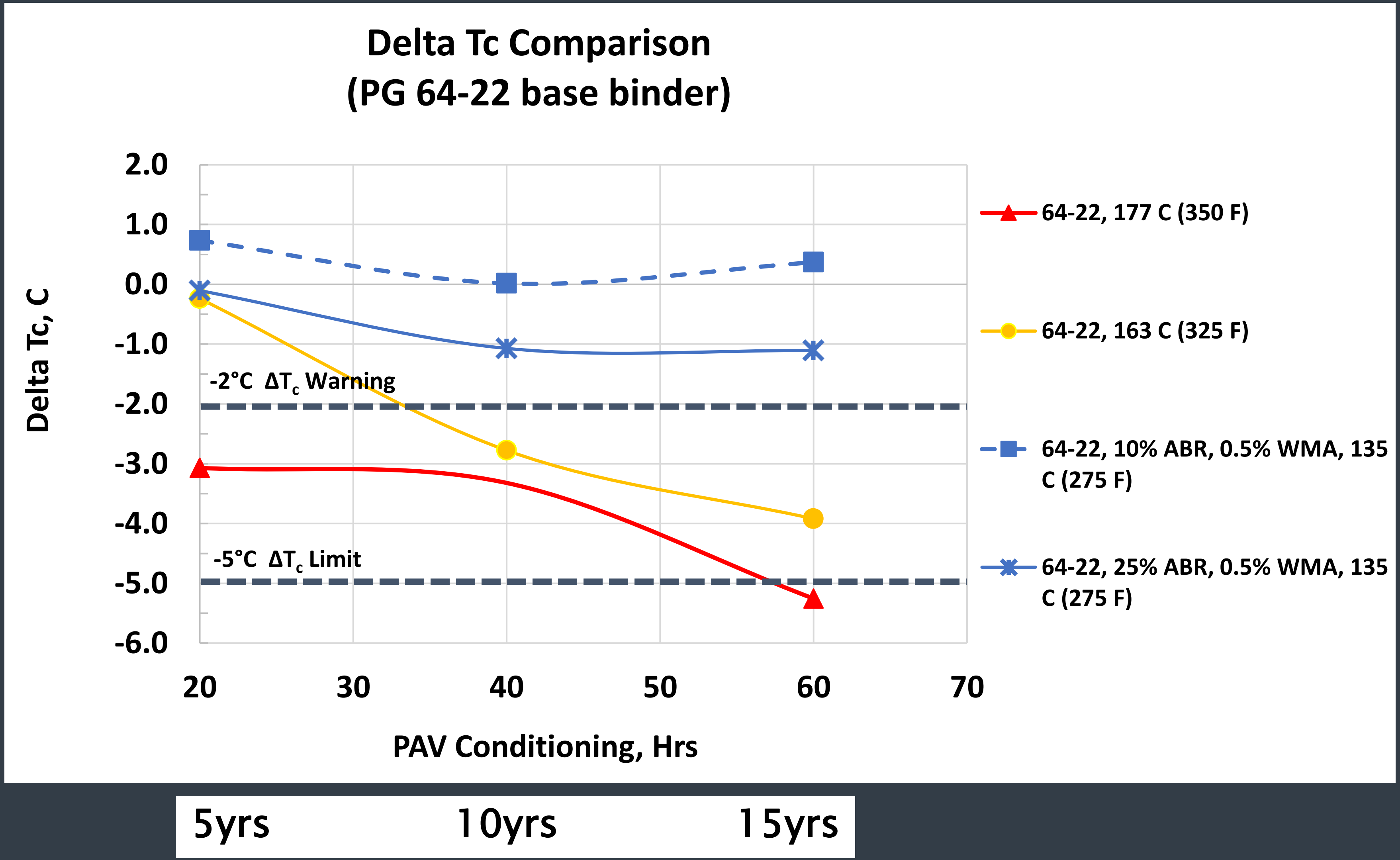
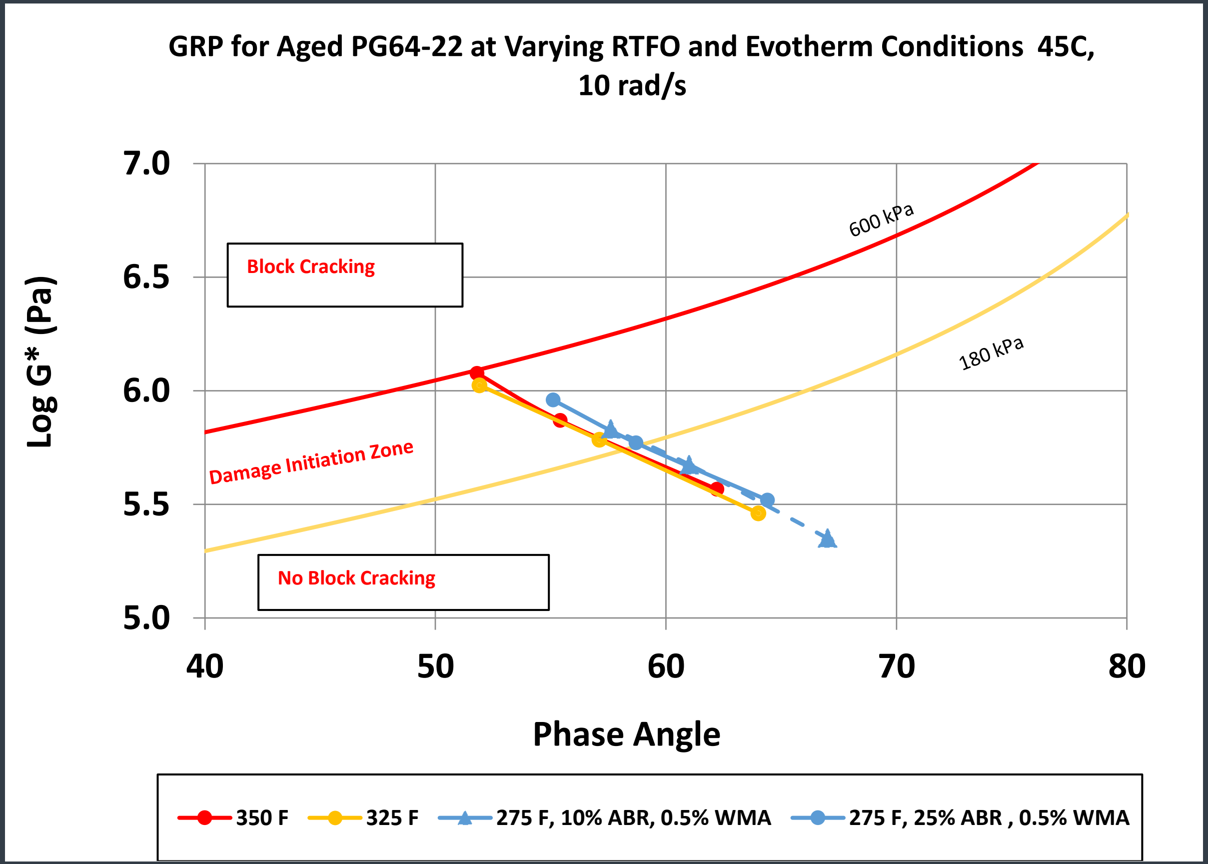
Lowering Temperature Improves Long-Term ΔTc



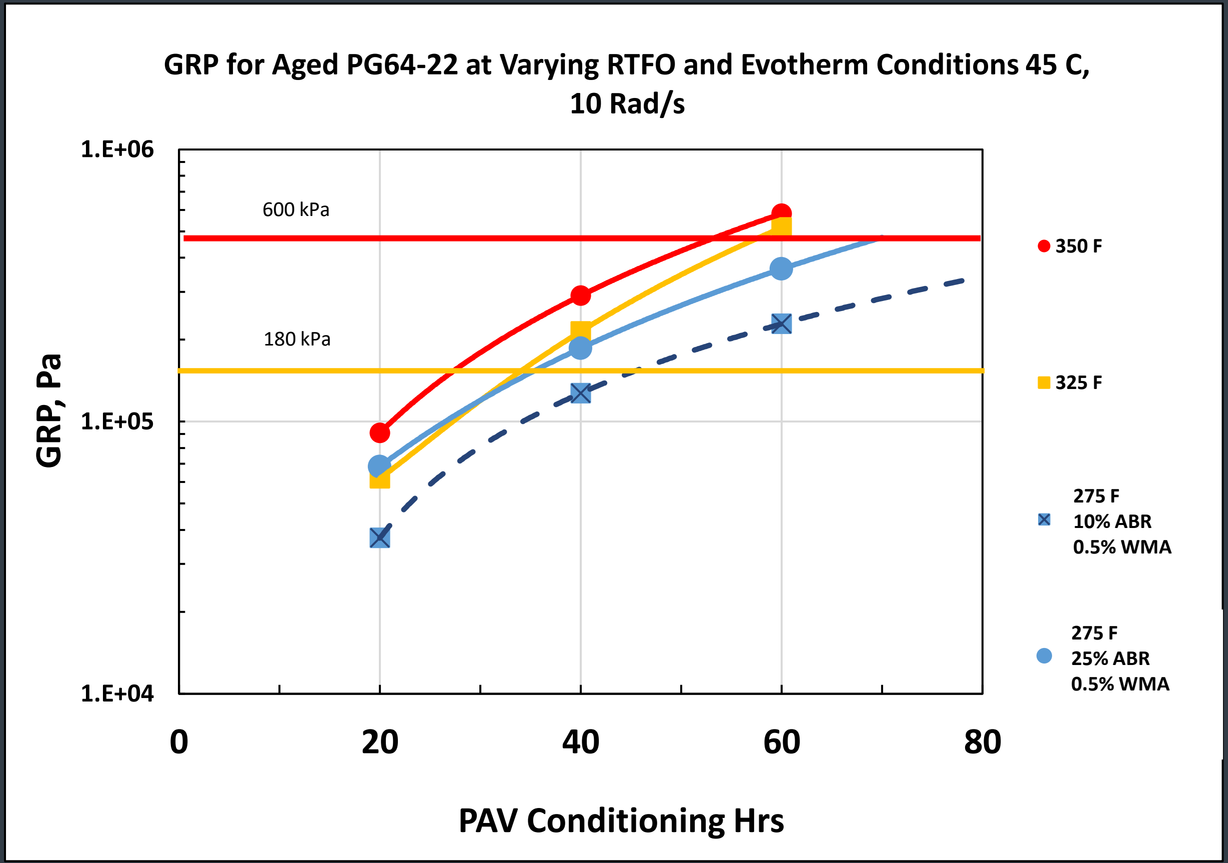
$\Delta Tc = T_{cont} S - T_{cont} m$

Glover–Rowe Parameter with Low Temperature

Black Space Diagram



GRP Values



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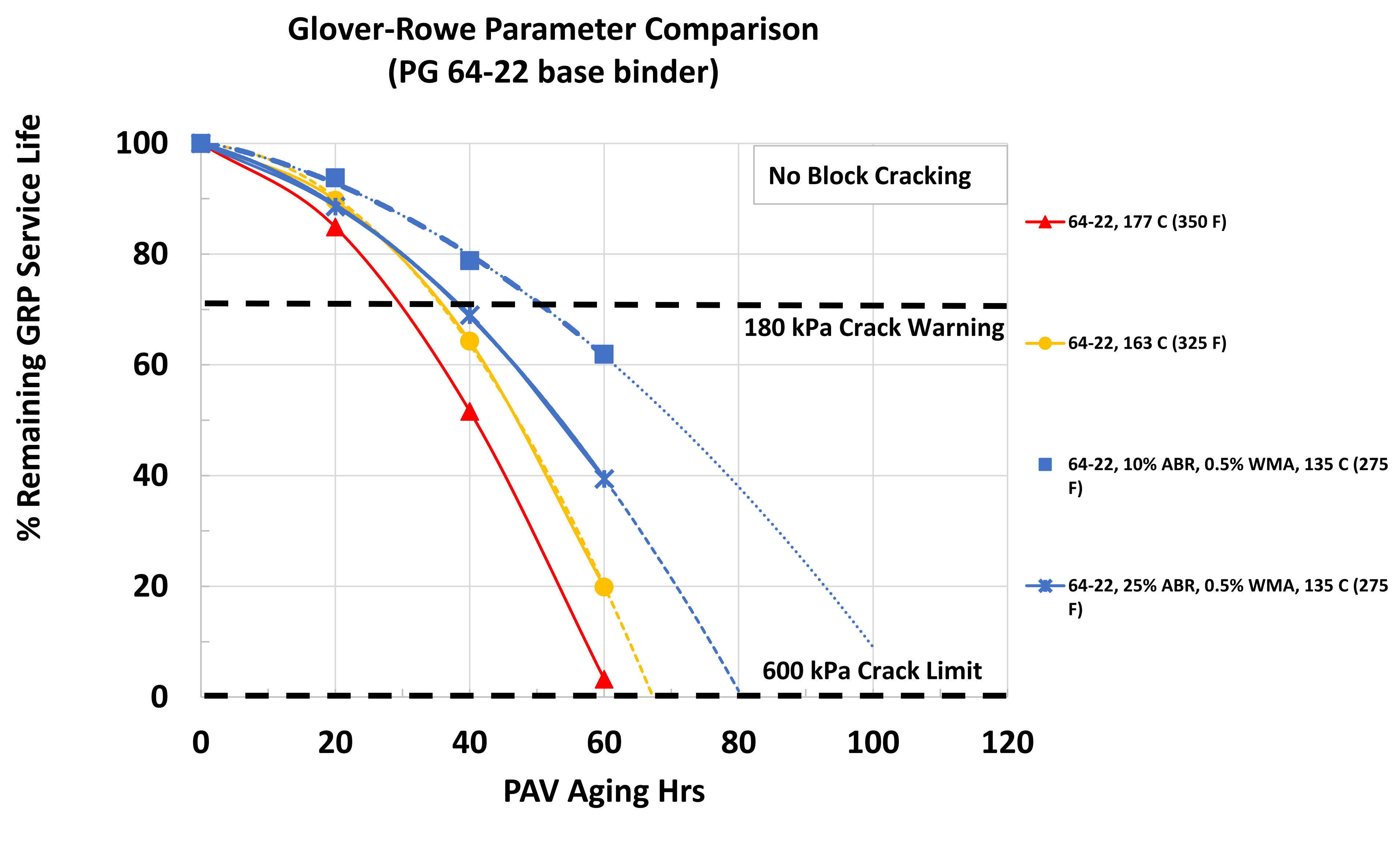
Glover–Rowe Service Life Predictions



$$GRP = \frac{G^*(\cos\delta)^2}{\sin\delta}$$

% remaining life =

$(GRP_{limit} - GRP)/GRP_{limit} * 100$

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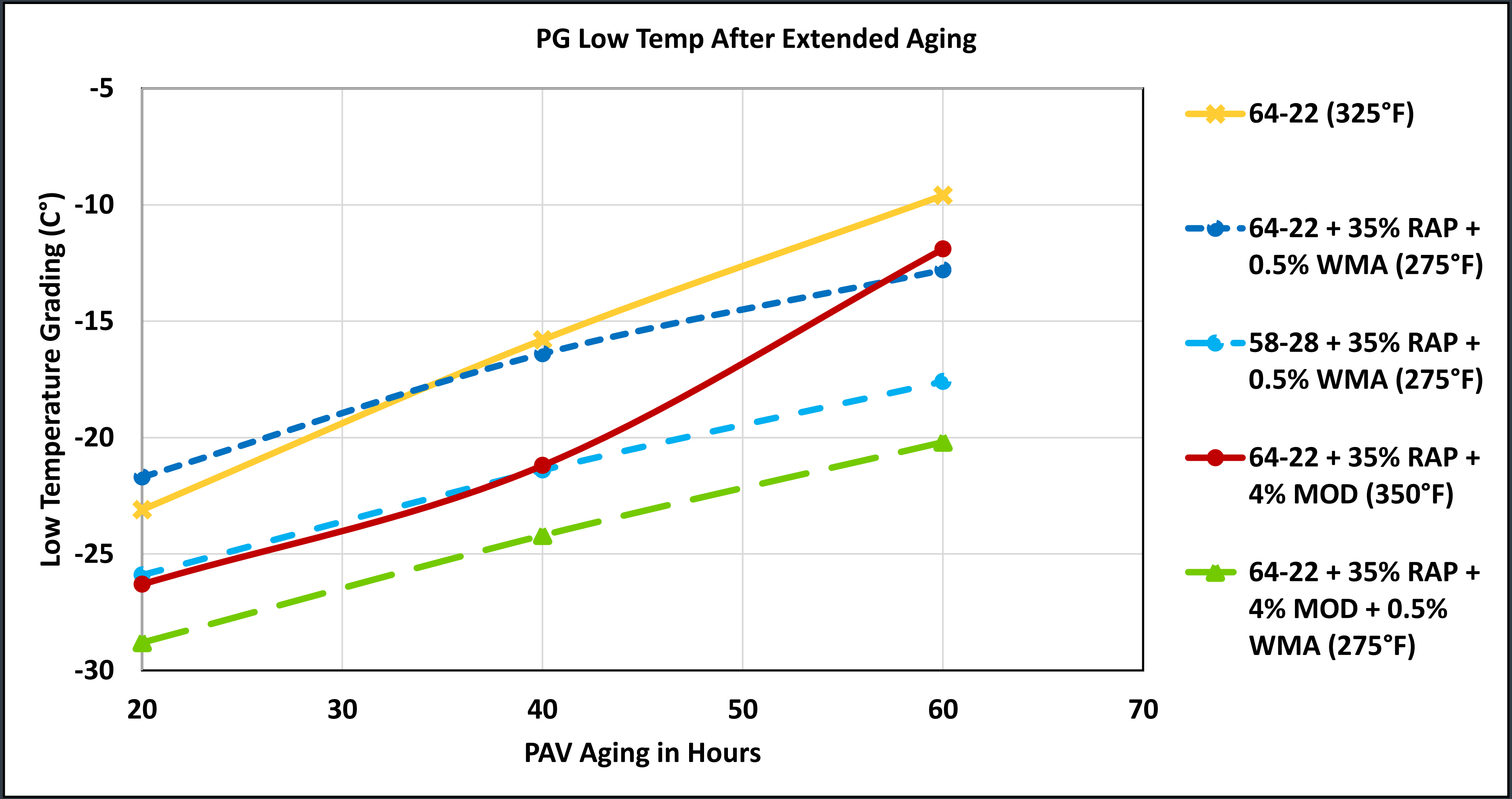
PG Low Temp After Extended Aging with Modifier Comparison

Grade bumping and Modifiers also shift graph.

WMA shift from lower mix temperature of greater significance



5yrs	10yrs	15yrs

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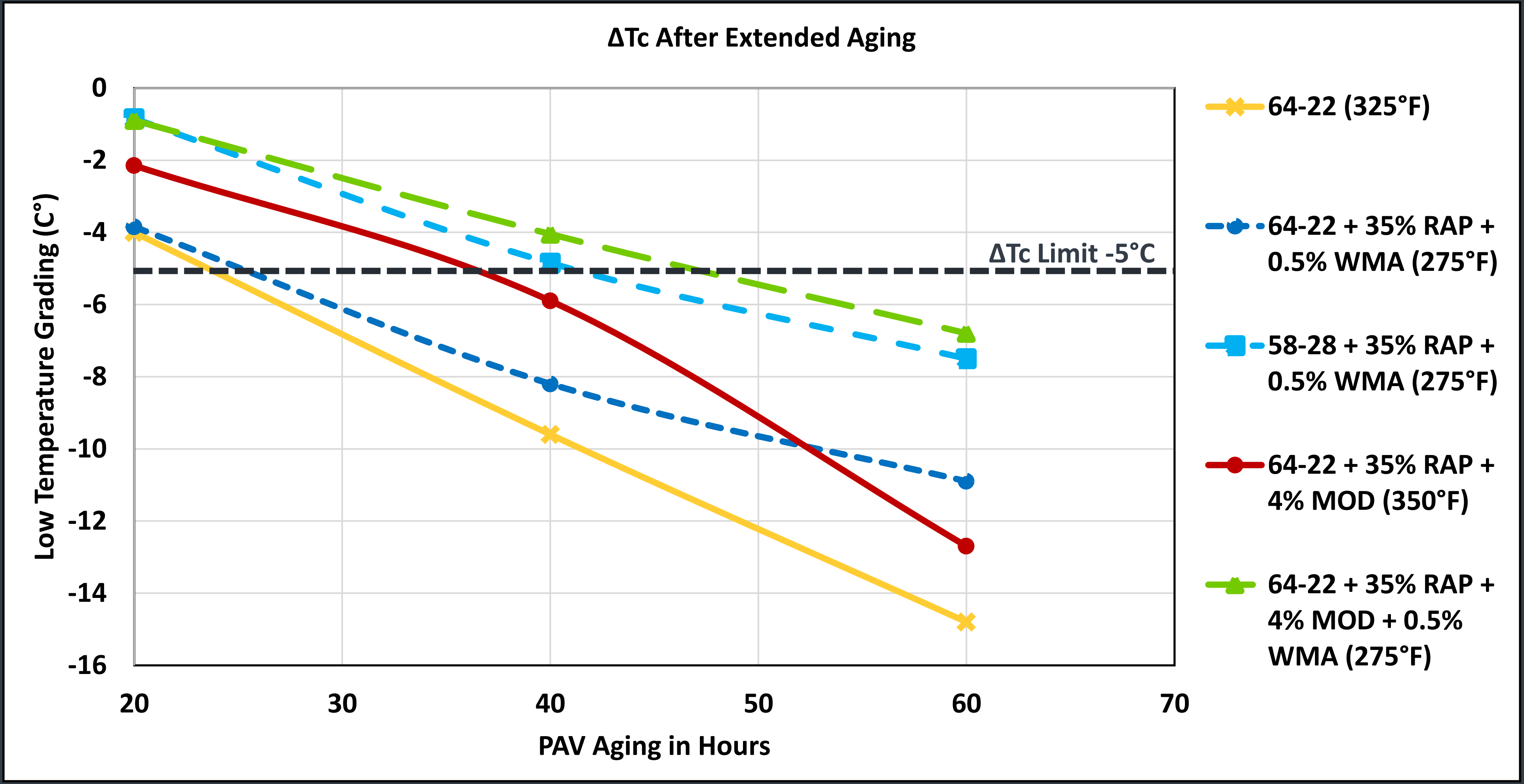
ΔTc After Extended Aging with Modifier Comparison

Grade bumping and Modifiers also shift ΔTc data.

Elevated mix temperature can complete erode benefit from binder modification



5yrs 10yrs 15yrs

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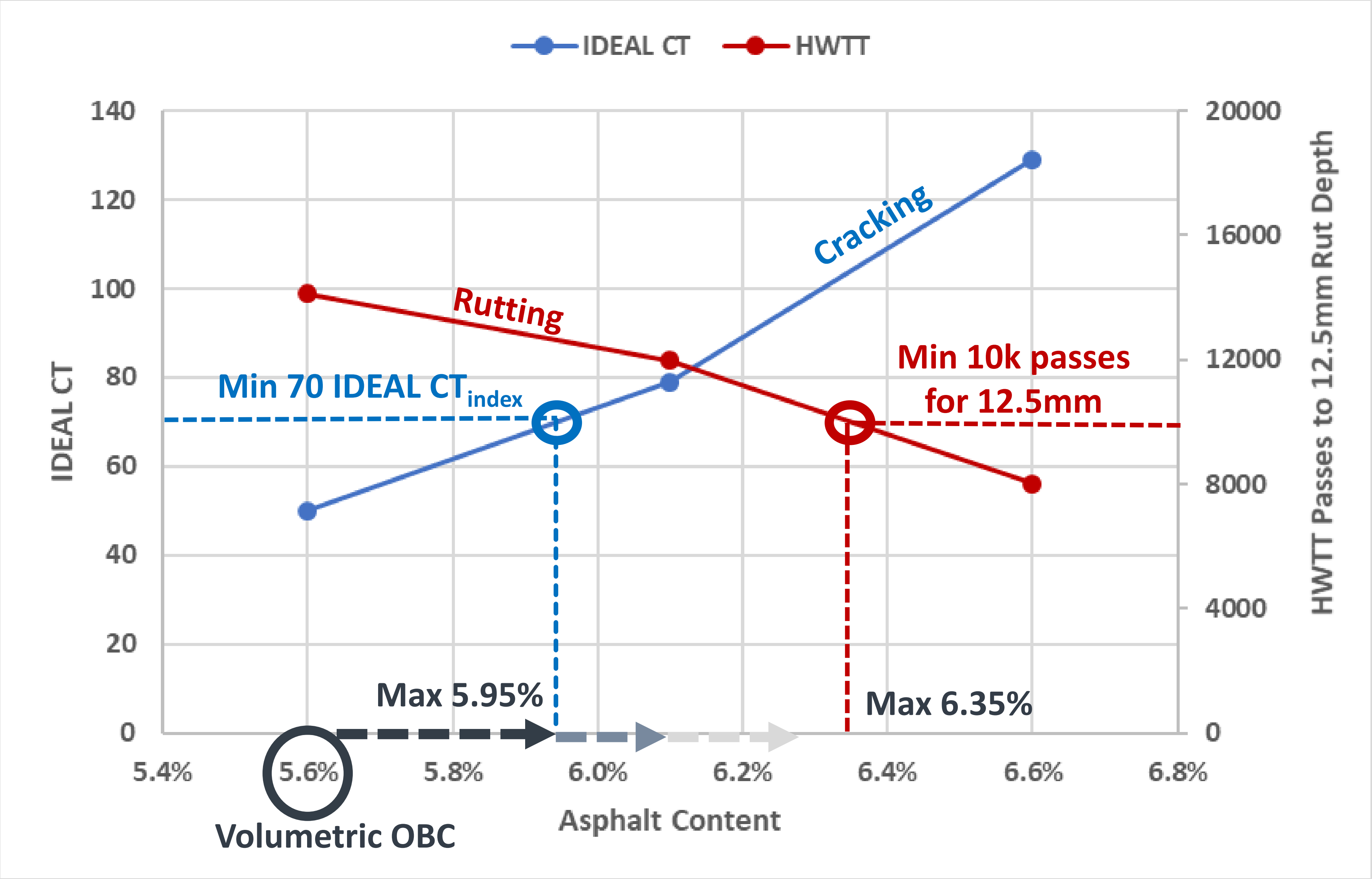
Mixture Performance Testing – Pillar II

BMD Trends- Typical Approach



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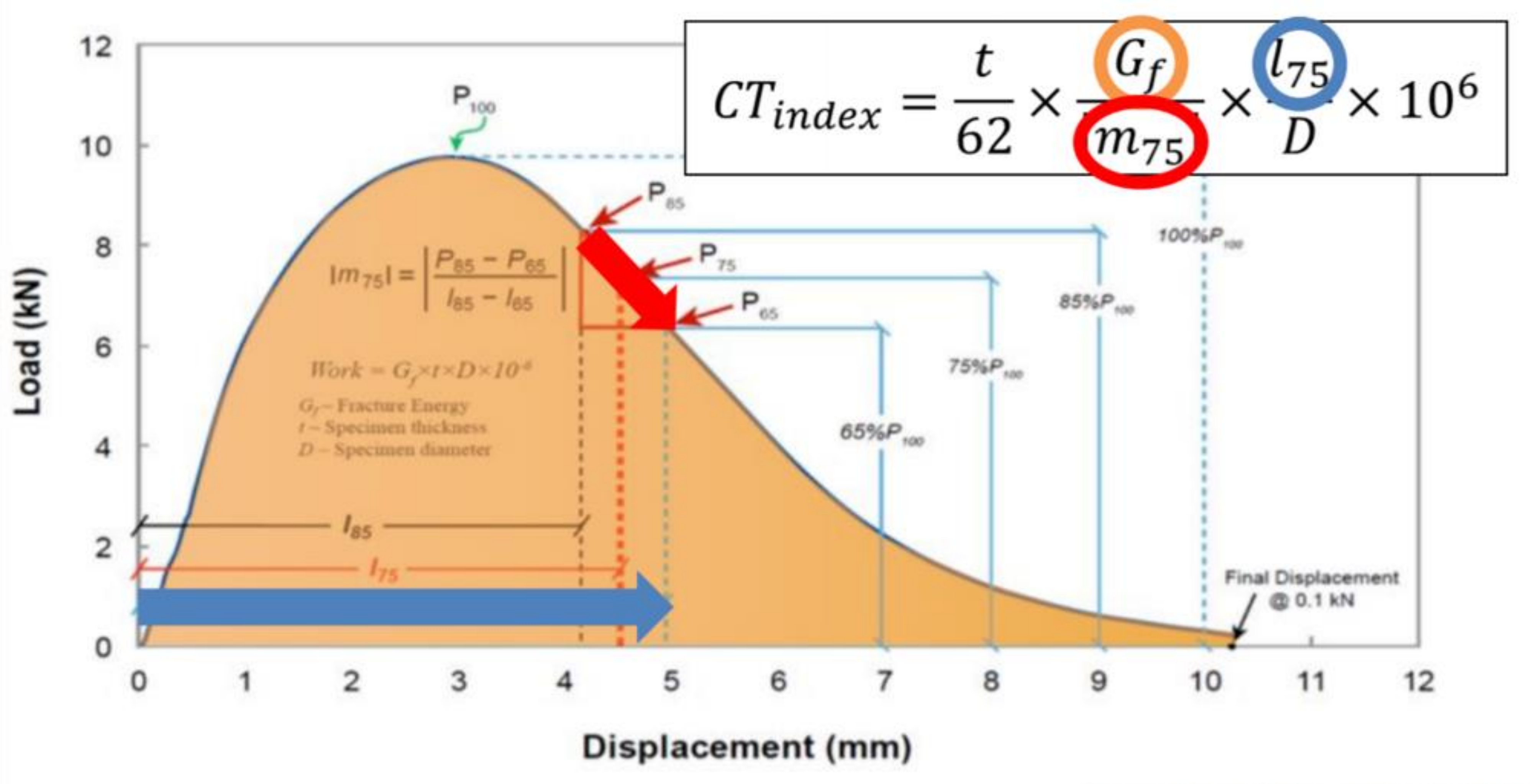
BMD – How Does IdealCT Work?



(Road and Materials, 2019)

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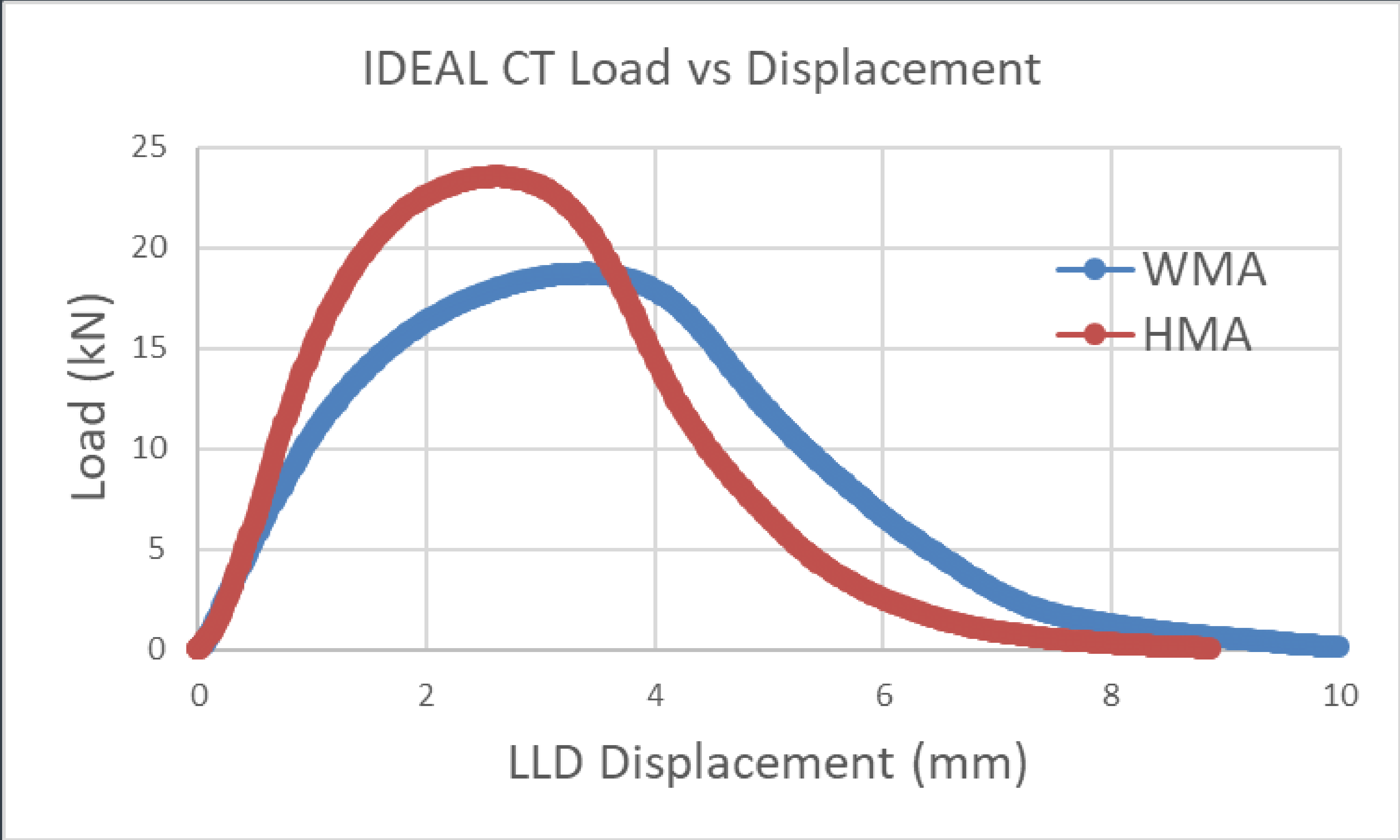
BMD – How WMA Impacts IDEAL CT



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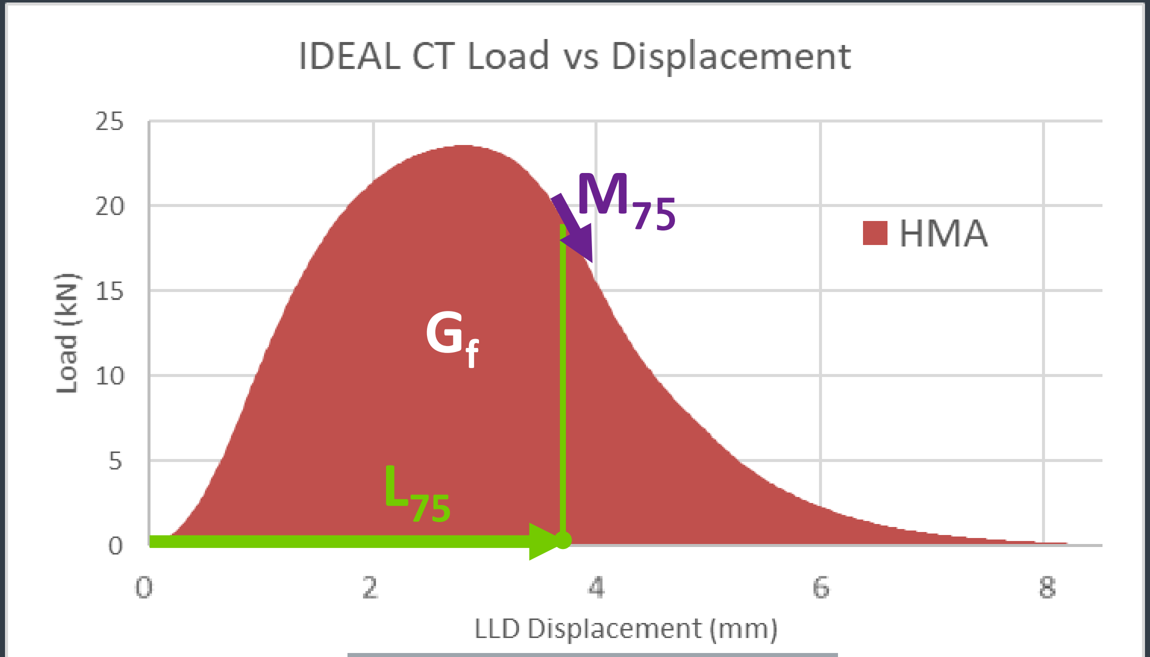
BMD – How WMA Impacts IDEAL CT

$$CT_{index} = \frac{t}{62} \times \frac{G_f}{M_{75}} \times \frac{l_{75}}{D} \times 10^6$$

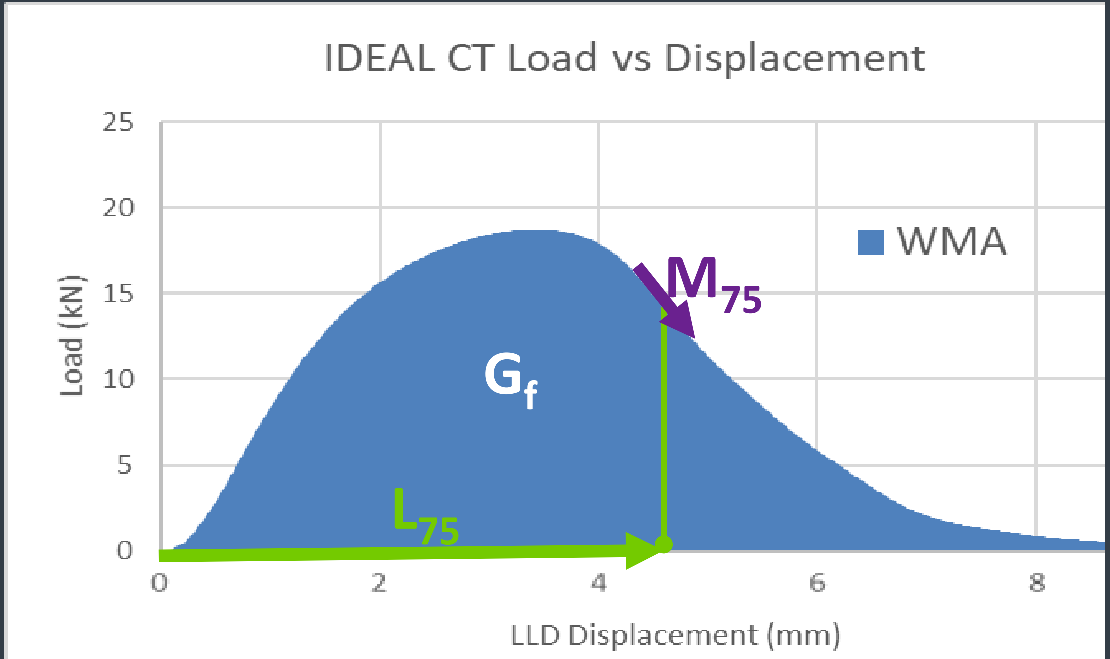


CT_{index}=20

G_f = 9319 J/m^2

L_{75} = 3.76 mm

M_{75} = 11.64 N/m



CT_{index}=42

G_f = 9485 J/m^2

L_{75} = 4.69 mm

M_{75} = 7.06 N/m

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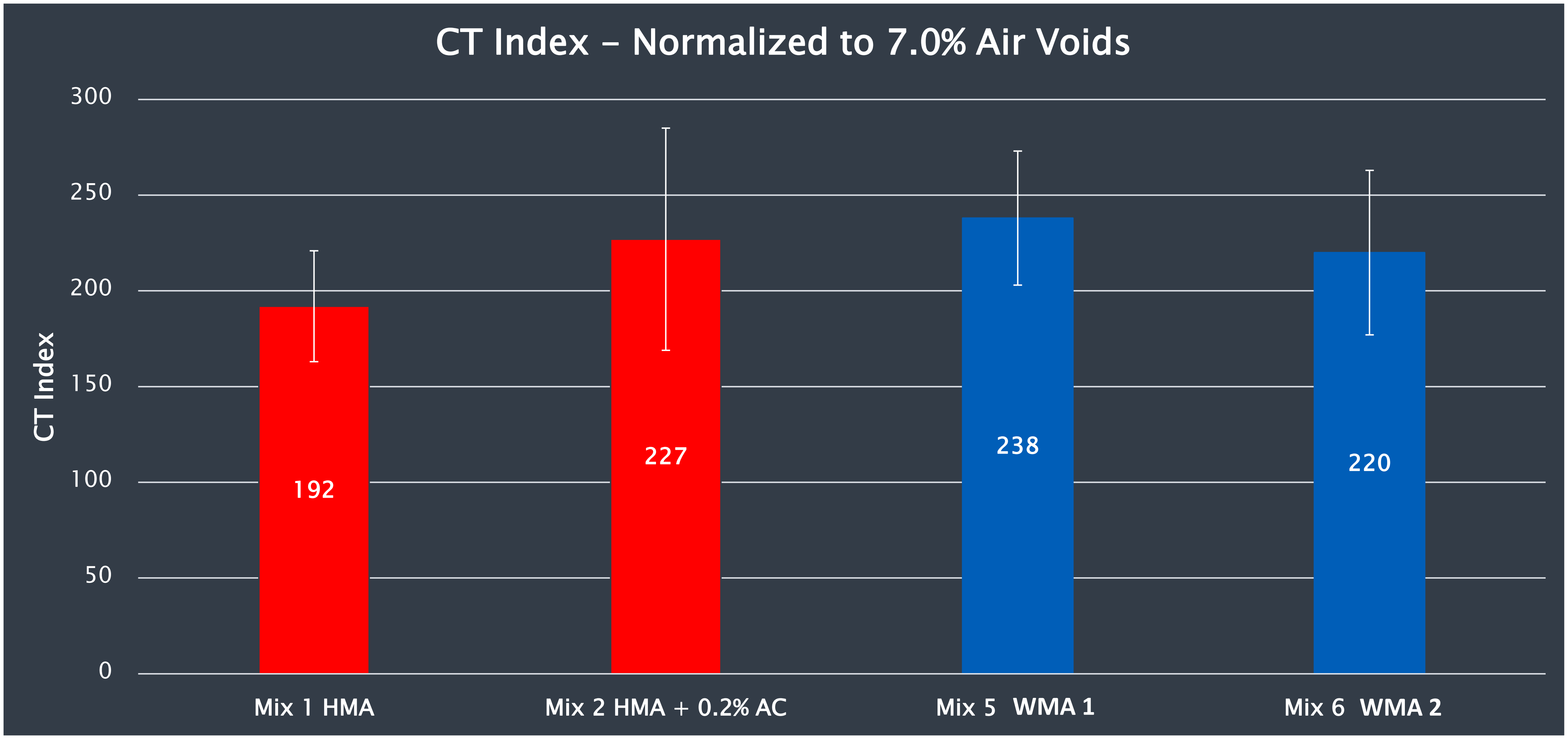
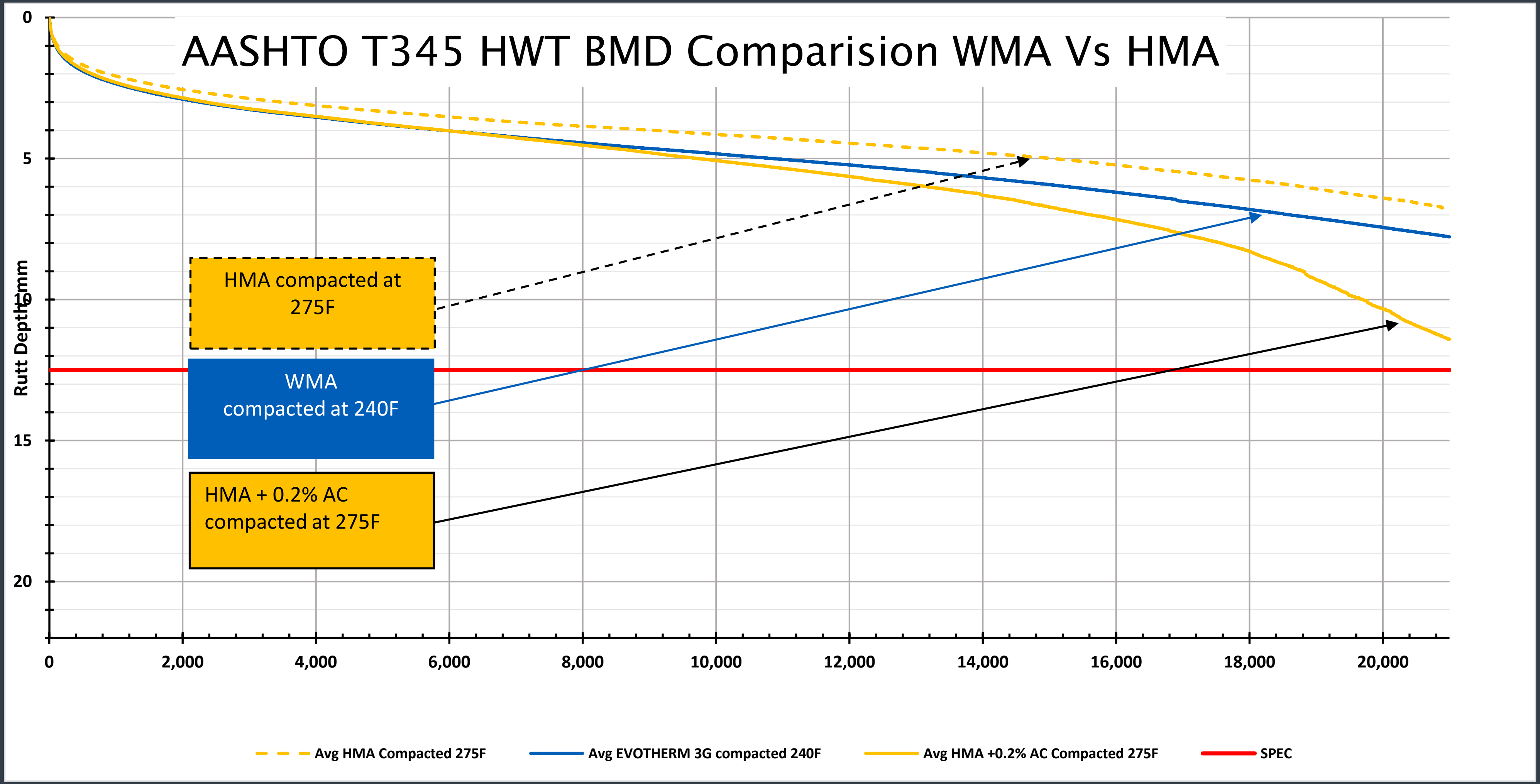
BMD – WMA vs Increased AC content



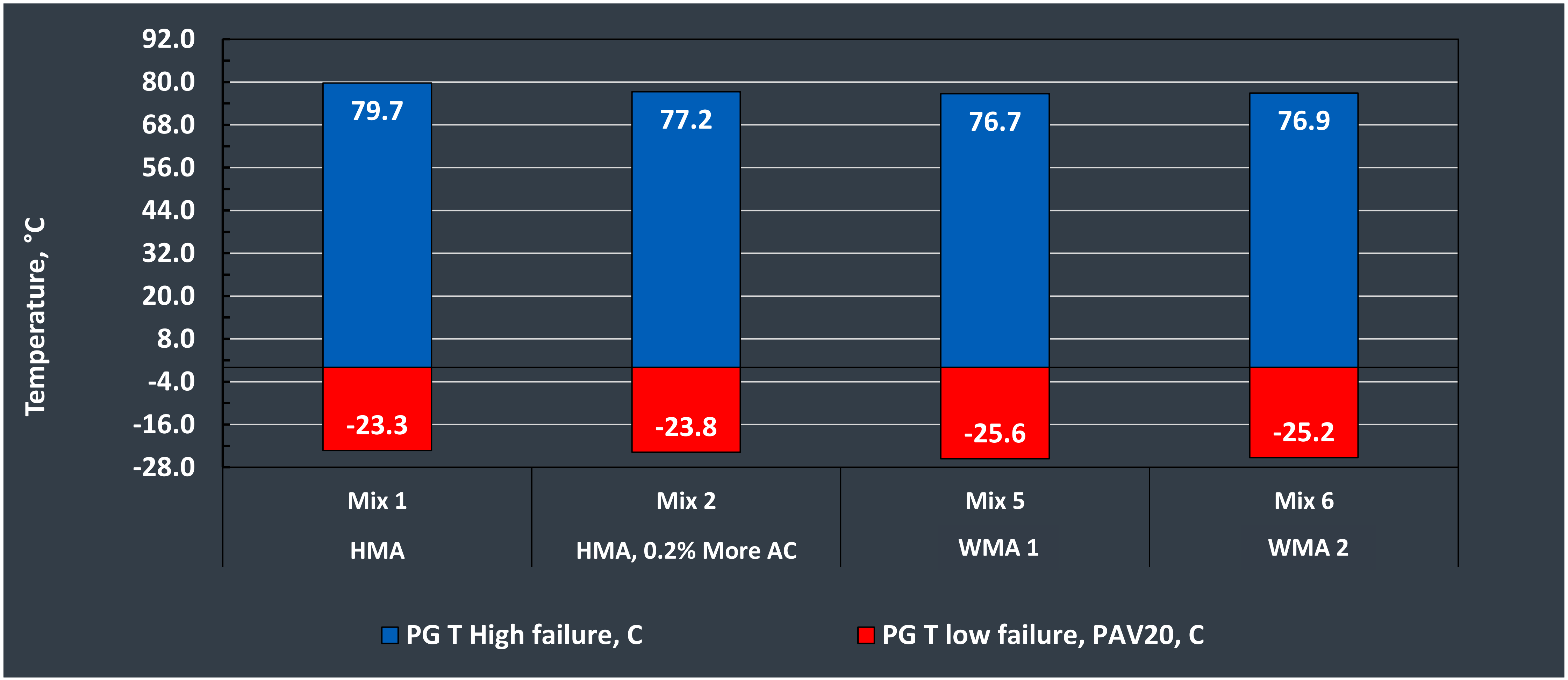
Avg CT Index values improve when produced as WMA and when adding AC

BMD – WMA vs Increased AC Content



No significant change in WMA rutting performance as compared HMA; increased AC% shows more potential to rut.

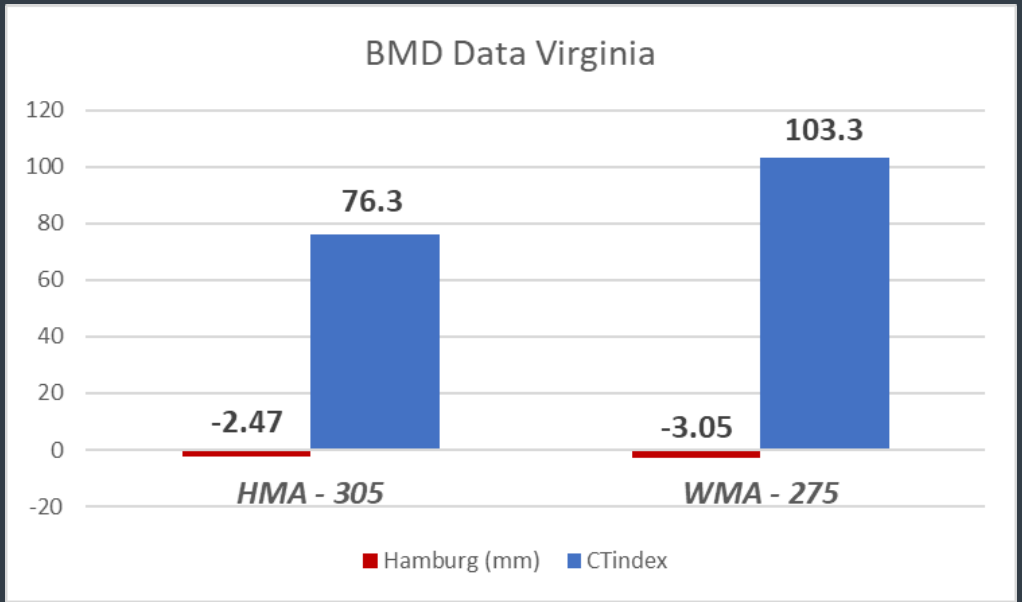
Recovered AC Analysis

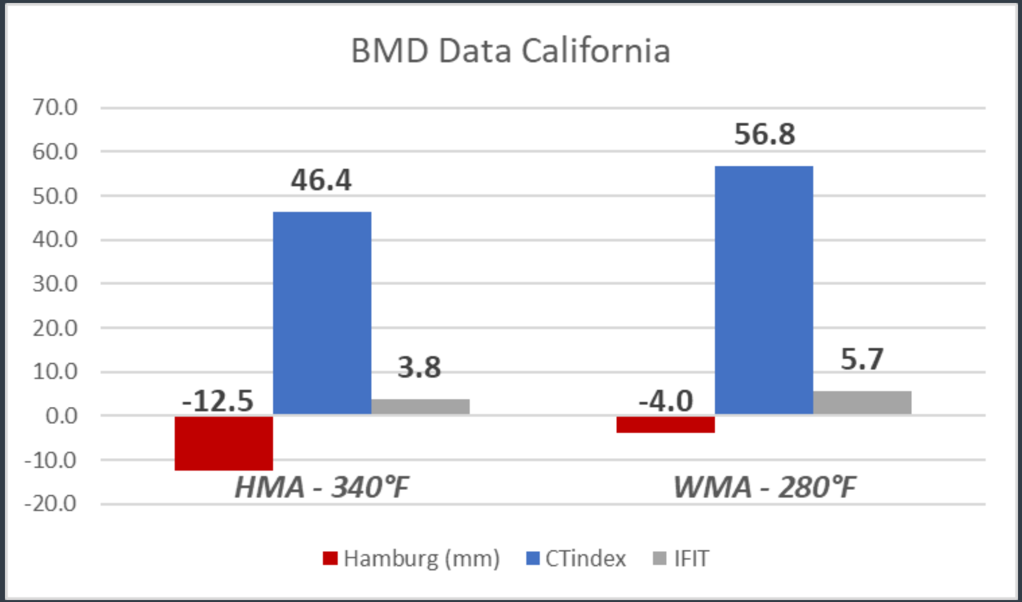


STOA Only - PG true grade indicates better low temperature performance for WMA vs HMA
High temperature impact confirmed by HWT performance

Mixture Performance Testing – BMD

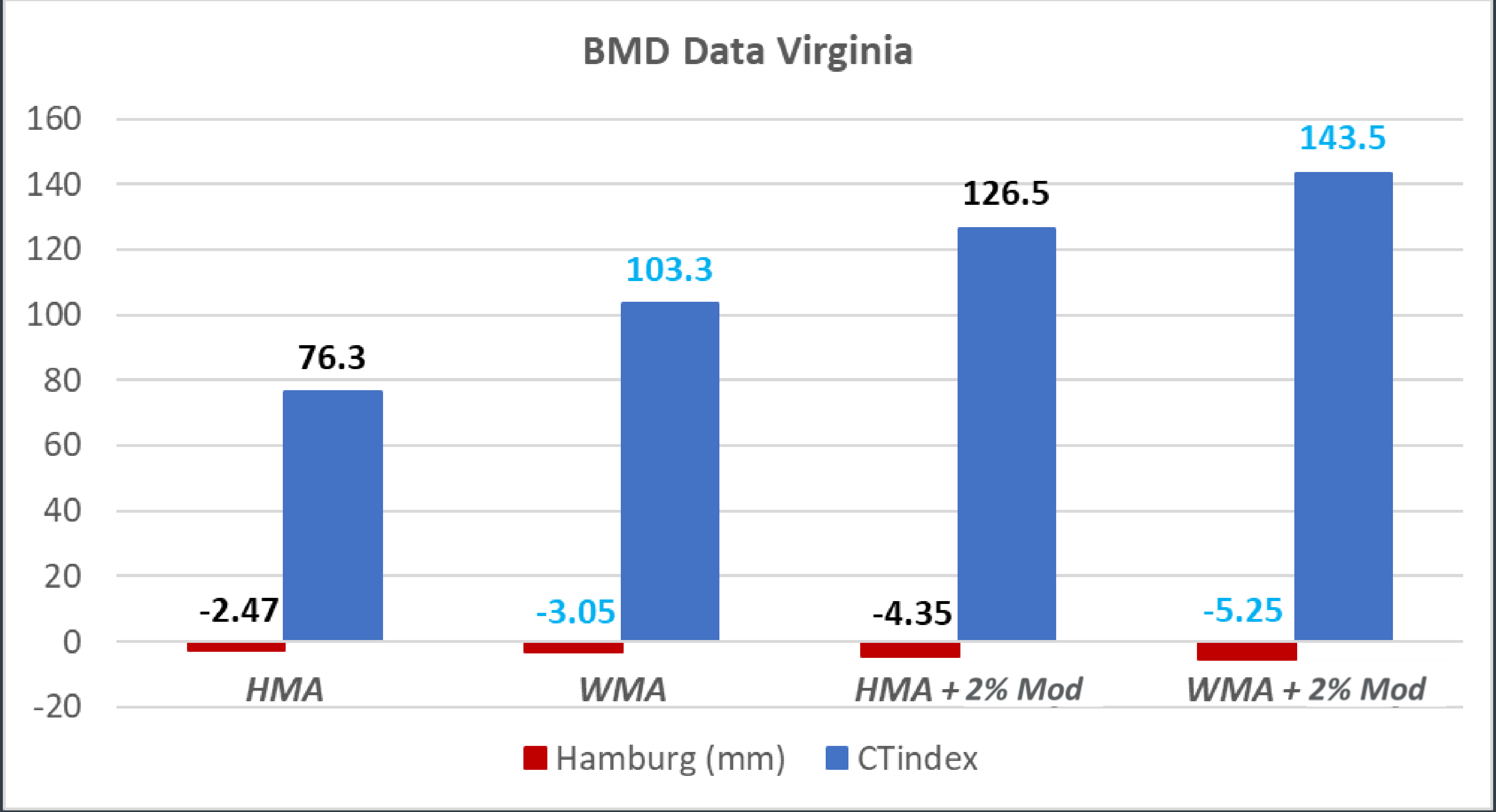
- Virginia California BMD work with WMA.
- WMA improves IDEAL CT by temperature reduction
- Rutting is not affected by temperature reduction





Mixture Performance Testing – BMD with Binder Modifier

- WMA Shift and a Modifier Shift



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Evotherm WMA Application – Compaction

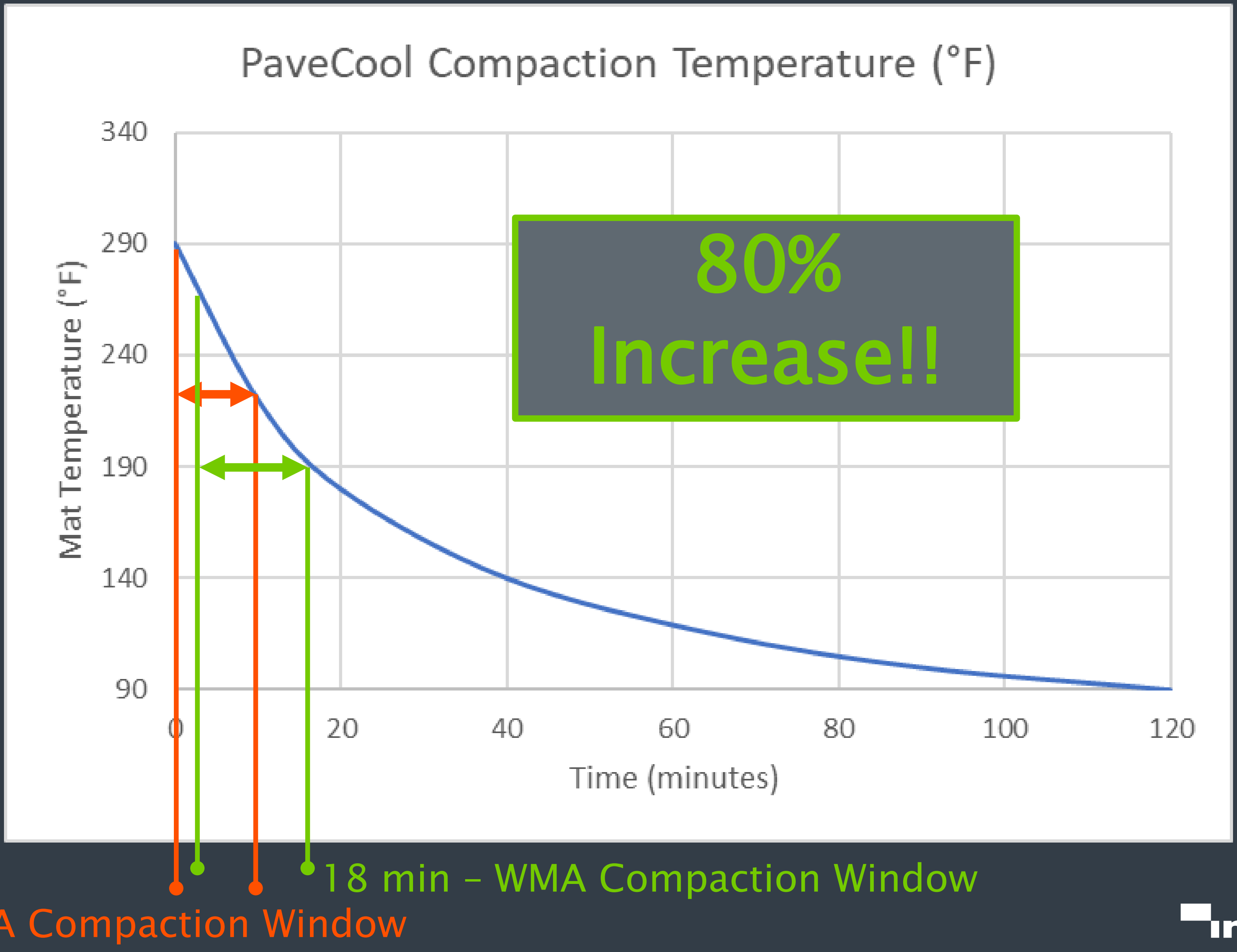
Compaction Window

<u>Assumptions</u>

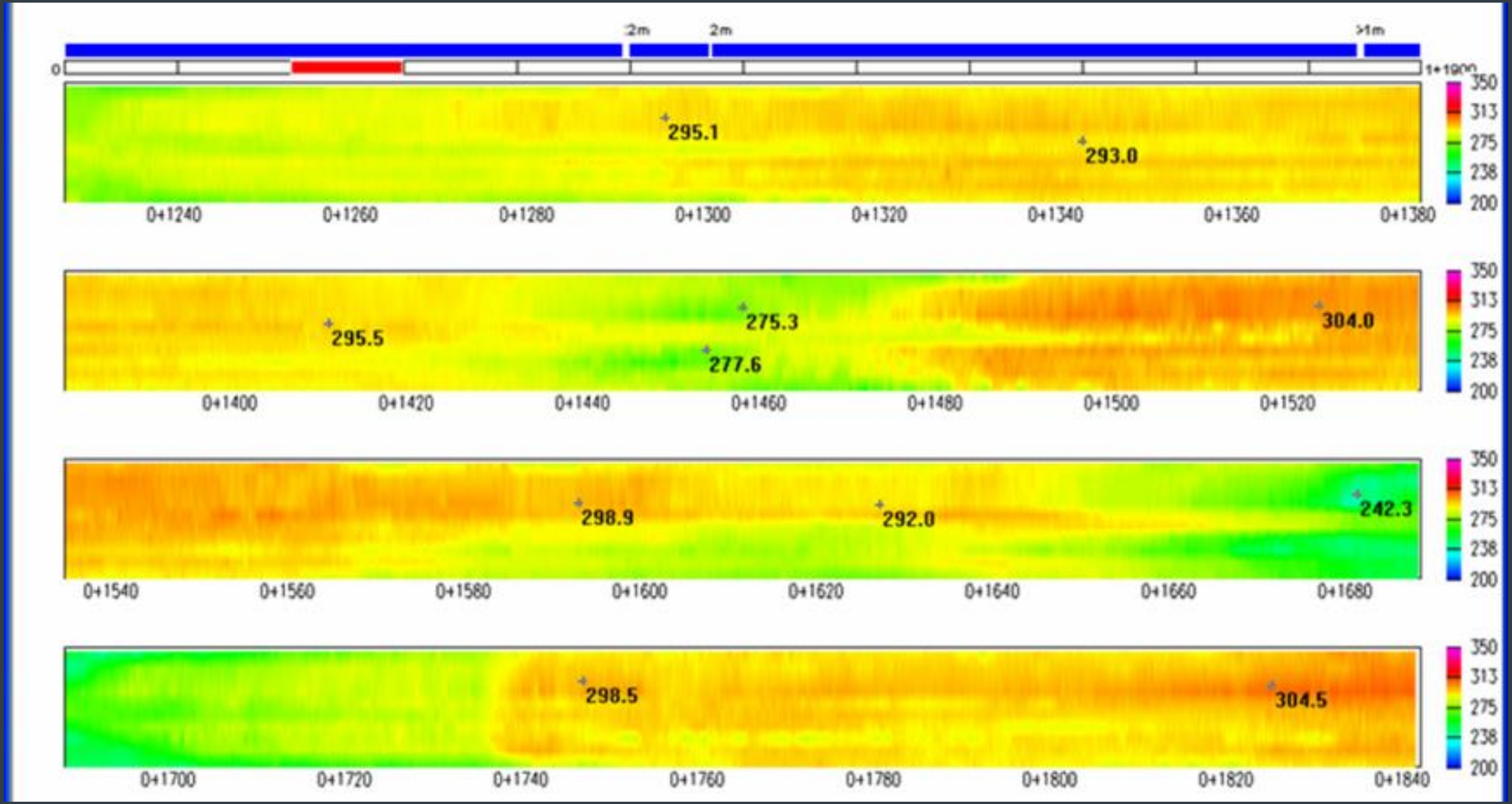
- 2 in lift
- 50°F Ambient Temps
- 5 mph wind speed
- Dense graded mix

<u>HMA</u>
Mix Temp - 305°F
Compaction Temp
Window 290°F - 220°F

<u>WMA</u>
Mix Temp - 275°F
Compaction Temp
Window 260°F - 190°F



Thermal Segregation – HMA



62°F Difference

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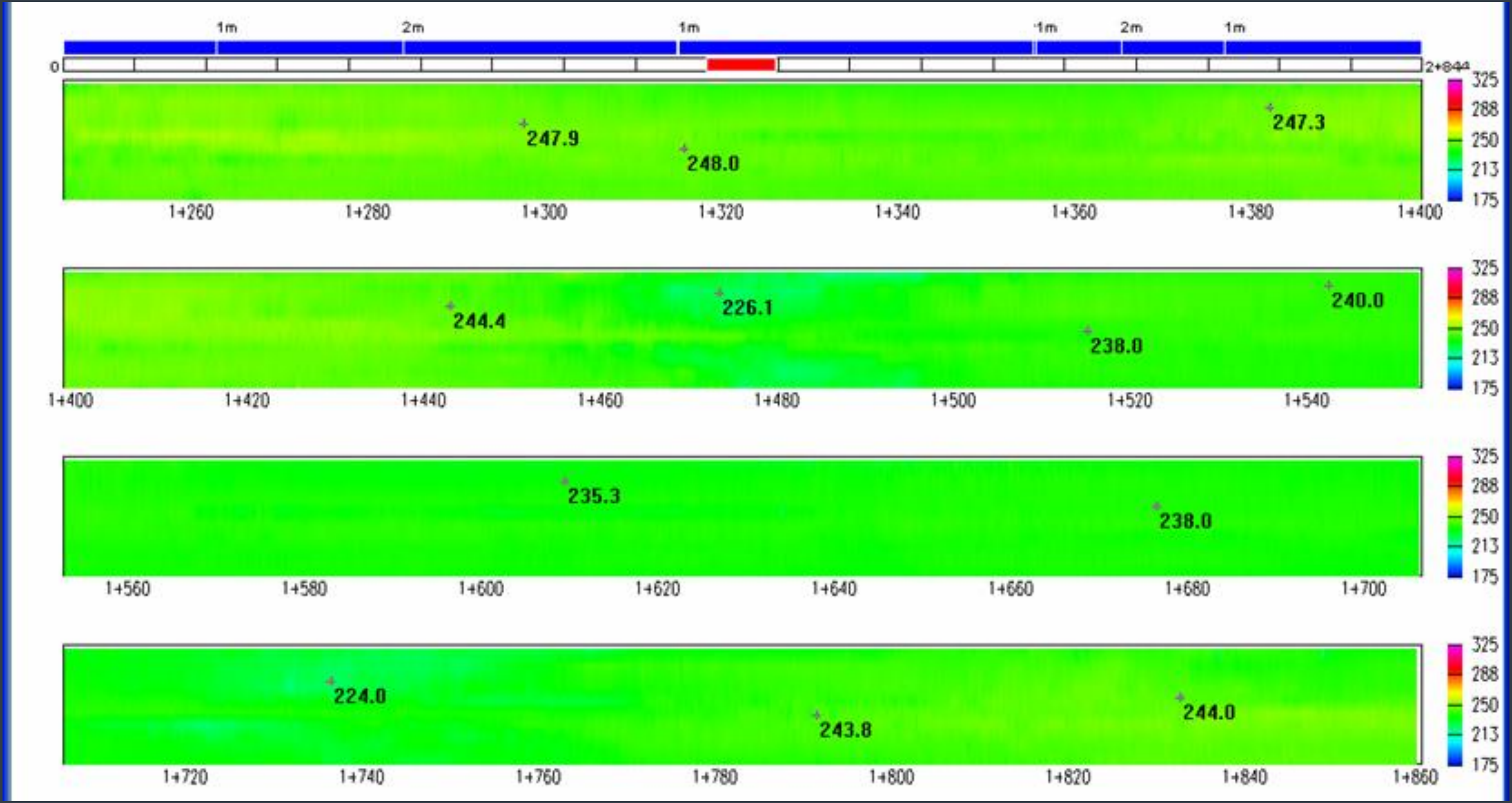
Thermal Segregation – WMA



24°F Difference

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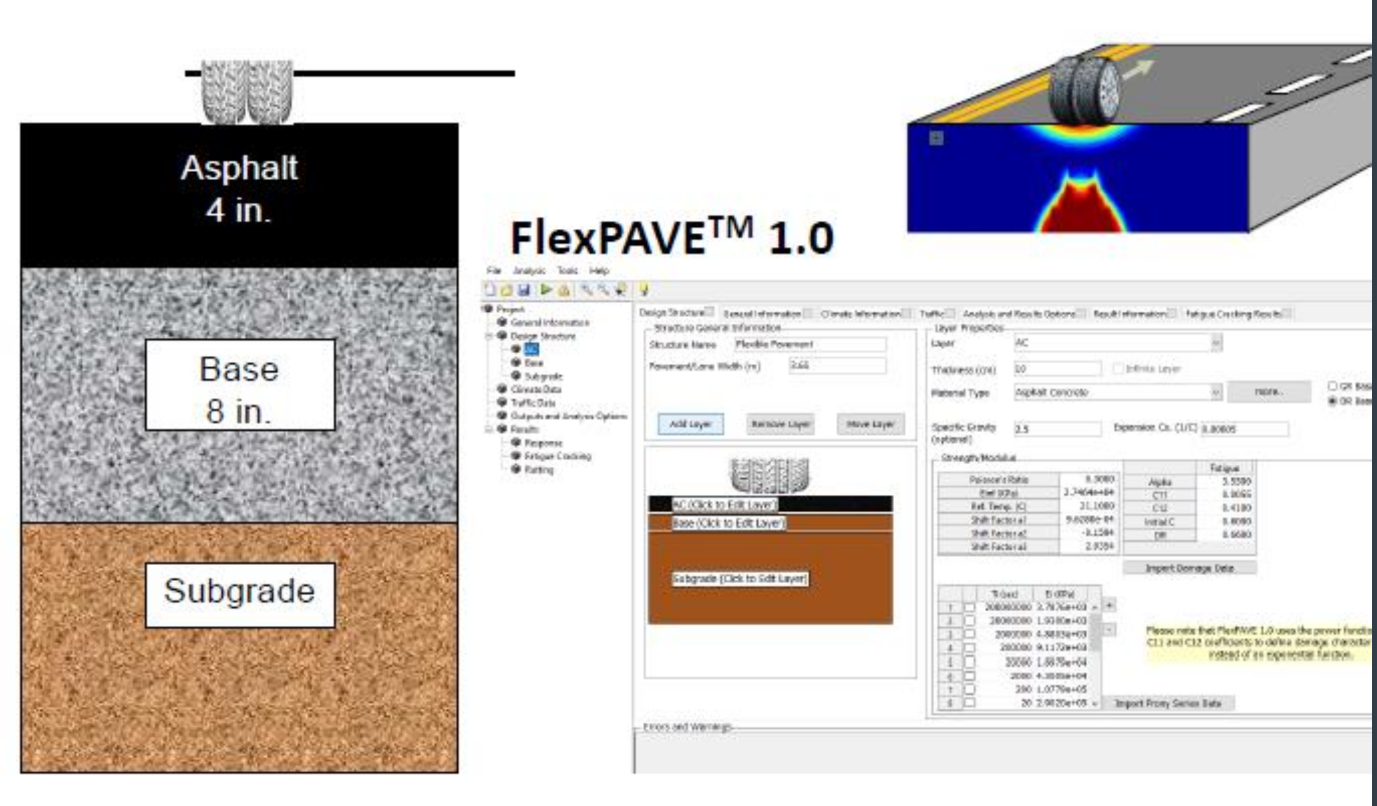
WMA in Pavement Design – Pillar III

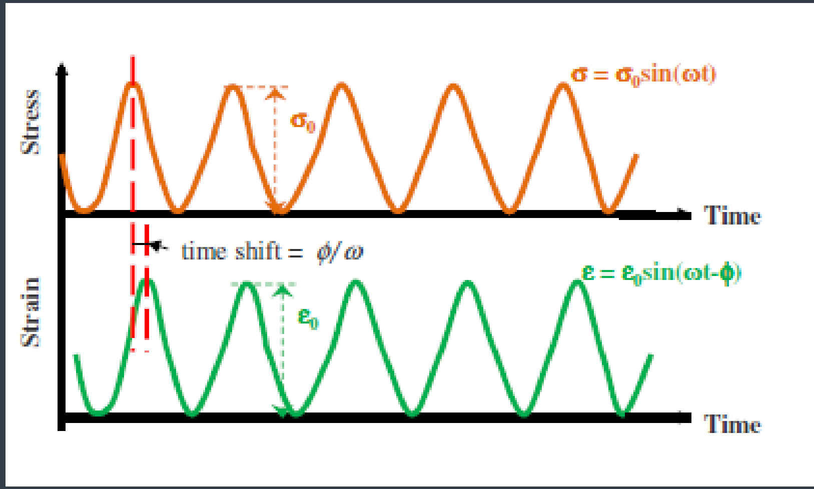
Integrated Approach

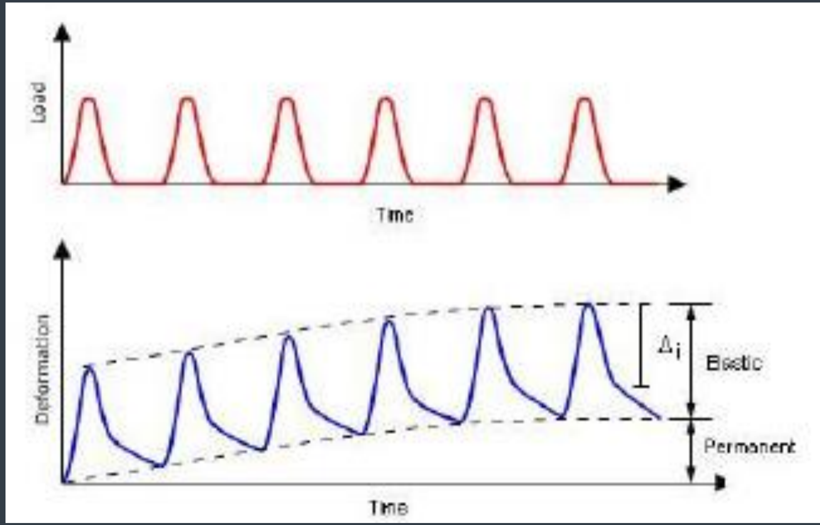
- "The actual ranking and evaluation of the material's fatigue behavior can be obtained from structural simulations that depend on the **traffic level, climate, pavement structure, and other material properties**, i.e., the dynamic modulus, damage characteristic curve (C vs S), and failure criterion (G^R or D^R)."

Wang, Yizhuang. Development of the Framework of Performance-Engineered Mixture Design for Asphalt Concrete. North Carolina State University. 2019.

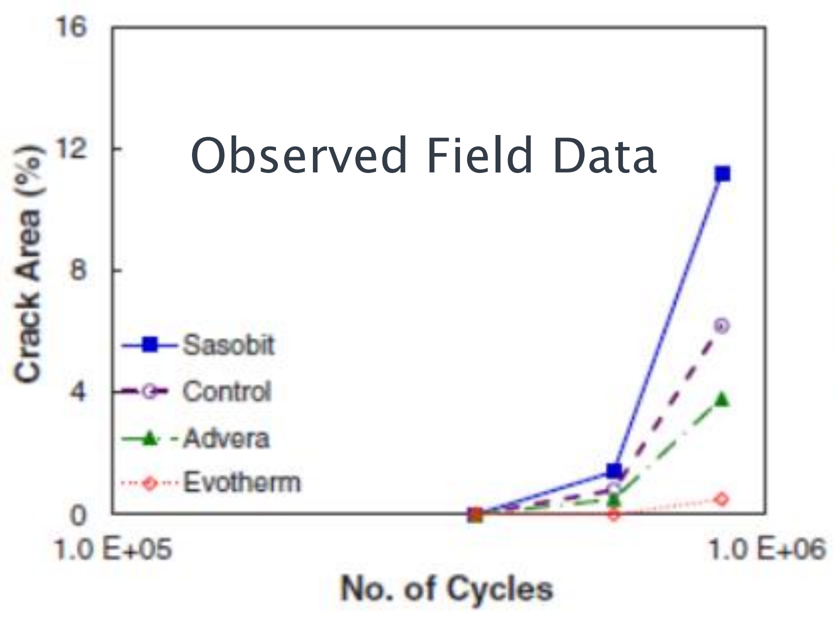
Background Info – Pavement Design

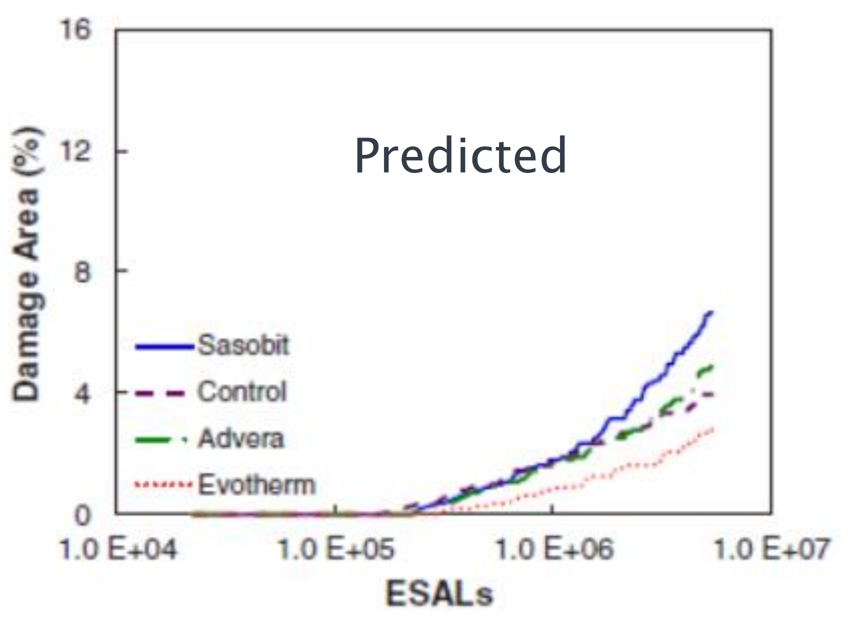


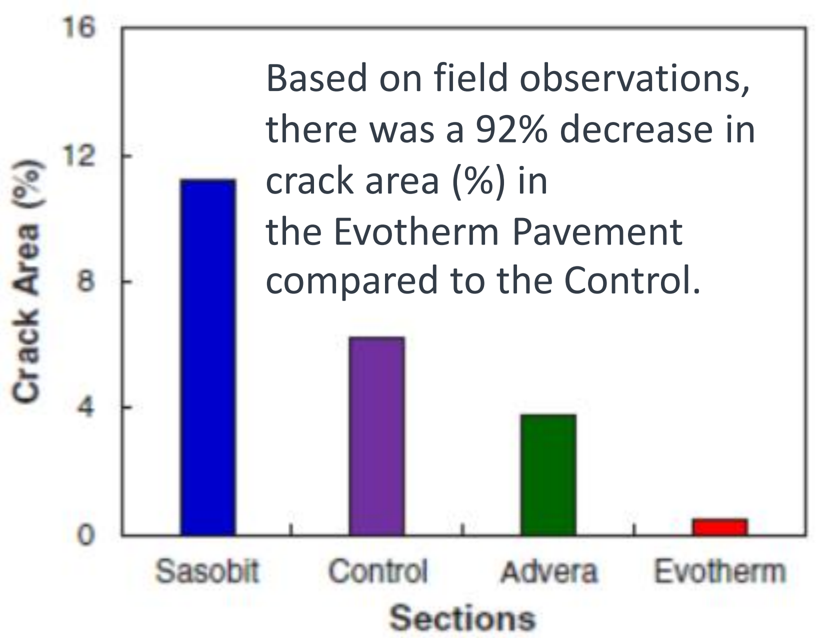




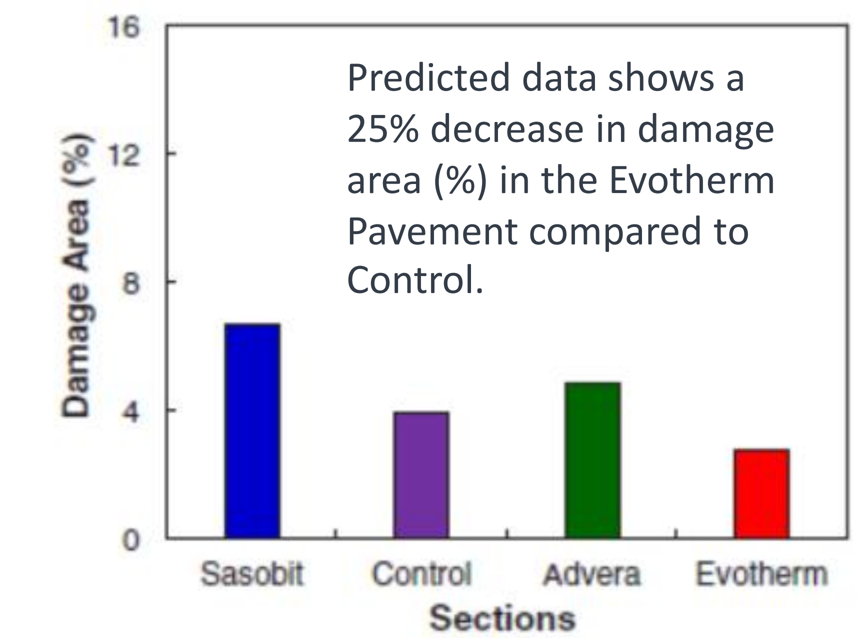
Observed vs Predicted WMA Field Performance







Based on field observations, there was a 92% decrease in crack area (%) in the Evotherm Pavement compared to the Control.



Predicted data shows a 25% decrease in damage area (%) in the Evotherm Pavement compared to Control.

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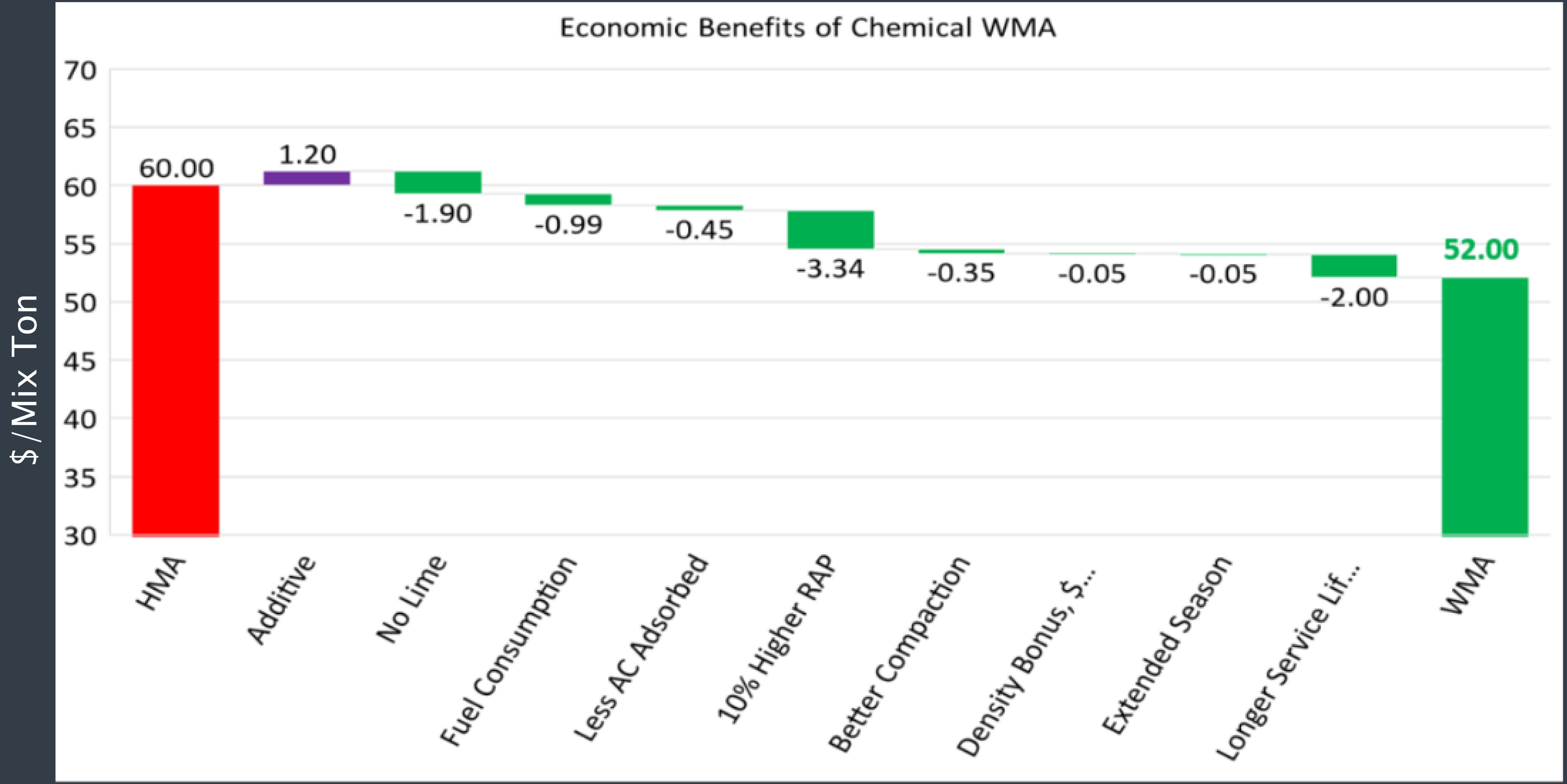
Observed vs Predicted

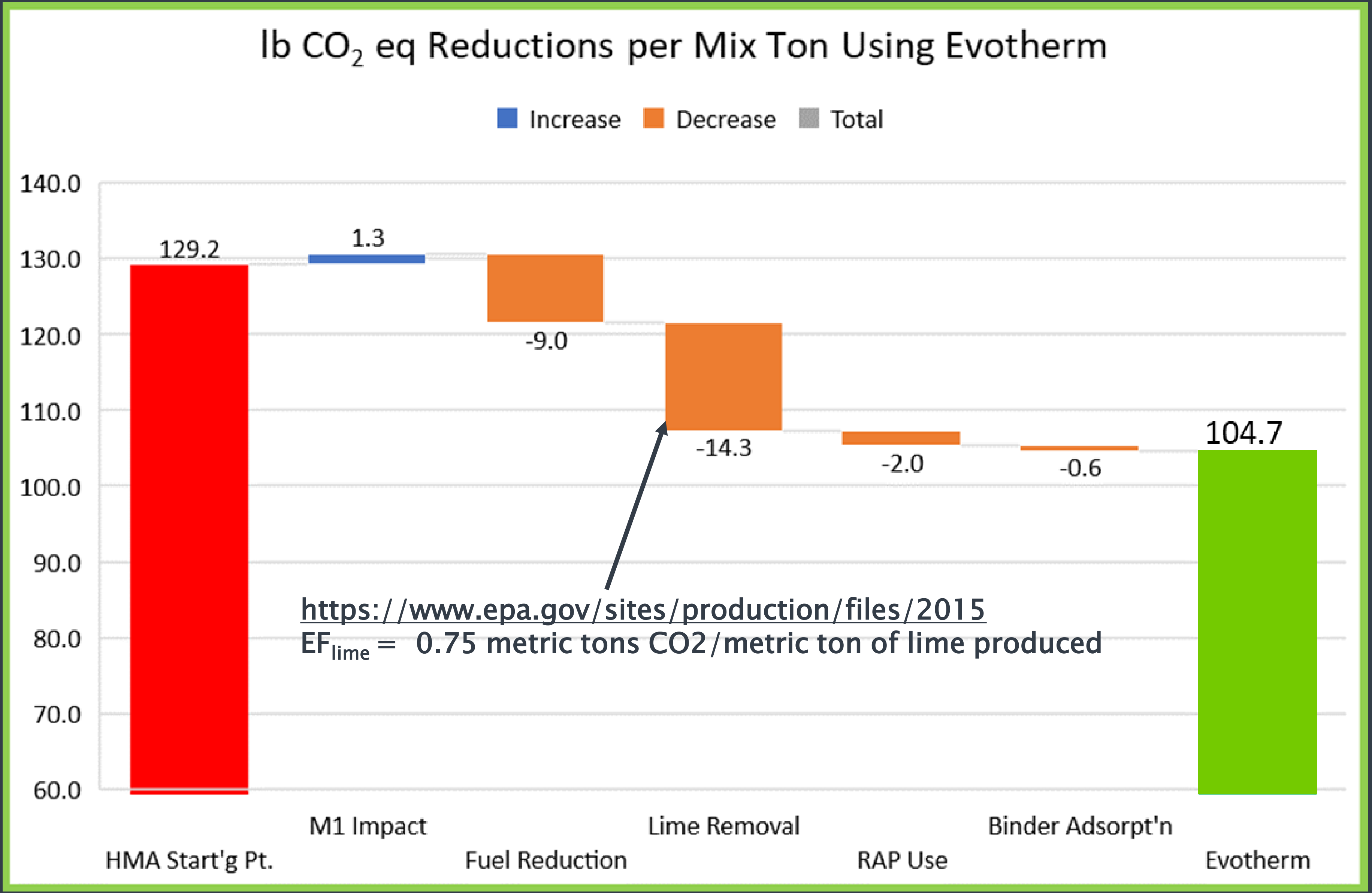
- Existing data suggest **improved** fatigue performance with Evotherm Warm Mix Asphalt mixtures.

- A research study using laboratory produced mixtures and plant produced mixtures is underway to determine material property inputs and the impact of warm mix asphalt temperatures and improved density on field performance.

WMA Economic Benefits



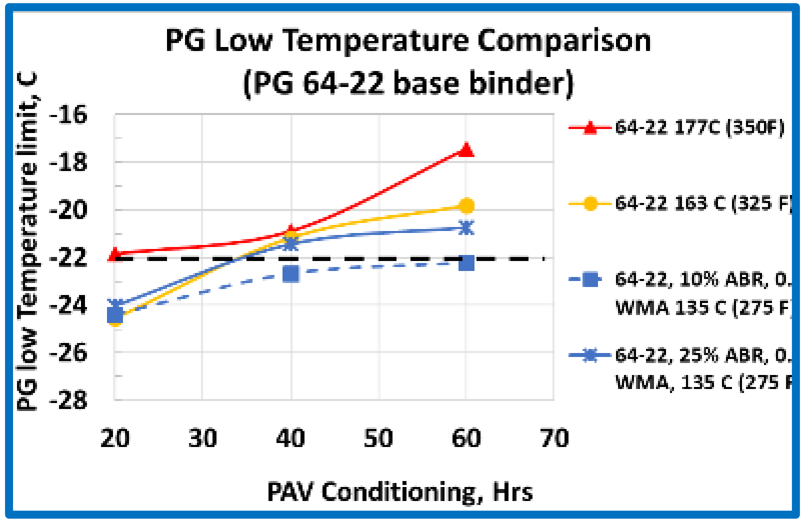
WMA Environmental Benefits



WMA Three Pillars – Summary

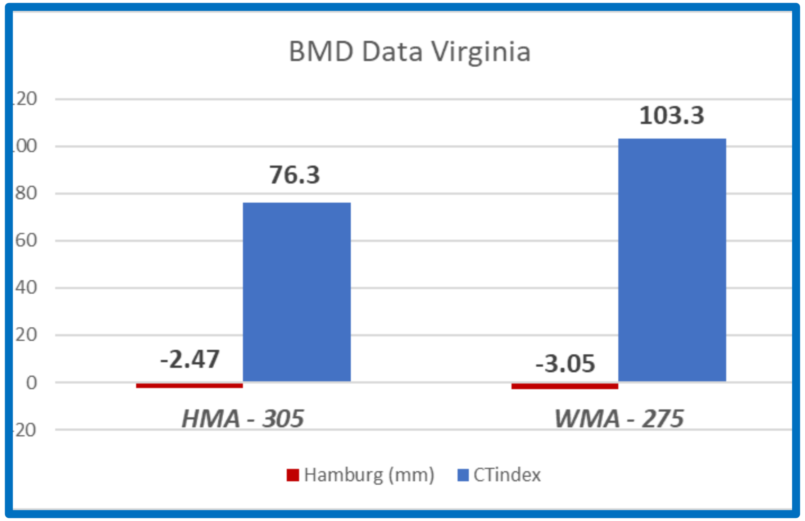
Binder Analysis

More Resilient Binders
with Reduced Temperature



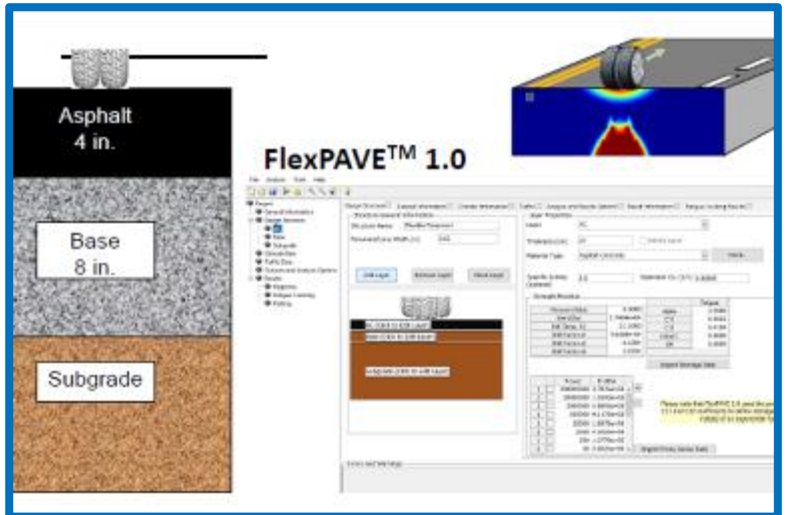
Mixture Characterization

Balance Mix Design improvements
with temperature reduction



Pavement Response

Mixture Data can be used to
design longer lasting pavements



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Questions?

If you see something that you want to hear more about, we have additional data available to present in more detail on these topics.

Adam Schaefer

Field Applications Engineer

adam.schaefer@ingevity.com

Mobile 843-494-0066

Craig Reynolds

Technical Marketing Manager

craig.reynolds@ingevity.com

Mobile 331-229-2175

Trey Wurst, P.E.

Technology Development Engineer

trey.wurst@ingevity.com

Mobile 864-933-9804

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