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Evaluating Impact of Warm Mix Asphalt Production

How Lower Temperatures Improves Asphalt Binder & Mix Performance

Agenda

- Sustainability & Durability
- WMA Economics and CO_2 reduction
- Binder Aging
- Binder Service life
- Long-term binder performance
  - Binder blend comparison
- Field Mix Evaluation

Acknowledgements

- Dennis Muncy, Binder Formulations Chemist at Ingevity, whose binder work is the basis of this presentation
- Everett Crews, PhD, Director of R&D at Ingevity, who provided input on Asphalt Sustainability and Durability
- Lincoln Beard, Rebekah Way and Bill Criqui, Ingevity, who generated the binder and mix samples and performance data

TODAY'S TECHNOLOGICAL IMPERATIVES

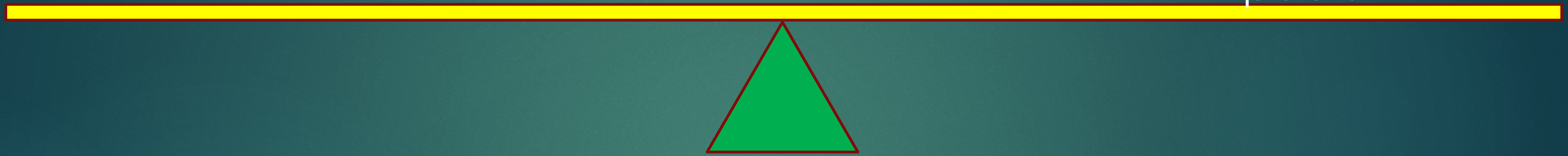
-SUSTAINABILITY

- Reducing waste and re-usability
- Asphalt Institute Foundation
  - Improved Durability
- Europe
  - Zero Odors
  - Higher Recycled Content (RAP, Plastics)
  - Circular Economy
- Greater Asphalt Pavement Sustainability

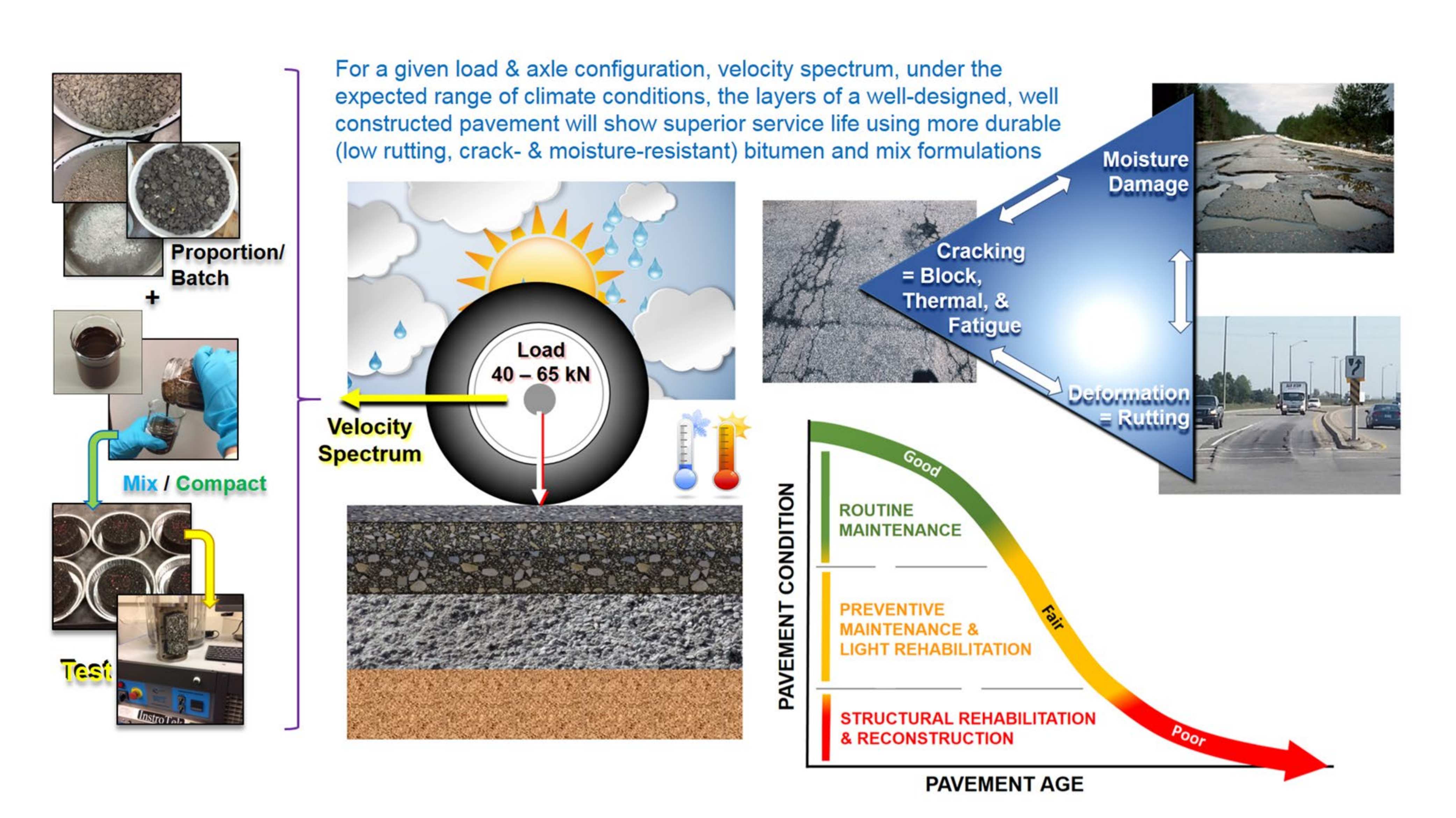
GREATER SUSTAINABILITY

Positive
Economic and Technological Advancement

Negative
Environmental and Societal Impacts



ASPHALT TECHNOLOGY IS REALLY GOOD



GREATER SUSTAINABILITY

Positive
Economic and Technological Advancement

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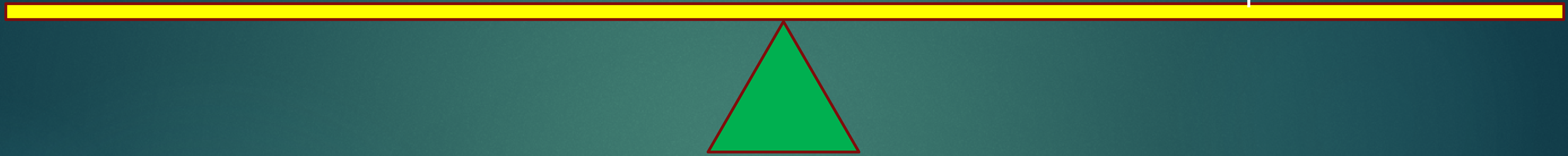
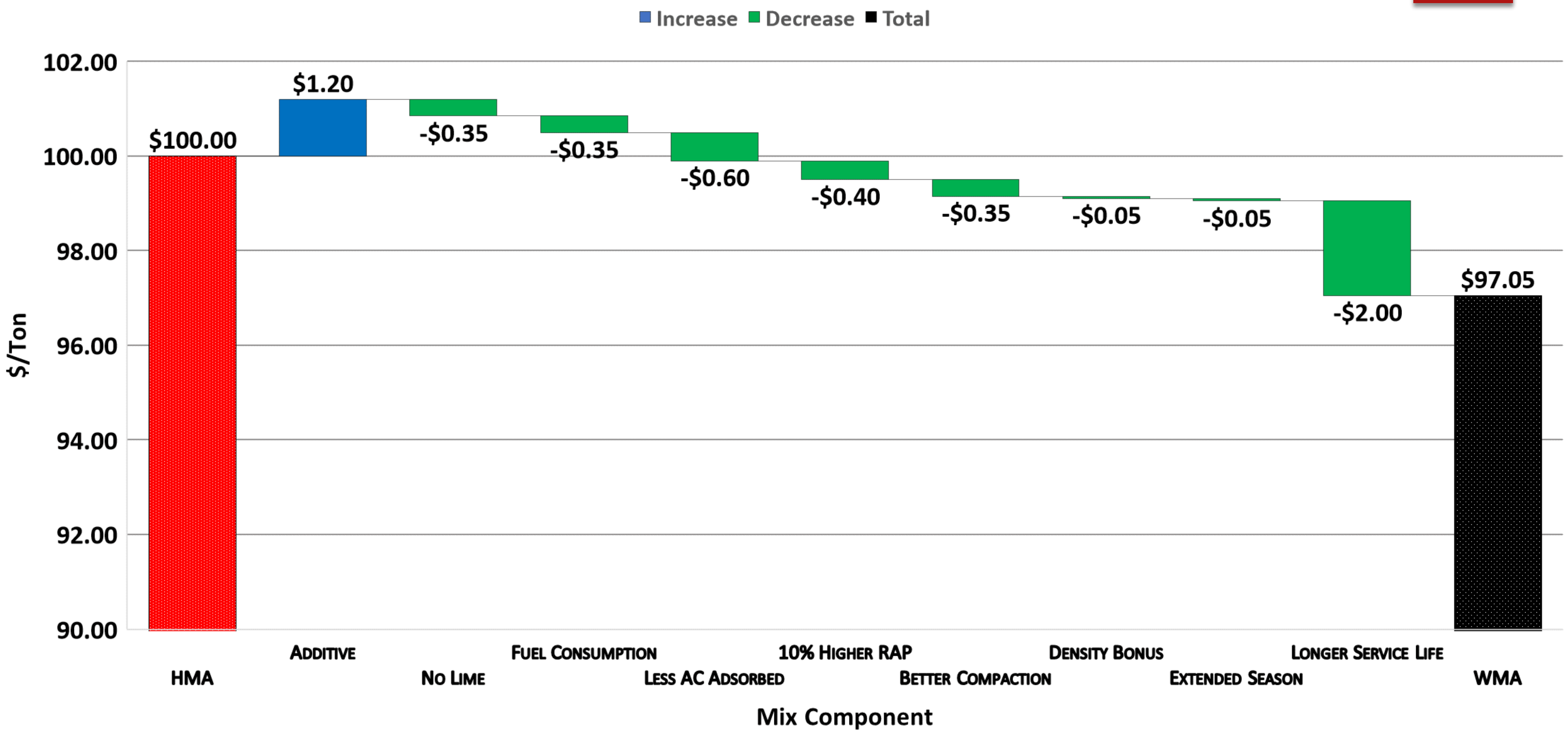


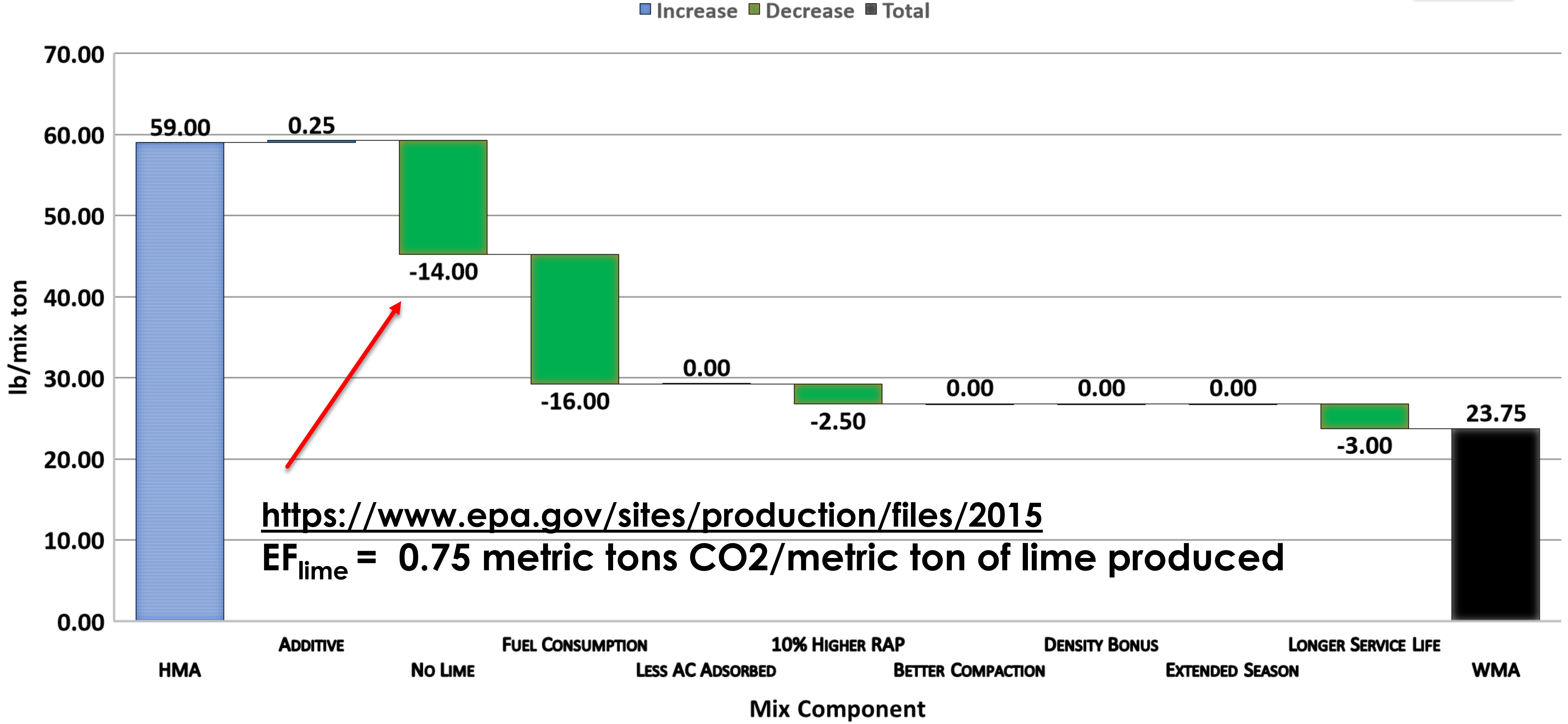
Asphalt Industry Is Good at
Materials Selection and Mixture Design
Production/Construction, Preservation, Maintenance, Rehabilitation, End-of-Life

Needs for Greater Sustainability
Durability, Longer Life
Lower Environmental Impact (Less Emissions, Less Fuel, More Recycling)
Need Alternative Delivery Systems (versus adversarial low bid)

Economic Benefit of Chemical WMA



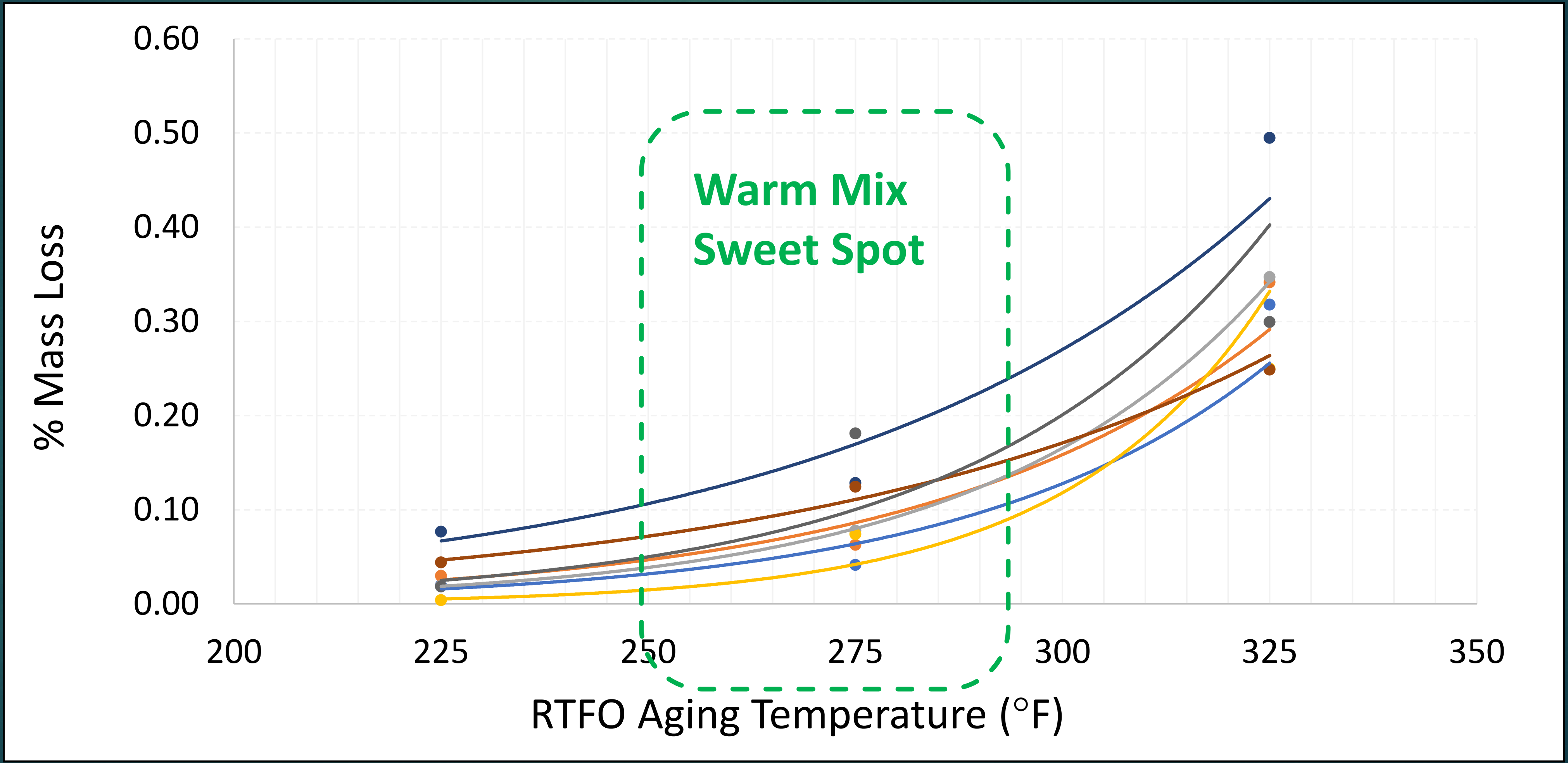
CO_2 REDUCTIONS



https://www.epa.gov/sites/production/files/2015

EF_{lime} = 0.75 metric tons CO2/metric ton of lime produced

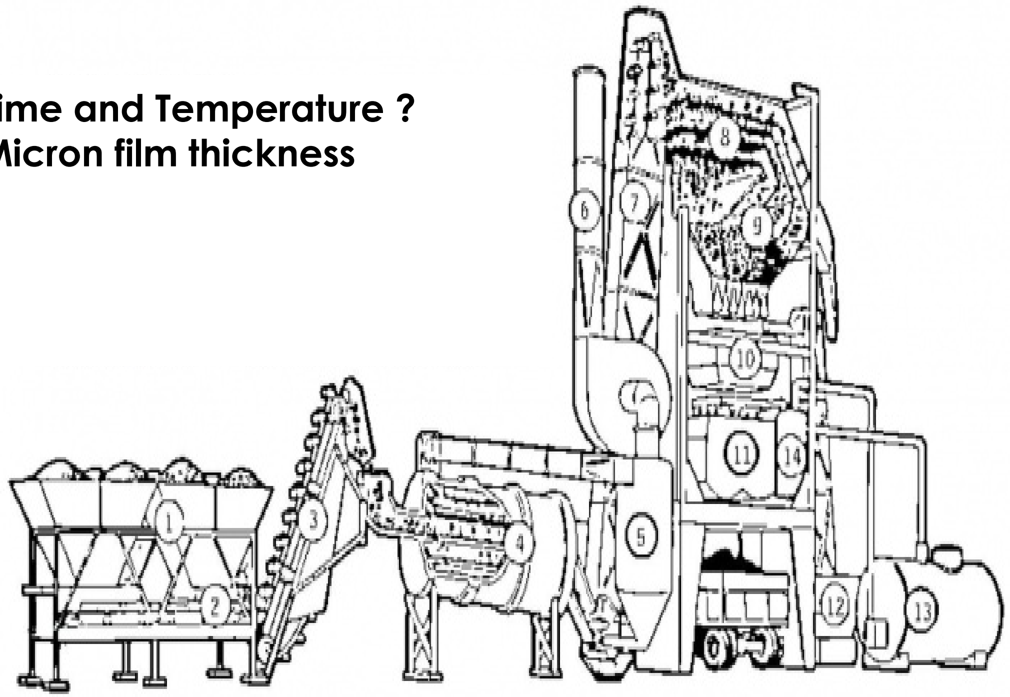
WARM MIX BENEFITS: Mass Loss Reduction with Temperature Decrease



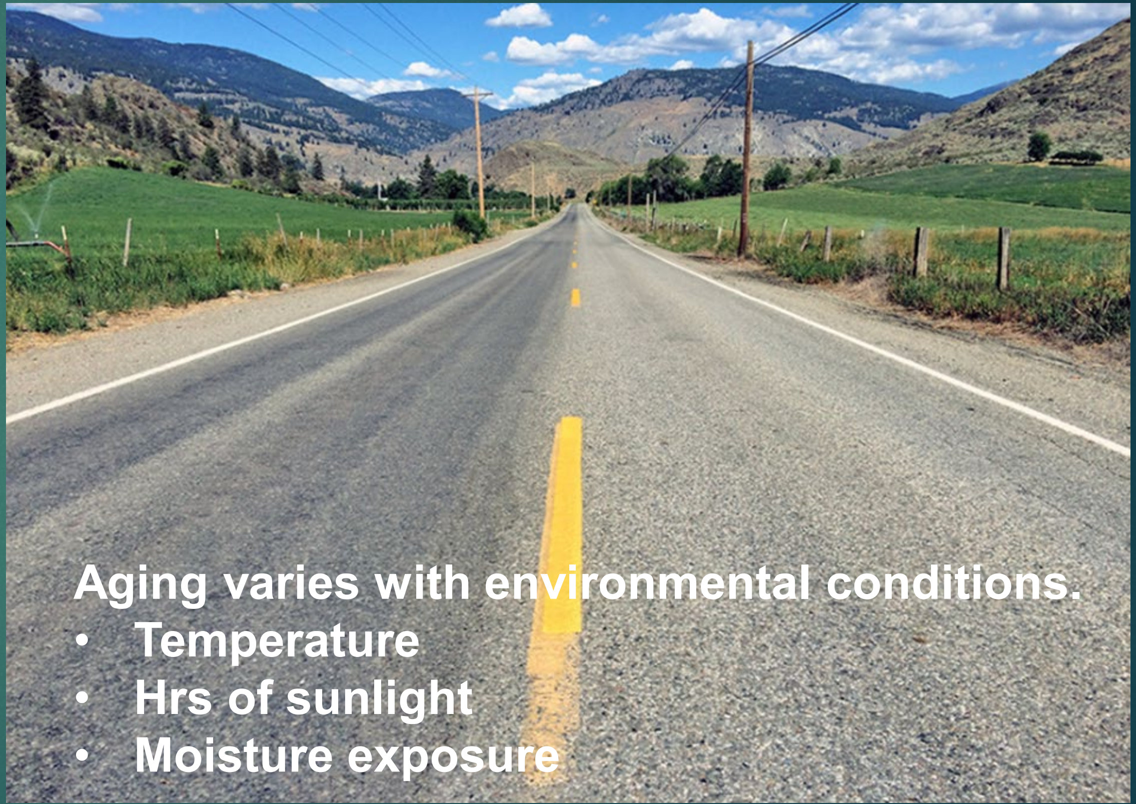
2 Types of Binder Aging

Short-Term "Spurt" Aging

Time and Temperature ?
Micron film thickness



In-Service Aging

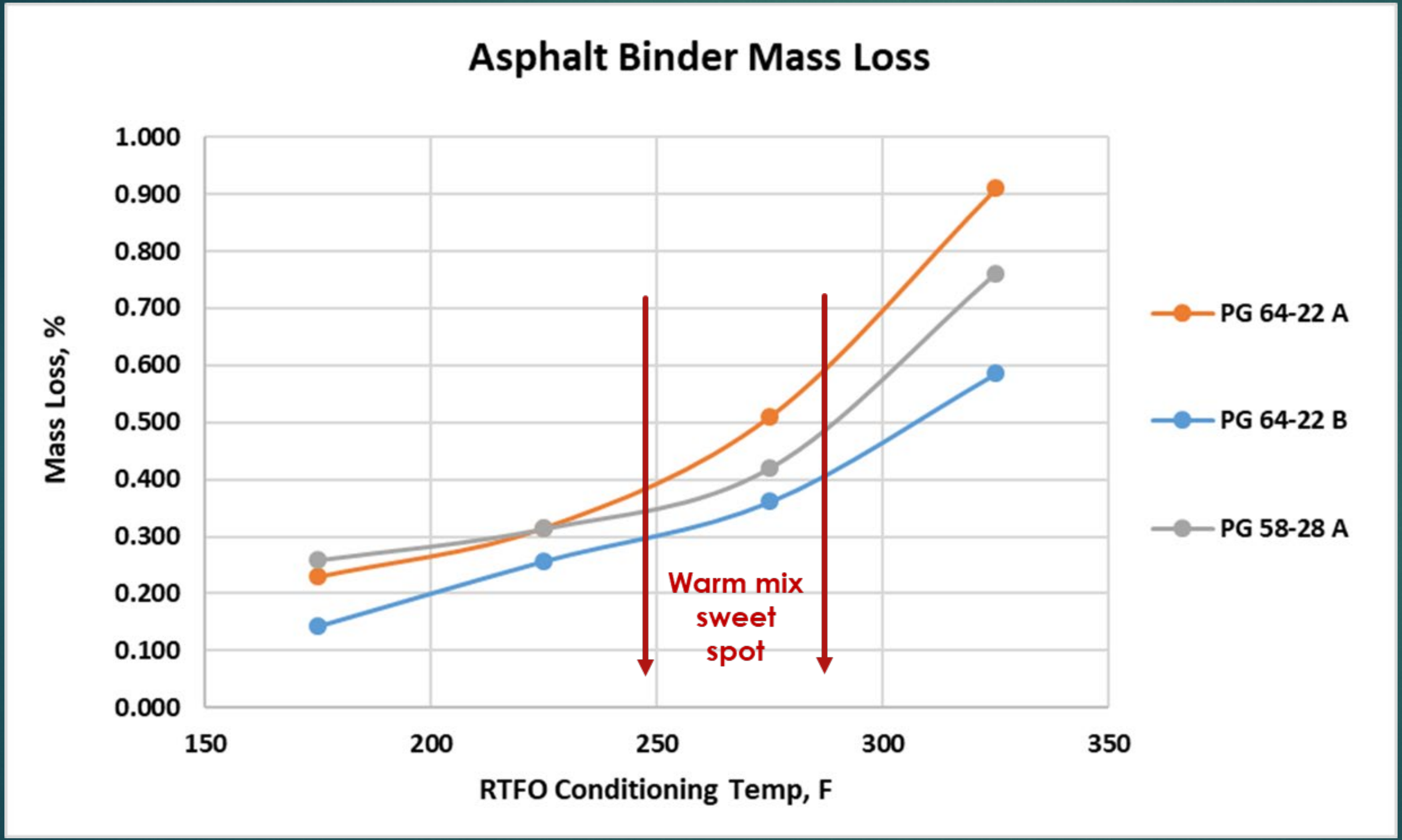


Lab Tools Used to Simulate Aging

Short-term Aging
Rolling Thin Film Oven

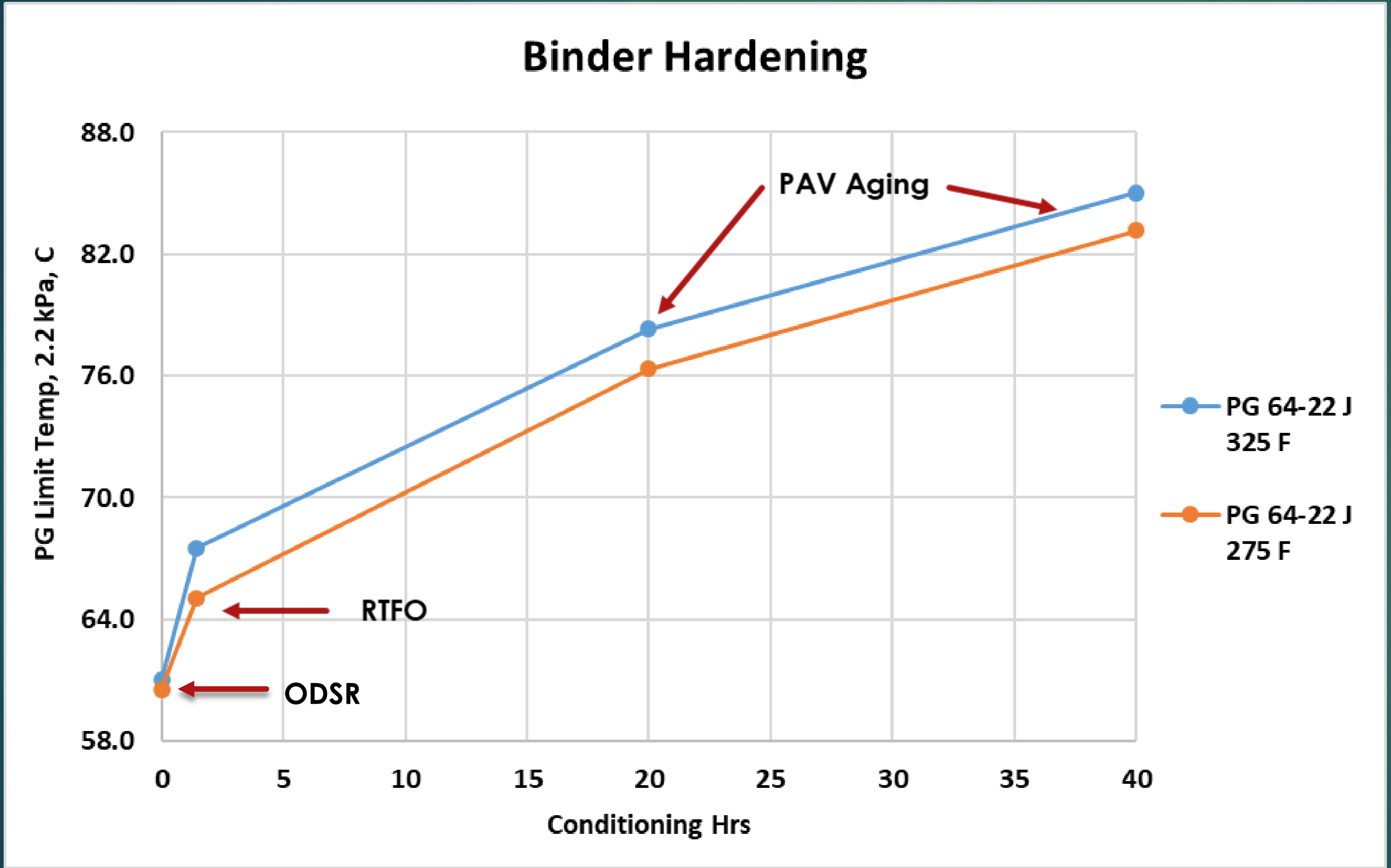
In-service Aging
Pressure Aging Vessel

Screening neat asphalts



< 50 F reduced mass loss approx. 40%

Impact of Binder Aging Rate



Sample	PG 64-22 Std RTFO	PG 64-22 RTFO -50 F
	PG High Temp	
	G*/sin d / Hr	
ODSR to RDSR	4.58	3.18
RDSR to 40 Hr PAV	0.45	0.47

Rate of Std RTFO stiffness change is 10 times greater than PAV aging rate

50 F lower RTFO reduces RTFO binder aging rate ~30%

Binder Service Life

Short Term Aging + Long Term (In-Service) Aging

In-service Aging

- Environment (Mother nature)
- Increase density – lower aging/improved durability

Short-term aging → Controllable?

Binder Service Life

Impact of Basic Short-Term Production Controls

- Mix design/Aggregate structure
- Binder grade
- AC content
- Volumetric properties such as In-place density, etc.

Impact of Short-term aging → is this controllable?

- Reduce Production and Paving Temperatures
- Why cook off the "Goodies"
- What's the impact of lower production temperatures?

Characterizing Binder Life

PG Grading System

- 1 PAV cycle (2 – 6 yrs service life depending on depth Smith et al., TRB, 2018)
- Is this enough?

Time to Failure Criteria

Short Term Engineering Controls

- Vary RTFO Temps

In Service - Multiple PAV Cycles

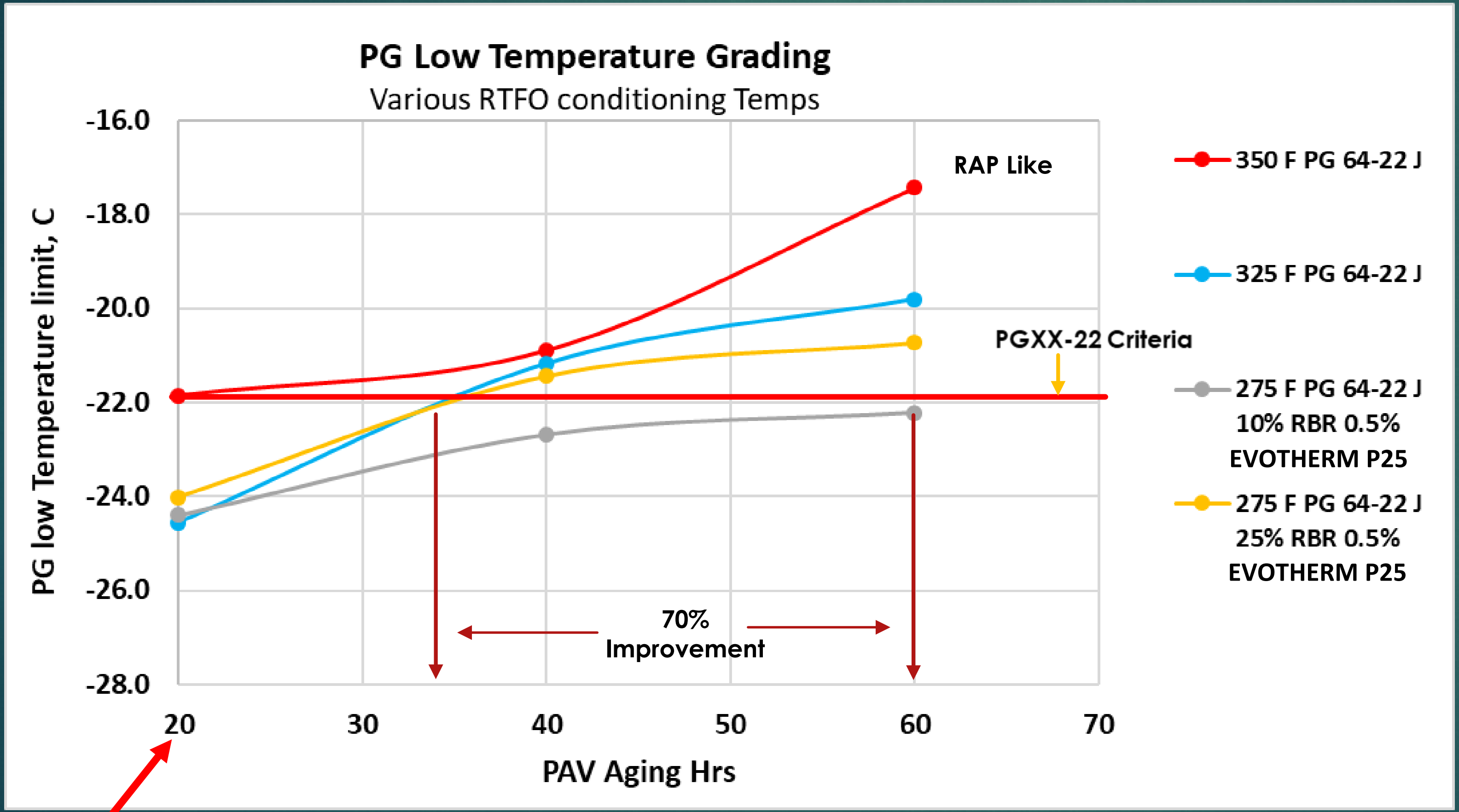
- Extend PAV cycles to a failure criteria

Binder Failure Performance Comparison

Materials and Tests

Binder Blend	RTFO Temp	PAV Conditioning, Hrs	PG Tc low	Delta Tc	Glover-Rowe Parameter
PG 64-22	350 F (Std +25 F)	60	✓	✓	✓
PG 64-22	325F (Std)	60	✓	✓	✓
PG 64-22, 10% RAP ABR, 0.5% WMA	275 F (std – 50 F)	60	✓	✓	✓
PG 64-22, 25% RAP ABR, 0.5% WMA	275 F (std – 50 F)	60	✓	✓	✓

Binder Performance after Extended Aging



Standard PG Testing Ends Here

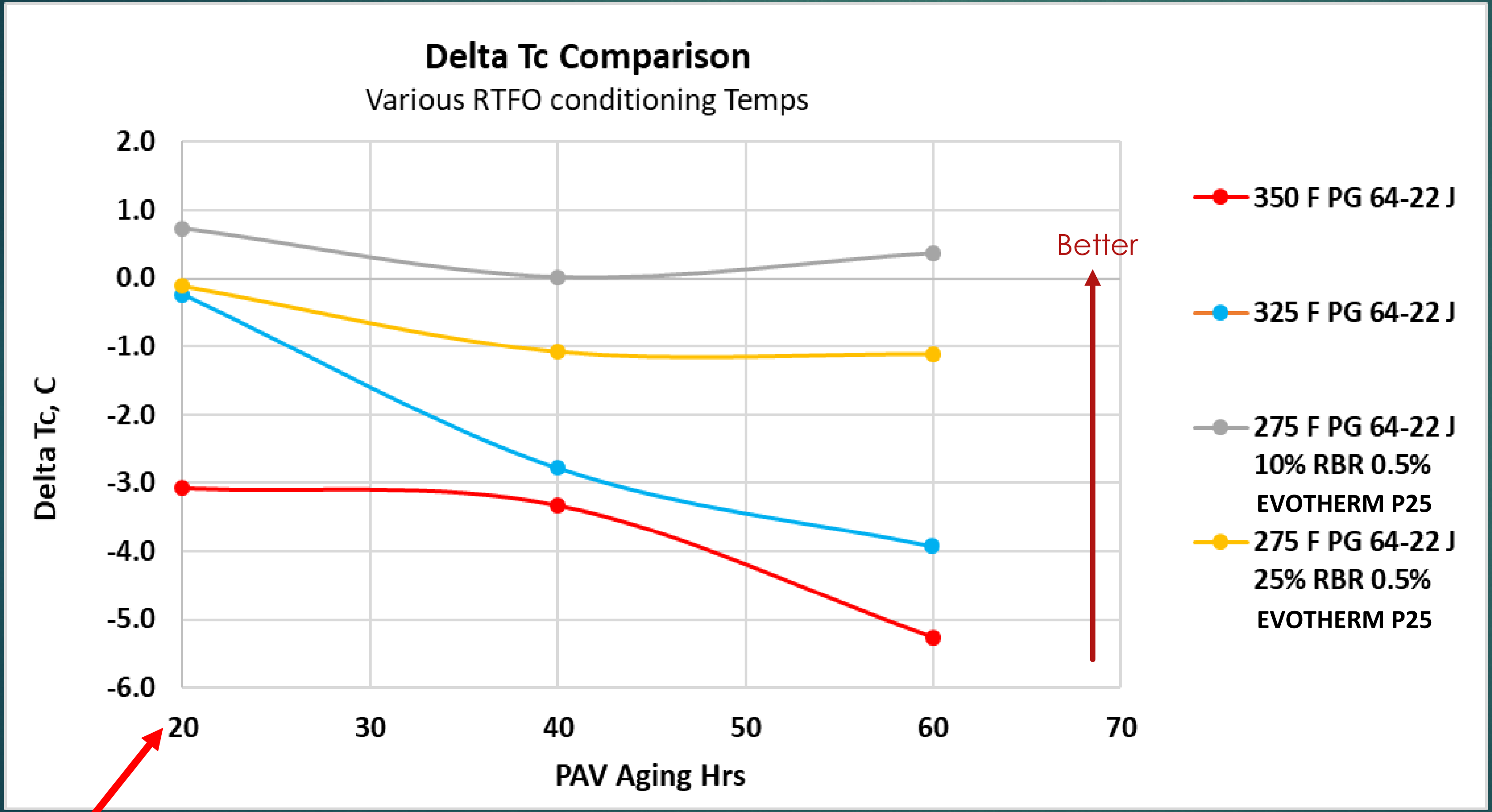
20 Hr PAV = 2 – 6 yrs service life

WMA blends contained a EVOTHERM P25

Standard RTFO, 325 F
Warm Mix RTFO, 275 F (50 F < Std)

- PG 64-22, RTFO 350 F, out of spec after 20 Hr PAV
- PG 64-22 w/ 10% RAP, RTFO 275 F, maintained -22 grade after 60 Hrs PAV

Binder Performance after Extended Aging



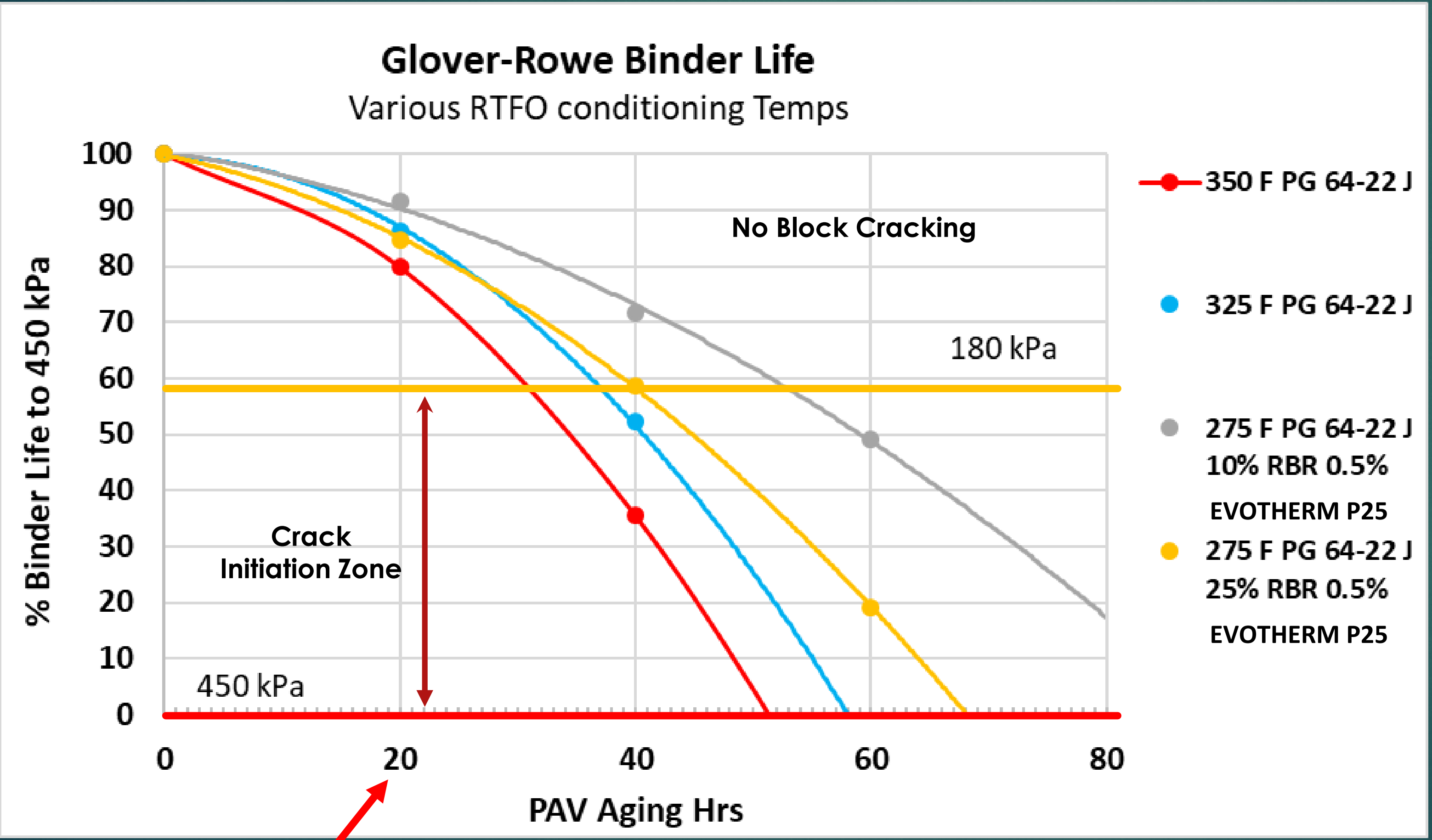
Standard PG Testing Ends Here

Delta Tc = T_{cont} S – T_{cont} m

Standard RTFO, 325 F
Warm Mix RTFO, 275 F
(50 F < Std)

- Binder blends with EVOTHERM P25 show consistent Delta Tc

Binder Performance after Extended Aging



Standard PG Testing Ends Here

20 Hr PAV = 2 – 6 yrs service life

GRP < 180 kPa No Block Cracking
180 < GRP < 450 kPa Cracking Initiation Zone
GRP > 600 kPa Block Cracking

- Binder at 350 F (25F > std Temp) showed reduced PAV Hrs to GRP
- Binder blends w/ WM additive showed increased PAV Hrs to common GRP

Summary of Binder Testing

WMA Production temperatures in RTFO

- Reduce binder mass loss
  - Less binder waste
  - Less CO_2 produced
  - Less environmental impact
- Improved binder low temperature performance & fatigue cracking performance
- WMA temperatures can compensate for RAP binder stiffness & extend binder service life

Mixture Testing

HMA VS WMA MIX PERFORMANCE EVALUATION

Field Mix Evaluation 1

Mix Type

9.5 mm Mix

- PG 64-22S
- 40% RAP
- 0.3% MWA (EVOTHERM J1)
- 2.0% Rejuvenator (EVOFLEX CA-7)

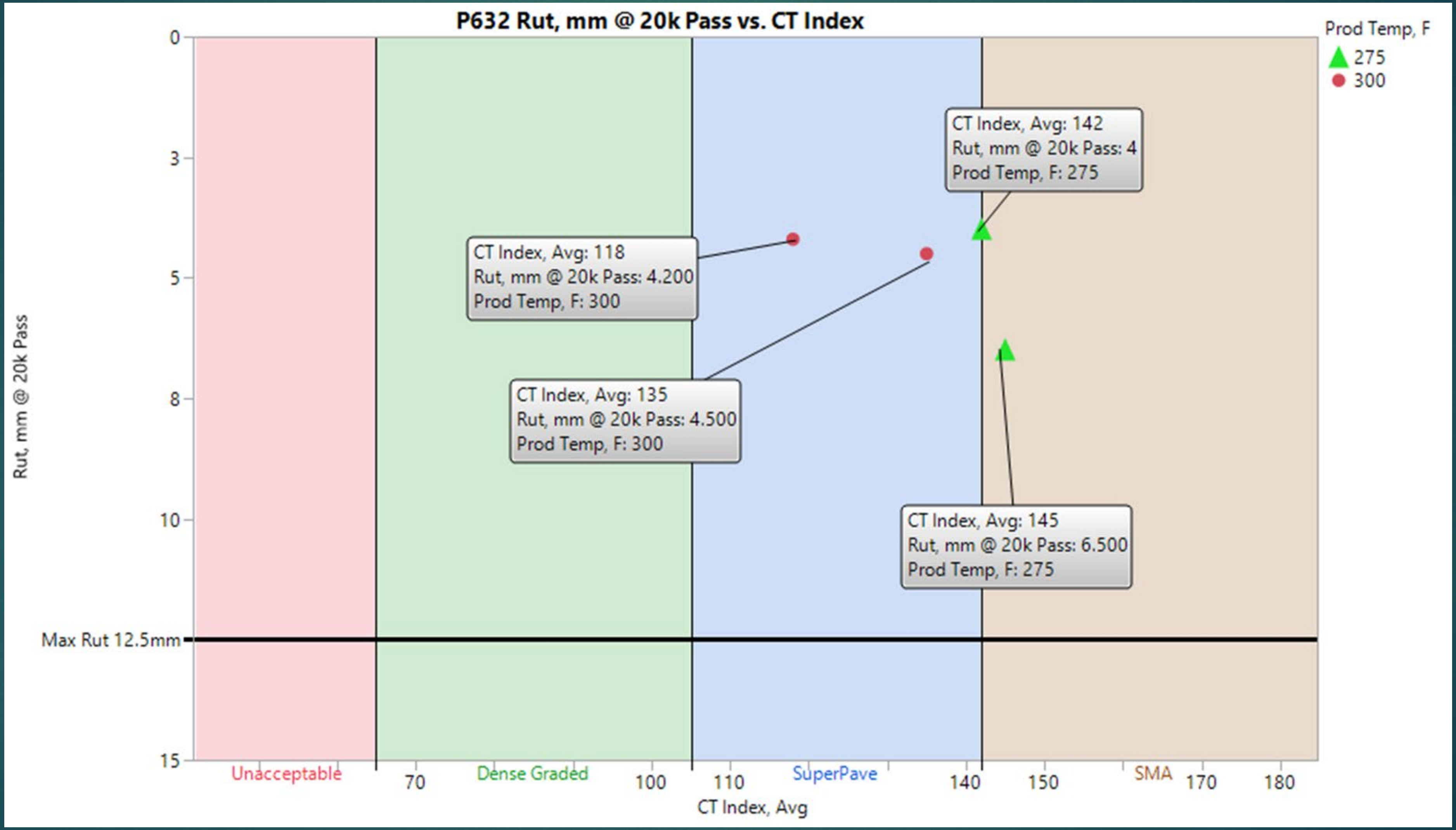
Production Variable

- HMA 305 F
- WMA 275 F

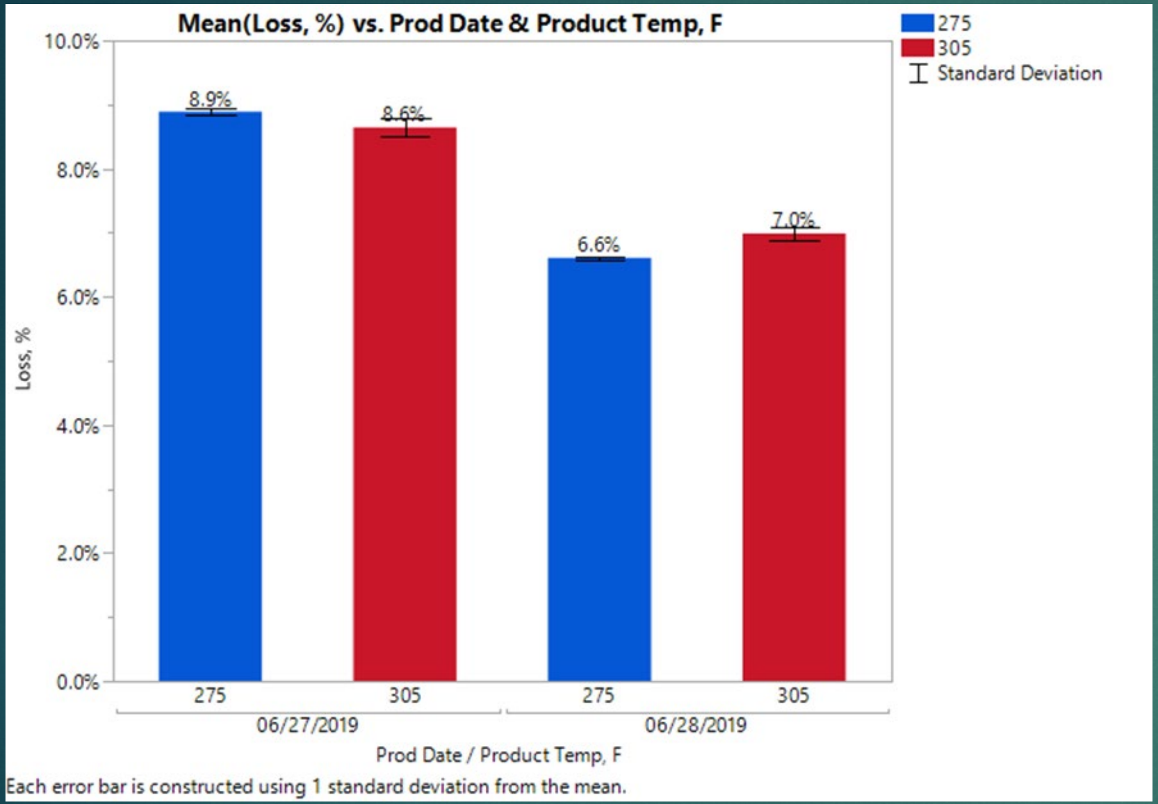
Testing

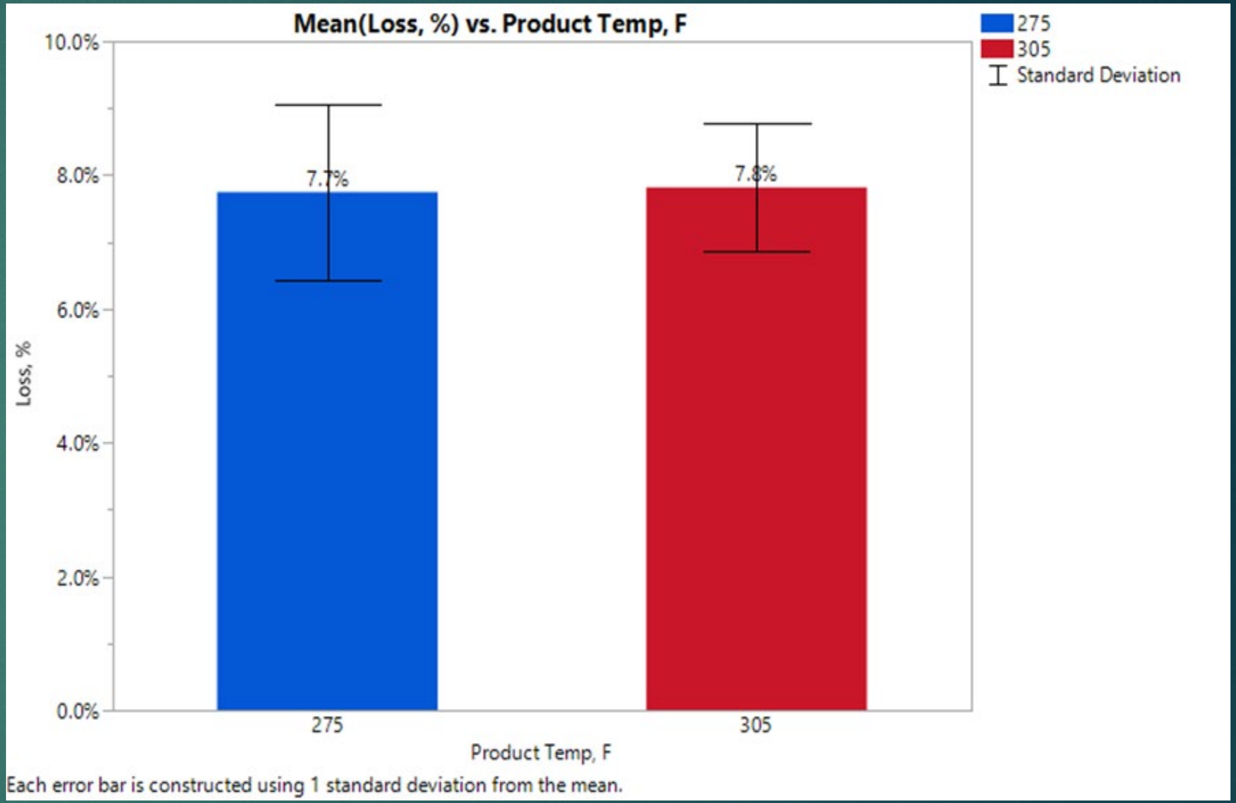
- Hamburg Wheel Tracker – AASHTO T 324-17
- IDEAL CT – ASTM D8225
- Cantabro - AASHTO TP 108-14

HWT and IDEAL CT



Cantabro Testing





Field Mix Evaluation 2

Mix Type

9.5 mm Mix

- PG 58-28
- 40% RAP
- 0.3% MWA (EVOTHERM J1)

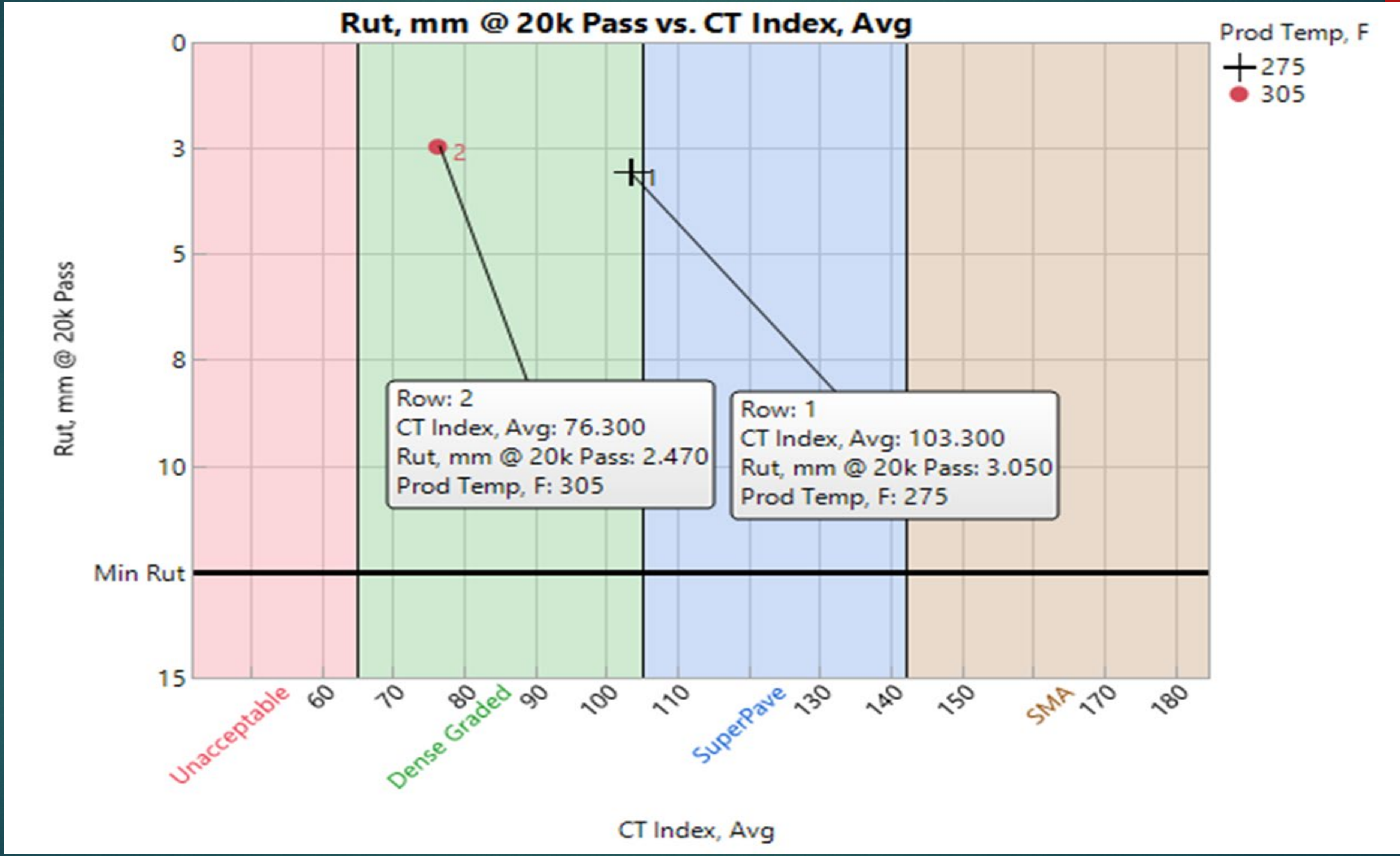
Production Variable

- HMA 305 F
- WMA 275 F

Testing

- Hamburg Wheel Tracker – AASHTO T 324-17
- IDEAL CT – ASTM D8225

HWT and IDEAL CT



Use Warm Mix and Lower Production Temperatures!

Don’t Cook off the “Goodies”

Questions?