NCHRP 9-58
The Effects of Recycling Agents on Asphalt Mixtures with High RAS and RAP Binder Ratios

Project Update

Asphalt Mixture & Construction Expert Task Group
September 20, 2017

Research Team

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Outline

- NCHRP 9-58 Objectives & Research Plan
- **Revised Phase II**
  - Field Projects, Materials, & Laboratory Tests
  - Practical Evaluation Tools for High RBR Binder Blends & Mixtures
  - Engineering Binder Blends
- Moving Forward
- Phase III Work Plan

NCHRP 9-58 Objectives

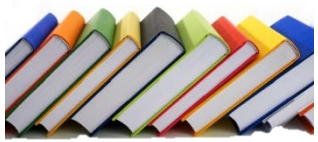
- **High RBR** = 0.3 – 0.5
- Assess effectiveness of RAs to
  - **partially restore binder rheology**
  - **improve mixture cracking performance** at optimum dosage rates
- Evaluate the **evolution of RA effectiveness** with aging
- Recommend **evaluation tools**

NCHRP 9-58 Research Plan

PHASE I

Identification of Gaps in Knowledge on RA Use with High RBRs

- **Task 1.** Gather Information
- **Task 2.** Design Laboratory Experiment
- **Task 3.** Document Results in First Interim Report



PHASE II

Investigation of Effectiveness of RAs in Restoring Binder Rheology, Development of Blending Protocol, and Associated Mixture Performance

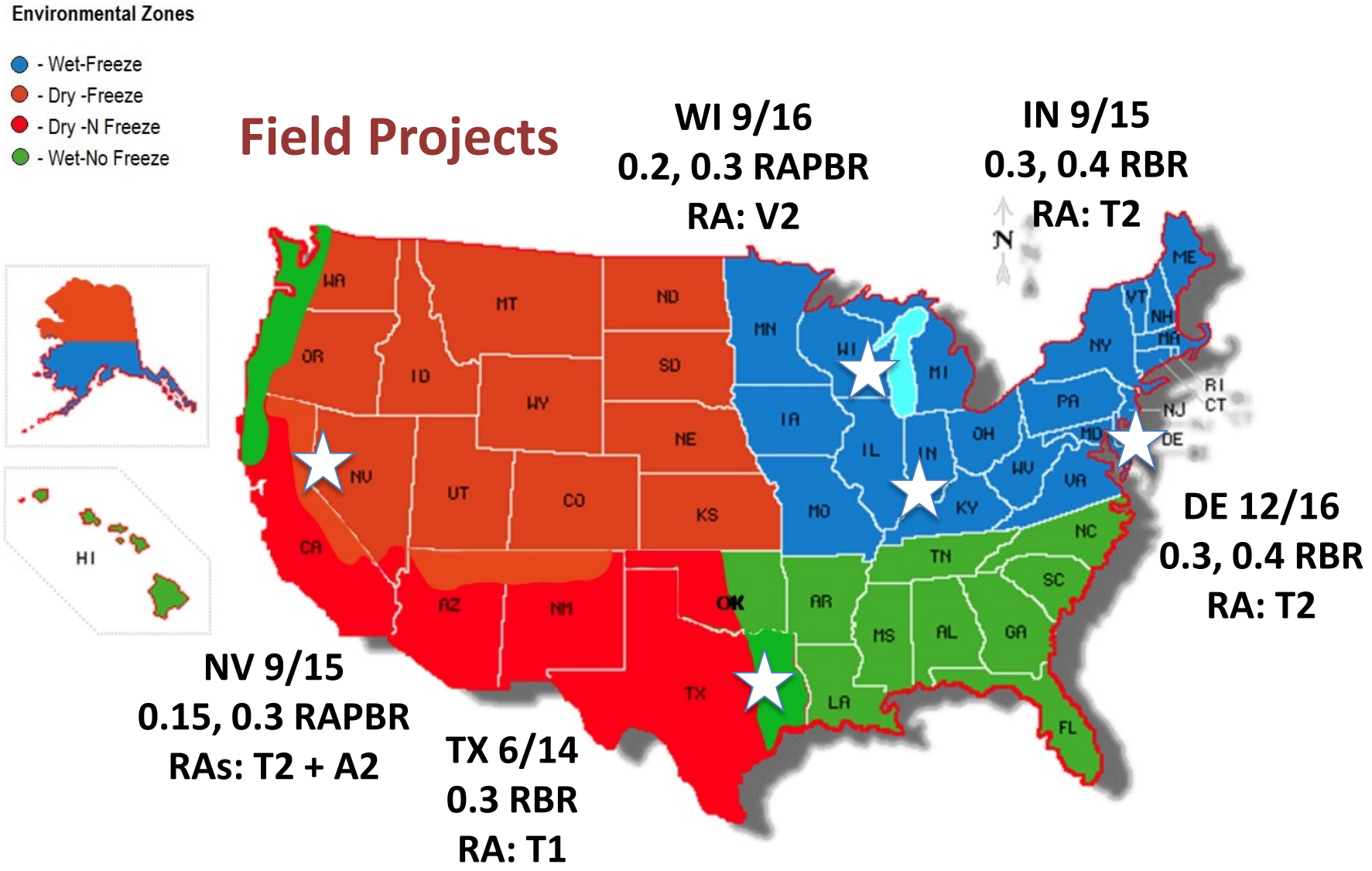
- **Task 4.** Conduct Laboratory Experiment
- **Task 5.** Design Field Experiment and Document Results in Second Interim Report

PHASE III

Validation of RA Use in Mixtures with High RBRs

- **Task 6.** Conduct Field Experiment
- **Task 7.** Propose Revisions to AASHTO Specifications and Test Methods
- **Task 8.** Develop Training Materials and Best Practices and Deliver Workshop
- **Task 9.** Document Results in Final Report

Field Projects



Revised Phase II Materials Combinations

TX
NH
NV
IN

(ΔT_c)
TX PG 64-22 (-4.6), PG 70-22P (-4.9)
NH PG 64-28 (+1.4)
NV PG 64-28P (-3.6)
IN PG 64-22 (-1.2), PG 58-28 (-8)
MN PG 58-28 (0)

TX MWAS,
TOAS
CA TOAS
IN MWAS

T1, T2
A1, A2
V1, V2
B

TX
NV
IN

Revised Phase II Lab Tests – BINDER & MORTAR

- BOTH: PGH, PGL

$$\Delta T_c = (T_S - T_m)$$

- Glover-Rowe

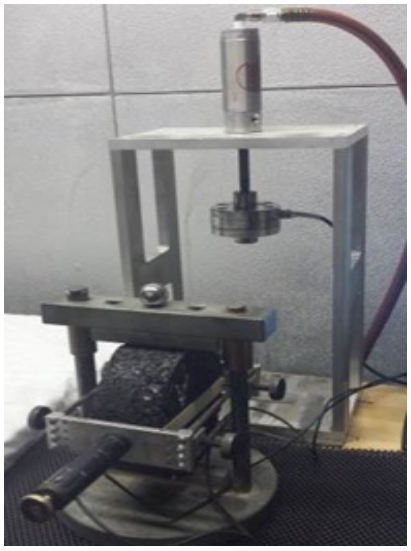
$$G\text{-}R = \frac{G^*(cos\delta)^2}{sin\delta}$$ @ 15 °C, 0.005 rad/sec

- $T_{\delta=45}$ @ 10 rad/sec

- Carbonyl Area Growth by FT-IR
- T_g End & T_g Inflection by DSC
- SAR-AD

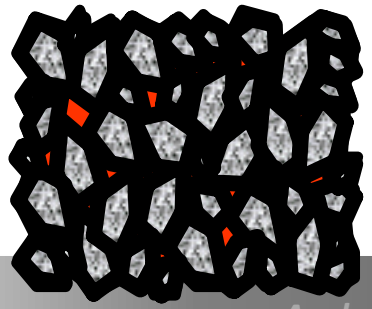
Revised Phase II Lab Tests - MIXTURE

- Stiffness
  - M_R @ 25 °C
  - E*, ϕ + Mixture G-R
- Cracking Resistance
  - FI, CRI by I-FIT (SCB)
  - DCC by S-VECD
  - CRI by UTSST
  - S, m-value by BBR Sliver
- Rutting Resistance
  - RD by HWTT, APA Jr

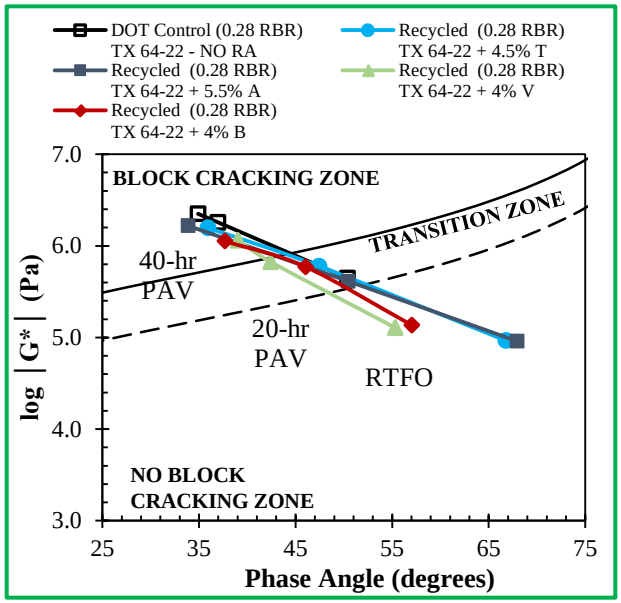


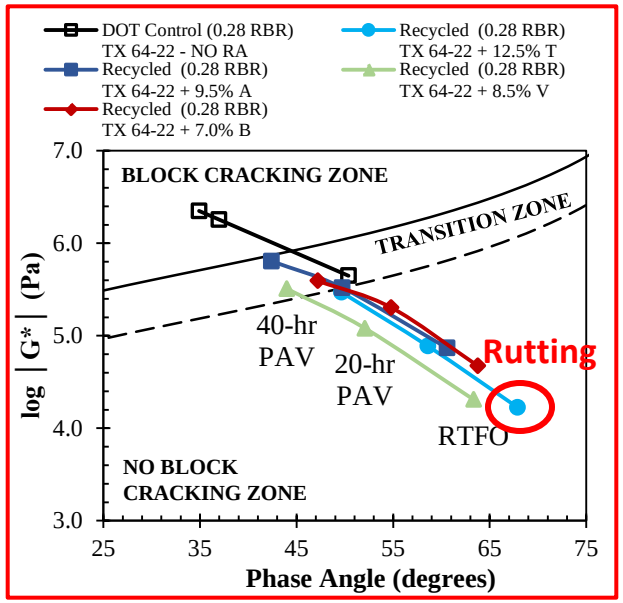
Practical Evaluation Tools

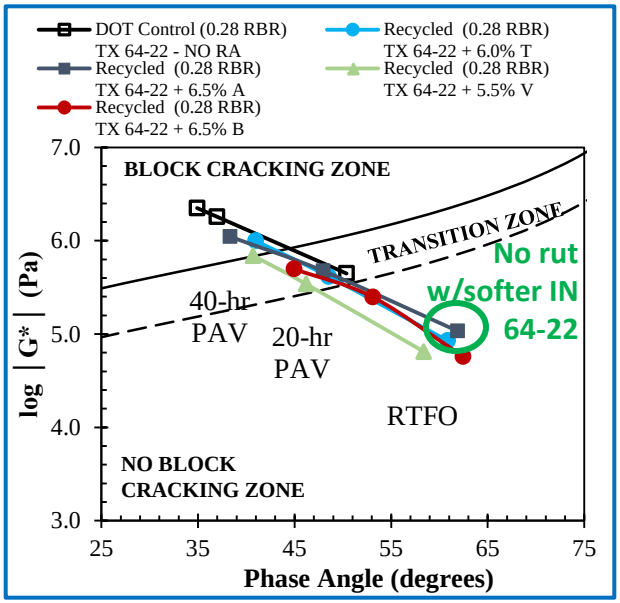
- RA Dosage Selection (w/Aging)
  - Restore PGL (and Verify PGH)
  - Achieve ΔT_c = -5.0
  - Restore *Continuous* PGH
- Balanced Binder Blends
  - Estimate PGH & RA Dosage
- Mixture Validation



RA Dosage Selection







1) Dosage to restore PG
(Restore PGL - verify PGH)

2) Dosage to reduce ΔT_c to -5.0

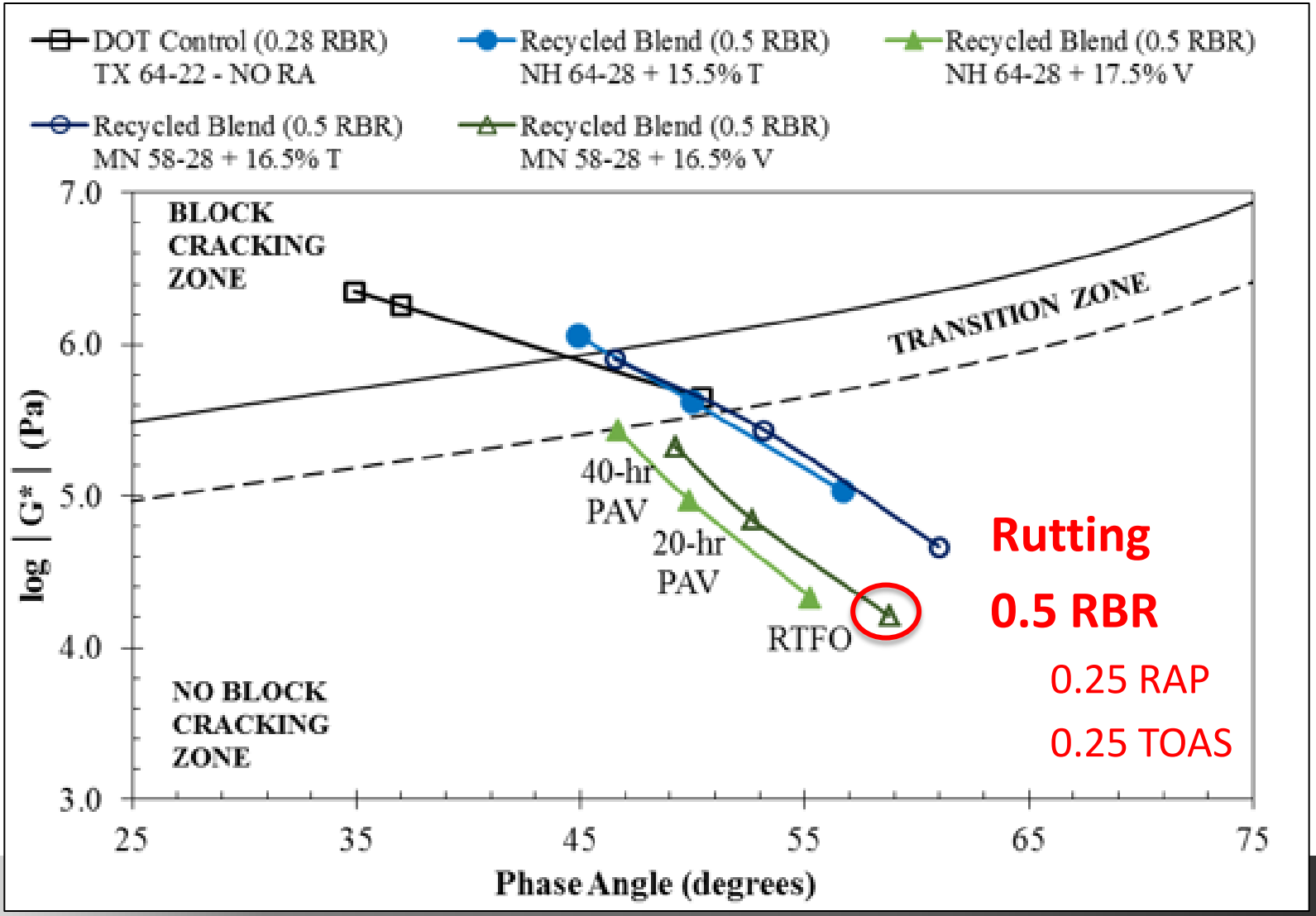
3) Dosage to restore PGH to target PGH

Dosage too low

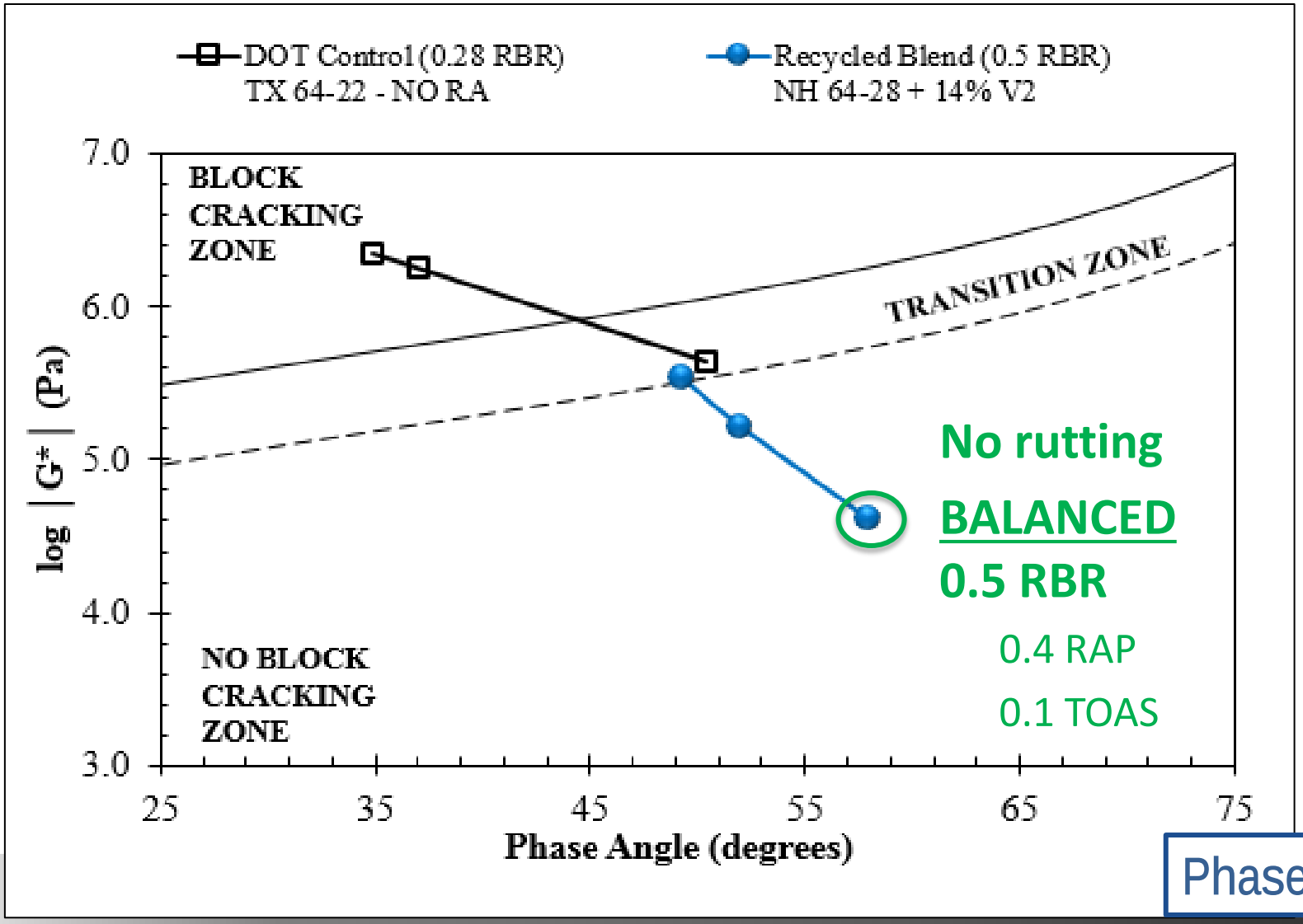
Dosage too high

Adequate Dosage

RA Dosage Selection: Restore *continuous* PGH

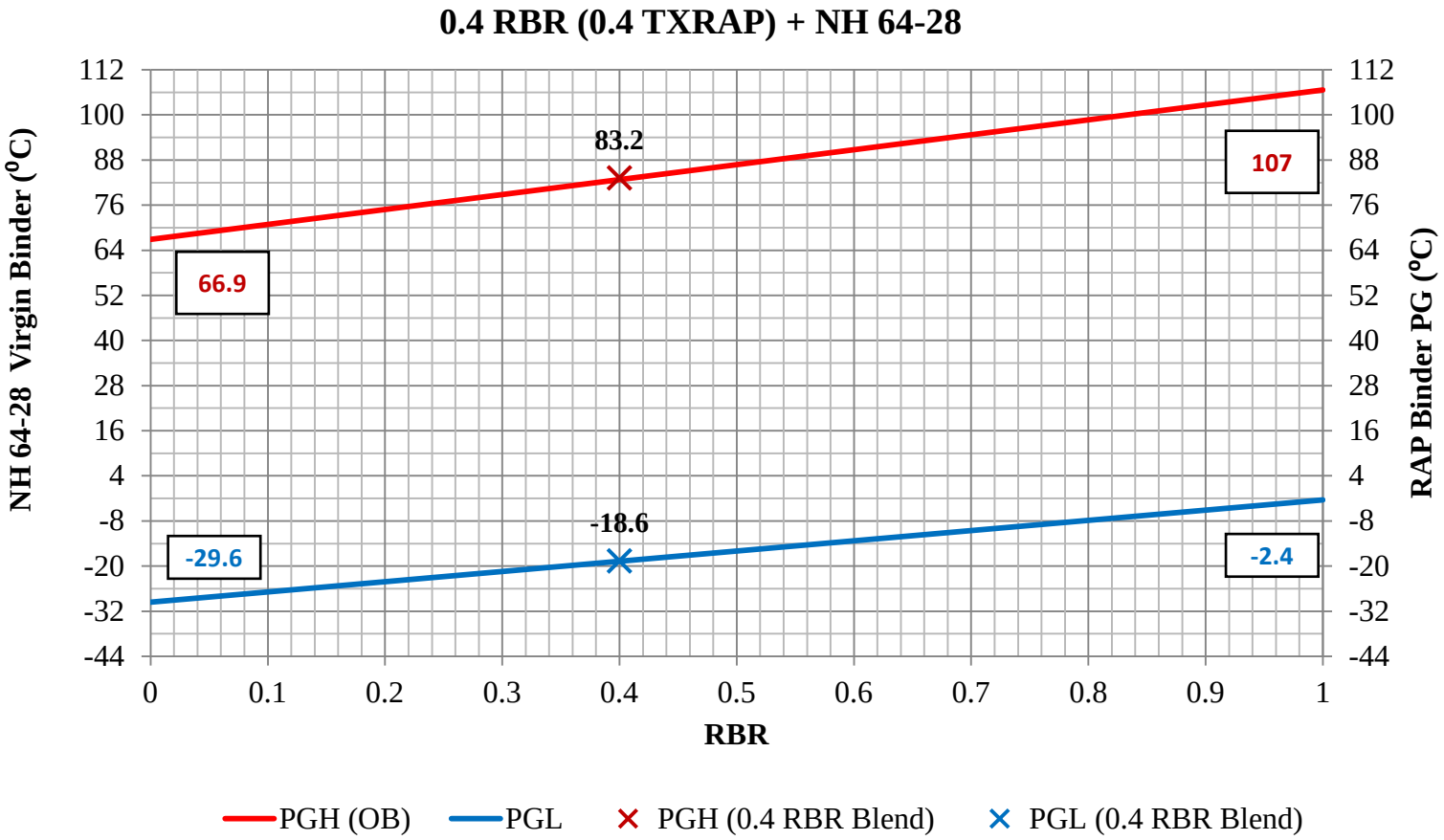


RA Dosage Selection: Restore *continuous* PGH



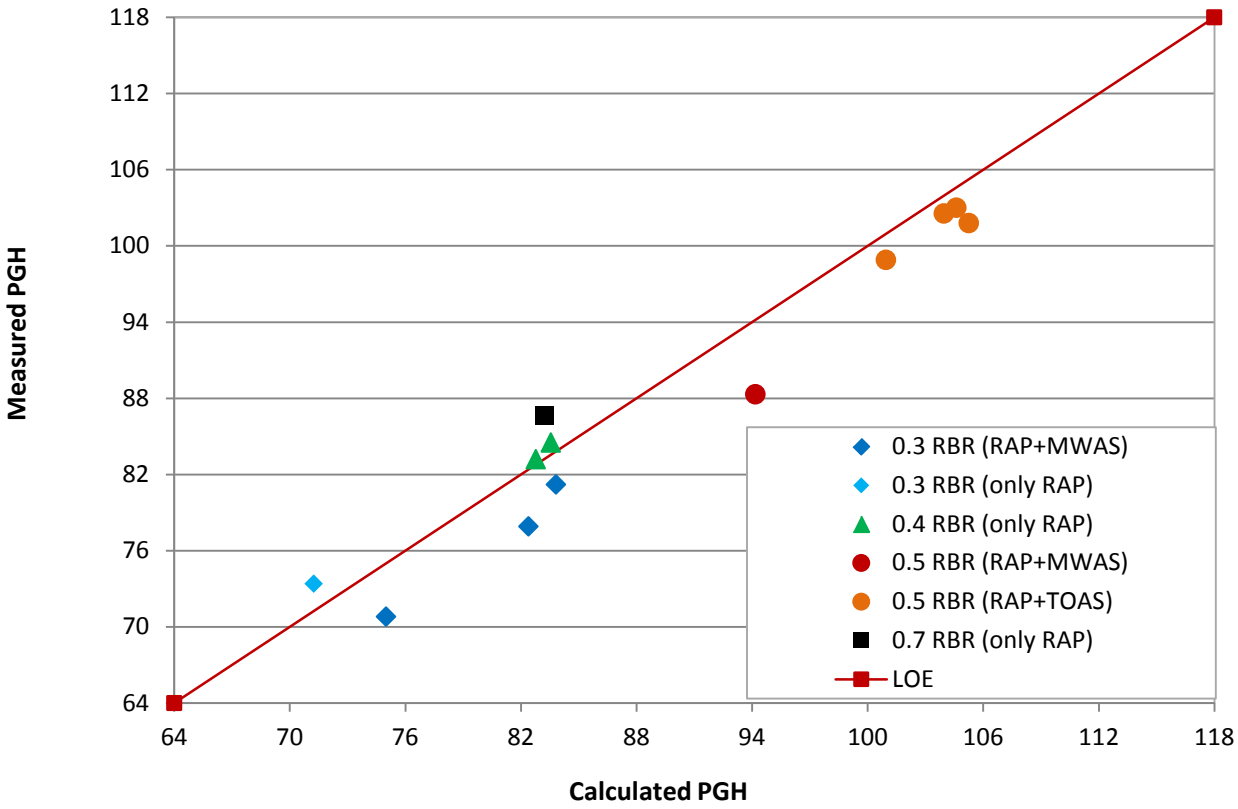
Phase III

Balanced Binder Blends - Blending Chart



$$PGH_{Blend} = (RAPBR \times PGH_{RAP}) + (VBR \times PGH_{V.binder})$$

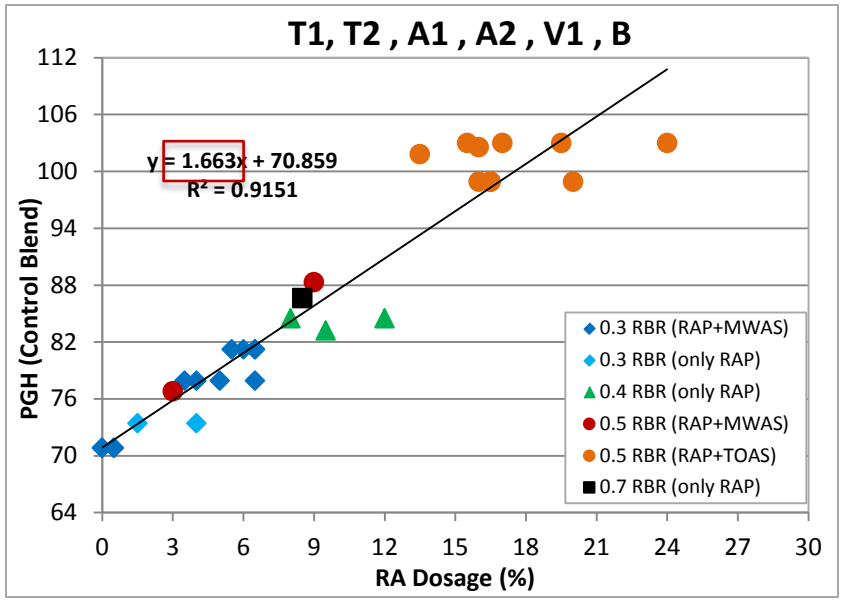
Balanced Binder Blends - Estimate PGH



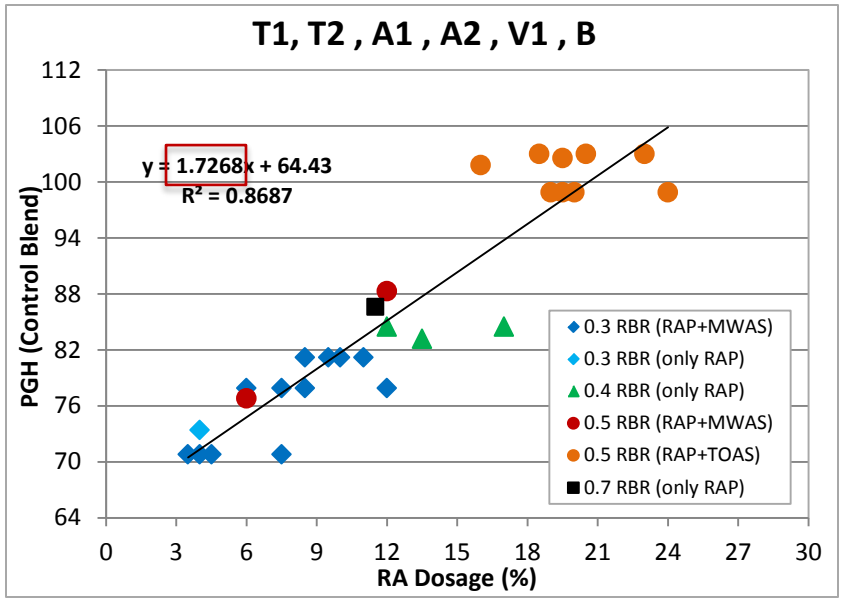
$$PGH_{Blend} = (RAPBR \times PGH_{RAP}) + (RASBR \times PGH_{RAS}) + (VBR \times PGH_{V.binder})$$

All recycled binder blends without RA

Estimate RA dosage to restore *continuous* PGH



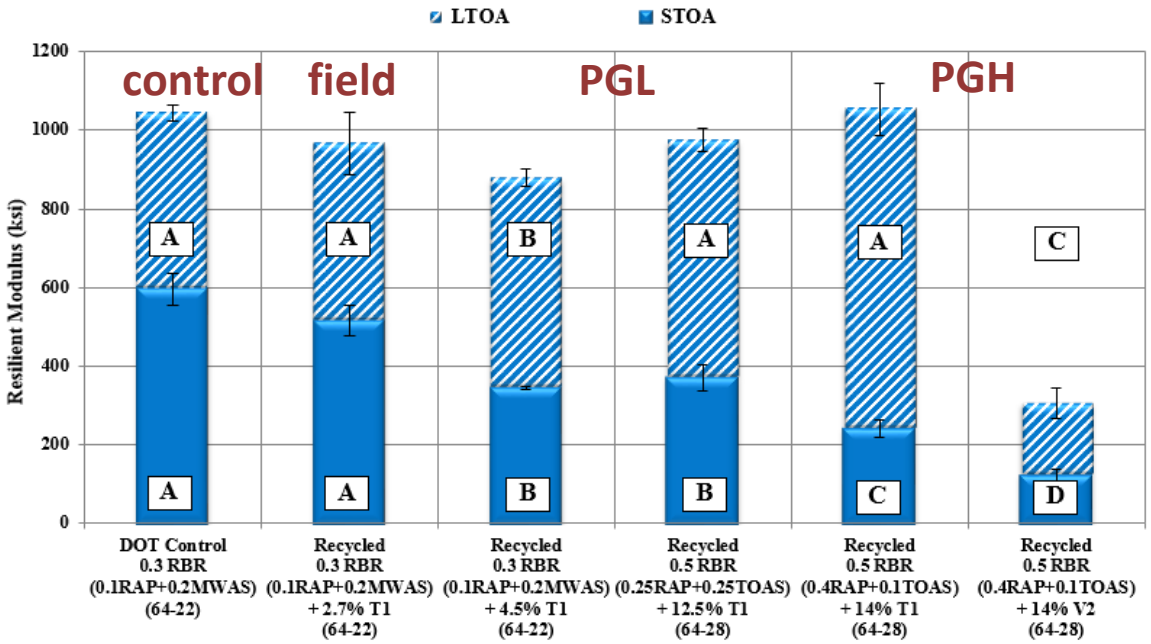
Dosage to restore PGH to **70**



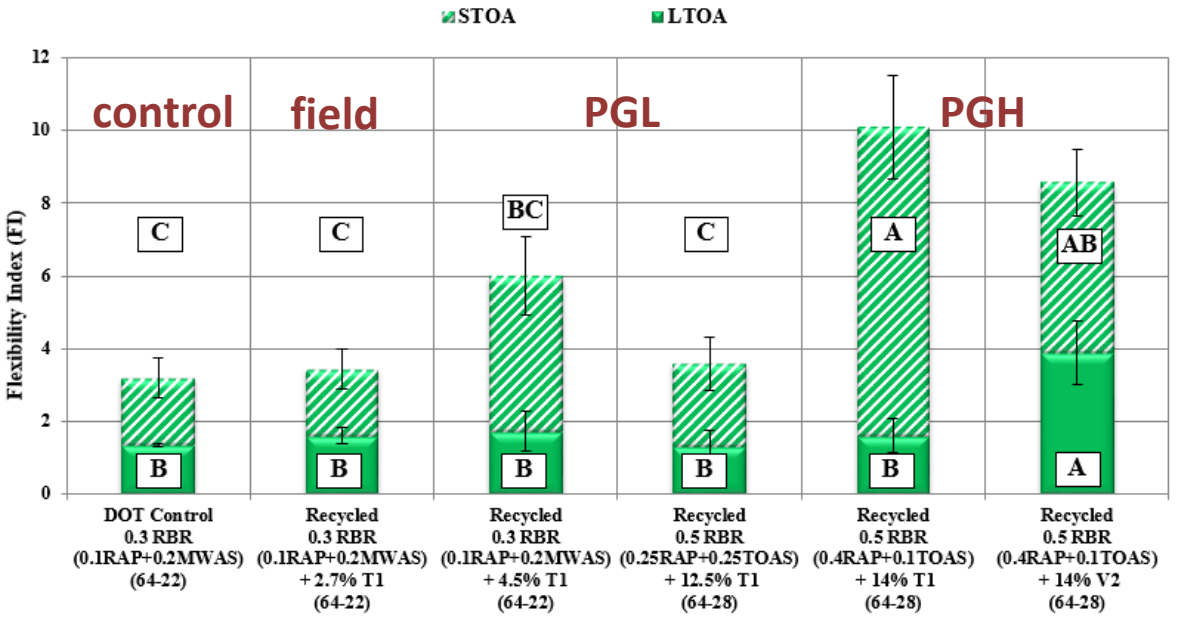
Dosage to restore PGH to **64**

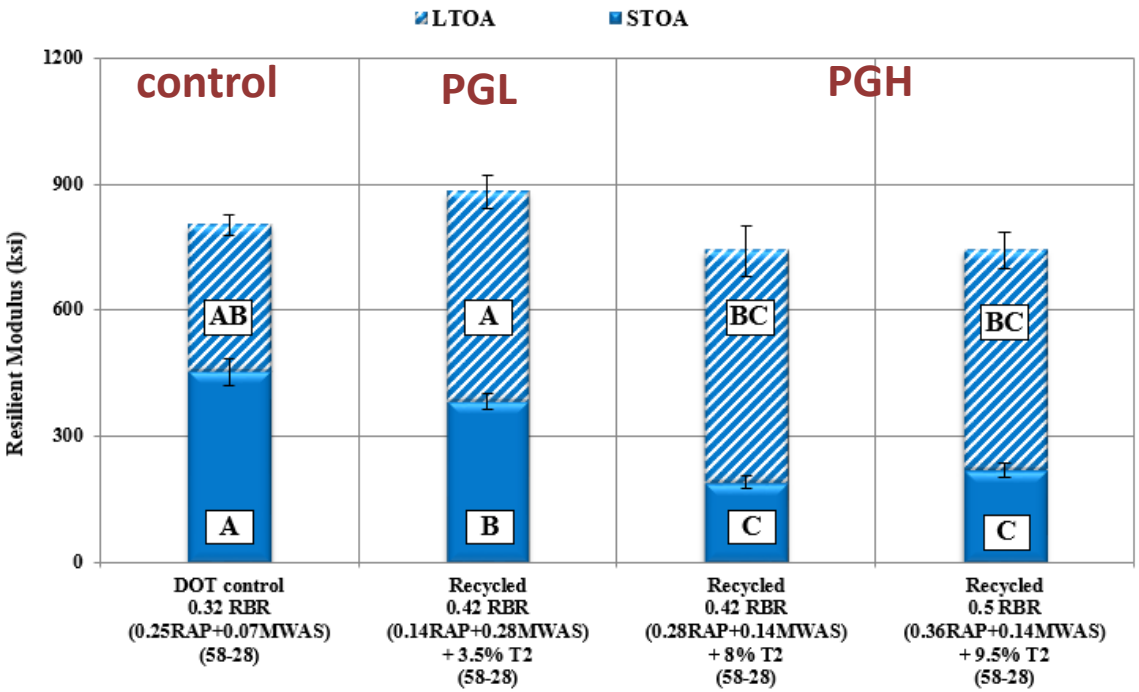
$$\%RA = (PGH_{Blend} - PGH_{Target})\ /1.7$$

Phase III



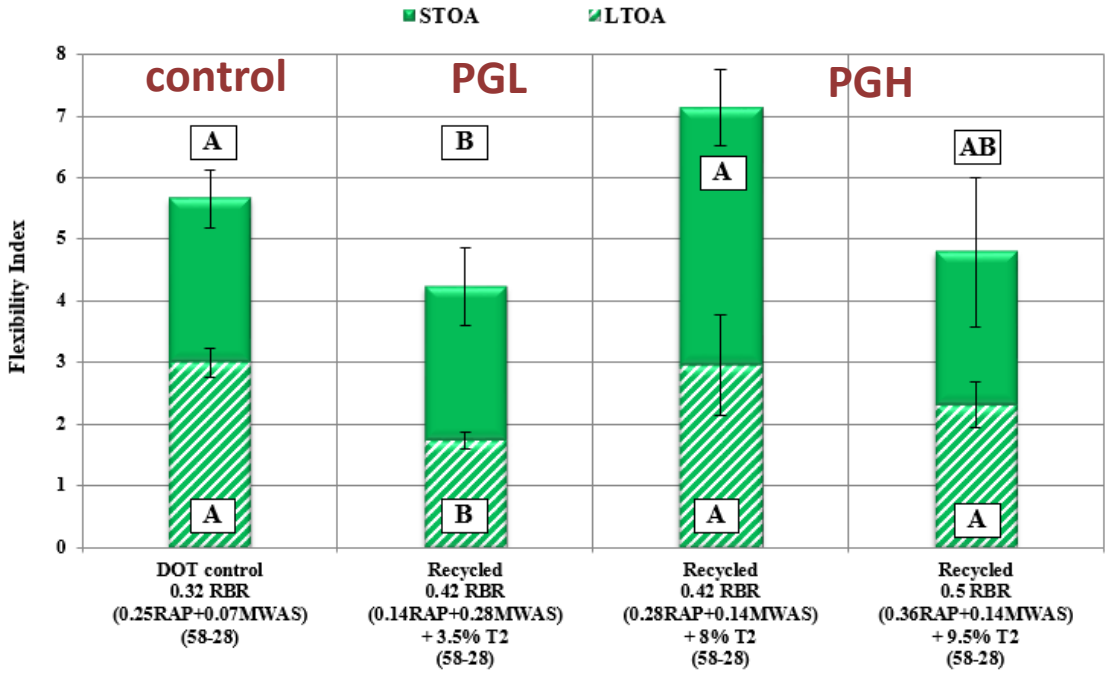
TX
Mixture Validation





IN

Mixture Validation



Phase III

Engineering Binder Blends

- Chemical Compatibility

- Representative Binder Blending

- Binder Blend Aging Prediction

- Rheological Balance

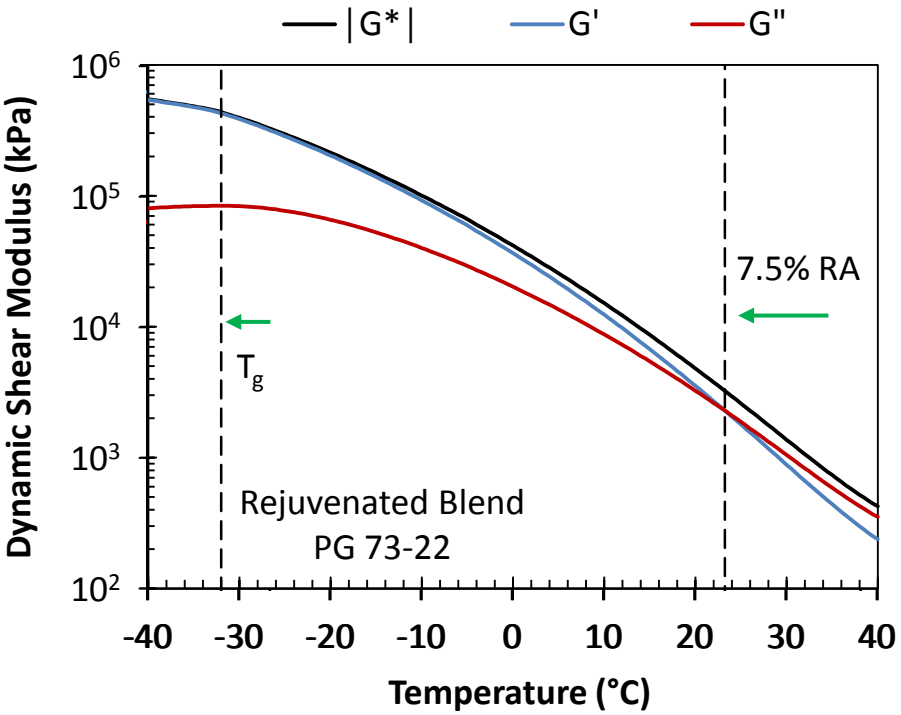
RHEOLOGICAL BALANCE

	Highlights	Tools/Partner
Rejuvenation	**Restore PG, reduce G-R, reduce $T_{\delta=45^\circ}$**	DSR/TTI
Aging	**Increase in G-R and $T_{\delta=45^\circ}$**, with some at faster rate than control blends	DSR & FT-IR/TTI
	RA can experience chemical changes with aging that affect rheology	DSR & FT-IR/TTI

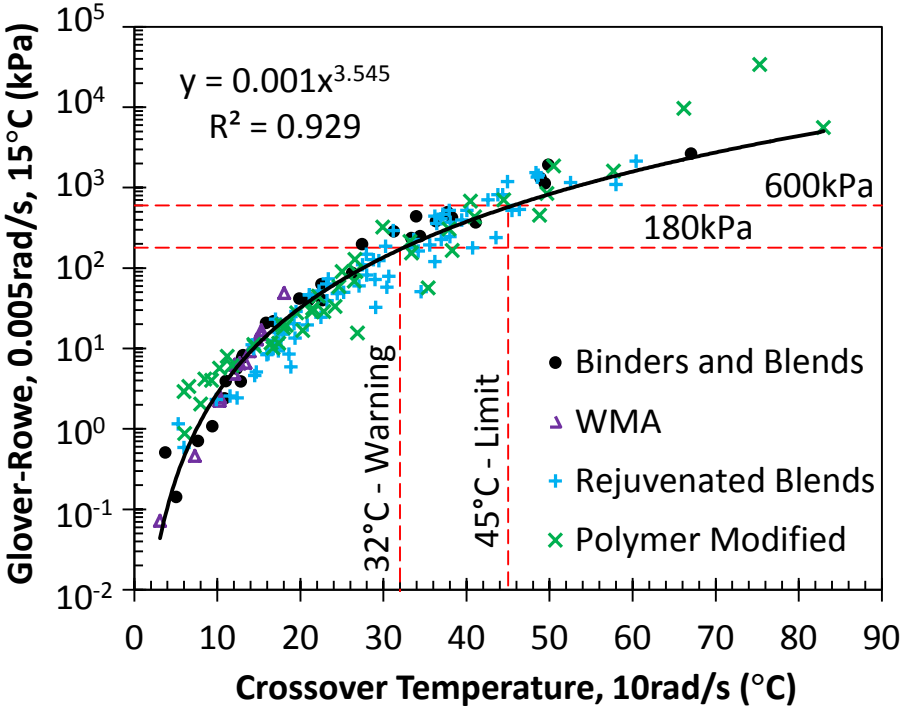
Phase III

Rheological Balance: Crossover Temperature ($T_{\delta=45°}$)

Determination by T Sweep



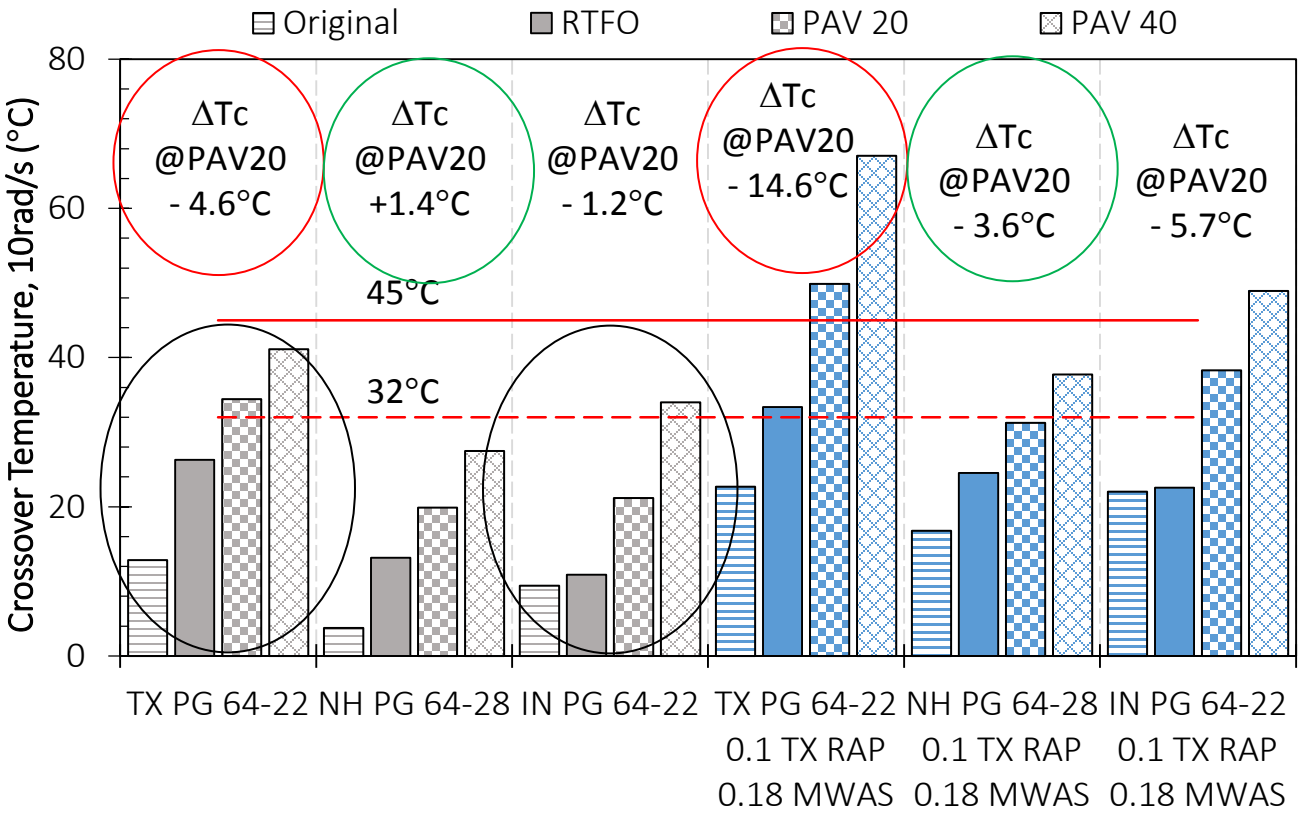
Preliminary Thresholds



Note: $T_{\delta=45°}$ in this study was obtained from mastercurves and time-temperature superposition.

Rheological Balance: Crossover Temperature ($T_{\delta=45^\circ}$)

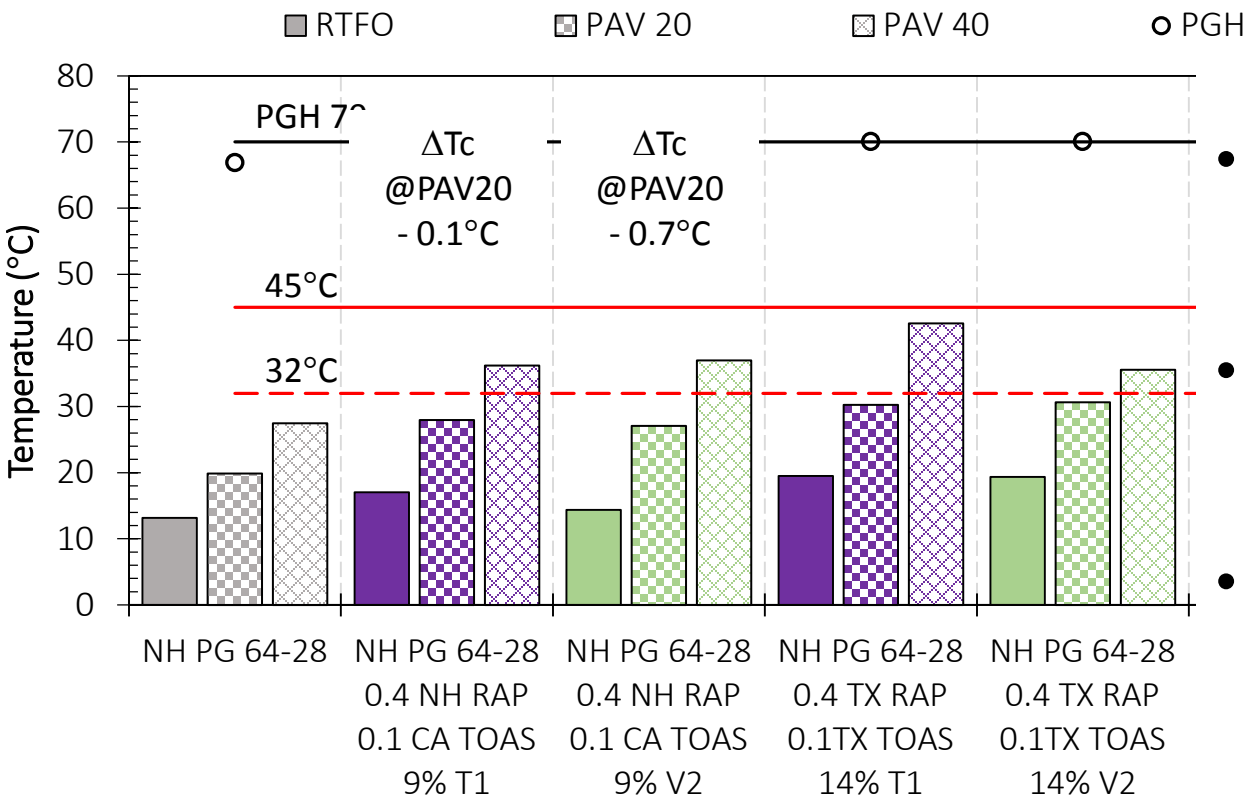
Base Binders and DOT Control Blends



- Important to select high quality base binder with better ΔT_c and $T_{\delta=45^\circ}$
- Binders of same PG can have different $T_{\delta=45^\circ}$
- Challenging TX materials combo

Rheological Balance and Long-Term Aging

High RBR Rejuvenated Blends



- Balanced – rutting and cracking resistance.
- Balanced – RAP and RAS
- It is possible to recycle and rejuvenate high RBR blends.

Moving Forward

Phase III

- Mixture Cracking Resistance

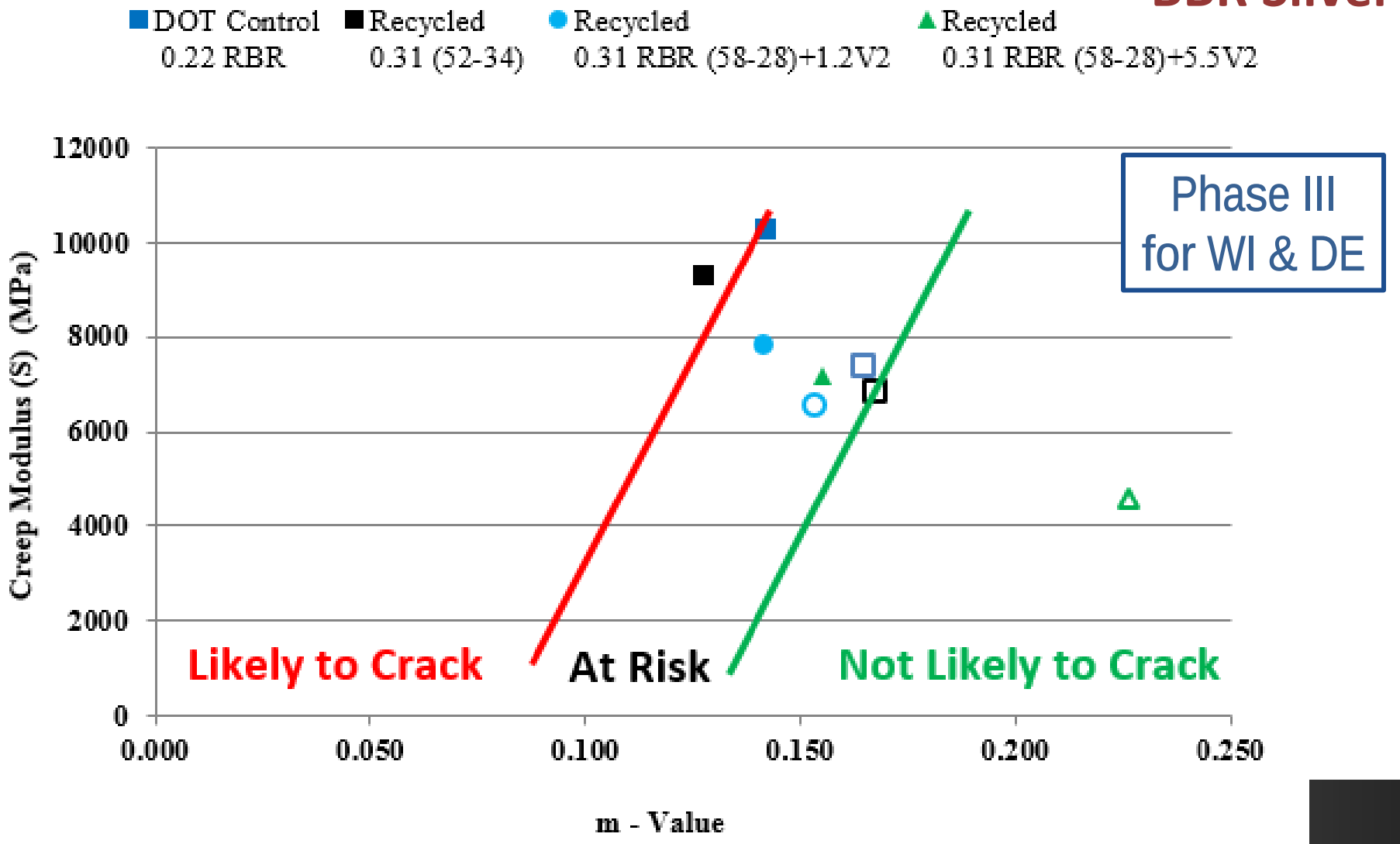
- Binder Availability

- RA Type Selection

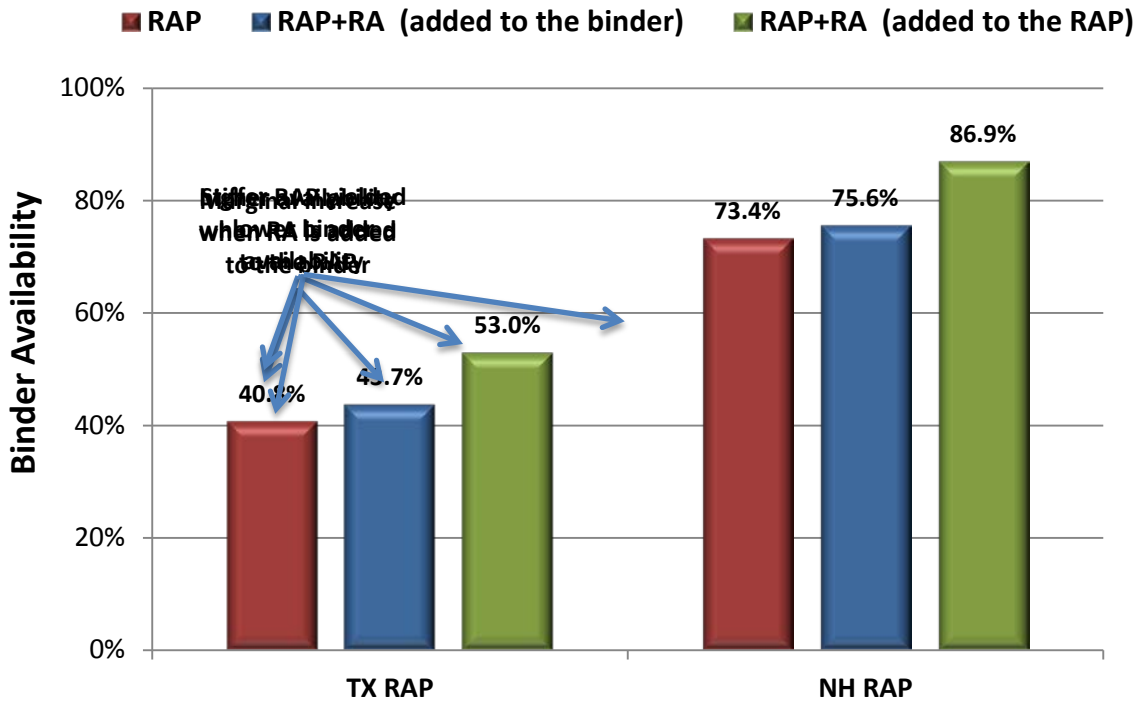
- Climate Effects

Mixture Cracking Resistance

BBR Sliver



Binder Availability: TX & NH RAP with RA



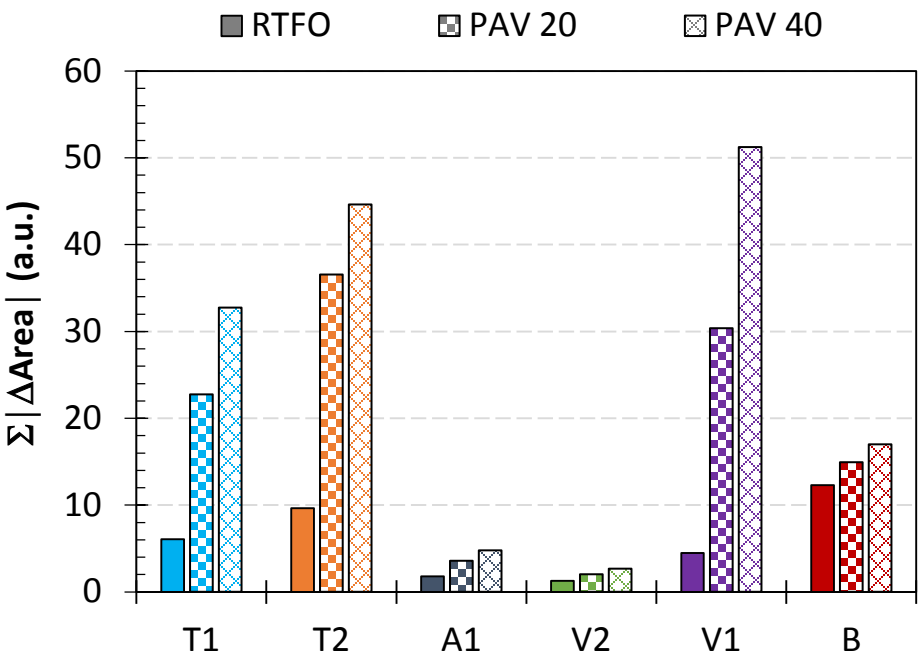
PGH – 107.6 PGH - 90.0

- 0.3 RBR
- TX & NH RAP binder contents = 4.7%, 4.0% respectively
- Mixture Total binder content: 4.5%

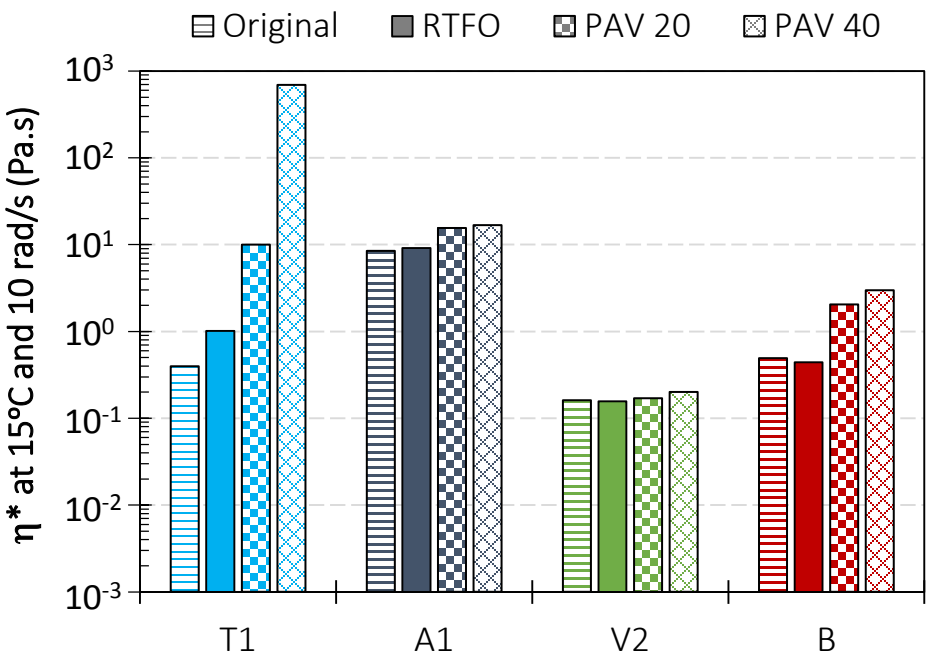
Phase III for IN, NV, WI, & DE + Unheated

RA Type Selection

Chemistry – FT-IR



Rheology - DSR

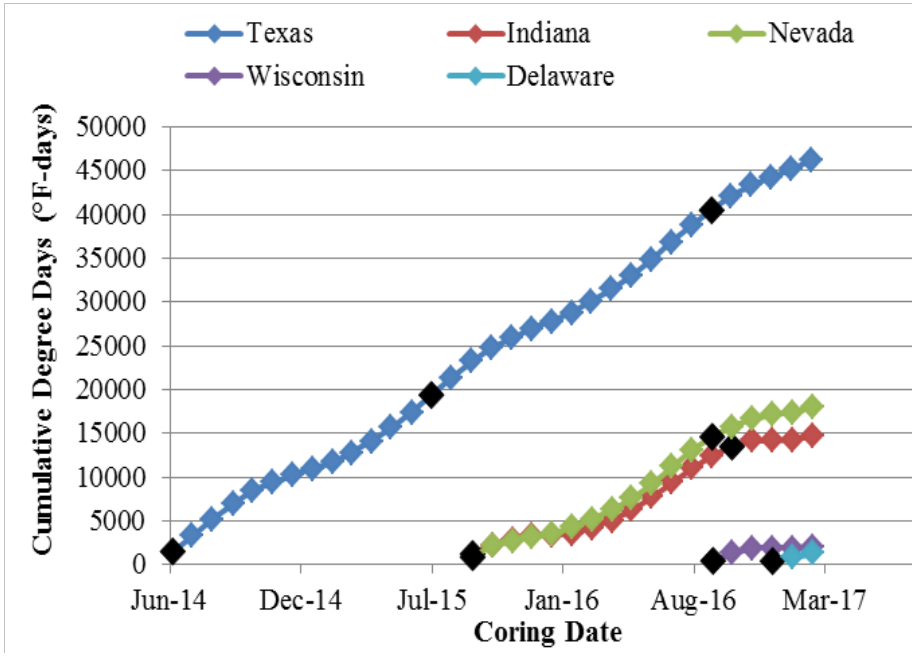


- RA with smallest Δ FT-IR registered minimal Δ in rheology
- T1 w/ greatest Δ in rheology & among highest Δ FT-IR.

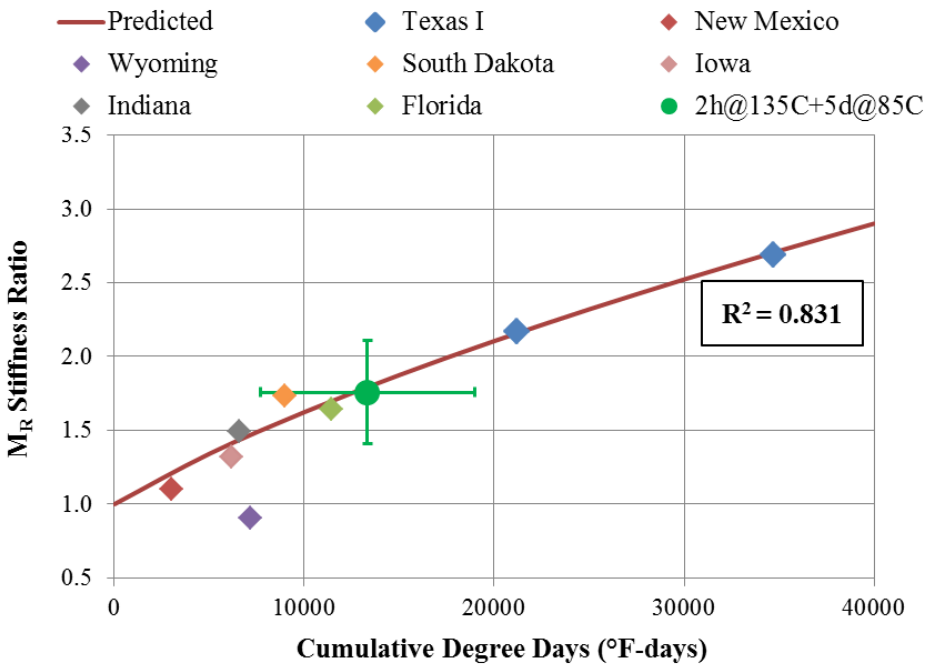
Phase III w/ 0.5 RBR blends w/WI matls + ΔG-R & $\Delta T_{\delta=45}$ w/aging + FI

Climate Effects

9-58 Cumulative Degree Days (CDD)



9-52 Ratio vs CDD



- 9-52: STOA 2hrs @ 135C + LTOA 5d @ 85C

= 16,000 CDD = 11 mos warmer, 22 mos colder climates

Phase III w/M_R, Cracking Resistance + Limited Extracted Binders w/G-R

Phase III Work Plan

UTILIZE
WI & DE Materials

VERIFY
Practical Tools

PROVIDE
Materials Selection Guidance

PROPOSE
RBR, RA Dosage Limits

Binder & Mix Thresholds

EVALUATE
Lab vs Field Aging

REVISE
AASHTO Standards

NCHRP 9-58 Products

- **High RBR** = 0.3 – 0.5
- **Material Selection Guidelines**
- **RA Dosage Selection Method**
- **Evaluation Tools** w/aging protocols, RA blending methods, binder blend & mixture tests & thresholds
  - AASHTO recommended practice
- Better Understanding of
  - Recycled Binder Availability (Degree of Blending)
  - Chemical Compatibility
- Future Research

THANK YOU!

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