

Preliminary Dosage Selection Method for Utilizing Rejuvenators in High RBR Asphalt Concrete Mixtures

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Outline

- ❑ NCHRP 9-58 Motivation, Objectives, & Research Plan
- ❑ Phase II Preliminary RA Dosage Selection Method
 - **Field Projects**
 - **Materials**
 - **Laboratory Tests**
 - **Results – Binder, Mortar, Mixture**
- ❑ Next Steps



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

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Motivation – High Recycled Binder Ratio (RBR)



Economic & Environmental Benefits

- Natural Resources
- Energy
- Emissions

Engineering Concerns

- Compactibility
- Stiffness &
Embrittlement
- Cracking Resistance





Mitigation – Recycling Agent (RA)

BENEFITS



Engineering

- Reduced Stiffness, Improved Compactibility
- Improved Cracking Resistance



Economic

REMAINING ISSUES

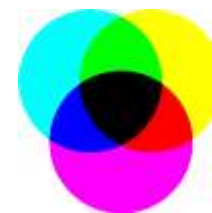


Engineering

- Reduced Embrittlement
- Aging



- Blending



- Mixture Performance



NCHRP 9-58 Objectives

- ☐ Assess effectiveness of RAs to
 - **restore blended binder rheology**
 - **improve mixture cracking****performance** at optimum dosage rates



- ☐ Evaluate the **evolution of RA effectiveness**
- ☐ 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



Environmental Zones

- - Wet-Freeze
- - Dry -Freeze
- - Dry -N Freeze
- - Wet-No Freeze

Field Projects

WI 2016?

IN 9/15: 0.4, 0.5 RBR
RA: T2

MO 2016: 0.4, 0.5 RBR
RA: T1

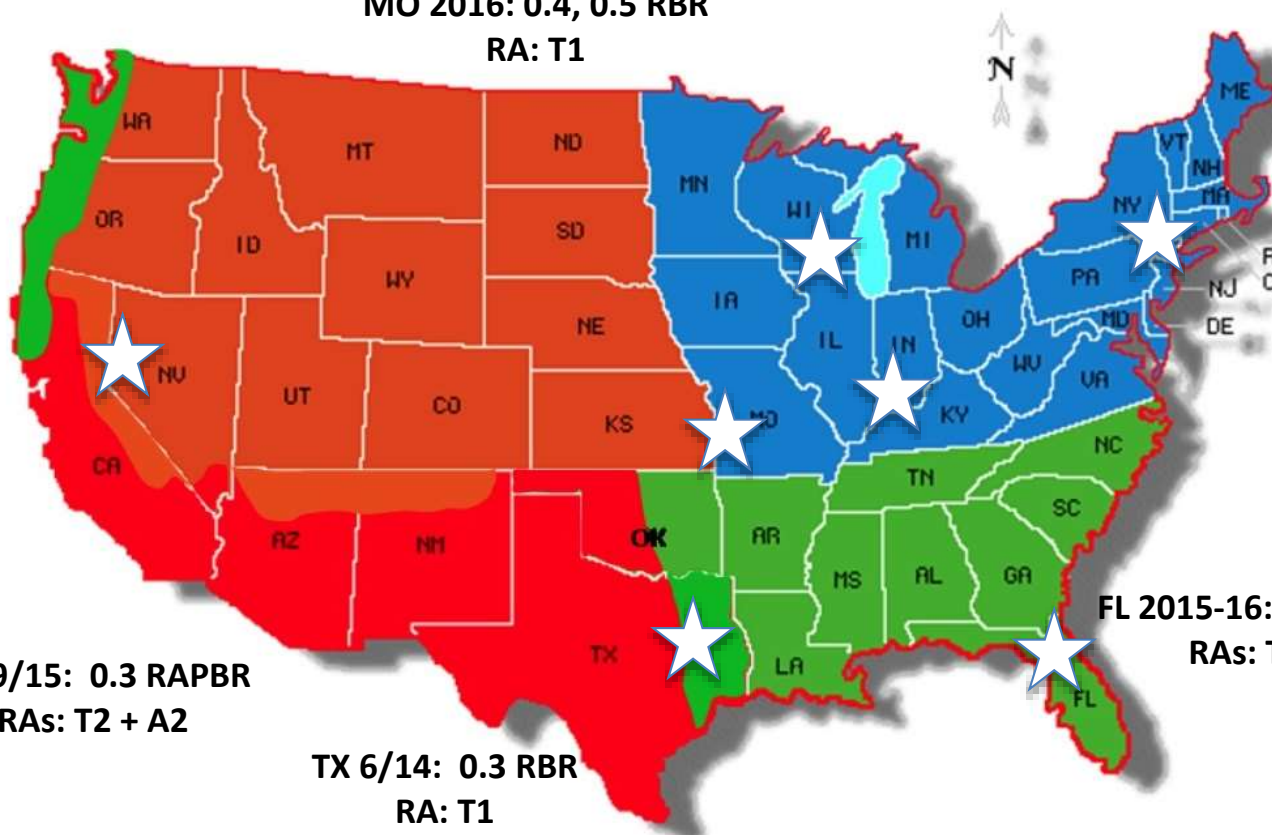


NV 9/15: 0.3 RAPBR
RAs: T2 + A2

TX 6/14: 0.3 RBR
RA: T1

FL 2015-16: 0.4, 0.6 RBR
RAs: T1 + T2

NY 2016?



TX (Expanded) & NV Field Materials

- ❑ TX: PG 64-22 + 0.3 RBR (0.1 RAP+0.2 MWAS)
+ 2.7% Tall Oil T1 (Target=PG 70-22)
- ❑ +0.4 RBR w/RAP only, 0.5 RBR balanced RAP/RAS
- ❑ + Aromatic Extract A1
- ❑ + NH PG 64-28 & NV PG 64-28P
- ❑ + TX TOAS
- ❑ NV: PG 64-28P + 0.3 RBR (0.3 RAP)
+ 2.0% Tall Oil T2 & + 2.0% Tall Oil A2 (Target=PG64-28)



Laboratory Tests – BINDER & MORTAR

☐ PG - BOTH

☐ G-R



Laboratory Tests - MIXTURE

□ Stiffness

- $M_R @ 25^\circ\text{C}$
- E^*

□ Fatigue Resistance

- S-VECD



**SELECT
MATERIALS**

**PREP
MATERIALS**

**CONDUCT LAB
TESTS**

**SELECT
DOSAGE**

**VERIFY
DOSAGE w/
MIXTURE**

**VERIFY
DOSAGE w/
BINDER**

**OK
PERF?**

YES

**CONFIRM
OPT**

YES

**OK
PERF?**

NO

NO



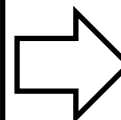
SELECT MATERIALS

**Target and control
binder PG grade**

RAP and/or RAS source(s)

Recycling Agent (RA)

**RAP and/or RAS Recycled Binder
Ratio (RAPBR/ RASBR)**



PREP MATERIALS

**Extract and recover binder from
RAP and/or RAS source(s)**

**Prepare control + recycled
binder blends:**

- **With no RA**
- **With low RA dosage**
- **With high RA dosage**



CONDUCT LAB TESTS

**Obtain high PG grade (PGH)
and low PG grade (PGL) per
AASHTO M320:**

- **Target binder**
- **Binder blend with no RA**
- **Binder blend with low RA dosage**
- **Binder blend with high RA dosage**



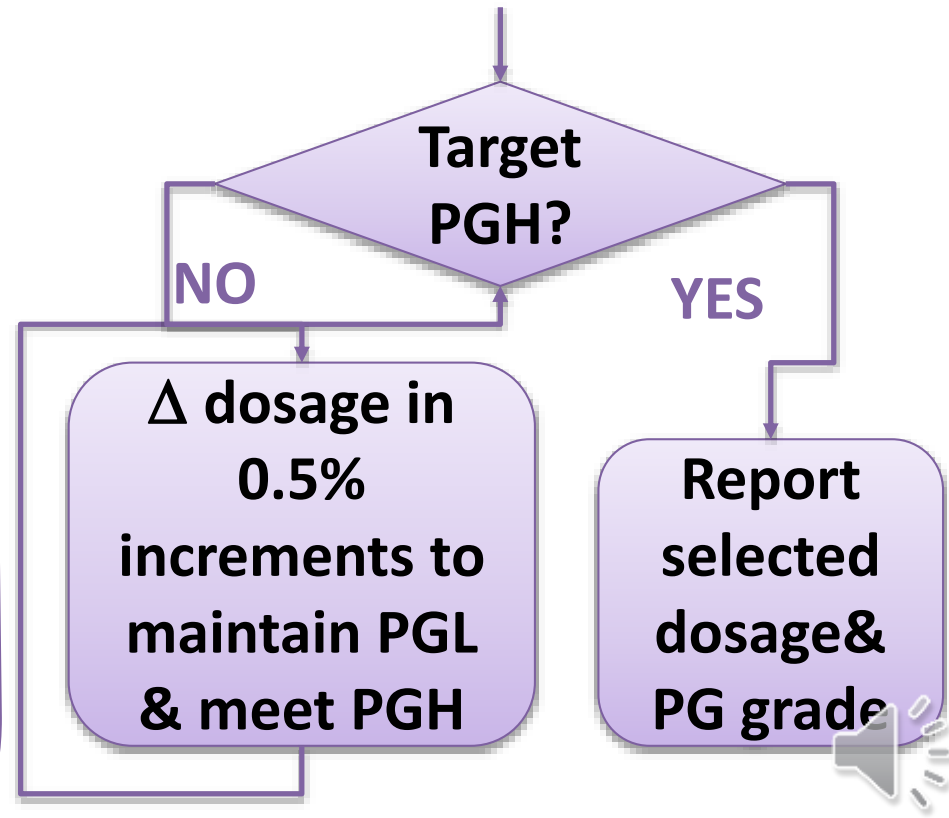
SELECT DOSAGE

**Plot original & RTFO
PGH, S- & m-
controlled PGL vs.
dosage for all blends**

**Establish linear
regression equations**

**Select RA dosage in
0.5% increments to
meet target binder
PGL using warmer
PGL regression line**

**Verify PGH of
selected dosage vs.
target binder PGH
using colder PGH
regression line**



VERIFY DOSAGE w/BINDER

**Prepare control + recycled binder
blend at selected dosage**

Age the binder blend

- RTFO, RTRO + PAV 20 hrs, RTFO + PAV 40 hrs

**Measure Glover-Rowe parameter
and FTIR carbonyl area**

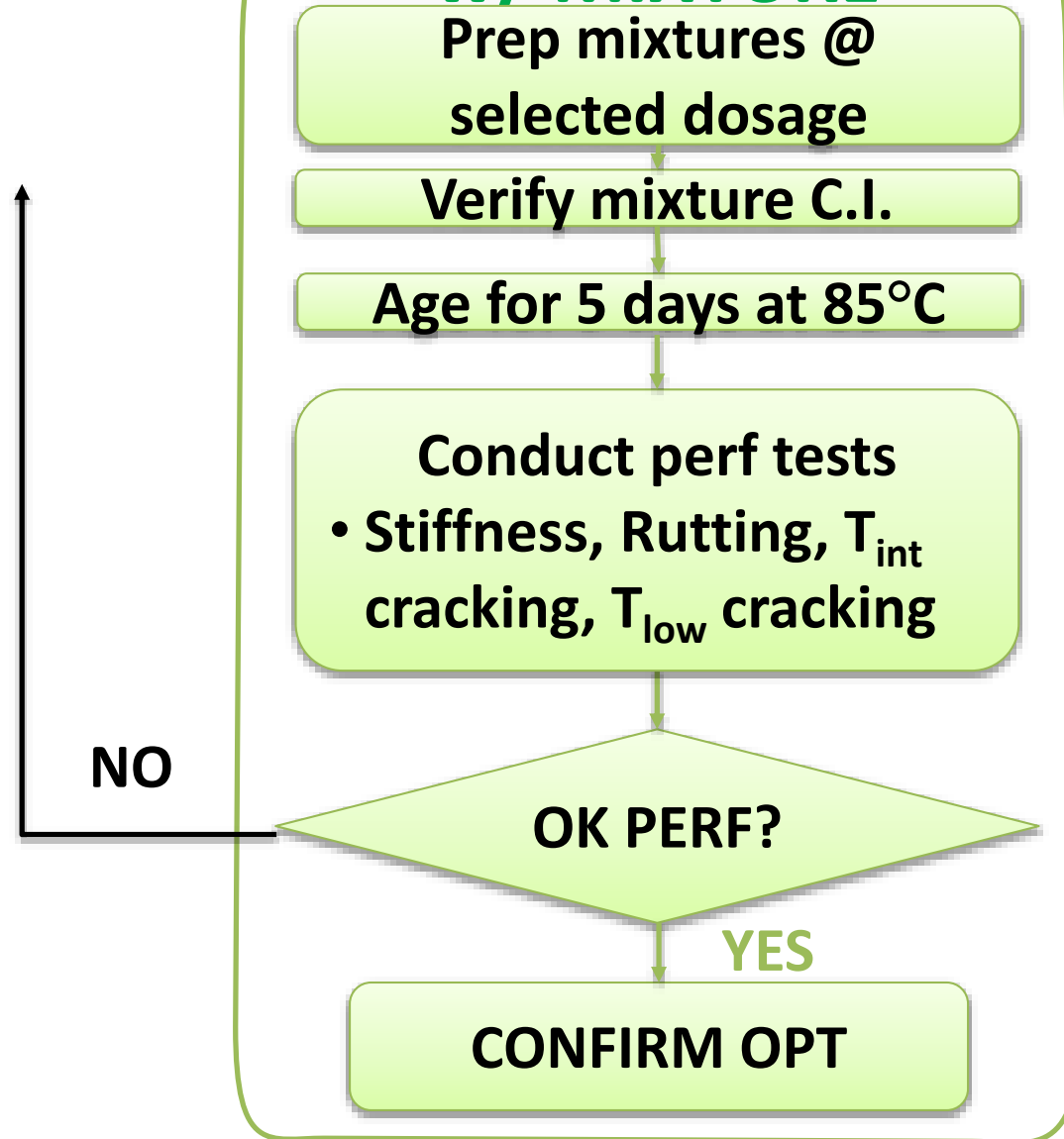
OK PERF?

YES

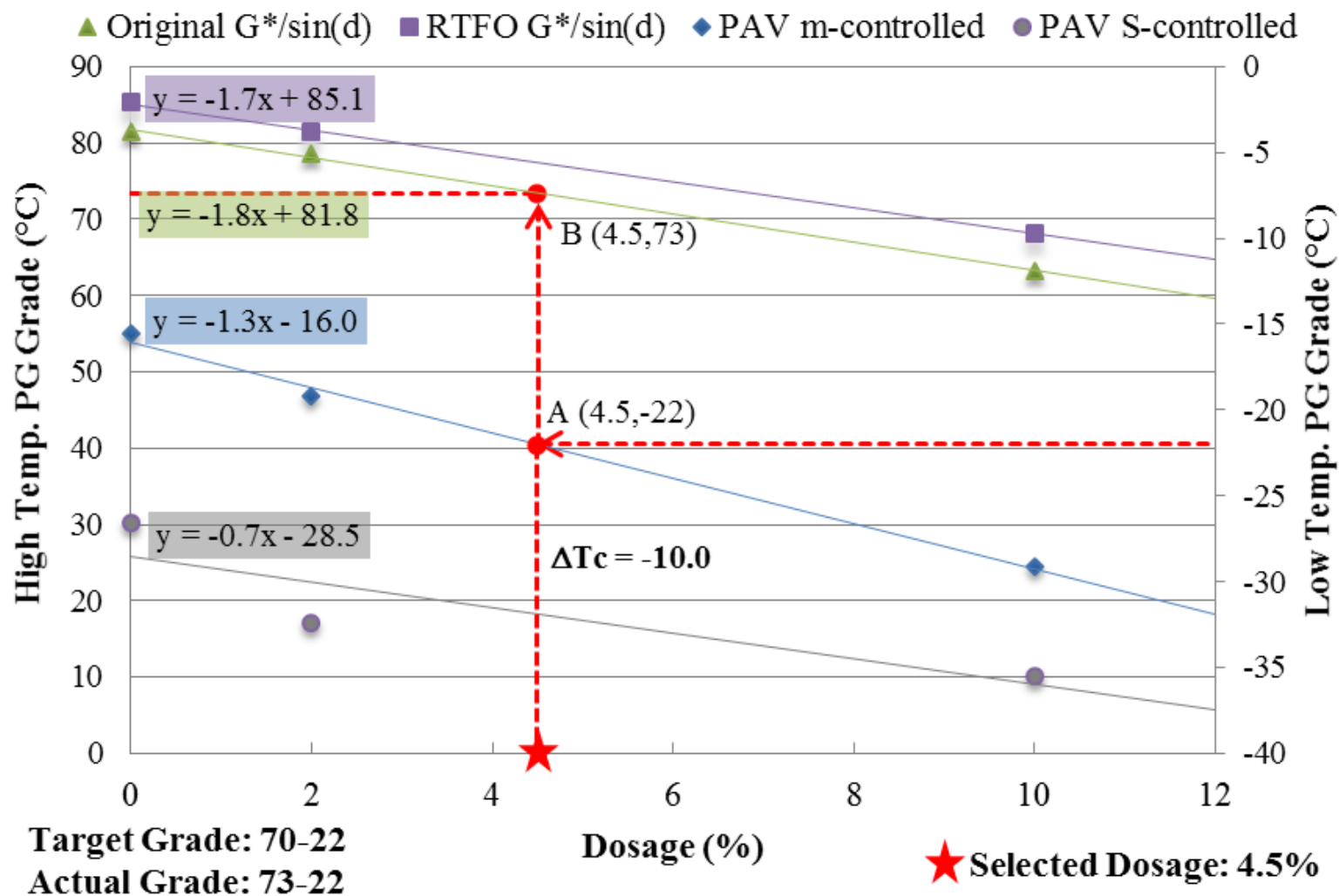
NO



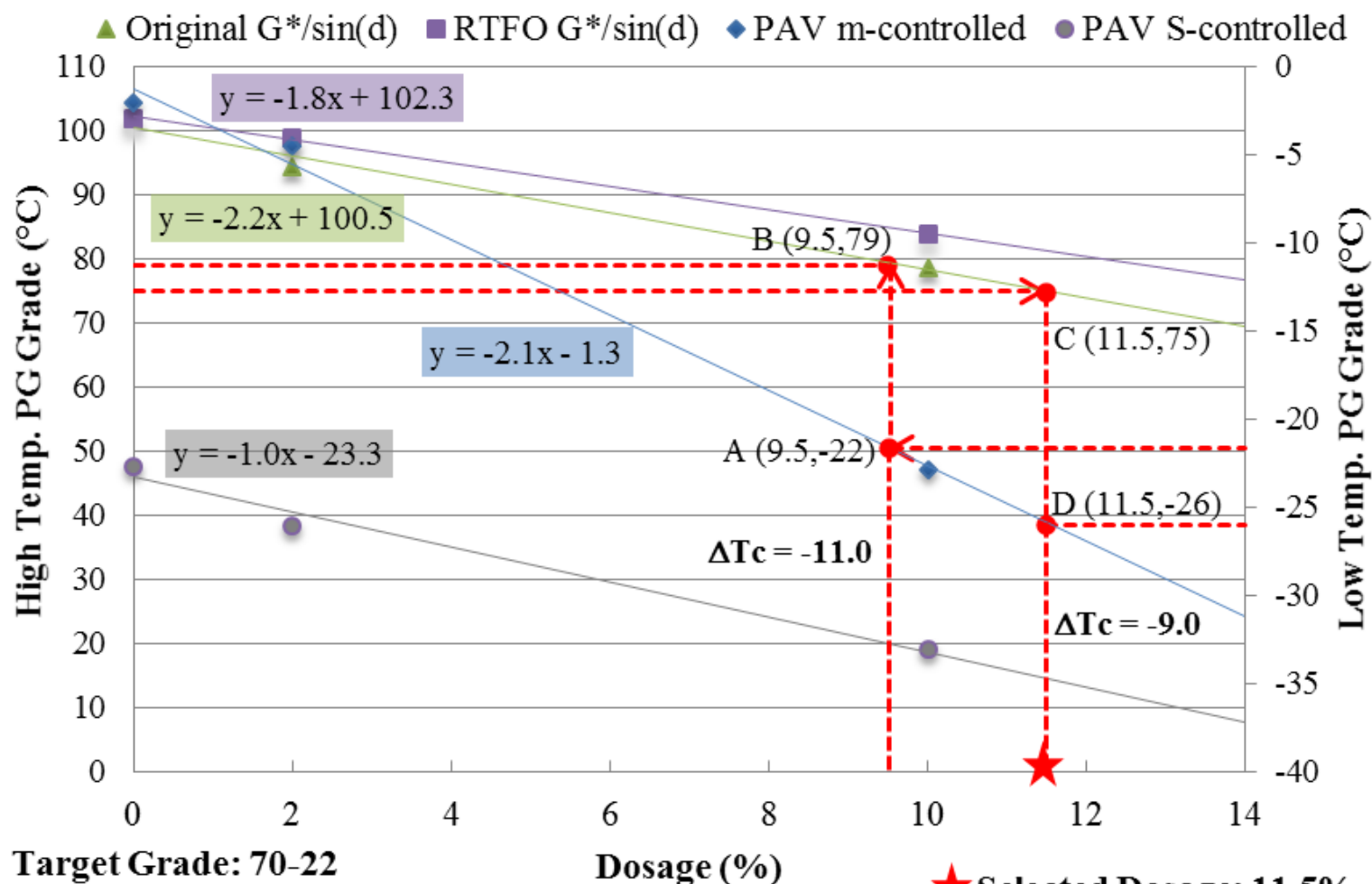
VERIFY DOSAGE w/ MIXTURE



0.3 RBR (PG 64-22 | 0.1 TxRAP | 0.2 TxMWAS | T1)



0.5 RBR (64-22 | 0.25 TxRAP | 0.25 TxTOAS | T1)



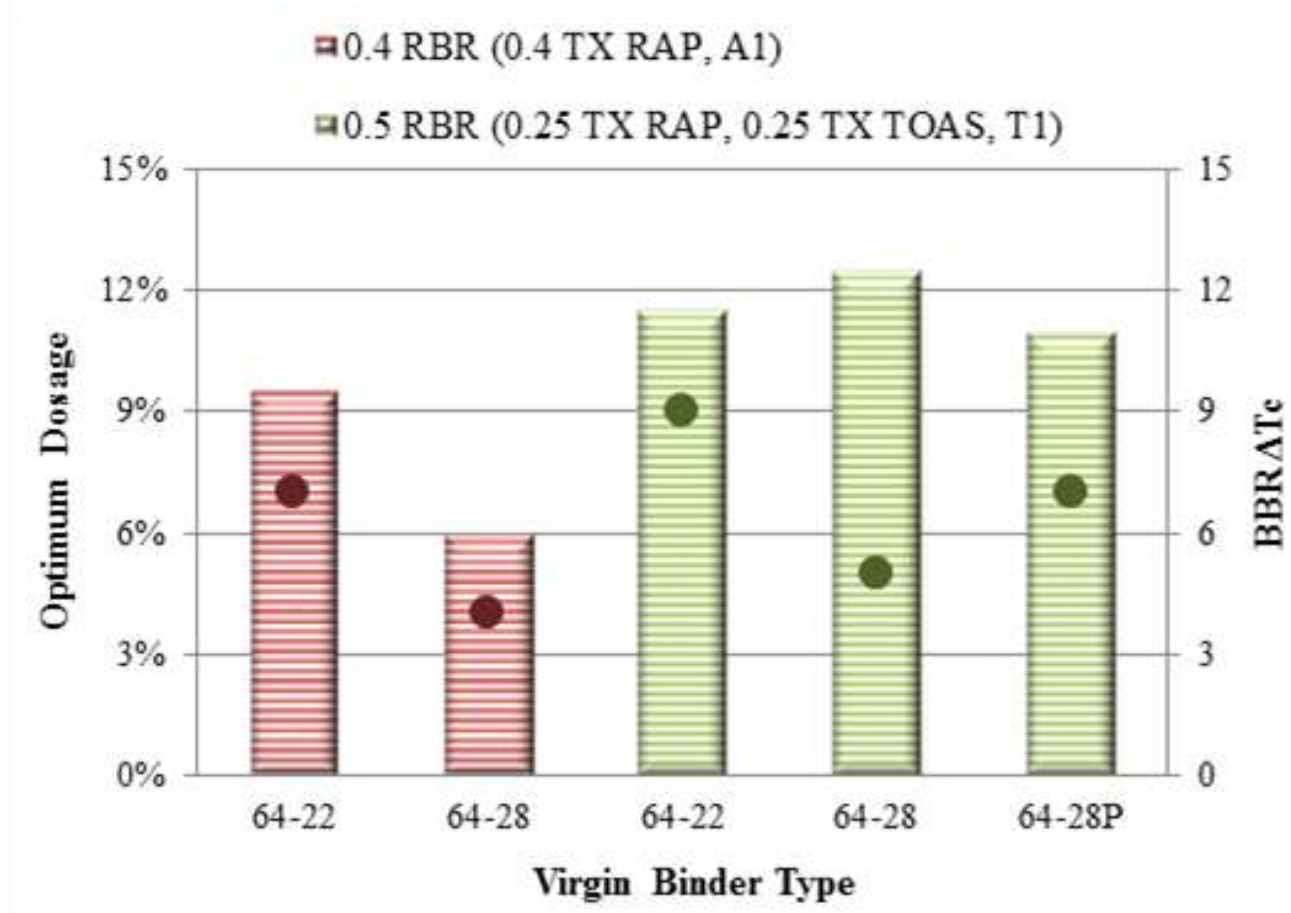
DOSAGE SELECTION

Materials					Binder		
Virgin	RBR	RAP	RAS	RA	Opt Dosage	Field Dosage	ΔT_c @ Opt
64-22 TX	0.3	0.1 TX	0.2 TX MWAS	T1	4.5	2.7	10
64-22 TX	0.3	0.1 TX	0.2 TX MWAS	A1	5.5	-	9
64-22 TX	0.4	0.4 TX	-	T1	7.5	-	8
64-22 TX	0.4	0.4 TX	-	A1	9.5	-	7
64-22 TX	0.5	0.25 TX	0.25 TX MWAS	T1	7.5	-	9
64-22 TX	0.5	0.25 TX	0.25 TX TOAS	T1	11.5	-	9
64-28 NH	0.4	0.4 TX	-	A1	6.0	-	4
64-28 NH	0.5	0.25 TX	0.25 TX TOAS	T1	12.5	-	5
64-28P NV	0.5	0.25 TX	0.25 TX TOAS	T1	11.0	-	7
64-28P NV	0.3	0.3 NV	-	T2	1.5	2.0	3
64-28P NV	0.3	0.3 NV	-	A2	2.0	2.0	2

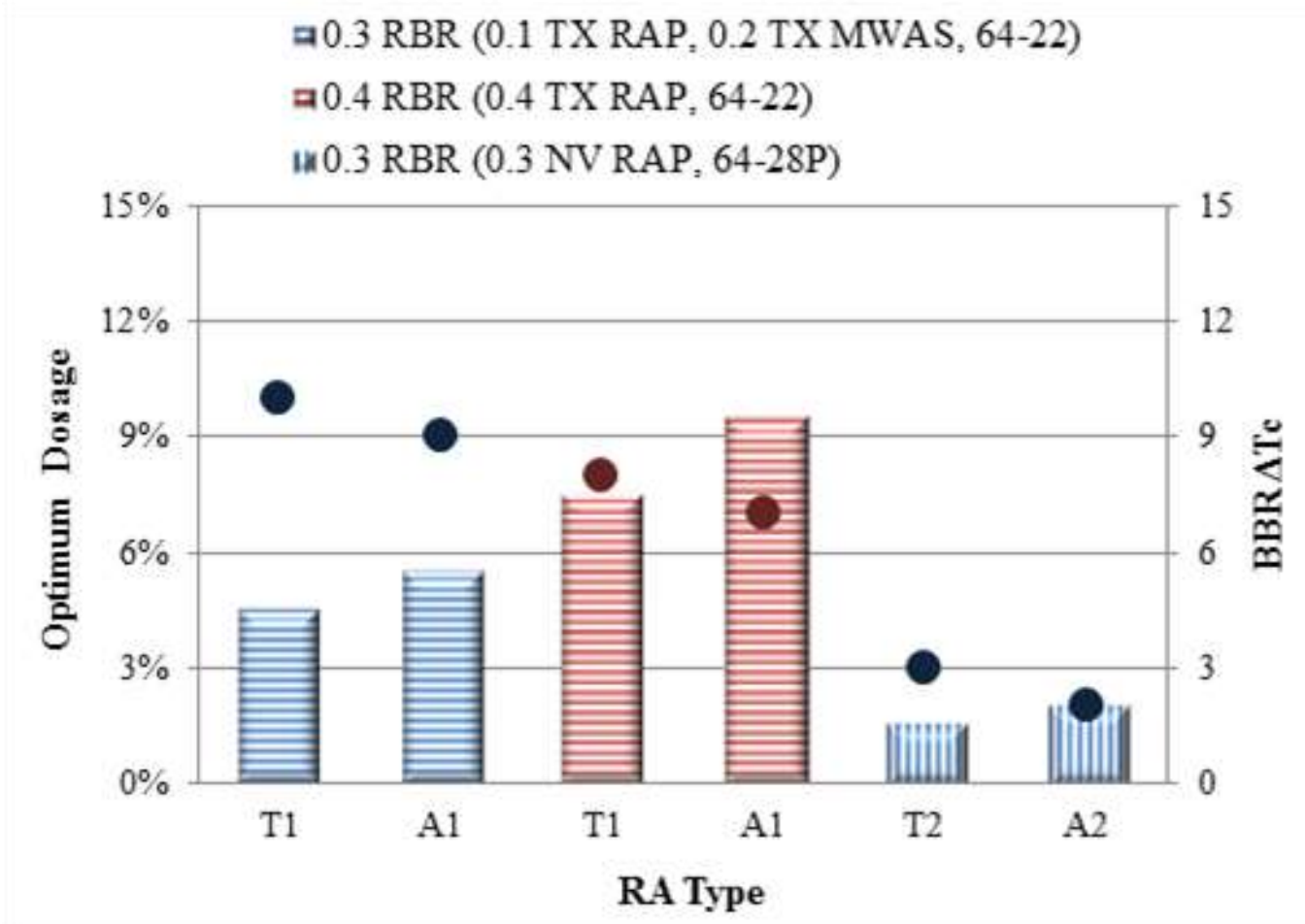
- 0.5% increments
- Restore PGL, then maintain & restore PGH
- High ΔT_c ??
- Aging effects – using optimum w/G-R @ 0, 20, 40hr PAV



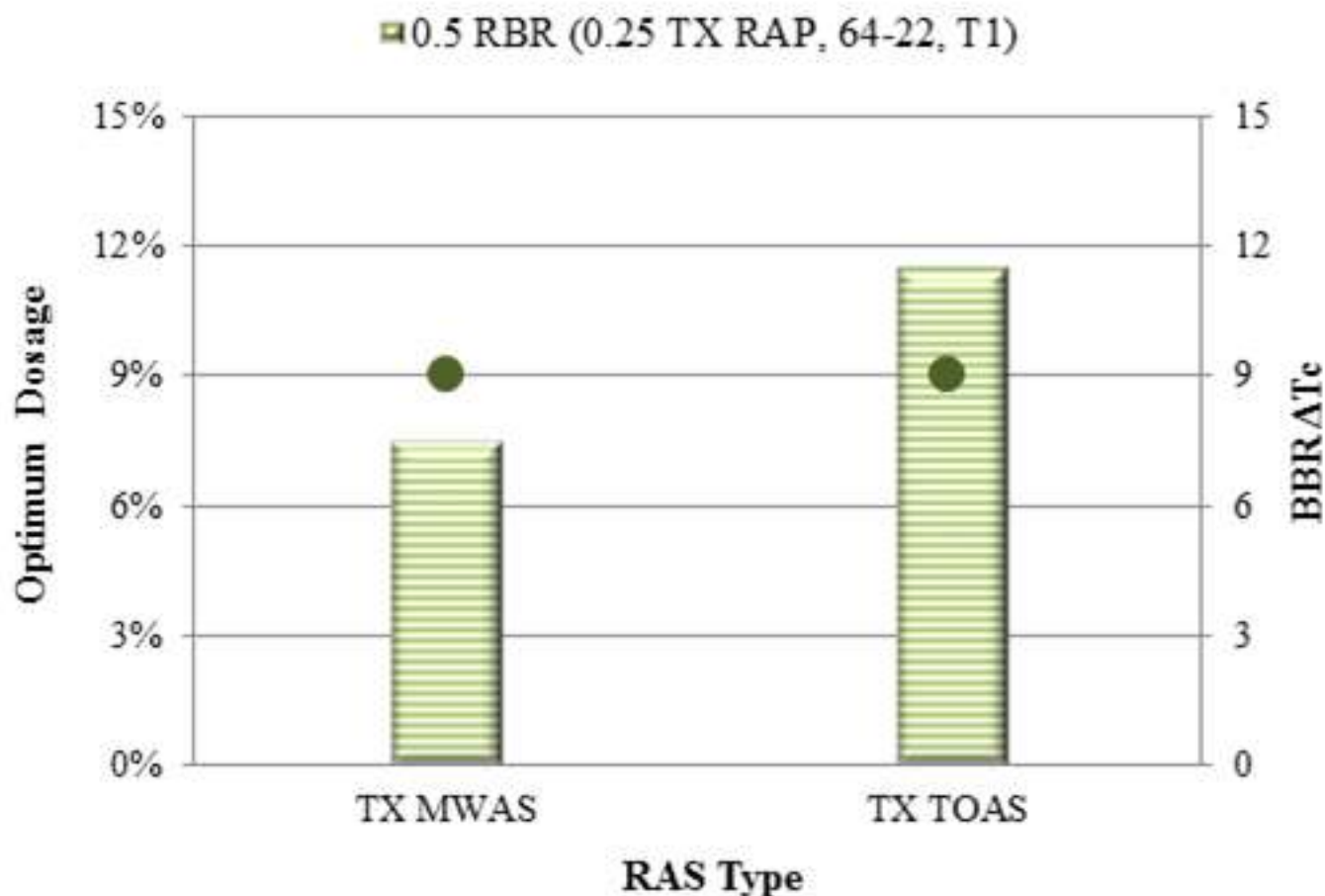
DOSAGE SELECTION – VIRGIN BINDER TYPE



DOSAGE SELECTION – RA TYPE

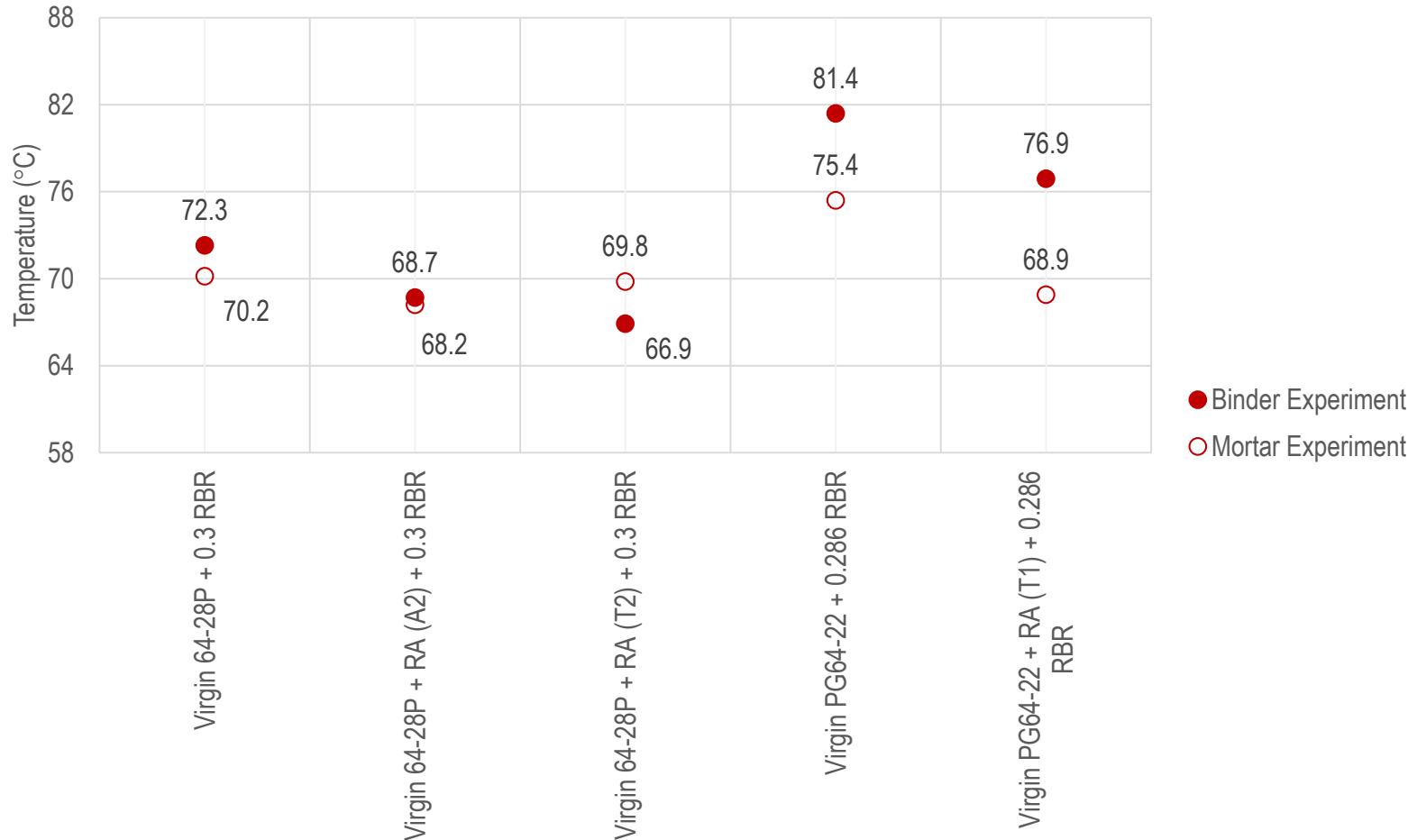


DOSAGE SELECTION – RAS TYPE



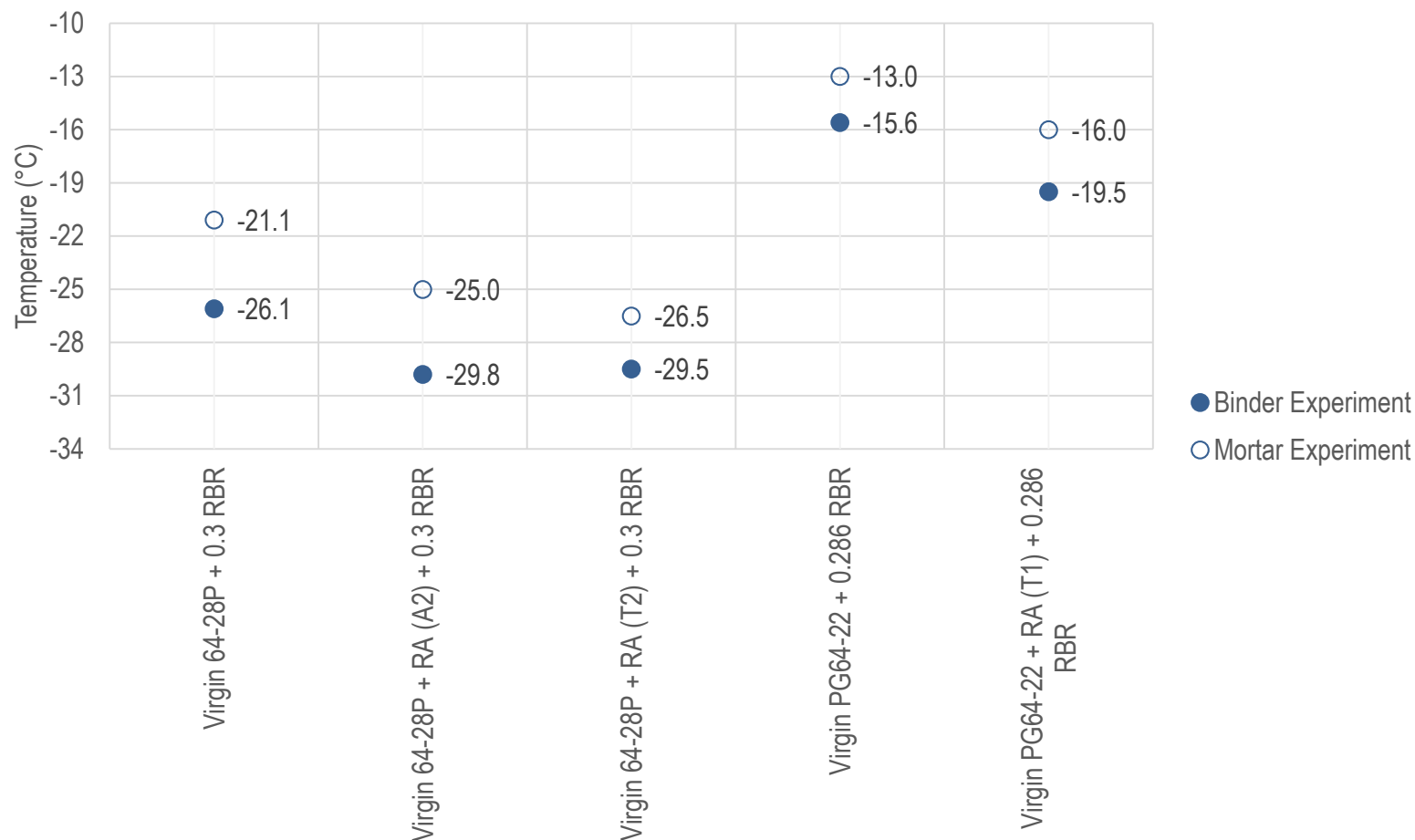
RA Dosage Selection – Mortar Verification

High Temperature (°C)

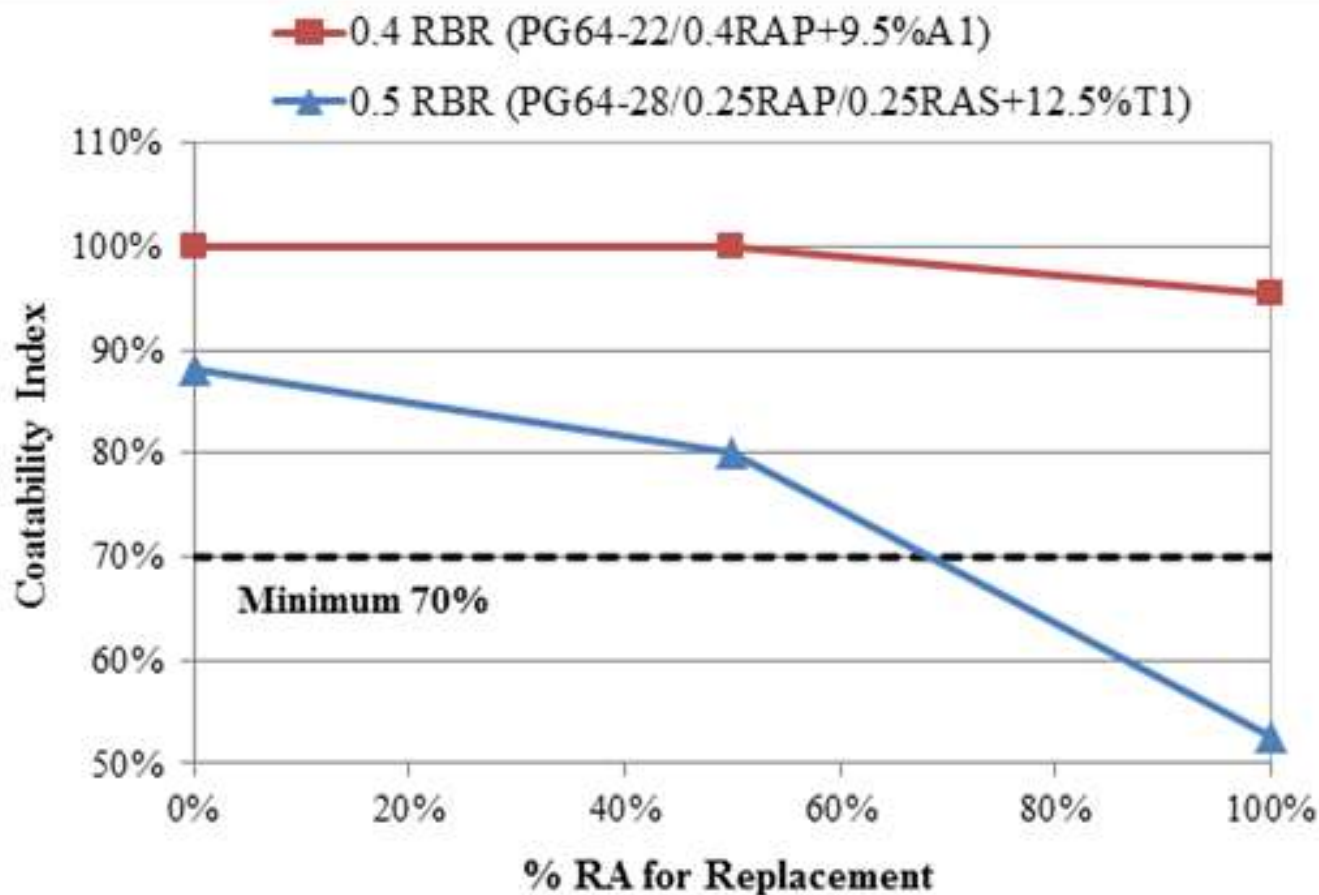


RA Dosage Selection – Mortar Verification

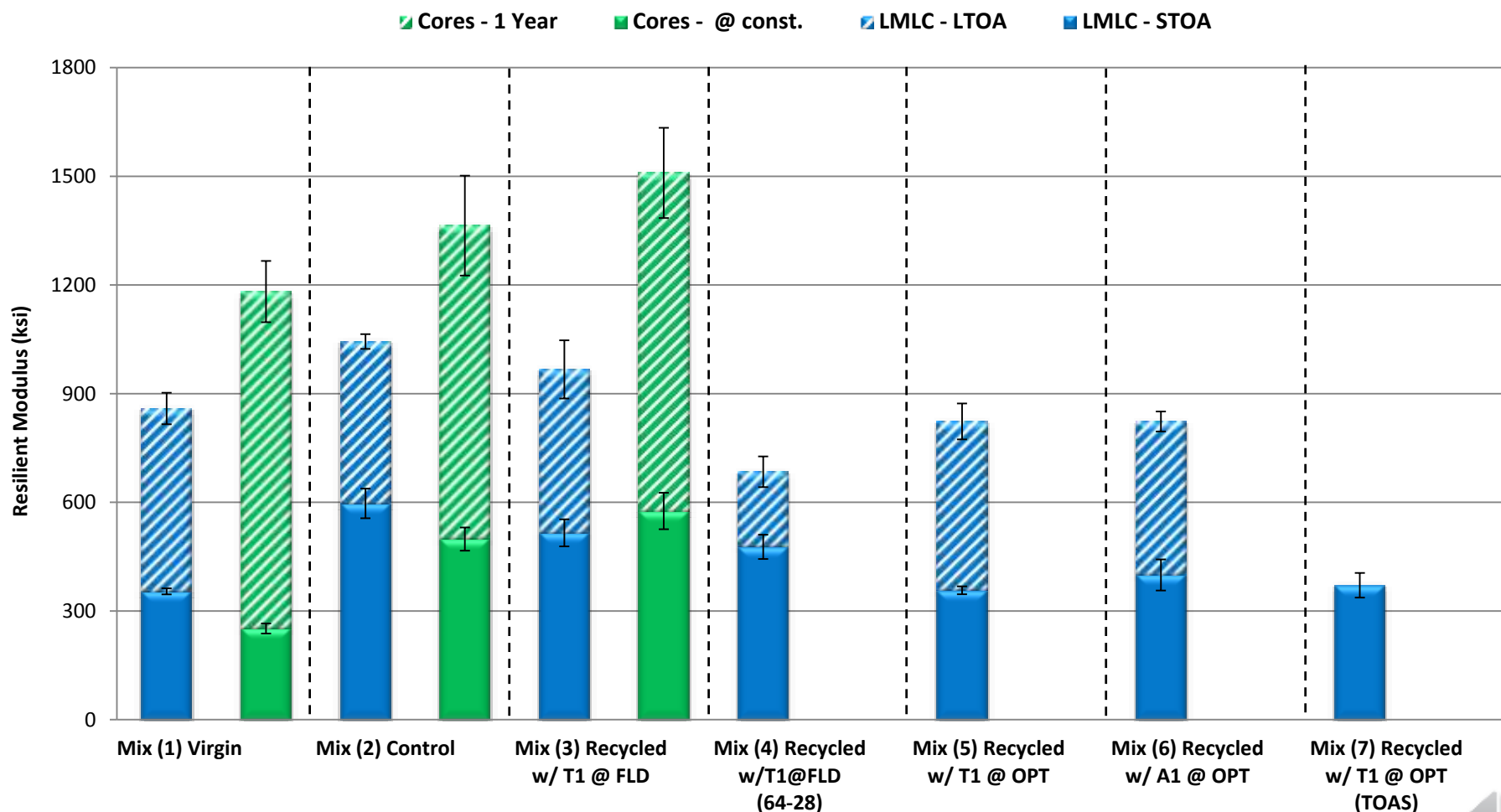
Low Temperature (°C)



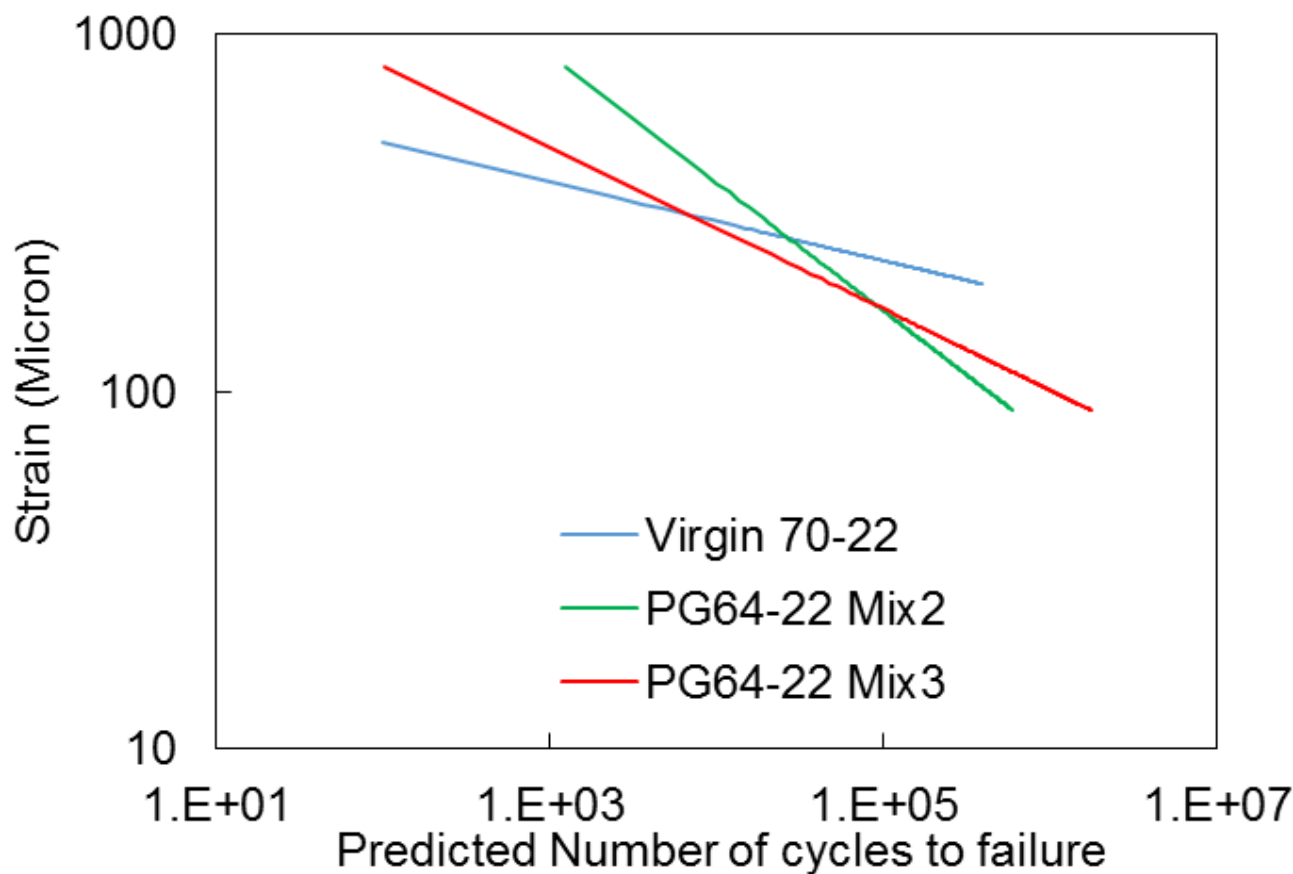
COATABILITY: W/RAP 100% ADD, W/RAS 50/50 ADD/REPLACE



RA Dosage Selection – Mixture Validation - M_R



RA Dosage Selection – Mixture Validation S-VECD



Next Steps

- ☐ **Binder Aging – FTIR, G-R @ opt w/aging vs virgin, control**
- ☐ **Binder Compatibility**
- ☐ **Mixture Cracking Validation – SCB, LVECD, UTSST?**
- ☐ **Additional Field Projects**

