NATIONAL ACADEMIES Sciences Engineering Medicine

TRB TRANSPORTATION RESEARCH BOARD

# TRB Webinar: **Capturing Durability of Recycled Asphalt Mixtures**

*November 24, 2025*

*12:00PM – 1:30 PM*

# PDH Certification Information

1.5 Professional Development Hours (PDH) – see follow-up email

You must attend the entire webinar.

Questions? Contact Andie Pitchford at TRBwebinar@nas.edu

***The Transportation Research Board has met the standards and requirements of the Registered Continuing Education Program. Credit earned on completion of this program will be reported to RCEP at RCEP.net. A certificate of completion will be issued to each participant. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the RCEP.***

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# Purpose Statement

This webinar that will help engineers unlock significant economic benefits by designing balanced, durable asphalt mixtures with high recycled material content. Presenters will showcase findings from NCHRP Report 1130: Capturing the Durability of High Recycled Binder Ratio Asphalt Mixtures, which revisits the forthcoming AASHTO PP 127 standard practice and expands its scope to include durability factors such as aging, moisture susceptibility, and raveling.

# Learning Objectives

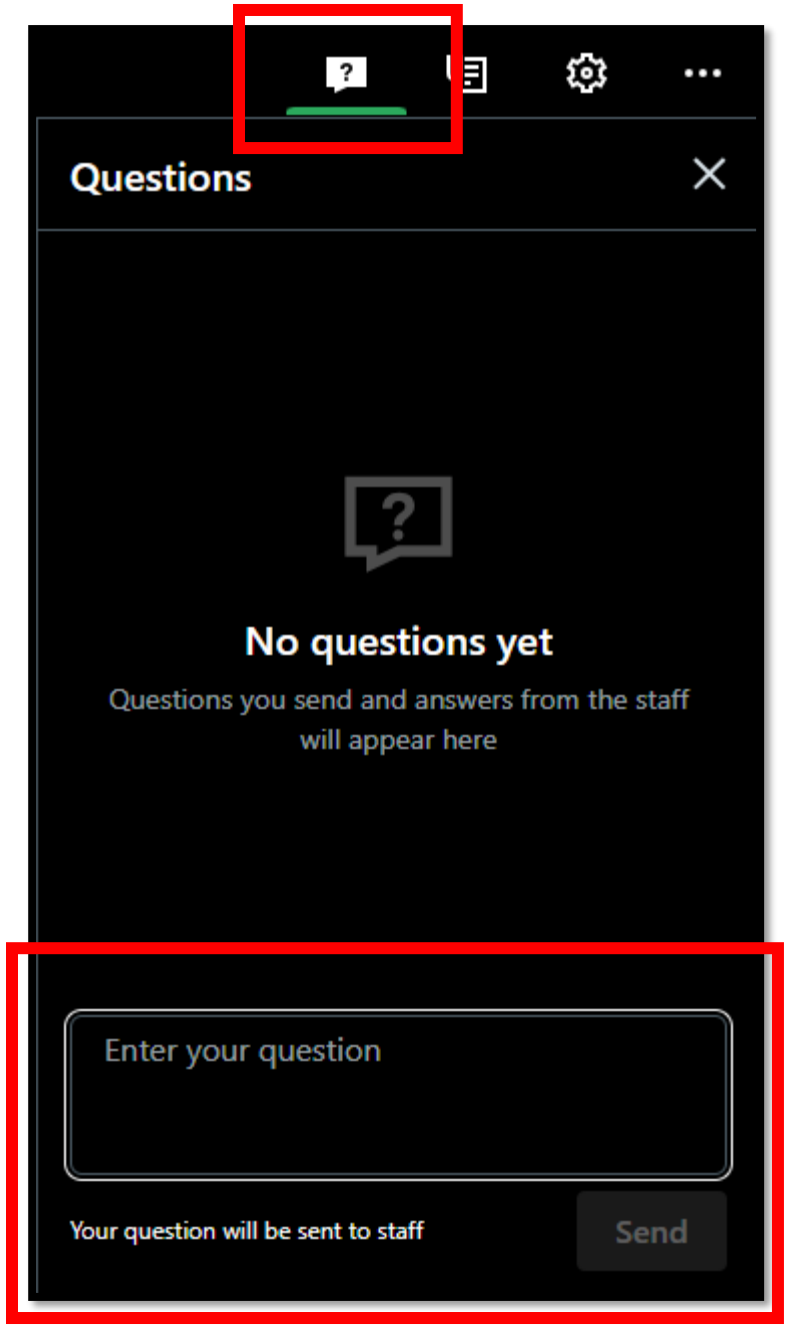
At the end of this webinar, participants will be able to:

(1) Understand the framework and approach outlined in forthcoming AASHTO PP 127 for designing and evaluating balanced and durable asphalt mixtures with high recycled binder ratios (RBR)

(2) Utilize the evaluation tools and thresholds in forthcoming AASHTO PP 127 to assess mitigation strategies and ensure balanced performance in high RBR asphalt mixtures

# Questions and Answers

- Please type your questions into your webinar control panel
- We will read your questions out loud, and answer as many as time allows



# *Today's Presenters*

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Texas A&M Transportation Institute

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National Center for Asphalt Technology NCAT AT AUBURN UNIVERSITY

NATIONAL ACADEMIES Sciences Engineering Medicine

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# Capturing Durability of Recycled Asphalt Mixtures

Texas A&M Transportation Institute

National Center for Asphalt Technology NCAT at AUBURN UNIVERSITY

VTRC Virginia Transportation Research Council

WEBINAR

NOVEMBER 24, 2025

- MOTIVATION & EXPERIMENT DESIGN
- RESULTS & AASHTO PP 127
- AGENCY PERSPECTIVE

# Research Team & NCHRP 09-65 Panel

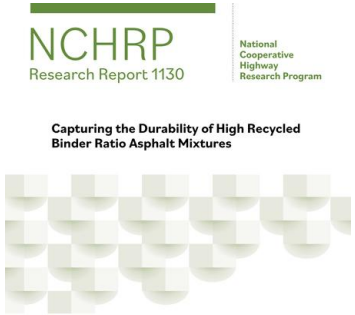
- TTI: *Amy Epps Martin*, *Edith Arambula-Mercado*, Yong-Rak Kim, Juliana Montanez, Santosh Kommidi
- NCAT: *Nam Tran*, Fan Yin, Raquel Moraes, Carolina Rodezno, Madhav Verma, Biswajit Bairgish Kommidi
- Consultant: Gayle King

- Panel: Erv Dukatz, Eliana Carlson, Erik Lyngdal, Tanya Nash, Geoff Rowe, Aaron Schwartz, Andrew Wargo, Dave Mensching + Ed Harrigan, Anthony Avery
- Implementation Panel: *Stacey Diefenderfer,* Chandra Akisetty, Ben Arras, Ashley Buss, Erv Dukatz, Kim Schofield, Aaron Schwartz, David Vivanco + Sid Mohan, Kevin Padilla

# Objectives

- NCHRP 09-65: Produce comprehensive AASHTO Practice for design & evaluation of **durable recycled asphalt mixtures with high RBR (0.3-0.5)** to withstand traffic & environmental conditions (aging, moisture) & preclude:
  - Surface Cracking
  - Moisture Susceptibility
  - Raveling
- Webinar: Understand framework & approach in AASHTO PP 127; Utilize evaluation tools & thresholds to ensure balanced performance in recycled asphalt mixtures with high RBR

# Background




**9-65** (0/35)
2021-24

RILEM (RBA)
TxDOT 7062 (RBA)
TAMUQ (RAs)

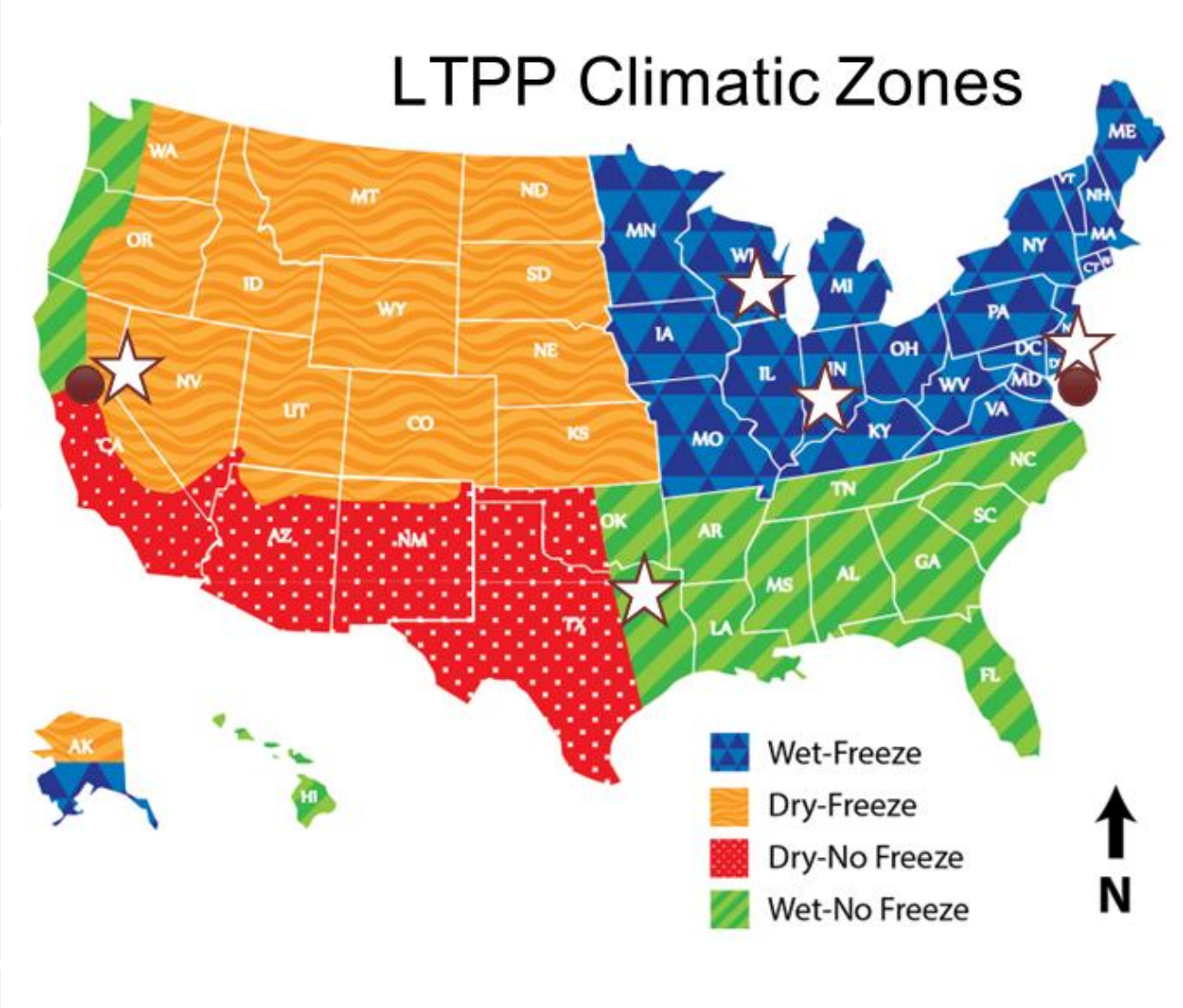
NAPA QIP-131 (RAs)
**20-44(24)** (2/8)
2019-22

**9-68** (0/25)
2022-25
**9-70** (0/4+9)
2025-28
TxDOT BMD
NCIT (strategies)
CAPRI (9-58)


**9-58** (5/15)
2014-19

**(#field projects / #mixtures)**

# Field Projects & Climatic Zones



# Durability Assessment Framework

## NORTH/FREEZE: Dry-Freeze & Wet-Freeze

| | | |
|---|---|---|
| Int Cracking | $CT_{Index}$ | STOA+6hrs@135C, @ 25C |
| Low Cracking | $G_f$ | STOA, @ PGL+10C |
| Rutting | $N_{12.5}$ | STOA, @ 45C |
| Moisture | SIP, SN | STOA, @ 45C |
| | TSR | STOA w/FT, @ 25C |
| Raveling | %AggLoss (Cantabro), %AL Ratio | STOA, Aging+Moisture, @ 25C |

## SOUTH/NO FREEZE: Dry-No Freeze & Wet-No Freeze

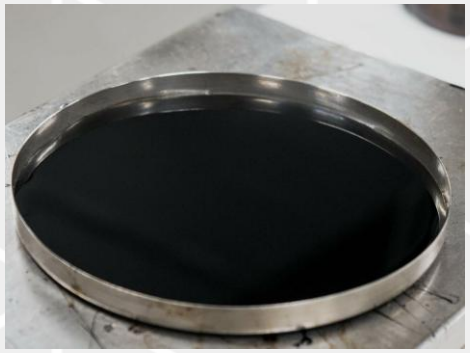
| | | |
|---|---|---|
| Int Cracking | $CT_{Index}$ | STOA+8hrs@135C, @ 25C |
| Rutting | $N_{12.5}$ | STOA, @ 50C |
| Moisture | SIP, SN | STOA, @ 50C |
| | TSR | STOA w/out FT, @ 25C |
| Raveling | %AggLoss (Cantabro), %AL Ratio | STOA, Aging+Moisture, @ 25C |

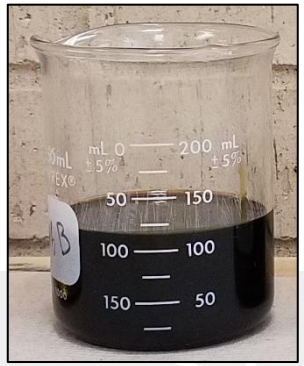
# Mix Designs & Experiments

| Region | Aggregate | RAM | RBR (RAP+RAS) | OAC (%) | EXPERIMENT | | |
|---|---|---|---|---|---|---|---|
| | | | | | Crack | Moisture | Ravel |
| North Freeze | North Moisture Resistant (NR) | NE RAP | 0.21 | 5.95 | X | X | X |
| | | NE RAP | 0.37 | 5.61 | X | X | X |
| | | NE RAP + NE TOAS | 0.22+0.22 | 5.85 | X | X | X |
| | North Moisture Susceptible (NS) | MidW RAP | 0.20 | 5.20 | X | X | |
| | | MidW RAP | 0.29 | 5.20 | X | X | |
| | | MidW RAP + MidW TOAS | 0.23+0.10 | 5.20 | | X | |
| South No Freeze | South Moisture Resistant (SR) | SE1 RAP | 0.16 | 5.79 | X | X | X |
| | | SE1 RAP | 0.29 | 5.75 | X | X | X |
| | South Moisture Susceptible (SS) | SE2 RAP | 0.22 | 5.15 | | X | |
| | | SE2 RAP | 0.39 | 5.15 | | X | |

# Component Materials

- 4 Aggregate sources
- 8 Virgin Binders
  - 4 Unmodified Binders
  - 2 Softer Binders
  - 2 PMA Binders
- 4 RAP sources
- 2 RAS sources
- Additives
  - Recycling Agent
  - Anti-Stripping Agent





# Durability Strategies (Cracking due to High RBR, Moisture)

quantity

- **PROPORTIONS**
  - Reduce RBR Content
  - Increase Effective Binder ($V_{be}$)
    - Adjust Aggregate Gradation
    - Increase Additive Dose
    - *Decrease Recycled Binder Availability (RBA)*

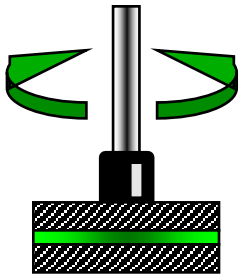
    RAP=85%, RAS=75%
- **MULTIPLE = Employ *Combo***
- ***NONE***


quality

- **MATERIALS**
  - Change Binder Source
    - *Softer PG* (PGH, PGL, Both)
    - *PMA*
    - Same PG (*Diff DTc*)
  - Include Additive
    - *Recycling Agent*
    - WMA
    - *Anti-Stripping Agent*
  - Change RAP Source
  - Change Aggregate Source

# Binder Tests & Aging (Virgin, RAM)

**By DSR**



***PGH***

- Unaged
- RTFO
- PAV 20

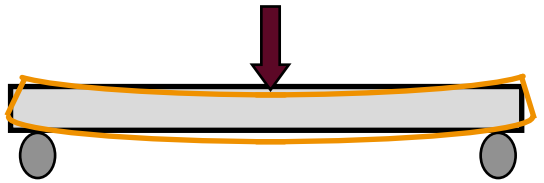
***G-R (traditional, modified x2) + $w_c$, $G_c$, $T_{Gc}$, R-value, d x2***

- Unaged
- RTFO
- PAV 20
- PAV 40

***Jnr, %R by MSCR***

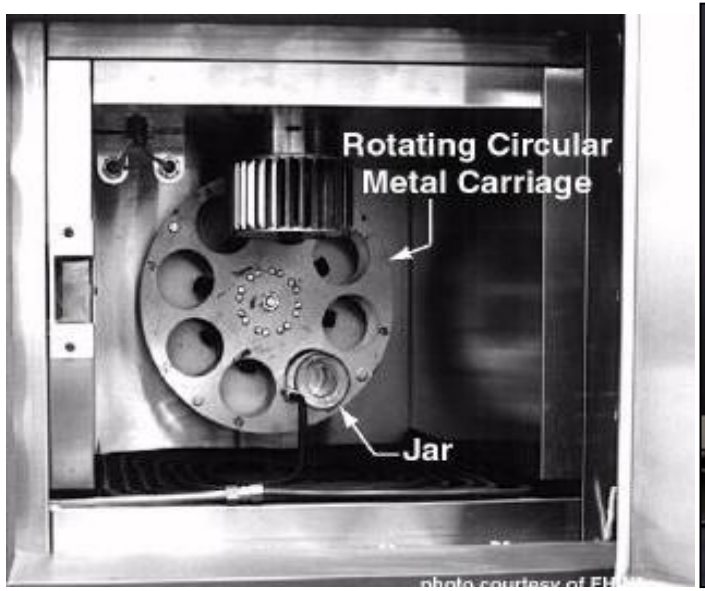
- RTFO

**By BBR**



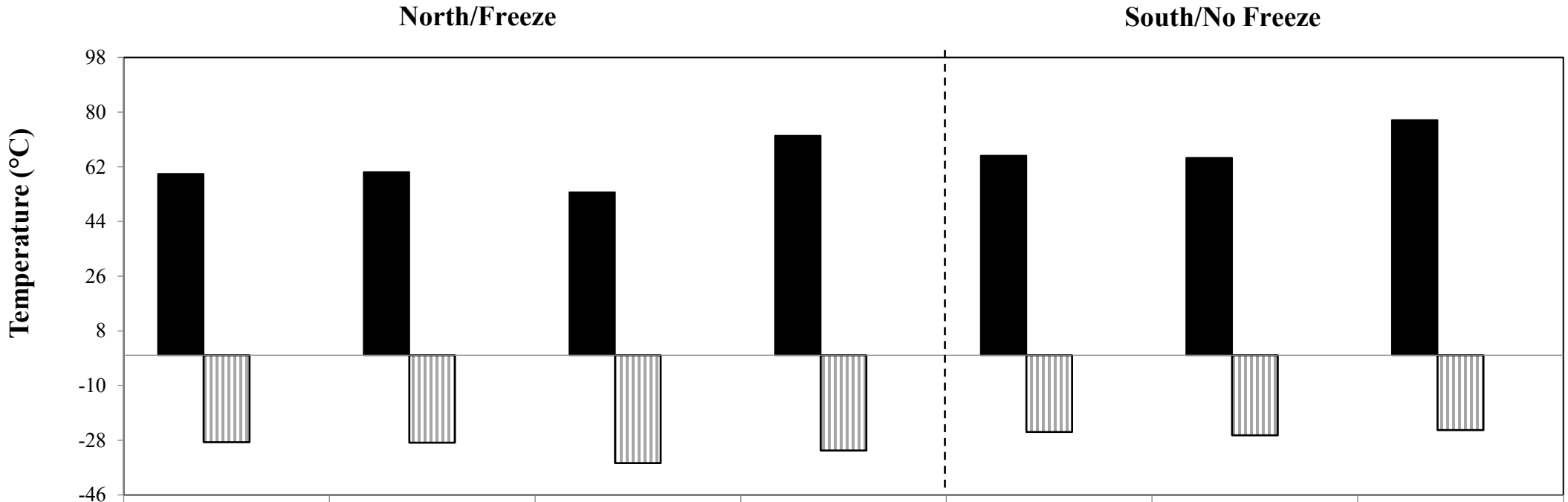
***PGL, $DT_c$***

- PAV 20




# Binder Results

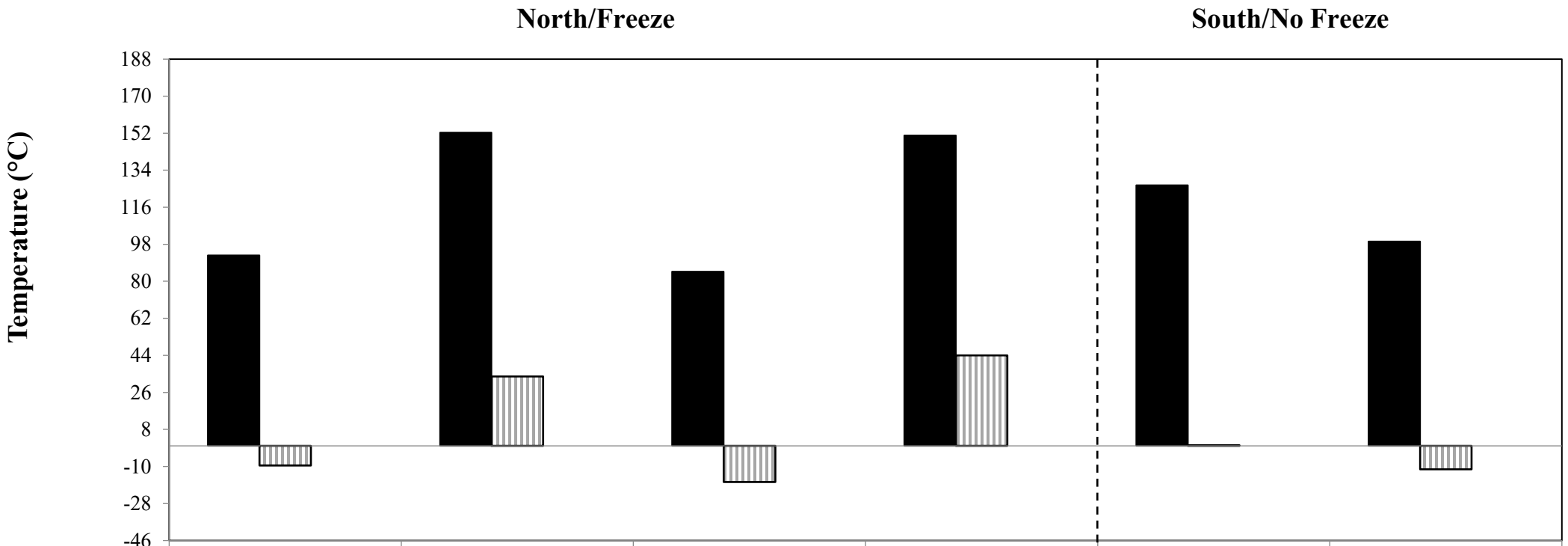
- PGH, PGL, $\Delta T_c$: Virgin Binders




| | 58-28_Low | 58-28_High | 52-34 | 70-28 | 64-22_Low | 64-22_High | 76-22 |
|---|---|---|---|---|---|---|---|
| ■ PGH | 59.6 | 60.3 | 53.6 | 72.3 | 65.7 | 65.0 | 77.4 |
| ▨ PGL | -28.6 | -28.8 | -35.5 | -31.4 | -25.3 | -26.4 | -24.6 |
| ΔTc | 0.4 | 2.0 | 2.5 | -0.6 | -1.4 | 1.3 | -1.0 |

# Binder Results

- PGH, PGL, $\Delta T_c$: RAM Binders

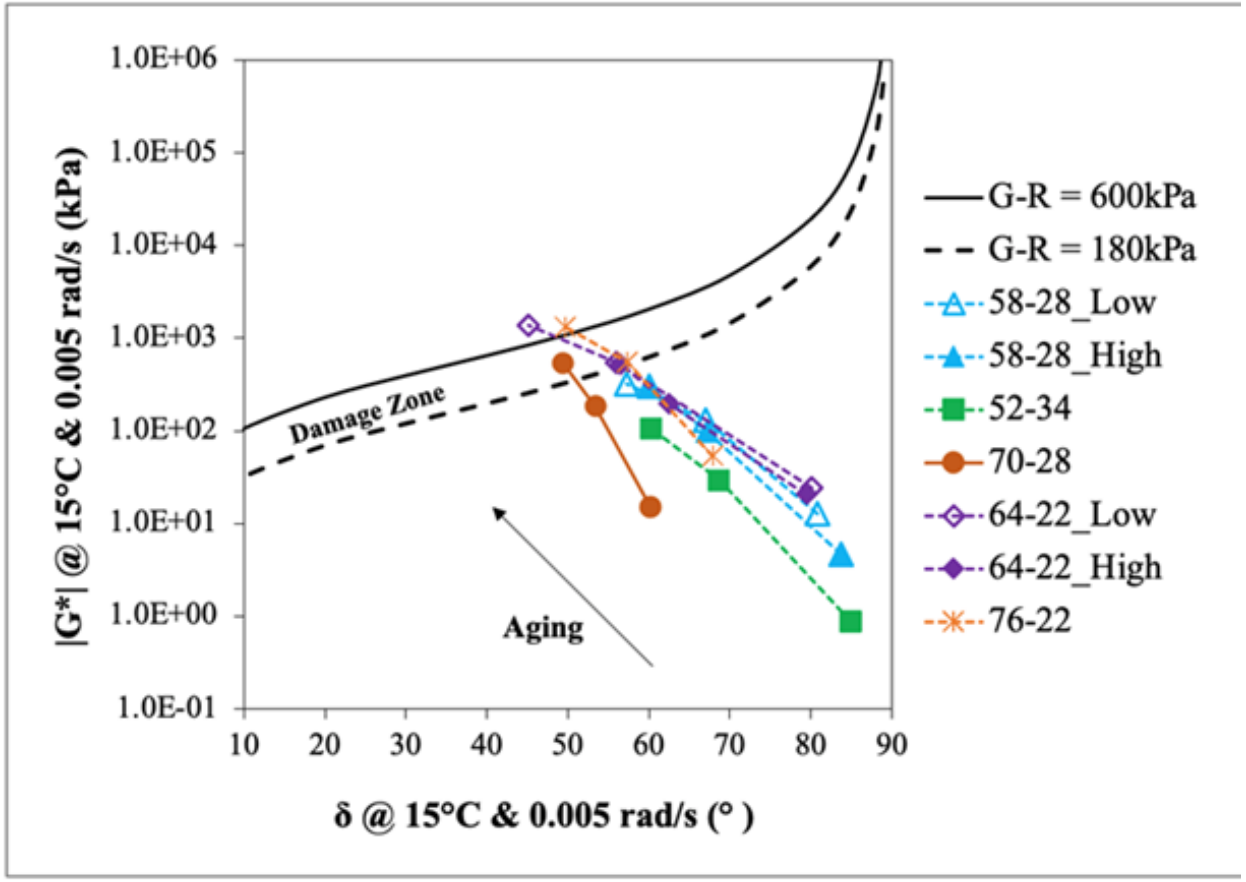



| | NE RAP | NE TOAS | MidW RAP | MidW TOAS | SE1 RAP | SE2 RAP |
|---|---|---|---|---|---|---|
| ■ PGH | 92.6 | 152.3 | 84.8 | 151.0 | 126.7 | 99.3 |
| ▨ PGL | -9.5 | 33.7 | -17.6 | 44.0 | 0.3 | -11.4 |
| ΔTc | -7.8 | -58.6 | -7.4 | -94.1 | -12.8 | -9.9 |

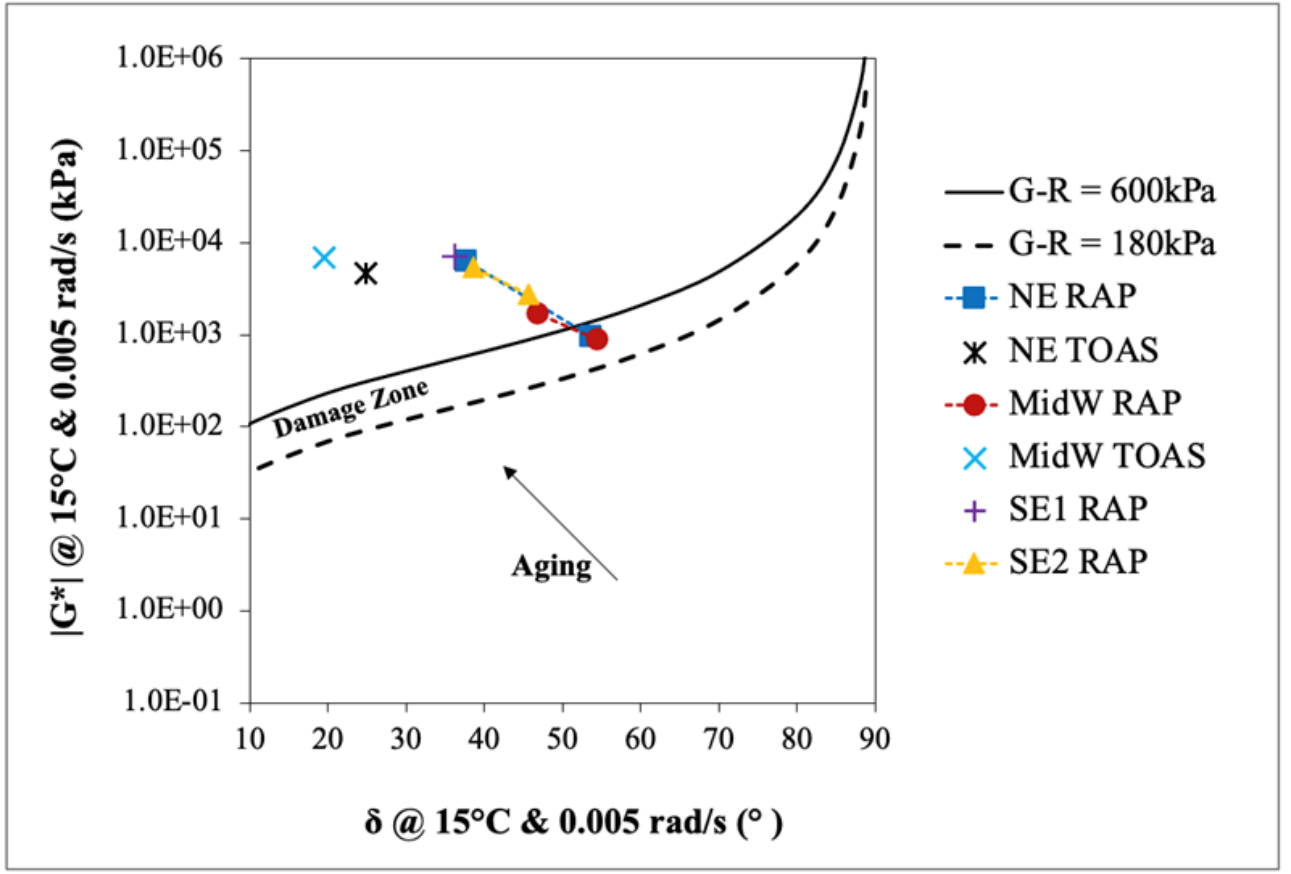
# Binder Results

- G-R at 15°C and 0.005 rad/s

## Virgin Binders




## RAM Binders



# Stepwise Durability Assessment Approach

**Evaluate Cracking w/Aging**

1. Low RAPBR no strategy
2. High RAPBR no strategy
3. High RAP/RASBR no strategy

- As needed, try strategy:
  - i. Softer (Component)
  - ii. Higher DTc (Component)
  - iii. PMA (Component)
  - iv. Rejuvenator (Additive)
  - v. RBA (Proportion)
  - vi. Hybrid Combo

**Evaluate Rutting @ Climatic T**

- IFF cracking resistant
- Check for balanced performance for primary distresses

- + indication of moisture effects

**Evaluate Moisture Susceptibility**

- IFF balanced
- Check for moisture effects
- As needed, add ASA

- + effects of other factors

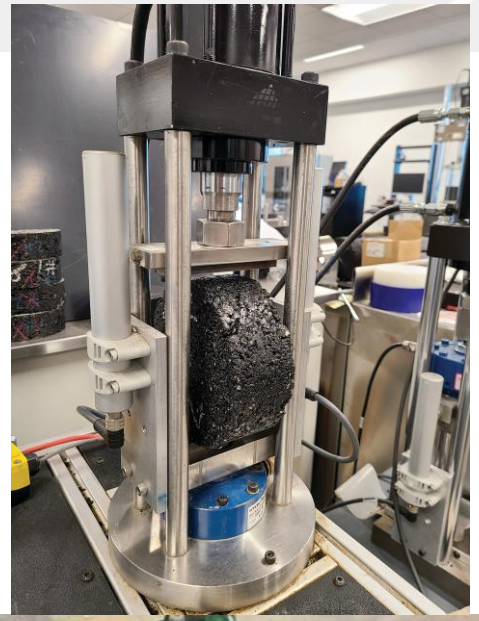
**Evaluate Raveling w/Aging & Moisture**

- IFF balanced & moisture resistant
- Check for abrasion effects

# Mixture Tests

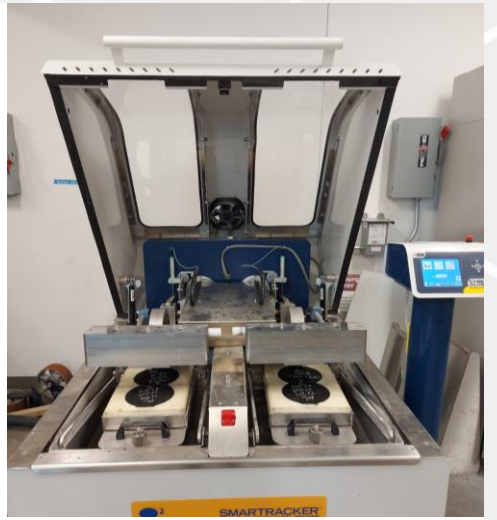
## Cracking

- IDEAL-CT
- DCT



## Moisture

- HWT (w/Rutting)
- TSR




## Raveling

- Cantabro

# Mixture Conditioning

- **Aging**
  - STOA: 4hrs@135℃
  - 6hrs@135℃

  PMA: 3d@95℃
  - 8hrs@135℃

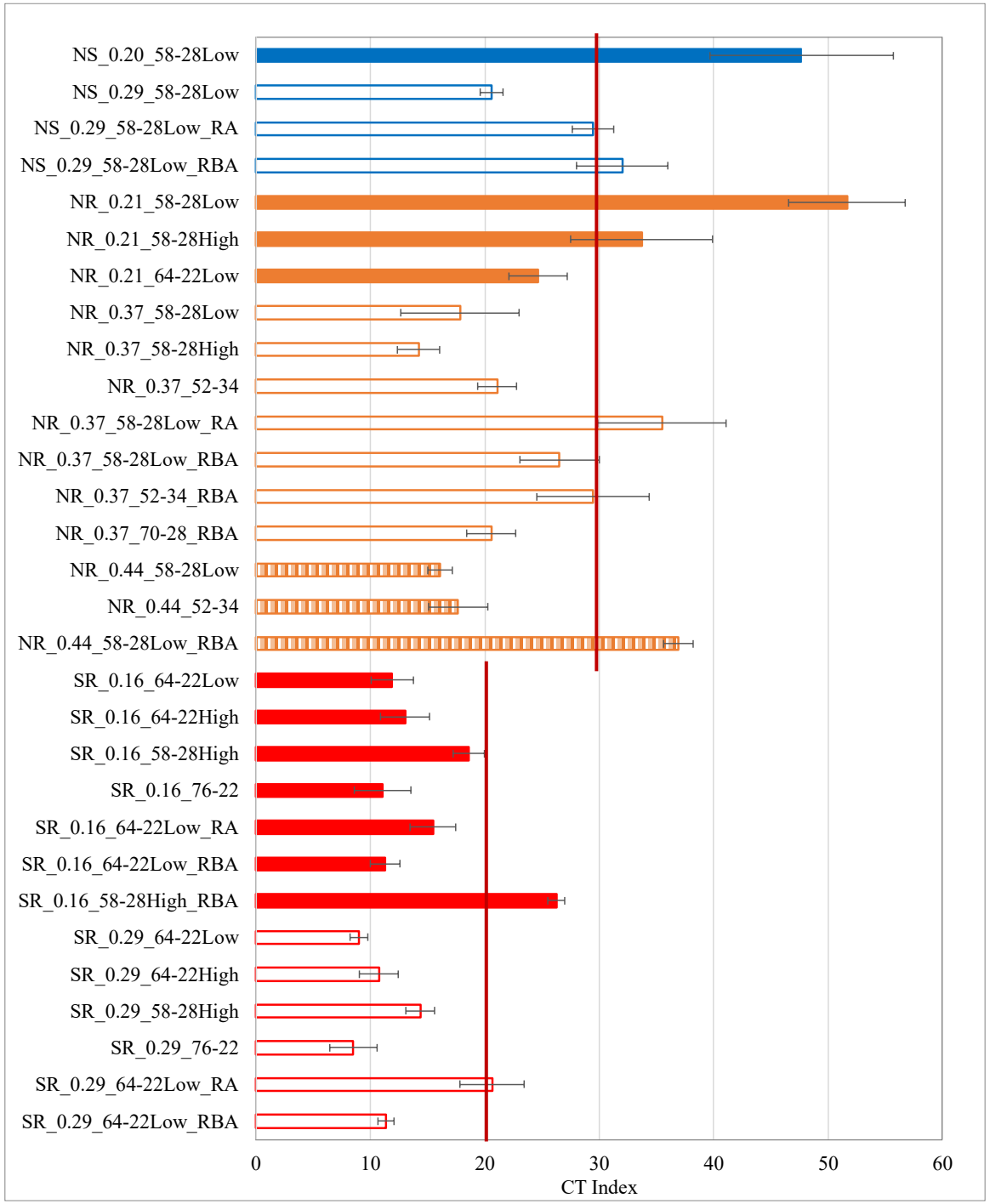
  PMA: 5d@95℃

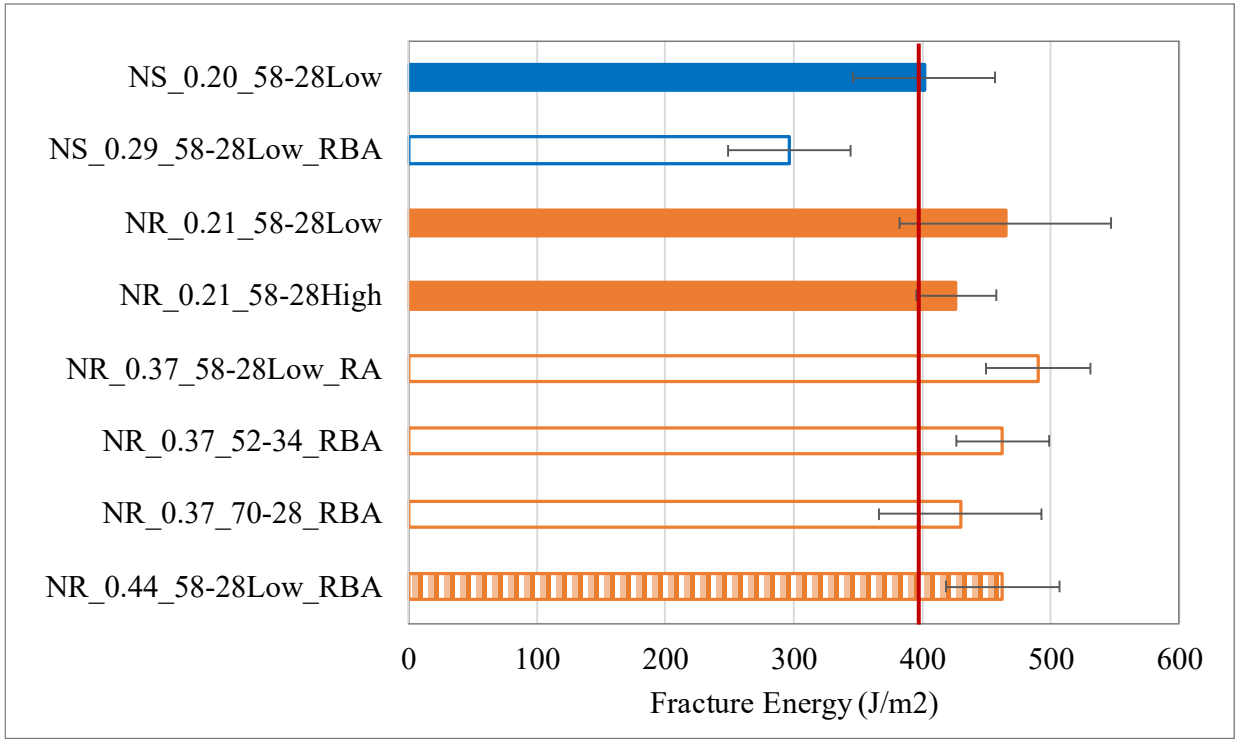
- **Moisture**
  - Freeze per T283
  - No Freeze

- **Traffic**
  - LA Abrasion

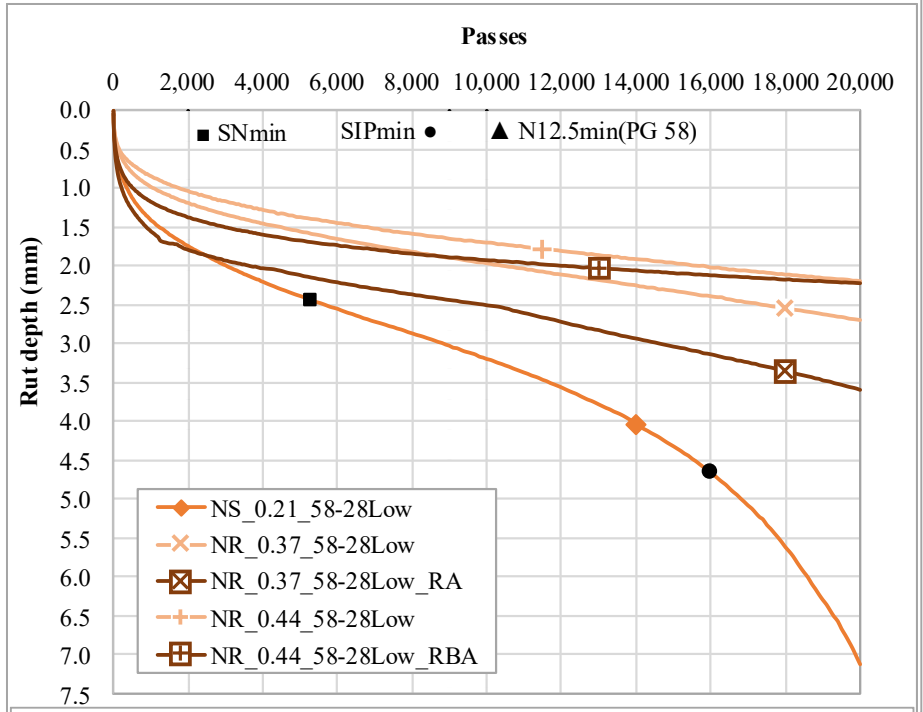
  w/out steel balls

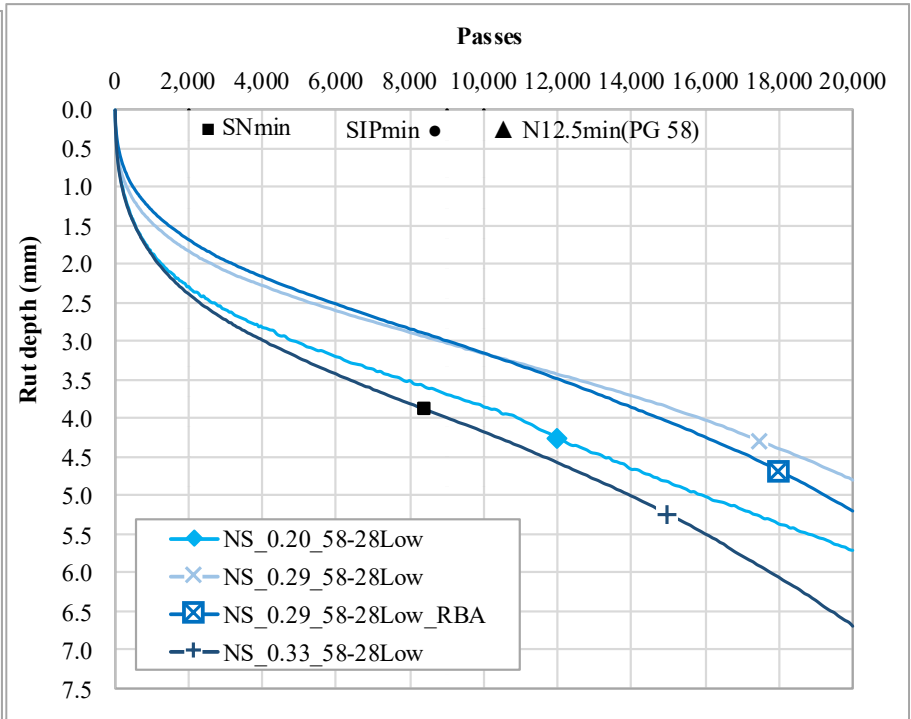
# Cracking Results

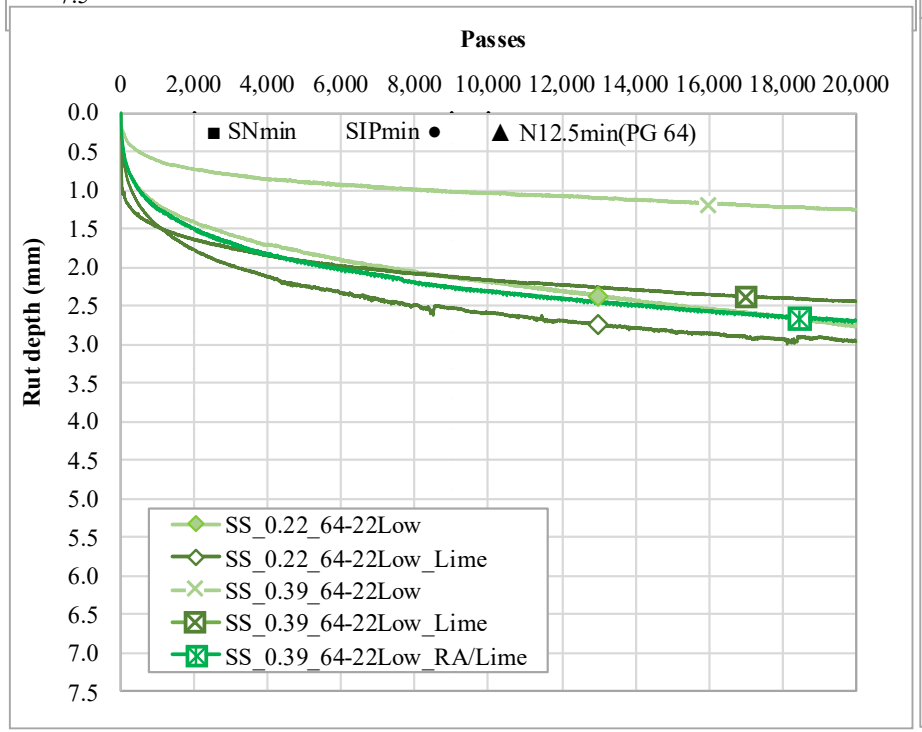


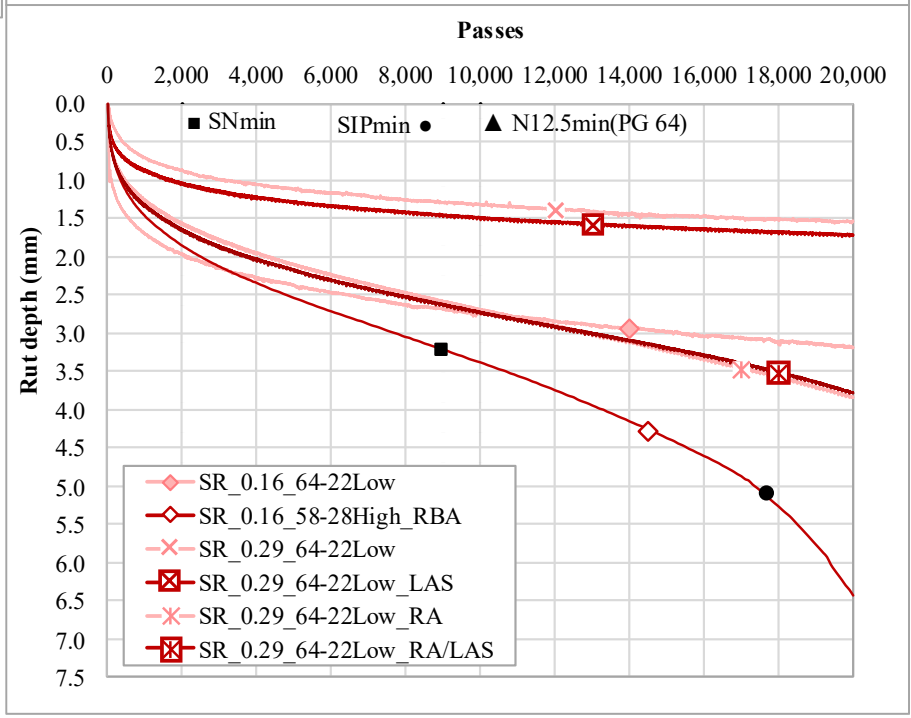



# Rutting Results



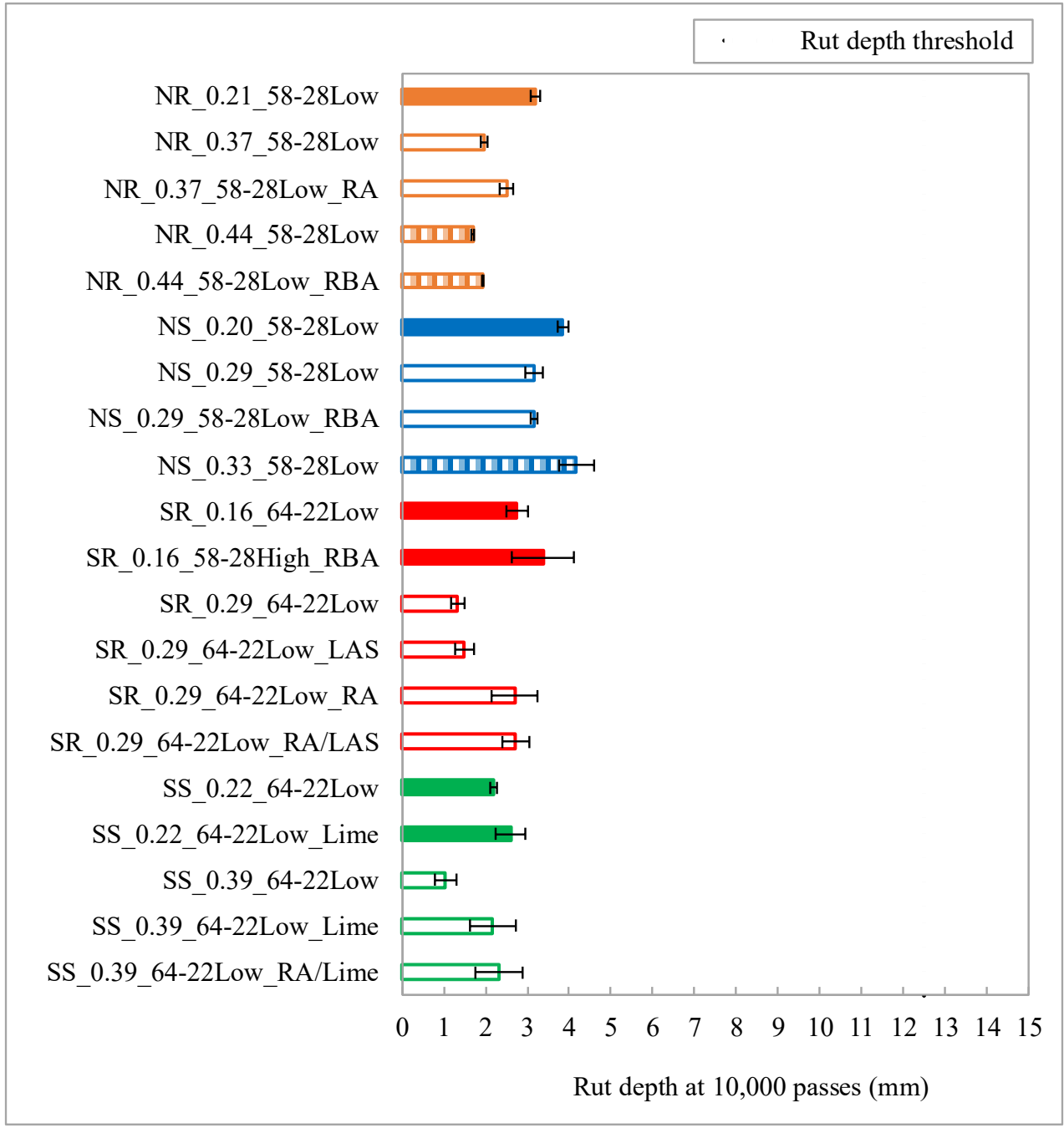



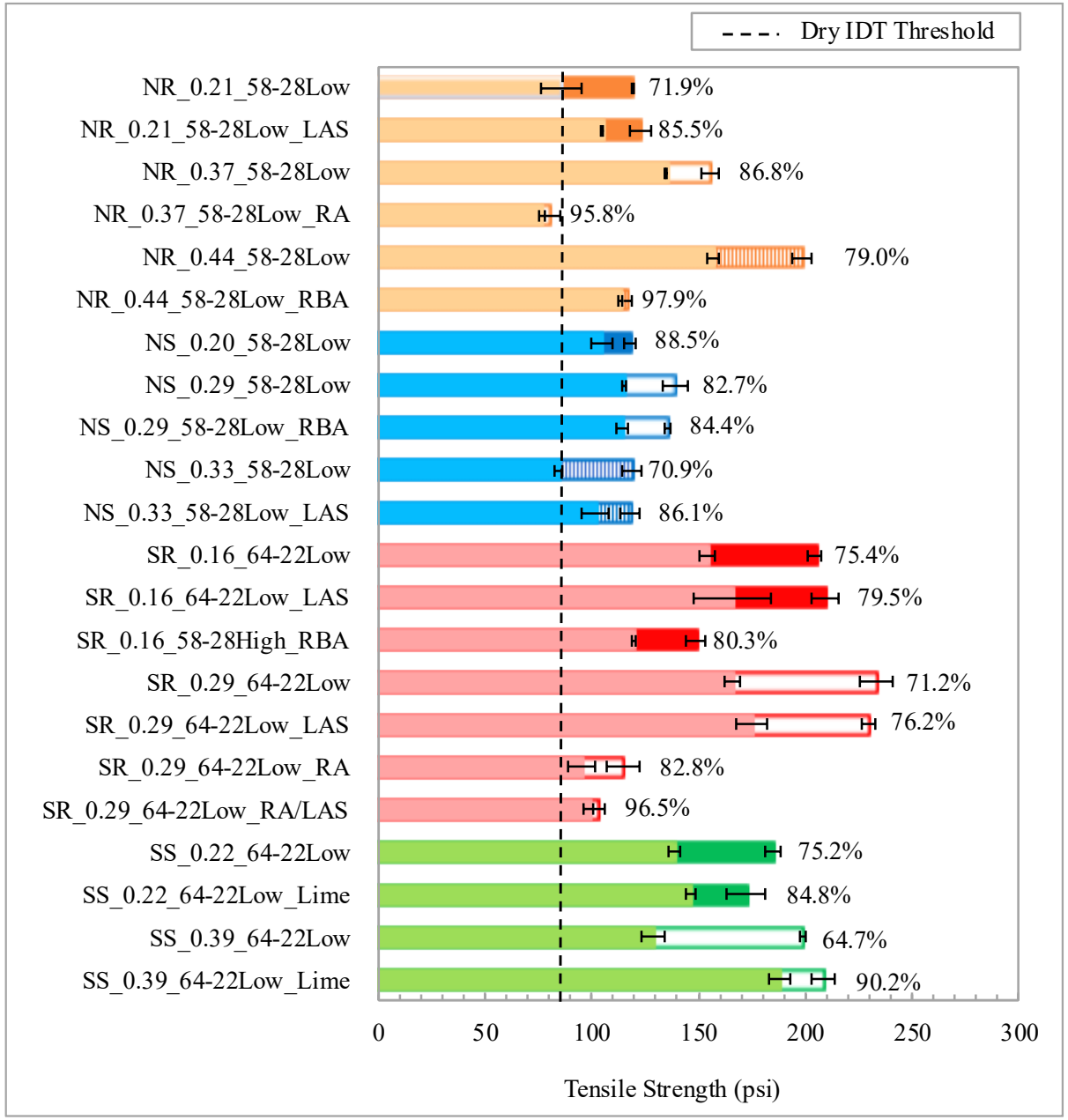



# Rutting Results

## Rut depth at 10,000 passes

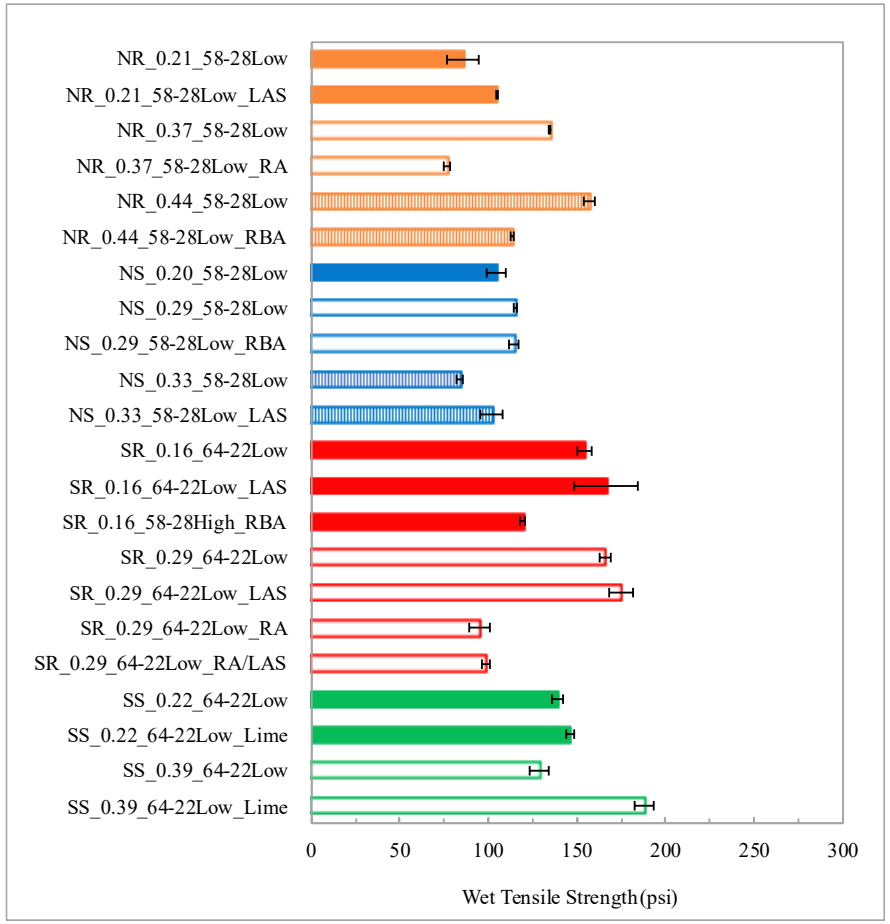


# IDT & TSR

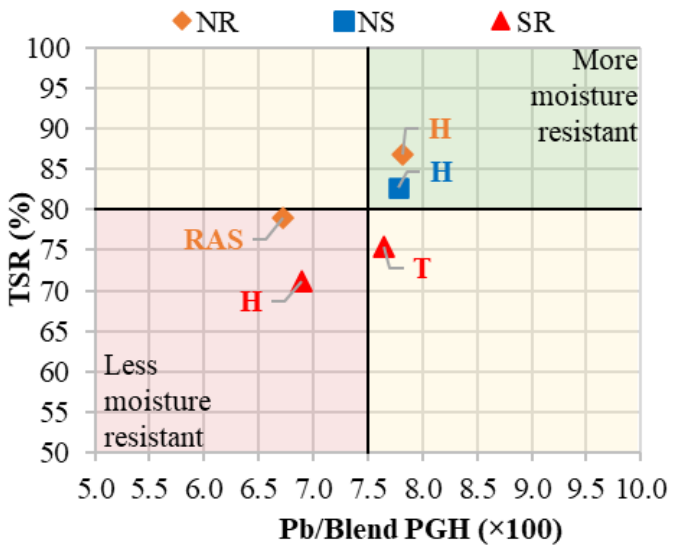


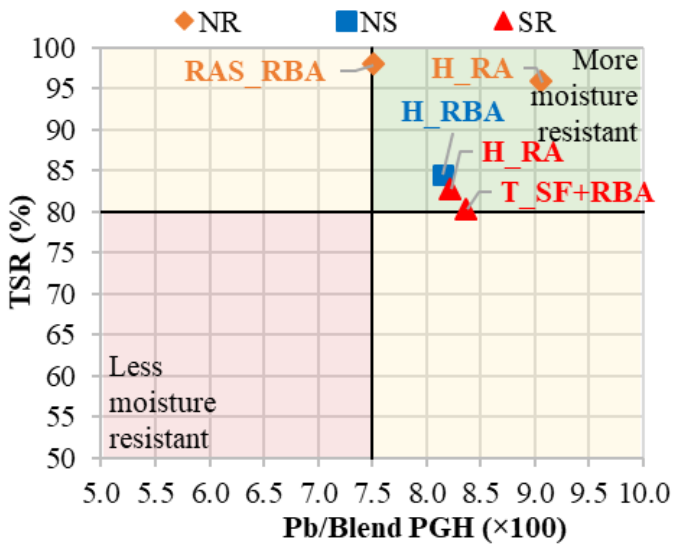

# Moisture Results

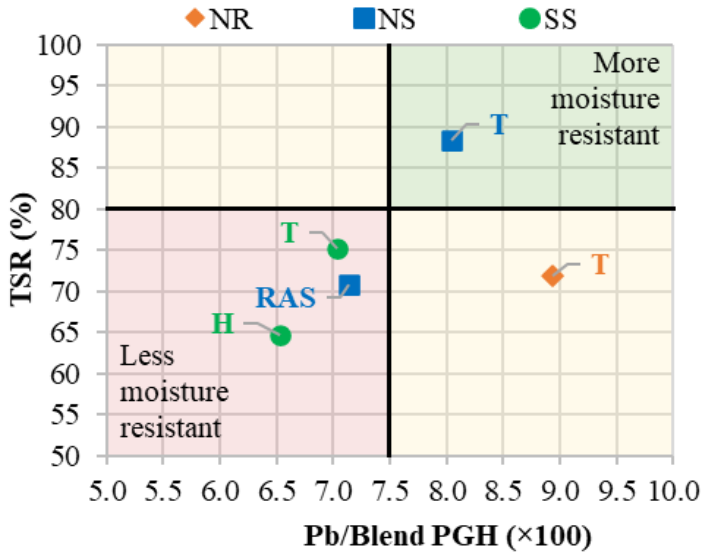
## WET IDT

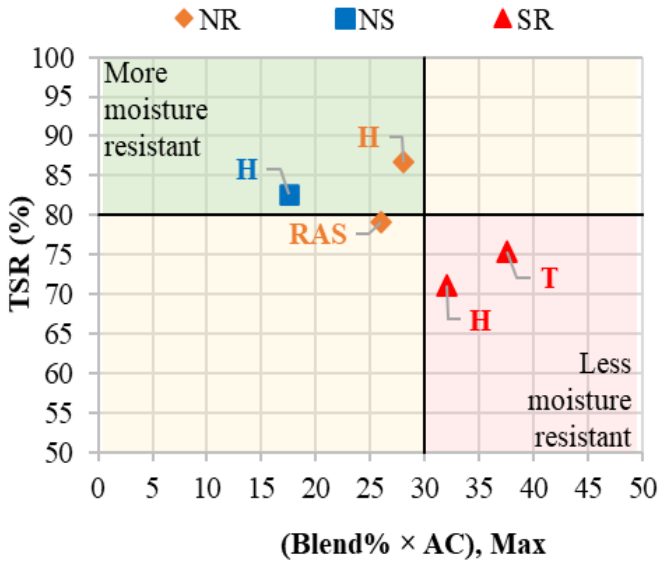


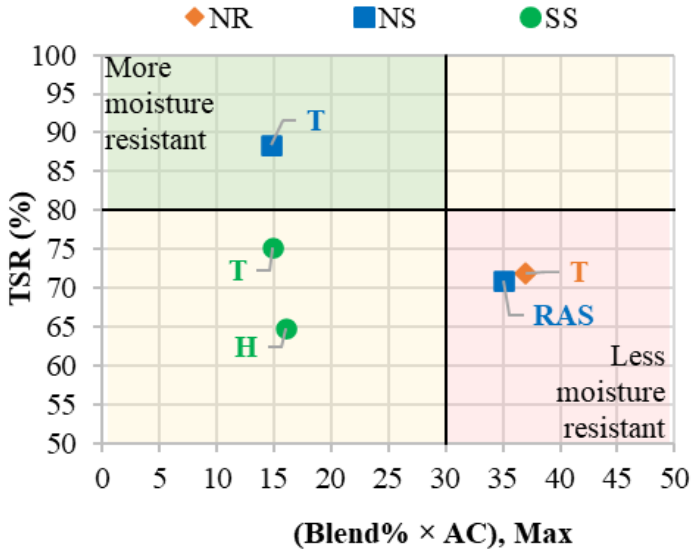
# Moisture Results



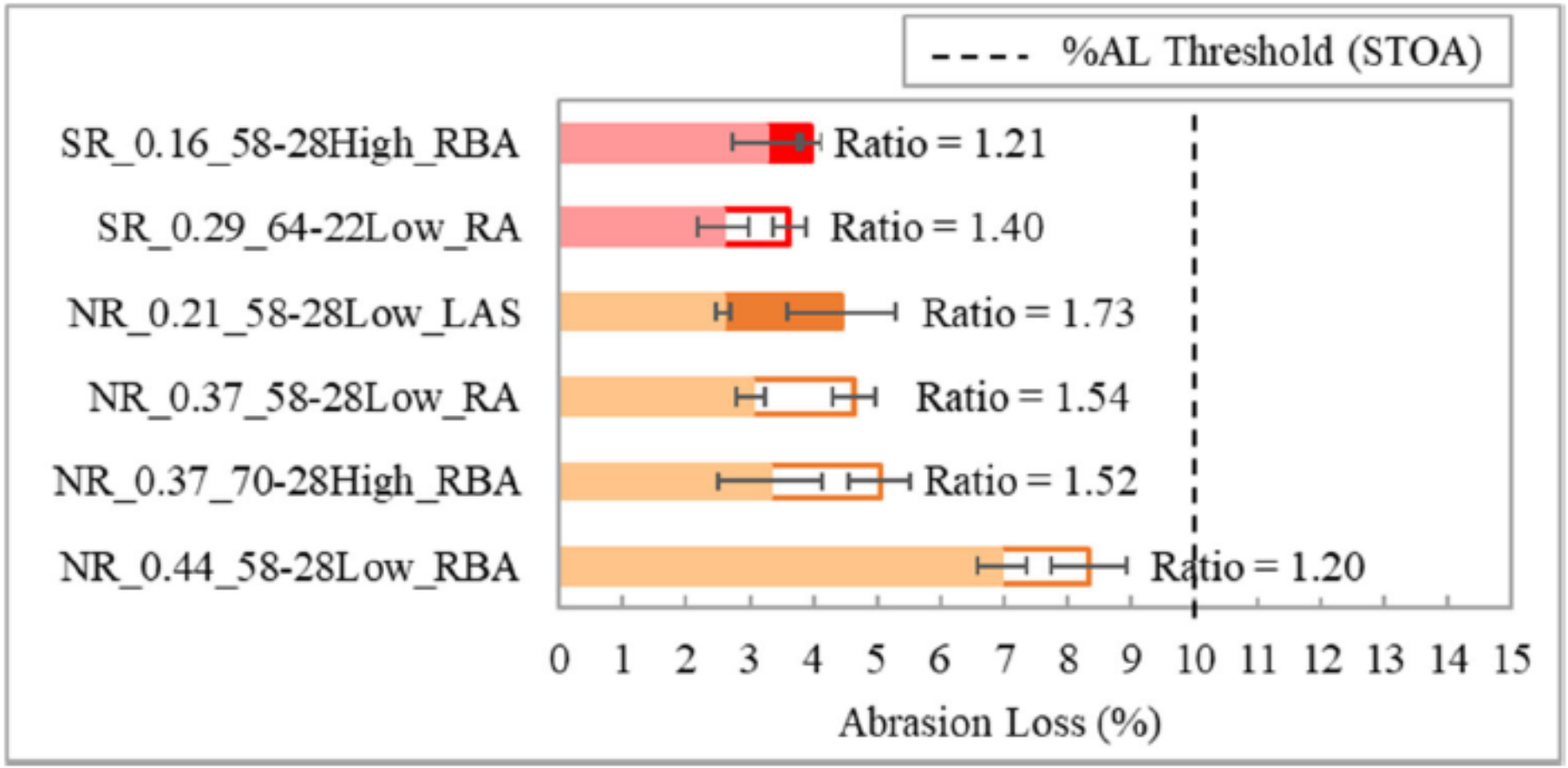



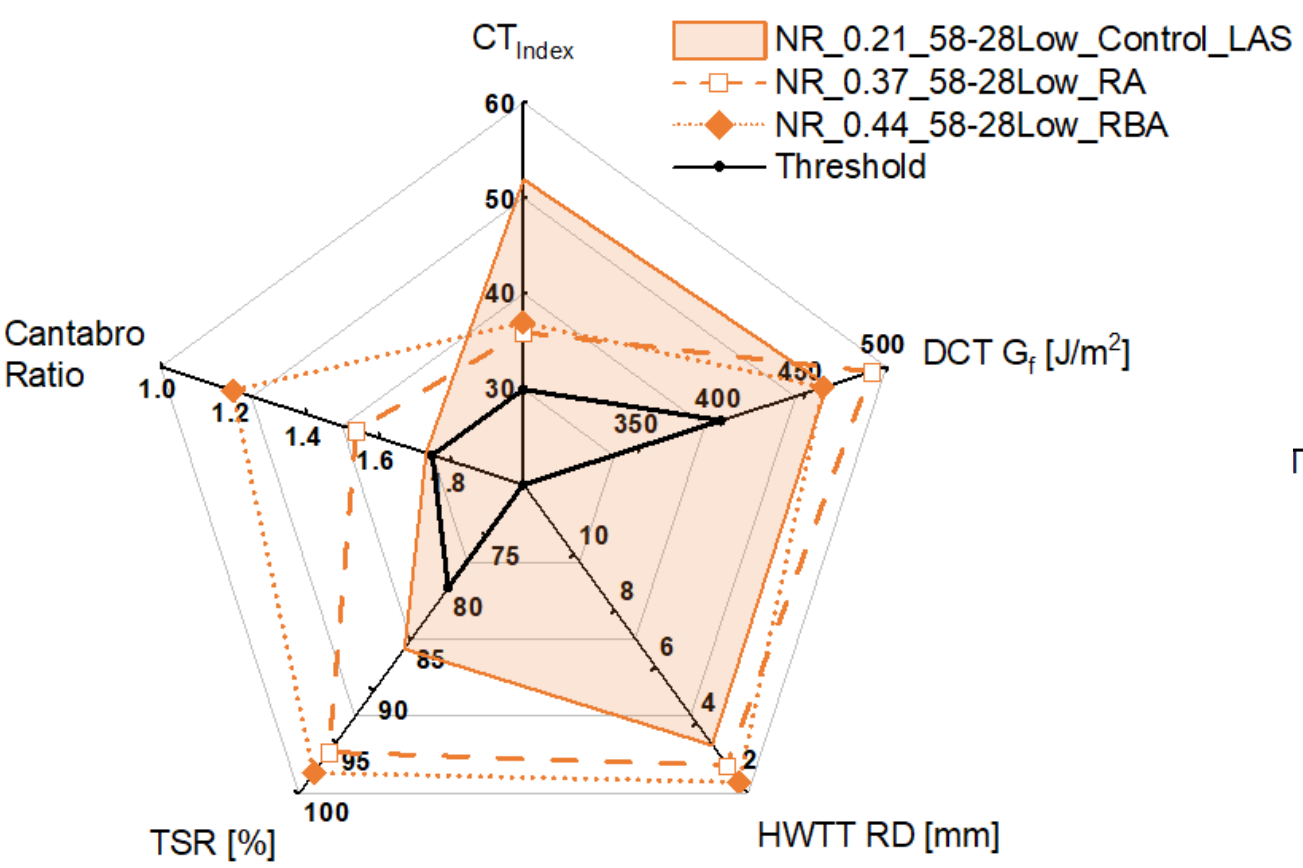



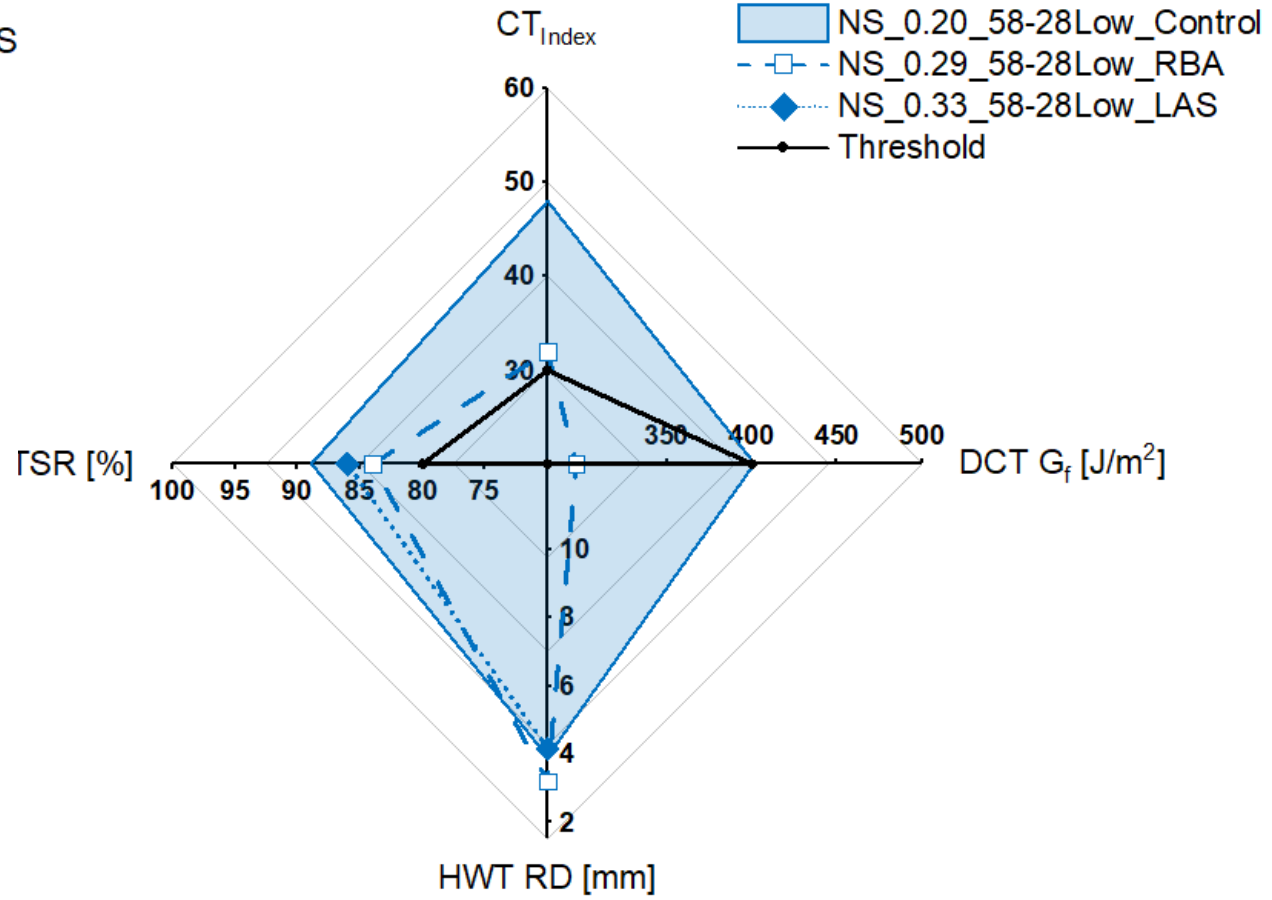
# Raveling Results South and North Moisture-Resistant (SR, NR) Mixtures

## Cantabro

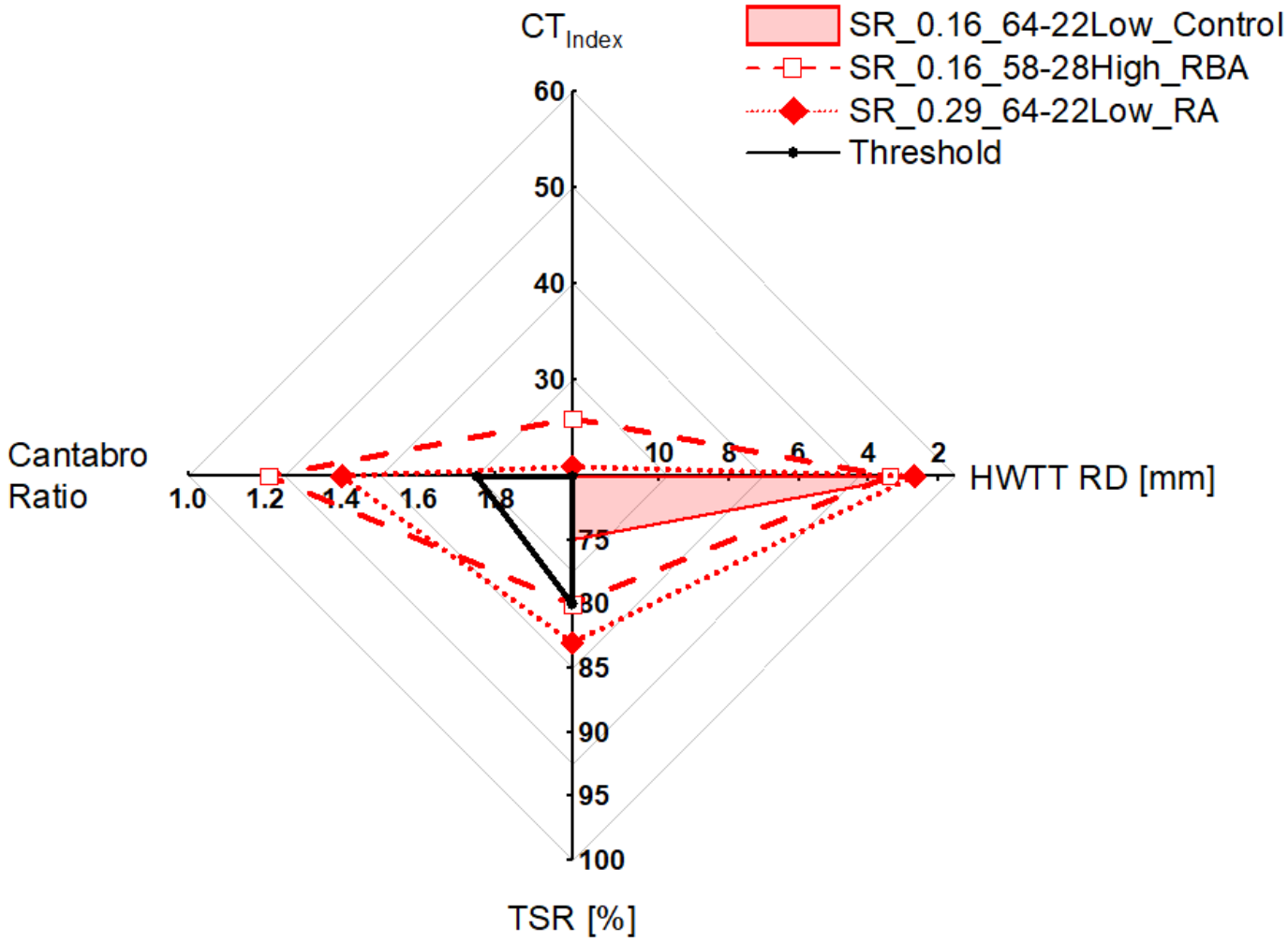


# Combined Durability Evaluation: North



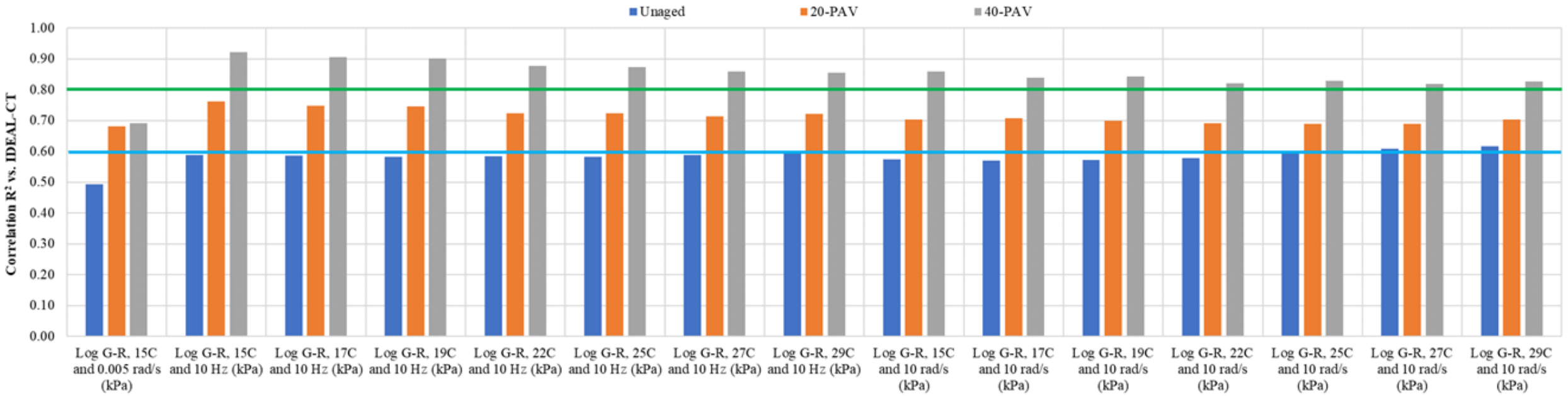



# Combined Durability Evaluation: South



# Binder vs Mixture Cracking Resistance

- No strong correlation: $CT_{Index}$ & binder QUANTITY (Pb, Pb-virgin) or QUALITY (RBR, PG)
- Need combined parameter with both binder QUANTITY & QUALITY
- Moderate-Strong correlation for $CT_{Index}$ & G-R (PAV20, PAV40) for mixtures with same mix design but different virgin binders



# Key Findings for Selected Materials Combos

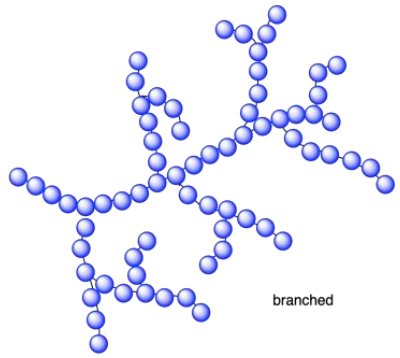
- Stepwise Approach can develop robust, durable recycled asphalt mixtures with high RBR

- High RAM Cracking Strategies with critical aging & current thresholds do NOT result in rutting, moisture susceptibility, or raveling with selection dependent on materials combos:
  - Decreased RBA
  - Recycling Agent (evaluate cost, moisture susceptibility)
  - Combination

# Key Findings for Selected Materials Combos

- Both Binder QUANTITY & QUALITY are important
  - Pb/Blend PGH x 100 ≥ 7.5 to preclude moisture damage
  - RAP Pb/RAP PGH correlates with RAP DoA
  - G-$R_{10Hz}$ & G-$R_{10rad/s}$ with PAV40 best correlate with $CT_{Index}$

- RAM Properties that facilitate High RBR=G-R, PGH with ASA as effective moisture strategy
- Aggregate water absorption influences moisture susceptibility
- Combined aging + moisture conditioning for characterization of PMA & mixtures needs further evaluation



# AASHTO PP 127

- Scope
- Referenced Documents
- Terminology
- Summary of Practice
- Significance & Use
- Hazards
- **Component Materials Selection & Proportioning Guidelines**
- **Binder Blend Preparation + Rheological Evaluation Tools**
- **Asphalt Mixture Preparation + Performance Evaluation with Stepwise Approach**
- **Cracking Mitigation Strategies (Recycled Binder Availability, Recycling Agent)**
- Report
- Keywords
- References

Standard Practice for

## Development of Balanced and Durable Asphalt Mixtures with High Recycled Asphalt Materials Contents

AASHTO

AASHTO Designation: PP 127-25[1]

First Published: 2025

Technical Subcommittee: TS 2d, Proportioning of Asphalt–Aggregate Mixtures

# Component Materials Selection & Proportioning

## Virgin Binder

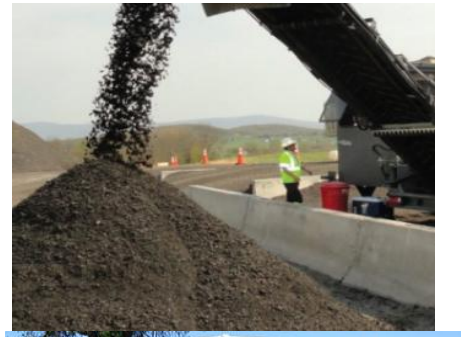
- PGH ≤ 64
- $DT_c$ @ PAV20 ≥ -3.5

## Aggregate

- Absorption ≤ 1.0
- [max $P_i$ x $AC_i$ ≤ 30]

## RAP

- PGH ≤ 100
- $DT_c$ @ PAV20 ≥ -7.5
- Increased $P_b$/PGH



## RAS

- PGH ≤ 150

$$[\frac{P_b}{PGH(blend)} x\ 100 \geq 7.5]$$

$$RBR = RAP_{BR} + RAS_{BR}$$

$$= \frac{(Pb_{RAP} \times P_{RAP}) + (Pb_{RAS} \times P_{RAS})}{100 \times Pb_{total}}$$

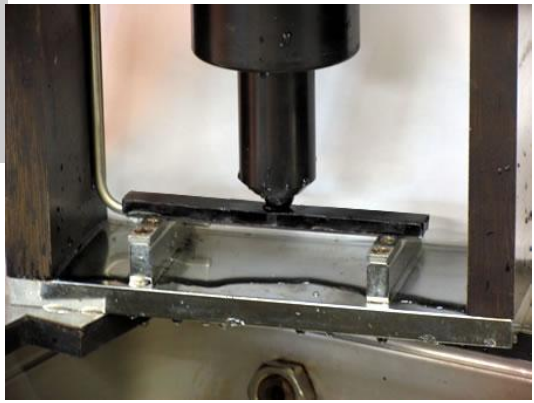
$RBR_{TOTAL} \leq 0.5$

$RAP_{BR} \leq 0.35$

$RAS_{BR} \leq 0.15$

# Binder Blend Rheological Evaluation

| | T & Aging | Standard | Parameter | Suggested Threshold |
|---|---|---|---|---|
| RUT | $T_{high}$ Unaged, Short-Term | DSR | PGH | Target Climate $\frac{P_b}{PGH(blend)} \geq 7.5$ |
| CRACK | $T_{int}$ Track w/Aging | DSR | R-value | 1.5≤ R-value ≤ 2.5 (20-hr PAV)<br>2.0≤ R-value ≤ 3.2 (40-hr PAV) |
| | | DSR | G-R=$\frac{\lvert G^* \rvert (\cos\delta)^2}{\sin\delta}$ | ≤ 180 kPa (20-hr PAV)<br>(≤ 5000 kPa @ 10rad/s)<br>≤ 600 kPa (40-hr PAV)<br>(≤ 8000 kPa @ 10rad/s) |
| CRACK | $T_{low}$ Long-Term | BBR | $\Delta T_c$ | ≥ -5.0 (20-hr PAV)<br>≥ 7.0 @ $\Delta T_c$=-2.0<br>≥ 10.0 @ $\Delta T_c$=-6.0 |
| | | ABCD | $\Delta T_f$ | |



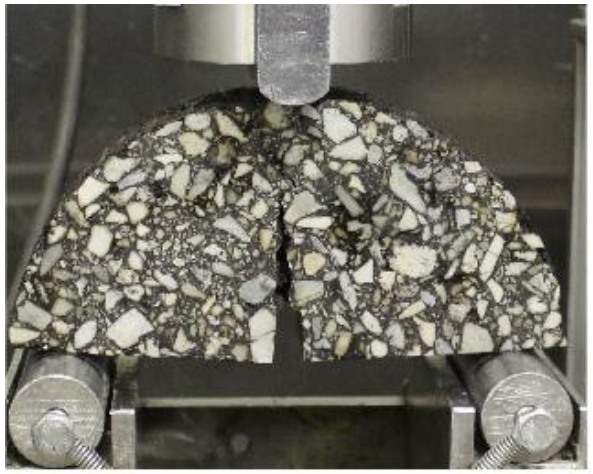
**Short-Term Aging = RTFOT; Long-Term Aging = PAV @ 100°C**

# Mixture Performance Evaluation

Short-Term (STOA) = 2hr@135˚C loose
Long-Term (LTOA) = 6 or 8hrs@135˚C loose, 5d@85˚C
compacted (PMA: 3 or 5d @ 95˚C loose)

$T_{high}$ + Moisture → $T_{int}$ Long-Term → $T_{low}$

Short-Term



Long-Term

| T & Aging | Test | Parameter | Freeze Threshold | No Freeze Threshold |
|---|---|---|---|---|
| RUT / MOISTURE **$T_{high}$ Short-Term** | HWTT | $N_{12.5}$ | ≥ 10,000 for PG 58 @45℃<br>≥ 15,000 for PG 64 @45℃<br>≥ 20,000 for PG 70 @45℃ | ≥ 10,000 for PG 64 @50℃<br>≥ 15,000 for PG 70 @50℃<br>≥ 20,000 for PG 76 @50℃ |
| | | SIP | ≥ 9,000 @45℃ | ≥ 9,000 @50℃ |
| | | SN | ≥ 2,000 @45℃ | ≥ 2,000 @50℃ |
| CRACK / MOISTURE **$T_{int}$ w/Aging** | E* | G-$R_m$ = $\frac{\lvert E^* \rvert (\cos\varphi)^2}{\sin\varphi}$ | ≤ 8,000 MPa after STOA, ≤ 19,000 MPa after 5d@85℃ | |
| | IDEAL-CT | $CT_{index}$ | ≥ 30 after 6hrs@135℃ | ≥ 20 after 8hrs@135℃ |
| | I-FIT | FI | ≥ 7 after STOA | |
| | IDT | TSR | ≥ 80% with F/T | ≥ 80% without F/T |
| CRACK / MOISTURE **$T_{low}$ Long-Term** | DCT | $G_f$ | ≤ 400 J/m² after 4hrs@135℃ | |
| | UTSST | $CRI_{Env}$ | ≥ 17 after 5d@85℃ | |

# Stepwise Approach


**1** Evaluate cracking with aging at intermediate T (I-FIT, IDEAL-CT).

As needed, utilize strategies:

- Substitute binder (softer grade, PMA, Δ source)
- Additive including recycling agent
- Decreased RBA
- Adjusted aggregate gradation
- Reduced RBR
- Combined strategies

**2** Check for balanced performance at high T (HWTT).

**3** Evaluate moisture susceptibility at high and intermediate T (HWTT, TSR by IDT).

As needed, utilize strategies:

- Liquid anti-stripping
- Lime
- Other additives
- Δ aggregate source

**4** For Freeze climate, Evaluate cracking with aging at low T (DCT, UTSST).

# Next Steps

- Training (NCHRP 20-44(60))

- Revisions
  - Determining RBA (NCHRP 09-68)
  - Thresholds for Long-Term Cracking in Field (CAPRI)
  - Long-Term Aging (NCHRP 09-70)

# Agency Perspective: AASHTO PP 127 Outcomes

Practices for designers to follow

Guidance for agency specifications

- Design and evaluation of high RAM mixtures
  - Stepwise approach
  - Choice of materials for design
  - Evaluation of binder and mixture
  - Strategies for improving durability during design

- Guidance that can be incorporated into specifications
  - Evaluation tools use current binder and BMD test procedures
  - Suggested mixture thresholds based on climatic zones


# Agency Perspective: Component Materials Selection

## Apply material thresholds for acceptable performance

- Binders – Virgin, RAP, and RAS
  - PG high
  - Intermediate temp DSR properties
- Aggregates
  - Absorption
- RBR
  - Maximum values for RAP+RAS and RAS
- RA dose selection guidance

# Agency Perspective: Binder and Blend Evaluation

- Linking virgin binder/RAM binder/RA blend properties to rutting and cracking
  - Binder blend preparation procedures
  - Aging protocols

- Suggested thresholds and criteria for acceptable binder performance
  - PG high
  - Intermediate temp DSR
  - ΔTc

# Agency Perspective: Mixture Evaluation Tools

- Linking lab results to field performance
  - Specimen fabrication procedures
  - Aging protocols

- Suggested thresholds and criteria for acceptable mix performance
  - Test options for rutting, moisture, and cracking susceptibility
  - Thresholds based on climatic zone
  - Variety of test options
    - HWTT, dynamic modulus, I-FIT, TSR, IdealCT, BBR-mixture, DCT, TSRST

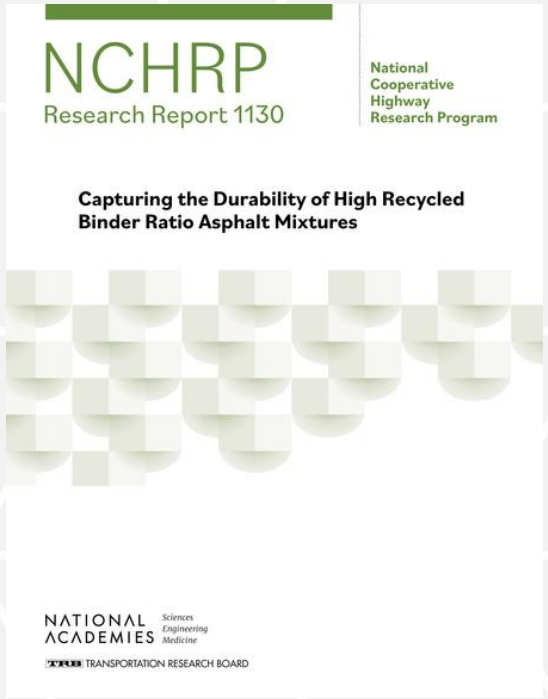
# Agency Perspective: Strategies to Improve Performance

## Address cracking

- Decrease RBA
- Alternate binder – softer grade, different source, polymer-modification
- Recycling agent use
- Adjust aggregate gradation
- Reduce RBR / RAP content

## Address moisture

- Liquid anti-strip
- Lime
- Other additives
- Change aggregate type




NCHRP Report 1130

# THANK YOU

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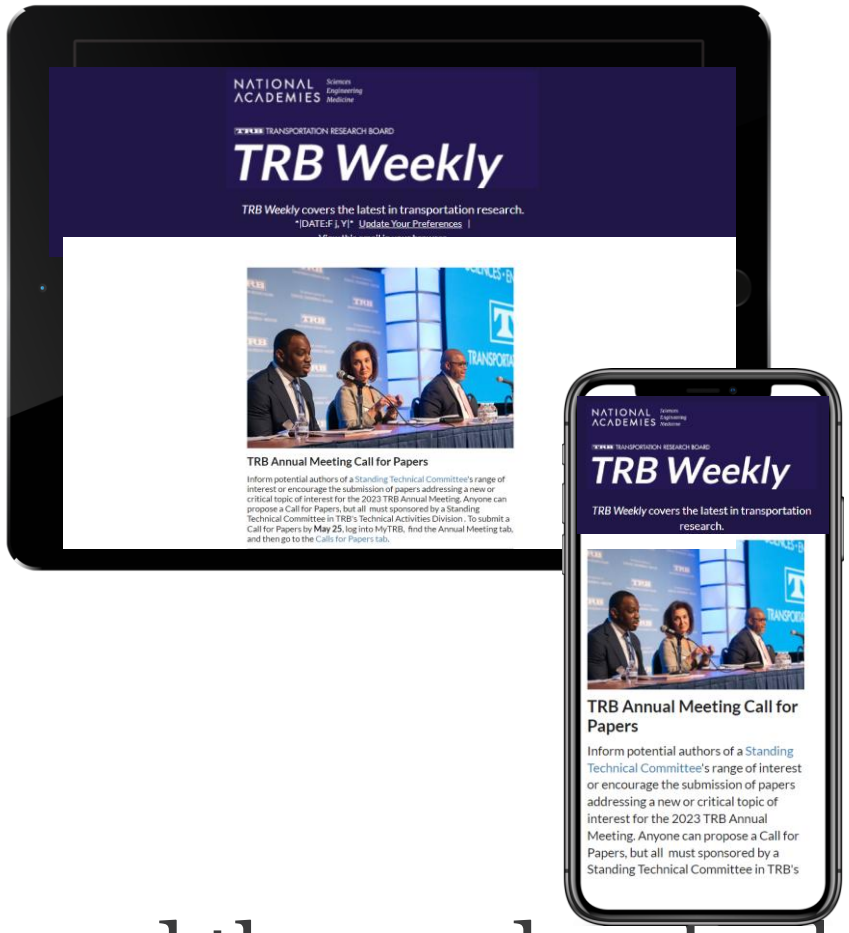


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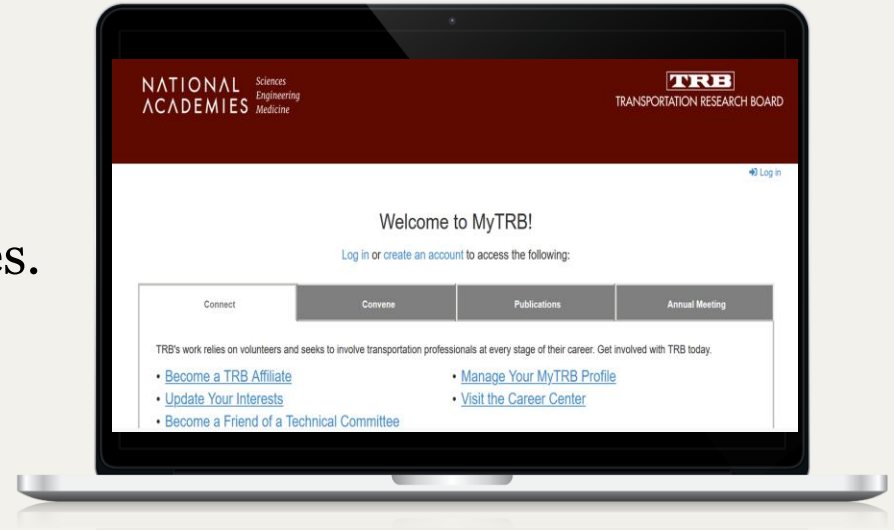


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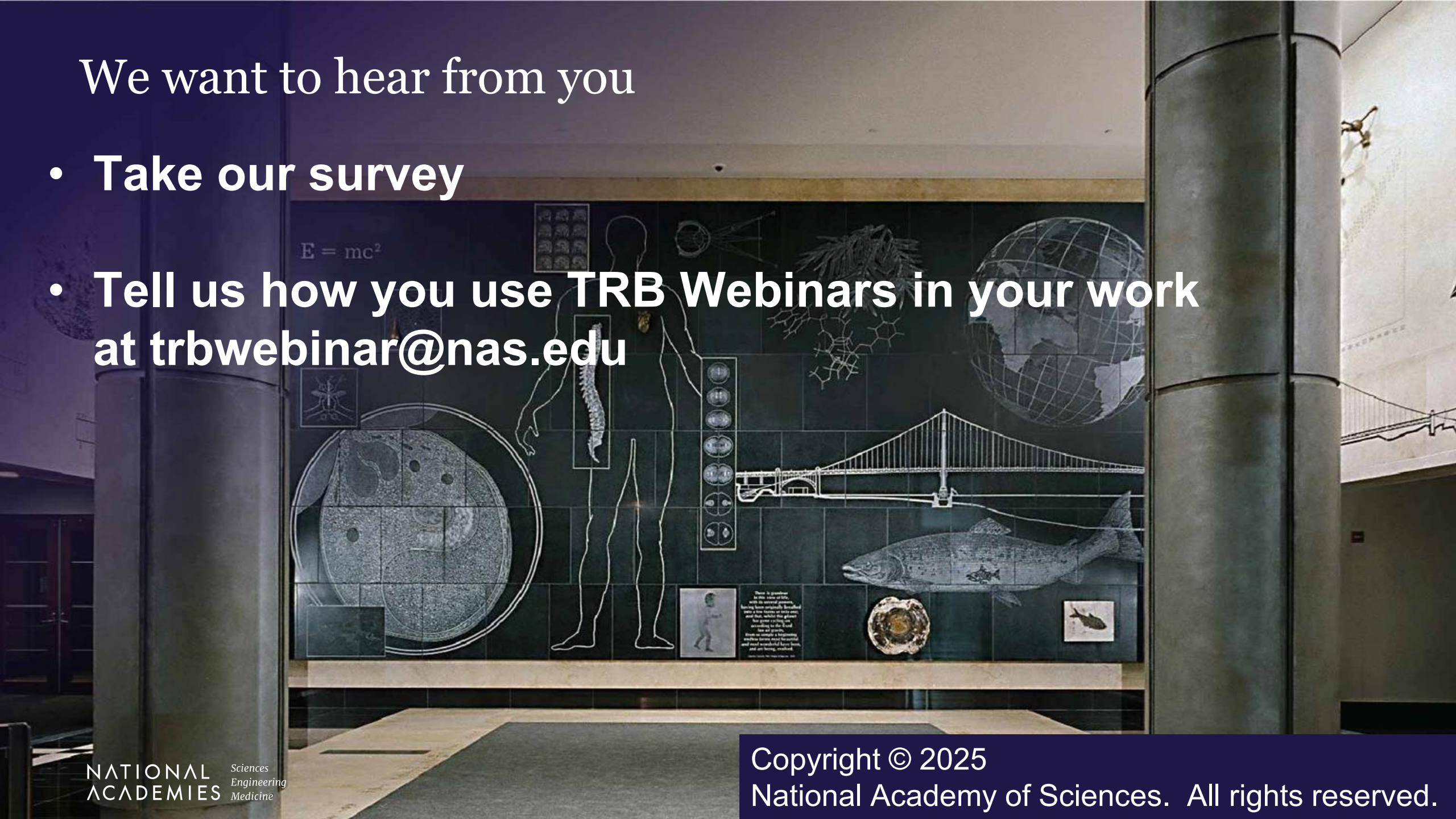


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