Linking Laboratory Performance and Mechanistic Modeling to Predict Cracking Resistance of Asphalt Overlays

University of New Hampshire

National Center for Asphalt Technology NCAT at Auburn University

Meisam Khorshidi[1](meisam.khorshidi@unh.edu), MD Tanvir Shaon[2], Eshan V. Dave[1], Jo E. Sias[1], Adeniran Coker[1], Randy West[2], Fan Yin[2], Carolina Rodezno[2]

[1]University of New Hampshire, USA; [2]National Center for Asphalt Technology, USA

TRB

NRRA National Road Research Alliance

Motivation

- **Overlays are the primary rehab strategy** for aging pavements in cold-temperate climates.
- **Reflective and thermal cracking** often govern service life
- **Premature cracking → higher life-cycle costs**
- **Need performance-based guidance** for crack-resistant overlay selection
- **MnROAD Reflective Cracking Challenge (MRCC) provides controlled full-scale test sections** to support this guidance

Objectives

- **Cracking resistance characterization** of 10 overlay mixtures (binder grades + modifiers: rubber, plastics, fibers) using **fracture, fatigue, modulus, and low-temperature tests**
- **Mechanistic–empirical prediction** of thermal and reflective cracking using **PavementME™, TxACOL, FlexPAVE™, and IlliTC tools** with mixture-specific inputs under MnROAD traffic and climate
- **Ranking comparison and validation: lab indices → mechanistic predictions → early MRCC field reflective cracking** to identify best screening tests and tools for cold-climate overlays

Research Approach

MRCC Field Sections

- Ten overlay mixtures constructed at MnROAD under identical structure, traffic, and climate.
- Reflective cracking measured in cut sections to establish early field ranking.

Laboratory Testing

- Reheated and long-term aged plant-mix specimens prepared for each mixture.
- Fracture, fatigue, modulus, and low-temperature tests used to quantify cracking resistance.

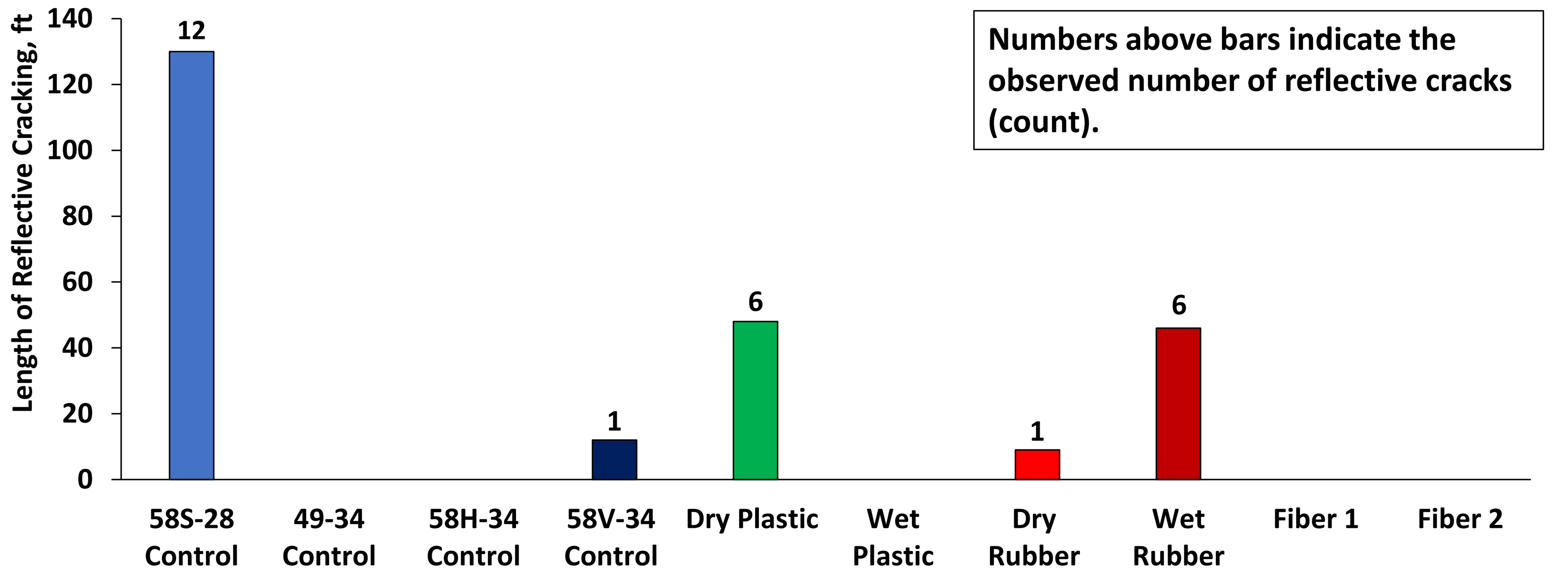
Mechanistic Prediction & Comparison

- PavementME™, TxACOL, FlexPAVE™, and IlliTC run with mixture-specific inputs.
- Lab- and model-based rankings compared with MRCC field performance.

MRCC Overlay Mixtures

Cell	Mixture/Additive	Binder PG	Dosage
2230	58S-28 Control	58S-28	-
2231	58V-34 Control (Superpave 5)	58V-34	-
2232	Wet Plastic	58V-34 (52-34 base)	1.0% LLDPE plastic & 1.5% reactive elastomeric terpolymer (RET) by weight of the binder
2233	Fiber 1	58H-34	3.4 ounces per ton of mix
2234	Fiber 2	58H-34	1 lb. fiber per 1 ton of asphalt mix
2235	Wet Rubber	58V-34 (52-34 base)	10% by weight of the binder
2236	Dry Plastic	49-34	0.5% LLDPE pellets by weight of aggregate
2237	Dry Rubber	49-34	12% by weight of the binder
2238	49-34 Control	49-34	-
2239	58H-34 Control	58H-34	SBS modified

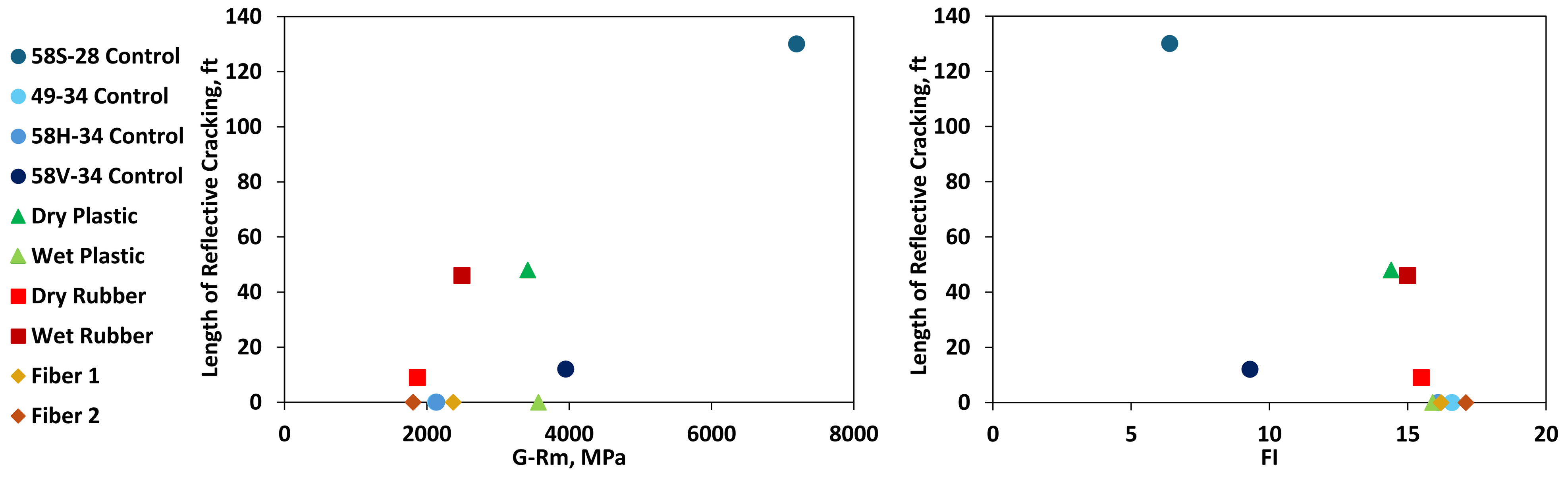
Early Field Performance (MRCC reflective cracking)



Laboratory Results vs Field Ranking

Mixture Type	G-Rm	CT-Index	FI	Gf	Sapp	CFE	CPR
58S-28 Control	A	C	C	D	B	A	A
49-34 Control	D	B	A	C	A	E	B
58H-34 Control	D	A	A	B	A	B	B
58V-34 Control	B	C	B	B	A	B	B
Dry Plastic	B	A	A	A	A	C	B
Wet Plastic	B	B	A	B	A	B	B
Dry Rubber	D	A	A	A	A	E	B
Wet Rubber	C	B	A	A	A	B	B
ACE Fiber	C	A	A	A	A	D	C
Forta Fiber	D	A	A	B	A	C	C

- **Connecting Letters Report (CLR)** analysis grouped mixtures with statistically similar performance for each laboratory index; **Group A** denotes the highest index values, with subsequent letters indicating progressively lower values.
- **Overall, 58S-28** most often grouped with the weaker performers, while the best cracking resistance was most consistently observed for **PG-34 binder mixes (49-34 and 58H-34)** and innovative modifiers, particularly **Dry Rubber** and the **fiber mixes**.

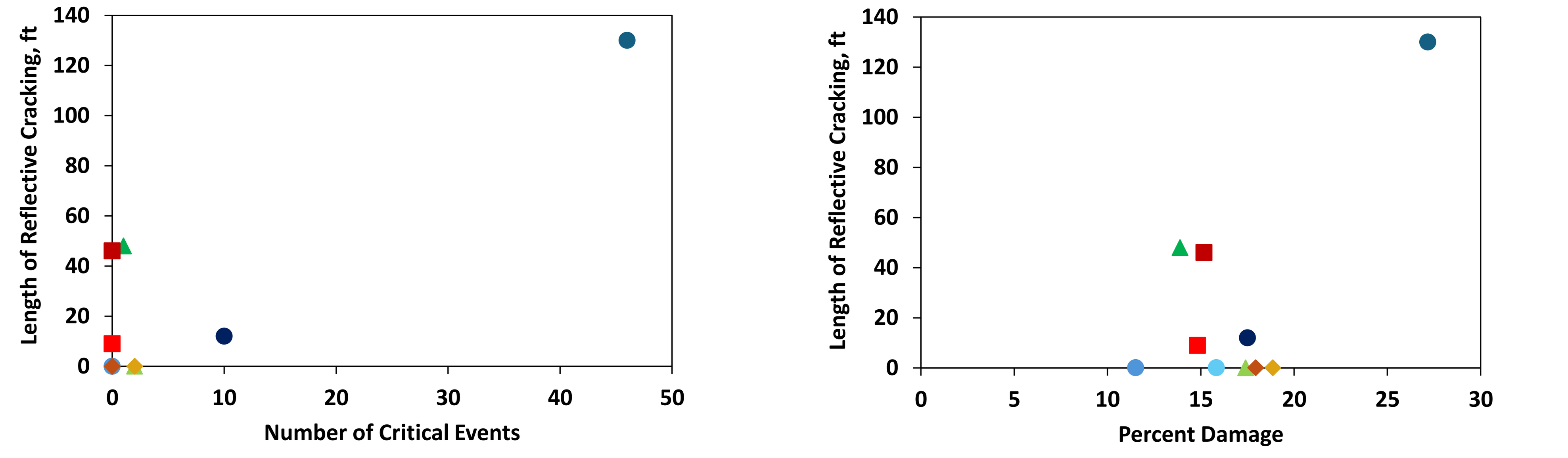


- Rankings from aged-condition **G-R$_m$ and FI** aligned best with early reflective cracking, with **G-R$_m$** showing **greater sensitivity and clearer separation among mixtures**.

Mechanistic Model Predictions vs Field Performance Ranking

Mix ID	Field Performance	PavementME	TxACOL	FlexPAVE	IlliTC
58S-28 Control	1	5	2	1	1
49-34 Control	8	1	1	6	8
58H-34 Control	8	8	6	10	8
58V-34 Control	4	6	3	4	2
Dry Plastic	2	3	9	9	5
Wet Plastic	8	10	4	5	3.5
Dry Rubber	5	4	7	8	8
Wet Rubber	3	9	8	7	8
Fiber 1	8	7	5	2	3.5
Fiber 2	8	2	10	3	8

- **Ranks (1 worst → 10 best)** follow **predicted reflective cracking, except IlliTC (critical events) and FlexPAVE™ (% damage)**.
- **Both FlexPAVE™ and IlliTC flagged the worst mixtures**; IlliTC matched field performance most consistently overall.



Conclusions & Future Work

- After 3 years, reflective cracking in the cut sections controlled early performance; **58S-28** Control was the clear **worst performer** (130 ft), while **49-34 Control, 58H-34 Control, Wet Plastic, and Fiber 1/2** showed **zero** measurable **reflective cracking**.
- The laboratory suite **ranked 58S-28 lowest overall**, and mixtures with **PG-34 binders (49-34 and 58H-34) plus modifiers, especially Dry Rubber and fibers, highest** in cracking resistance.
- Rankings from aged-condition **G-R$_m$ and FI** aligned best with early reflective cracking, confirming them as the most reliable lab indicators for screening cold-climate overlays.
- **IlliTC** and refined **FlexPAVE™** successfully identified the worst mixture (58S-28), with IlliTC showing the most consistent overall agreement with field ranking, while PavementME™ and TxACOL showed conflicts for some mixes (notably 49-34 Control).
- **Track MRCC sections long-term** to confirm whether early mixture rankings persist as cracking develops.
- **Develop ML/statistical models** to predict overlay performance curves from MRCC + companion + agency datasets.

Acknowledgments

- Dr. Michael Vrtis and Jacob Calvert, Minnesota Department of Transportation
- Brian Hill, Illinois Department of Transportation
- Dr. Katie DeCarlo, Heritage Research Group
- National Road Research Alliance (NRRA) and Additive Group Pooled Fund Study
- Graduate School and Asphalt Research Group, University of New Hampshire

SCAN ME