

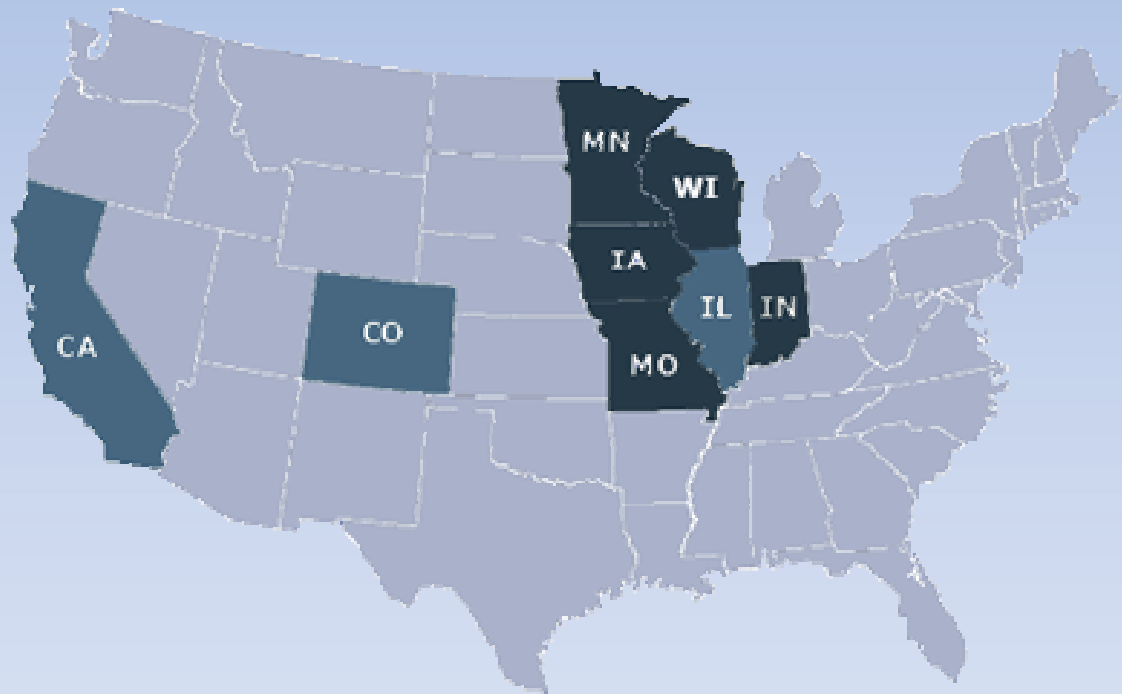


Performance of Recycled Asphalt Shingles in Hot Mix Asphalt Pooled Fund Study TPS-5(213)

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Pooled Fund Partners

- Missouri
- Iowa
- Minnesota
- Indiana
- California
- Illinois
- Colorado
- Wisconsin
- FHWA



Why a Pooled Fund Study?

- Increasing number of RAS applications
 - Growing interest in post-consumer RAS
 - Multiple state demonstration projects
 - Answer remaining questions on design, performance, and environmental concerns
 - Address QC/QA concerns of RAS
-

Pooled Fund Study Tasks

- Conduct demonstration projects
 - Laboratory performance testing
 - Pavement condition surveys
 - Develop database of RAS Mixture performance
 - Technology transfer
-

Demonstration Projects



RAS Research Objectives

Agency		Research Interest
Iowa	»	Percentage of RAS
Minnesota	»	Post-Man. vs. Post-Consumer
Missouri	»	Coarse vs Fine Grind RAS
Indiana	»	RAS with WMA
Colorado	»	Replacement of RAP with RAS
Illinois	»	RAS with SMA

Laboratory Testing Plan

- Binder Characterization
 - Dynamic Shear Rheometer - Rutting
 - Bending Beam Rheometer - Thermal Cracking

 - Mixture Characterization
 - Dynamic Modulus - Rutting
 - Flow Number - Rutting
 - Flexural Beam Test - Fatigue Cracking
 - Fracture Energy - Low Temperature Cracking
-

Iowa Demonstration Project

- Tri-State Paving
- July 2010
- State Highway 10
- 16 miles
- 2" overlay
- 12.5mm
- PG 64-28
- 30k Tons



Iowa Mix Properties

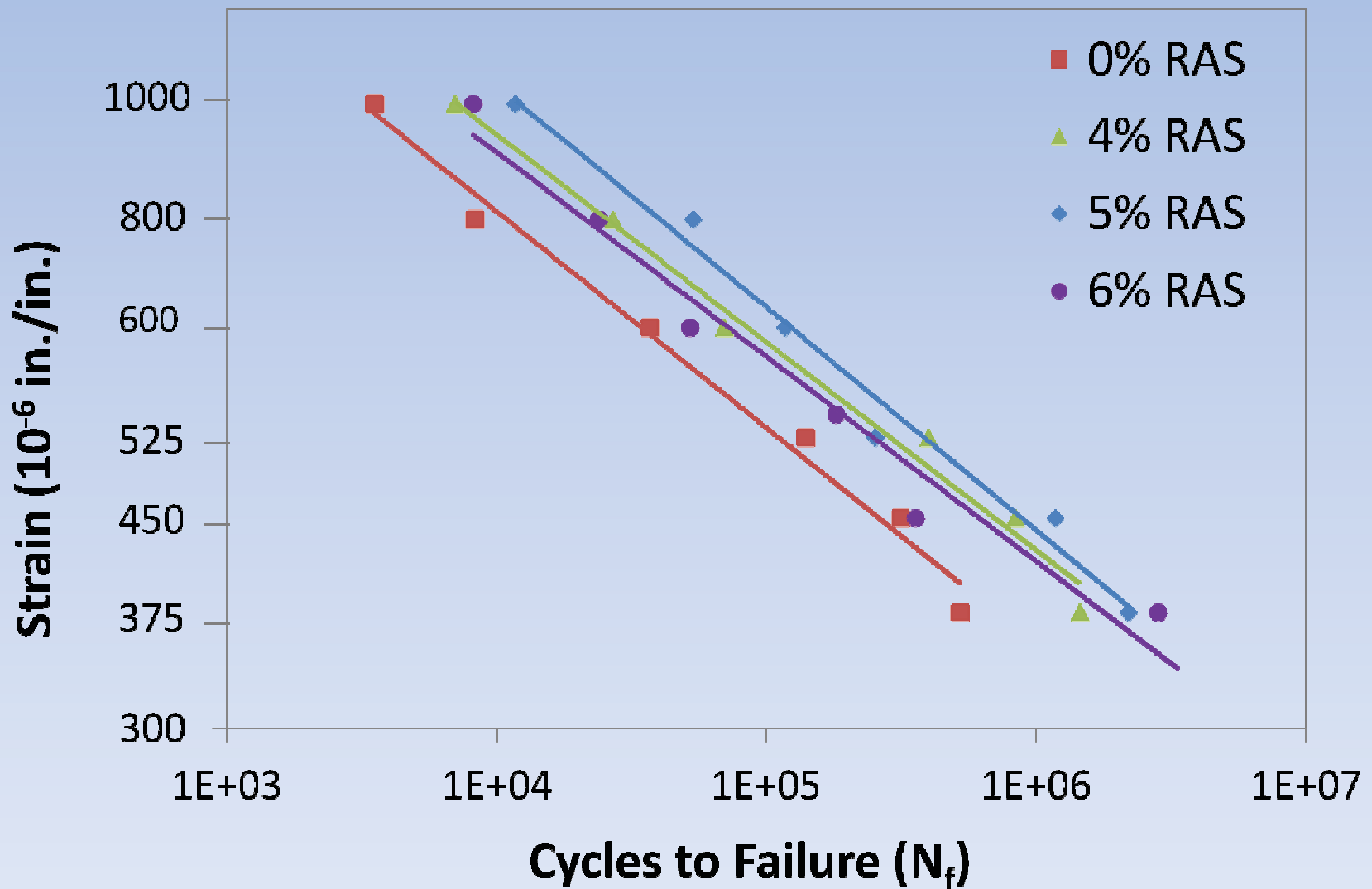
% RAS	0	4	5	6
% Binder Replacement	0	15.1	17.5	19.8
Low PG Grade	-20	-19	-17	-14
High PG Grade	73	76	81	86

RAS High PG Grade = 124.1

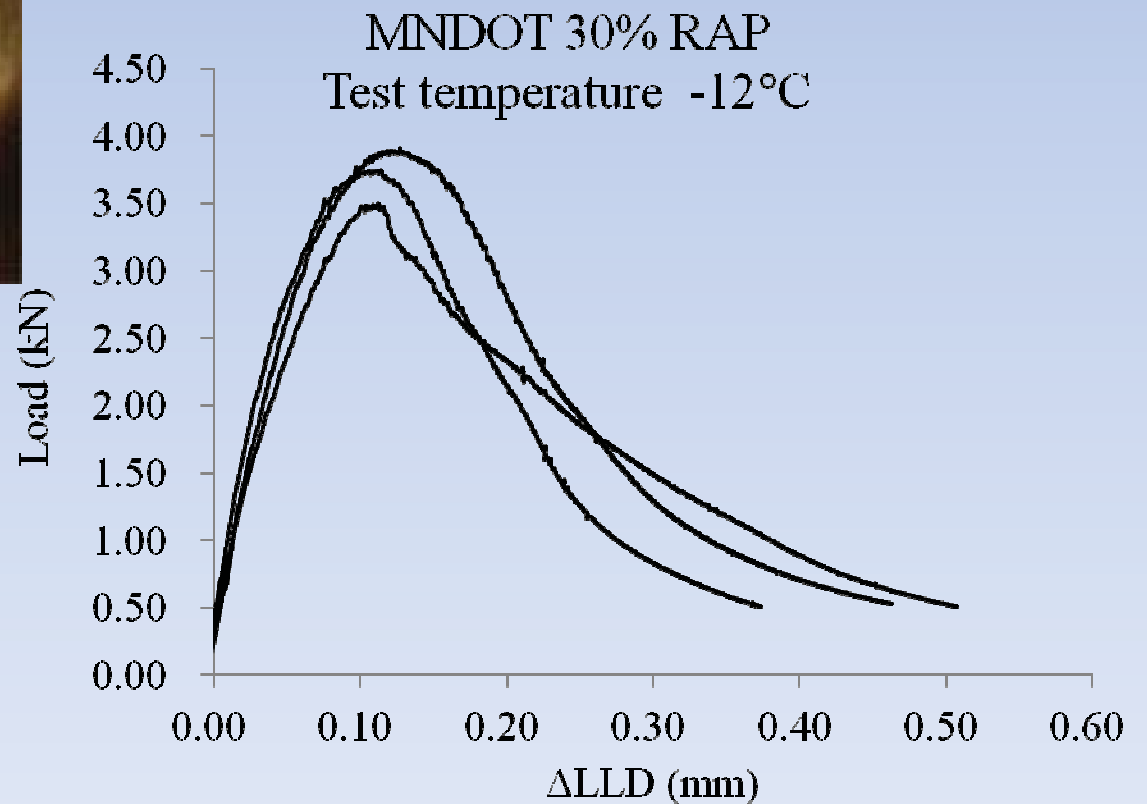
4-Point Bending Beam



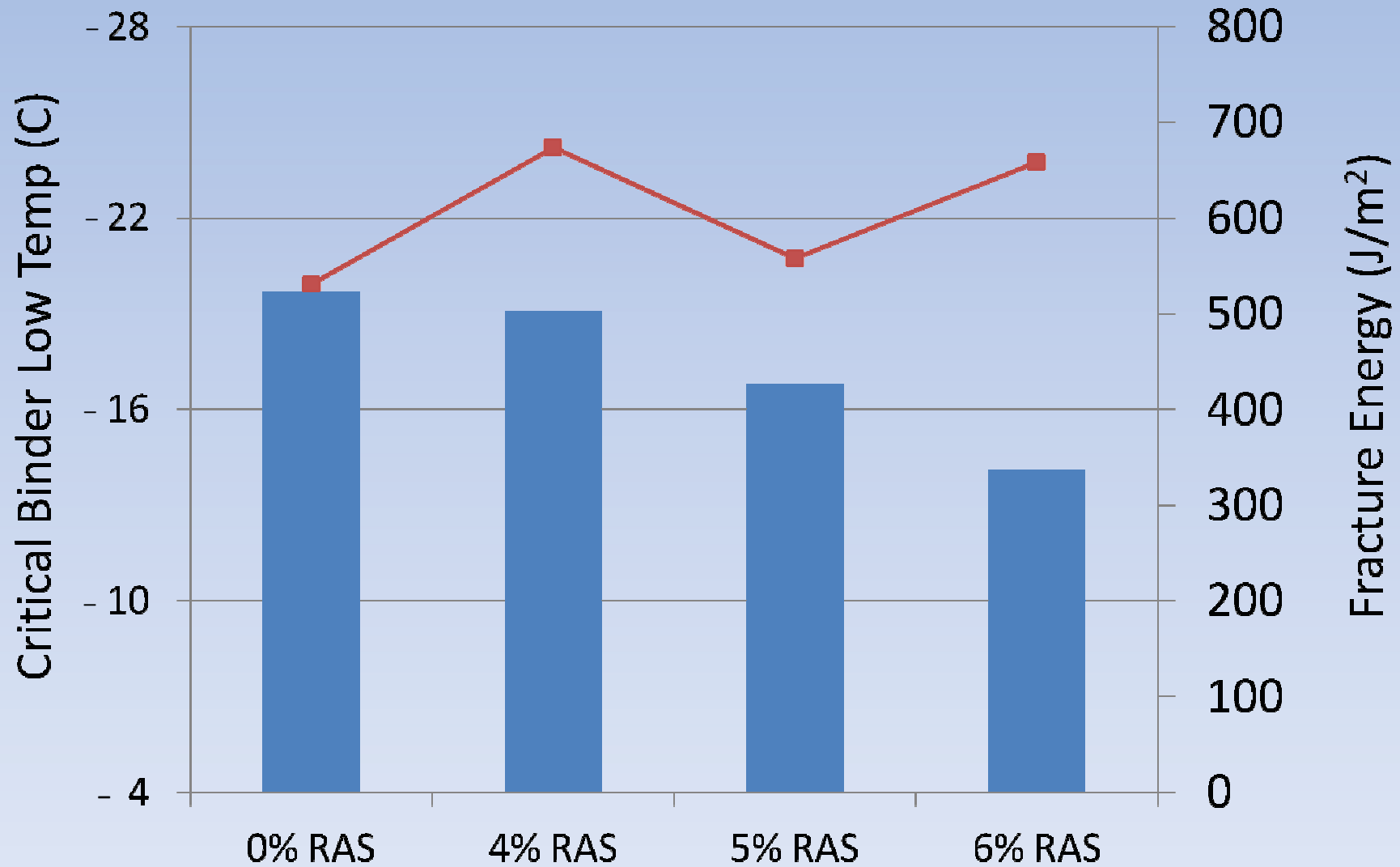
lowa Fatigue Life



Semi-Circular Bending Test

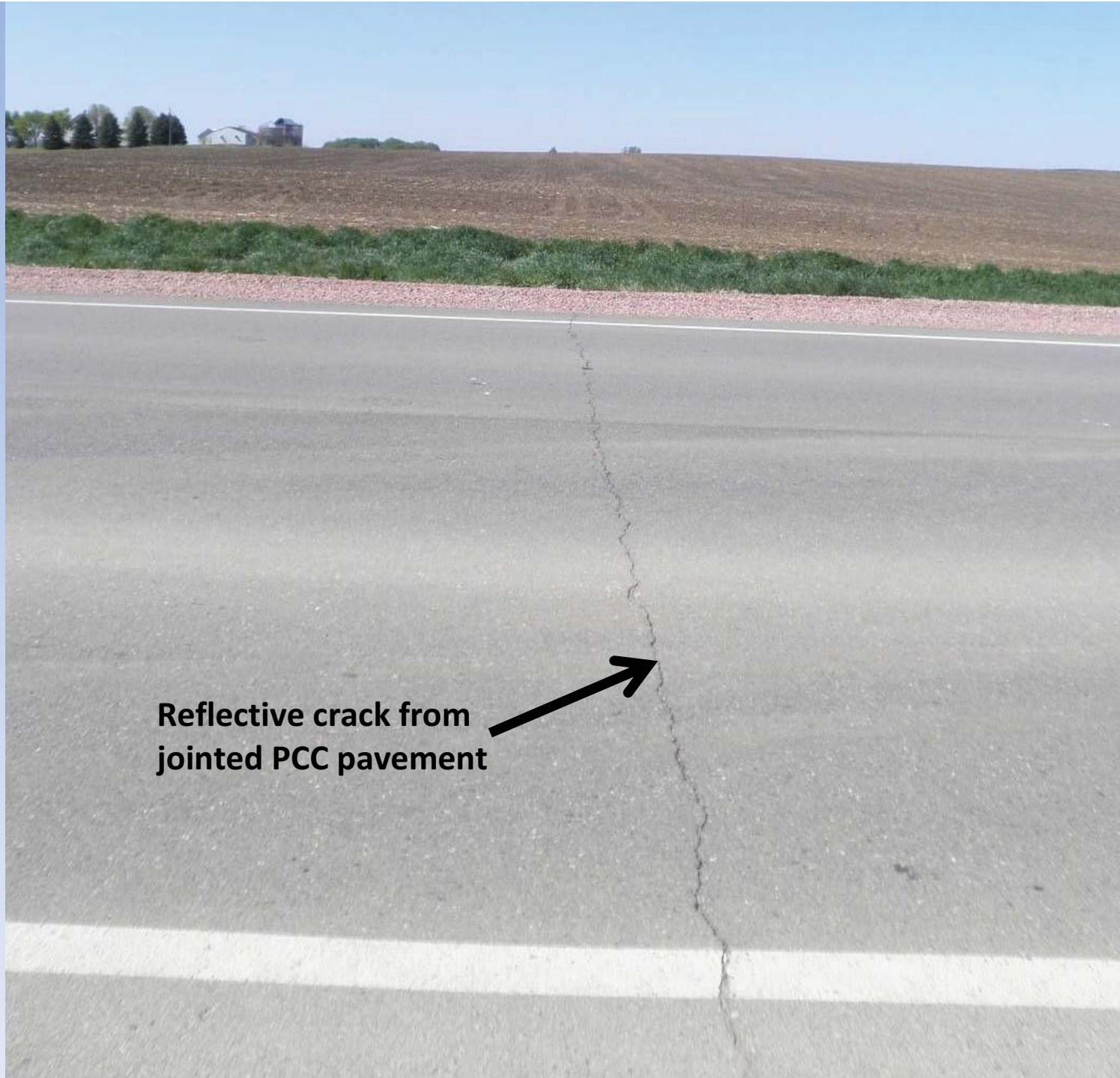


Low Temperature Testing



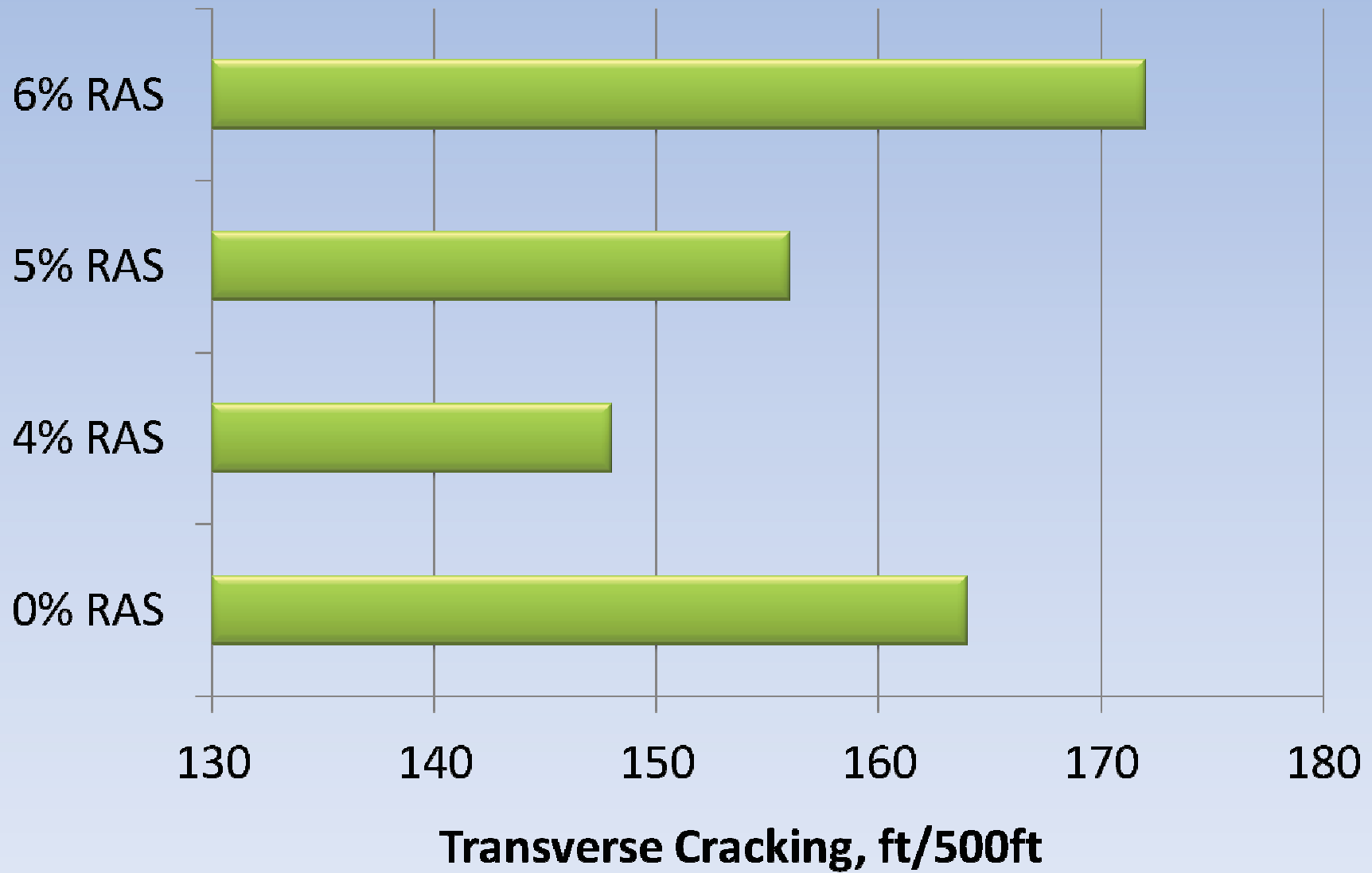






**Reflective crack from
jointed PCC pavement**

Iowa Pavement Evaluation



Minnesota

- 2008 Reconstruction of MnRoads on I-94
- Cells 5, 6, 13-23
- 5% RAS in Shoulders
- Post-Manufactured & Post-Consumer
- 30% RAP as control mix
- 12.5mm, 3" Overlay
- PG 58-28

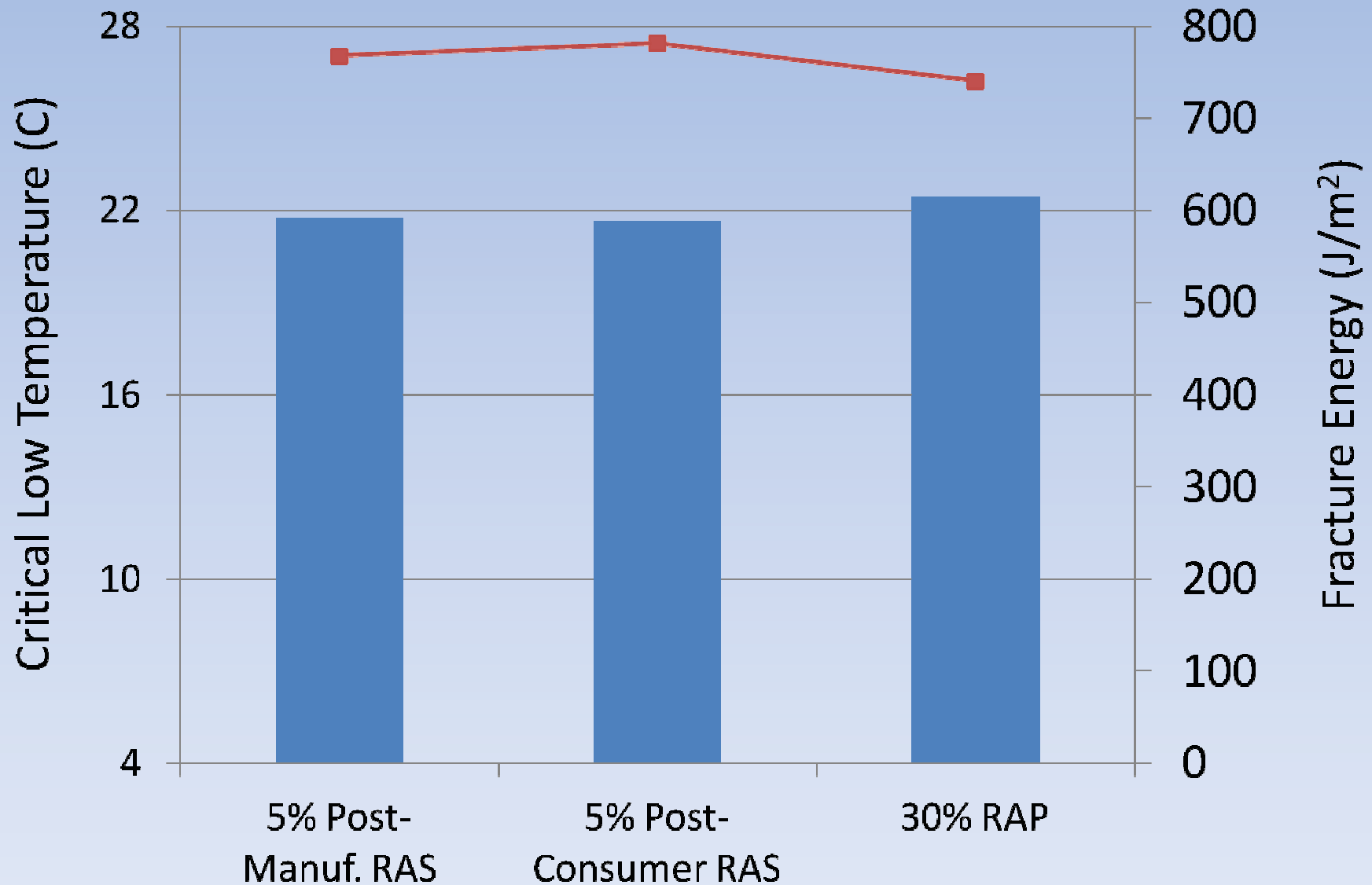


Minnesota Mix Properties

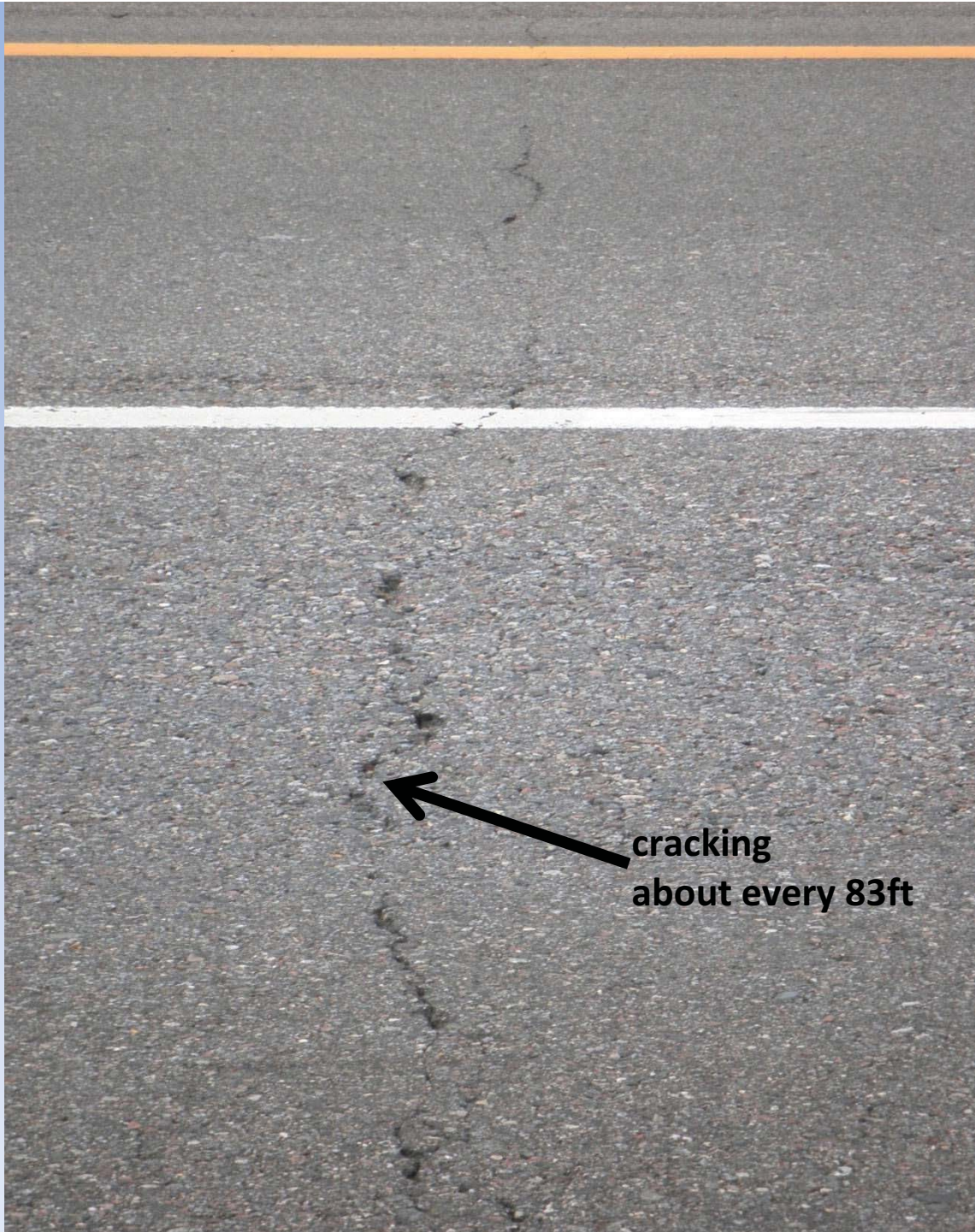
	5% Post-Manuf.	5% Post-Consumer	30% RAP
% Binder Replacement	19	26	31.6
Low PG Grade	-21.7	-21.6	22.4
High PG Grade	71	71	69

RAS High PG = 109.1 RAS High PG = 122.5

Low Temperature Testing







**cracking
about every 83ft**

Missouri RAS

100% passing 3/8"

95% passing #4



25.0% AC

100% passing 1/2"



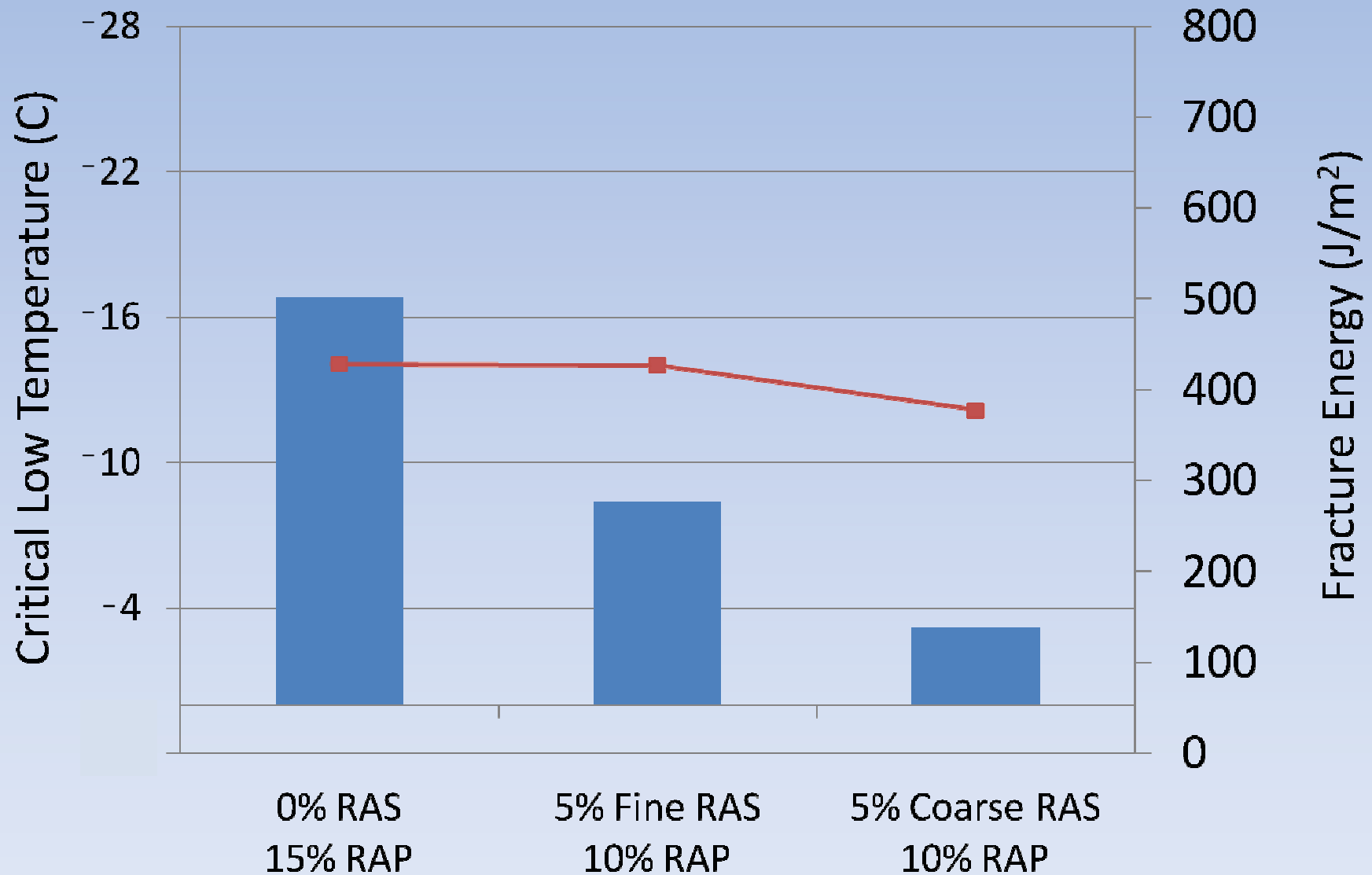
21.7% AC

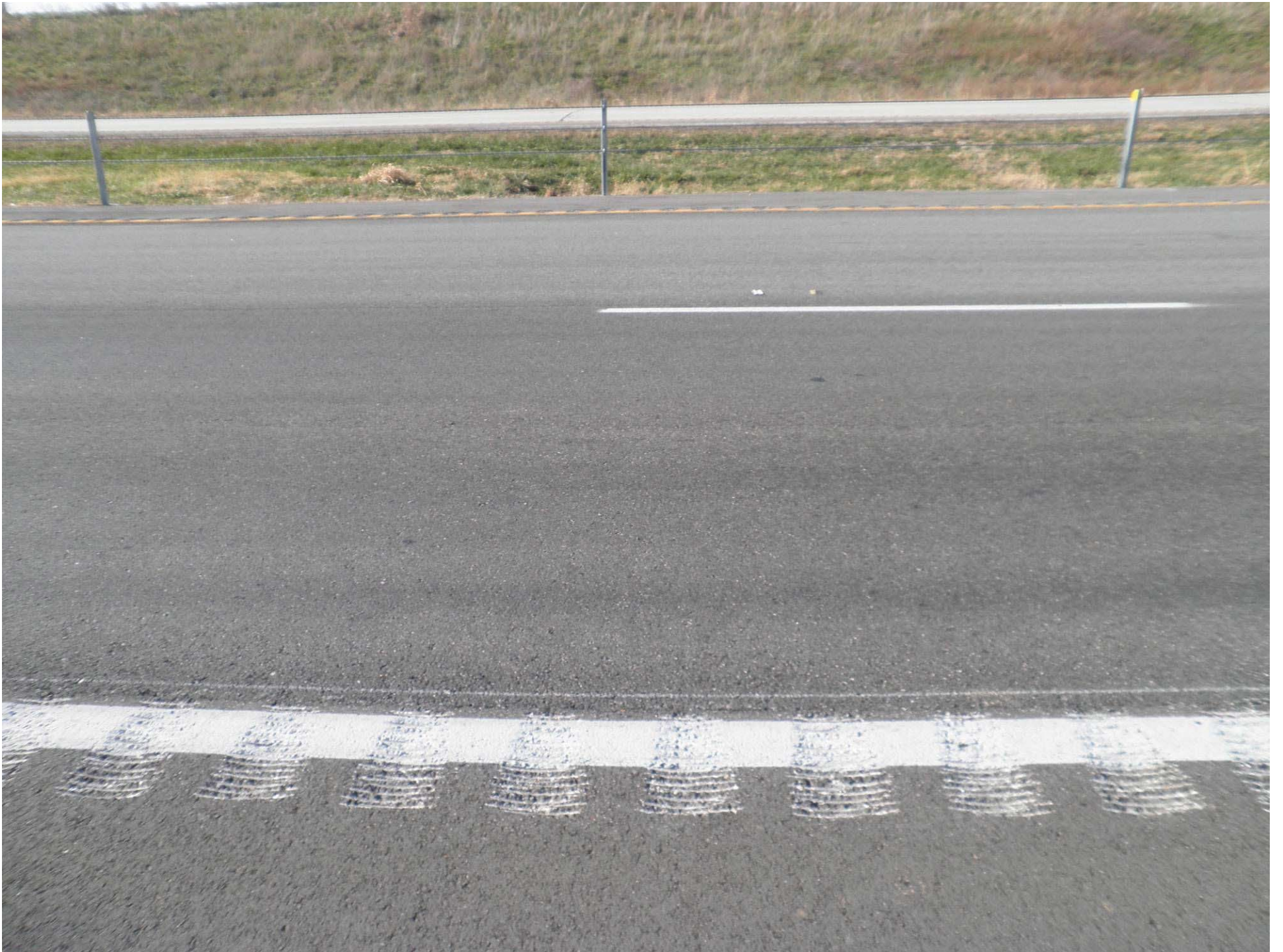
Missouri Mix Properties

	15% RAP	5% RAS (Fine) 10% RAP	5% RAS (Coarse) 10% RAP
% Binder Replacement	19.1	30.2	29.2
Low PG Grade	-17	-8	-3
High PG Grade	75	90	88

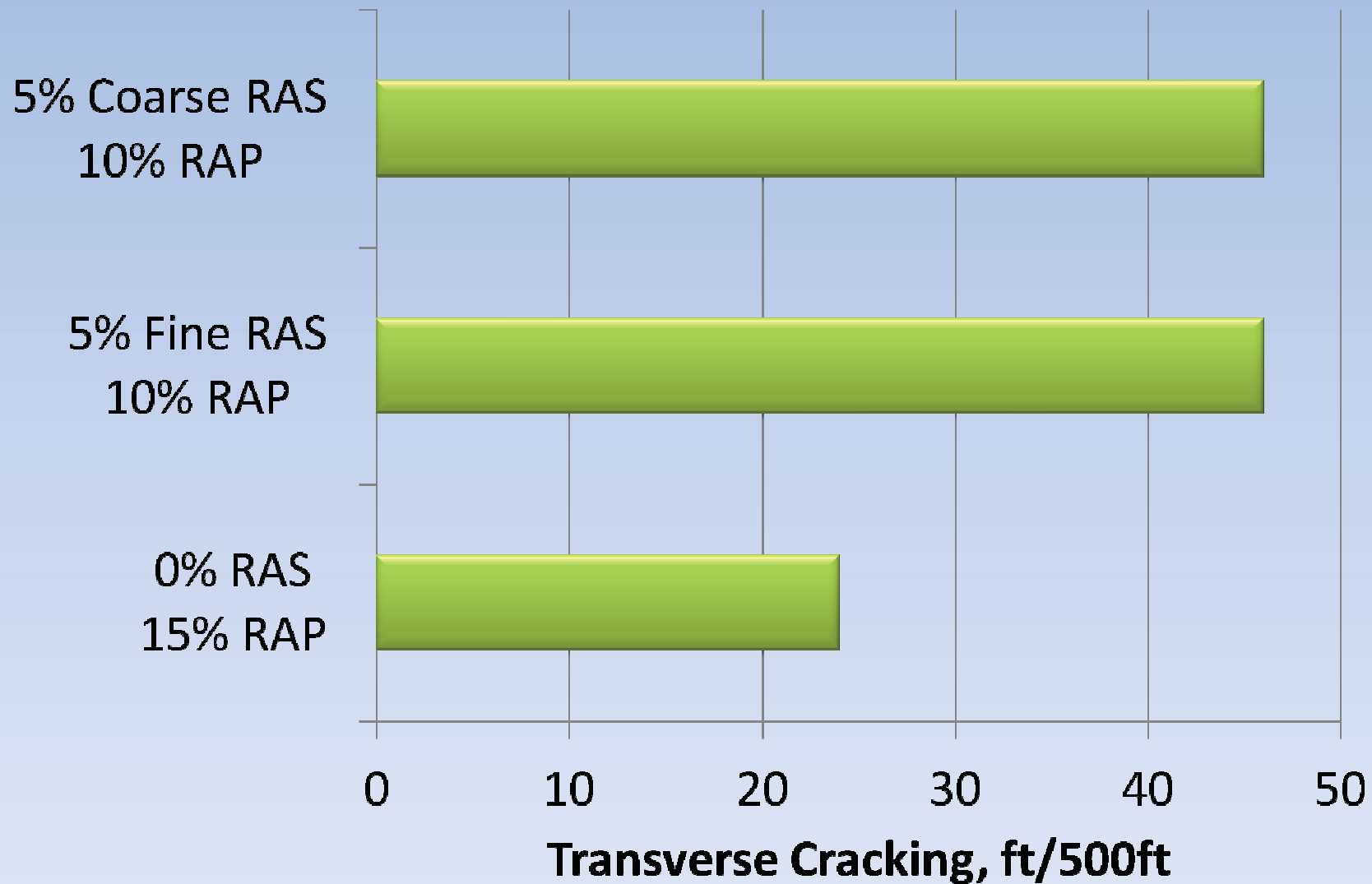
RAS High PG = 137 RAS High PG = 146

Low Temperature Testing





Missouri Pavement Evaluation



Indiana

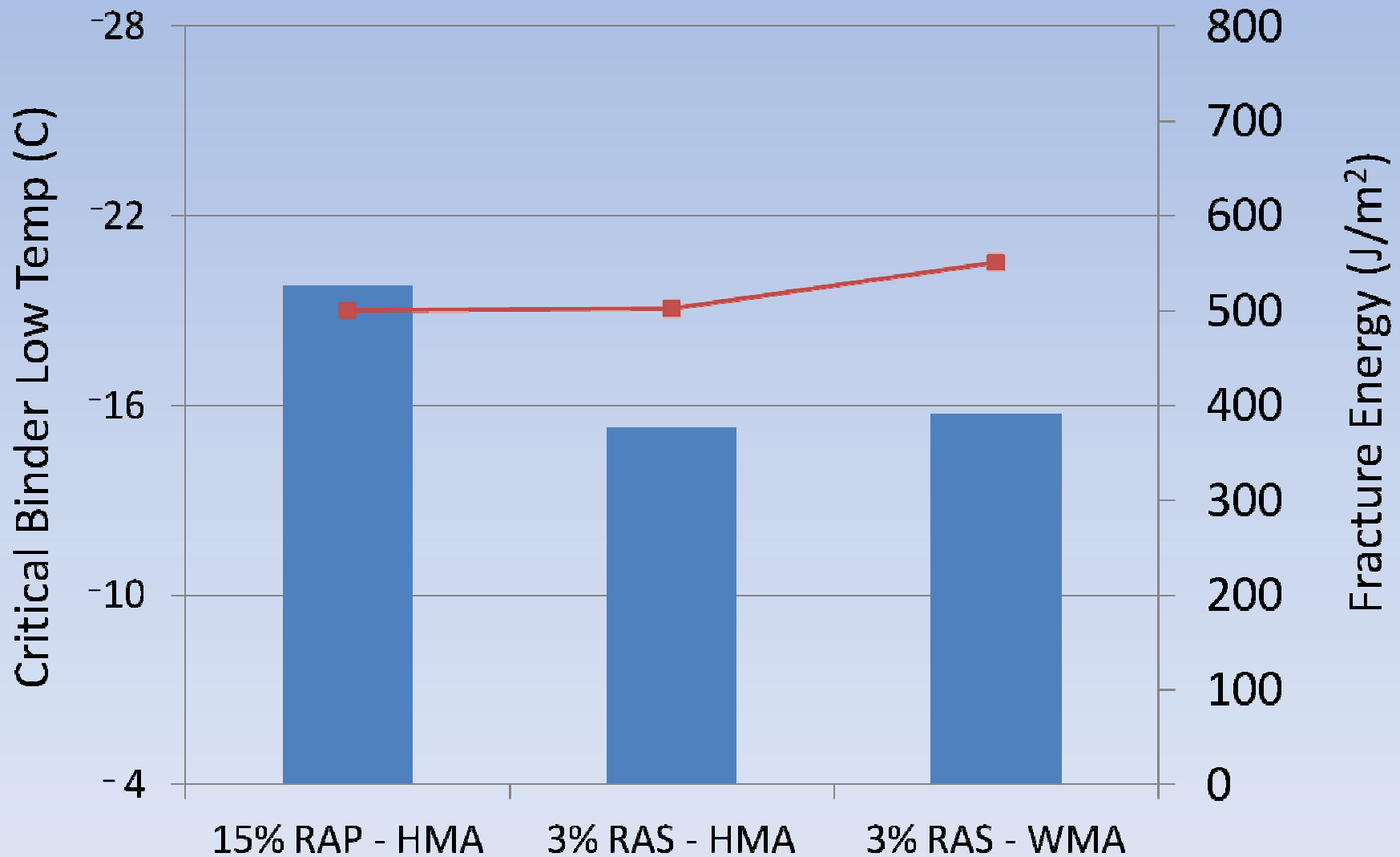
- US 6 in north central Indiana
- July 2009
- 9.5mm, 1.5" overlay
- Post-Consumer RAS
- Warm Mix vs. Hot Mix
- Foamed Technology
- 10M > 30M EASLs
- PG 70-22



Indiana Mix Properties

	15% RAP HMA	3% RAS HMA	3% RAS WMA
% Binder Replacement	18	12.6	12.6
Low PG Grade	-20	-15	-16
High PG Grade	76	78	79

Low Temperature Testing







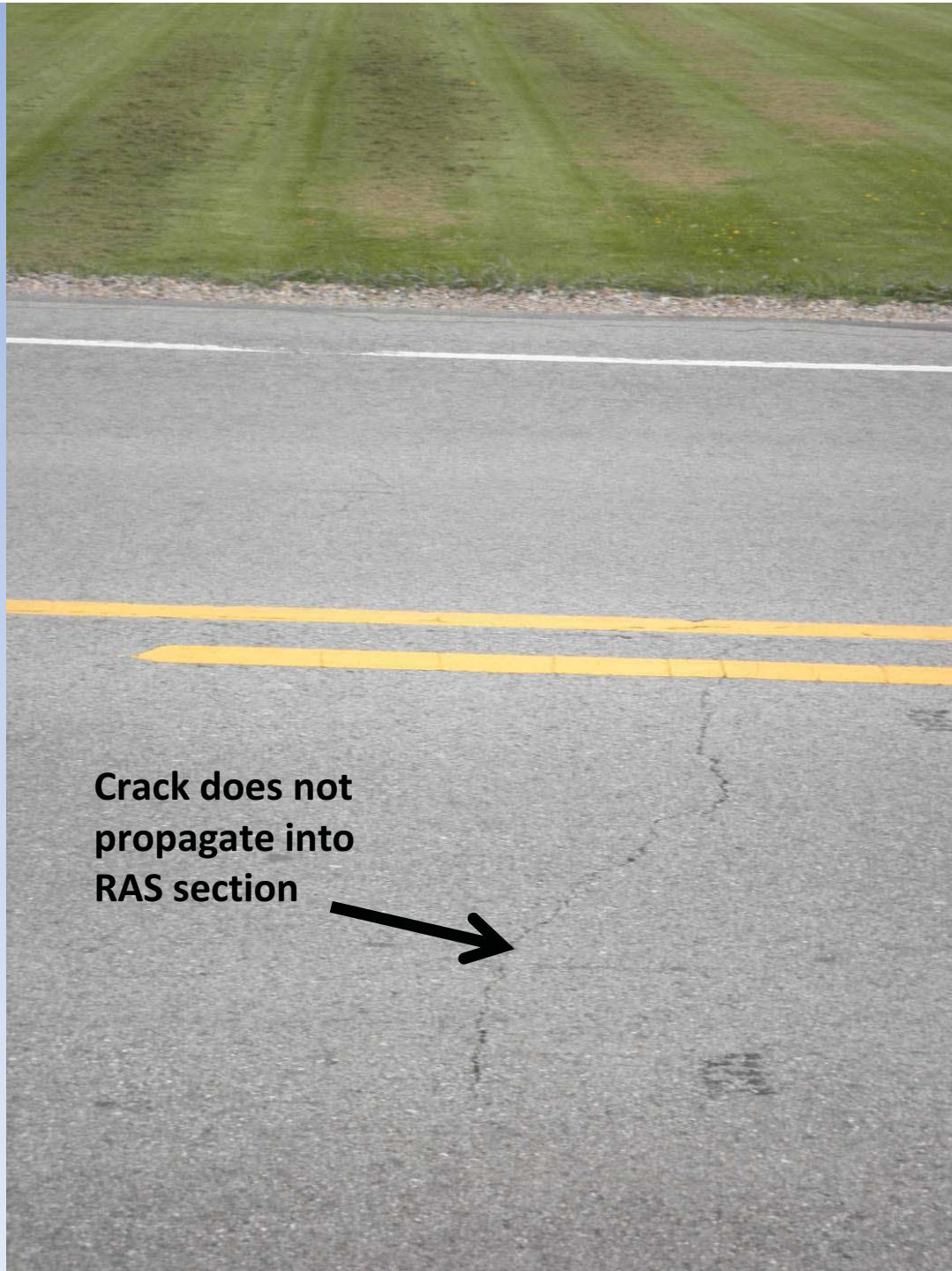




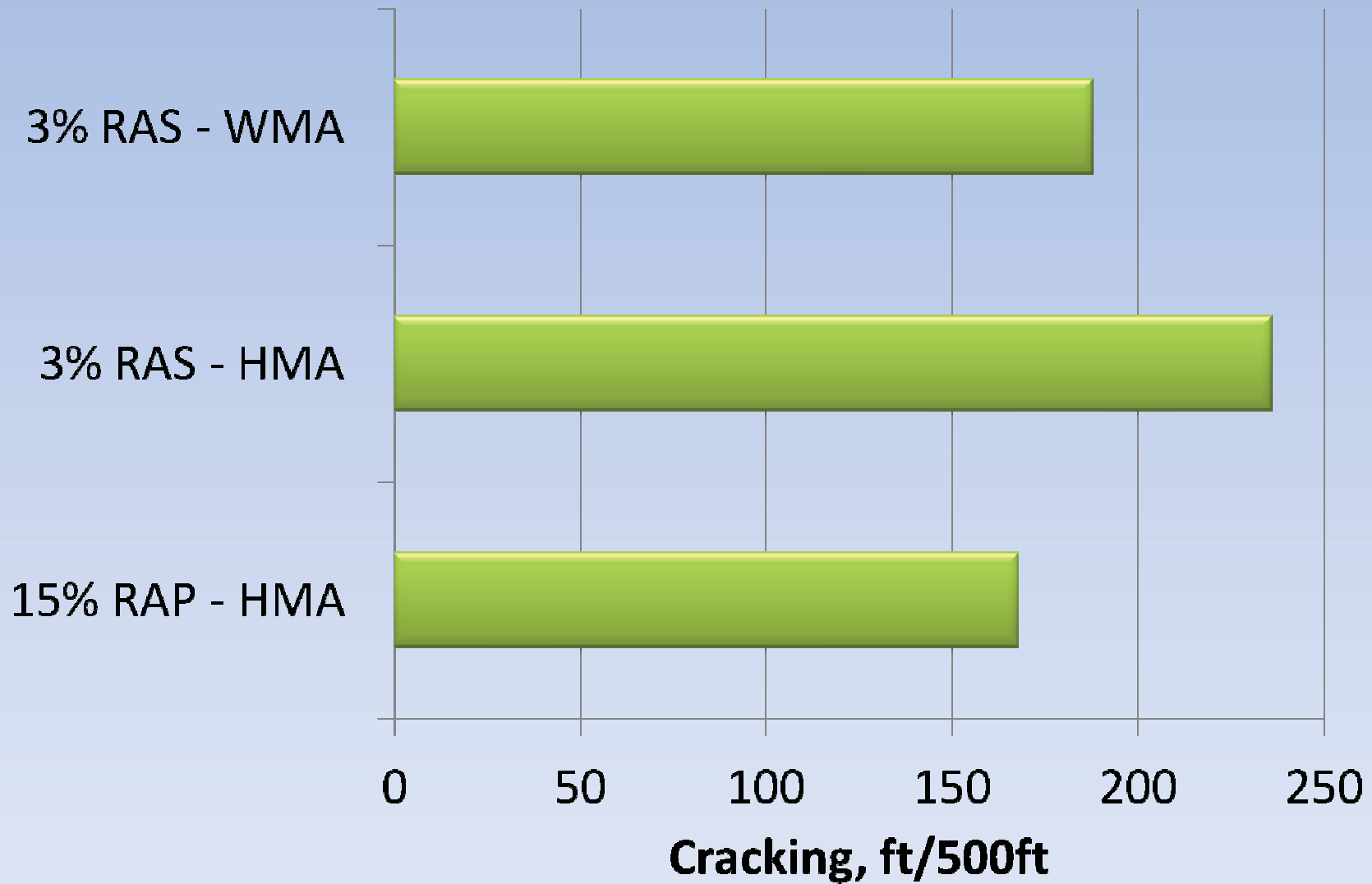
**Reflective cracking from
jointed PCC pavement**

Edge cracking

**Crack does not
propagate into
RAS section**



Indiana Pavement Evaluation



Colorado

- State Highway 36
- June 2011
- Between Boulder and Denver
- Post-Manufactured RAS
- Replaced 5% RAP with 3% RAS
- Maintained 70% virgin AC
- Tabs visual during laydown







Illinois

- Interstate 80
- July 2011
- Fiber replacement in SMA
- Optimum PG Grade with 5% RAS
 - 76-22
 - 70-22
 - 64-22
 - 58-22 w/12% GTR
- Post-Consumer RAS





Continuing Work

- Continue to evaluate pavement performance
 - Continue laboratory testing and analysis
 - California & Wisconsin demonstration projects
 - Develop specification recommendations
 - Technology Transfer
-

Questions?



www.intrans.iastate.edu/tpf-5-213
