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

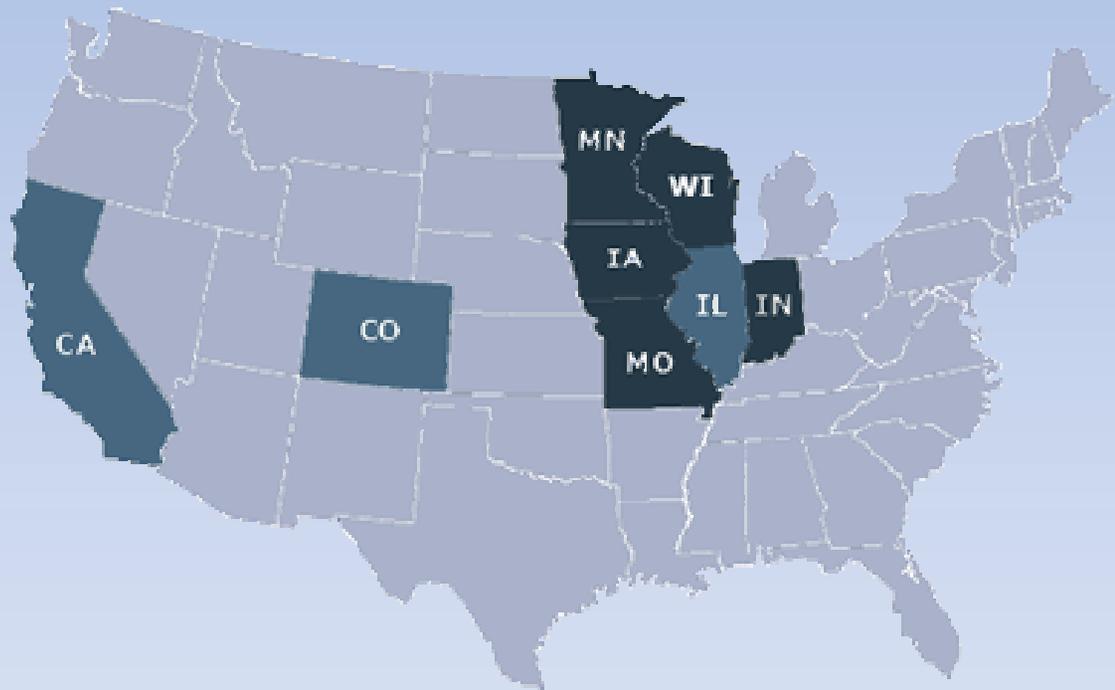
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Mihai Marataneu	(Minnesota University)
Jim McGraw	(Minnesota DOT)

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# Pooled Fund Partners

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



# Why a Pooled Fund Study?

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- 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
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# Pooled Fund Study Tasks

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

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# RAS Research Objectives

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<b>Agency</b>		<b>Research Interest</b>
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

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# Laboratory Testing Plan

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- 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
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# Iowa Demonstration Project

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



# Iowa Mix Properties

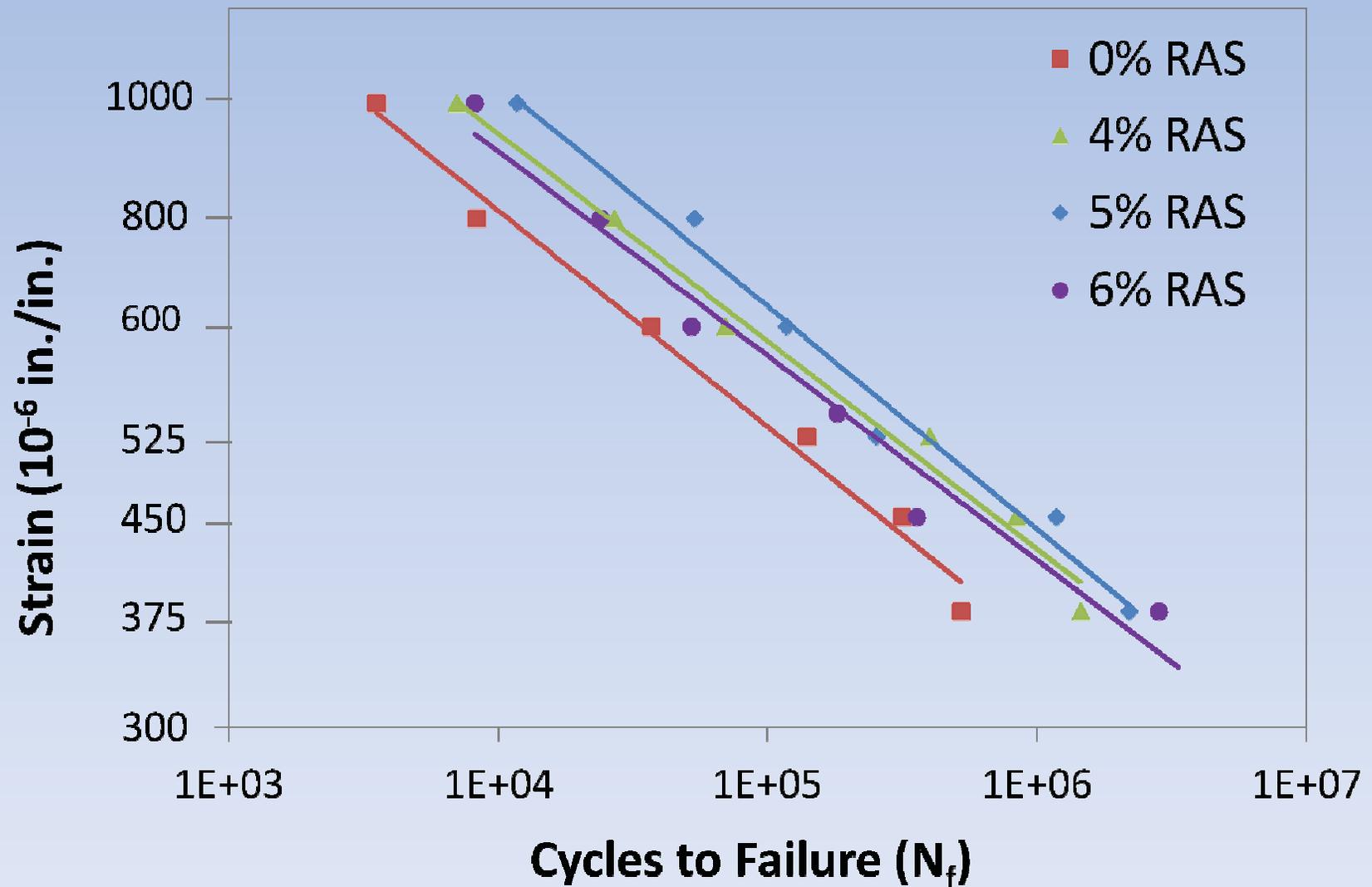
% RAS	0	4	5	6
% Binder Replacement	0	15.1	17.5	19.8
Low PG Grade	-20	-19	-17	-14
High PG Grade	73	76	81	86

RAS High PG Grade = 124.1

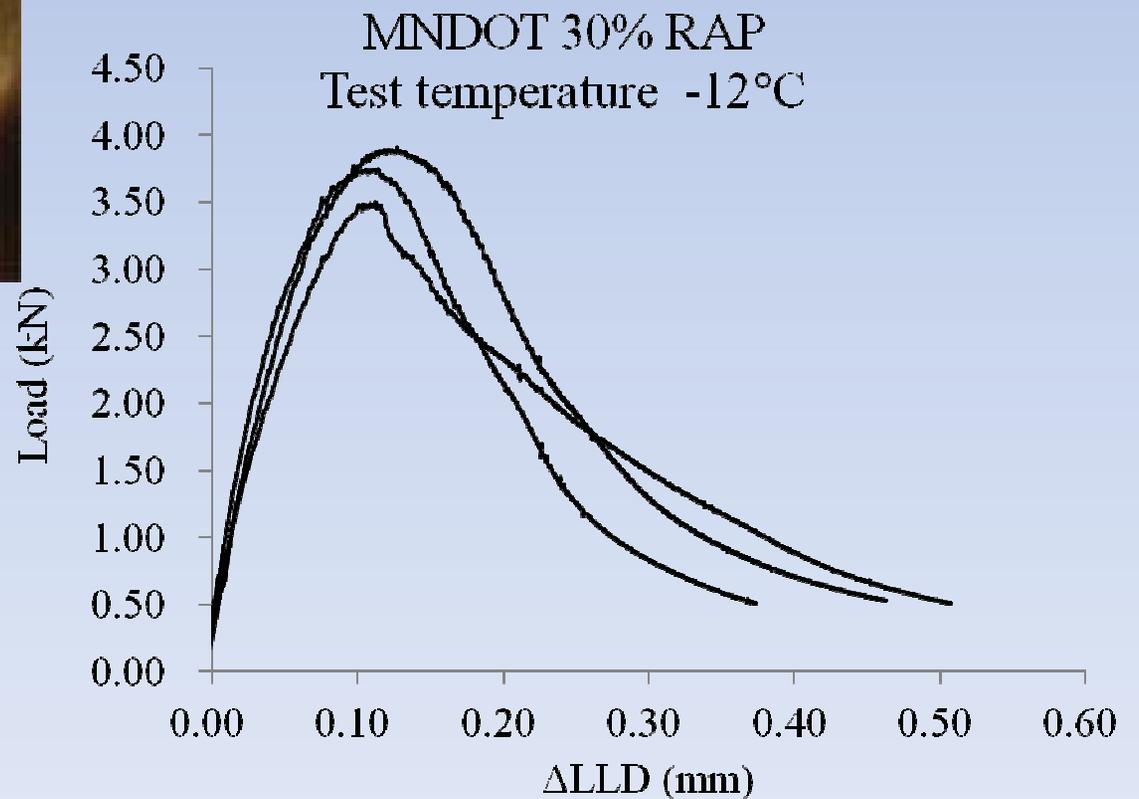
# 4-Point Bending Beam



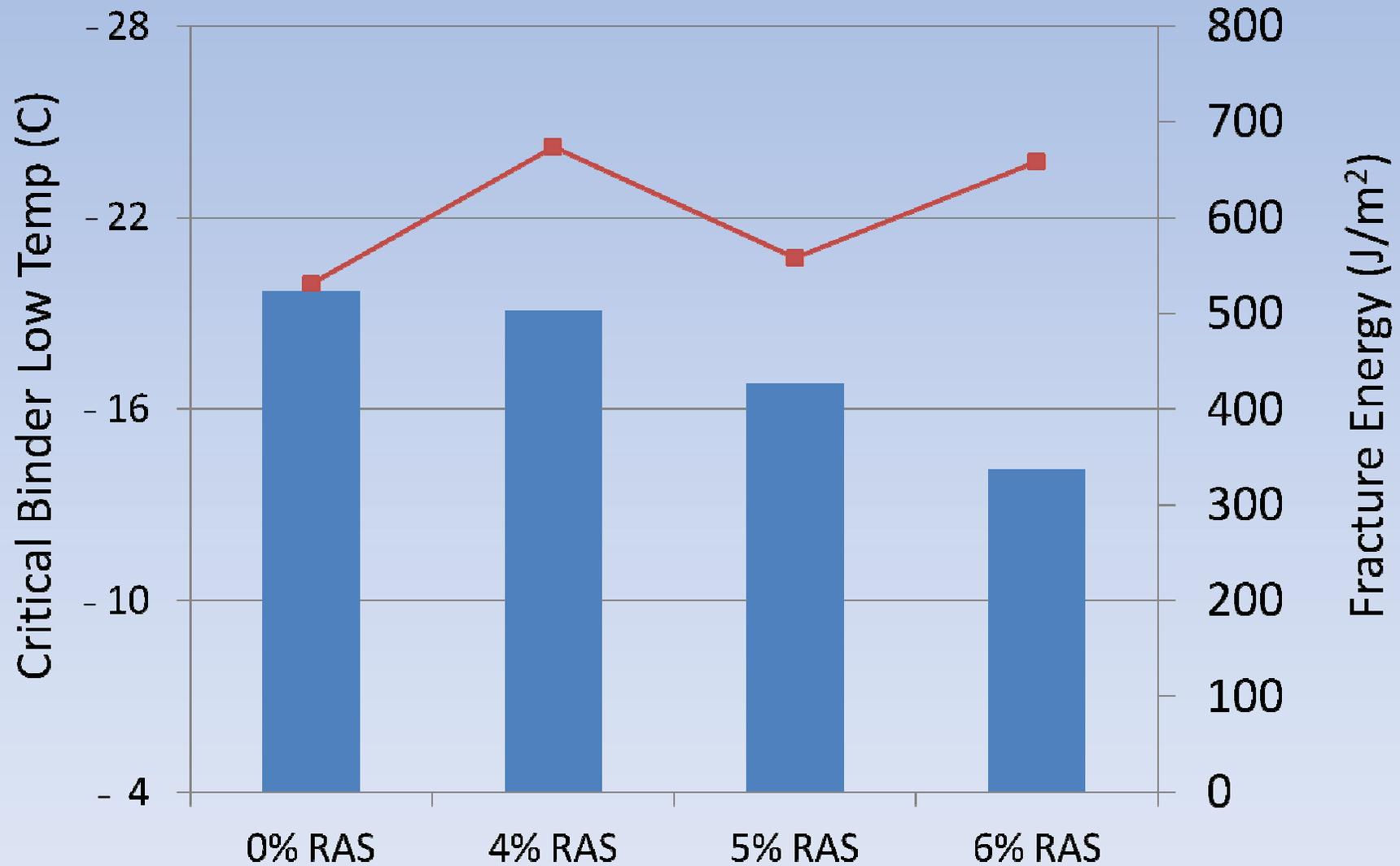
# lowa Fatigue Life



# Semi-Circular Bending Test

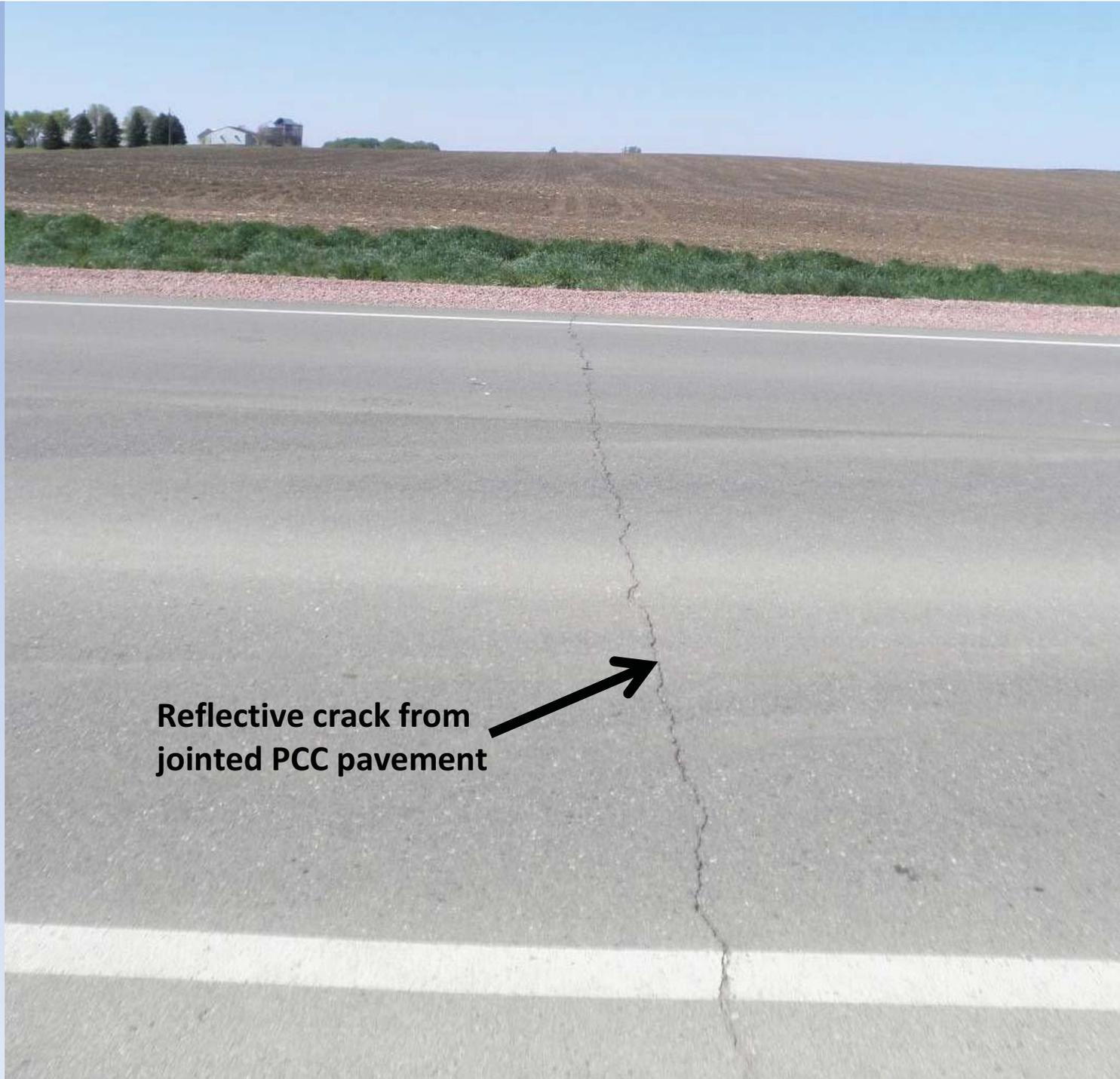


# Low Temperature Testing



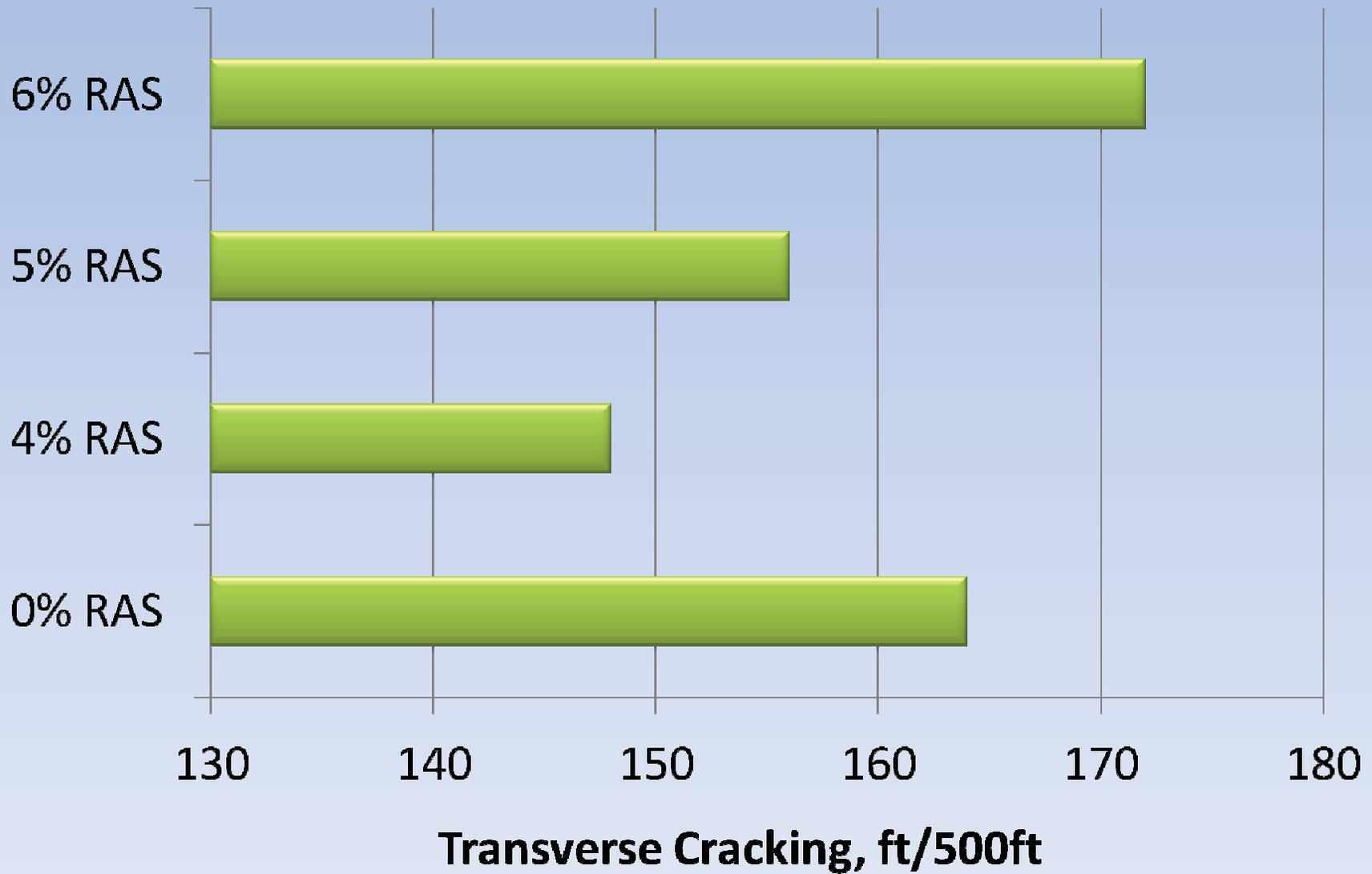






**Reflective crack from  
jointed PCC pavement**

# Iowa Pavement Evaluation



# Minnesota

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- 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

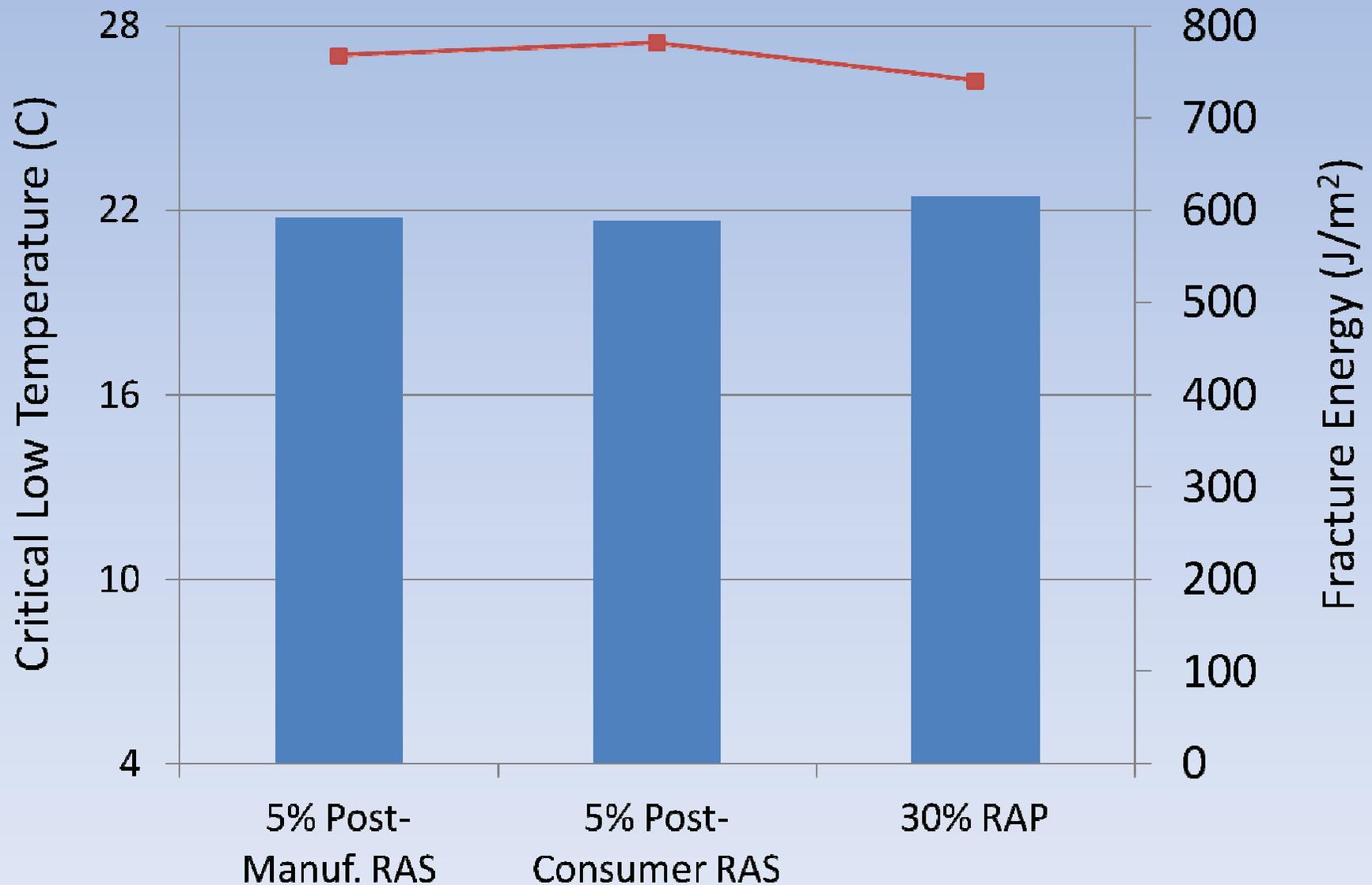


# Minnesota Mix Properties

	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

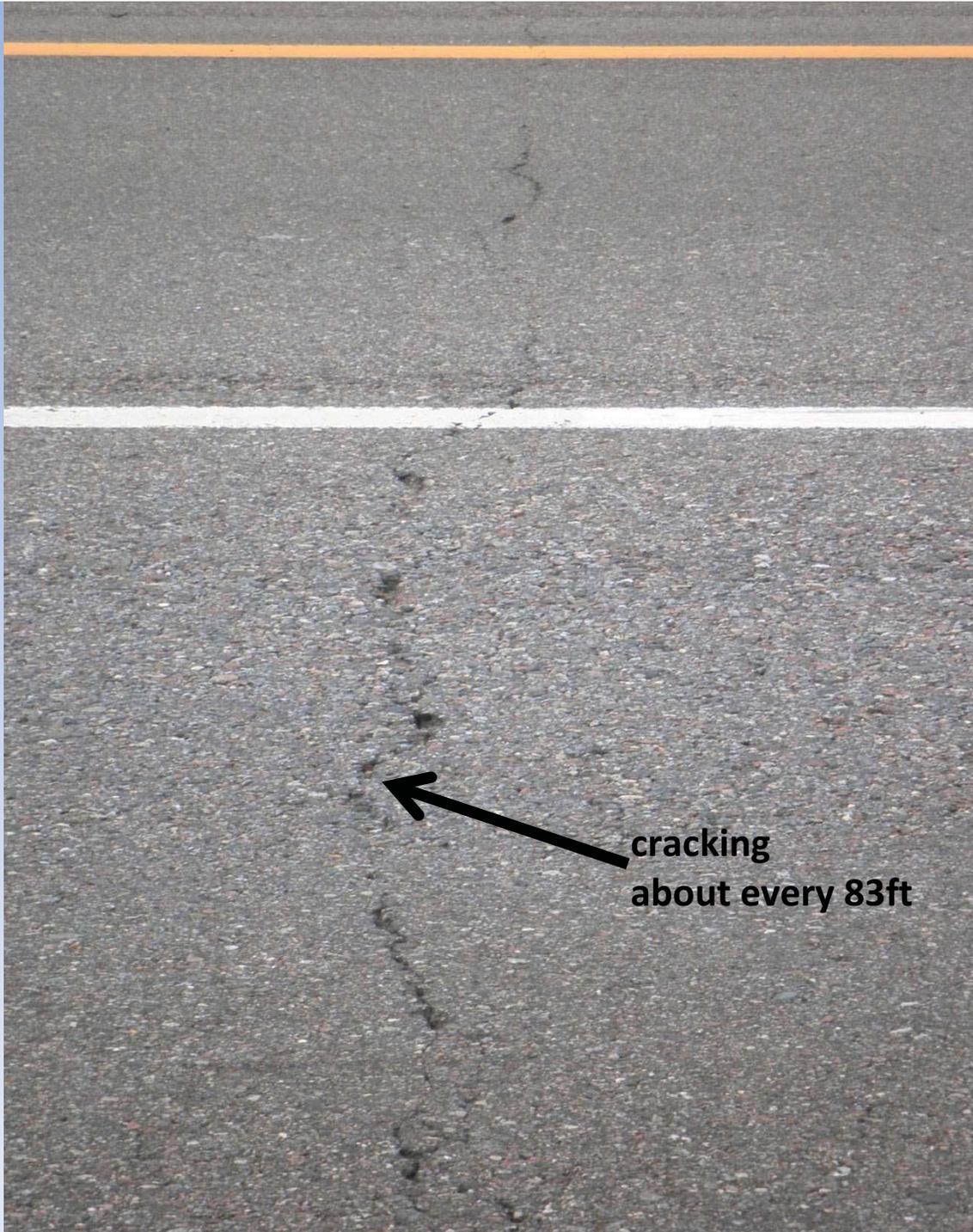




1000  
20

00

11274



cracking  
about every 83ft



# Missouri RAS

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100% passing 3/8"

95% passing #4



25.0% AC

100% passing 1/2"



21.7% AC

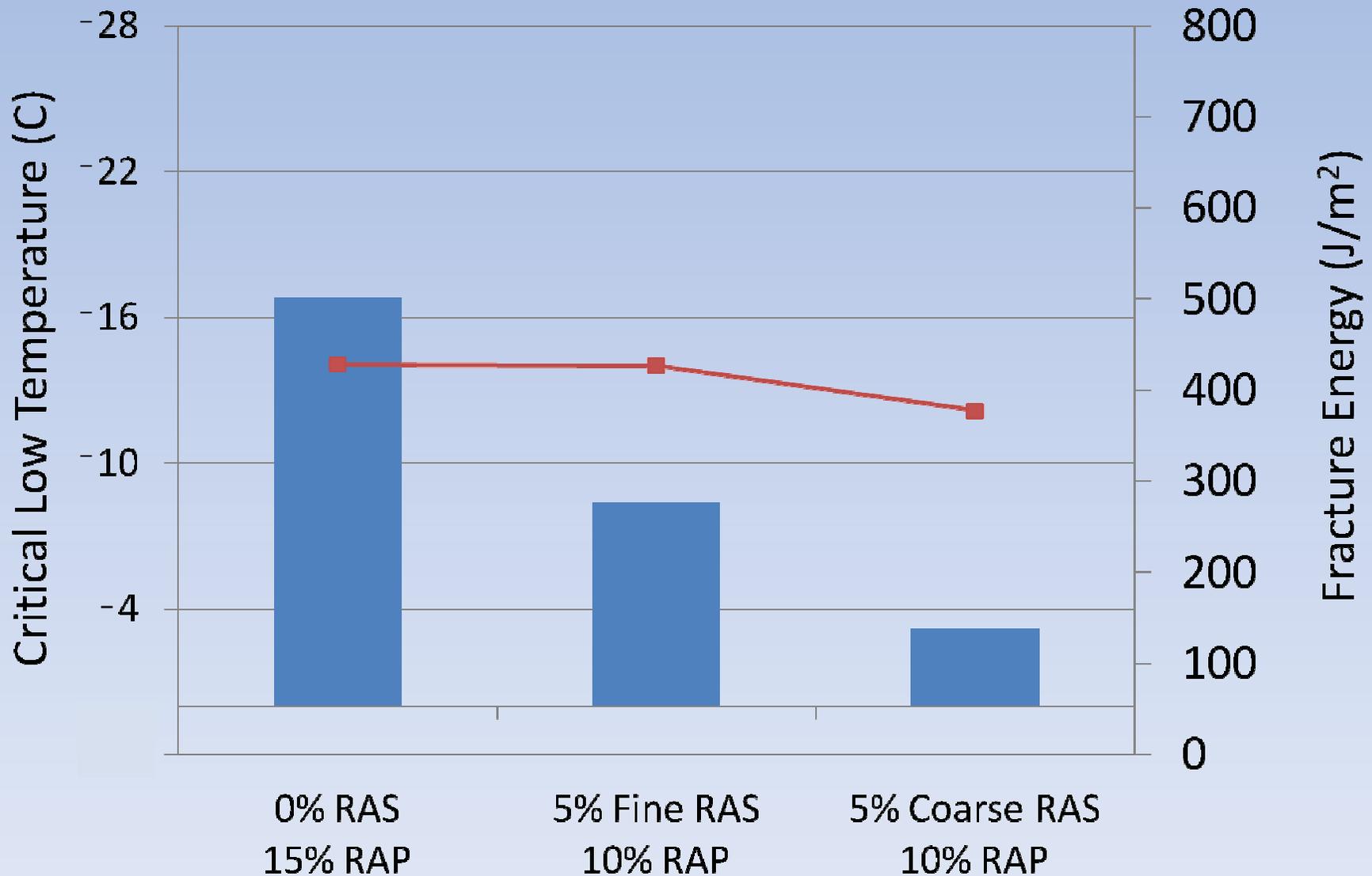
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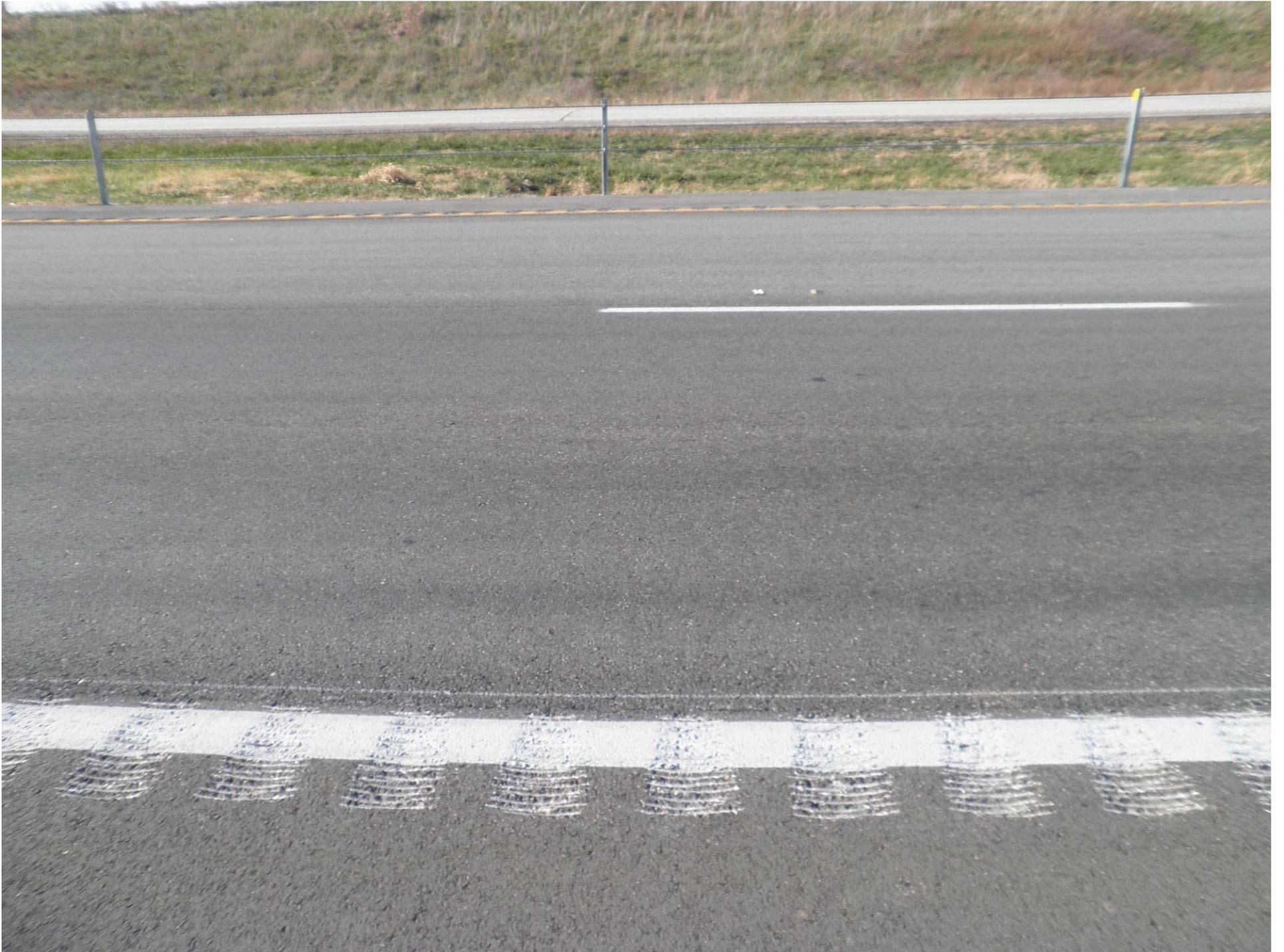
# Missouri Mix Properties

	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

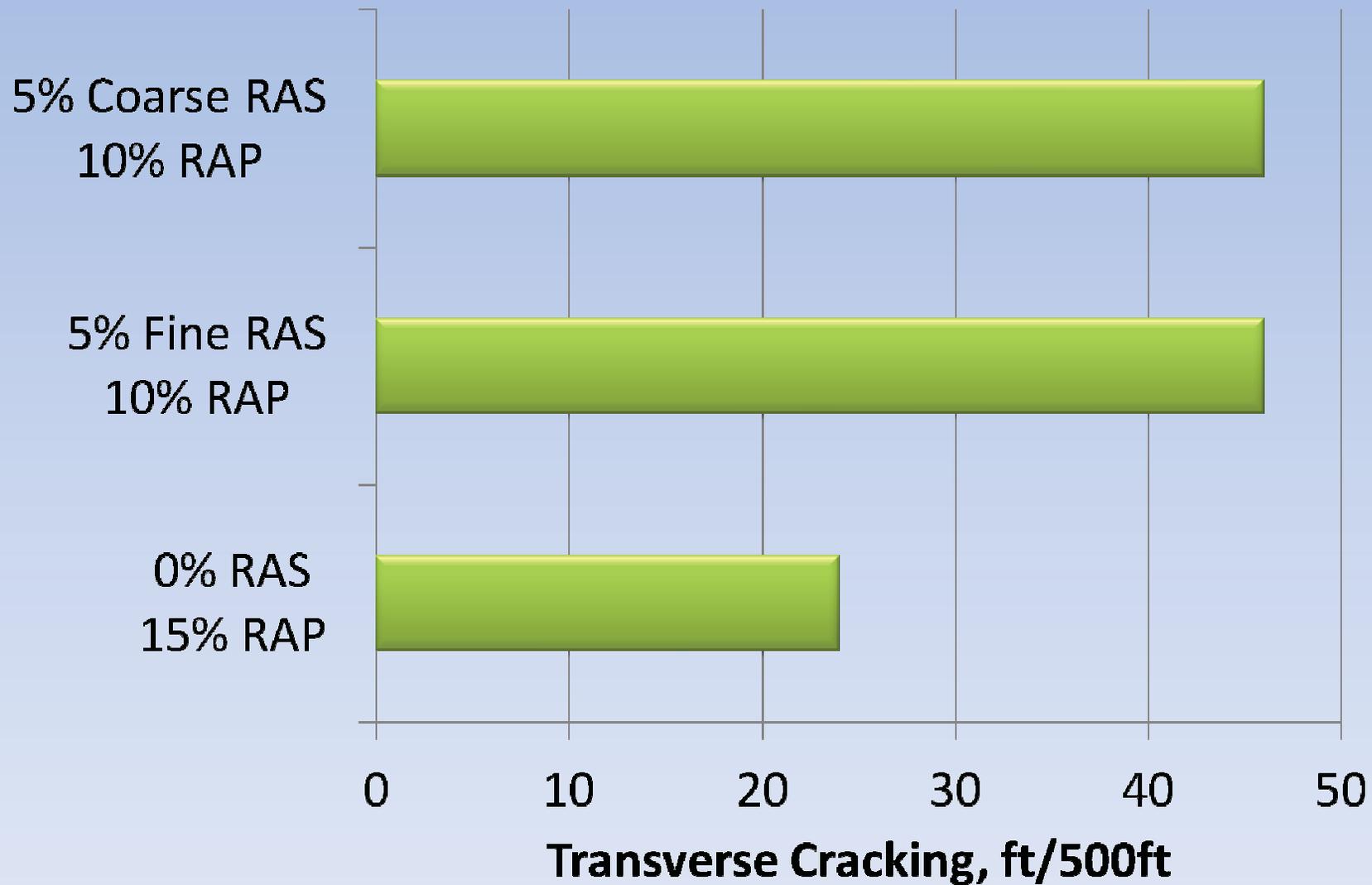
RAS High PG = 137   RAS High PG = 146

# Low Temperature Testing





# Missouri Pavement Evaluation



# Indiana

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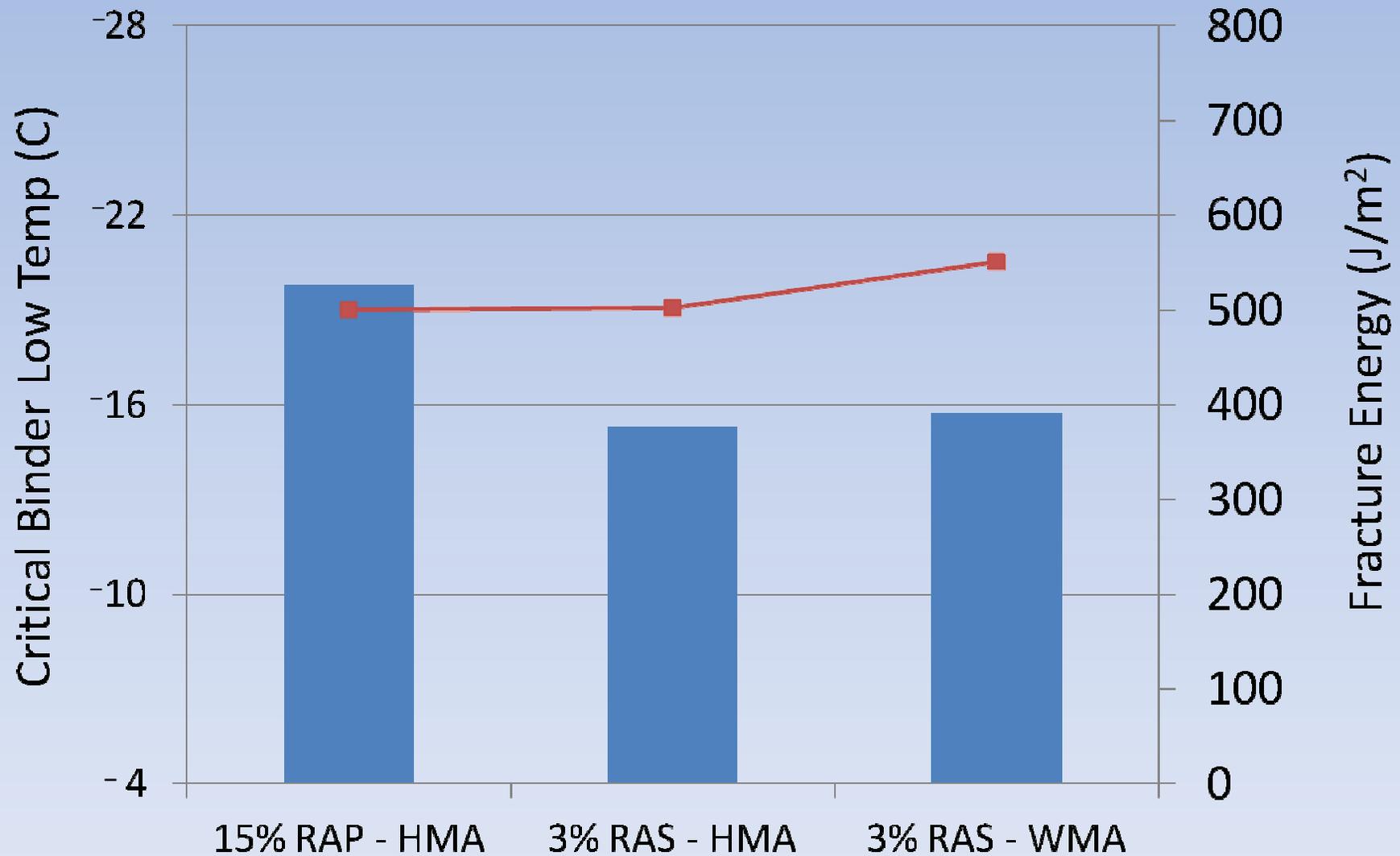
- US 6 in north central Indiana
- July 2009
- 9.5mm, 1.5" overlay
- Post-Consumer RAS
- Warm Mix vs. Hot Mix
- Foamed Technology
- 10M > 30M EASLs
- PG 70-22



# 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











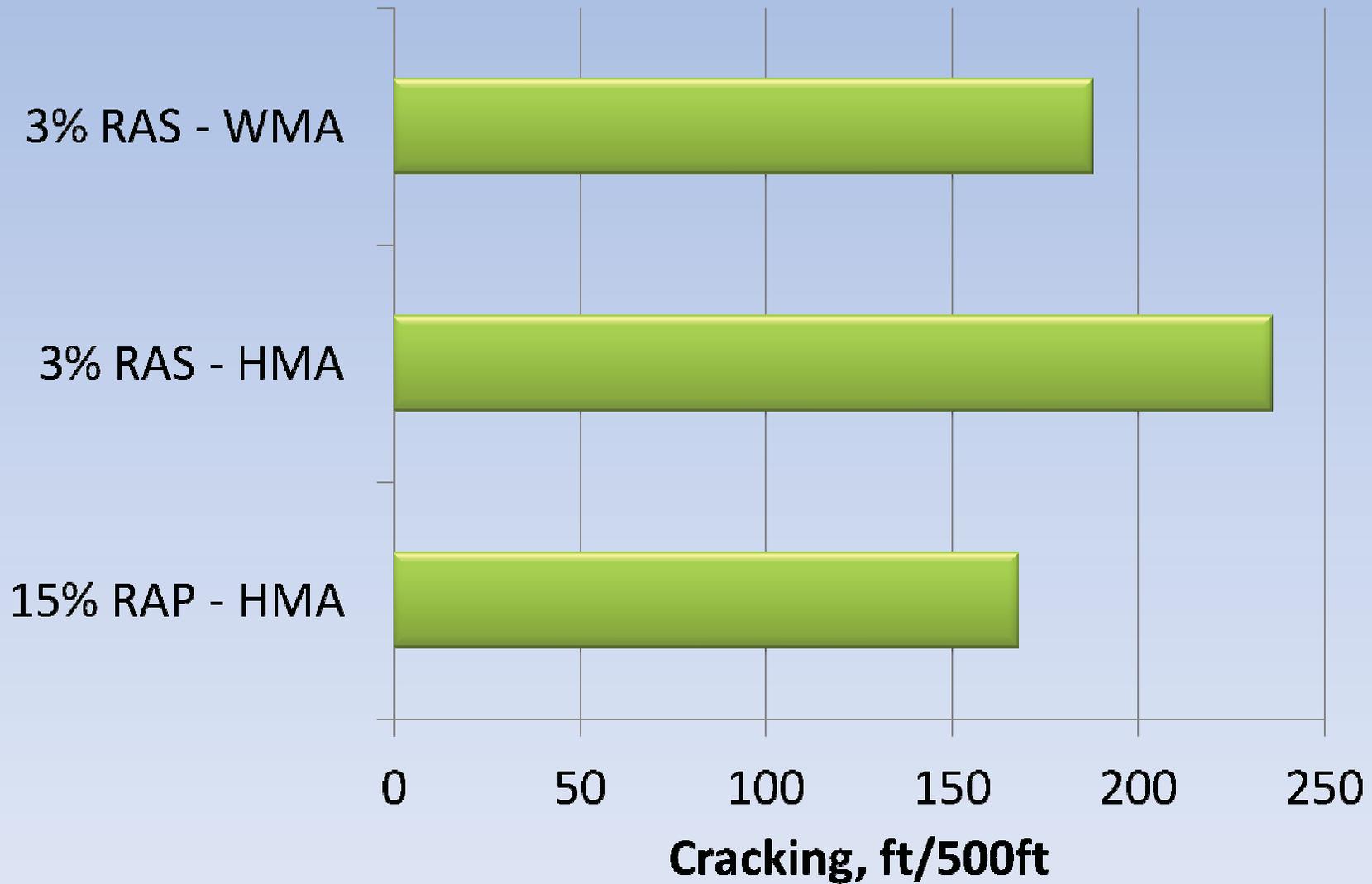
Reflective cracking from jointed PCC pavement

Edge cracking

**Crack does not  
propagate into  
RAS section**



# Indiana Pavement Evaluation



# Colorado

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- 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

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



[www.intrans.iastate.edu/tpf-5-213](http://www.intrans.iastate.edu/tpf-5-213)

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