Investigation of Low Temperature Cracking – TPF-5(132)

NCAUPG Technical Conference

2/16/2012

TPF-5(132)

- Researchers

  Mihai Marasteanu
  Eyoab Zegeye Teshale
  Ki Hoon Moon
  Mugur Turos

  Chris Williams
  Ashley Buss

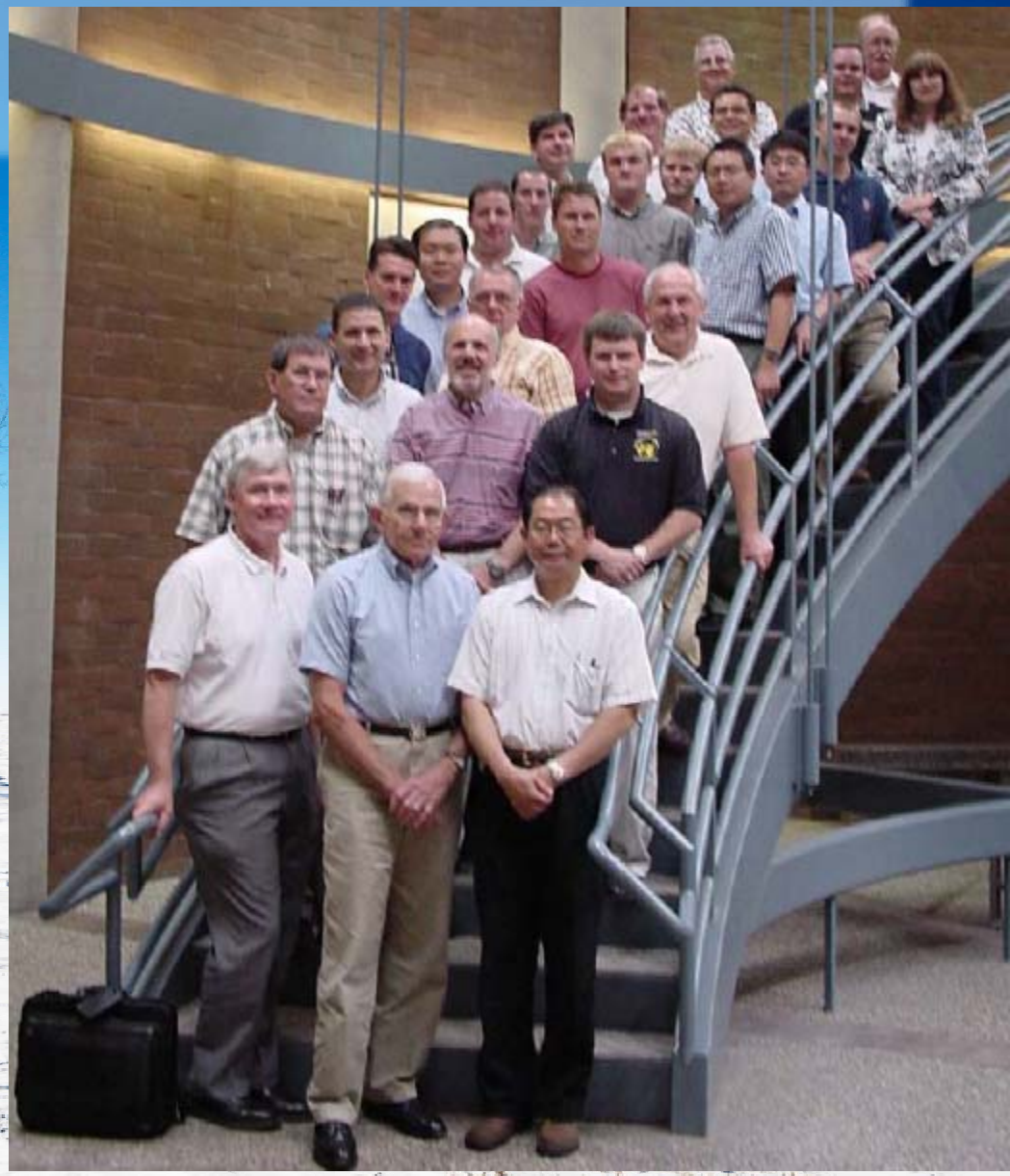
  Bill Buttlar
  Eshan Dave
  Sarfraz Ahmed

  Hussain Bahia
  Raul Velasquez
  Amir Arshadi

- Partners (MnDOT, LRRB, CTDOT, NYDOT, IADOT, WisDOT, NDDOT)

Phase I

- Conclusions
  - Binder testing not enough
  - Must move toward fracture-based testing
  - Improve TC Model
    - Include effects of physical hardening
    - Thermal cycling



August 2003 TAC

Phase II

- Characterize low temperature cracking performance
  - Mix Tests
    - Disc-Shaped Compact Tension Test
    - Semi-circular Bending Test
    - Indirect Tension Test (IDT Creep)
  - Binder tests

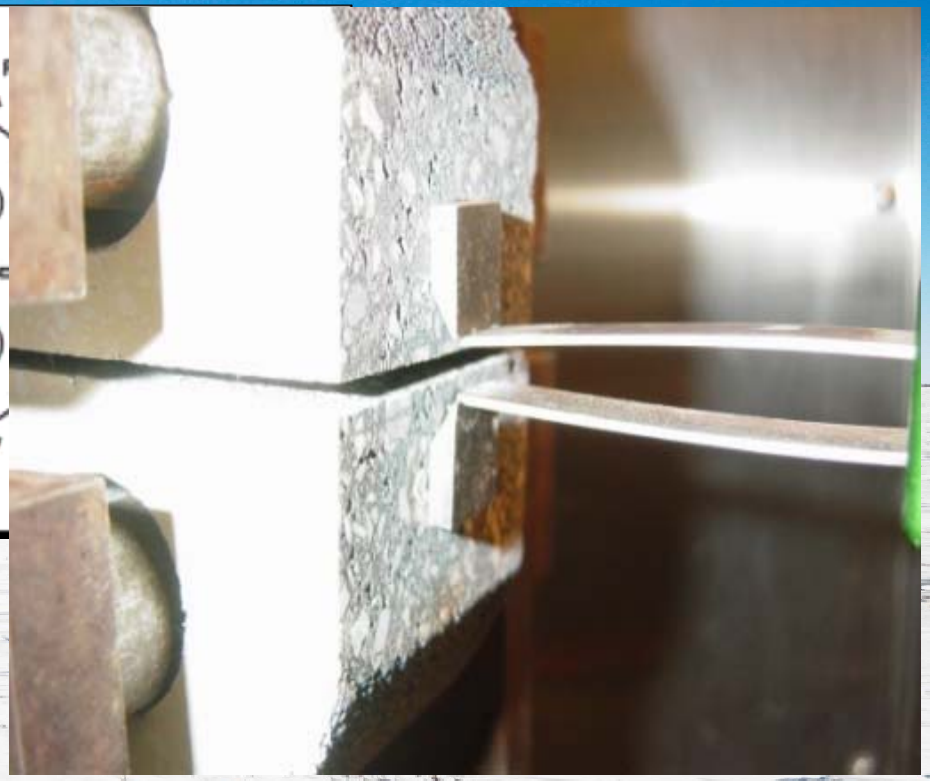
    Single Edge Notched Beam

    Dilatometic (Volume Change)

Phase II

- Improve modeling for pavement design
  - Asphalt Thermal Cracking Analyzer
  - Single Edge Notched Beam
- Field Validation
- Implementation

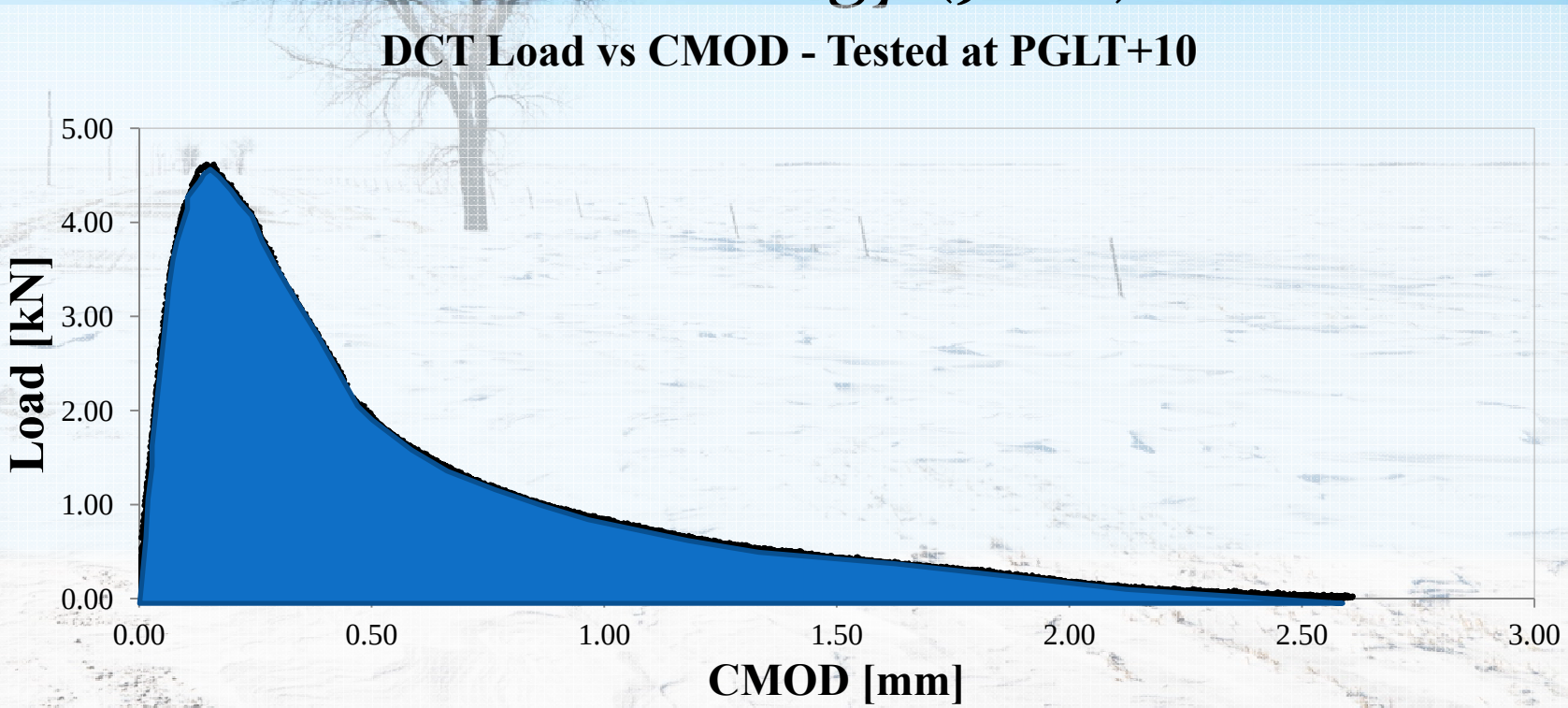
Disc-Shaped Compact Tension Test (DCT)



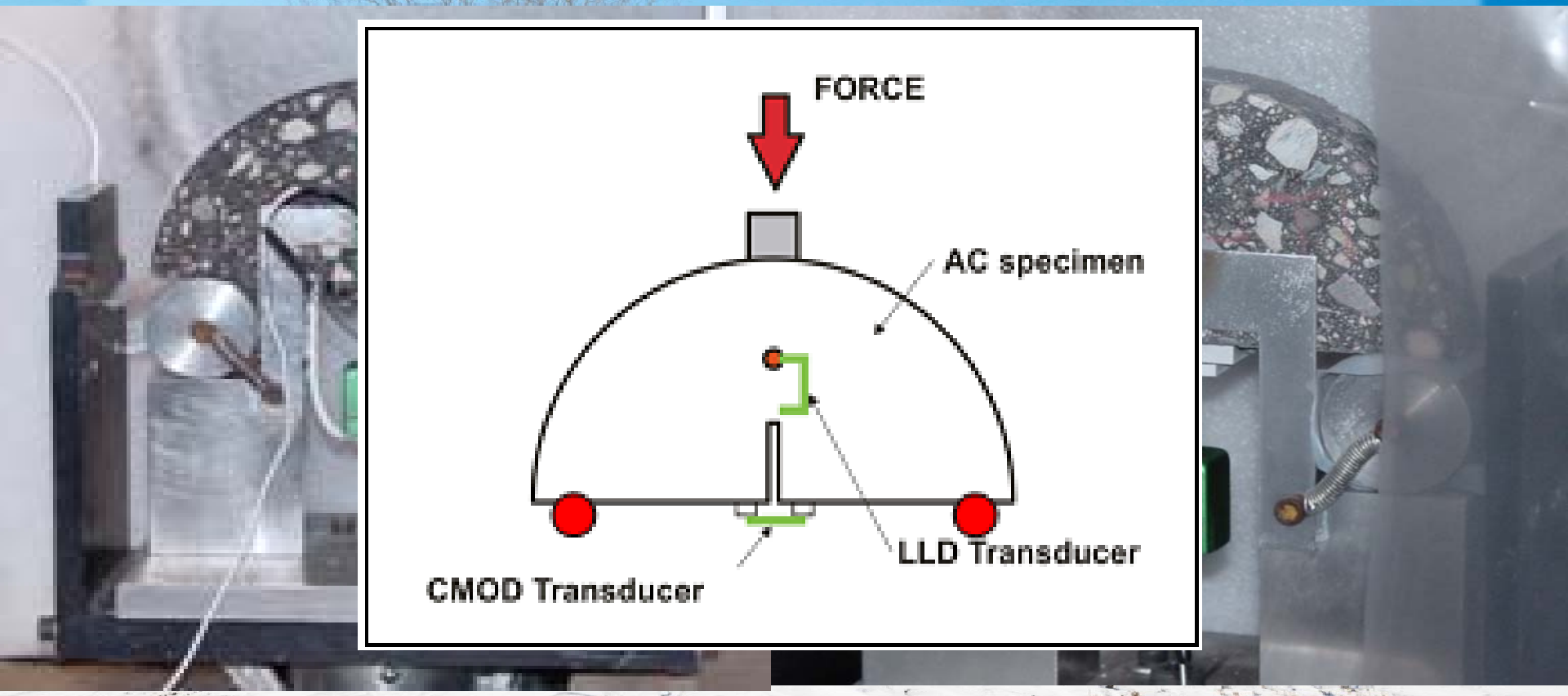
Buttlar, et. al

Disc-Shaped Compact Tension (DCT)

- ASTM D7313
- 10°C warmer than PG low temperature
- Measure Fracture Energy (J/m²)



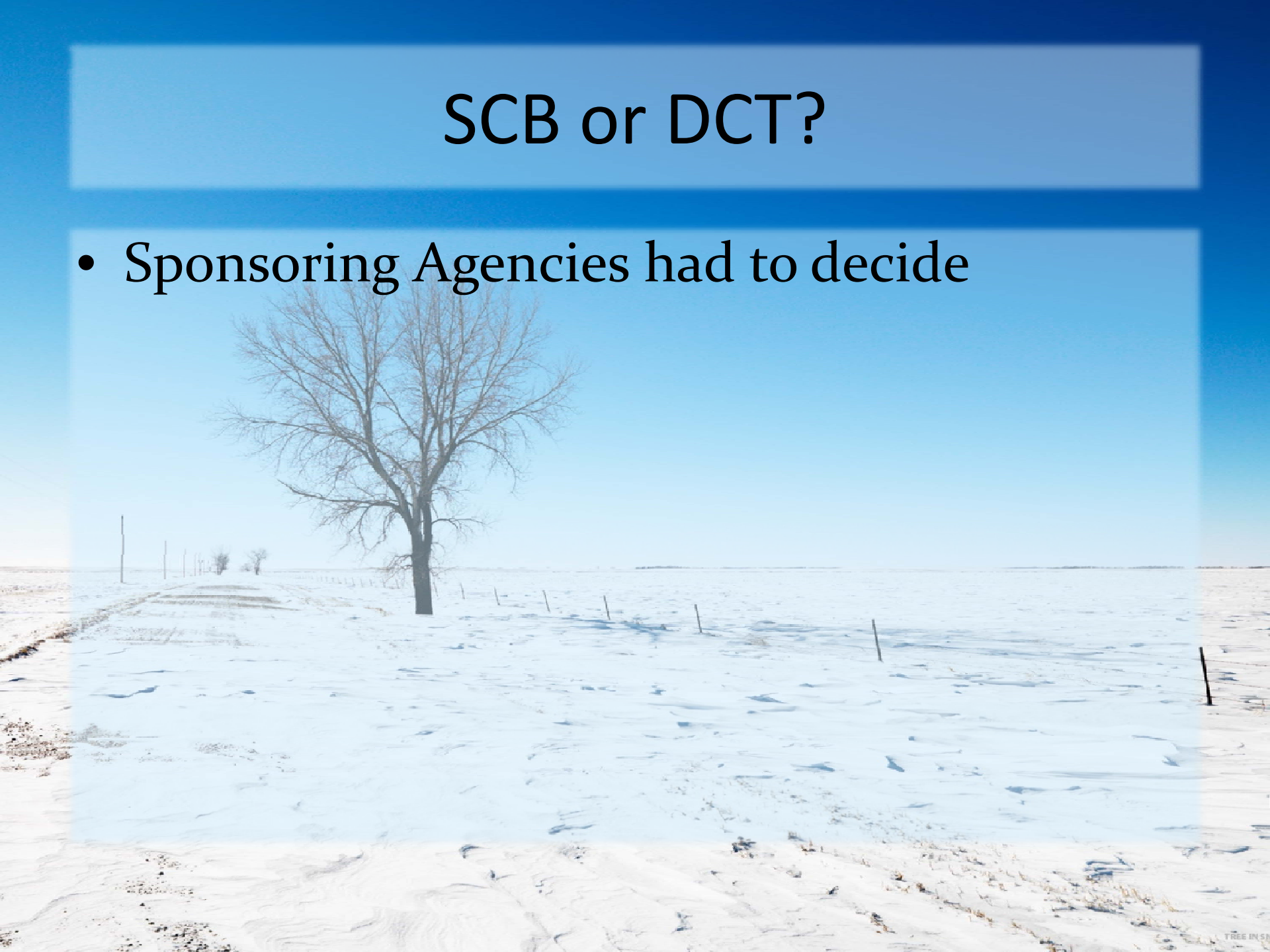
Semi-Circular Bending Test (SCB)



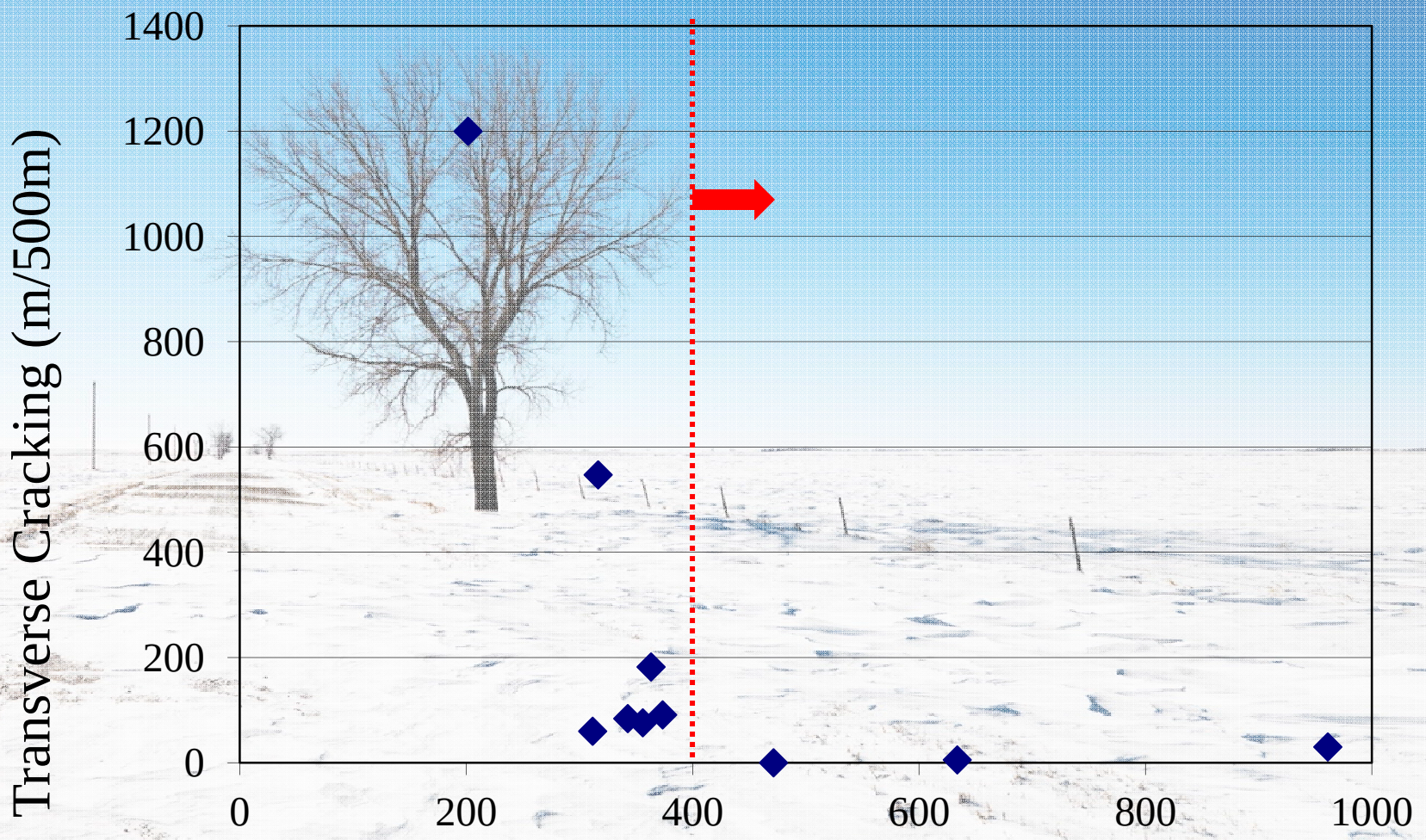
Marasteanu, et. al

SCB or DCT?

- Sponsoring Agencies had to decide

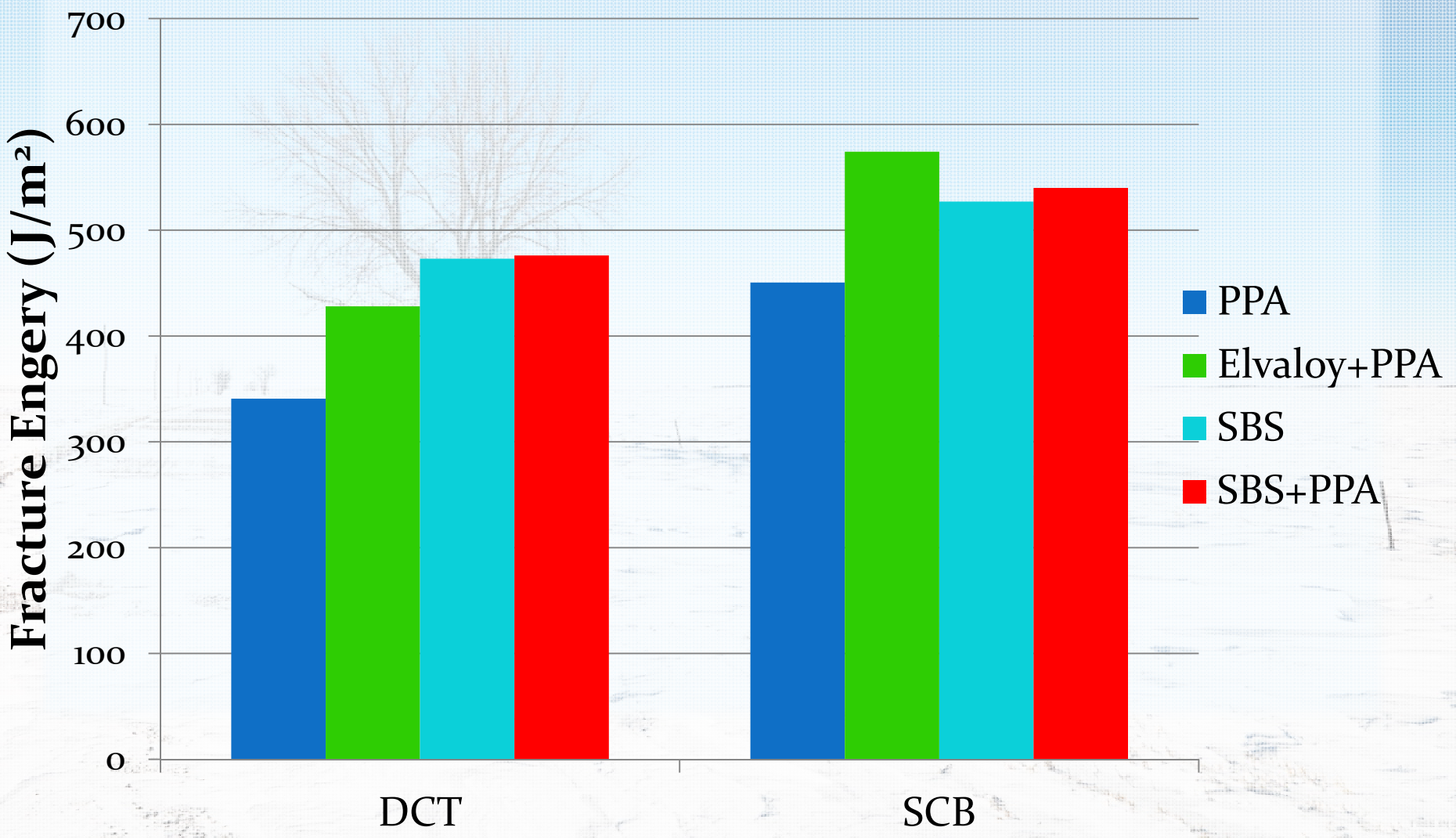


DC(T) Fracture Energy at PG Low Temperature Grade +10C (Buttlar et al., 2010)



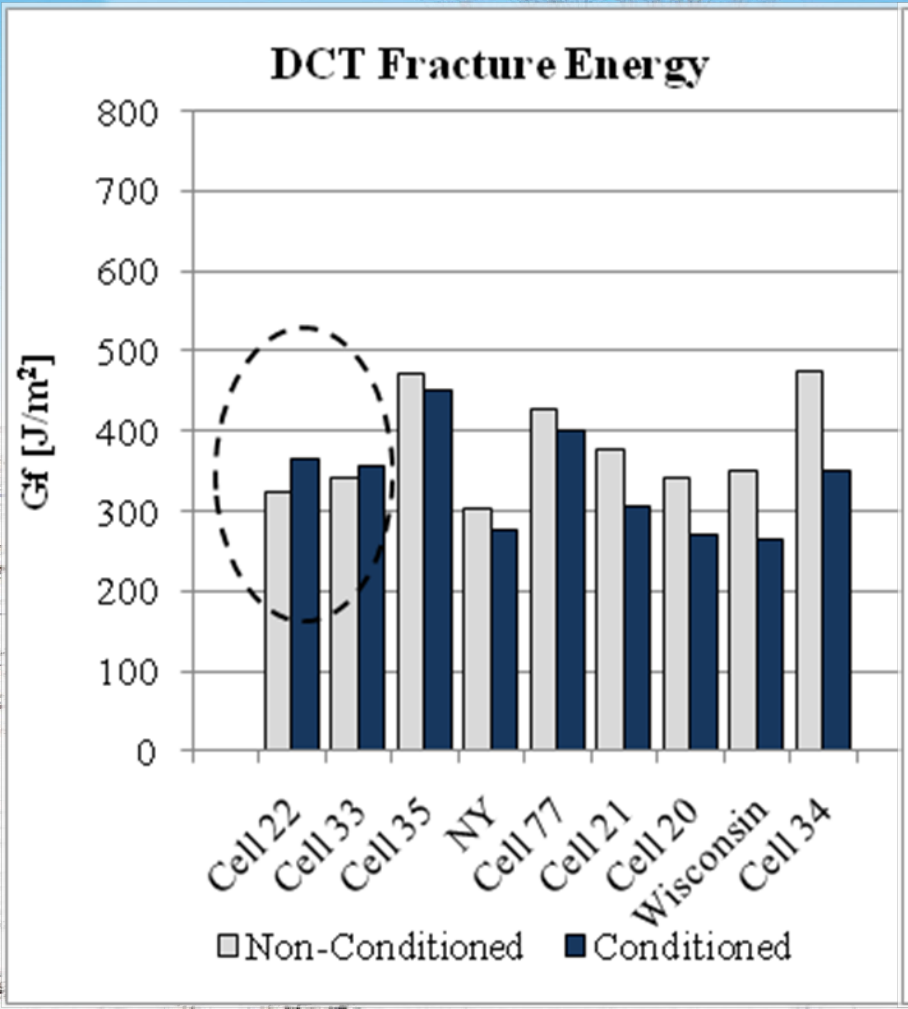
Buttlar, et. al

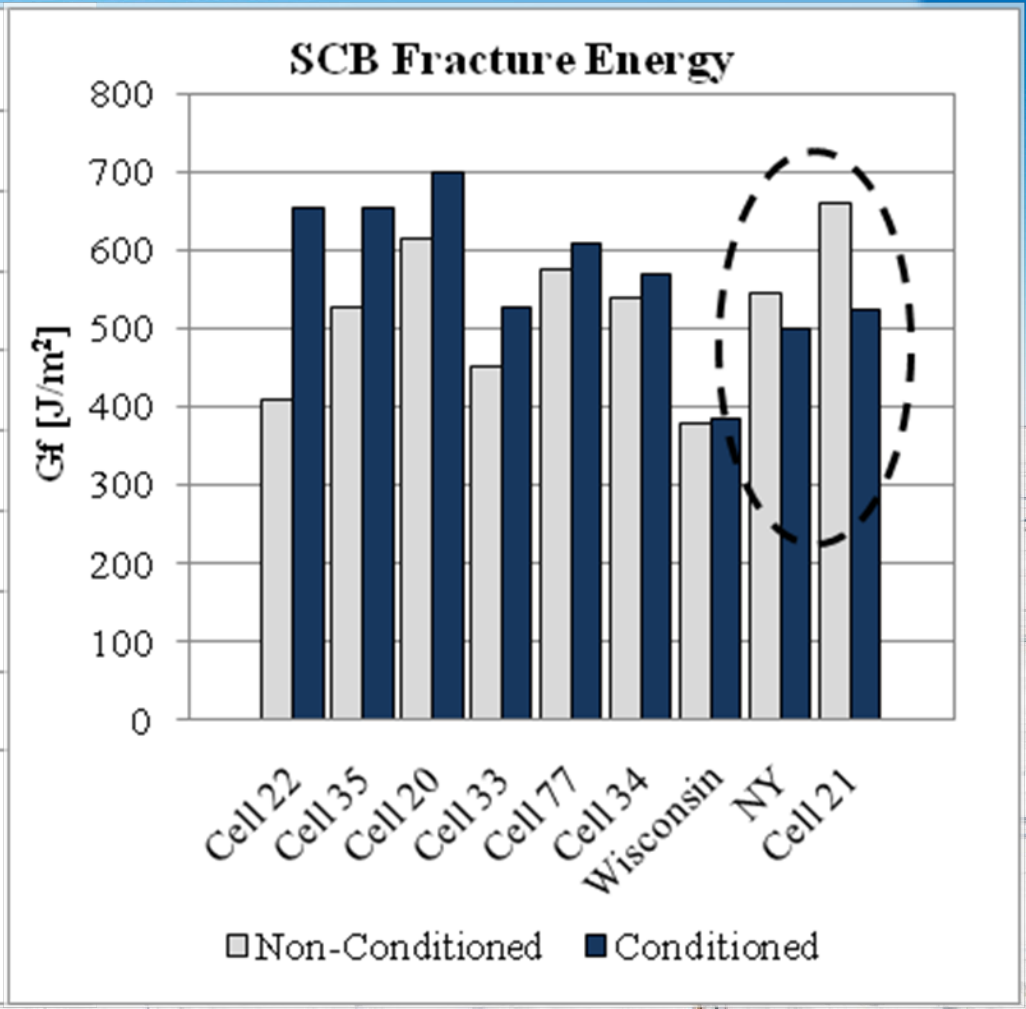
Effects of Modifiers



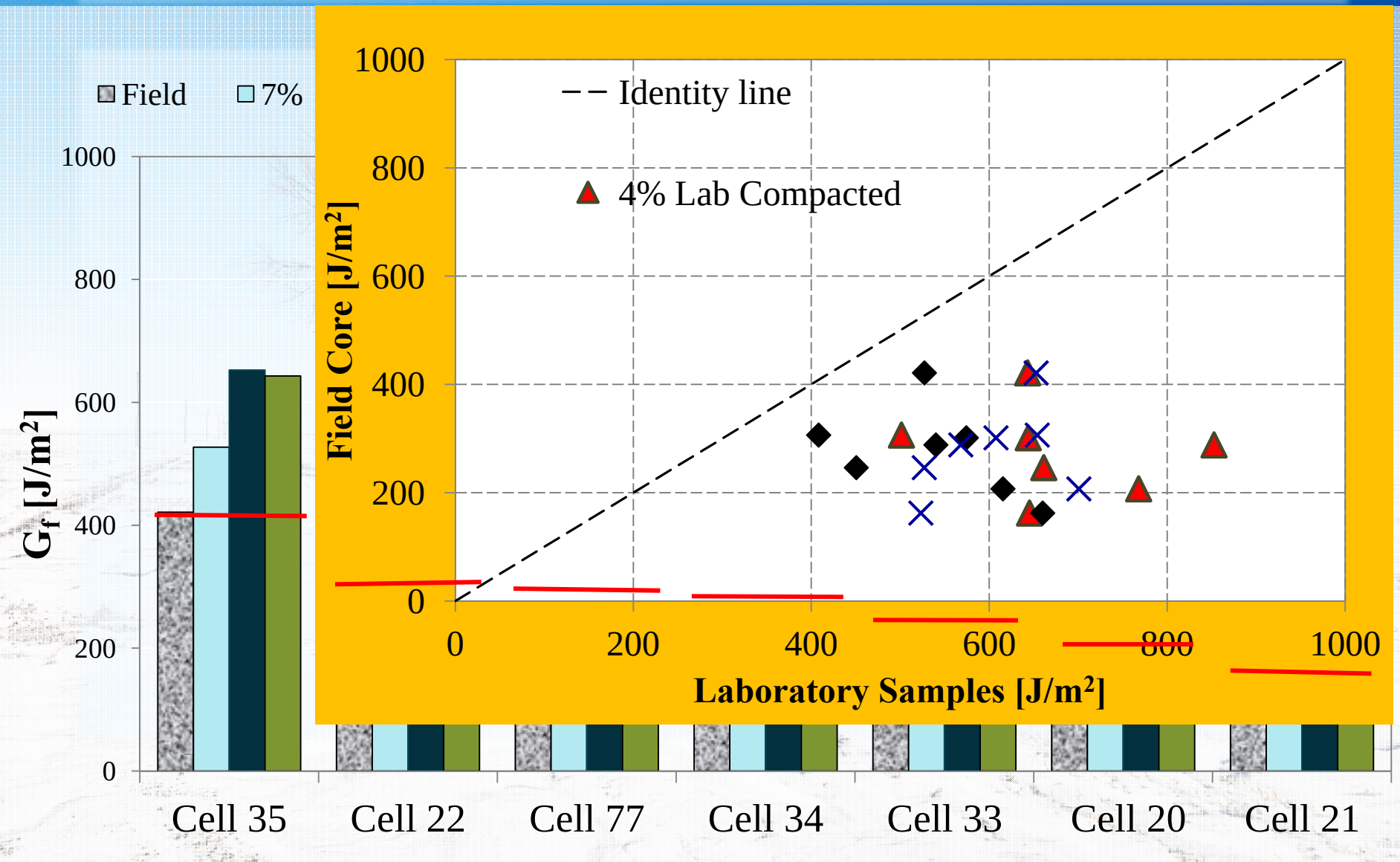
Effects of Conditioning

- AASHTO R30-02 (5 days at 85°C)





SCB – Cores (2-3 years old) vs. Lab



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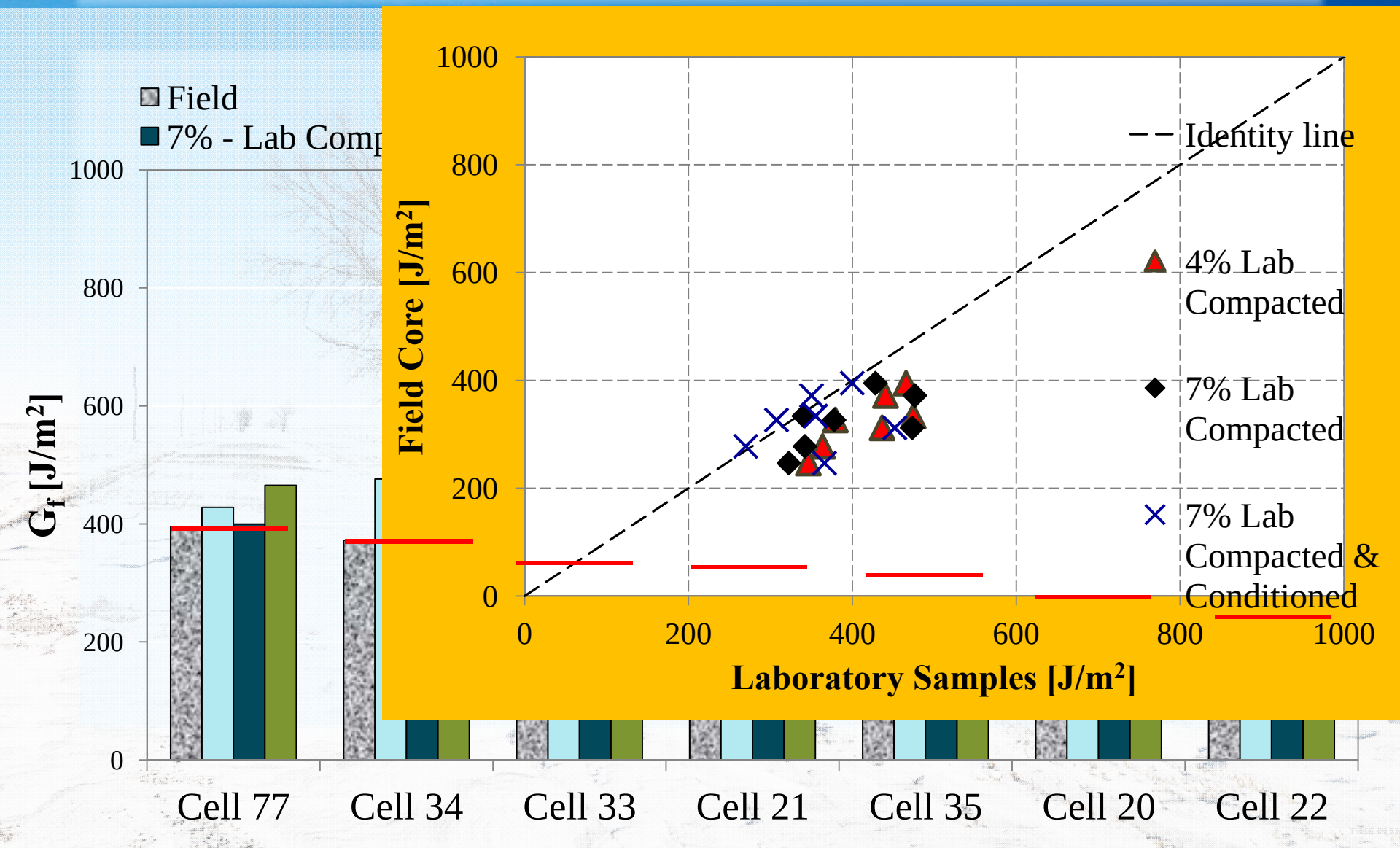
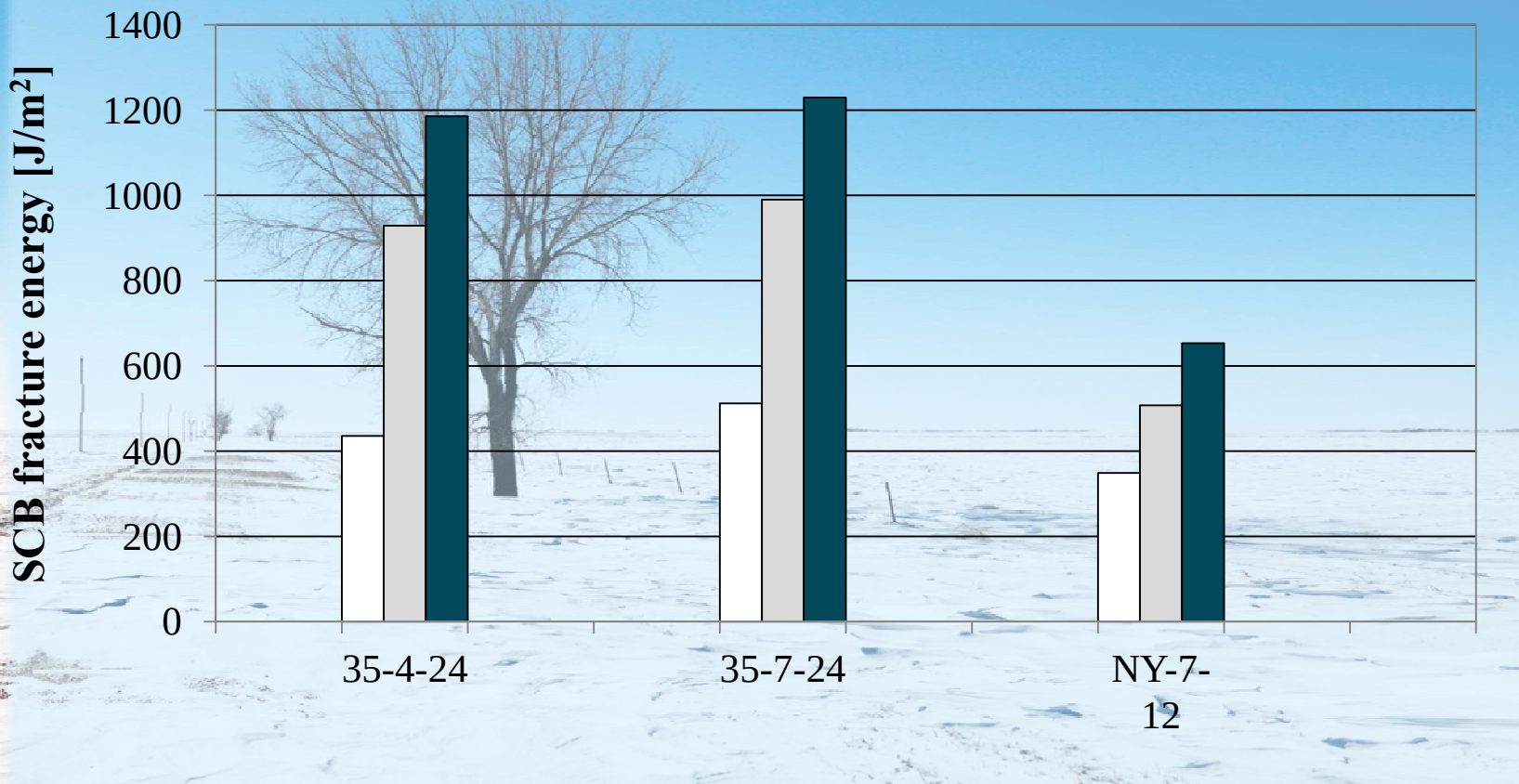


Multi-Lab Variability - SCB



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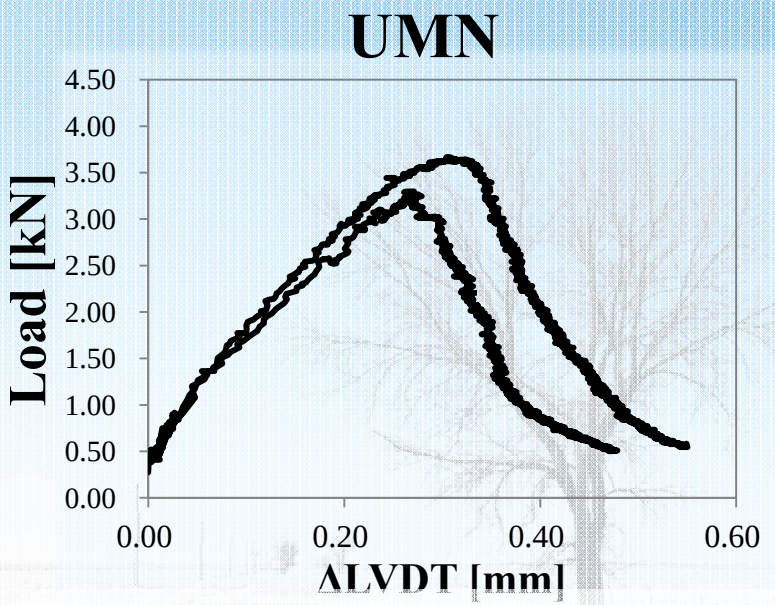

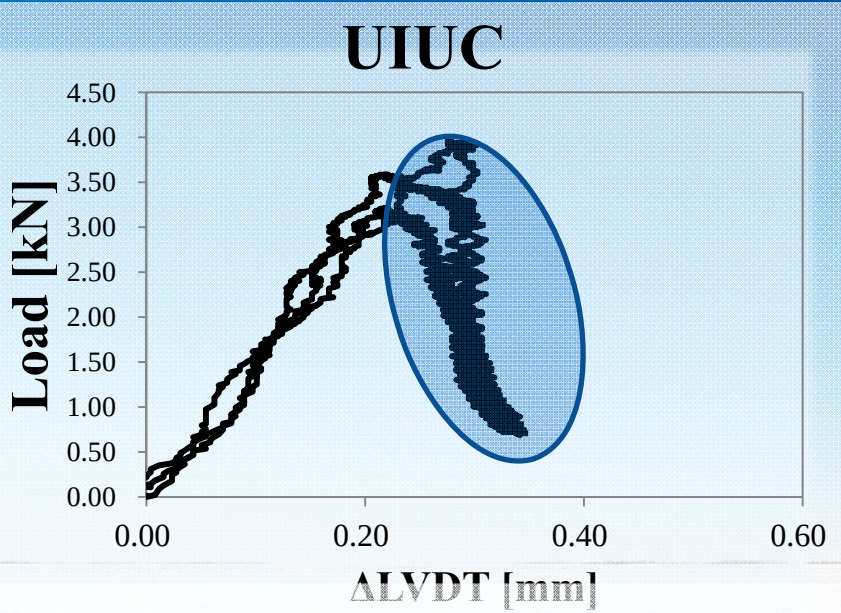

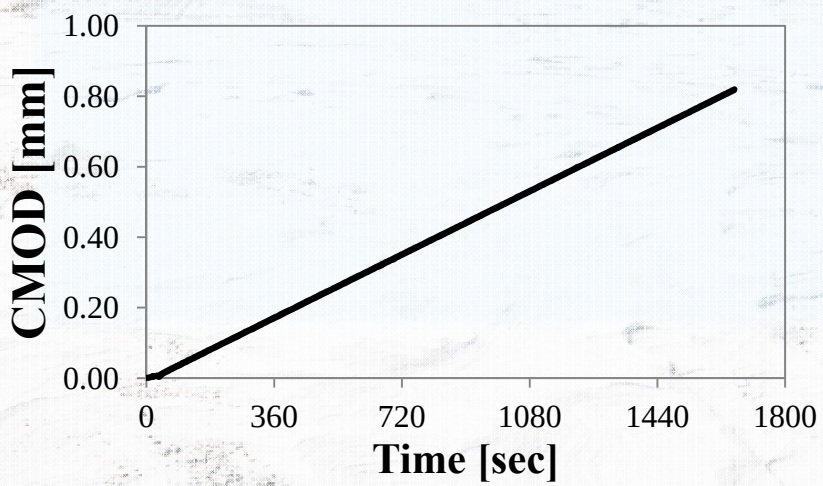

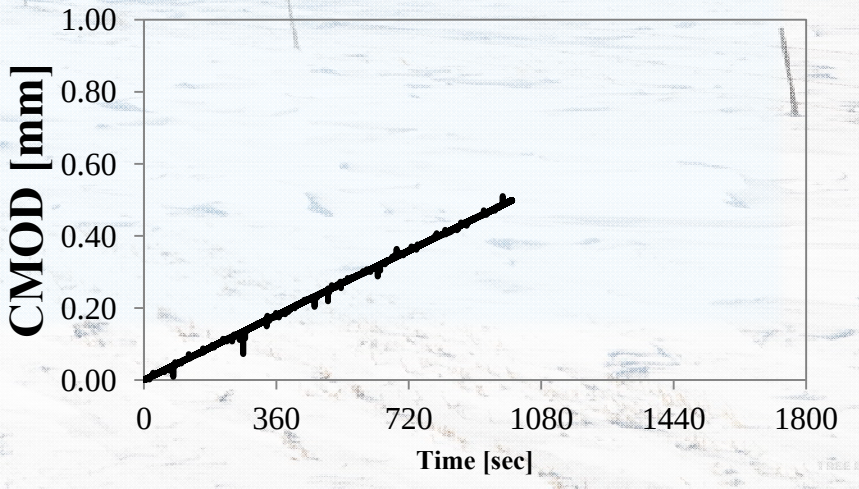

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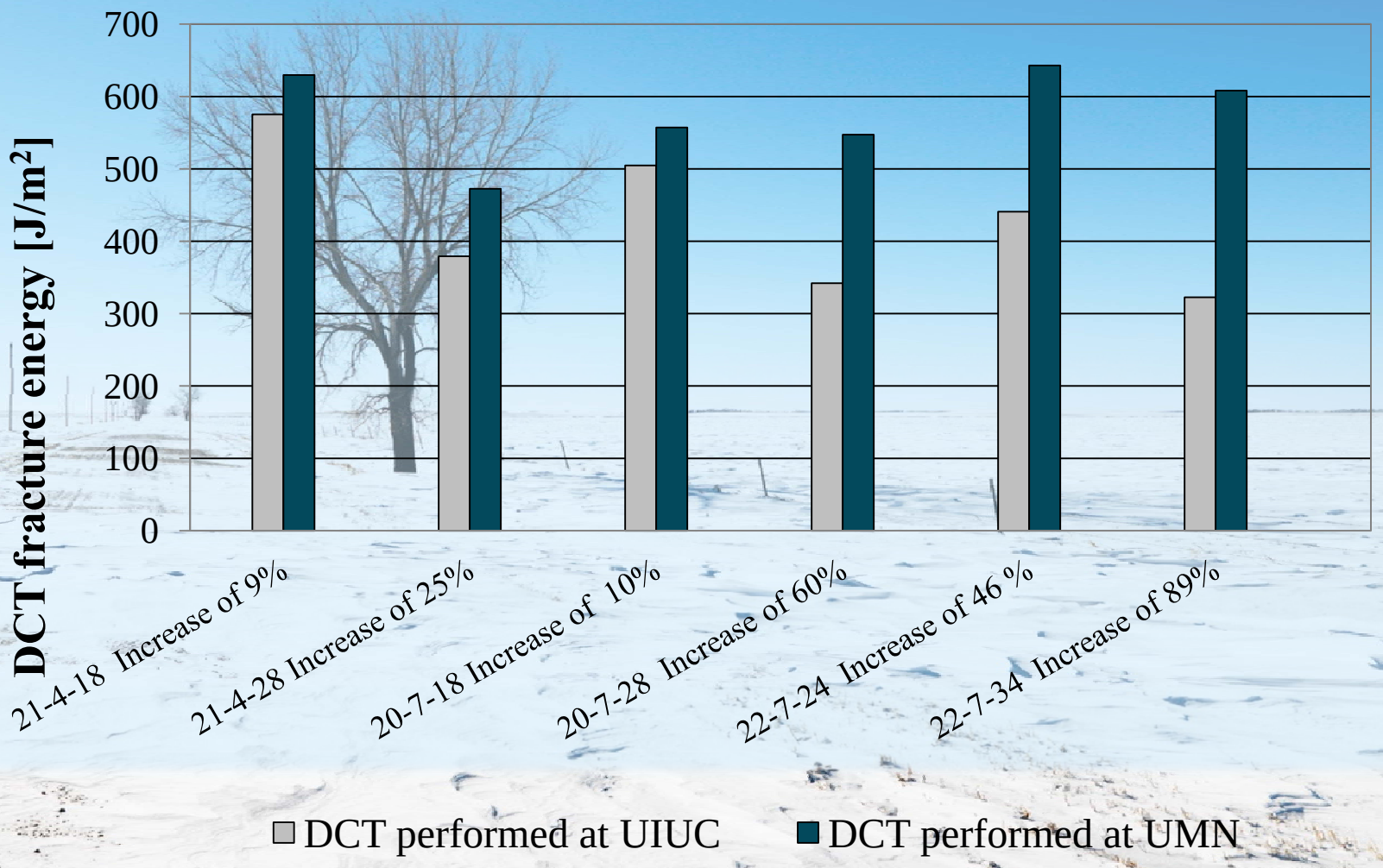

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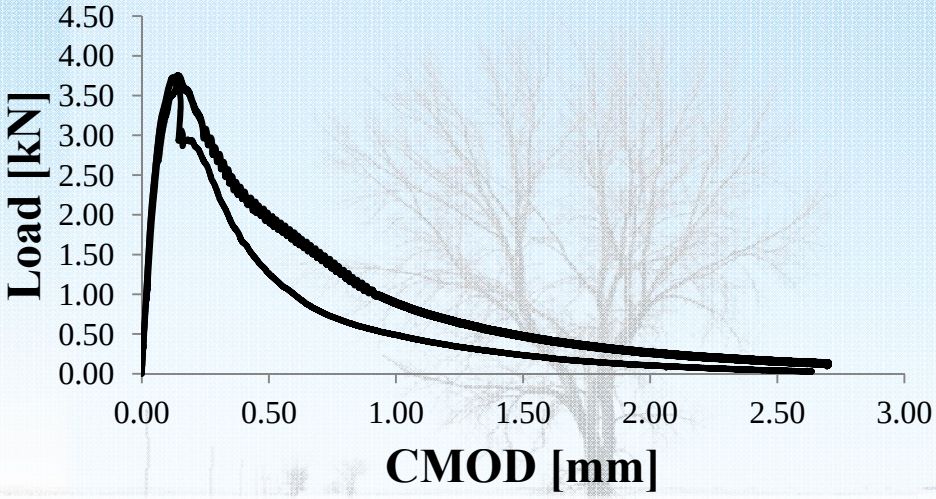
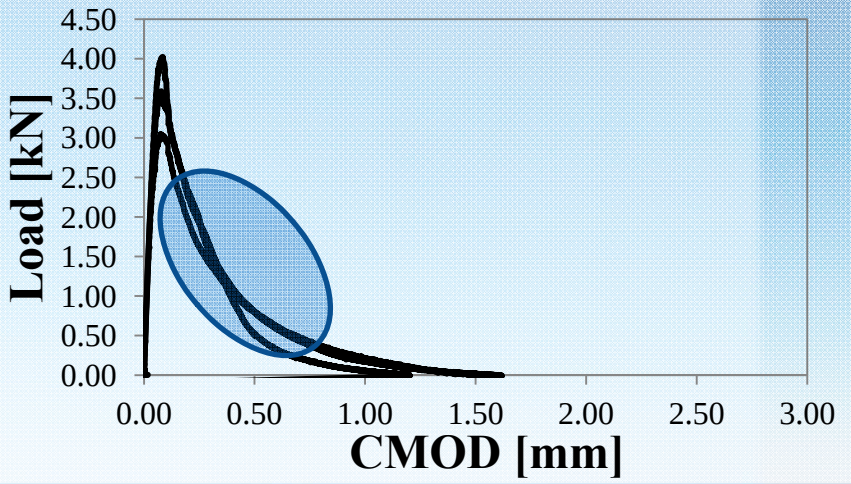
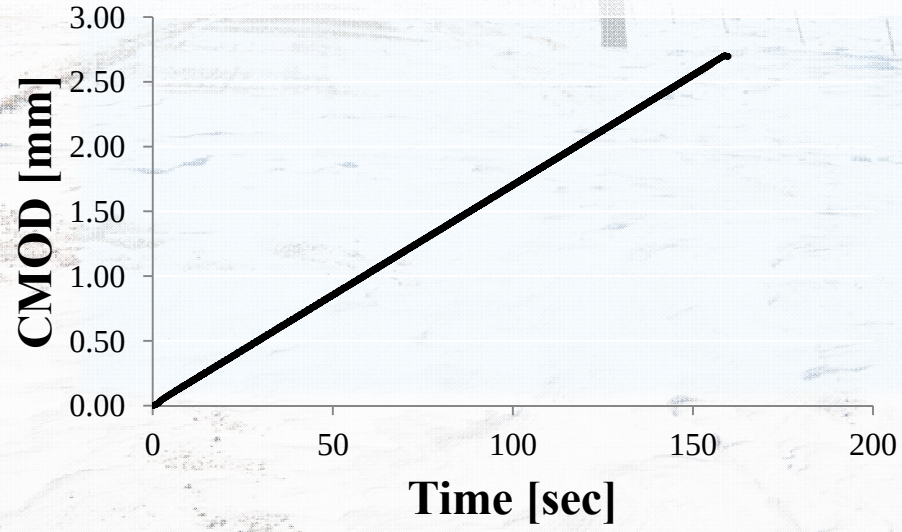
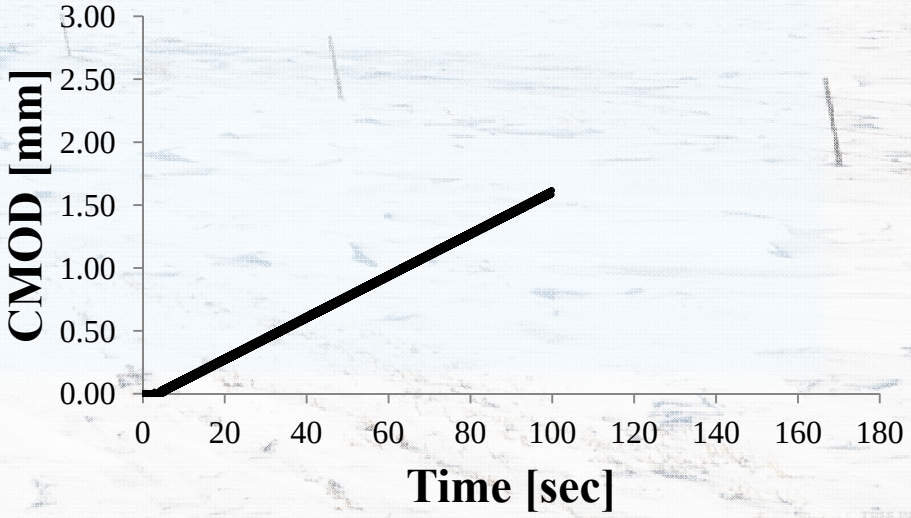








Item	DCT	SCB
Loading fixtures	$3,000	$1,000
X-Y Tables to facilitate coring and sawing	$1,500	0
CMOD Extensometer (Epsilon)	$1,400	$1,400
LLD extensometers (SCB only)	0	$4,000
Temperature-Chamber*	$20,000	$20,000
Temperature modules and thermocouples	$400	$400
PC for Data Acquisition	$1,000	$1,000
Labview Based Interface Board	$700	$700
Coring barrels (qty = 5)	$500	0
Labview Software for Data Acquisition	$1,500	$1,500
Labview Programming**	$3,000	$3,000
*Dual water cooled masonry saws****	*$10,000*	*$10,000*
Dual saw system for flat face and	*$7,000*	*$7,000*

DCT or SCB?

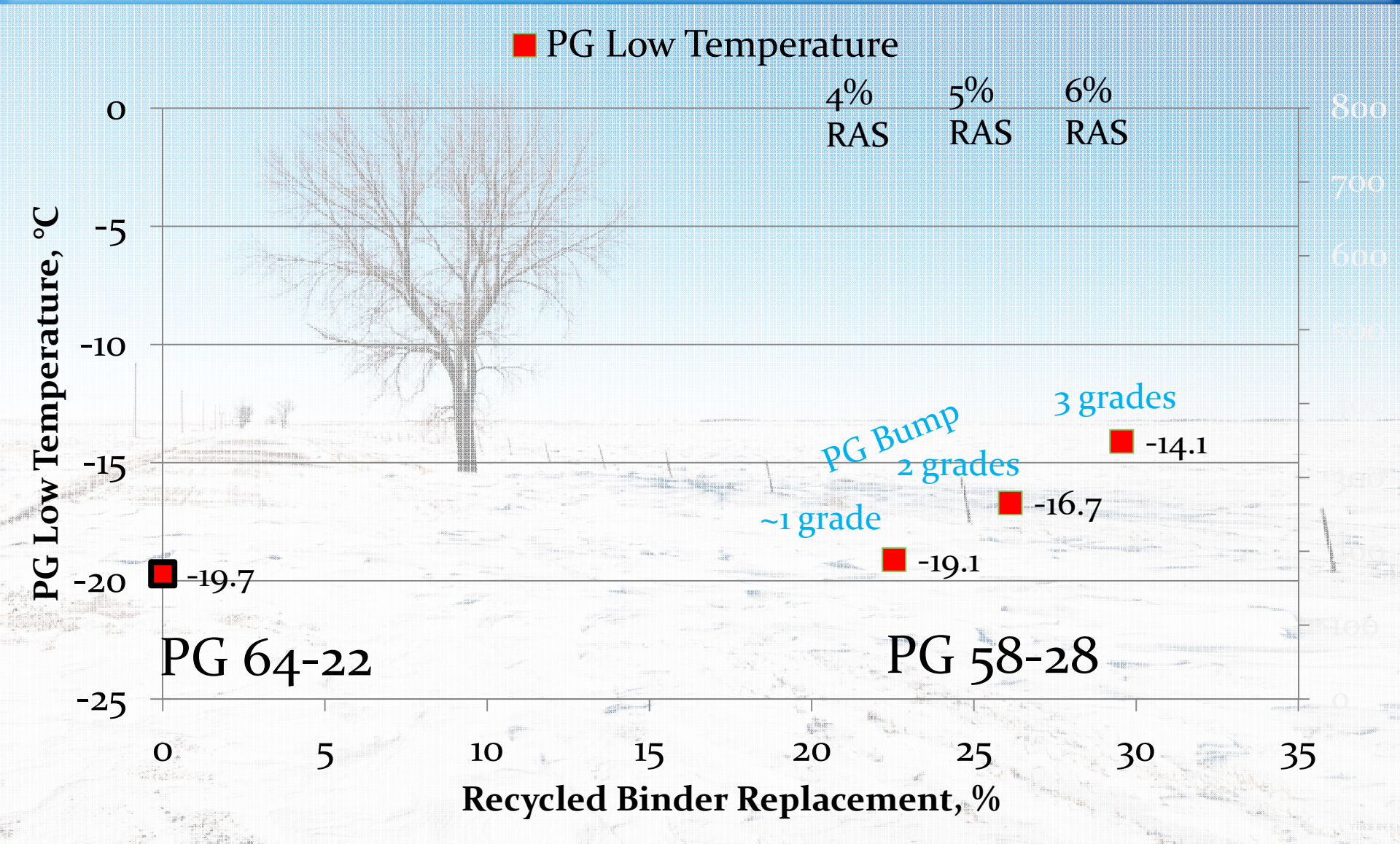
DCT vs. SCB

Item	DCT	SCB	Even
Equipment needed			x
Cost of test setup			x
Test time requirement	15 min	30 min	
Ease of sample preparation		x	10-15 min
Repeatability of results	< 10% COV x	< 20% COV	
Loading mode			?
Loading rate	0.1 mm/min	0.03 mm/min	?
Lab vs. Field	x		
Ability to test thin lifts in field		x	
OVERALL CHOICE			Clyne, 2011

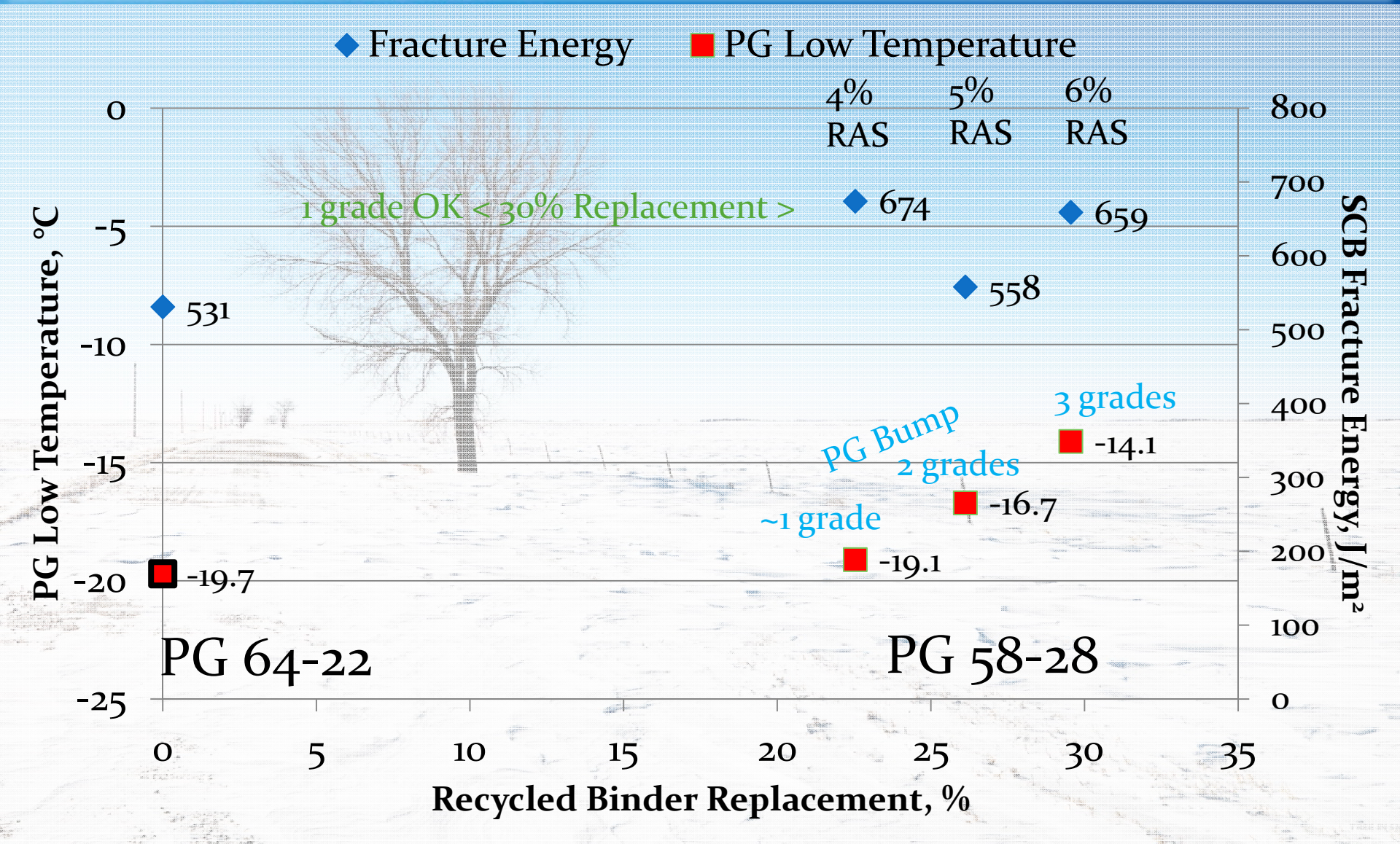
Implementation

- Draft AASHTO standards
  - DCT
  - SCB
- Awaiting additional cracking surveys to select a threshold
- Initially = 400 J/m² is desirable

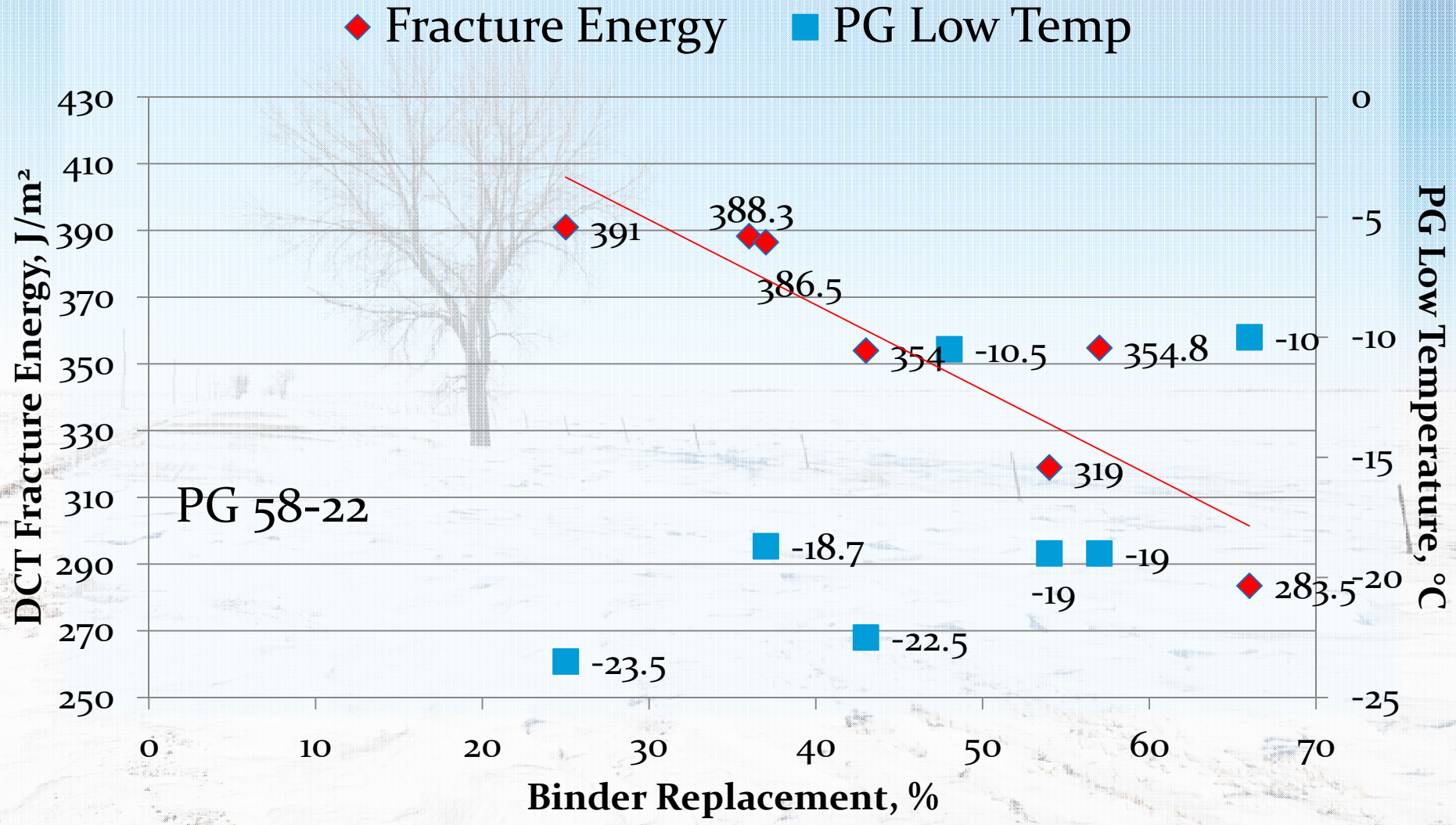
Base PG Bumping Criteria



Base PG Bumping Criteria on Fracture Energy

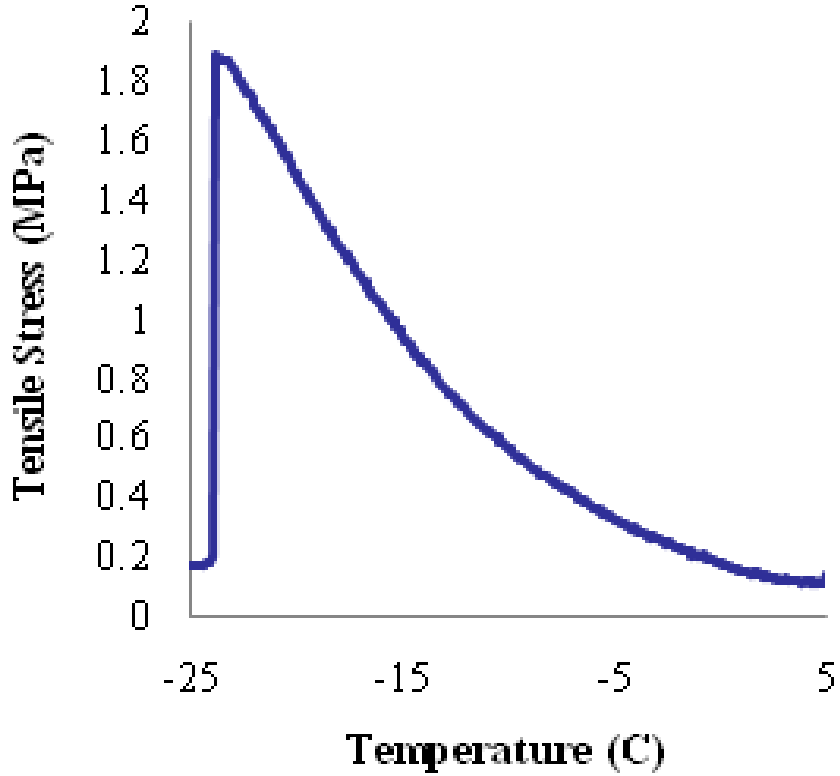


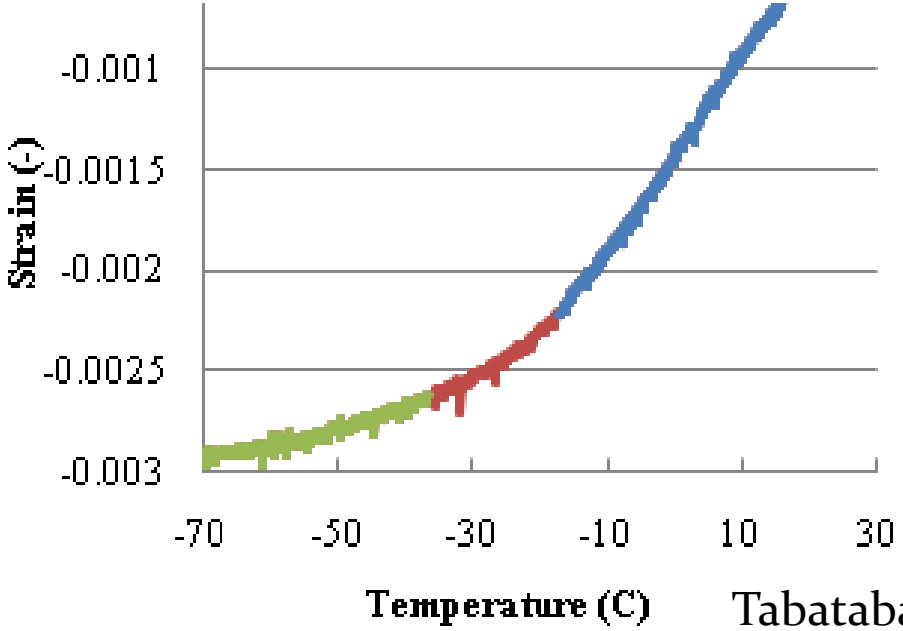
Illinois Tollway (Williams, 2010)



Modeling

- Need to understand thermo-volumetric changes in the mixture
  - CTE above and below glass transition temperature
- Need to understand impacts of thermal cycling
- Asphalt Thermal Cracking Analyzer (ACTA)





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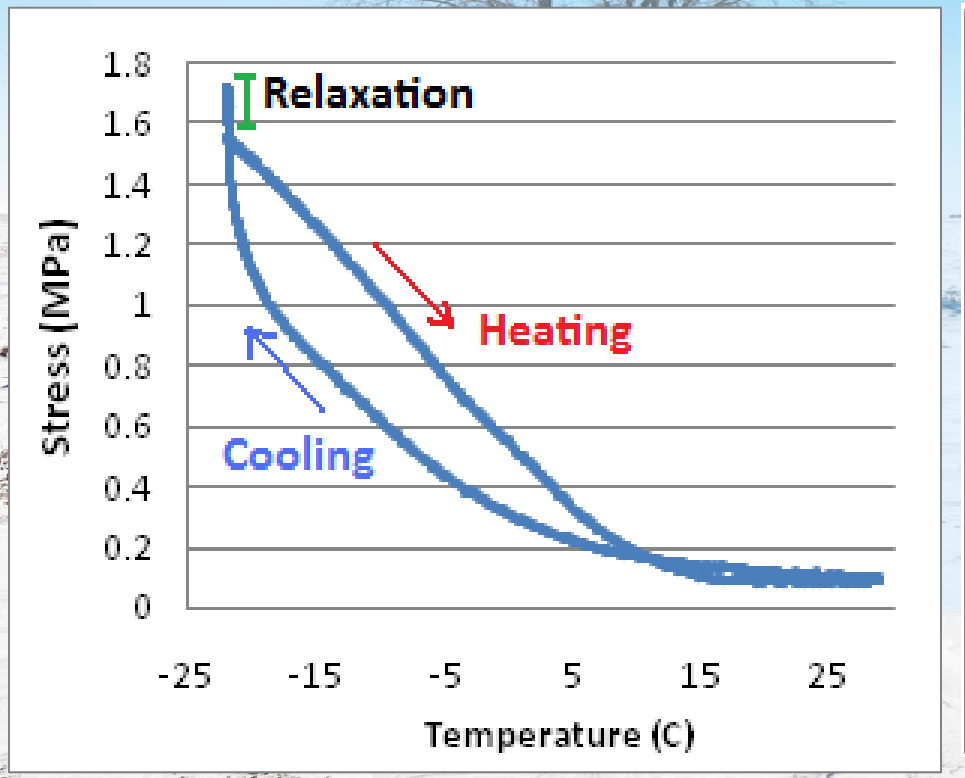
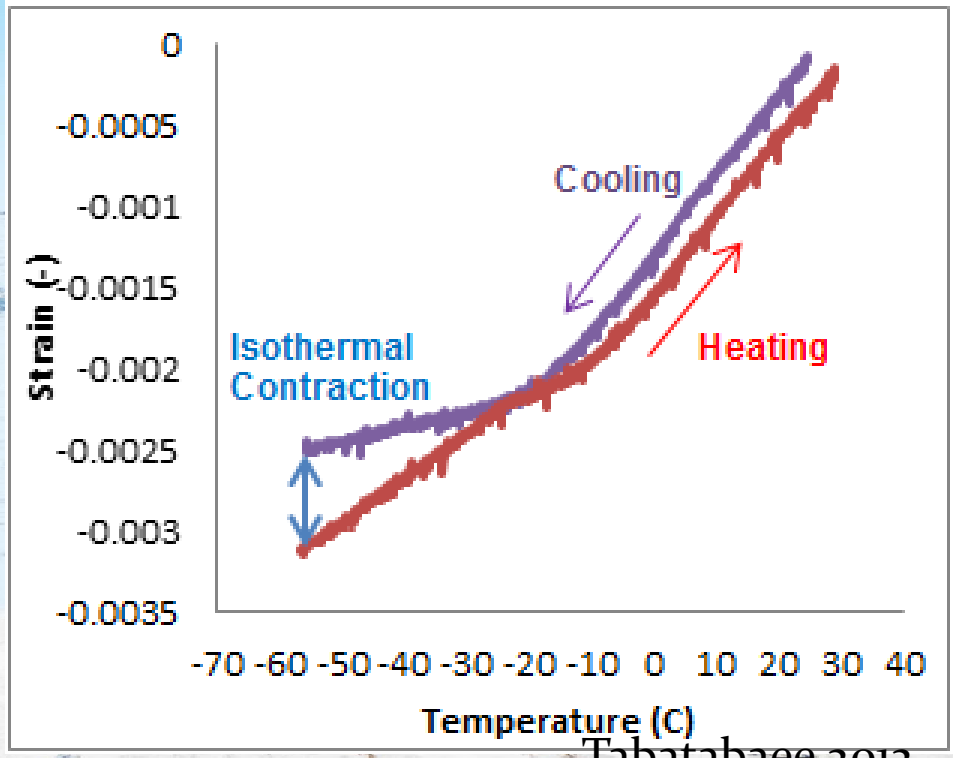
Thermal Cycling with ACTA

- Temperature decreased at 0.1 to 1 °C/min then held for 1 to 10 hrs





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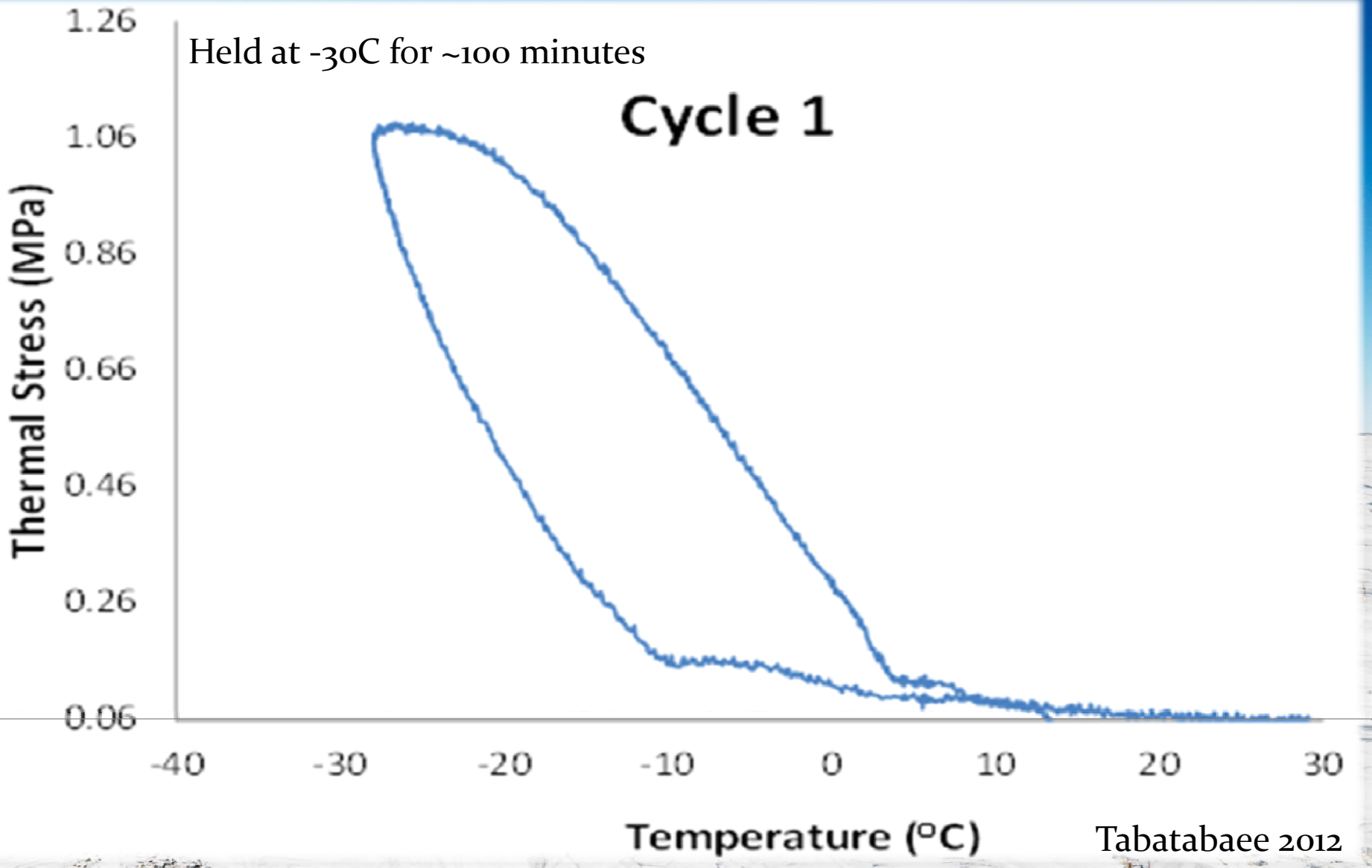
Thermal Cycling with ACTA



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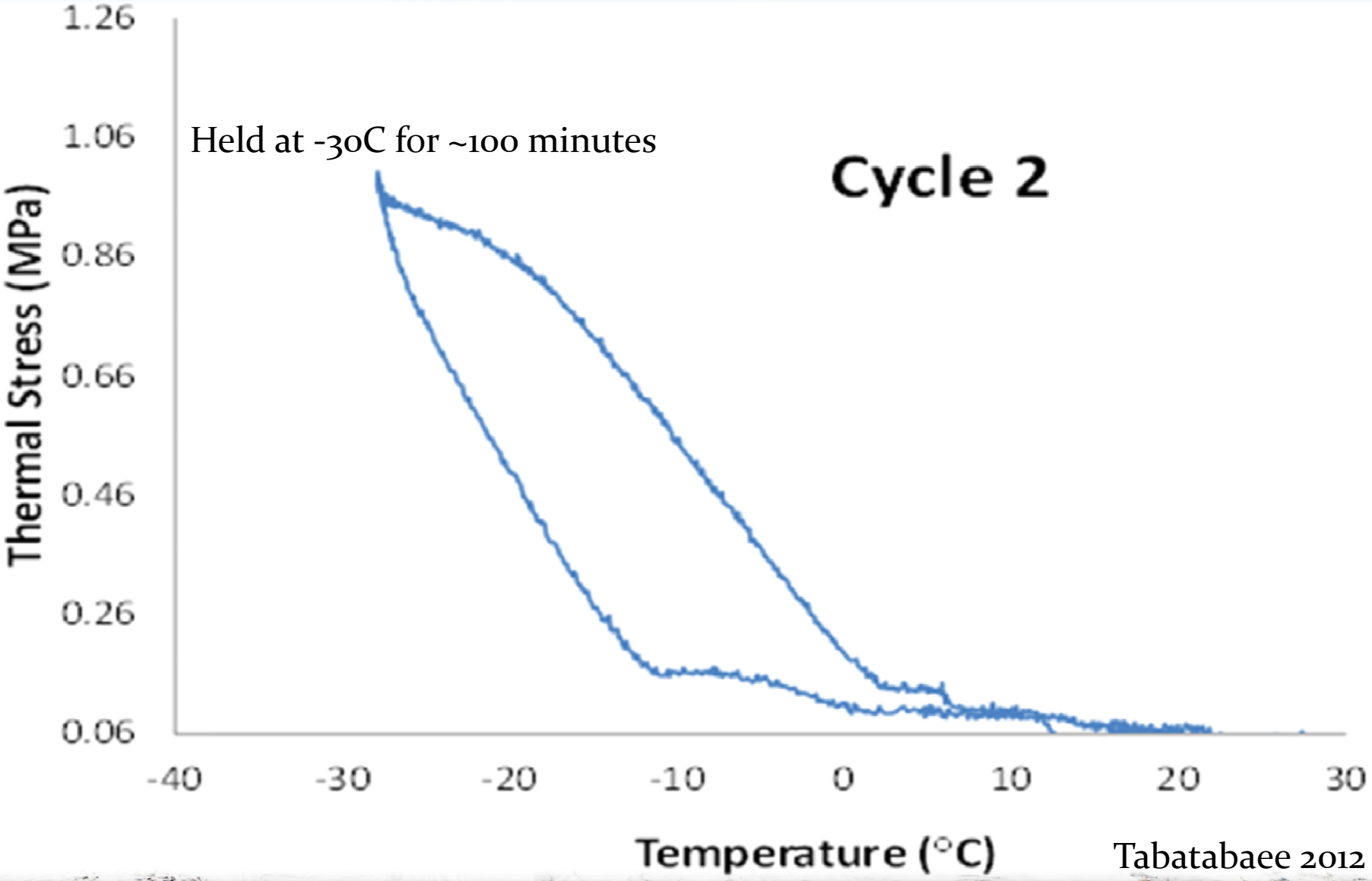
Thermal Cycling with ACTA



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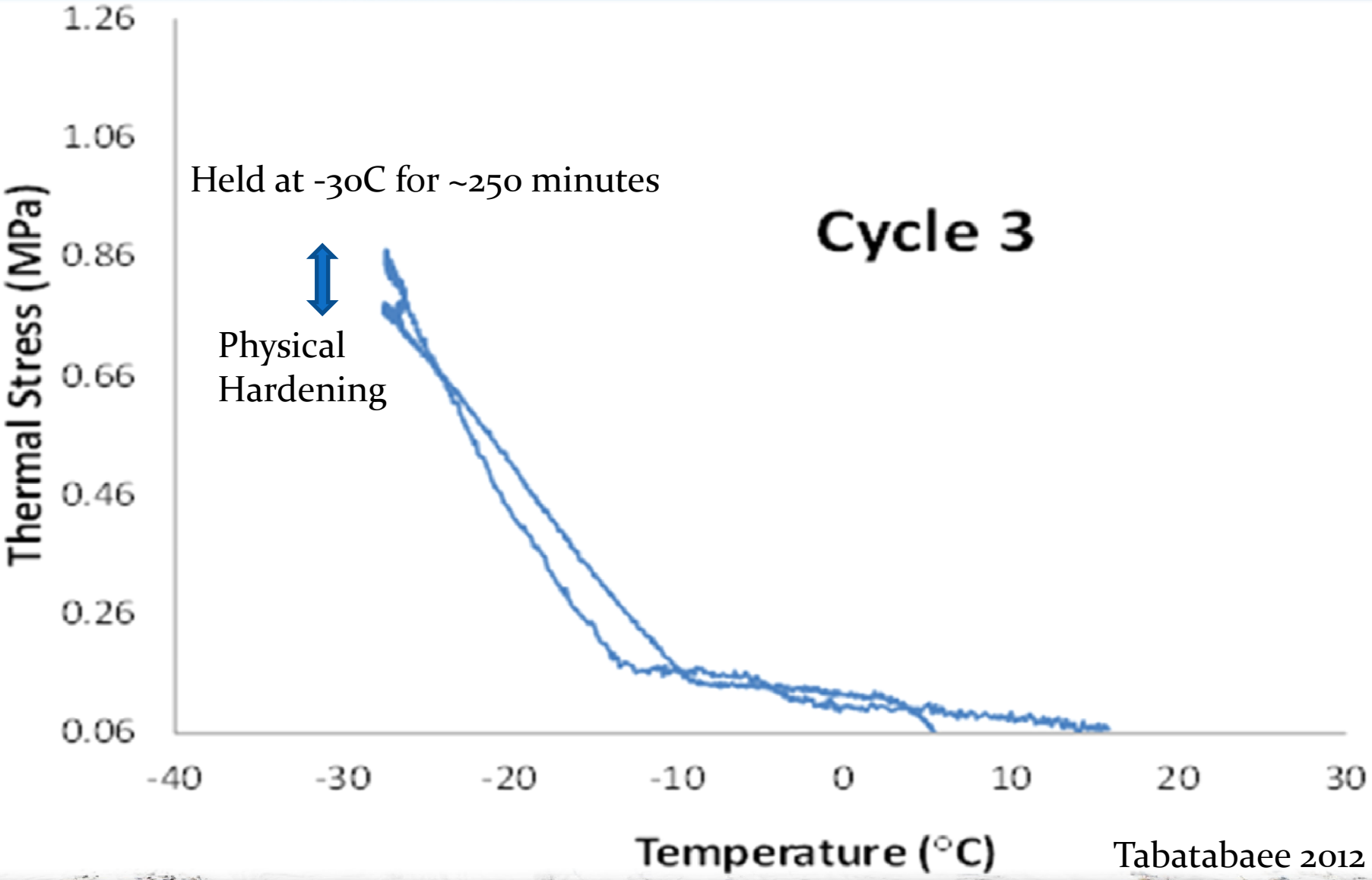
Thermal Cycling with ACTA



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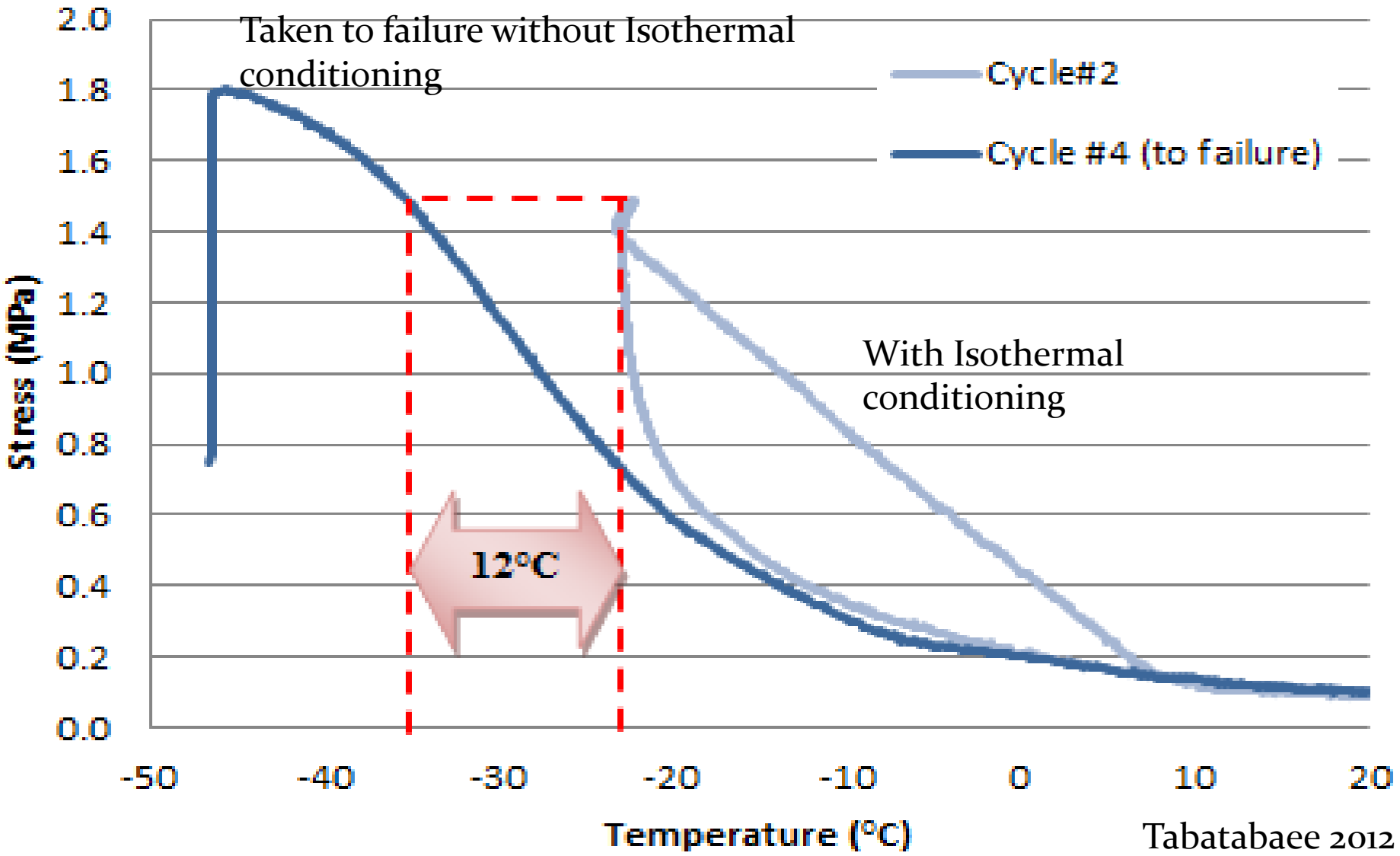
Thermal Cycling with ACTA



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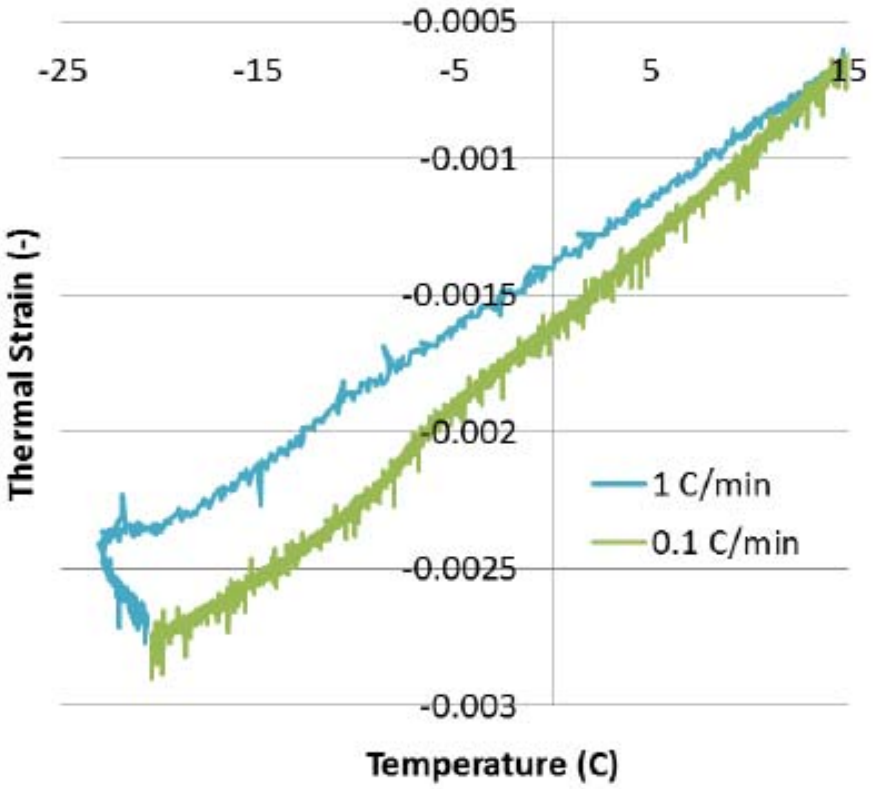
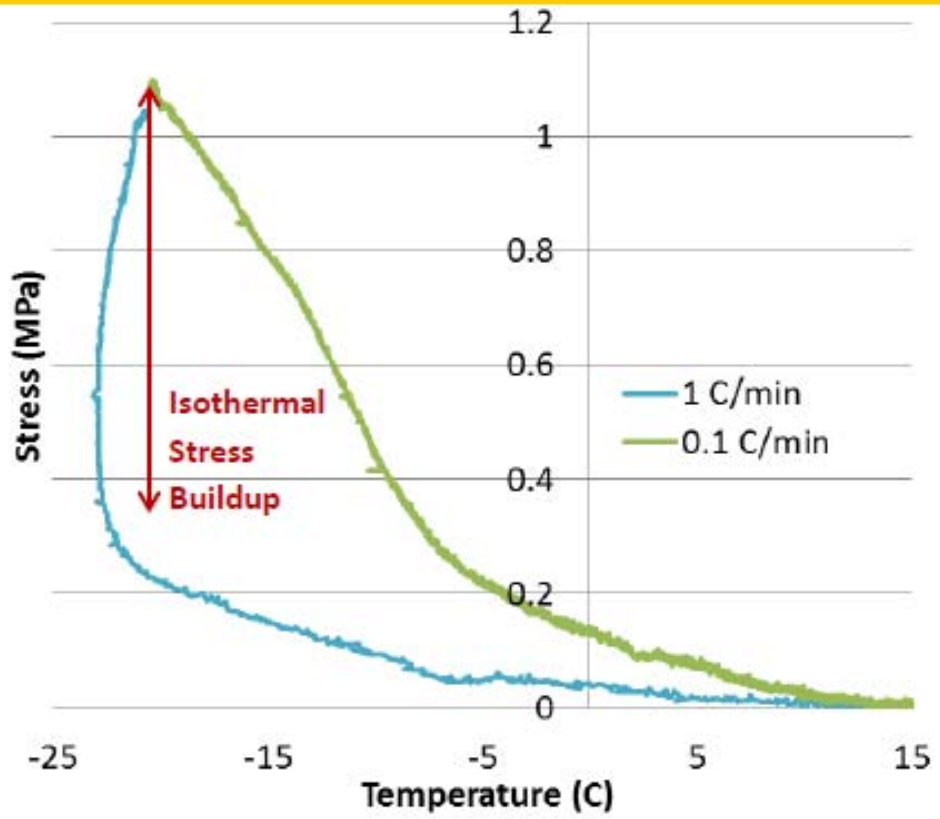
Effect of Cooling Rate





- Delayed strain during fast cooling takes place isothermally
- If enough isothermal time is given, mixes reach same stress level

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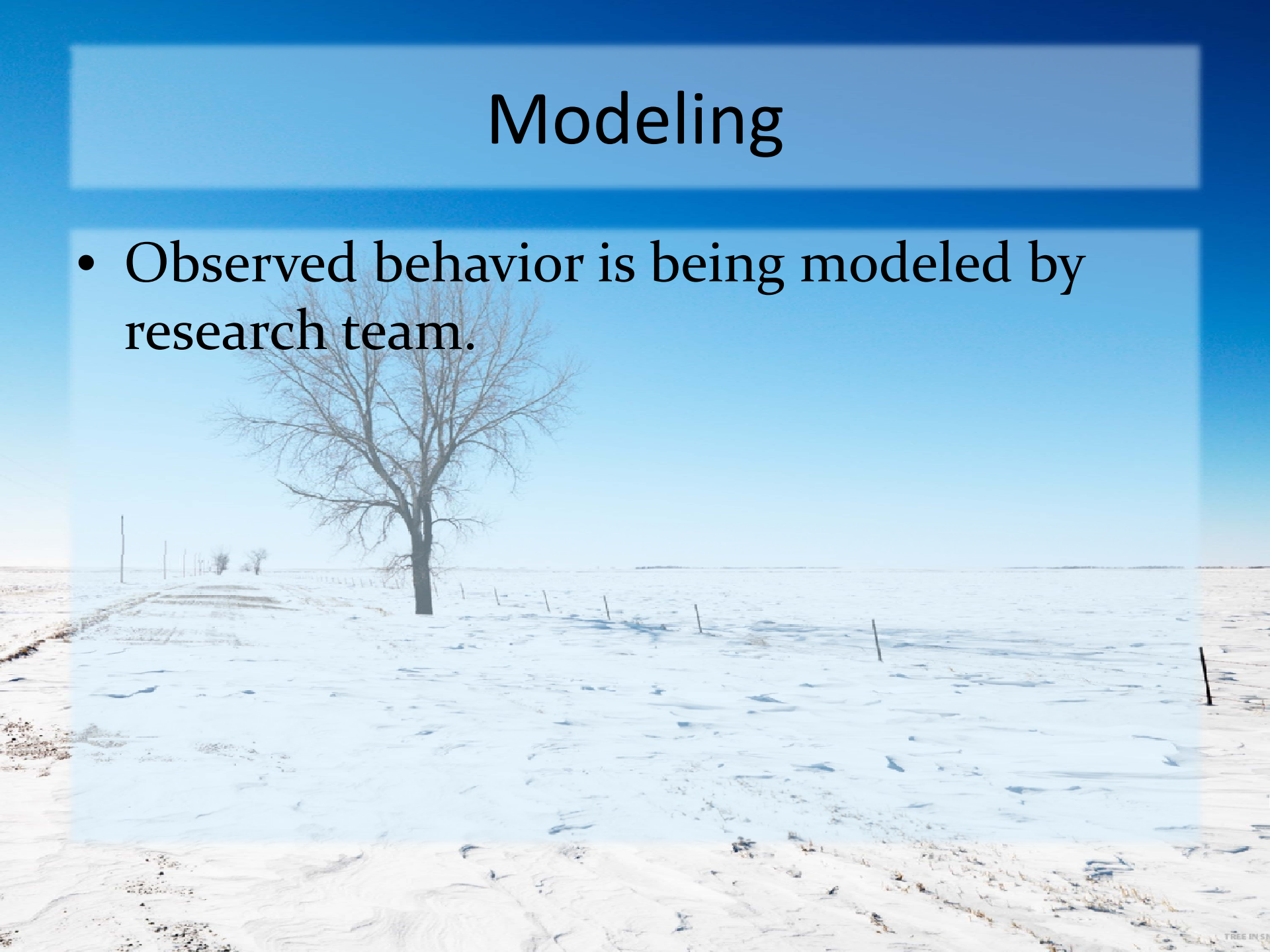
Modeling

- Observed behavior is being modeled by research team.



Thank you

QUESTIONS?

Scott Schram

Iowa DOT

scott.schram@dot.iowa.gov