

TPF-5(230)
Evaluation of Plant-Produced High-
Percentage RAP Mixtures in the Northeast

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RAP ETG Meeting

July 24, 2012

Current Participants

- NHDOT lead agency
- States: MD, NH, NJ, NY, PA, RI, and VA
- FHWA - pending
- Research Team: UNH, Rutgers, UMass
Dartmouth, NC State

High RAP Pooled Fund Study

- Contractors have volunteered to produce mixtures at different RAP contents
- Mixtures sampled and taken to lab for testing
- SGC specimens compacted at time of production
- Data collected on plant operations, raw material info, placement location & conditions (field cores if possible)

Testing

- Recovered Binder
 - PG grade
 - CCT
 - ABCD
 - 4 mm DSR
- Mixture
 - Dynamic Modulus
 - Hamburg & TSR
 - Low Temperature Creep & Strength
 - Fatigue (S-VECD protocol)
 - Overlay Tester
 - Beam Flexure

Outline

- Summary of completed Phase I testing
 - Stiffness
 - Fatigue
 - Low Temperature
- Phase II Silo storage study
 - Extracted binder
 - Stiffness

Phase I Mixtures: 2010 Production

Plant	NMAS (mm)	PG Grade	RAP Content (%)			
			0	20	30	40
Callanan NY (drum)	12.5	64-22	x	x	x	x
		58-28			x	x
Pike VT (batch)	9.5	58-28	x	x	x	x
		52-34	x	x	x	x
Pike NH (drum)	12.5	64-28	x	x	x	x

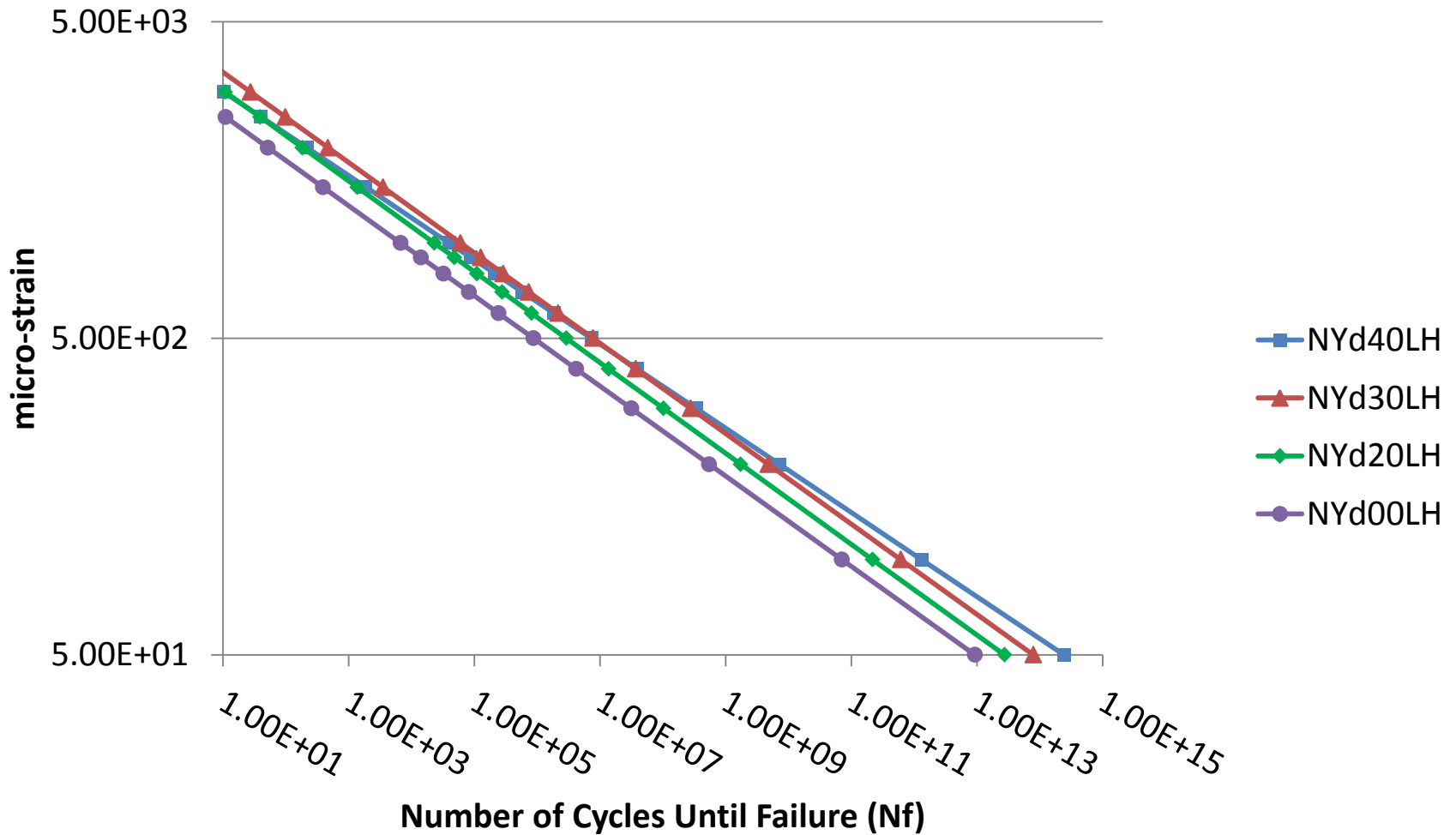
Phase I: Published Results Summary

- AAPT 2012 by Mogawer, et al.
- Increased RAP generally increased stiffness and decreased cracking resistance (OT)
- Softer binder grade effective in some cases for mitigating increase in stiffness and cracking (OT)
- Apparent effect of plant production (silo storage, temperature) on stiffness
- Reheated materials stiffer, effect of RAP and/or silo storage time

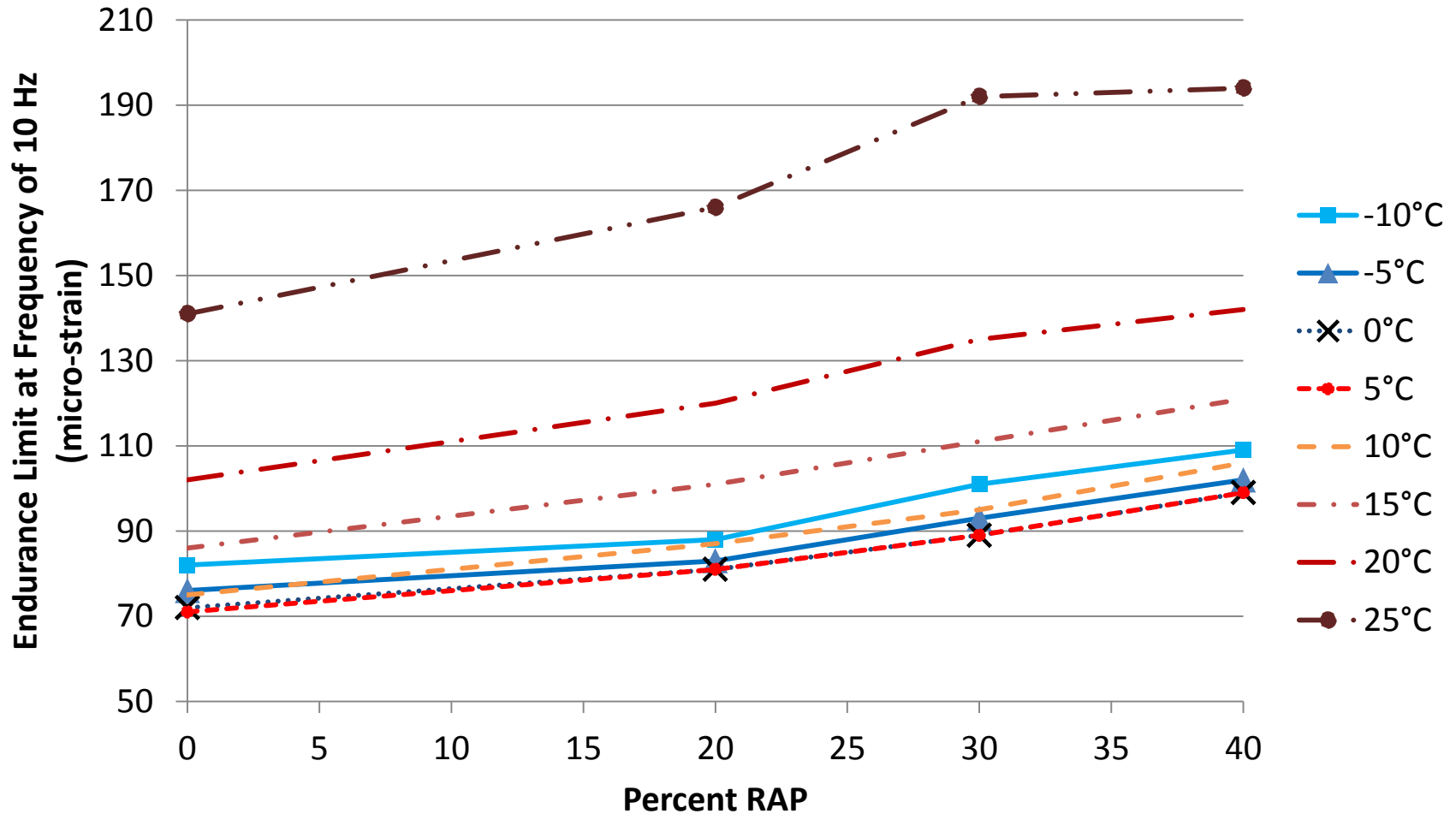
Phase I: Current Results Summary

- Fatigue (S-VECD)
- Low Temperature
 - Extracted Binder
 - Low Temperature creep and strength
 - TSRST
- NY Mixtures shown

Fatigue Life Prediction NY PG 64-22



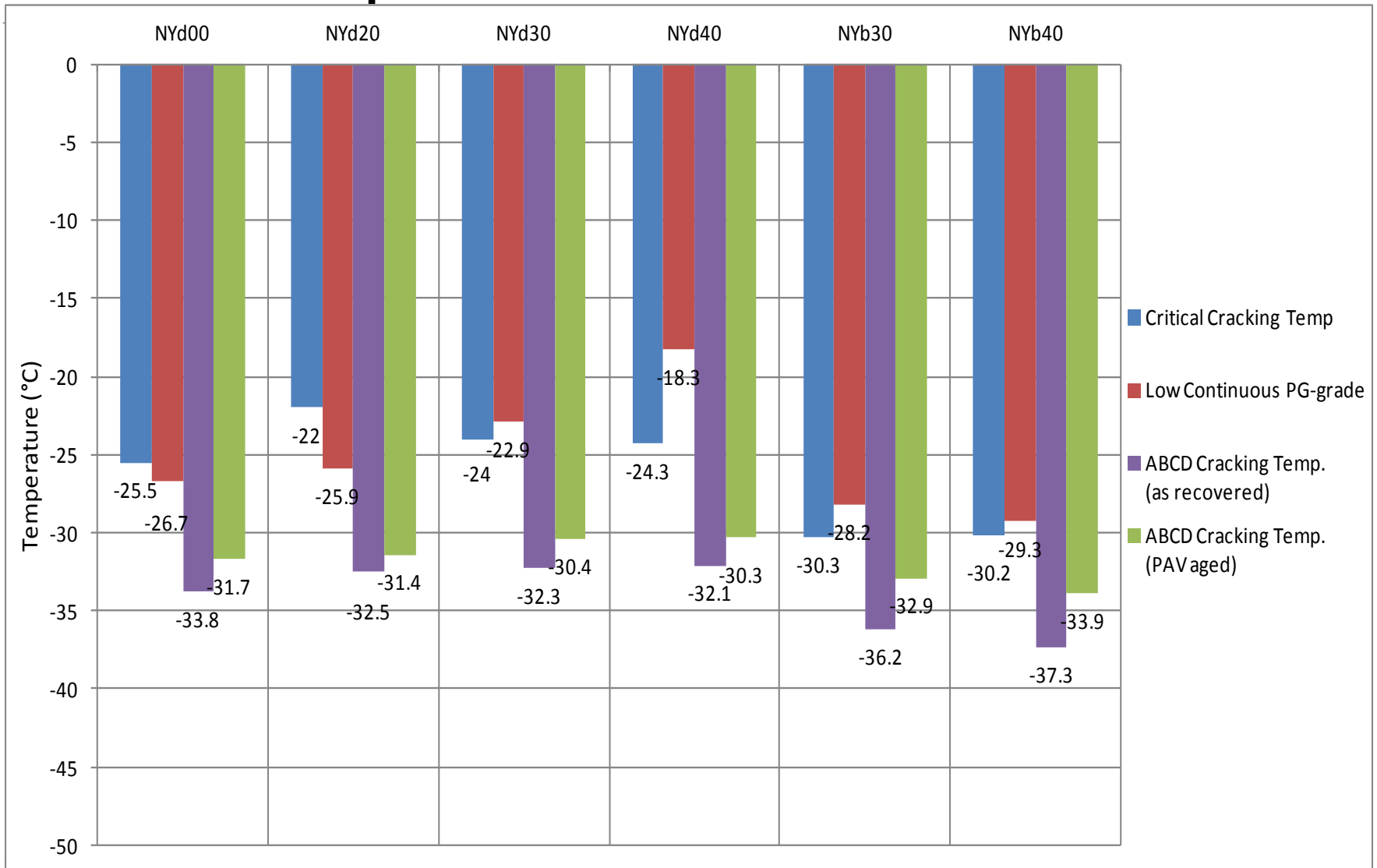
Endurance Limit for NY Mixtures PG 64-22



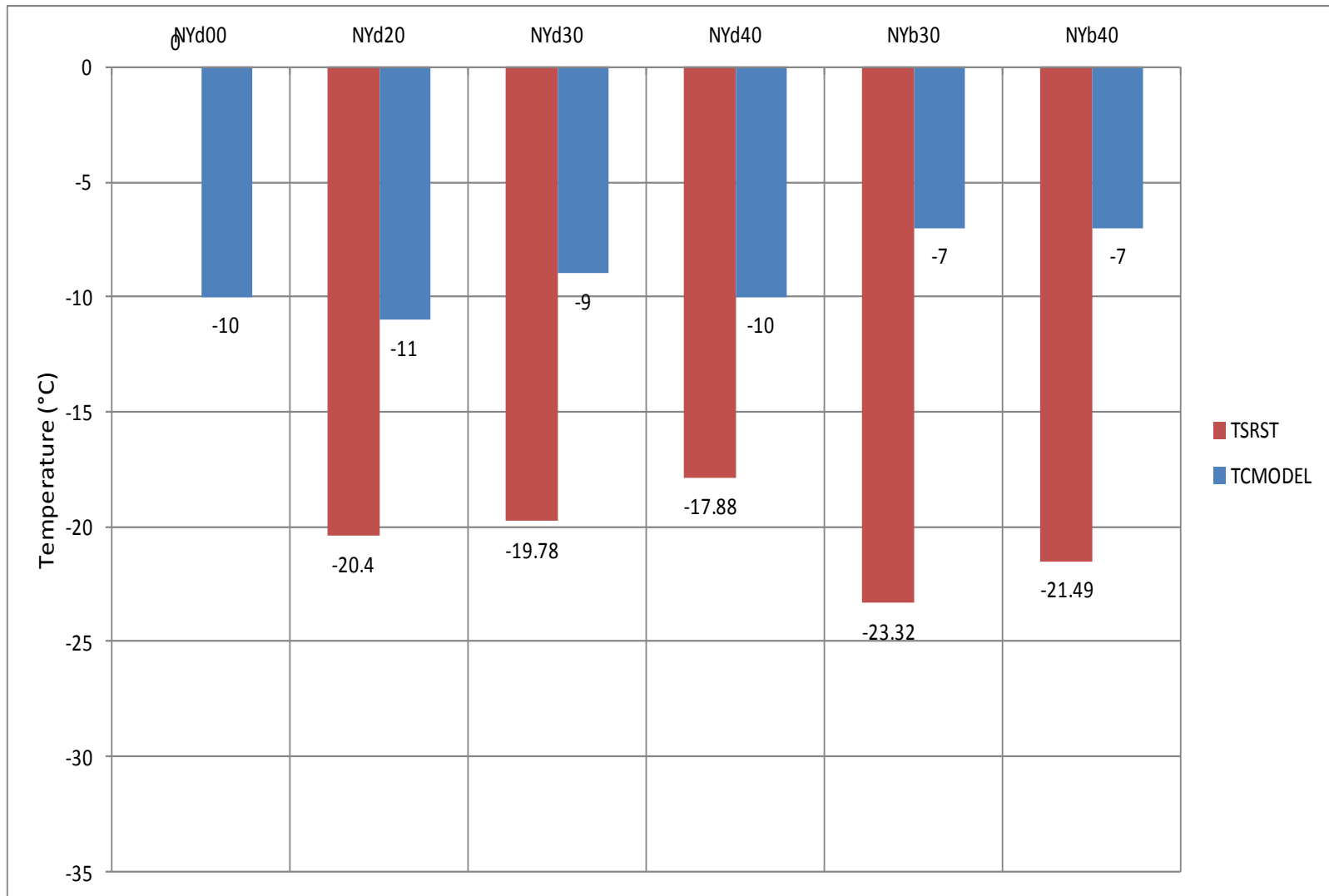
SVECD Fatigue Summary

- Higher RAP contents generally higher N_f , rankings change with strain/stress level
- Softer binder grade decreases slope of N_f curve
- Higher RAP contents increase endurance limit

Low Temp Extracted Binder Results



Low Temp Mixture Testing Results

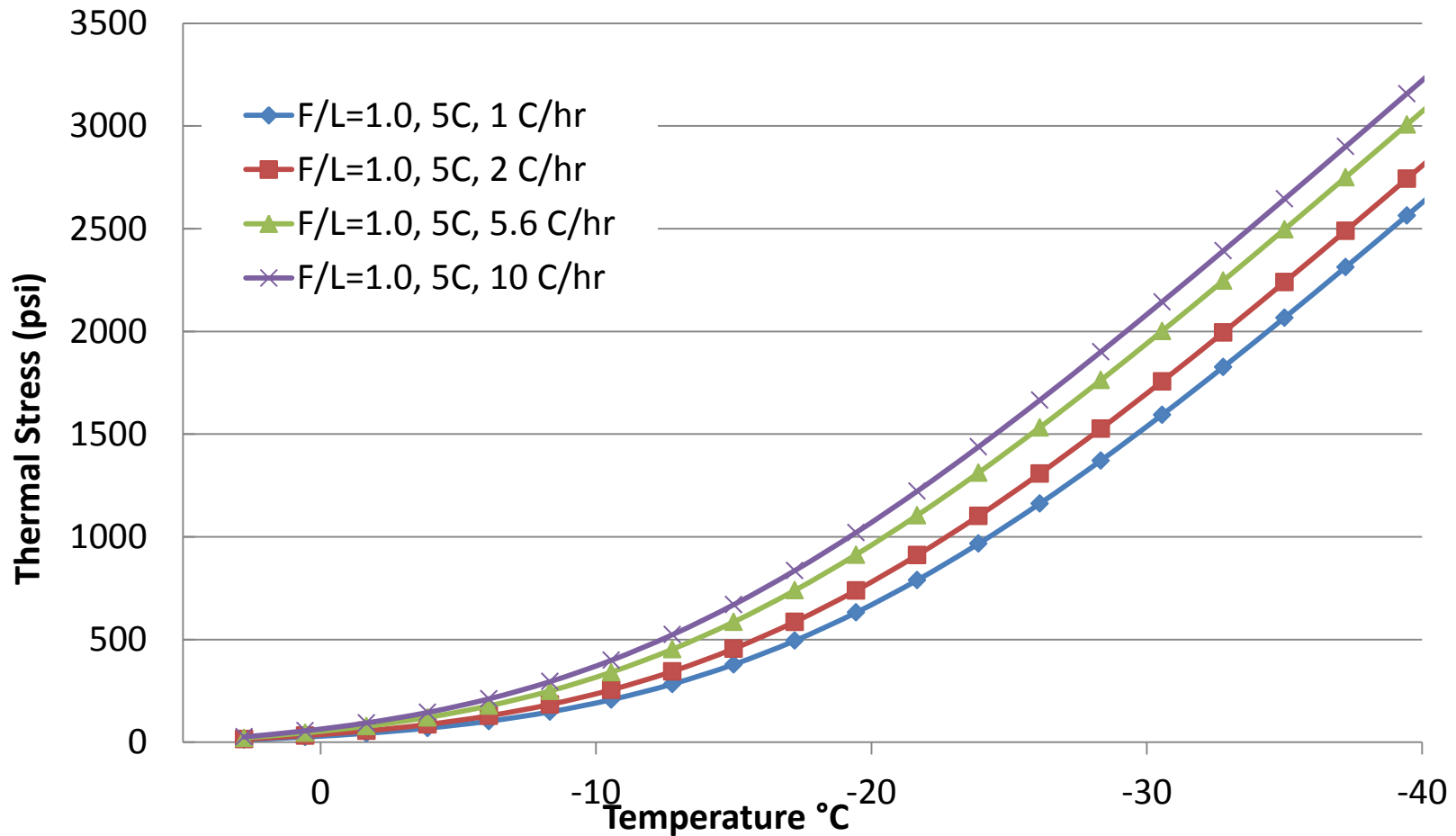


Testing and Analysis Parameters

Method	Initial Temp (C)	Cooling Rate (C/hr)
Binder CCT	0	10
ABCD	0	20
TCMODEL (mix)	10	5.6
TSRST	5	10

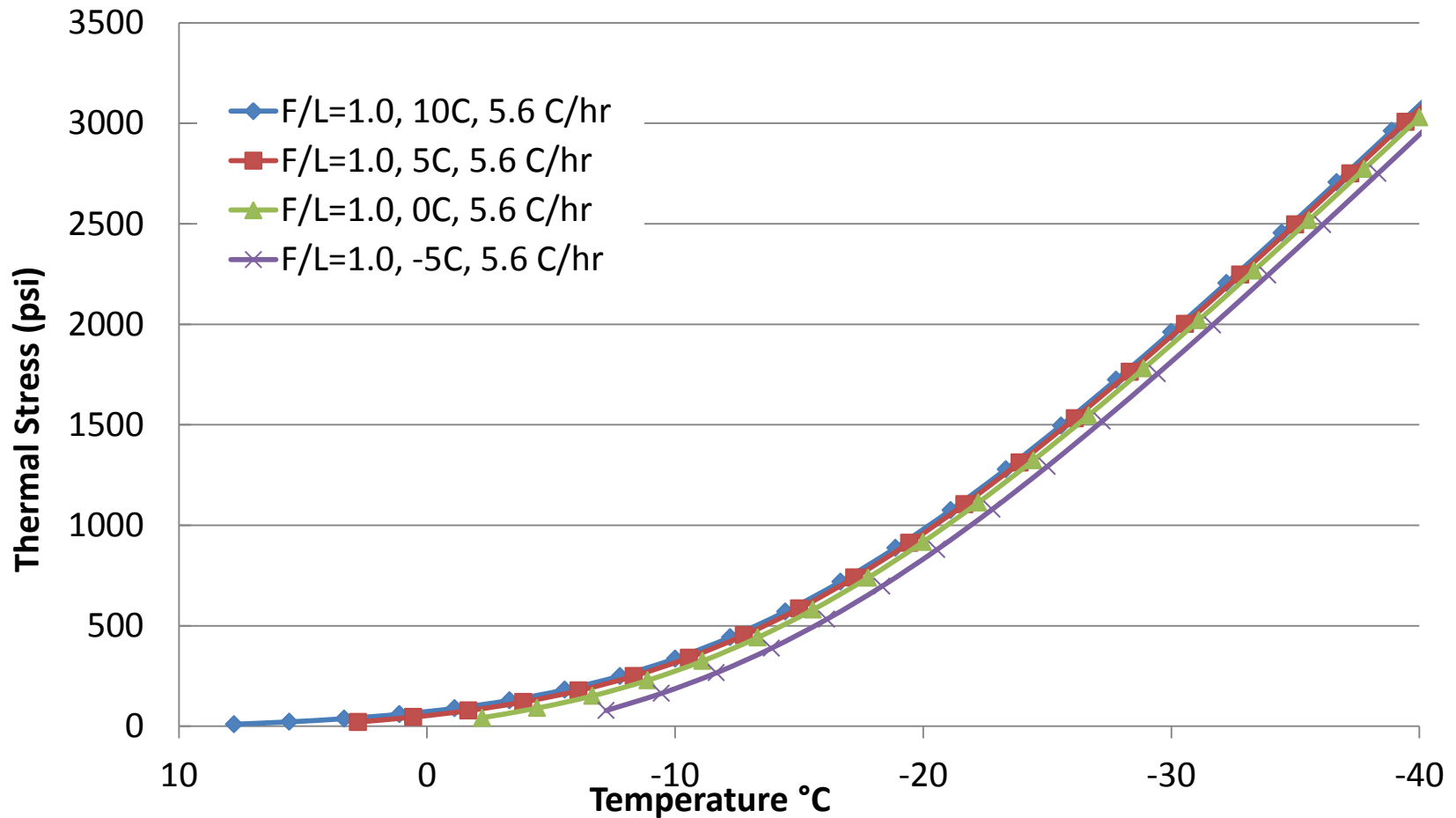
Impact of Cooling Rate

TCMODEL: NY40% PG64-22

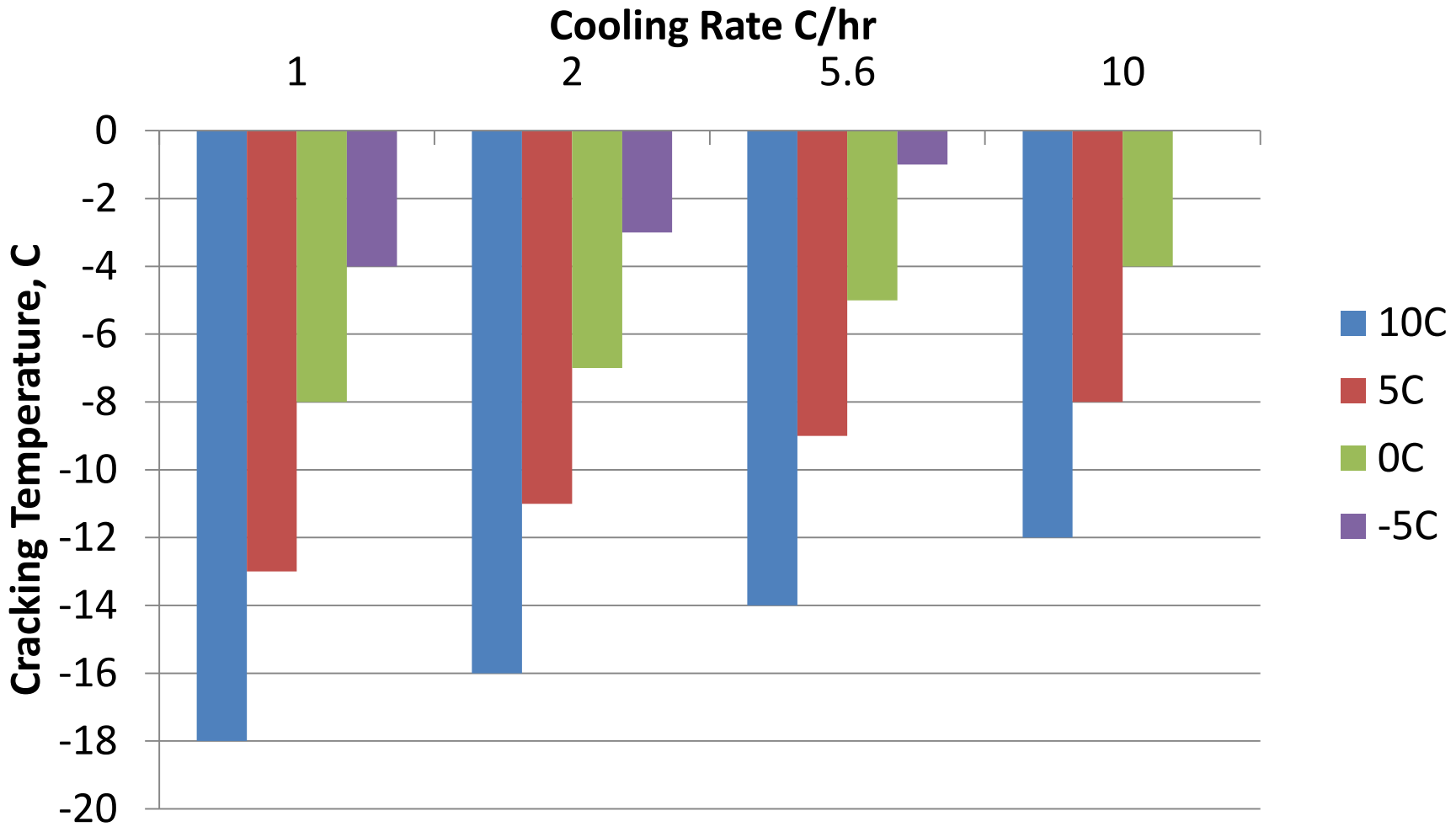


Impact of Initial Temperature

TCMODEL: NY40% PG64-22



TCMODEL: NY Virgin PG 64-22

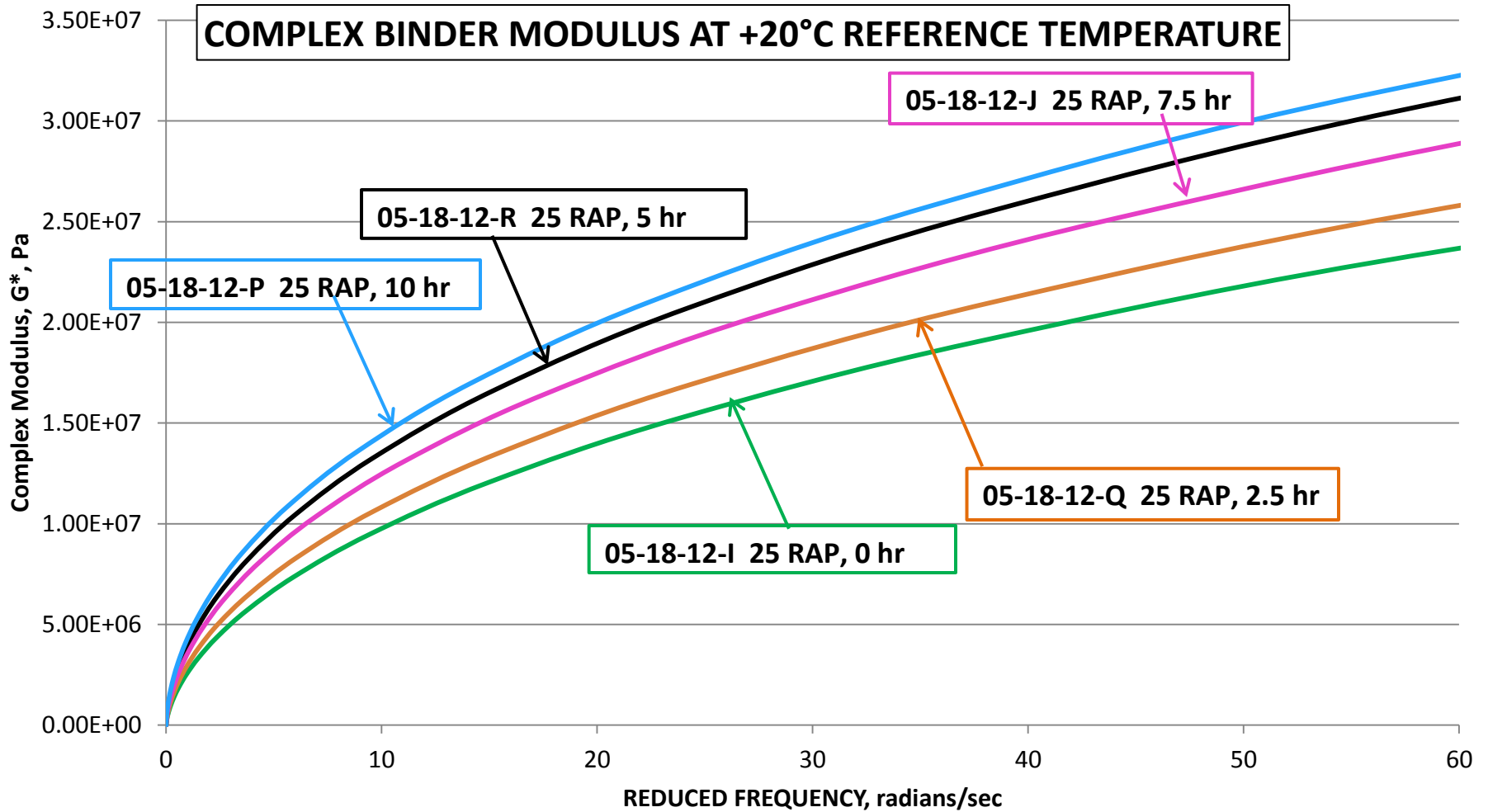


Low Temperature Summary

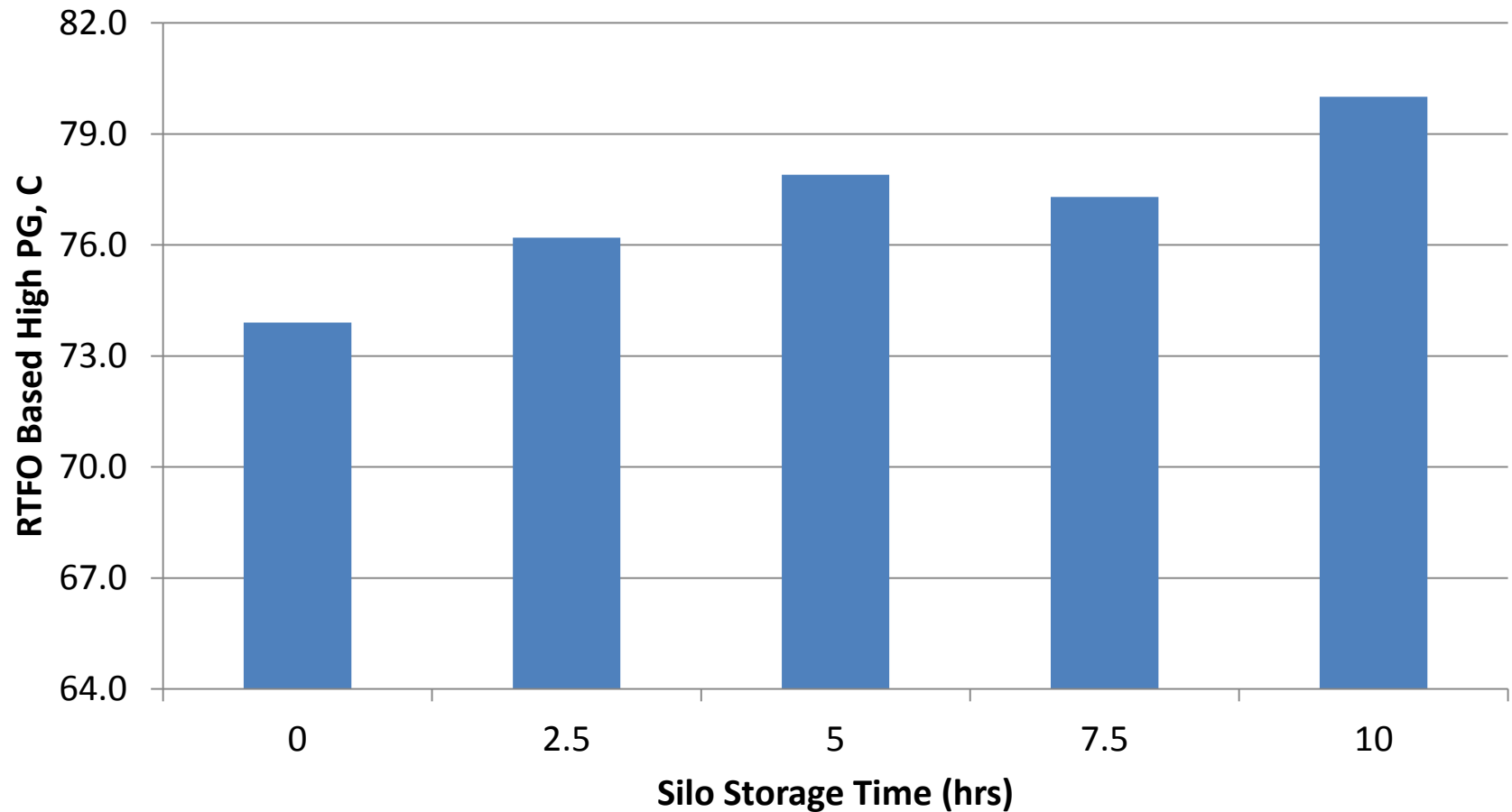
- Generally warmer cracking temperatures with increase in RAP content
- Softer virgin binder may help mitigate
- Impact of starting temperature and cooling rate used for testing and analysis
- Further investigation and analysis continuing

Silo Storage Study

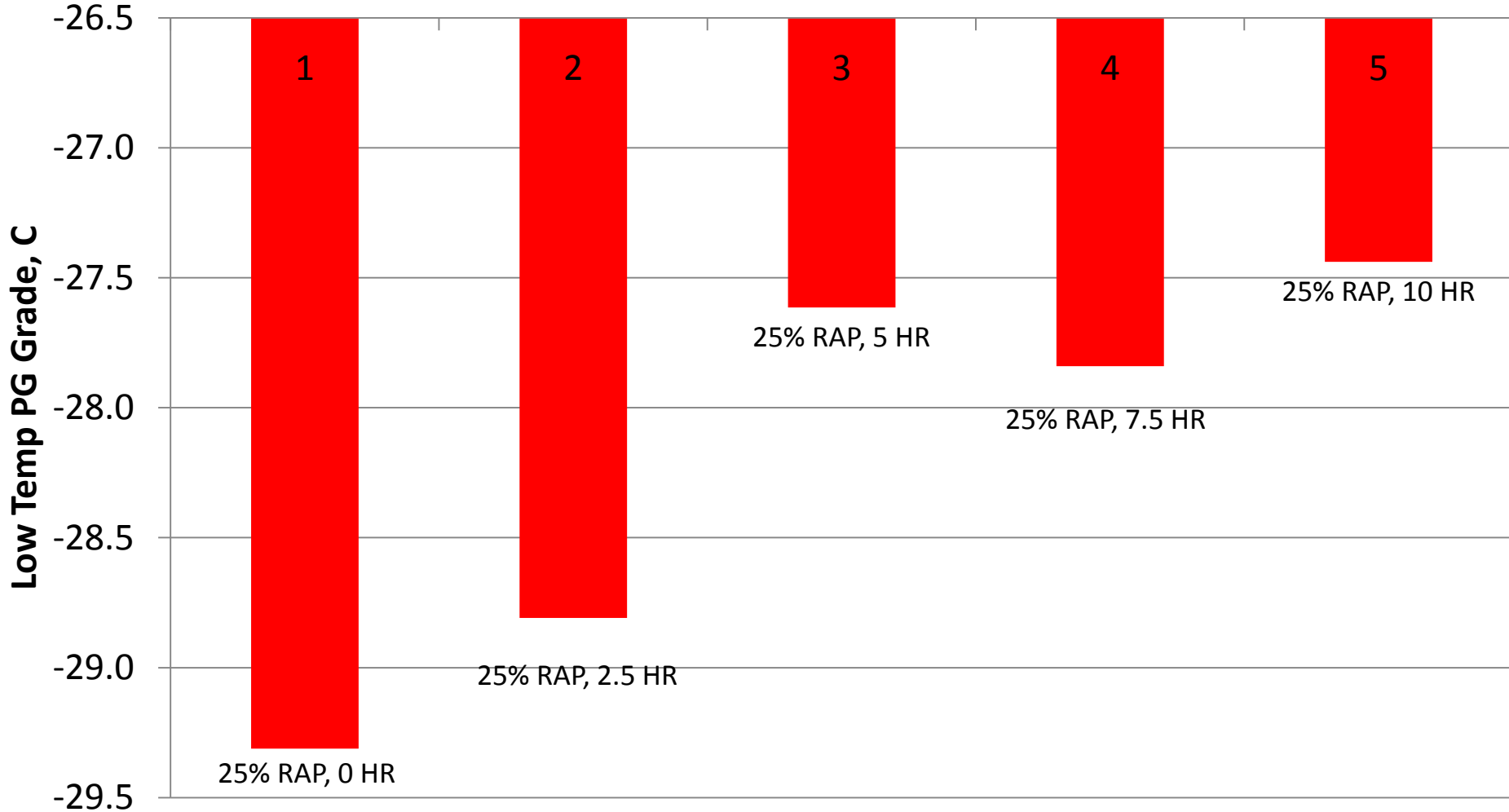
- Callanan 12.5 mm mixture with PG 64-22
 - Virgin: 0, 2.5, 5.0, 7.5 hours storage (~340 F)
 - 25% RAP: 0, 2.5, 5.0, 7.5, 10.0 hours storage (~340 F)
- Mix testing
 - Plant compacted specimens
 - Loose mix collected and compacted in lab
 - $|E^*|$, fatigue, TSRST
- Binder extracted & recovered from plant compacted specimens
 - PG grading, 4 mm $|G^*|$



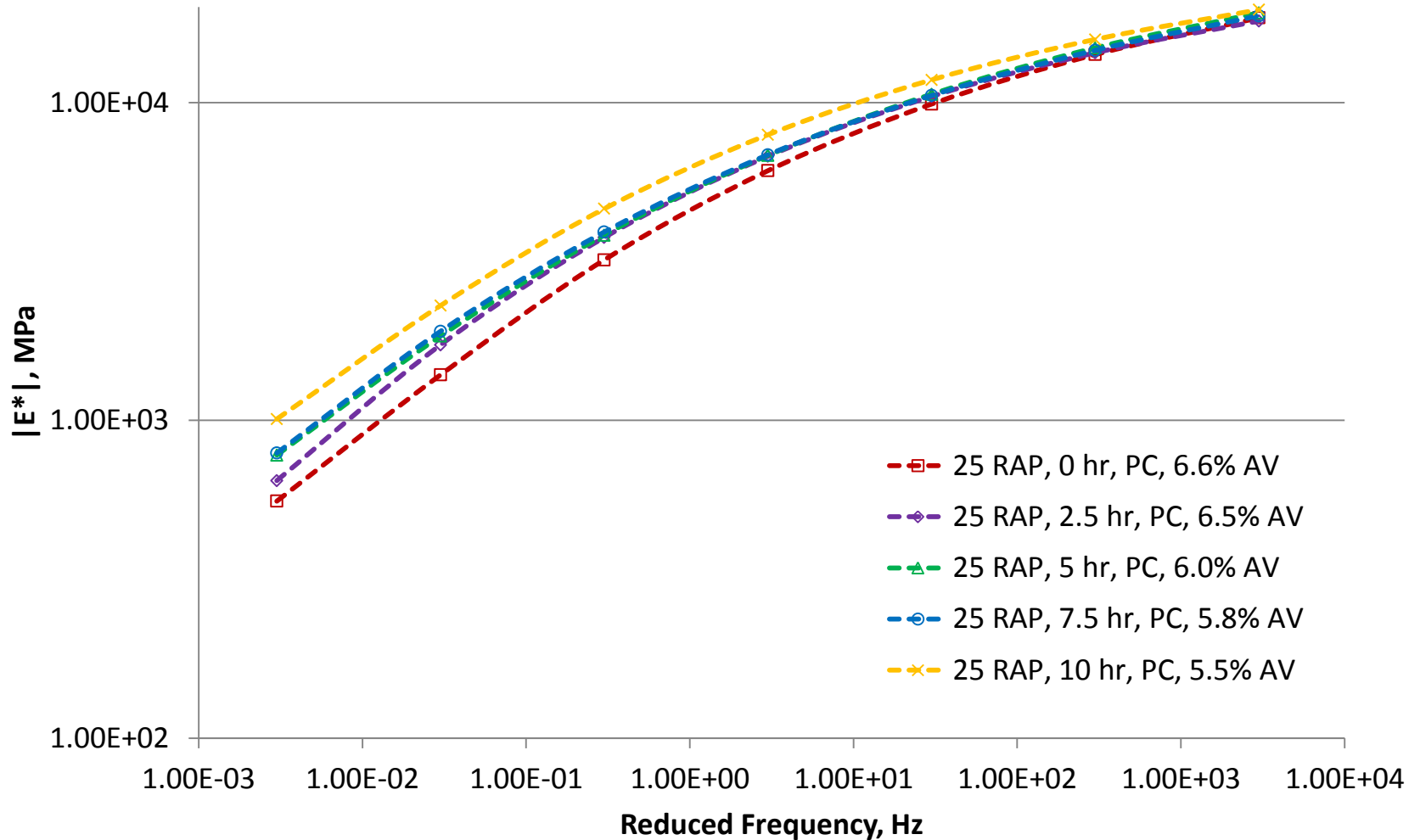
High Temp Grade 25% RAP Recovered



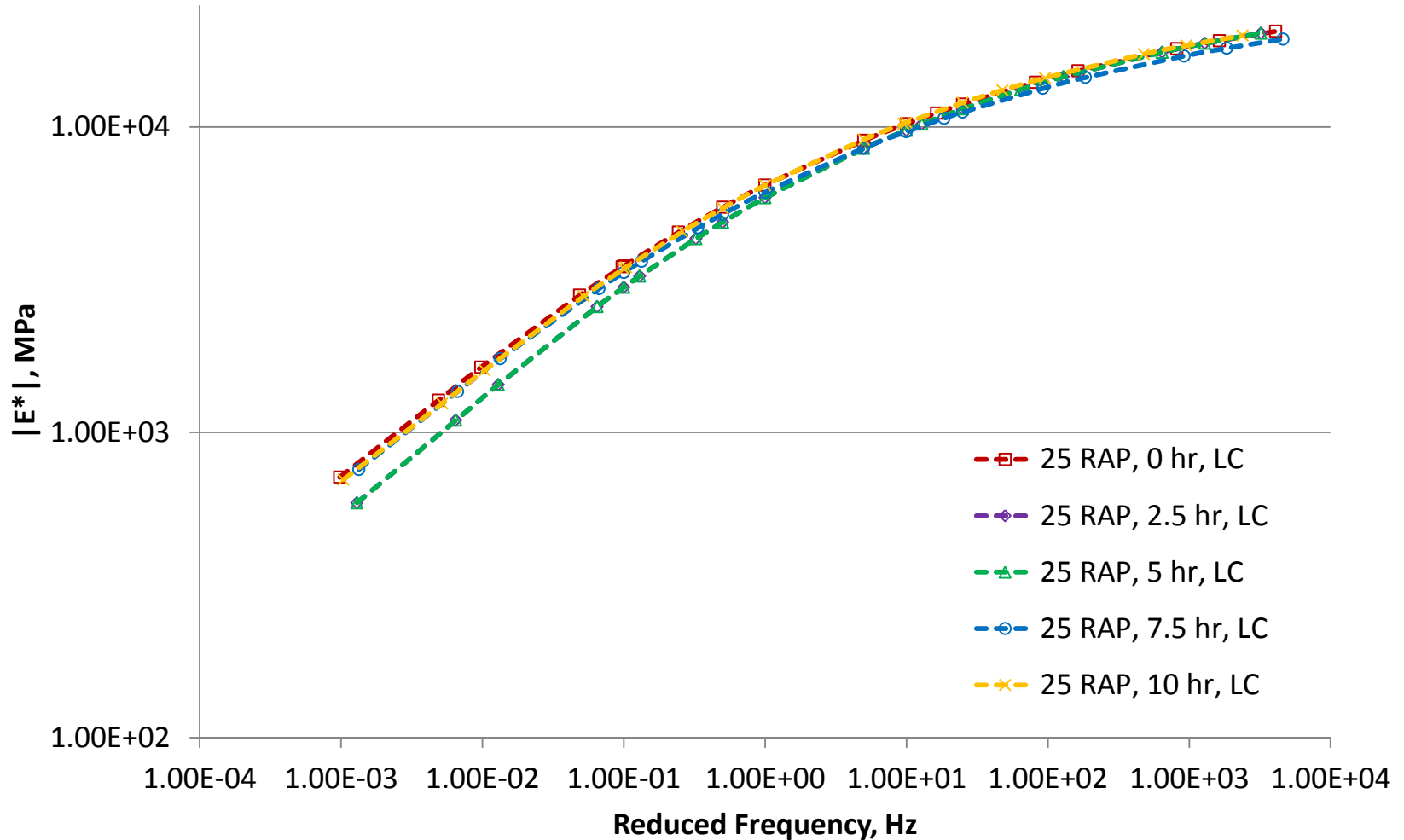
LOW TEMP GRADE 25% RAP RECOVERED BINDER



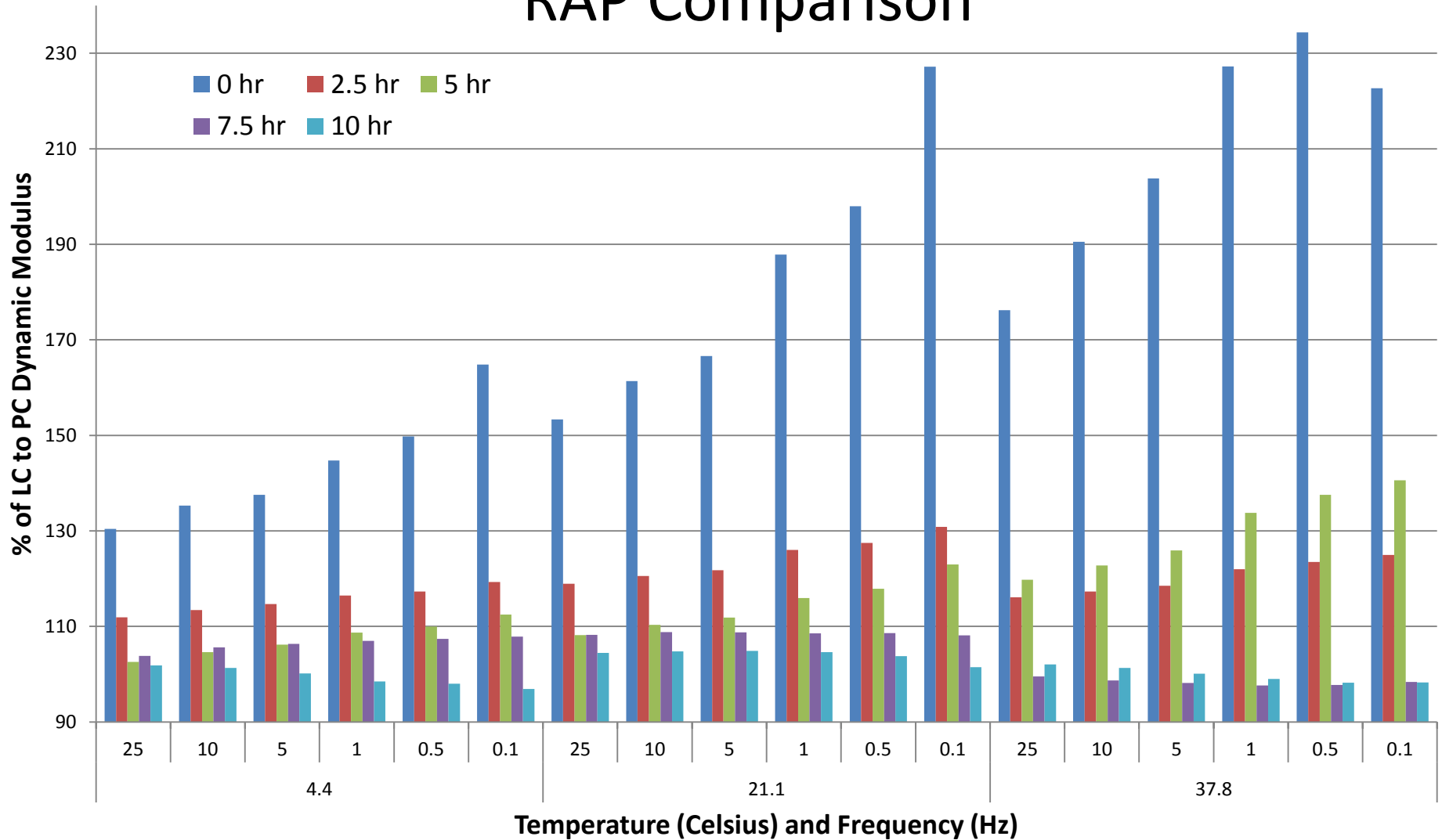
Plant Compacted Dynamic Modulus: 25% RAP



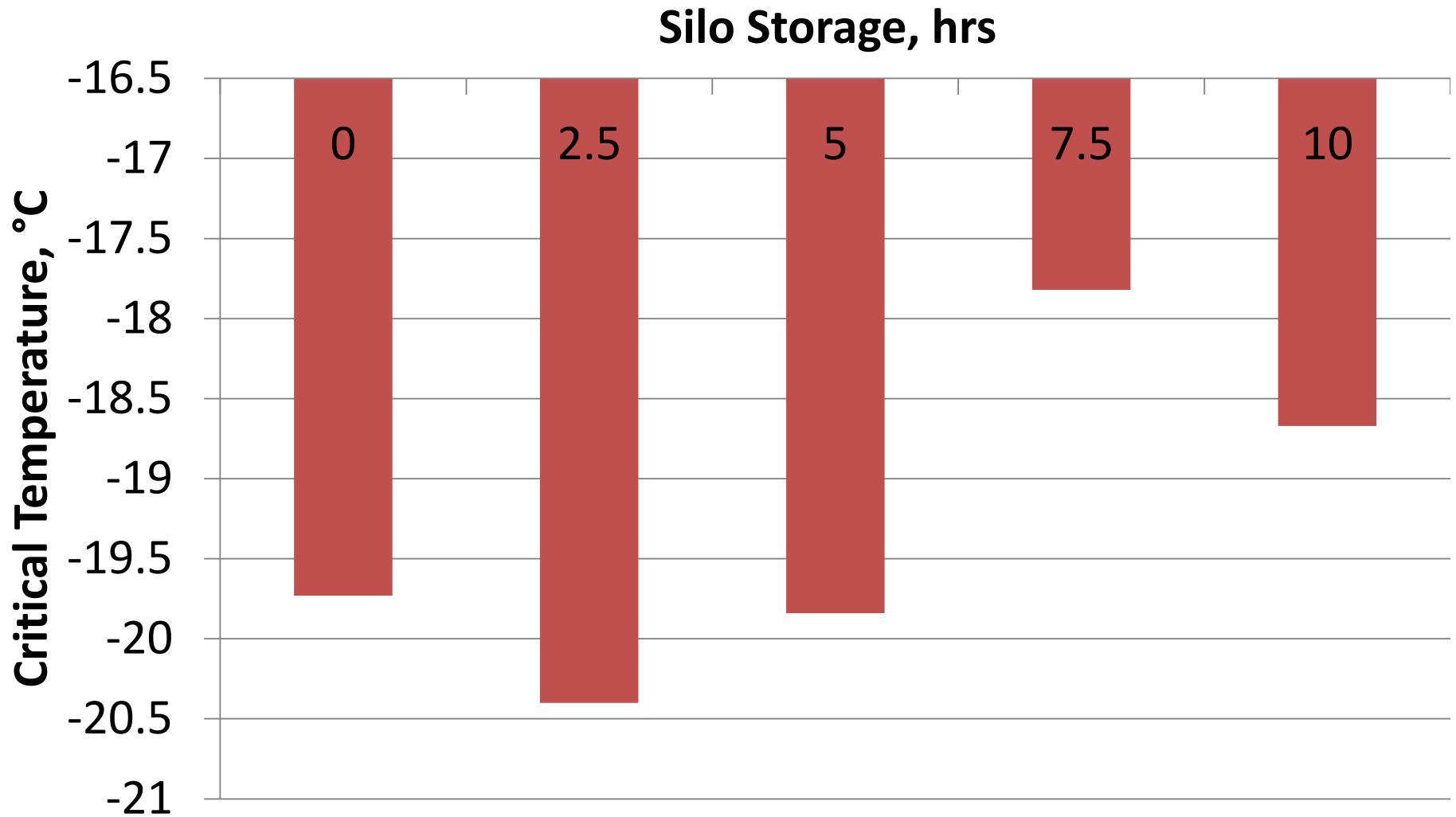
Lab Compacted Dynamic Modulus: 25% RAP



Lab- versus Plant-Compacted Dynamic Modulus RAP Comparison



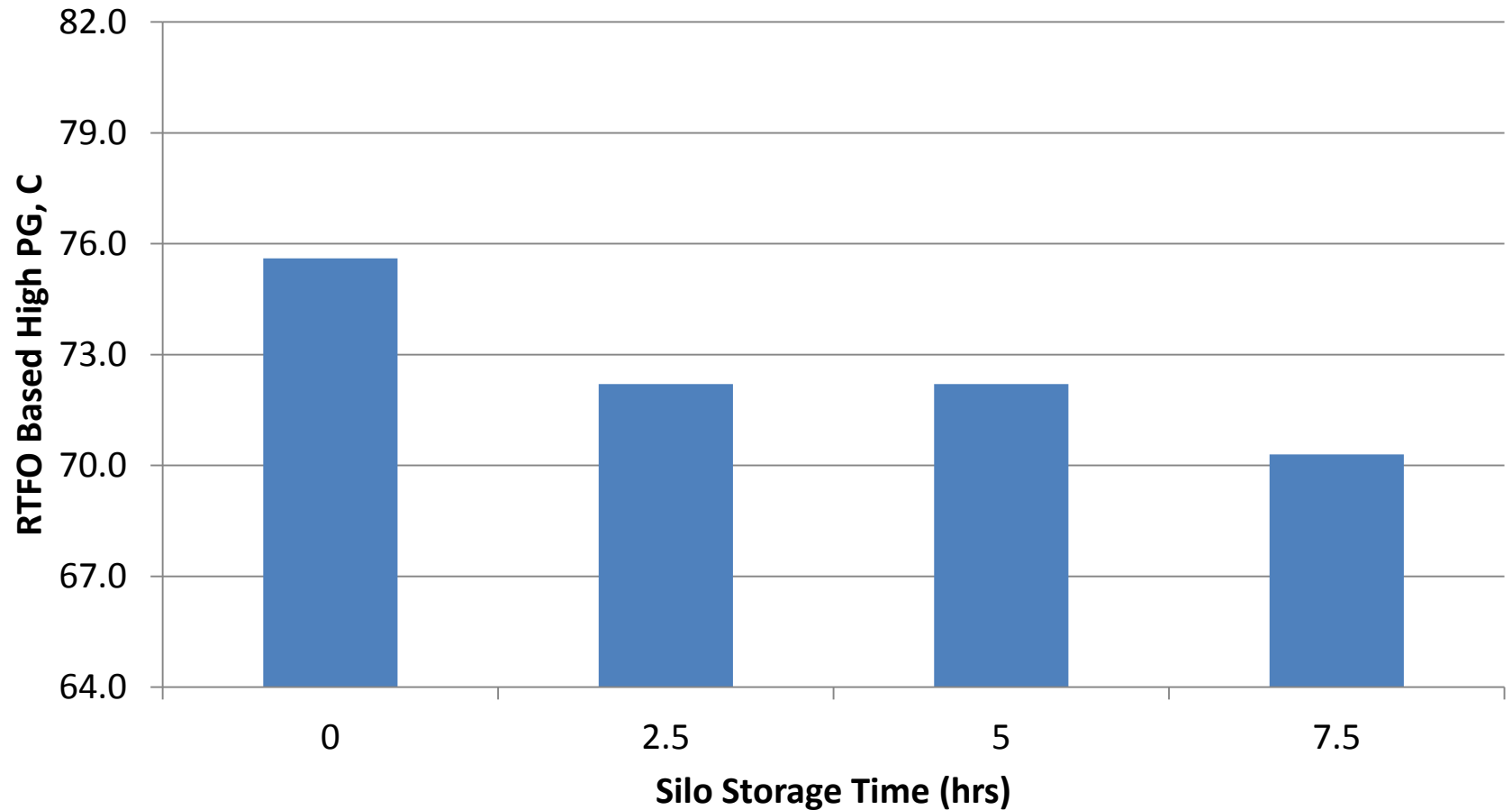
TSRST Results



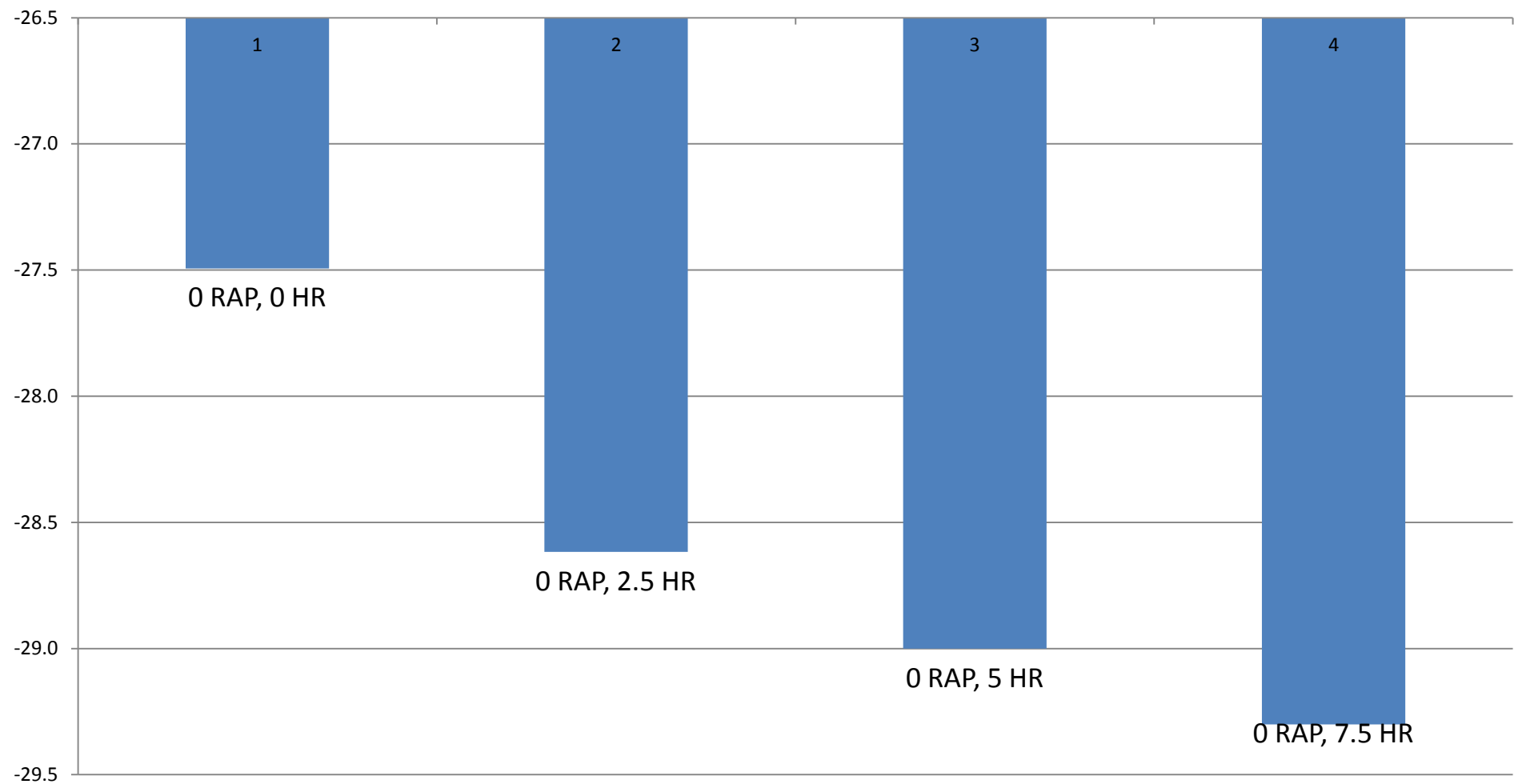
25% RAP Silo Storage Summary

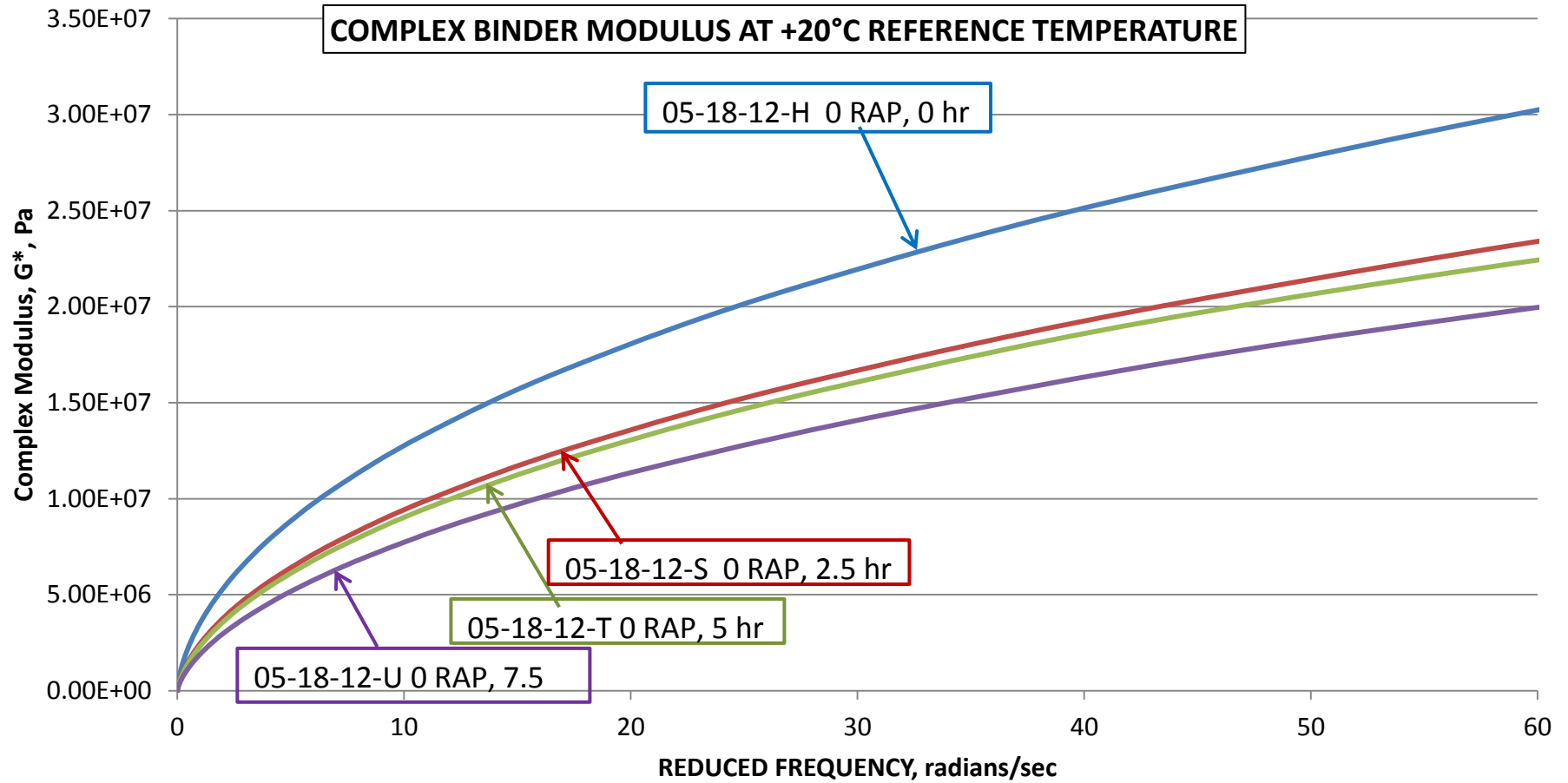
- Stiffening of binder with increase in storage time
- General stiffening trend with increase in storage time for mix
- Reheat mixtures stiffer than plant compacted but difference decreases with storage time

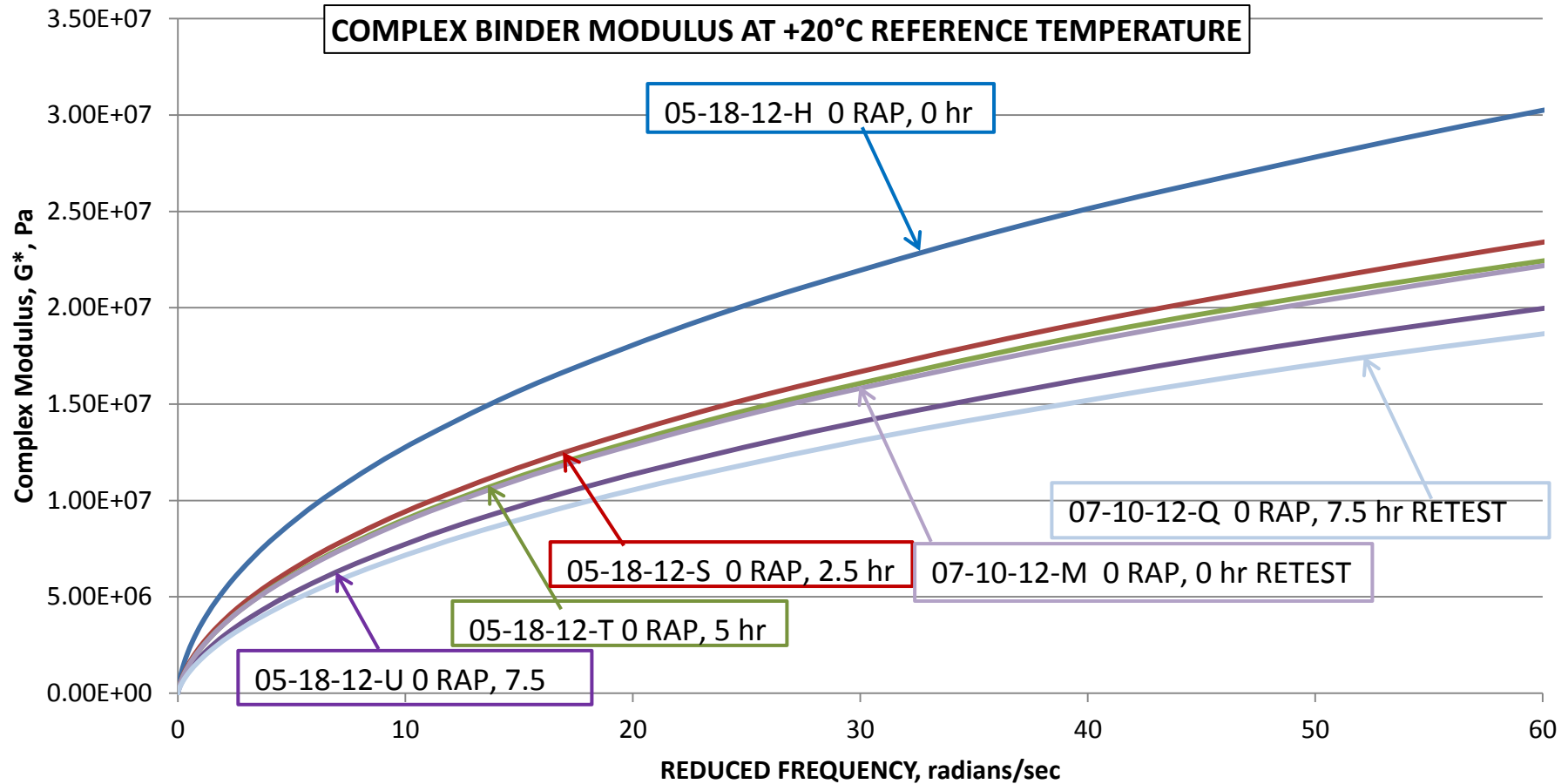
High Temp Grade Virgin Recovered



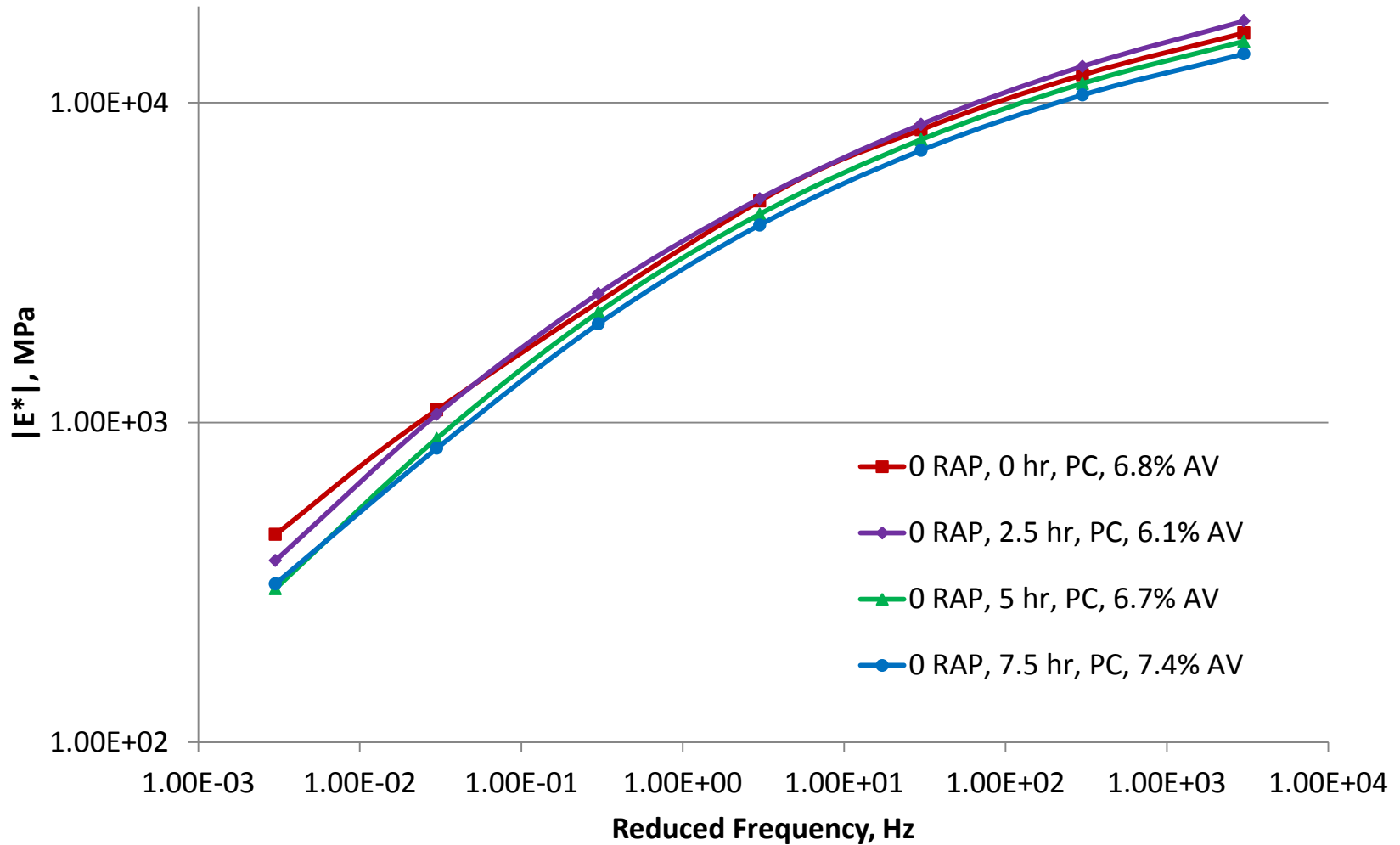
LOW TEMP GRADE VIRGIN MIX RECOVERED BINDER



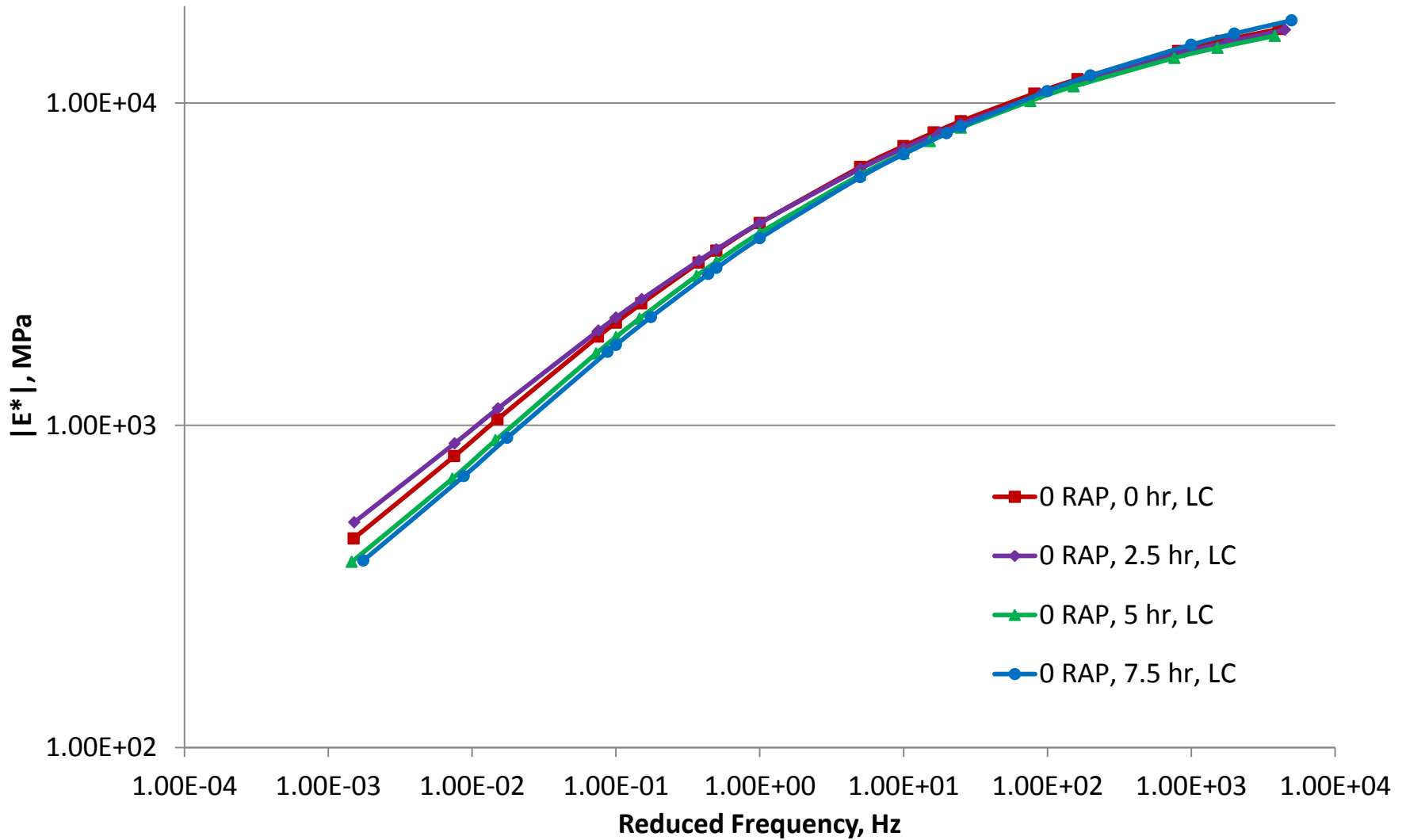




Plant Compacted Dynamic Modulus: Virgin



Lab Compacted Dynamic Modulus: Virgin



So, what happened?

Continuing work

- Phase II mixtures
 - NH mixtures – field sections
 - VA mixtures
 - 2012 mixtures
- New virgin silo storage study mixtures
- NCSU work refining fatigue criterion for RAP mixtures in SVECD approach
- Low temperature analysis, actual cooling rates and temperatures

Discussion