FLH Study on Polymer Modified Emulsions

Evaluating performance-based emulsion tests

Midwestern PPP Meeting

October 28, 2009, Schaumburg, IL

Outline

- ✓ **Background / Objectives of Study**
- ✓ **Tasks & Findings**
  - Literature Review
  - Industry Survey & Outreach
  - Strawman specifications & Field Trials
  - Recommendations & Final Report
- ✓ **Conclusions / What's Next**

Objectives/Need for Study

- ✓ No national standards exist within a single document to guide practitioners on the use of polymer modified asphalt emulsions
- ✓ The currently measured physical & chemical properties of emulsions do not always correlate with performance.
- ✓ Encourage level "playing field" for producers

CQS-1HLM CRS-2L RoadArmor® PMCRS CHFRS-2P

CRS-2P HFRS-2sP LMCRS-2P Ralumac® CRS-LTP

CRS-2R

CRS-2HLM PASS® MSE®

Objectives/Need for Study

- ✓ Address cost/benefit of polymer modification
- ✓ Address parking lots & biking trails
- ✓ Address climate extremes for FLH

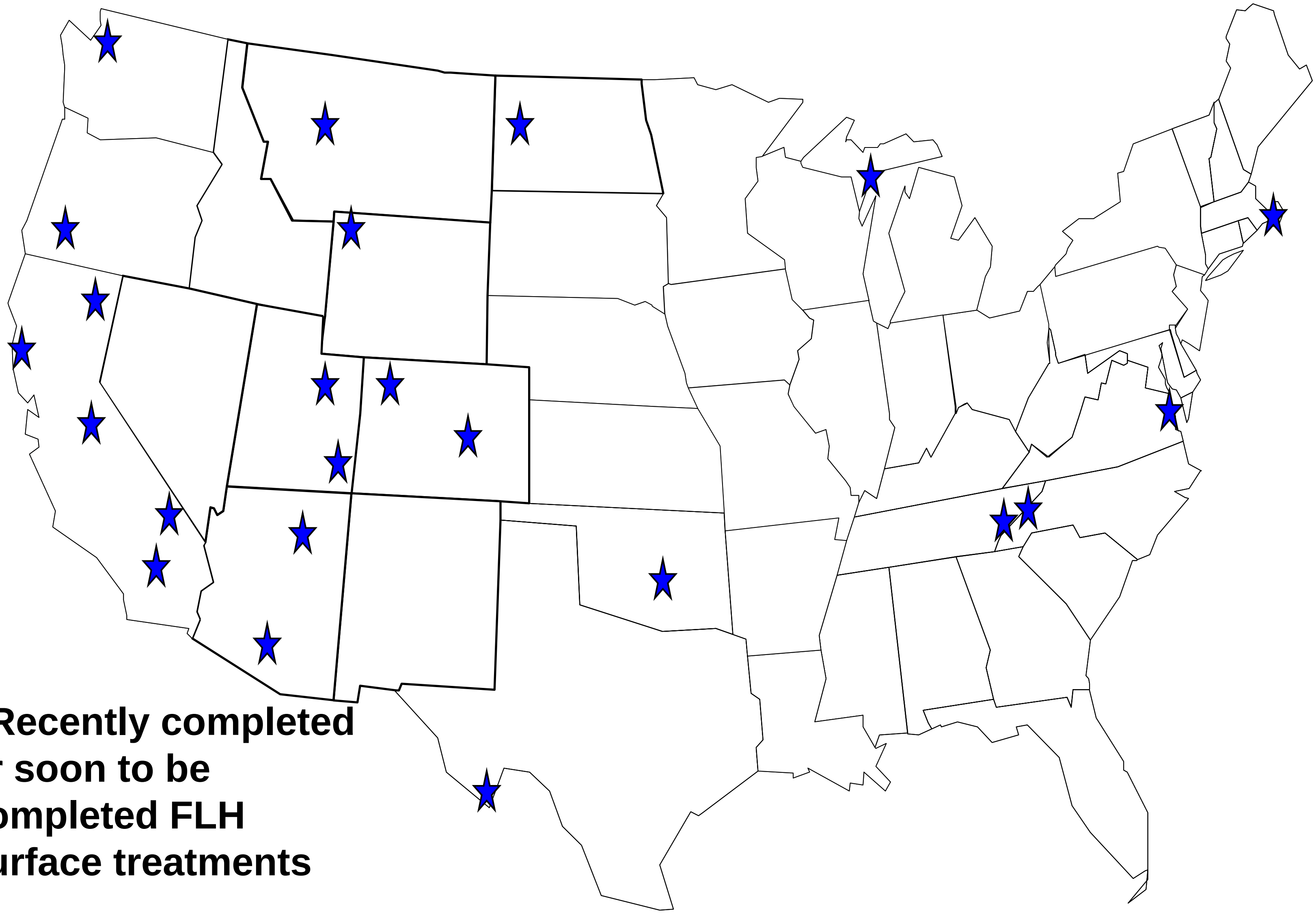
In brief, FLH desired guidance on **when, where, how, and why** to use polymer modified asphalt emulsions.

Climate Extremes

Death Valley N.P.

Bryce Canyon N.P.

Information Gap – No climatic grading system or guidance for emulsions



- Recently completed or soon to be completed FLH surface treatments

Objectives/Need for Study
Research Needs

- ✓ Pavement Preservation Research Roadmap needs: Materials 05: "Performance Grading System for Asphalt Emulsions"
- ✓ TRB Research Needs Statement
  - Pavement Preservation Committee - AHD18
  - Support from General Issues in Asphalt Committee (AFK10)
- ✓ Research Needs Total in the Millions of Dollars

Background of Study

- ✓ **Scope**
  - Use of polymer modified asphalt emulsions in surface treatment applications:
    -Chip Seals
    -Slurry Seals (micro-surfacing)
    -Cape Seals
  - Strawman specification and field trials primarily focused on rheology (testing on residue)

Background of Study

- ✓ **Principle Investigators:**
  - National Center for Pavement Preservation (NCPP), Larry Galehouse
  - GHK, Inc. is a sub-consultant (Gayle and Helen King)
- ✓ **Lab Testing Services: PRI**

Background of Study

- Technical Panel Includes: AEMA, FHWA, & Suppliers representatives
- Contributors include: Academia, ETGs, Industry, Suppliers

Literature Review

- ✓ **Common polymer dosage rates: 3 – 5 %**
- ✓ **Unequivocally, PMEs have significant performance benefits over unmodified emulsions**
  - Improved elasticity / ductility
  - Improved chip/stone retention
  - Improved high temperature performance

Literature Review

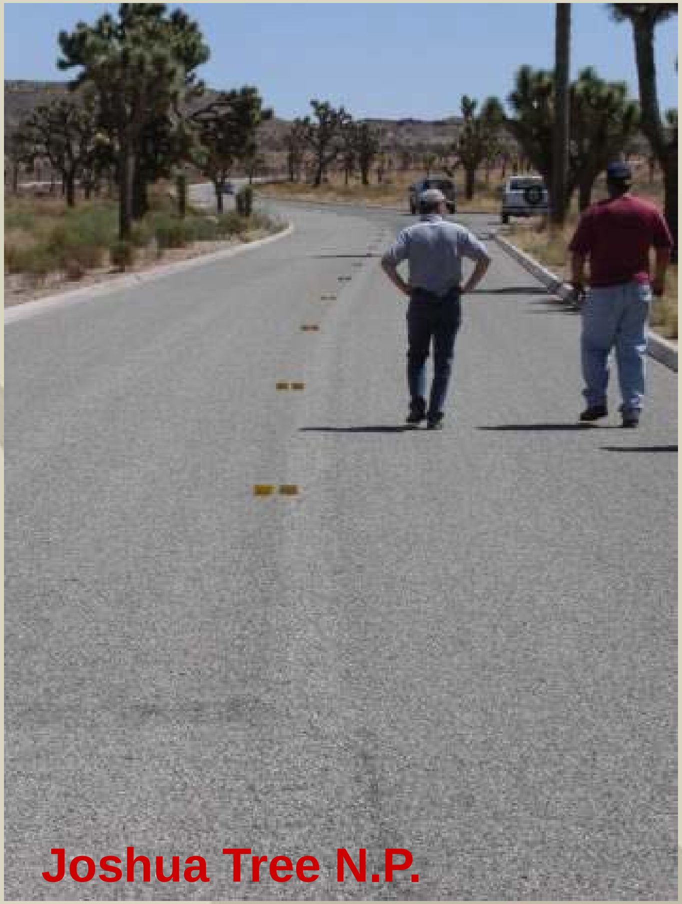
- ✓ Non-roadway applications (biking trails, parking lots): No pertinent literature
- ✓ Polymer concentration: Formation of continuous polymer network within an PME is critical to optimizing performance benefits
- ✓ Most common polymer modification: SBR and SBS
- ✓ Benefits of PME likely far outweigh its additional cost.

Industry Survey & Outreach

- Knowledge gathering sessions: Industry, academic, federal & local government agencies
- On-line user/ producer survey
- Presentations & input: AEMA/ARRA/ISSA, TRB, ETGs, AASHTO, PPPs

Goals of the On-Line Survey

- Solicit industry and agency input
  - To create a framework for performance-based asphalt emulsion specifications
  - Validate and/or influence direction of specifications/testing



Joshua Tree N.P.

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Survey Questionnaire Areas

- ✓ Approved Supplier Certification Program
- ✓ Residue Recovery Methods
- ✓ Emulsion Specification Tests
- ✓ Emulsion Residue Specifications
- ✓ Application-Specific Performance-Related Specifications
- ✓ Construction/Acceptance

National Center for Pavement Preservation

Survey Primary Recommendations

- ✓ **Approved Supplier Certification program**
  - Reduce shipping & construction delays
- ✓ **Update AASHTO T-59 & ASTM D-244**
  - Adopt a low temperature residue recovery method
  - Revise emulsion viscosity method
    - **Lab test: Brookfield or paddle method**
    - **Field acceptance test**

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Survey Primary Recommendations

- ✓ Residue performance-graded specifications
  - Superpave binder tests preferred
  - Aging: Use PAV, do not use RTFO
- ✓ Need performance-related tests for applications
  - Must include aggregate
  - Evaluate cure time to traffic
- ✓ Aggregate testing important

Strawman Specification Emulsion Residue Recovery & Testing

Purpose	Test	Conditions	Report
Residue Recovery	Forced Draft Oven	24 hrs @ambient + 24 hrs @60°C	✓% Residue
Tests on Residue from Forced Draft Oven			
High Temperature (Rutting/Bleeding)	DSR-MSCR DSR freq sweep	T_h T_h	✓J_{nr} ✓G* & phase angle
Polymer Identifier (Elasticity/Durability)	DSR-MSCR	T_h @3200 Pa	✓% Recoverable Strain
High Float Identifier (Bleeding)	DSR – non-linearity	T_h	✓Test to be developed
Tests on PAV after Forced Draft Oven Residue			
Low Temperature (Aged Brittleness)	DSR freq sweep	10 & 20° C Model low T	✓G* ✓Phase Angle
Polymer Degradation (Before/After PAV)	DSR-MSCR	T_h @3200 Pa	✓Recoverable Strain Ratio

T_h = high pavement temp; DSR = dynamic shear rheometer
MSCR = multiple stress creep recovery

Emulsion Residue Recovery

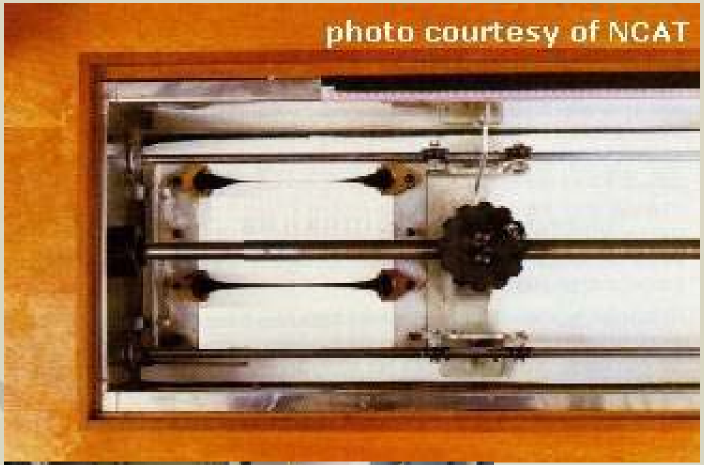
- ✓ **Forced Draft Oven (FDO) Method:**
  - ASTM D7497 - 09
  - Standard Practice for Recovering Residue from Emulsified Asphalt Using Low Temperature Evaporative Technique
  - 24 hour ambient; 24 hour in 60°C oven

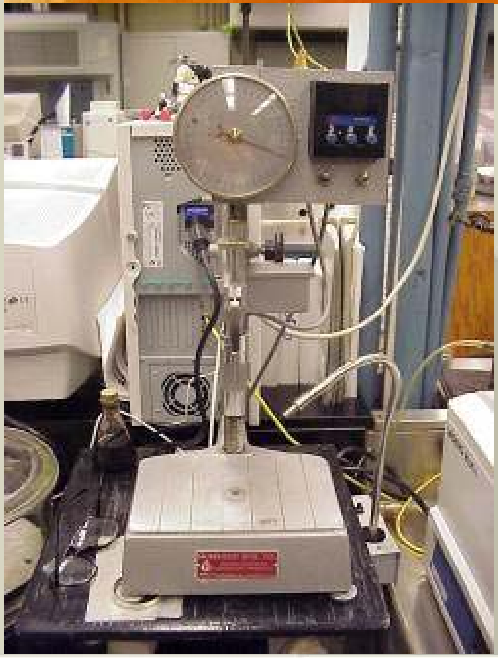
TTI evaluating other methods

Residue Performance Test: AASHTO M 316

- ✓ Penetration 25°C, 100-175 dmm
- ✓ Ductility, 30 cm at 4°C and 125 cm at 25°C
- ✓ Elastic Recovery, 50%
- ✓ Polymer solids content (2.5% minimum)

"One size fits all" specification. No traffic or climate criteria





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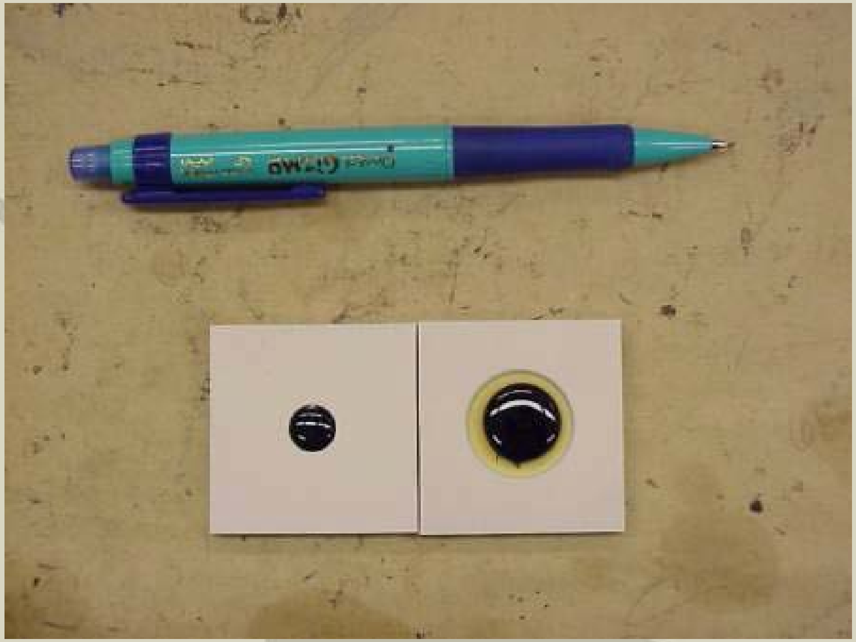
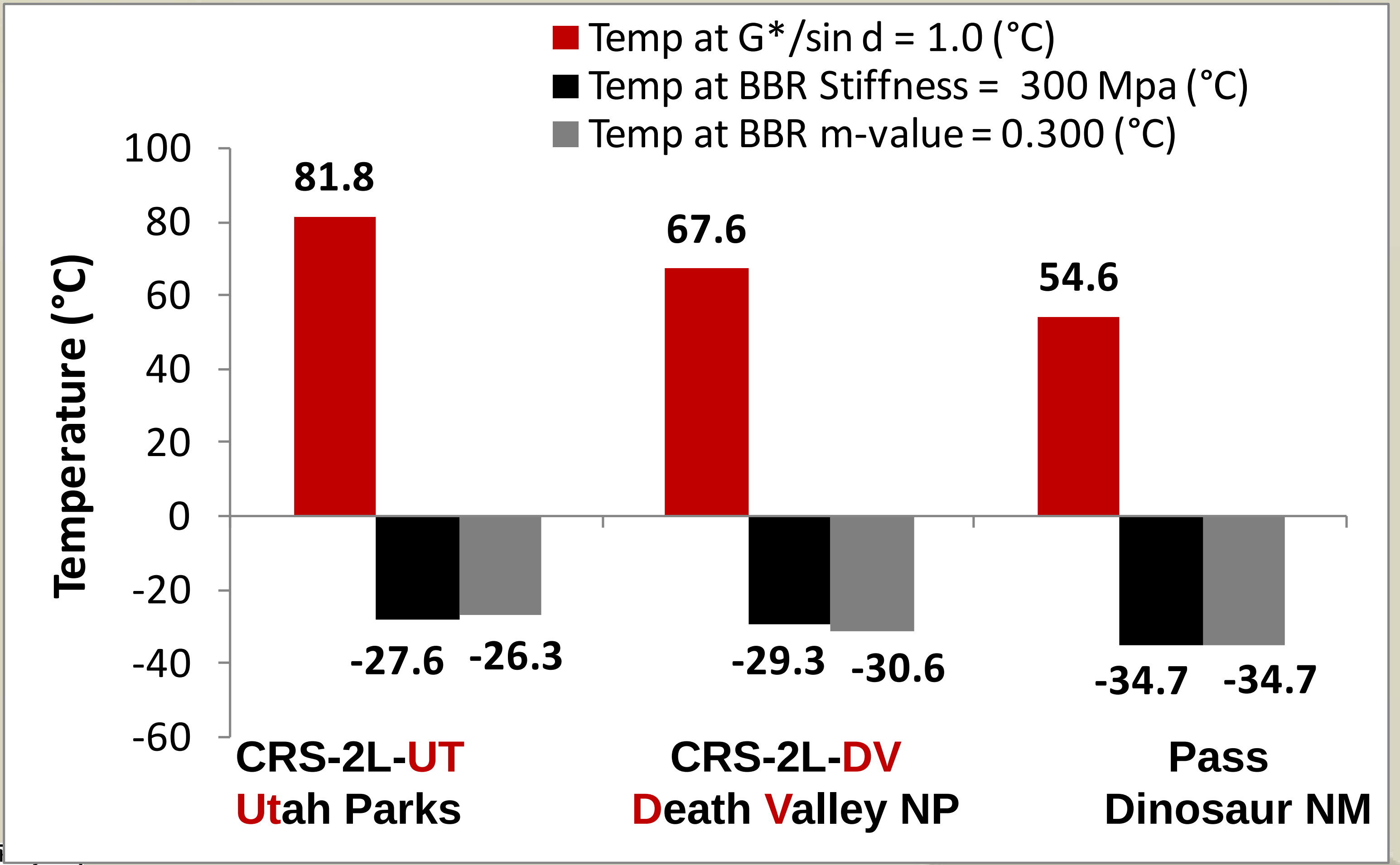
Dynamic Shear Rheometer



Residue Performance Test: High Temperature Grade

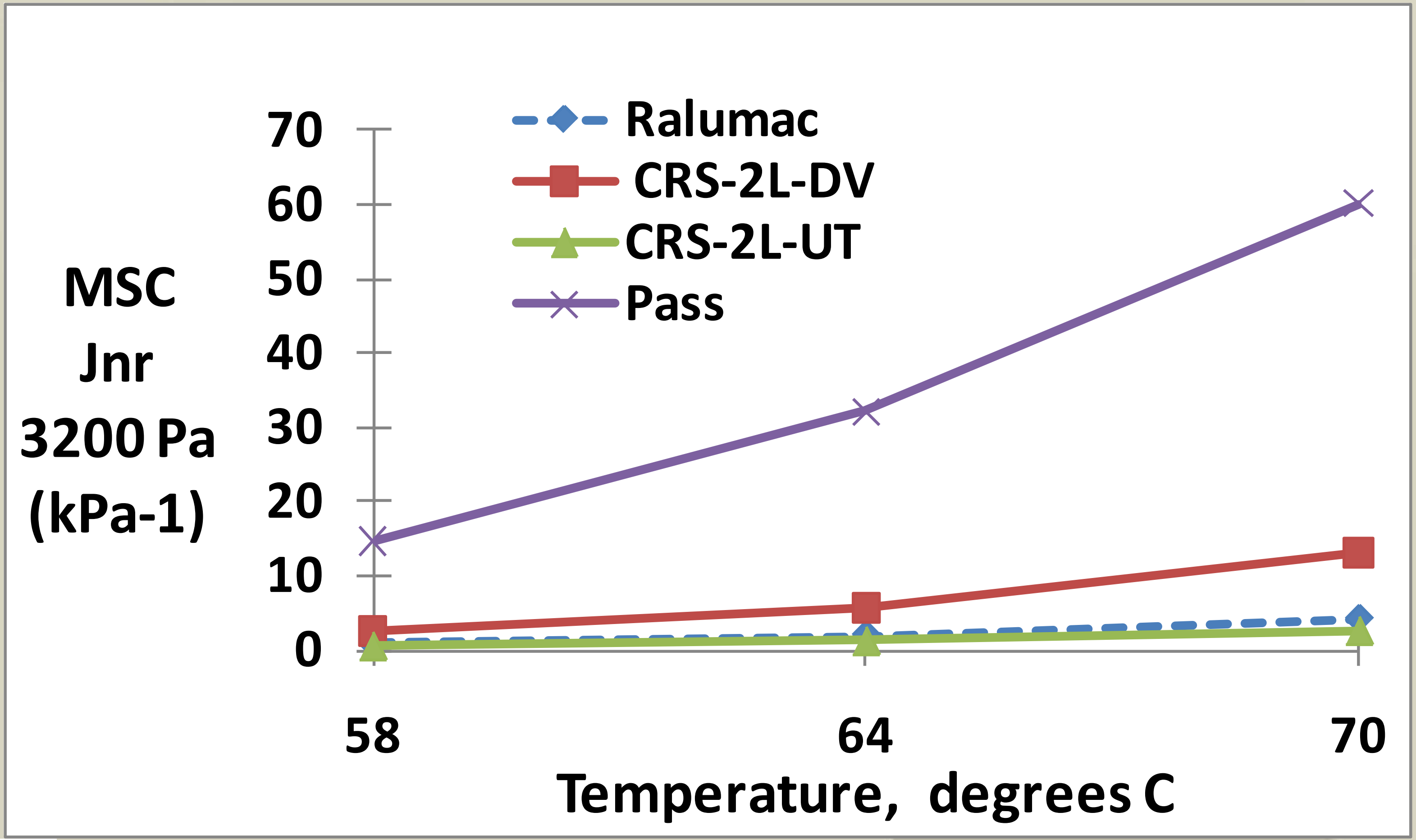
- DSR Frequency Sweep
  - G* and phase angle
- Multi-Stress Creep Recovery Test (MSCR)
  - J_{nr} (compliance)
- Spec limit determined for each emulsion grade based upon application & traffic
  - Test temperature set by climate
    - 6°C increments from LTPPBind

Chip Seal Emulsion Residue Temperature Grading (SHRP Parameters)

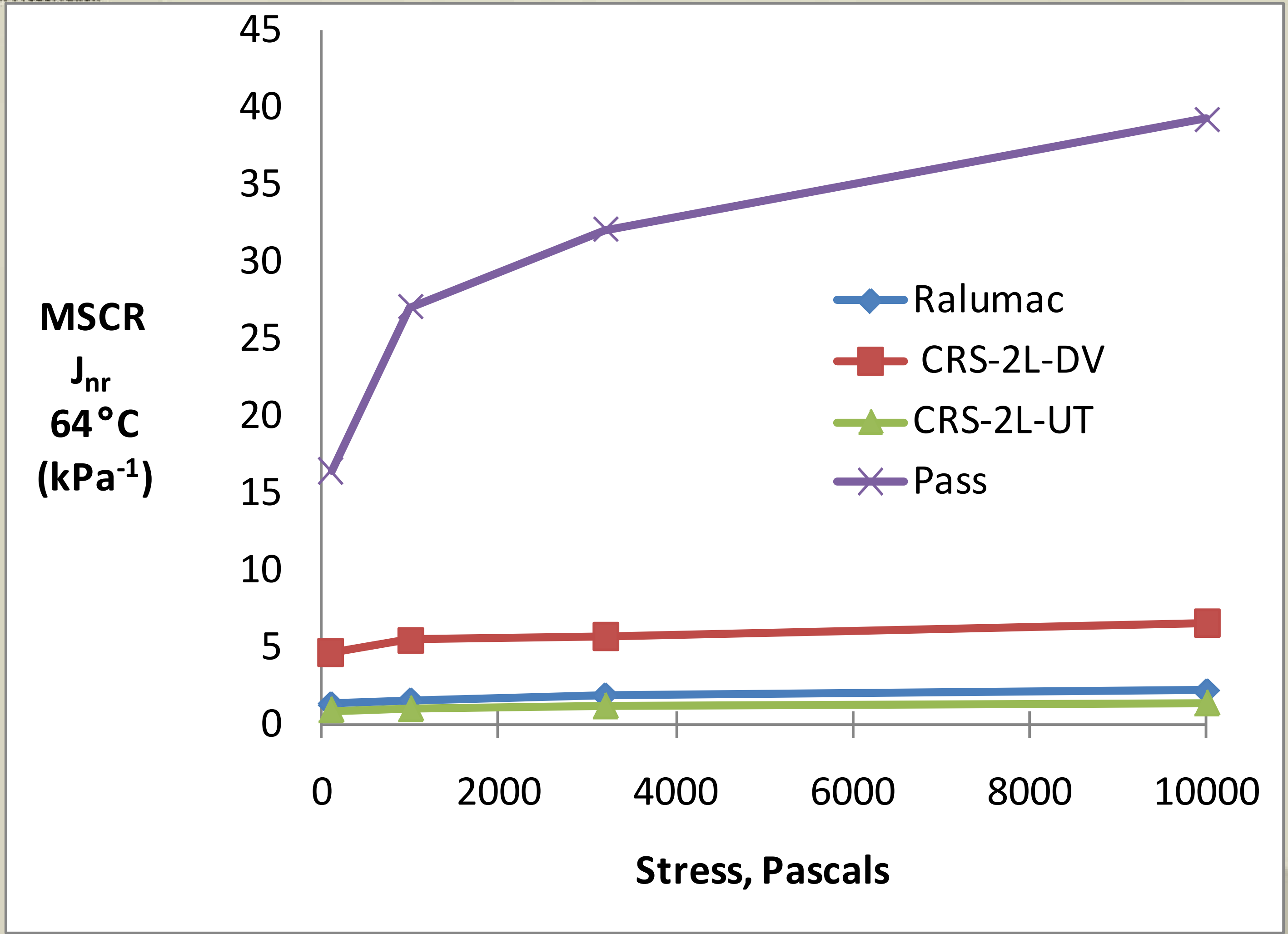


MSCR

Effect of Temperature on J_{nr} @ 3200 Pa



MSCR - J_{nr} vs Stress

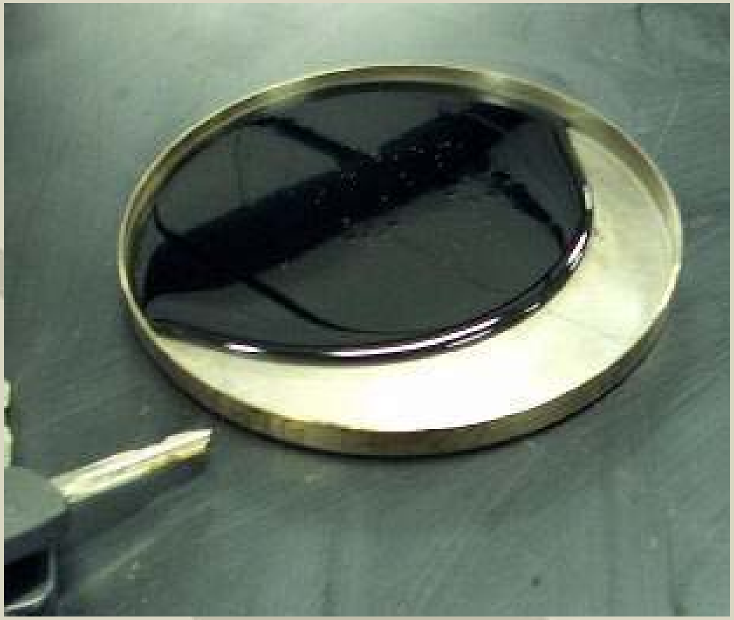


Residue Performance Test: Aging on the Pavement

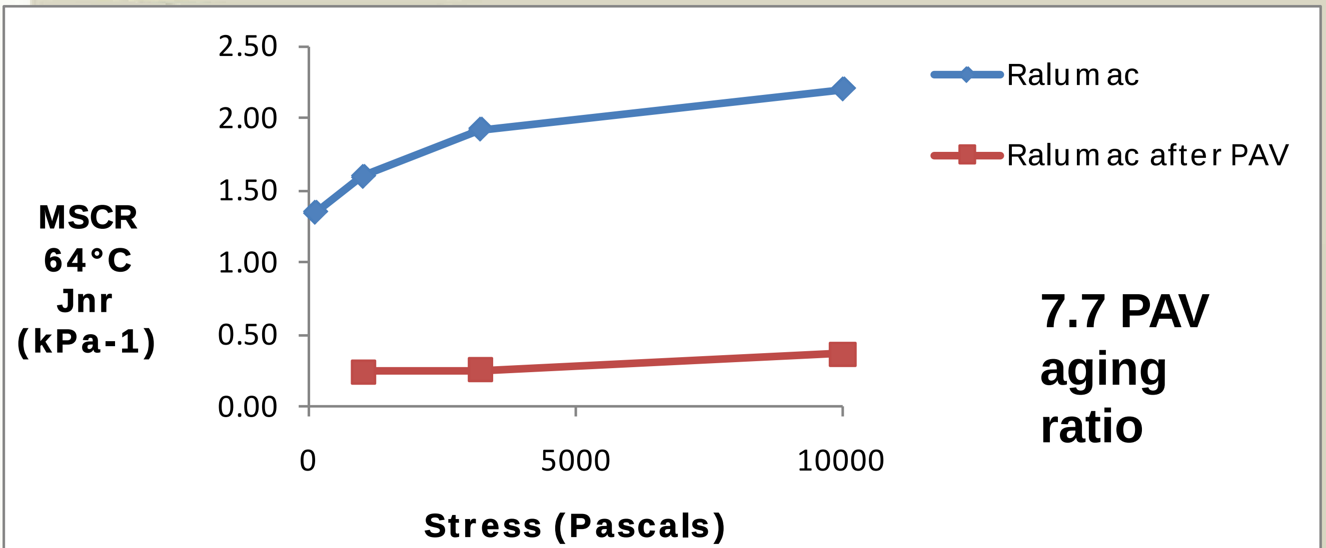
- PAV – Pressure Aging Vessel
  - Emulsion cured in PAV pan per FDO procedure
  - Use standard PAV time & temp for climate

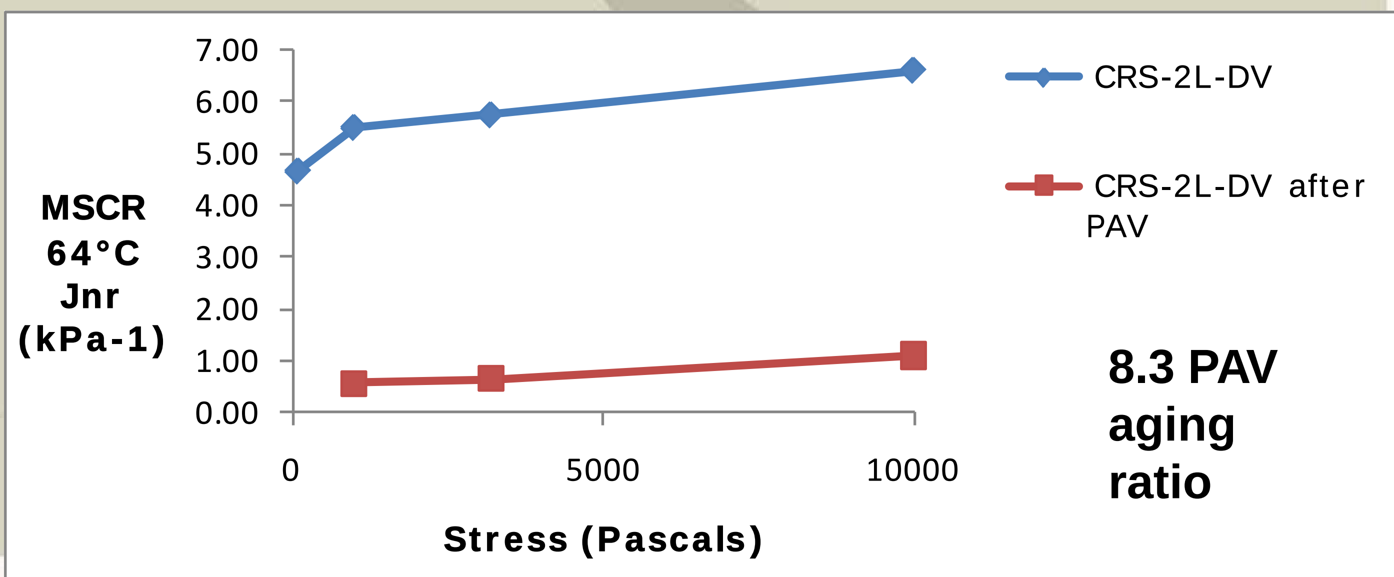
No Hot Mix Plant – No RTFO

Pressure Aging Vessel (PAV)



Effect of Aging on 64°C J_{nr} for Ralumac & CRS-2L(DV)





Residue Performance Test: Low Temperature Grade

- DSR Frequency Sweep
  - Determine G* and δ after PAV
- Spec limit set by application & traffic
- Alternative methods:
  - Intermediate temperature test with CAM model extrapolation
  - T_L+10°C using 4-mm plates
- Climate temperature from LTPPBind

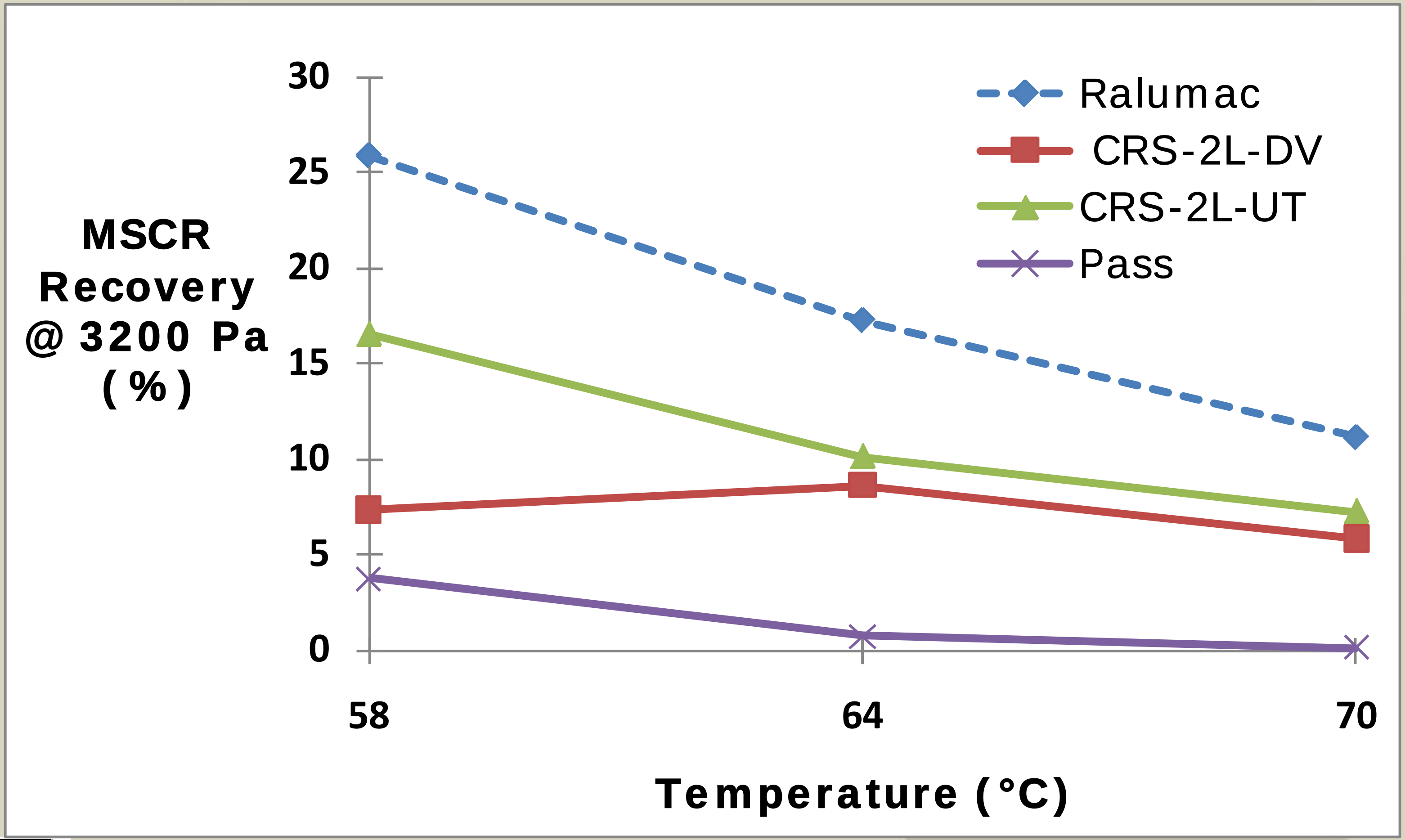
Note: replaces BBR

Residue Performance Test: Polymer Elasticity

- Multi-Stress Creep Recovery Test (MSCR)
  - Determine % recovered strain

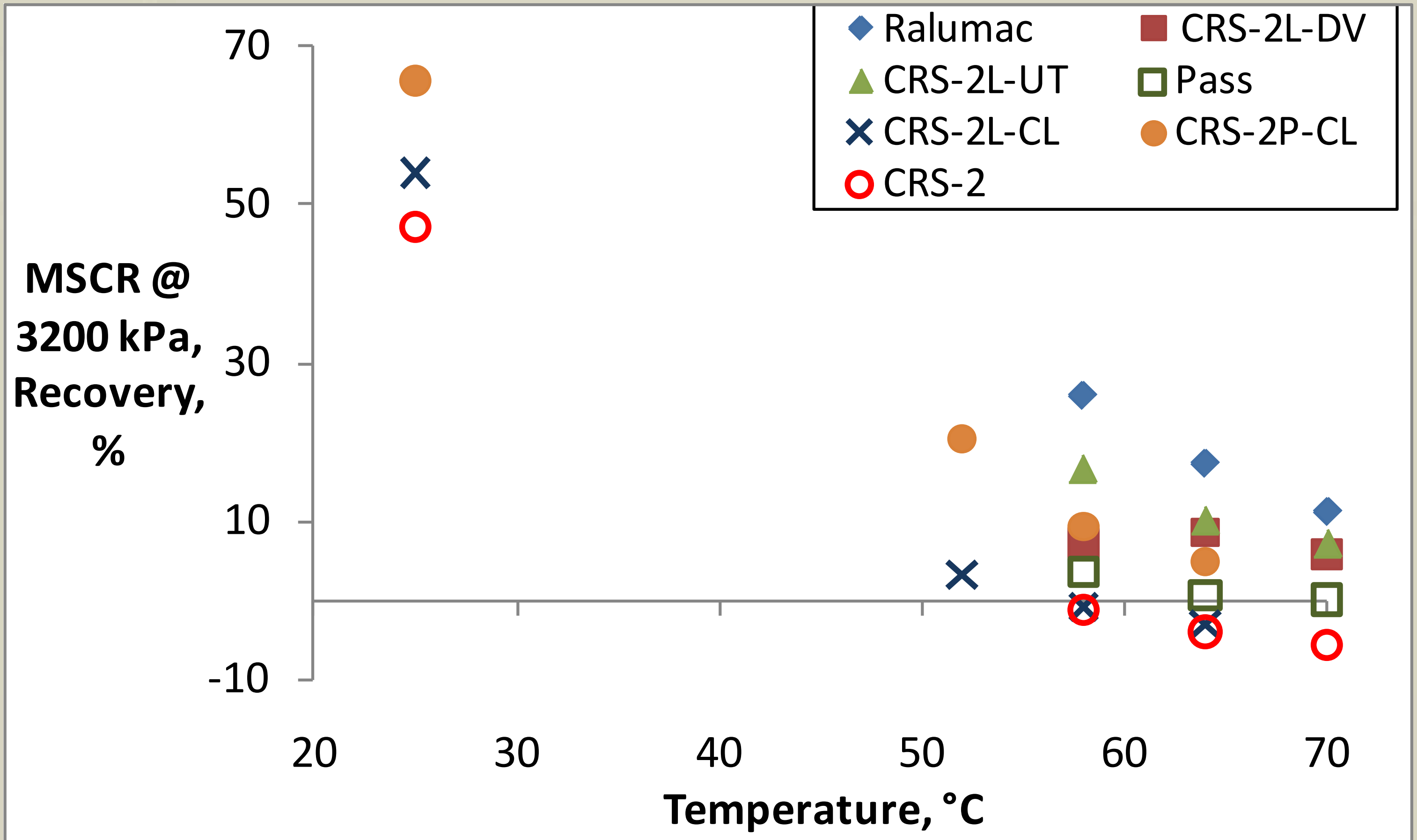
MSCR

Effect of Temp on Recovery @ 3200 Pa



MSCR

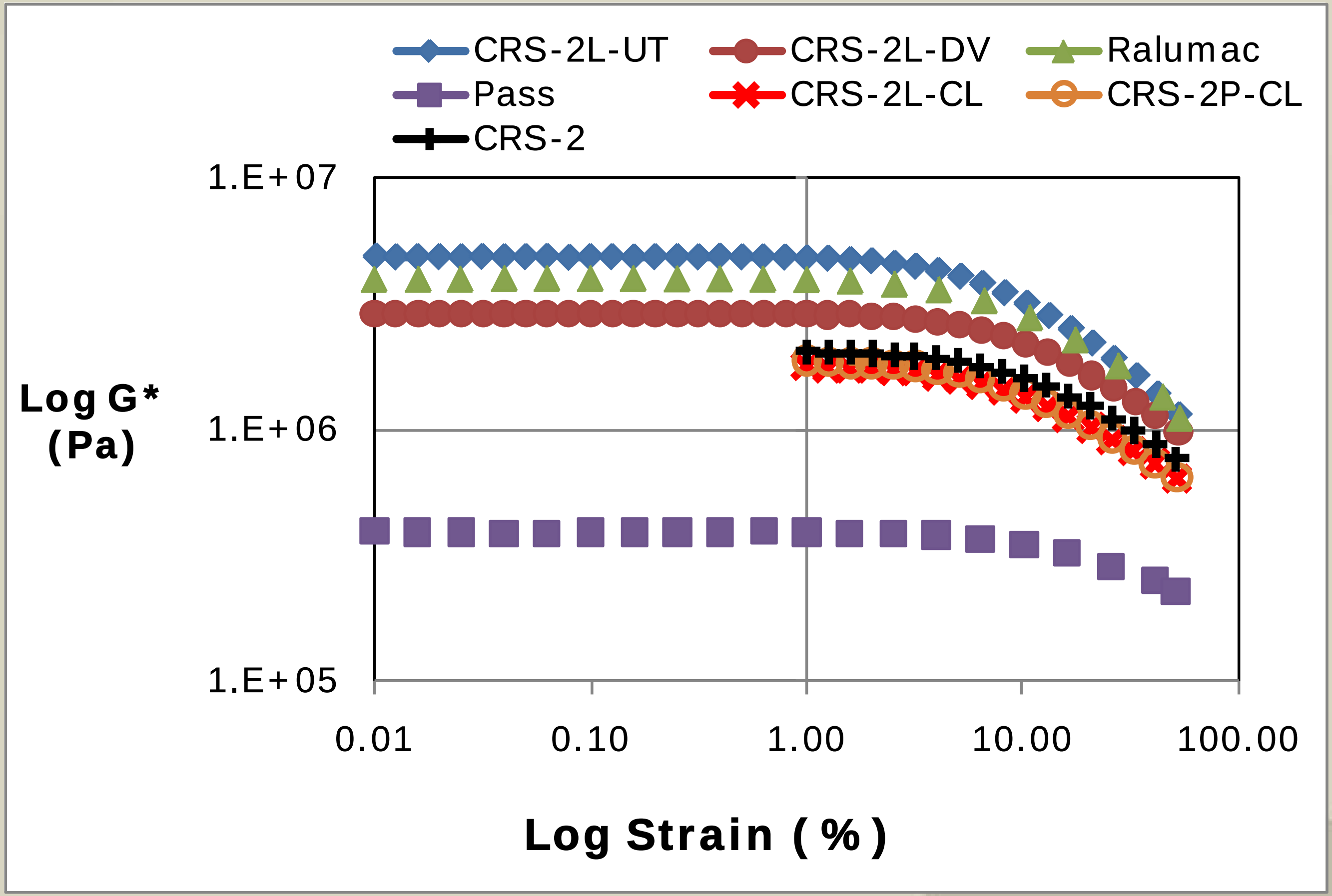
Effect of Temp on Recovery @ 3200 Pa



Residue Performance-Related Test: Chip Loss

- **Cohesive failure**
  - Ambient temperature - shelling
    - **DSR Strain Sweep**
      - Determine strain for given % modulus loss
      - Test before & after PAV aging
  - Low temperature - snow plow damage
    - **Vialit Pendulum ???**
- **Adhesive failure – dry & wet**
  - Needs R&D

Strain Sweeps on PME Residues



Performance-Related Test: Chip Seal - Cure Time for Traffic

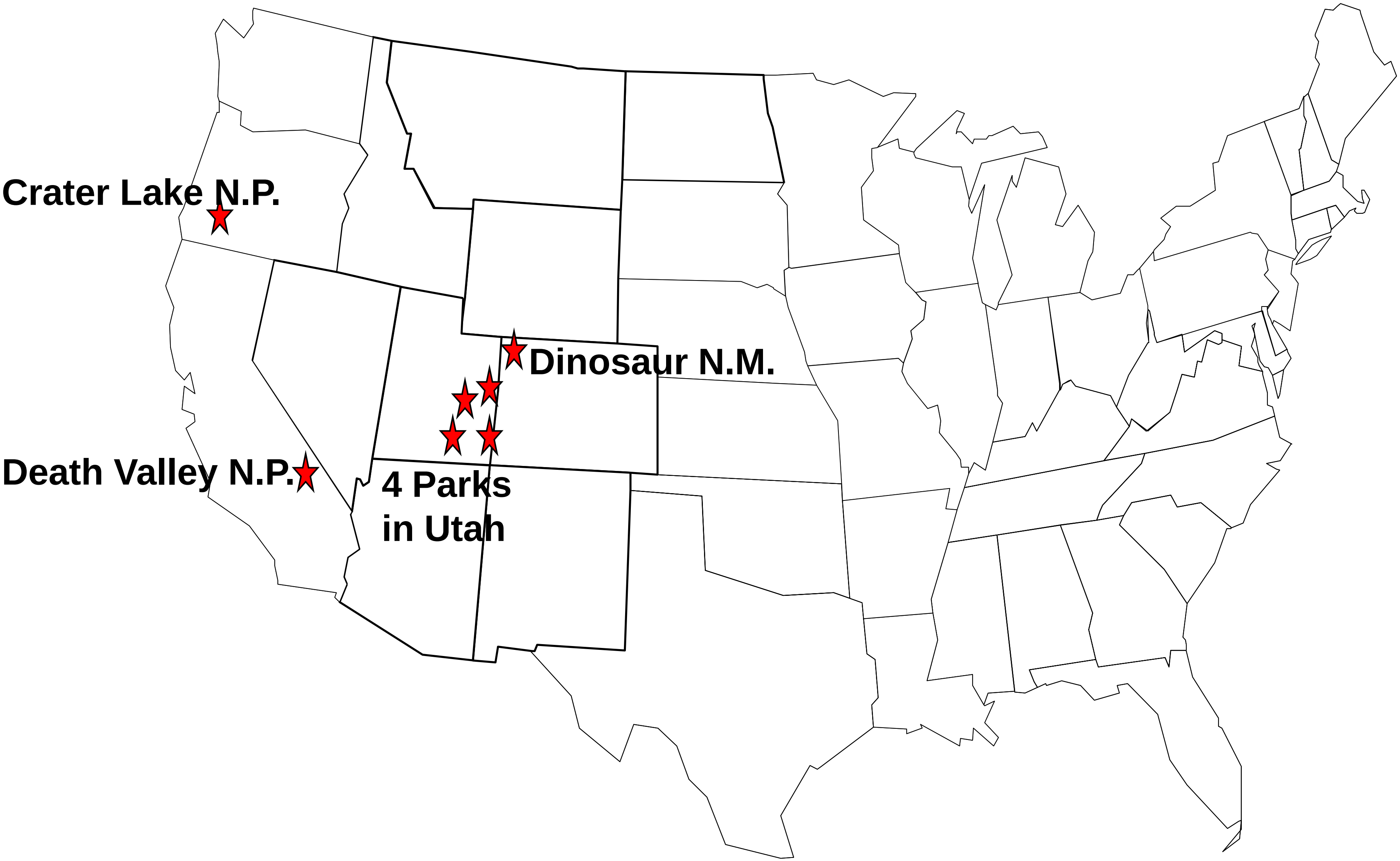
- **Sweep Test - ASTM D7000**
  - Standard Test Method for Sweep Test of Bituminous Emulsion Surface Treatment Samples

Performance-Related Test: Chip Seal - Cure Time for Traffic

✓ Sweep Test – Modified ASTM D7000 Results

Project / Emulsion	Test Lab	Mass Loss (%) Average	STD	Range
Arches /CRS-2L-UT	BASF	11.1 %	2.0	5.3
Arches /CRS-2L-UT	Paragon	16.5 %	0.4	0.9
Arches /CRS-2L-UT	PRI	13.1 %	1.0	2.4
Arches /CRS-2L-UT	**Ave.**	**13.5 %**	**2.7**	**5.4**
Death Valley /CRS-2L-DV	BASF	9.7 %	1.5	3.2
Death Valley /CRS-2L-DV	PRI	11.9 %	1.1	3.0
Death Valley/CRS-2L-DV	**Ave.**	**10.8 %**	**0.2**	**1.1**
Dinosaur/ Pass	PRI	Insufficient curing @ 2hrs, all chips lost		

Surface Treatment Project Locations – For Evaluating Strawman Specifications



Utah Parks - Construction

- **90 miles total 9/6/08 – 10/17/08**
  - Arches & Canyonlands Nat'l Parks,
  - Natural Bridges & Hovenweep Nat'l Monuments
- **Chip Seal – 1,140,000 sy (fogged)**
  - CRS-2L (SBR latex modified)
- **Microsurfacing - 60,000 sy**
  - Natural latex modified Ralumac®

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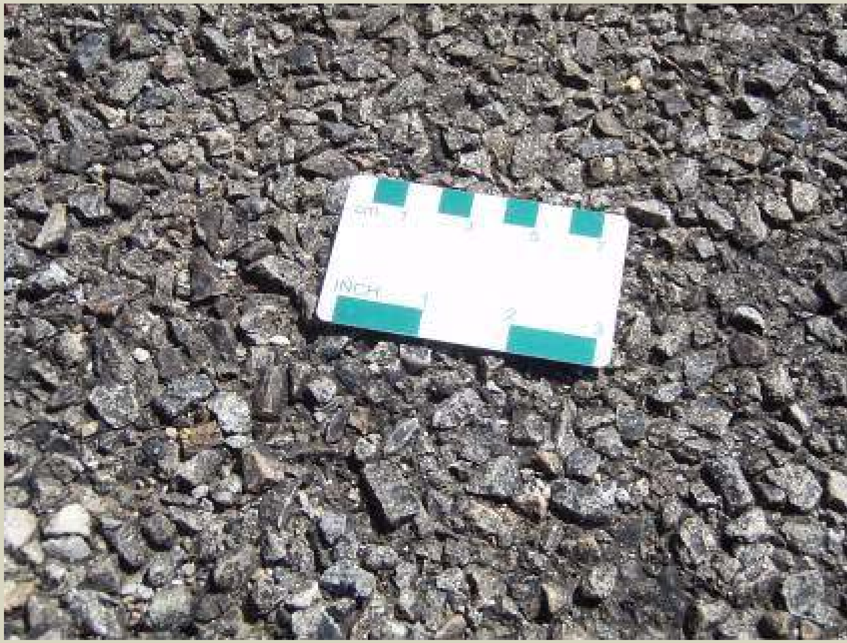
Utah Parks - Performance

Arches National Park chip seal test section:

- ✓ 1800-2000 ADT in the spring & summer
- ✓ Pre-existing condition: transverse cracking

Milepost (location)	Cracking (unsealed)	Raveling (loss of chips)	Flushing/ Bleeding
2.76 (Rt 10)	27 feet (3%)	None	390 sq ft (3.5%)

Utah Parks – Performance Arches National Park



Utah Parks - Performance

Canyonlands National Park chip seal test section:

✓ Pre-existing condition - good

Milepost (location)	Cracking (unsealed)	Raveling (loss of chips)	Flushing/ Bleeding
8.84 (Rt 11)	None	None*	Very minor

*Some snow plow scrapes at centerline.

Utah Parks – Performance Canyonlands National Park

Utah Parks – Performance Micro-surfacing

Utah Parks - Performance

Other Observations:

- ✓ Fog seal has worn off surface of aggregates
- ✓ Bleeding at most intersections within Park
- ✓ Some raveling of the micro-surfacing
- ✓ Snow plow damage and scrapes were noted

Dinosaur National Monument

- ✓ **11.4 miles – 9/23/08 – 9/30/08**
- ✓ **Chip seal – 135,000 sy**
  - Neoprene modified emulsion, PASS®
- ✓ **Test plan:**
  - PRI: emulsion & aggregates
  - CFLHD Lab: acceptance testing only

Dinosaur National Monument - Performance

Dinosaur National Monument chip seal test section:

- ✓ Pre-existing condition: very good; 2-year old pavement

Milepost (location)	Cracking	Raveling (loss of chips)	Flushing/ Bleeding
Park Entrance (Rt 10)	None	Very minor (not in wheel paths)	None

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Dinosaur National Monument - Performance

Dinosaur National Monument - Performance

Dinosaur National Monument - Performance

Other Observations:

- ✓ Fog seal has worn off surface of aggregates
- ✓ Some minor bleeding at intersections within Park
- ✓ Chips were easily dislodged by fingers
- ✓ Residue asphalt not as "stretchy" as ARCH and CANY

Death Valley National Park

- ✓ **13 miles – 11/11/08 – 11/14/08**
- ✓ **Chip seal – 161,400 sy**
  - SBR latex modified CRS-LM
- ✓ **Test plan:**
  - PRI: emulsion & aggregates
  - Paragon: emulsion & aggregates
  - BASF: emulsion & aggregates
  - CFLHD Lab: acceptance testing only

Crater Lake National Park

- 23 miles chip seal
  - Summer 2009
  - 367,000 sy
- SB/S modified CRS-2P (1 or 2 tankers) SBR modified CRS-2L on remainder
- Test Plan
  - PRI, Paragon, BASF, Kraton Polymers, Ultrapave: emulsion & aggregates
  - WFLHD Lab: acceptance testing only

Recommendations

- ✓ Polymer modified asphalt emulsions should be used for surface treatments (chip, slurry, micro) for all traffic and climate conditions
- ✓ Pursue performance based specifications as opposed to specifying polymer percentages
- ✓ Adopt low temperature residue recovery method

Recommendations

- ✓ **Continue validating strawman specifications**
  - Test methods & field performance
- ✓ **Further Investigation Needs**
  - Critical limit for J_{nr}
  - Optimum test temperatures & operating conditions for MSCR recovery
  - Use of DSR for determining low temperature properties
  - Improve inter-lab agreement with Sweep Test

Development of Transportation Pooled Fund Study

To further the numerous research projects underway and to support the Emulsion Task Force with specification development, it is suggested that a Transportation Pooled Fund Study (TPF) be developed.

Transportation Pooled Fund Program

Development of Transportation Pooled Fund Study

- ✓ **The Need…**
  - Validation of lab testing protocol with field performance
  - Refinement of testing methodology
  - Better establish failure mechanisms and validate tests that will predict premature failure
  - If a TPF study is not set up to validate and support spec development…who will??

Development of Transportation Pooled Fund Study

- **The Current Support…**
  - PP ETG's Emulsion Task Force (customer)
  - Pavement Preservation Research Roadmap, TRB
  - Industry (technical input)
  - FHWA Office of Asset Management ($20k)
  - FHWA Federal Lands Division ($20k)

- Need Support of at least 8 to 10 State DOT's with commitment of $20k or more
- Is a State willing to lead or co-lead effort?

Thank You.

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