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SBR and Natural Rubber Latex-Modified Emulsions for Micro Surfacing

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Chris Lubbers
BASF Corporation

Erland Lukanen, P.E.
Minnesota DOT Office of Materials

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Outline

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- Asphalt emulsion primer
- What are polymers?
- Polymers for micro surfacing emulsions
  - Modification of asphalt emulsions
  - Latex polymer networks
  - Impact on binder + mix properties
- MN DOT micro surfacing perspective
- SBR latex-modified TH 55 demo details

Asphalt Emulsions - Formulation

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- **Components**
  - Asphalt
  - Surfactant (surface active agents, emulsifiers)
  - Water
  - Mechanical energy (colloid mill)
- **Other Ingredients**
  - Additives (calcium chloride, cutback agents,…)
  - Modifiers – *Polymers*

Asphalt Emulsions – Component Distribution

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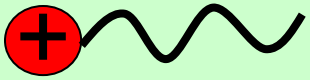
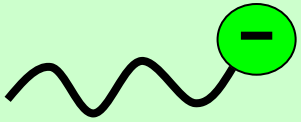
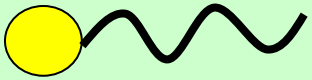
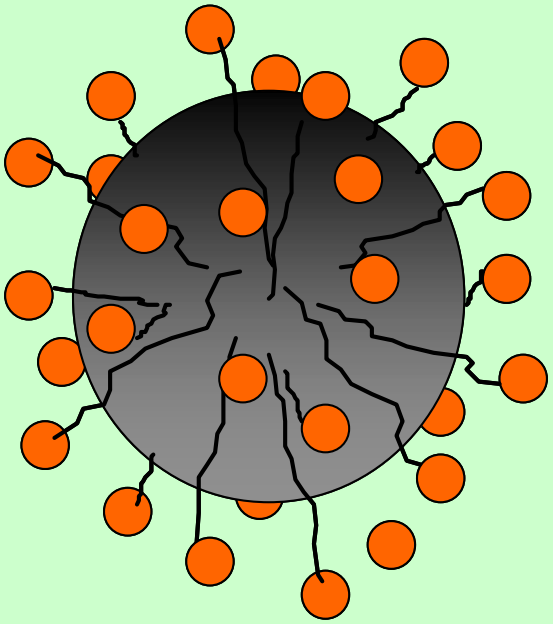
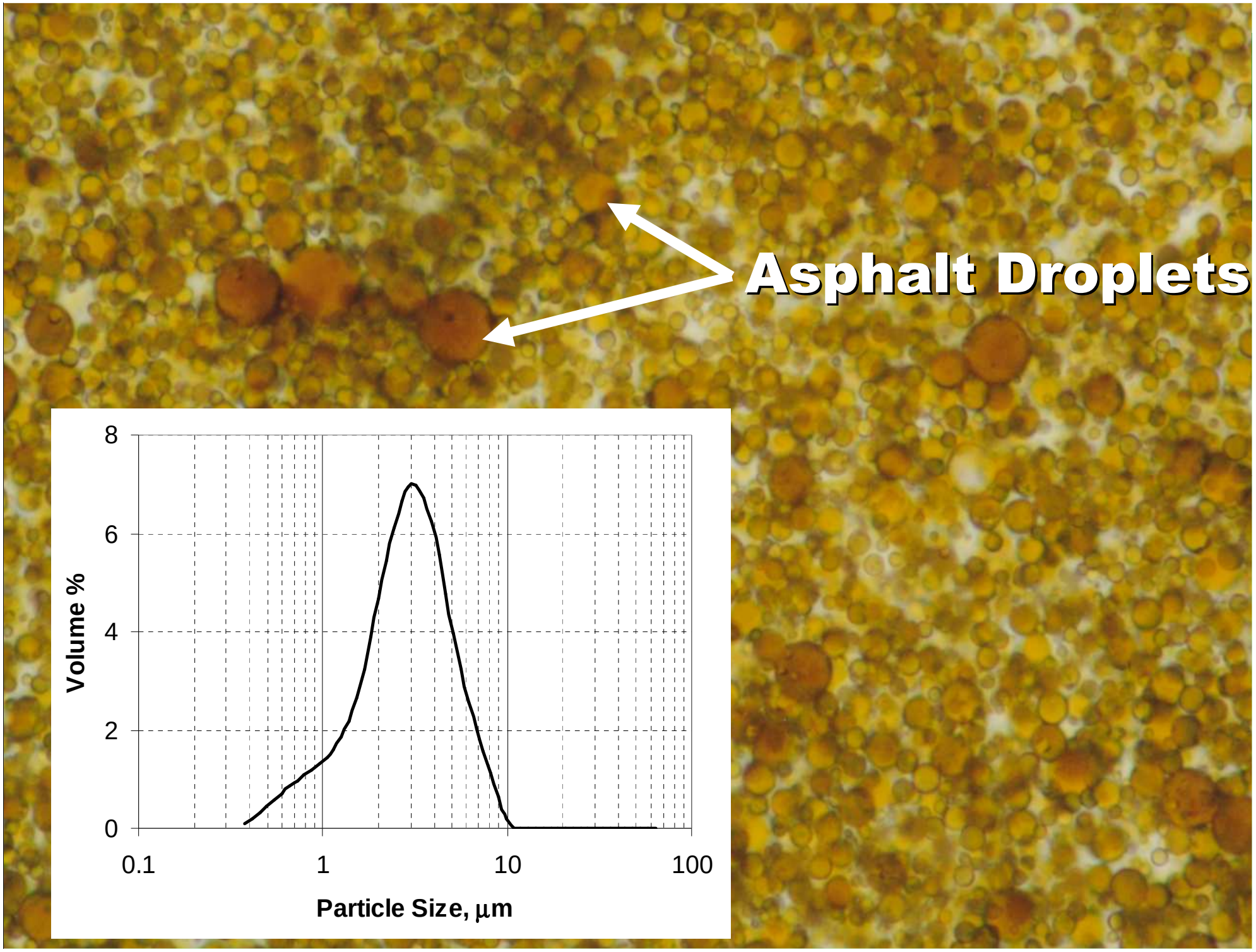
- **Dispersion of asphalt in water**
  - Water – continuous phase
  - Asphalt – non-continuous or dispersed phase
    - Stabilized by surfactant
- **Surfactant → emulsion class.**
  - Cationic 
  - Anionic 
  - Nonionic 




Asphalt Droplets
8
6
4
2
0
Volume %
0.1
1
10
100
Particle Size, µm

What are Polymers?

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- **Comprised of many small molecules**
  - **Poly** = many
  - Mono**mers** = small molecules or repeat units
- **Monomers chemically react → larger molecules**
  - Water-based polymers – latex form (SBR, NRL)
- **Properties are determined by:**
  - Types and sequence of monomers
  - Molecular weight

Polymer Types for Micro Surfacing

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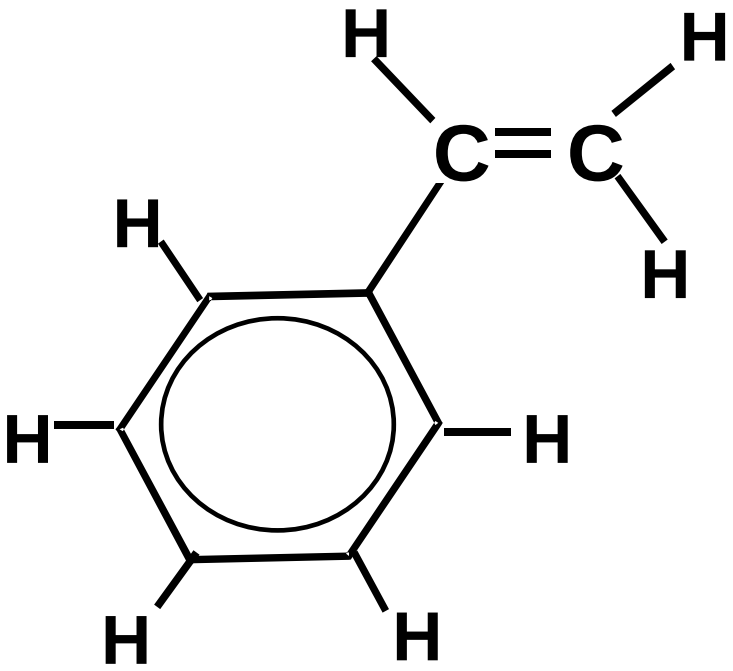
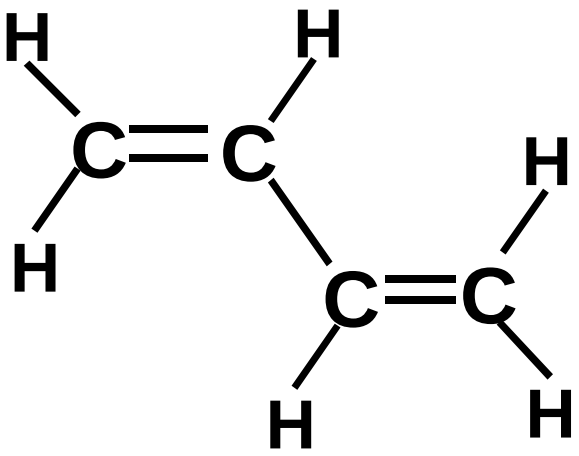
- **SBR Latex – Micro Surfacing**
- **Natural Rubber Latex – Ralumac (Micro Surfacing)**
- **Other – Ground Tire Rubber - GTR (REAS)**

Typical Synthetic Latex Monomers



Styrene



Butadiene

Polymers for Micro Surfacing Emulsions

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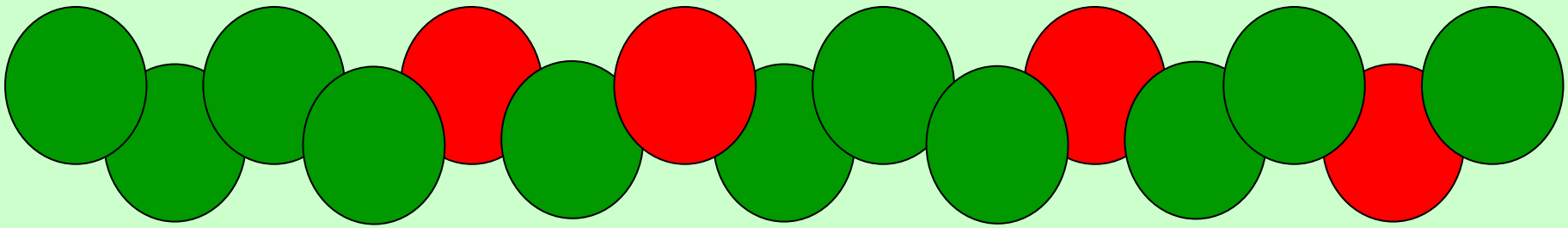
- **Elastomer – Styrene-Butadiene Rubber - SBR**
  - Latex form – polymer particles dispersed in water
  - Random monomer addition – typ. 75/25 Bd/styrene
  - High molecular weight – 1,000,000 g/mole
    - 13,900 Bd “mers”, 2400 styrene “mers”
  - Broad distribution – chains many different lengths



Polymers for Micro Surfacing Emulsions

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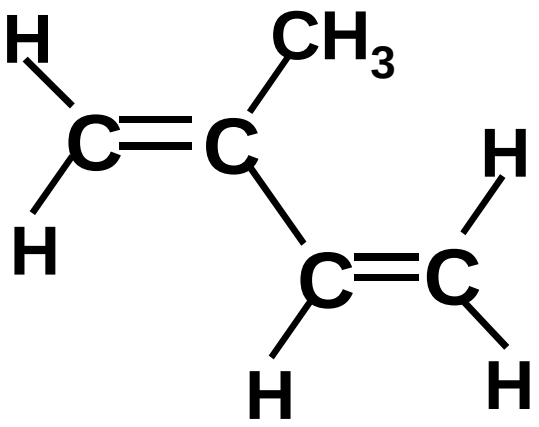
- **Elastomer – Polyisoprene – Natural Rubber**
  - Latex form – polymer particles dispersed in water
  - Homopolymer of isoprene – harvested from trees
  - High molecular weight – 1,000,000 g/mole
  - Broad distribution – chains many different lengths



Isoprene

Viscoelastic Behavior
Cured Latex Modified Asphalt Emulsion

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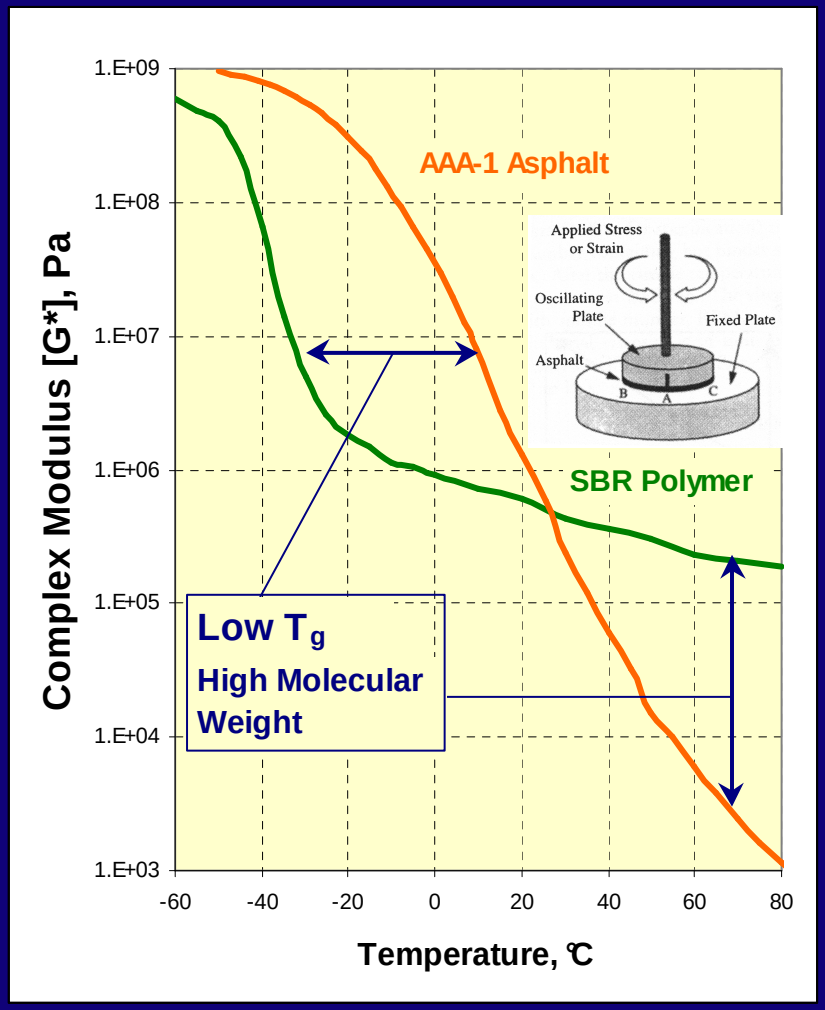

- G* = f(T) = deform. resist.
- Asphalt
  - High G* at low T – brittle
  - Low G* at high T – viscous
  - ΔG*(80°C – 20°C) = 1000x
- SBR Polymer
  - Lower G* at low T – flexible
  - Higher G* at high T – elastic
  - ΔG*(80°C – 20°C) = 10x

Polymer Modification of Asphalt Emulsions

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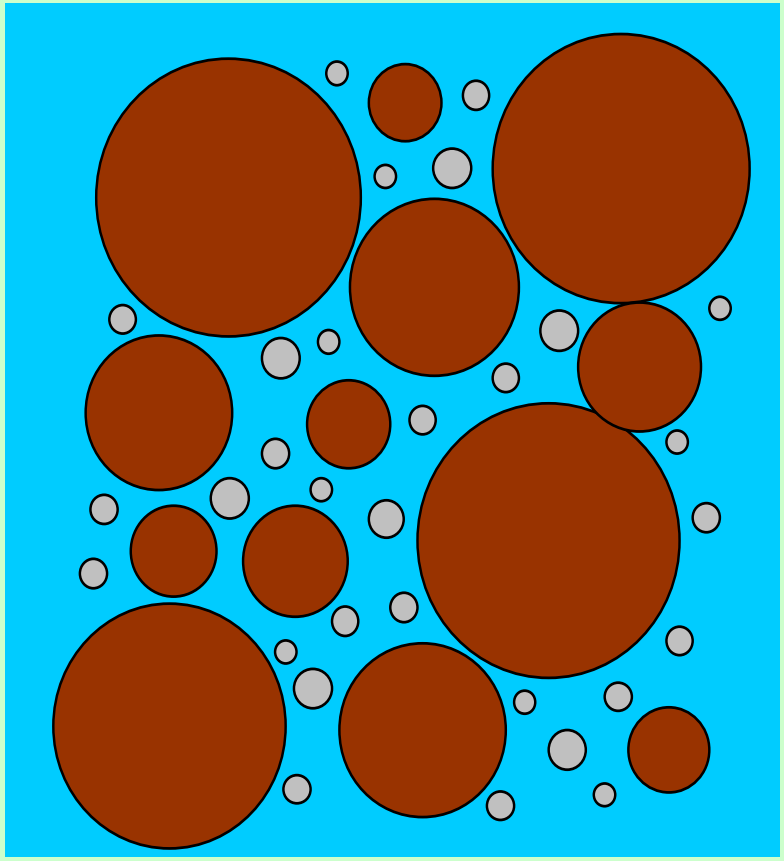
- **Add latex external to asphalt**
  - Methods
    - soap batching
    - co-milling – asphalt line
    - co-milling – soap line
  - Polymers – SBR, NR latex
  - Lower asphalt process T
  - No special mill, handling



- **Polymer in water phase**
- **Continuous polymer film formation on curing**

Latex Polymer-Modified Asphalt Emulsion

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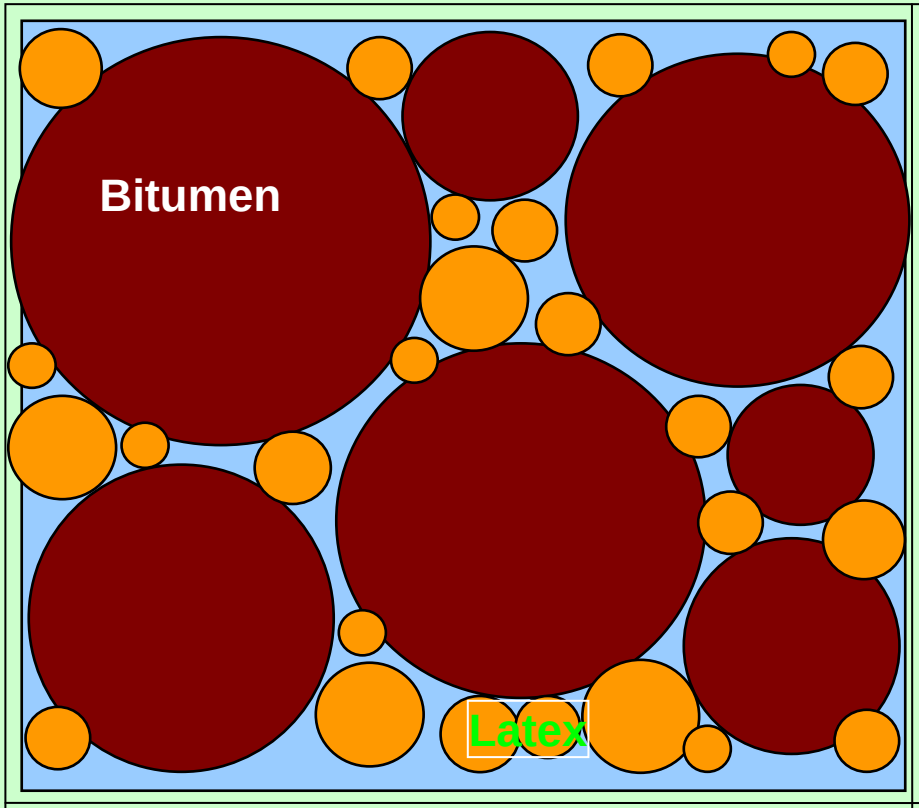
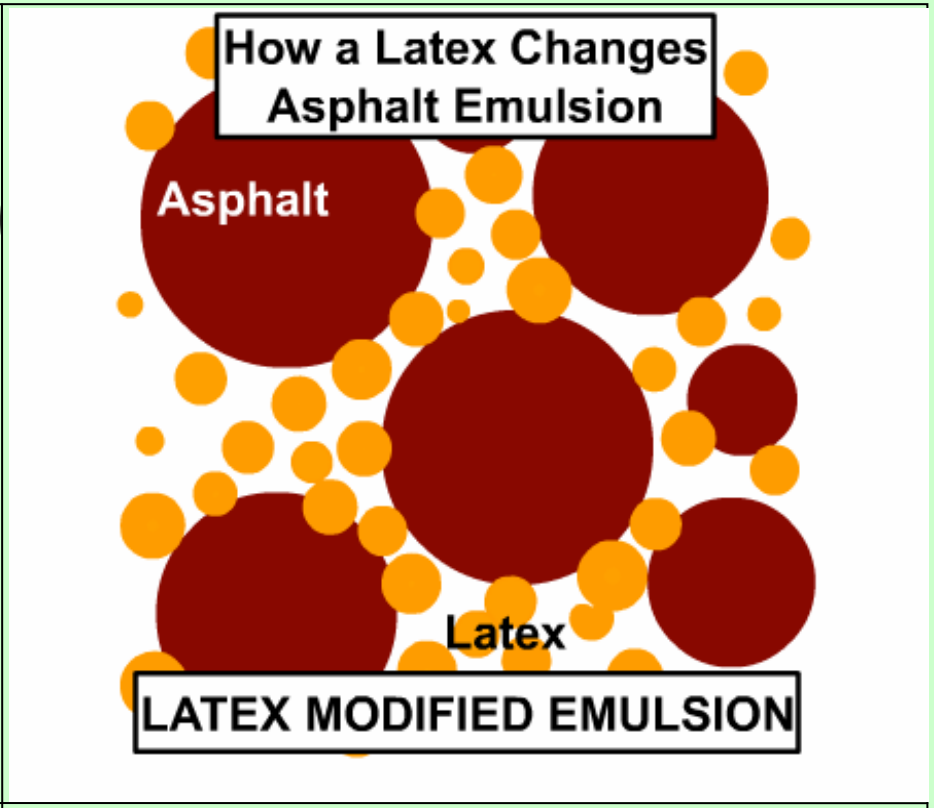


Latex Modified Emulsion



Cured Bitumen Emulsion

- **Optimum for Fine Polymer Network Formation**

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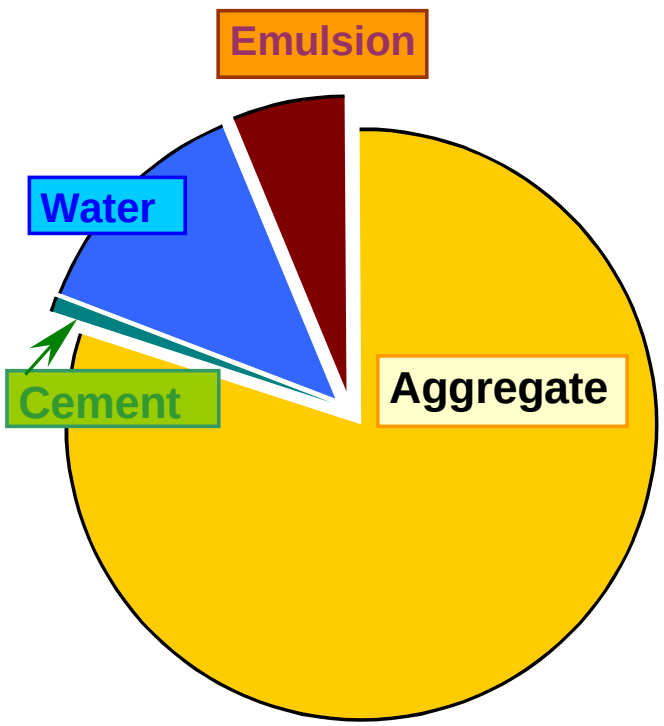
Microsurfacing Operation

1min<Mix Time<3 min

Cohesion Development<1 hr

Microsurfacing – High ADT + ESAL's

Micro Surfacing Mix Formulation



Latex Polymer = 3% of Asphalt (1/4 of Cement)

- **Blade Coating Operation**
  - **2 m wide + <1 cm thick**
  - **4-5 km/hour**
  - **Traffic within 1 hour**
- **Latex Polymer Binds**
  - **Asphalt**
  - **Fines**

  to Aggregates

Micro Surfacing–Polymer Morphology Field Application

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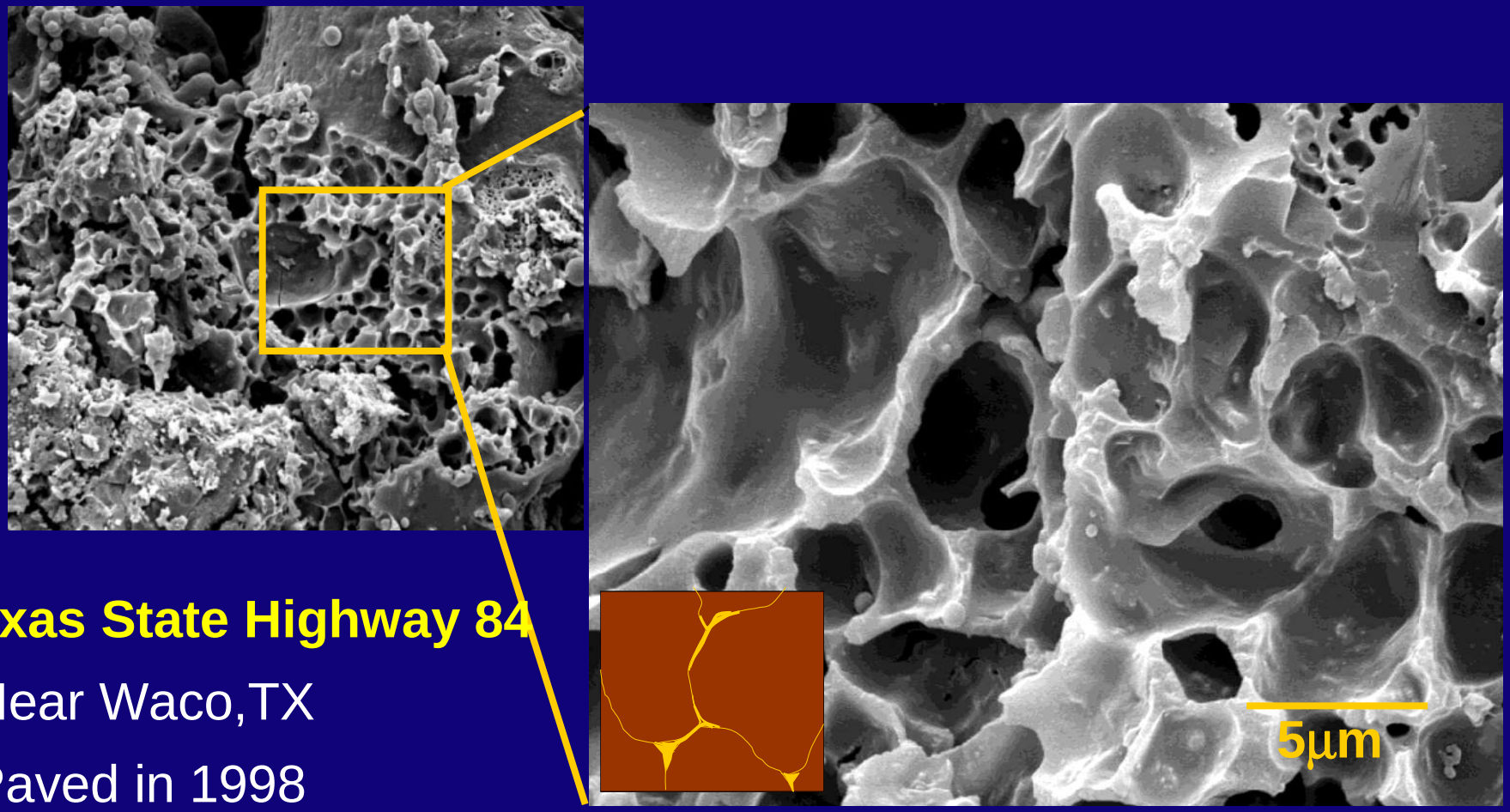

Texas State Highway 84

- Near Waco,TX
- Paved in 1998
- Samples taken in 2001

Cured Latex Polymer Network

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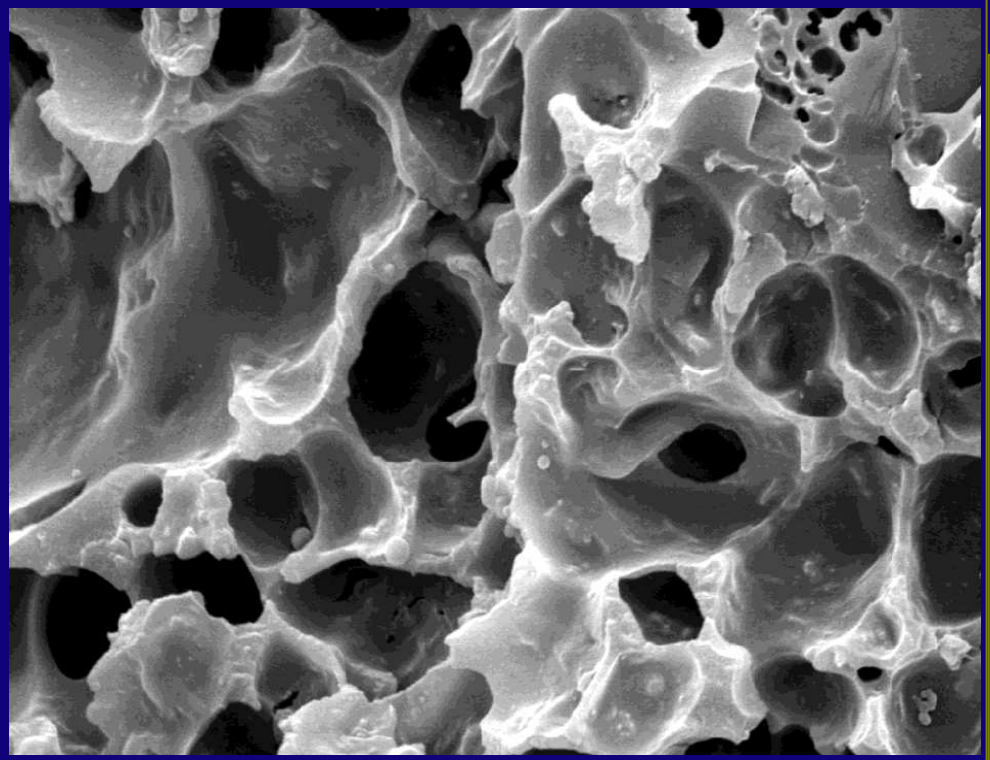
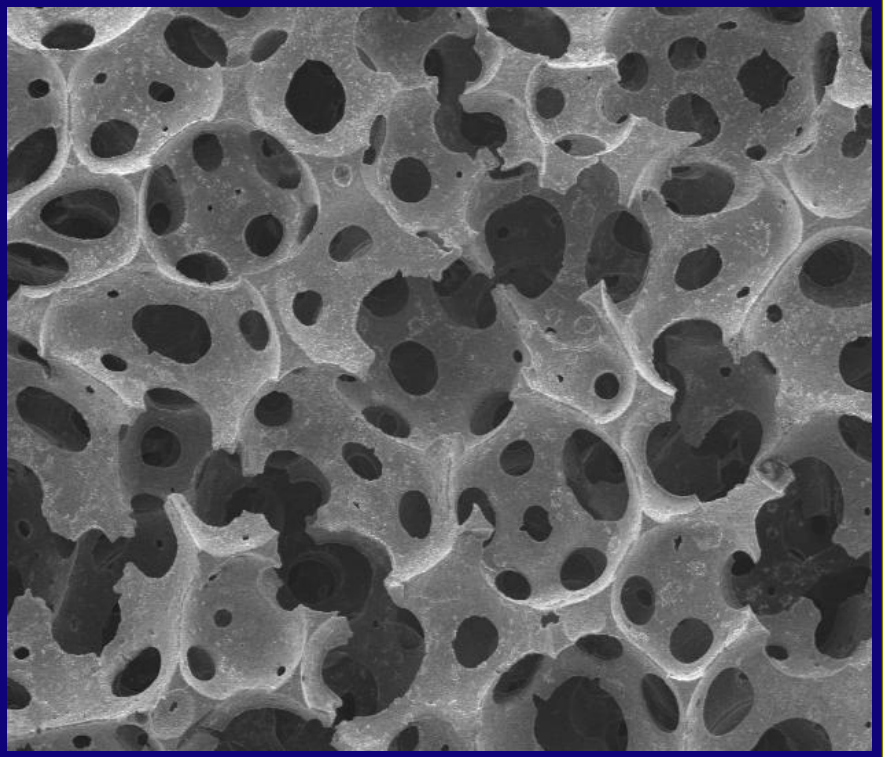


Micro Surfacing



Latex Foam

Wet Track Abrasion Loss – ISSA TB-100

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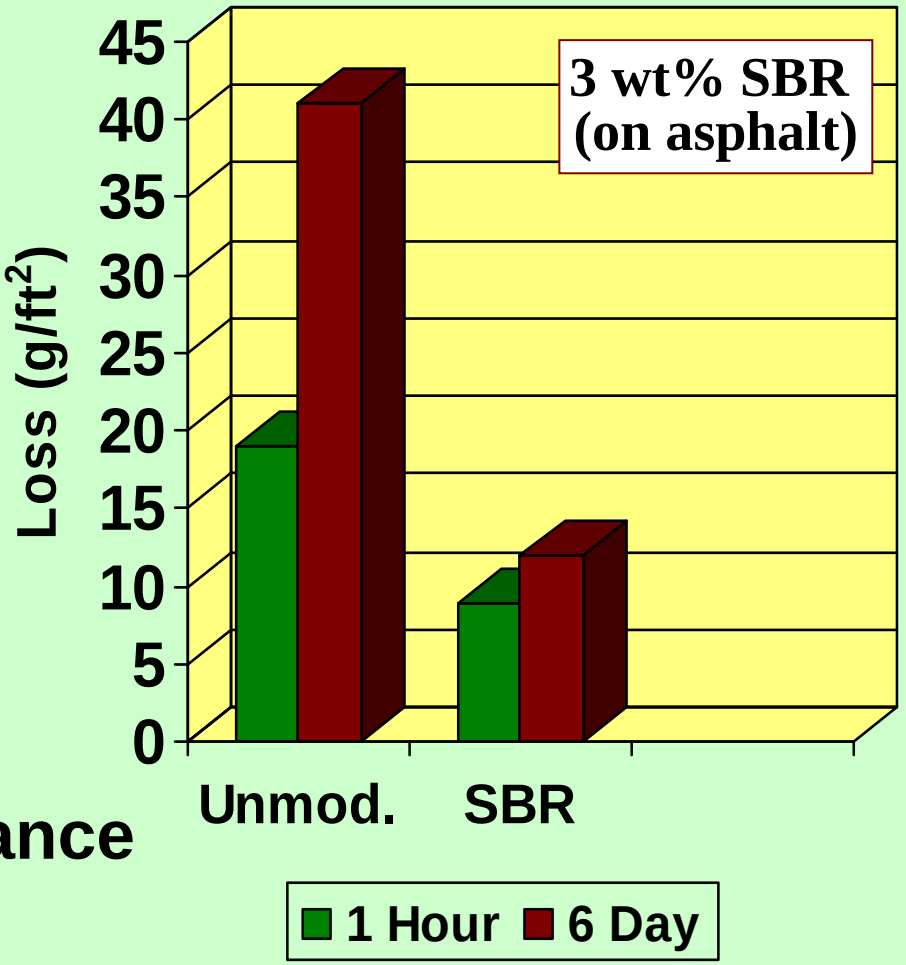
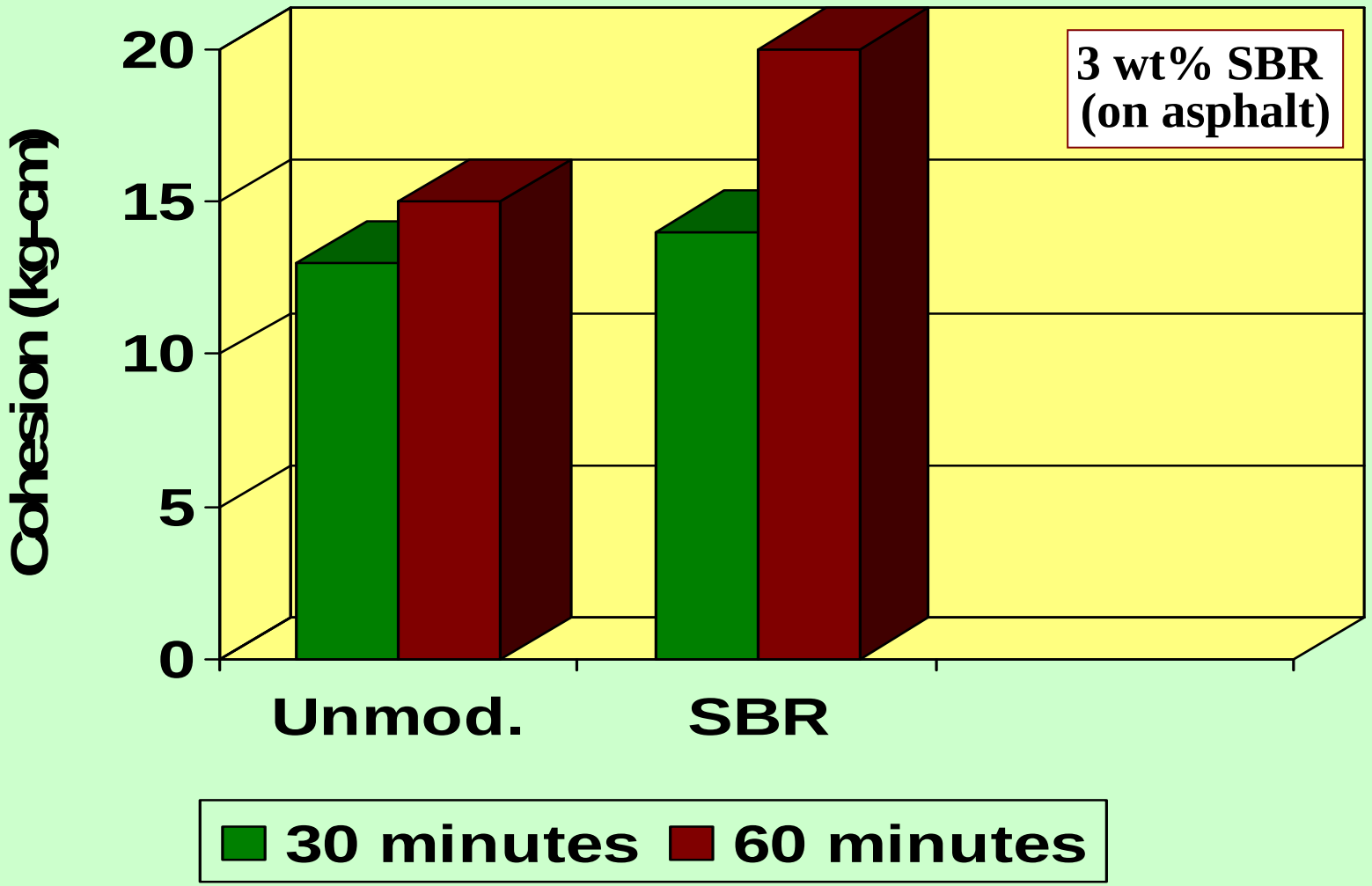
SBR latex polymer

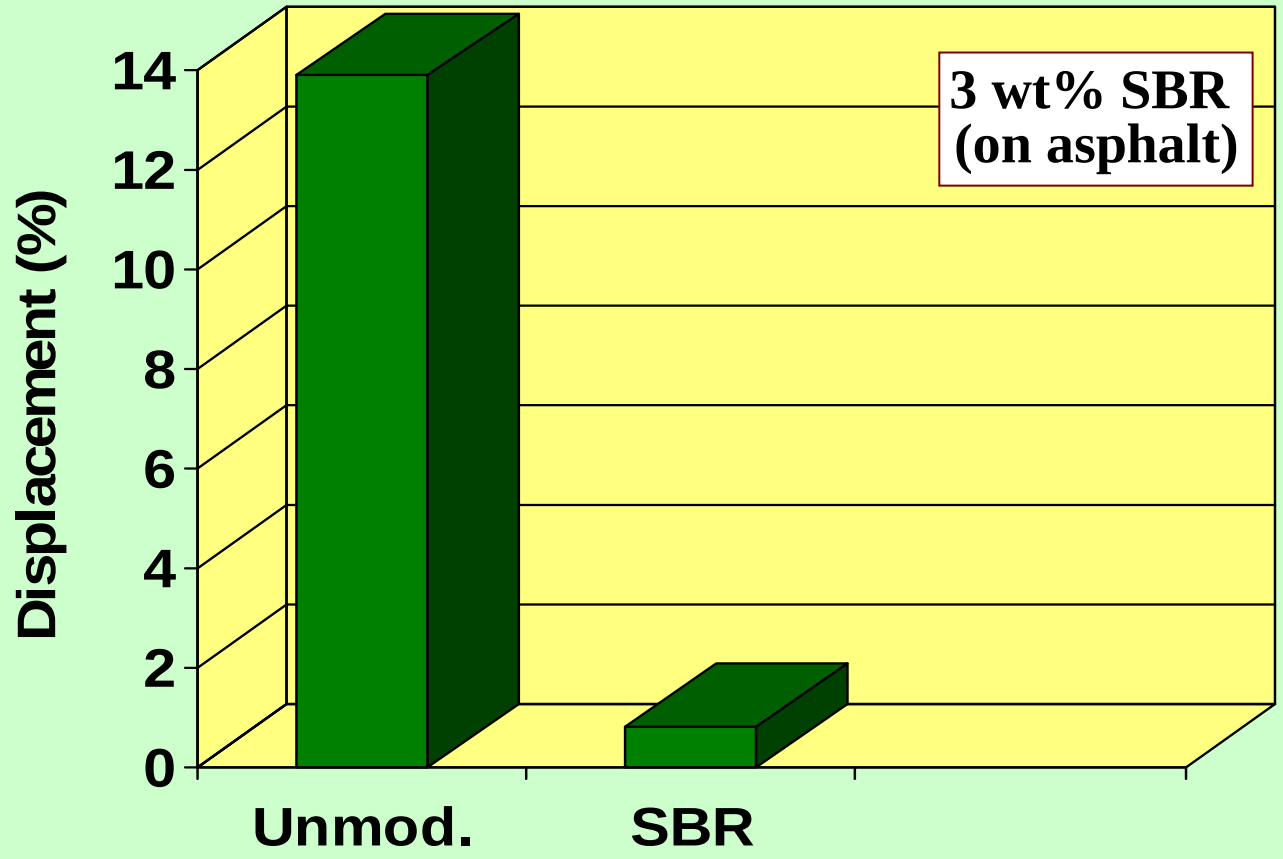
- **50% reduction in loss**
  - one hour soak
- **67% reduction in loss**
  - six day soak
- **Surface of mix**
  - tougher
  - more abrasion res.
- **Adhesion + water resistance**
  - improved



Cohesion Development – ISSA TB-139

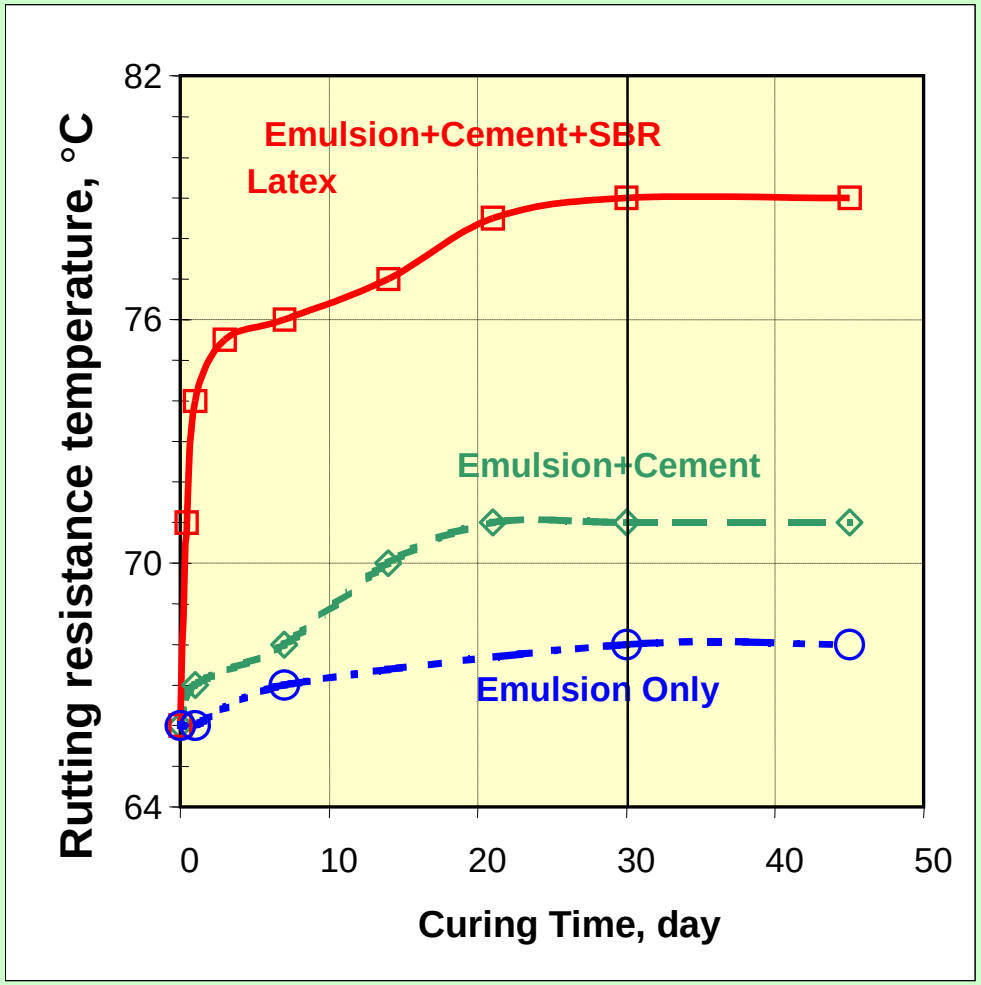


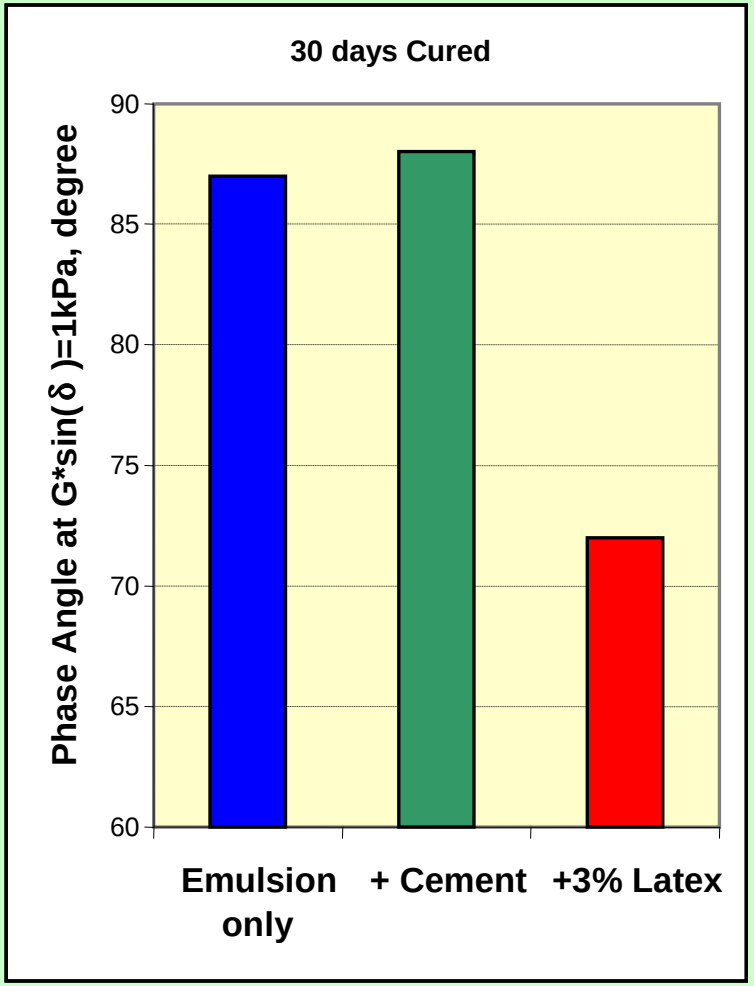
Lateral Displacement – ISSA TB-147



- SBR latex at 3% will decrease lateral disp. by ~ 90%

Microsurfacing Residue – SHRP Grade





Advantages of Latex Polymer Network

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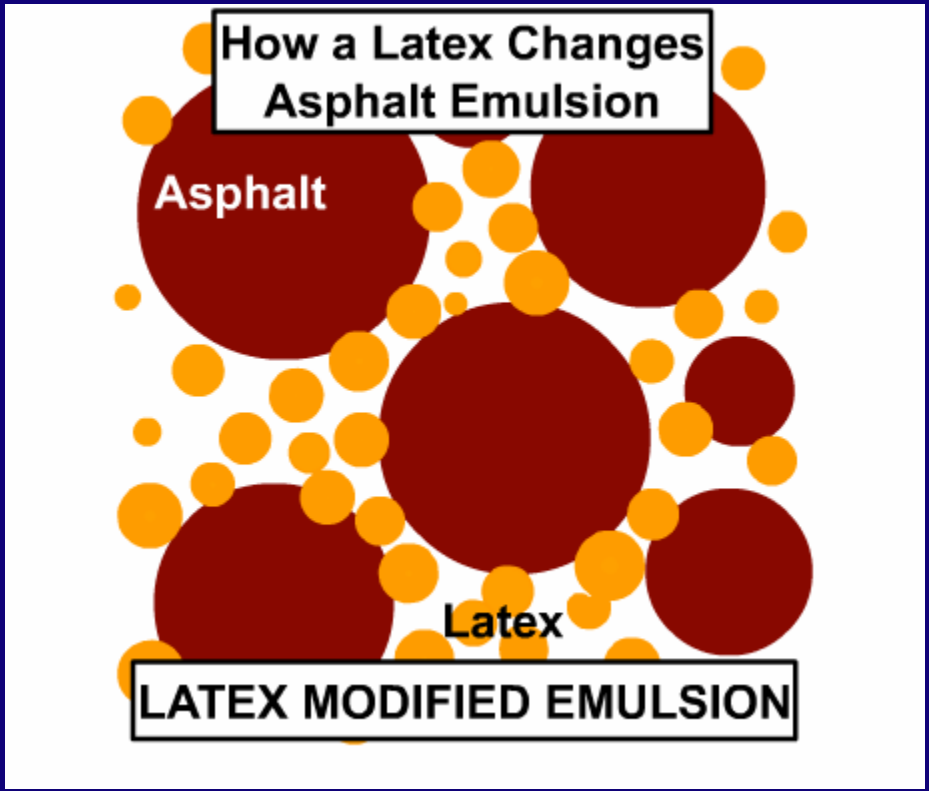

- **Latex polymer honeycombs** remain flexible
  - Absorb stresses without permanent deformation

SBR+NRL-Modified Micro Surfacing Summary

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- **Micro Surfacing**
  - Improved mix cohesion
  - Reduction in abrasion loss of aggregate
  - Resistance to deformation

Micro Surfacing in Minnesota History

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- **Intro to micro surfacing from Koch in late 1980s**
- **Small trial projects until 1999**
- **1999 – First large contract for micro surfacing**
  - **Single statewide contract to demonstrate**
    - rut filling
    - friction improvement
    - ride improvements
  - **About 125 lane miles**

Micro Surfacing in Minnesota Current Practices

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- **Roadways with over 10,000 AADT**
- **Project selection in Pavement Management System**
- **Much of our micro surfacing work done at night**
  - Minimizes traffic disruption
  - Requires a 1000-foot night time test strip
    - To demonstrate micro surfacing mix meets our one-hour cure time requirement

Micro Surfacing in Minnesota Current Specification

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- Requires natural rubber latex polymer
- Contractor provided mix design
- Ambient temperature above 50°F
- Work complete before September 15th

Micro Surfacing in Minnesota Current Application Areas

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- Pavement preservation
- Rut filling
- Centerline longitudinal joint treatment (18” wide)
- Friction improvements
- Some ride improvements

Micro Surfacing in Minnesota Performance

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- **Generally adds about five years to the life of our bituminous pavements (ride criteria)**
- **Failure modes include:**
  - Debonding
  - Raveling and abrasion wear
- **Is it cost effective?**
  - About neutral for LCCA

Minnesota DOT
SBR Latex-Modified Micro Surfacing Demo
2008 MPPP - TH 55

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TABLE I
AGGREGATE ANALYSIS
VANCE BROTHERS, INC.

SIEVE #	ISSA TYPE II SPECIFICATIONS	% PASSING
4	90-100	96.9
8	65-90	75.6
16	45-70	53.3
30	30-50	37.5
50	18-30	24.6
100	10-21	15.8
200	5-15	10.8

TEST	ISSA SPECIFICATION	RESULT
Sand Equivalent	65	83

TABLE II
MICRO-SURFACING EMULSION FORMULATION
VANCE BROTHERS, INC.

COMPONENT	PERCENTAGE, BY WEIGHT EMULSION
Emulsifier	1.7
Latex NX 1138	3.5
Water	32.8
Hydrochloric Acid	to pH 2.0
Asphalt: Amoco Whiting AC-20	62.0

SBR Latex-Modified Micro Surfacing Formulation
+
ISSA Type II Aggregate Gradation (AASHTO T11/T27)

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SBR Latex-Modified Micro Surfacing Demo
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TABLE III
MICRO-SURFACING EMULSION TEST RESULTS
VANCE BROTHERS, INC.

TEST PROCEDURE	RESULTS
Residue, %	65.5
Sieve, %	.0105

TABLE IV
MICRO-SURFACING JOB MIX FORMULATION
VANCE BROTHERS, INC.

COMPONENT	PERCENTAGE, ON DRY AGGREGATE BASIS
Type I Portland Cement	0.25-0.75
Total Water	10-12
Pre-Wet Solution (4% Emulsifier in Water)	As Required
Emulsion	12-13
Aggregate:	100

Residue after Distillation (AASHTO T59)
+
Job Mix Formula

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TABLE V
MICRO-SURFACING MIX EVALUATION
VANCE BROTHERS, INC.

TEST PROCEDURE	ISSA SPECIFICATION	RESULTS
Mixing Time, seconds	120 Minimum	120+
Wet Cohesion , kg-cm @ 30 minutes	12 Minimum	19
@ 60 minutes	20 Minimum or Near Spin	22
Wet Track Abrasion Loss, g/ft^2,		
One-hour Soak	50 Maximum	12.8
Six-day Soak	75 Maximum	25.5
Lateral Displacement, %	5% Maximum	5.0
Vertical Displacement, %	None Specified	16.5
Excess Asphalt by LWT		
Sand Adhesion, g/ft^2	50 Maximum	36.2
Wet Stripping, %	90 Minimum	90+
Classification Compatibility, Grade Point	11 Minimum	11+

Mix Design Testing

- ISSA TB-113
- ISSA TB-139
- ISSA TB-100
- ISSA TB-147
- ISSA TB-109
- ISSA TB-114
- ISSA TB-144

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