Session W13 - Introduction to Modified Asphalt Binders (Part 1)

PRESENTED BY: AMAP
The Association of Modified Asphalt Producers
Visit our website…

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• Contact AMAP directly by:
  ▪ Phone: (314) 843-2627
  ▪ E-mail: amap@sbcglobal.net
Presenters:

• **Bob Kluttz**  
  Kraton Polymers  
  (281) 676-2426  
  Bob.Kluttz@kraton.com

• **Laurand Lewandowski**  
  Owens Corning  
  (740) 321-7663  
  Laurand.Lewandowski@owenscorning.com

• **Ron Corun**  
  Axeon Specialty Products  
  (410) 952-4020  
  Ronald.Corun@axeonsp.com
Contributors:

- Gaylon Baumgardner (601) 933-3217
  Paragon Technical Services
  Gaylon.Baumgardner@ptsilab.com

- John Casola (973) 740-1534
  Malvern Instruments
  John.Casola@malvern.com

- Ron Corun (410) 952-4020
  NuStar Asphalt LLC
  Ronald.Corun@nustarasphalt.com

- Bob Kluttz (281) 676-2426
  Kraton Polymers
  Bob.Kluttz@kraton.com

- Laurand Lewandowski (740) 321-7663
  Owens Corning
  Laurand.Lewandowski@owenscorning.com

- Chris Lubbers (936) 524-9262
  Kraton Polymers
  Chris.Lubbers@kraton.com
Modified Asphalt Binders

The Basics covered include:

- **PART 1**
  - Reasons for Modification
  - Types of Modification
  - Chemistry
  - Polymer modification
  - Modified Emulsions

- **Part 2 (Session T23)**
  - Handling
  - Lay down
  - Field Experience
  - Testing to AASHTO M320
  - Testing for Modified Asphalt
Outline – Part 1

• Section 1 - Introduction to Asphalt Modification
  ▪ Reasons for Modification
  ▪ Distresses in Asphalt Pavements
  ▪ Types of Modification
  ▪ Use of Modified Asphalt
  ▪ Chemistry of Asphalt Cements
  ▪ Chemistry/Macrostructure of Modified Asphalt Cements
  ▪ Compatibility (Microscopy)
Outline – Part 1

• Section 2 – Introduction to Polymer Modification
  ▪ What are Polymers?
  ▪ Types of Polymers
  ▪ Compatibility of Polymers with Asphalt
  ▪ Effects of Polymers
  ▪ Analysis of polymers
  ▪ Recovery of PMA

• Section 3 - Emulsions of Modified Asphalt
  ▪ Asphalt emulsion formulation
  ▪ Modification of asphalt emulsions
  ▪ Impact on performance and performance parameters
Outline – Part 2 (Session T23)

• **Section 4 - Handling of Modified Asphalts**
  - Recommended Plant Operations
  - Handling of Asphalt Binder at the Terminal
  - Handling of Asphalt Binder at the HMA Plant
  - Laydown of Modified Asphalt Mix
  - Contractor Liquid Asphalt QC Plan

• **Section 5 - Performance of Modified Asphalt Mixtures**
  - Laboratory Studies
  - Field Studies
  - Life Cycle Cost Analysis
Outline – Part 2 (Session T23)

• Section 6 – Specifications and Testing
  ▪ Pre-Superpave
  ▪ Superpave
  ▪ PG Specifications AASHTO M320
  ▪ PG Testing Equipment
  ▪ PG Plus Tests
  ▪ MSCR Test
Section 1 - Introduction to Asphalt Modification

Presented By:
Ron Corun

Prepared for the Association of Modified Asphalt Producers Training Program
Reasons for Asphalt Modification

• Decline in asphalt pavement performance
• To meet new Superpave PG requirements.
• Competition with Portland Cement Concrete (PCC) requires the asphalt industry to build economical pavements that perform for a long time – *Perpetual Pavements*
Decline in Asphalt Performance

• Perception that asphalt cement has changed since the 1970’s
  ▪ Asphalt refineries have taken all of the “goodies” out of the asphalt!
  ▪ It’s not as sticky as it used to be!
• Some asphalt cements have changed since the Arab oil embargo of the 1970’s
  ▪ New crude sources
  ▪ Changed refinery processes to produce more gasoline and less asphalt

Good

Bad
Decline in Asphalt Performance

• Don’t blame all of the problems on the liquid asphalt!
• Other changes since the 1970’s
  ▪ Baghouse fines going back into the mix
  ▪ Changes in traffic
Evolution of Traffic

- Interstate highways - 1956
- AASHO Road Test - 1958-62
  
  - still widely used for pavement design
  - legal truck load - 73,280 lbs
- Legal load limit increased to 80,000 lbs in 1982
  
  - 10% load increase
  - 40-50% greater stress to pavement
- Radial truck tires have higher contact pressure
  
  - Bias-ply truck tires – 75 psi
  - Radial truck tires – 125 psi
Decline in Asphalt Performance

- Research into decline in asphalt pavement performance led to Superpave system
Pre-Superpave Asphalt Property Measurements

Penetration (1900s)

Viscosity (1950s)

Penetration test run @ 25°C

Viscosity test run @ 77°C
Superpave Asphalt Binder Specification

- Grading System Based on Climate

PG 64-22

Performance Grade

Average 7-day max pavement design temp

Min pavement design temp
Useful Temperature Interval

• Maximum to Minimum temperature range where the binder is expected to perform properly.

• PG 64-22 has a UTI of 86°
  \[(64° - (-22°)) = 86°\]

• Superpave system bumps the binder grade for heavy, slow truck traffic

• PG 76-22 has a UTI of 98°
  \[(76° - (-22°)) = 98°\]
Useful Temperature Interval (UTI)

Log Viscosity vs. Temperature

- Glassy Solid: $T_g$
- Visco-elastic
- Liquid: $T_s$

UTI: Useful Temperature Interval
Rule of 92

• If UTI < 92°, asphalt binder is seldom modified
  ▪ Some crude sources are exceptions – California crudes

• If UTI = 92°, most asphalt binders are modified
  ▪ Some crude sources are exceptions – Venezuelan crudes

• If UTI > 92°, asphalt binder will be modified

• Modification will increase the UTI of asphalt binder
Performance Graded Asphalt

Log Modulus

Temperature, °C

Bending Beam Rheometry

Dynamic Shear Rheometry

PG 58-16
PG 64-22
PG 76-22
Competing with PCC

- Pavement type selection typically made using Life Cycle Cost analysis
- Historically asphalt had lower initial cost, but PCC claimed longer life and lower maintenance costs
- Recent increase in oil prices have virtually eliminated asphalt initial cost advantage
- Asphalt must now compete with PCC on long term performance
- Asphalt long term pavement concept – “Perpetual Pavement”
Competing with PCC

• Pavement structure designed to accommodate traffic loadings
  ▪ Thickness is dependent on multiple factors
    • Environment
    • Traffic
    • Subgrade strength
    • Asphalt mix properties

• Improve mix properties with modified asphalt and reduce thickness

• Reduce thickness – Reduce Cost!
Distresses in Asphalt Pavements

- High Temperature Permanent Deformation
- Low Temperature Thermal Cracking
- Load-Associated Fatigue Cracking
  - Bottom-up cracking
  - Top-down cracking
- Aging
- Stripping
Ideal Asphalt Binder and Asphalt Mixture

- Improved resistance to rutting, cracking, aging and stripping.
- Improves the lifecycle cost of the asphalt pavement.
High Temperature Permanent Deformation (Rutting)

- Rutting is caused by the accumulated plastic deformation (flow) in the asphalt mixture with repeated application of loads at upper pavement service temperatures.
- Rutting is influenced by the aggregate and mix design.
- Modifiers can stiffen the binder and provide a more elastic material.
Plastic Flow

original profile

weak asphalt layer

shear plane

Modified asphalt can help strengthen the weak asphalt layer
Modified Binders Affect Mix Performance

• Pavement study using same mix, but different binders.

PG 67-22 Unmodified Asphalt
15mm rutting

PG 63-22 Modified Asphalt
No rutting
Low Temperature Thermal Cracking

- Thermal shrinkage cracking results from either a single thermal cycle where the temperature reaches a critical low temperature or from thermal cycling above the critical low temperature.
- Low temperature thermal cracking is predominantly influenced by the binder properties.
- Modifiers can improve the low temperature flexibility of the mixture.
Load-Associated Fatigue Cracking

- Load-associated fatigue cracking is caused by continuous application of loads over a period of time.
- Load-associated fatigue cracking is influenced by binder and mixture properties and pavement thickness.
- Two types of fatigue cracking
  - Bottom-up
  - Top-down
Bottom-Up Fatigue Cracking
Top-Down Cracking

NJ I-287
Top-Down Cracking

- Relatively new distress
- May be related to stresses at edges of radial truck tires
- University of Florida research on top-down cracking correlated the failures with a minimum Dissipated Creep Strain Energy (DSCE) value
  - Most effective way to increase DSCE is to use Polymer-Modified Asphalt (PMA)
Aging

- Aging or embrittlement occurs during the mixing and laydown process
- Aging also occurs during the service life of the asphalt pavement
- The asphalt binder displays large increases in stiffness due to oxidation and volatile loss in the binder
- Polymer modified asphalts typically have thicker asphalt films on the aggregates
- Thicker asphalt films are more resistant to oxidation and the mixes containing polymer modified asphalts typically have a longer life
Stripping

- Stripping is loss of bond between the aggregates and asphalt binder which typically begins at the bottom of the HMA layer and progresses upward.
- Stripping is driven by the aggregate’s surface affinity for water.
- Additives can change the surface of the aggregate from hydrophilic (water-loving) to hydrophobic (water-hating).
Types of Anti-Stripping Agents

• Hydrated Lime
  ▪ Added as a powder (dry hydrate to damp aggregate) or as a slurry (lime slurry marination)
  ▪ Typically 1% by weight of total mix

• Liquid Antistrip Additives
  ▪ Several types including amines, amidoamines, phosphate esters
  ▪ Liquids added to the asphalt
  ▪ Typically 0.25% to 0.75% by weight of asphalt binder
  ▪ Heat stable and resistant to degradation
  ▪ Less expensive than hydrated lime

• Other Anti-Stripping Additives
  ▪ Polymeric anti-stripping additives
  ▪ Natural asphalt primed aggregate
Stripping

- Polymer modified asphalts are generally stickier than neat asphalts and have thicker film coatings on the aggregates
- Result - Better adhesion of asphalt to aggregate
- Result – Better resistance to moisture damage
  - Typically higher TSR values
  - Typically better Hamburg test results
Types of Modification

- Chemical Additives
  - PolyPhosphoric Acid (PPA)
- Polymer Modifiers
  - SBR Latex
  - Block Copolymers (SB, SBS, SEBS)
  - Polyolefins
  - Ethylene Copolymers
  - Reactive Elastomeric Terpolymers (Elvaloy)
- Crumb Rubber
- Engineered Binders
Polyphosphoric Acid

- Polyphosphoric acid is a liquid totally miscible with asphalt.
- Consists of higher molecular weight species, $\text{H}_4\text{P}_2\text{O}_7$, $\text{H}_5\text{P}_3\text{O}_{10}$ etc., with a distribution of chain lengths.
- Concentration ranges based on equivalent $\text{H}_3\text{PO}_4$ content with typical types used: 105%, 115%.
- Orthophosphoric acid, $\text{H}_3\text{PO}_4$, is not recommended as residual water can cause foaming.
Polyphosphoric Acid increases the high-temperature grading with no loss of the low-temperature properties.
PPA Modified Asphalt

• PPA is used either alone or in conjunction with polymers (SBS, Elvaloy or GTR) to increase the asphalt stiffness improving resistance to rutting.
• PPA addition typically does not impact the lower temperature performance of the modified asphalt
• PPA modified asphalt is storage stable
PPA Modified Asphalt

- Compatible antistrips need to be used
- Compatible warm mix additives need to be used
- Extracting PPA modified asphalt from asphalt mix
  - Toluene is recommended solvent
  - Only a fraction of the PPA is recovered when extracted from the mix
  - Common method of detection is based on phosphorus content
  - Phosphorus could have multiple sources (recycled engine oil...)

42
AMAP Position Statement

The Association of Modified Asphalt Producers supports the responsible use of modification of asphalt materials for improved performance. AMAP believes that through the innovation of material suppliers, new and improved products will be made available that will improve life cycle costs. AMAP does not endorse any specific form of modification.

After a review of the available information on the use of polyphosphoric acid in the modification of paving grade asphalts,

it is the position of AMAP that the correct use of the proper acid in the appropriate amount can improve the physical properties of bituminous paving grade binders.

AMAP endorses appropriate testing on the modified asphalt after the addition of any and all additives to determine the final product specification is met. However, incorrect application of the technology, as with many additives, can result in problems associated with construction and/or performance.
Polymer Modifiers

- Polymers are chosen based on adding beneficial properties to the asphalt
  - Increase resistance to rutting at high temperatures
  - Improve resistance to cracking at intermediate and low temperatures
  - Workability
- Polymers are chosen based on their ability to build a network within the asphalt
  - Stability – won’t separate in storage
  - Preferably - agitation not required
Polymer Modifiers

- Polymers typically blended into asphalt at a manufacturing facility at a terminal
- Very few “Dump & Stir” polymers
- Most polymers require substantial energy to blend them into asphalt
Polymer Modifiers

- Typically use high shear mill to blend polymer granules into liquid asphalt
- Add cross-linking chemical and agitate while modified asphalt goes through curing period
  - Curing period may be days
- Test cured PMA for specification requirements
Polymer Modifiers

Monitoring the Curing Process with an Ultraviolet Microscope

Initial Stage – High Shear Milling

Final Stage – High Shear Milling
Polymer Modifiers

Monitoring the Curing Process with an Ultraviolet Microscope

Intermediate Stage – Cross-Linking

Fully Cured PMA
Crumb Rubber

- Crumb Rubber is available from different waste streams
  - Reclaimed Rubber (raw unprocessed rubber)
  - Recycled Rubber (Processed tires)
- Ground Tire Rubber (GTR) can contain a wide range of polymers
  - Natural rubber
  - Styrene Butadiene Rubber (SBR)
  - Polybutadiene
- GTR also contains non-polymer ingredients
  - Carbon black
  - Silica
Ground Tire Rubber

- GTR contains polymers that have been locked-up by vulcanization
- Much of the GTR polymer is not available to create a network in the asphalt
- GTR imparts elastomeric properties to asphalt binder by adding discrete rubber particles
Ground Tire Rubber

• Types of GTR asphalt products
  ▪ Dry Process – “Plus Ride”
    • Add GTR into asphalt plant as an aggregate
    • Filler more than modifier
  ▪ Asphalt Rubber – Wet Process
    • 15-20% GTR added to asphalt in processing unit at the asphalt plant
    • GTR particles absorb light hydrocarbons and swell
    • After swelling, asphalt rubber is used immediately
    • Adequate agitation is suggested
Ground Tire Rubber

• Types of GTR asphalt products
  ▪ Terminal Blended GTR Modified Asphalt
    • Add GTR into asphalt at a terminal facility
    • Processing techniques and/or additives help stabilize the product
    • Adequate agitation at asphalt plant is suggested
  ▪ Hybrid GTR Binder
    • Terminal blended GTR modified asphalt may add polymer and/or other additives
    • Polymer network helps to hold rubber particles in suspension
    • Adequate agitation at asphalt plant is suggested

• GTR modified asphalt products typically require agitation to prevent separation
Engineered Binders

- Engineered binders are formulated for a specific application (OGFC, High Rap, etc.)
- Formulation may combine types of modification to achieve desired properties
Use of Modified Asphalts

• Hot Mix Asphalt (HMA) and Warm Mix Asphalt (WMA)
  ▪ Dense Graded Mix
  ▪ Gap Graded Mix / Stone Matrix Asphalt (SMA)
  ▪ Open Graded Mixes (Friction Course)

• Asphalt Emulsions (discussed in Section 3)
Section 2 - Polymers in Modified Asphalt

Presented By: Bob Kluttz
Prepared for the Association of Modified Asphalt Producers Training Program
Chemistry of Asphalt Cements

- Many factors affect the composition of the asphalt binder. The major causes of variation are the crude source and refining process.
- There are over 100 different crude sources used in the United States and Canada.
- There are several different refinery processes being used:
  - Fractional crude oil distillation under atmospheric pressure with steam
  - Topped crude distillation under vacuum with or without steam
  - Solvent Refining (Propane Deasphalting, Residual Oil Supercritical Extraction)
  - Air Blowing

# Crude Oils Used in Asphalt Production

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<th>North Atlantic Region</th>
<th>North Central Region</th>
<th>Southern Region</th>
<th>Western Region</th>
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<td>Alaska North Slope</td>
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<tr>
<td>Bachaquero (Venezuela)</td>
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<td>Amdel Sour</td>
<td>Amoco Pipeline</td>
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<td>Bonanza</td>
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<td>Coastal Mix</td>
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<td>Canadian Sweet</td>
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<td>Kirkuk (Iraq)</td>
<td>Coalinga (SJV)</td>
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<tr>
<td>Mexican</td>
<td>Local Sweet</td>
<td>Cottonwood</td>
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<td>Michigan Sweet</td>
<td>Maya (Mexico)</td>
<td>Elk Hill (SJV)</td>
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<td>Middle East</td>
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<td>California Coastal</td>
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Asphalt Composition

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<th>Arkansas-Louisiana</th>
<th>Boscan</th>
<th>California</th>
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<td>85.78</td>
<td>82.9</td>
<td>86.77</td>
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<td>Hydrogen (%)</td>
<td>9.91</td>
<td>10.19</td>
<td>10.45</td>
<td>10.93</td>
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<td>Nitrogen (%)</td>
<td>0.28</td>
<td>0.26</td>
<td>0.78</td>
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<tr>
<td>Sulfur (%)</td>
<td>5.25</td>
<td>3.41</td>
<td>5.43</td>
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<tr>
<td>Oxygen (%)</td>
<td>0.77</td>
<td>0.36</td>
<td>0.29</td>
<td>0.2</td>
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<tr>
<td>Vanadium (ppm)</td>
<td>180</td>
<td>7</td>
<td>1380</td>
<td>4</td>
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<tr>
<td>Nickel (ppm)</td>
<td>22</td>
<td>0.4</td>
<td>109</td>
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Polar Dispersed Fluid

- Asphalt is a collection of non-volatile, polar and non-polar organic molecules. The polar and polarizable molecules tend to associate strongly (amphoteric) to form an organized structure in a continuous phase of non-polar and low polarity materials.

Raymond E. Robertson, et.al., Chemical Properties of Asphalts and Their Relationship to Pavement Performance, AAPT, 1991.
Micellar Model for Asphalt

- Representation of peptized asphaltene micelles:
Compatibility

- Modifiers further complicate the already complex structure of asphalt
- A modifier may be more or less compatible with an asphalt
  - Compatibility determines the state of dispersion between two dissimilar components.
  - For asphalt this means the dispersion of the relatively aromatic, polar, associating molecules in a less aromatic, less polar solvent phase.
  - For modified asphalt cements this also means the dispersion of the modifier in the asphalt. To a large extent this determines the physical properties of the binder.
Morphology of Polymer Modified Asphalt Cements

Polymer exists as a separate phase dispersed in the asphalt phase. (~1-5 wt.% polymer) This is the most commonly observed system.

At higher polymer content (>7w%) the phases invert with asphalt phase domains dispersed in the continuous polymer phase.
Physical and Chemical Polymer Networks

Polymer forms a network in the asphalt through physical entanglements. This behavior gives the polymer-modified asphalt more elastic behavior. An example of this would be a PMA with a high % of elastomeric polymer.

Polymer can be chemically bonded to more polar components in asphalt to improve compatibility.
Methods for Describing Compatibility

- There are many methods used to measure the compatibility of materials.
- In asphalt cements test such as solubility parameters, Heithaus Compatibility Test and Flocculation Ratio.
- In polymer systems test such as Differential Scanning Calorimetry, Dynamic Mechanical Analysis and Microscopy are used.
- In modified systems, the methods of choice are separation test and microscopy.
Separation Test

- Use to measure the separation of polymer from the asphalt.
- Pour 50 grams of asphalt in a toothpaste tube.
- Place tube upright in an oven for 48 hours at 163 °C.
- Remove from oven, quench, run test on top third and bottom third of container.
  - $G^*$ or viscosity
  - $G^*/\sin \delta$
  - Phase Angle
  - Softening Point
Separation Test

- Vertical tube held at elevated temperature for extended time.
- Tube cooled
- Cut into thirds
- Tested top vs. bottom (ring & ball softening point or viscosity)
Microscopy

- There are numerous methods used to define the macro relationships of modified asphalt systems.
- These tests are more subjective than objective, but provide a clear visual indication of compatibility.
Fluorescence Microscopy

Initial Dispersion

Formation of Network

Maturing of Network

Fully Cured Dispersion
Section 2 - Polymers in Modified Asphalt

Presented By: Bob Kluttz

Prepared for the Association of Modified Asphalt Producers Training Program
Section 2- Outline

• Section 2 - Introduction to Polymer Modification
  ▪ What are Polymers?
  ▪ Types of Polymers
  ▪ Compatibility of Polymers with Asphalt
  ▪ Effects of Polymers
  ▪ Analysis of polymers
  ▪ Recovery of PMA
What Is a Polymer?
Some Examples

Polymers are everywhere… You eat them, You wear them, You work with them, You use them all the time!

- carbohydrates
- proteins
- nucleic acids
- wood
- cotton
- silk
- nylon
- polyester
- polystyrene
- PVC
- adhesives
- coatings
- fibers
- elastomers
- foams
What Is a Polymer?

A polymer is a long string (or net) of small molecules connected together through chemical bonds.

A polymer is made of distinct monomer units all connected together.

OK, but why is that important?
The chain connectivity of the polymer can give the chain great strength...and at the same time they can be very flexible.

It also make the polymer viscosity high in both the solution and melt state ...
Now liquids behave elastically to some degree ... they are viscoelastic.

They are easily moldable, castable, soluble, spinnable, etc. ... and so many useful objects can be made from them.
# Differing Monomers

(Repeat Units)

<table>
<thead>
<tr>
<th>Type</th>
<th>Sequence</th>
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<tr>
<td>Homopolymer</td>
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<tr>
<td>Copolymers</td>
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<tr>
<td>Random</td>
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<td>Block</td>
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<tr>
<td>Grafted</td>
<td>BBBBBBBAABBBBBBAAAABAAAAAAAAAAAAAAAAAAAAA</td>
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</table>
SBR and SBS

Block Copolymer

Random Copolymer

- Butadiene
- Styrene
How Reactive Terpolymers Modify Asphalt

- Like SBS polymers, reactive terpolymers reduce temperature susceptibility and increase the tensile properties of asphalt.
- Unlike the SBS polymers, Elvaloy® reacts with the asphalt to form an elastic network in the asphalt instead of around it.

\[
\text{Reactive Terpolymer} + \text{PPA as Catalyst or Heat} \rightarrow \text{Networked Asphaltene}
\]
Thermoplastic vs. Thermoset

Cool

Heat

Thermoplastic

Thermoset

Heat
“Dispersion” in Asphalt

• What is the appropriate scale?
  ▪ Millimeter scale – visible particles
  ▪ Micrometer scale – HMAC film thickness
  ▪ Nanometer scale – molecular size

• Working Premise – to truly be considered a binder modifier, the modifier must disperse at approximately the scale of HMAC film thickness and behave more as a liquid than as a solid at mixing and compaction temperatures.
Polymer Requirements for Asphalt Modification

• Requirements for Dispersion in Asphalt
  ▪ Thermoplastic
  ▪ Suitable Polarity
  ▪ Minimal Ionic Interactions
  ▪ Minimal Crystallinity

• Requirements for Processing in Asphalt
  ▪ Suitable Molecular Weight
  ▪ Suitable Stability
  ▪ Suitable Dispersibility at Processing Temp
So What Does That Leave?

- Low Crystallinity Polyolefins (LDPE, APP, etc.)
- Styrene Diene Polymers
  - Styrenic Block Polymers (SBS)
  - Random Styrene Diene Polymers (SBR)
- Olefin Vinyl Polymers (EVA)
- Olefin Acrylic Polymers (Ethylene Acrylates)
Physical Effects of Polymers in Asphalt

- Reduce Temperature Susceptibility
- Increase Tensile Strength
- Increase Elasticity
Temperature Susceptibility of Polymer Modified Asphalt

- Conventional Asphalt
- Blown Asphalt
- Polymer Modified Asphalt

Fraass Point
Softening Point

Temperature, F
Penetration, units
Viscosity, Poise
Analysis of Polymers in Asphalt

- Infrared Analysis
- NMR Analysis
- GPC Analysis
- Microscopy
IR Analysis of Polymer in Asphalt

Absorbance / Wavenumber (cm⁻¹)

File #1: G4692C21

ASPHALT 20
$^1$H NMR of Polymer in Asphalt

- Aromatic
- Olefinic
- Aliphatic
GPC of Polymer in Asphalt

Unaged

Roofing Compound 12% SBS
Recovery of PMA from Hot Mix

• Polymers may crosslink
• Polymers may adhere strongly to aggregate
• Polymers may be less soluble in the extraction medium than they are in hot asphalt
• There is no guarantee that extracting 98+% of asphalt will also extract 98+% of the polymer modifier.
Section 3 - Basics of Polymers in Asphalt Emulsions

Presented By:
Laurand Lewandowski

Prepared for the Association of Modified Asphalt Producers Training Program
Section 3 - Outline

• Section 3 - Emulsions of Modified Asphalt
  ▪ Asphalt emulsion formulation
  ▪ Modification of asphalt emulsions
  ▪ Impact on performance and performance parameters
Asphalt Emulsions - Formulation

• 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

- Dispersion of asphalt in water
  - Water – continuous phase
  - Asphalt – non-continuous or dispersed phase
    - Stabilized by surfactant

- Surfactant emulsion class
  - Cationic
  - Anionic
  - Nonionic
Particle Size & Distribution

Asphalt droplets

![Graph showing particle size distribution](image)

- Particle Size, µm
- Volume %
Polymer Modification of Asphalt Emulsions

- Emulsify polymer modified asphalt
  - “Pre-modified” emulsion
  - Polymers – SBS, SB-, EVA
  - Higher modified asphalt viscosity
    - Higher asphalt & mill temp.
  - Exit temperature > 100 °C
  - Heat exchanger, back pressure
- Polymer inside asphalt droplet
Polymer Modification of Asphalt Emulsions

- Add latex externally to asphalt
  - Methods
    - Soap batching
    - Co-milling – asphalt line
    - Co-milling – soap line
  - Polymers – SBR, NR latex
  - Lower asphalt process temperature
  - No special mill, handling
- Polymer in water phase
- Continuous polymer film formation on curing
Latex Polymer-Modified Asphalt Emulsion

- Optimum for Fine Polymer Network Formation
Chip Seal – Field Application
Curing of Chip Seal Emulsion

- Water in asphalt emulsion wicks the aggregate surface
- Order of migration = Water, latex particles, asphalt drops
Latex Polymer Distribution

- Latex particles migrate together with water!
- Polymer rich regions develop around aggregate
Chip Seal – CRS-2

Early Strength Development

- Water wicks agg. surface
- Positive correlation
  - Early chip retention
  - Aggregate H₂O absorptivity

Data provided by Paragon Technical Services
Early Strength Development – CRS-2P
ASTM D7000-04 – Sweep Test

Potential Chip Loss

Data Provided by Paragon Technical Services
Sweep Testing – CRS-2P vs. CRS-2
ASTM D7000-04
Microsurfacing Operation

1 min < Mix Time < 3 min

Cohesion Development < 1 hr.
Microsurfacing Mix Formulation

• Blade Coating Operation
  ▪ 2 m wide + <1 cm thick
  ▪ 4-5 km/hour
  ▪ Traffic within 1 hour

• Latex Polymer Binds
  ▪ Asphalt
  ▪ Fines
  ▪ Aggregates

Latex Polymer = 3% of Asphalt (1/4 of Cement)
Microsurfacing – Polymer Morphology Field Application

Texas State Highway 84
- Near Waco, TX
- Paved in 1998
- Samples taken in 2001

5μm
Wet Track Abrasion Loss – ISSA TB-100

- SBR Latex Modified Emulsion
  - 50% reduction in loss
    - One hour soak
  - 67% reduction in loss
    - Six day soak
  - Surface of mix
    - Tougher
    - More abrasion resistant
- Adhesion and water resistance improved
Advantages of Latex Polymer Network

- Latex polymer honeycombs remain flexible
- Absorb stresses without permanent deformation
Summary – Polymer Modified Emulsions

• Chip seals
  ▪ Early and long term chip retention
  ▪ High temperature strength
  ▪ Low temperature flexibility

• Slurry seals and microsurfacing
  ▪ Improved mix cohesion
  ▪ Reduction in abrasion loss of aggregate
  ▪ Resistance to deformation
Questions?
Thanks for your Participation

Please complete the evaluation to provide your feedback on this session and suggest topics for future events.

Remember to mark these upcoming events on your calendar!

March 7-11, 2017
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