Introduction to Modified Asphalt Binders

Materials Track Session
Materials 101
19 Feb 2013
Objectives

• Know why asphalt is modified and what owners/manufacturers are trying to accomplish
• Understand the basic types of asphalt modifiers; focus on the most prevalent types
• Be an active participant, have fun!
Why Modified Binders?

• Extend the range of temperatures over which the asphalt binder will perform its intended function
  - rutting
  - cracking
  - other reasons
• Longer lasting pavements
• Cheaper pavements...in the long run!
Log Log Stiffness, Viscosity, etc.

Modified 2

Modified 1

Unmodified

Log Temperature

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Other Reasons

• Reduce moisture damage in mixes
• Stick chips better and faster
• Reduce pavement thickness
  - maybe/maybe not
• Address construction issues
  - drain off on open graded mixes
• Synergistic co-modifier effect
• Many other reasons...
History of Modified Asphalts

- 1843 - British patent - polymer modified AC
- 1930’s - Test projects in Europe
- 1950’s - Neoprene Latex in U.S. & Canada
- 1970’s - Wide use of polymers in Europe
- 1980’s - Modified binders increase in U.S.
- 1990’s - SHRP PGAB specs increase demand
- 1990’s - PPA use enters paving market
- 2000 - U.S. HMAC market - 15% Modified
- 2003 - Projected 20% Modified HMAC
Modifier Selection Considerations

- Will it have the intended performance effect?
  - effect as stand along modifier
  - effect as co-modifier
- Does it meet purchase spec?
  - recipe vs performance vs both
- How much does it cost?
  - price volatility, availability
- How must it be handled and incorporated?
- Does it stay homogeneous?
- Is it heat stable?
- Does it affect constructability?
- Are there testing considerations?
Types of Modifiers

- Polymers and attendant stuff
- Inorganic acids (e.g., PPA)
- Construction Enhancers
- Waste Products (e.g., crumb rubber)
- Fillers and Fibers
- Antistripping agents
- Hydrocarbons
- Antioxidants
- Extenders
Log Log Stiffness, Viscosity, etc.

Modification via polymer

polymer modified

Polymer Modification

Unmodified

Log Temperature
Types of Polymers

• Elastic Type
  - SB diblock (Dynasol 1205)
  - SBS (Kraton D0243)
  - SBR latex (Ultrapave 1156)
  - Waste rubber (CRM WRF-14)

• Plastic Type
  - EVA (Exxon Polybilt 103)
  - polyethylene (Novaphalt)
Polymer Modified Asphalt (Elastic)

- Advantages
  - Performance history
  - Elastic effect
  - Improved cohesion
  - Many specs designed around stretchy polymers (no mysteries)
  - Favorable co-modifier with PPA

- Disadvantages
  - Can be challenging to manufacture
  - Compatibility can be a problem
  - Tougher to handle
  - Not heat stable
  - Challenge to emulsify
  - Sometimes supply/price not stable
  - Relatively expensive
A Word About Compatibility

Photomicrographs of same SBS polymer in 2 different asphalts
Elastic vs Plastic Polymers
(A civil engineer’s physical model)

- Rubber-like elastomer
  - molecular "rubber bands"
  - coiled up like springs
  - copolymers

- Plastomer
  - molecular rebars
  - side groups prevent movement
  - copolymers
Elastic Polymer Architecture
(A civil engineer’s physical model...again)

<table>
<thead>
<tr>
<th>Polystyrene</th>
<th>Polybutadiene</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard stuff</td>
<td>Soft rubbery stuff</td>
</tr>
<tr>
<td>Tg=100 C</td>
<td>Tg=-80 C</td>
</tr>
</tbody>
</table>
More Polymer Architecture

Called styrene butadiene diblock or SB

chemical crosslink (sulfur or other)
More Polymer Architecture

styrene butadiene styrene or SBS linear

styrene butadiene styrene or SBS radial
More Polymer Architecture

polystyrene groups randomly dispersed in structure

styrene butadiene random or SBR (synthetic latex)
How they work in asphalt

• Network forms
  - Polymer chains get tangled up
  - Physical crosslinks
  - Chemical crosslinks

• Finished properties depend on what’s going on with this network
How they work in asphalt

- **Styrene Butadiene Random**
  - this is SBR latex
  - works almost entirely from chain entanglement
  - not as efficient
  - relatively huge molecules
  - need lots of stretching to detect
  - one great big rubber band

- **Styrene Butadiene Styrene**
  - this is linear SBS
  - works from chain entanglement
  - works from physical crosslinks
  - works from chemical crosslinks
  - relatively efficient
  - relatively small molecules
  - small stretching to detect
  - bunch of tiny rubber bands
PMA Manufacture (SBS)

T = 360° – 400° F

React + agitation

To storage tank

Other important manuf. components: *heat* + *people*
Log Log Stiffness, Viscosity, etc.

Modification via strong acid

Acid modified

Unmodified

Acid Modification

Log Temperature

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Effect of PPA on Performance Grade

![Bar chart showing the effect of PPA on Performance Grade]

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Effect of PPA on Rutting Susceptibility

Salt River Aggregate, MAG 3/4-inch

Rut Depth (50 °C), mm

C

C+1% PPA

C+1% PPA + 0.75% lime

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AMA Manufacture

Base Asphalt → Blender → Static Mixer → Finished Product A

Base Asphalt → Blender → Static Mixer → Finished Product B

PMA

PPA

T = 300° – 340° F

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PPA Modified Asphalt

- Advantages
  - Easy to manufacture
  - Stays homogeneous and heat stable
  - No effect on low temp properties
  - Relatively cheap increase in PG
  - Stable supply
  - Performance history
  - Favorable co-modifier with polymers

- Disadvantages
  - Does not work with all asphalts
  - Can be negated by basic highway chemicals
  - No elastic effect ala SBS types of polymers
  - Cannot use for anionic emulsion bases
Construction Enhancers

• Purpose
  - reduce mix temperature
  - facilitate compaction

• Examples
  - warm mix chemicals (e.g., Evotherm, Rediset)
  - mechanical production (e.g., zeolite, foaming)
  - organic additives (e.g., Sasobit)
Fillers

- **Purpose**
  - fill voids, lower asphalt content

- **Examples**
  - baghouse fines
  - crusher fines
  - lime and cement
  - fly ash
  - carbon black
Fibers

• Purpose
  - Increase tensile strength
  - Inhibit draindown

• Examples
  - Natural
    ▪ Asbestos, rock wool
  - Manufactured
    ▪ Polypropylene, polyester, fiberglass, cellulose
Antistripping Agents

• Purpose
  - reduce moisture damage
  - stick asphalt to aggregate

• Lime and cement
• Amines
• Phosphate esters
• Organo silane
• Some polymers
  - SBR latex
Hydrocarbons

• Purpose
  - soften asphalt
  - rejuvenate old (RAP) asphalt
  - stiffen asphalt

• Rejuvenating agents (e.g., Raffex, Hydrolene)

• Refined waste engine oil bottoms

• Gilsonite, petroleum pitch
Extenders

• Purpose – reduce asphalt demand
• Examples
  - Sulfur (Shell Thiopave)
  - lignin
Oxidants and Antioxidants

- Oxidants
  - Purpose - increase binder stiffness
  - Example – manganese salts (aka Chemcrete, Resperion IntegraBase)

- Antioxidants
  - Purpose – increase durability by decreasing binder aging
  - Example – carbon black, some lead compounds
Waste Materials

- Purpose: replace asphalt binder or mix with cheaper waste product

- Examples:
  - Scrap tires
  - Shingles (pre- and post-consumer)
  - “Glassphalt”
  - “Poticrete”
Thank You!