Asphalt Rubber Binder and Mix Design

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Presentation Outline

- Asphalt Rubber Binder
  - Components
  - Properties
  - Quality Control
- Mix Design Considerations
  - Gap Graded or SMA
COMPONENTS

- Asphalt Cement (Bitumen)
- Crumb Rubber Modifier
- Additives
Asphalt Cement

• Variety of Grades and Designations
  – PG – Performance Grades
  – AR – AR-4000
  – AC – AC-10, AC-20
  – Penetration

• Softer Grades Typically Used in Asphalt Rubber
ASPHALT CEMENTS

USED FOR ASPHALT RUBBER BINDER

Type 1: Hot Climate          PG 64-16 (AC-20)
Type 2: Moderate Climate     PG 58-22 (AC-10)
Type 3: Cold Climate         PG 52-28 (AC-5)
Crumb Rubber

- Derived from scrap tires and other waste rubber products
- Comes in variety of grades and designations
  - Sieve size
  - Material origin or source
- Mesh size refers to first sieve with 5 to 10% retained
Crumb Rubber

- Usually identified by 3 types
  - Type 1 - (Grade A) - Coarse - 10 mesh
    - Used for spray applications like chip sealing
  - Type 2 - (Grade B) - 14 to 20 mesh
    - Used for hotmix and spray applications in moderate and cold climates
  - Type 3 - 30 mesh
    - Used for hotmix designs in extreme cold climates
Crumb Rubber

- **Variety of packaging available**
  - 50 lb paper sacks
  - Up to 1 ton supersacks

- **Major issue with Moisture**
  - Typically upper limit of 0.75%
  - Can cause foaming and safety issues
Additives

• **Used to aid or produce desirable properties**
• **Extender Oils**
  - Provides aromatics to assist crumb rubber interaction with asphalt cement
• **Anti-strip agents**
  - Increase/improve adhesion
• **High Natural Rubber**
  - Improve adhesion and flexibility
• **Polymers**
Properties

- Reactions
- Specification Testing
- Asphalt Rubber Binder Design Profile
Reactions between Components

• Dependant on:
  - Time
  - Temperature
  - Component interaction based on chemical makeup
Specification Testing

- Apparent Viscosity
- Penetration
- Softening Point
- Ductility
- Resilience
Apparent Viscosity

• Rotational Viscometer
  – Brookefield Viscometer
  – Haake Viscometer
  – Presented in centipose (cP) or Pascal Seconds (Pa-s)

• Monitors fluid consistency
  – Aggregate coating
  – Pumpability

• Brookefield sometimes used for acceptance – need calibration
Field Verification
Penetration
ASTM D 5  AASHTO T 49

- Measurement by Penetrometer
  - Results in tenths of millimeter units
- Needle at 39.2°F and 77.0°F
- Cone penetration used with larger size crumb rubber (10 mesh or larger)
Softening Point
ASTM D36    AASHTO T 53

- Ring and Ball Method
- Presented as °F or °C
- Indicator of material stiffness
- Shows tendency of material to flow at elevated temperatures
Ductility

ASTM D 5
AASHTO T 49

- Pulls sample apart at specific rate
- Measure of tensile properties
- Not considered reliable for asphalt rubber
Asphalt Rubber Binder and Mix Design

Resilience
ASTM D5329

• Measures elastic properties of binder
• Expressed as percentage of rebound
• Considered reliable and important
Asphalt Rubber Binder and Mix Design

Asphalt Rubber Binder Design Profile

- Evaluate compatibility between proposed components
- Provide guidance to field for proportioning
- Evaluate stability of binder over time
## Typical Asphalt Rubber Binder Design Results

<table>
<thead>
<tr>
<th>Test Performed</th>
<th>Minutes of Reaction</th>
<th>Specified Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>60</td>
<td>90</td>
</tr>
<tr>
<td>Viscosity, Haake at 177°C, Pa-s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Centipoise cP</td>
<td>2.7</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td>2700</td>
<td>2800</td>
</tr>
<tr>
<td>Resilience at 25°C, % Rebound</td>
<td>34</td>
<td>36</td>
</tr>
<tr>
<td>(ASTMD3407)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ring &amp; Ball Softening Point, °F</td>
<td>150.0</td>
<td>150.5</td>
</tr>
<tr>
<td>(ASTMD36)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Needle Penetration at 4°C, 200g, 60 sec., 1/10mm (ASTMD5)</td>
<td>22</td>
<td>24</td>
</tr>
<tr>
<td>Test Performed</td>
<td>60</td>
<td>90</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Viscosity, Haake at 177°C, Pa-s</td>
<td>3.6</td>
<td>2.4</td>
</tr>
<tr>
<td>Centipoise cP</td>
<td>3600</td>
<td>2400</td>
</tr>
<tr>
<td>Resilience at 25°C, % Rebound</td>
<td>38</td>
<td>28</td>
</tr>
<tr>
<td>(ASTMD3407)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ring &amp; Ball Softening Point, °F</td>
<td>149.0</td>
<td>141.0</td>
</tr>
<tr>
<td>(ASTMD36)</td>
<td>(ASTMD5)</td>
<td>(ASTMD5)</td>
</tr>
<tr>
<td>Needle Penetration at 4°C, 200g, 60 sec., 1/10mm</td>
<td>18</td>
<td>26</td>
</tr>
</tbody>
</table>
Quality Control

- Pre-job testing sets standard for comparison to field testing
- Establish target viscosity for field
- Significant fluctuations in field should be investigated
Quality Control

- Sample reheating has been shown to affect results
- Typically viscosity is lowered, resilience and softening point decreased, penetration increases
- Prepare all test samples at the same time
Asphalt Rubber Mixture
Design
Gap Graded or SMA
Gap Graded: Purpose

- Highly flexible lift
- High quality structural lift
- Typically nominal 2 inch lift
## Gap Graded: Gradation

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing With admixture</th>
</tr>
</thead>
<tbody>
<tr>
<td>$3/4''$</td>
<td>100</td>
</tr>
<tr>
<td>$1/2''$</td>
<td>80-100</td>
</tr>
<tr>
<td>$3/8''$</td>
<td>65-80</td>
</tr>
<tr>
<td>#4</td>
<td>28-42</td>
</tr>
<tr>
<td>#8</td>
<td>14-22</td>
</tr>
<tr>
<td>#200</td>
<td>0-2.5</td>
</tr>
</tbody>
</table>
Gap Graded: Crushed Faces

- Minimum 95% Single Crushed Faces
- To insure good particle interlock
Mix Design Steps

- Prepare Aggregate
- Determine aggregate specific gravities
- Determine maximum theoretical specific gravity
- Compact mix, determine optimum binder content
- Check mix volumterics
Gap Graded: Design

- Determine the maximum theoretical specific gravity (Rice test)
  - Pay extra in separating the aggregate
  - High binder content and film thickness
Gap Graded: Design

- Compact with Marshall hammer at three binder contents
- Typically 6.5, 7.5, 8.5 or 6.0, 7.0, 8.0 depending on aggregate source
- Mix at 325 °F
- Compact at 300 °F
Gap Graded: Design

- Check Volumetrics, select optimum binder content.
- Minimum VMA 17.0%
- Effective Voids 4.0 - 6.0%
Gap Graded : Typical Design

Typical binder content 6.5-8.5% by weight of the mix depending on aggregate source and gradation
Asphalt Rubber Binder and Mix Design

Questions?