Asphalt Rubber Binder

Asphalt Rubber— a blend of asphalt cement, reclaimed tire rubber and certain additives in which the rubber component is at least 15% by weight of the total blend and has reacted in the hot asphalt cement sufficiently to cause swelling of the rubber particles.

Asphalt Rubber Binder
Asphalt Rubber Binder

An overview of the

- Components
- Properties
- Quality Control
COMPONENTS

- Crumb Rubber
- Asphalt Cement
- Additives
CRUMB RUBBER

Crumb rubber is produced from grinding up whole scrap tires, tread buffings, and other waste rubber products. Crumb rubber comes in a variety of grades and designations presented by particular size and/or source.

Mesh size designation refers to the first sieve with an upper range specification between 5.0 & 10.0 percent retained.

Asphalt Rubber Binder
CRUMB RUBBER

Crumb Rubber Grades are usually identified as follows:

Type 1 or Grade A:

Coarse CRM, 10 mesh, usually used for spray applications like chip sealing

Type 2 or Grade B:

14 to 20 mesh, used for spray applications and hot mix design for hot, moderate and cold climates

Type 3

30 mesh, used for hot mix design in extreme cold climate regions and for dense-graded mixes and AR spray applied chip seals.
CRUMB RUBBER
Handling and Storage

A variety of packaging is available from 50 lb. paper sacks to 1 ton bulk bags.

**MOISTURE**: Protect from moisture during transport and site storage! Maximum moisture content limit is usually 0.75% by weight.

Excessive moisture content can cause rapid foaming and boil over of the asphalt rubber binder. If bulking of the crumb rubber is evident, up to 4.0% by weight of talc can be added to reduce the bulking.
Asphalt cements come in a variety of grades and designations.

Typically softer grades are used in blending asphalt rubber binder for a particular region than are used for production of conventional hot mix.
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)

Asphalt Rubber Binder
PERFORMANCE GRADED ASPHALTS

Example: PG 64-16

PG = Performance Grade

64 = 64°C High pavement design temperature based on average 7 day max.

-16 = -16°C Minimum pavement design temperature.
Sometimes used in conjunction with crumb rubber to enhance interaction or produce desirable property.

Some additives include:

- **Extender oils** - aid in the reaction of the crumb rubber by providing aromatics which are absorbed by the rubber, and help with dispersion by chemically suspending the rubber in the asphalt and soften the base asphalt.

- **Anti-stripping agents** - used to increase or improve adhesion.

- **High natural rubber** - used to improve adhesion and flexibility, and to compatibilize interactions.

- **Polymers**, used to enhance a specific property.
Effects of Extender Oils on Asphalt Cements

• Basic Chemical Components of Asphalt Cement
  • Asphalteens
  • Malteens
    • Polor Compounds
    • Group 1 Acidifins
    • Group 2 Acidifins
    • Saturated Hydrocarbons

Asphalt Rubber Binder
Properties Changes
Two PG 64-16 with 2.5% Raffex 120ACB EO

First PG 64-16

<table>
<thead>
<tr>
<th>Property</th>
<th>Without EO</th>
<th>With EO</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSR @ 58° C</td>
<td>2.73 kPa</td>
<td>1.44 kPa</td>
</tr>
<tr>
<td>DSR @ 64° C</td>
<td>1.27 kPa</td>
<td>0.68 kPa</td>
</tr>
<tr>
<td>DSR @ 70° C</td>
<td>0.59 kPa</td>
<td>0.33 kPa</td>
</tr>
<tr>
<td>Absolute Viscosity</td>
<td>2076 poise</td>
<td>1186 poise</td>
</tr>
</tbody>
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Properties Changes
Two PG 64-16 with 2.5% Raffex 120ACB EO

Second PG 64-16

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<td>3113 poise</td>
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<tr>
<td>Penetration @ 77° F</td>
<td>54 dmm</td>
<td>65 dmm</td>
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INFLUENCES ON BINDER PROPERTIES

- Asphalt Cement Source and Grade
- Rubber Source
- Amount of Rubber
- Gradation of Rubber
- Interaction Time
- Interaction Temperature
INTERACTIONS BETWEEN COMPONENTS

*Depend on:*

- Time
- Temperature
- Chemical makeup of components
A design profile not only determines the proportions of CRM and asphalt cement to meet target specification but evaluates the compatibility between materials used, component interaction and checks for stability of the blend over time.
<table>
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<tr>
<th>Test Performed</th>
<th>Minutes of Reaction</th>
<th>Specified Limits</th>
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<tr>
<td></td>
<td>60</td>
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<tr>
<td>Viscosity, Haake at 177°C, Pa-s Centipoise cP</td>
<td>2.7 2700</td>
<td>2.8 2800</td>
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<tr>
<td>Resilience at 25°C, % Rebound (ASTM D3407)</td>
<td>34</td>
<td>36</td>
</tr>
<tr>
<td>Ring &amp; Ball Softening Point, °F (ASTM D36)</td>
<td>150.0</td>
<td>150.5</td>
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<td>Needle Penetration at 4°C, 200g, 60 sec., 1/10mm (ASTM D5)</td>
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## Asphalt Rubber Binder

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<td>3.6 3600</td>
<td>1.5-4.0</td>
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<tr>
<td></td>
<td>3.5 3500</td>
<td>1500-4000</td>
</tr>
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<td></td>
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<td></td>
</tr>
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<td>18</td>
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SPECIFICATION TESTING

Various tests are performed to identify and monitor various physical properties.
APPARENT VISCOSITY

Measured by a rotational viscometer and presented in centipoise (cP) or Pascal Seconds (Pa-s).

- **Brookfield Viscometer**
- **Haake Viscometer (Rion VT-04 viscotester)**

Monitors fluid consistency of asphalt rubber binder to ensure pumpability, and to identify binder changes which might affect hot mix placement, compaction or performance.

If the Brookfield is the required method for acceptance, then the Haake viscometer should be calibrated and corrected to the Brookfield measurement for field use.

*Asphalt Rubber Binder*
Asphalt Rubber Binder
The High Viscosity Binder

• Basic Terms of Measurement Used
  – Centipoise (cP) or Millipascal Second (mPa-s)
  – Pascal Second (Pa-s)

  – 1 Pascal Second is equal to 1000 Centipoise
  – Example: 2.4 Pa-s = 2400 cP
Asphalt Rubber
The High Viscosity Binder

Crumb Rubber Modifier is used to increase the viscosity of the Asphalt Cement

But How Much?
Remember this
PG 64-16 with 2.5% Raffex 120ACB EO

Second PG 64-16

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Asphalt Rubber Binder
After Adding 18.5% CRM

- Apparent Viscosity @ 350°F after 60 minutes of reaction when measured with a Rion Viscotester (aka Haake)

  2400 cP

What do you think the Apparent Viscosity @ 350°F of the Asphalt Cement was before adding the Crumb Rubber Modifier?
67.5 cP

- Viscosity of the Asphalt cement increased from 67.5 cP to 2400 cP with the addition of 18.5% CRM
- Significant increase in Viscosity
- Significant level of Modification

*Asphalt Rubber Binder*
Effect of Rubber Quantity
Viscosity

Viscosity @ 350°F, cp

Rubber Percent by Weight of Total Binder

Asphalt - AC-20
Rubber - No. 16 sieve maximum nominal size
Ref: "Design Methods for Hot-mixed Asphalt Rubber Concrete Paving Materials," James G. Chehovits, Proceeding of the National Seminar on Asphalt-Rubber, October 1989
RESILIENCE

ASTM D5329

Appears to be a reliable measure of the elastic properties of the asphalt rubber binder.

Expressed as a percentage of rebound for the binder.

Resilience is one of the most important properties of AR binders and is considered a primary indicator of performance.
Effect of Rubber Quantity
Resilience

Resilience @ 77 F

Rubber Percent by Weight of Total Binder

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SOFTENING POINT

ASTM D36
AASHTO T 53

Ring and Ball method of measurement

➢ Results are presented in °F or °C.

➢ Indicator of material stiffness and extent of modification.

➢ Shows the tendency of the material to flow at elevated temperatures.

Asphalt Rubber Binder
Softening Point

<table>
<thead>
<tr>
<th>Type</th>
<th>Softening Point, deg. F</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC-5</td>
<td>112</td>
</tr>
<tr>
<td>AC-5R</td>
<td>143</td>
</tr>
<tr>
<td>AC-20</td>
<td>129</td>
</tr>
<tr>
<td>AC-20R</td>
<td>151</td>
</tr>
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</table>
PENETRATION

ASTM D 5
AASHTO T 49

Measured by a penetromometer and presented in tenths of a millimeter units (dmm). Asphalt rubber binder consistency can be evaluated at low, moderate, and high temperatures.

Needle penetration is usually the standard at 39.2°F and 77.0°F.

Cone penetration is typically used with asphalt rubber binder with larger particle size crumb rubber (10 mesh and up).

Asphalt Rubber Binder
Measurement is achieved by pulling a sample apart at a specified rate and temperature until fracture. This is one measure of the tensile properties of the asphalt rubber binder, but was originally used to evaluate internal consistency of the asphalt cement.

*Ductility should not be considered a reliable measure of ductile properties for an Asphalt Rubber Binder.*

**WHY?**

The discrete crumb rubber particles cause premature failure of the test specimen with a relatively large remaining cross-section.
% rubber is usually expressed 1 of 2 ways:

% by weight of total binder

% by weight of asphalt cement

**Example:**

19.0% by total binder = 23.5% by asphalt cement
QUALITY CONTROL

Begins with pre-job testing to set the standard to which field testing can be compared.

The asphalt rubber blend design evaluates the compatibility of the components to economically produce a binder that meets the project specifications.

The design profile is a good tool to indicate appropriate testing for monitoring the project. This profile establishes a target viscosity for field testing.

**Monitoring:** Significant fluctuation in viscosity (even if still meeting project specifications) can cause challenges with the hot mix placement or suggest that other specifications such as resilience, softening point, etc. are no longer being met.

*Asphalt Rubber Binder*
QUALITY CONTROL

Sampling Consideration
It is important to consider the required testing during field sampling of the Asphalt Rubber blend holding tanks. Reheating the retained 1-gallon sample for Central Laboratory test preparation has been shown to alter the physical properties of some AR Binders.

Typically Reduces:
• Viscosity
• Resilience
• Softening points,

Typically Increases:
• Penetration at 77°F and 39.2°F.

Individual test specimens should be prepared at the time of sampling for later testing.

Asphalt Rubber Binder
QUALITY CONTROL

Sampling Consideration

If individual test specimens are not obtained during tank sampling and central laboratory testing is required, the 1-gallon container should not be reheated over direct flame or hot plate. This would result in significant devulcanization of the rubber, and would impact the test results.

Reheat the sample by placing it (with lid loosened) in a forced draft oven at 350°F for approximately 1-2 hours until fluid. The sample may then be transferred to a hot plate and stirred continuously until proper test temperature is obtained.

Asphalt Rubber Binder
Thank You

Questions

Sam Huddleston
MACTEC Engineering & Consulting
3630 East Wier Avenue
Phoenix, Arizona 85040
(602) 437-0250
swhuddleston@mactec.com

Asphalt Rubber Binder