Asphalt Materials

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Classifications of Asphalt

• Cutbacks
• Emulsions
• Asphalt Cement (Binder)

Cutback Asphalt

• Paving asphalt liquefied by blending with petroleum solvents
• Resulting material can be sprayed/mixed at lower temperatures
• Primary uses:
  – penetrating prime coat
  – binders for storable cold mix asphalt

Types of Cutback Asphalt

<table>
<thead>
<tr>
<th>Type</th>
<th>Solvent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rapid Curing</td>
<td>Gasoline or Naphtha</td>
</tr>
<tr>
<td>Medium Curing</td>
<td>Kerosene</td>
</tr>
<tr>
<td>Slow Curing</td>
<td>Diesel</td>
</tr>
</tbody>
</table>

Grades of Cutback Asphalt

<table>
<thead>
<tr>
<th>Grade</th>
<th>Solvent</th>
<th>Asphalt Cement</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC-30</td>
<td>30 - 60</td>
<td>30 - 60</td>
</tr>
<tr>
<td>MC-70</td>
<td>70 - 140</td>
<td>70 - 140</td>
</tr>
<tr>
<td>MC-250</td>
<td>250 - 500</td>
<td>250 - 500</td>
</tr>
<tr>
<td>MC-800</td>
<td>800 - 1600</td>
<td>800 - 1600</td>
</tr>
<tr>
<td>MC-3000</td>
<td>3000 - 6000</td>
<td>3000 - 6000</td>
</tr>
</tbody>
</table>

Cutbacks are further divided by viscosity. For example:

MC-30: Kinematic Viscosity Min. 30 mm²/sec @ 140°F

MC-70: Kinematic Viscosity Min. 70 mm²/sec @ 140°F
Asphalt Emulsions

- Microscopic asphalt droplets suspended in water.
- Mostly 1-5 µm diameter
- Emulsifiers or surfactants hold these droplets in suspension.

The purpose of diluting the binder with water is to lower the viscosity. This allows the emulsion to be shot onto the roadway surface at much lower temperatures than straight binder.

If the emulsifying agent causes the particles to bear a negative charge, the emulsion is said to be anionic.

If the emulsifying agent causes the particles to bear a positive charge, the emulsion is said to be cationic.

Anionic emulsions (negatively charged) typically bond best with positively charged aggregates (limestones, dolomites).

Cationic emulsions (positively charged) typically bond best with negatively charged aggregates (granites, sandstones).

The process in which the binder globules begin to coalesce and the water evaporates is called breaking.

The amount of binder left after the water evaporates is called the residual asphalt.

The residual asphalt is expressed as a percentage of the emulsion.

Both the amount and type of water and emulsifying agent mixed with the binder affect the evaporation rate.

Negatively-Charged Emulsions are classified into 3 types:

- RS (Rapid Setting)
- MS (Medium Setting)
- SS (Slow Setting)
Positively-Charged Emulsions are also classified into 3 types

- **CRS (Rapid Setting)**
- **CMS (Medium Setting)**
- **CSS (Slow Setting)**

**Additional Nomenclature**

- **QS** = Quick Set
- **HF** = High Float
- **1** = Binder residue = 60% Minimum
- **2** = Binder Residue = 65% Minimum
- **h** = Hard Pen Asphalt Base
- **s** = Soft Pen Asphalt Base or sometimes Solvent
- **I and/or p** = Latex and/or Polymer

**Asphalt Emulsions**

*The most common uses of emulsions are for chip seals, tack coats, and fog seals.*

**Asphalt Binders**

The term “binder” covers both neat (unmodified) and modified asphalt cements, but doesn’t include emulsions and cutbacks.

Binders are the “glue” that holds the aggregate together in HMA.

Unlike emulsions and cutbacks, binders are typically required to be heated to over 300°F for use, unless modified for use as Warm Mix Asphalt (WMA).

Polymers can be added to the binder to enhance their high temperature performance.

**Superpave Asphalt Binder Specifications**

The grading system is based on Climate

- **PG 64 - 22**
- Performance Grade
- Meets all requirements up to this temperature (°C)
- Meets all requirements down to this temperature (°C)
- **Note:** These grades are specified in 6° increments

**High Temperature @ 98% Reliability**

The grading system is based on Climate
Low Temperature @ 98% Reliability

PG Binder Grades

Asphalt Description and Sources

Asphalt Cement or Asphalt Binder
- Black, cementious, waterproof material
- Originally mined from a natural lake (still operating today: Lake Asphalt of Trinidad and Tobago)
- Most asphalt today comes from the refining process

Not All Crudes Are The Same

Typical Crude Make-Ups

Asphalt Behavior Depends On:

- Temperature
- Time of Loading
- Aging (properties change with time)
Asphalt Behavior at Varying Temperatures

Asphalt is a viscoelastic material that has both the properties of an elastic solid and a viscous liquid, depending on the temperature.

Asphalt Flow Behavior

Effect of Loading Rate on Binder Selection

Example
- Toll road
  PG 64-22
- Toll booth
  PG 70-22
- Weigh stations
  PG 76-22
- 90 kph (55 MPH)
- Slow
- Stopping

Effect of Traffic on Binder Selection

- 10 to 30 million ESALs
  - Consider increasing one high temperature grade
- > 30 million ESALs
  - Increase one high temperature grade
- Newer recommendations are based on more gradual bumping in LTPPBind version 3.0+

NOTE: Multiple Stress Creep Recovery (MSCR) test specification will replace traffic grade bumping.

Asphalt aging over the pavement life

High Temperature Behavior

- High in-service temperature
  - Desert climates
  - Summer temperatures
- Sustained loads
  - Slow moving trucks
  - Intersections

NOTE: Multiple Stress Creep Recovery (MSCR) test specification will replace traffic grade bumping.
Low Temperature Behavior

- Low Temperature
  - Cold climates
  - Winter
- Rapid Loads
  - Fast moving trucks

“Ideal” Asphalt Binder

- Low stiffness at construction temperature
- High stiffness at high in-service temperature
- Low stiffness at low in-service temperature
- Excellent long-term durability

Polymer-modified Asphalt Binder

Polymer-modified
Unmodified

General Performance

Polymers

- Elastomers
- Plastomers
- Combinations
  - poly•mer
  - “many parts”

Elastomers

- Natural Latex Rubber
- Synthetic Latex
  - Styrene-butadiene (SB)
- Block Copolymer
  - Styrene-butadiene-styrene (SBS)
- Reclaimed Rubber

Plastomers

- Polyethylene
- Polypropylene
- Ethyl-vinyl-acetate (EVA)
- Polyvinyl-chloride (PVC)

EVA is a plastic that is used to create stiffer insoles for your shoes.
Quantifying the Effects of PMA for Reducing Pavement Distress

This study (published in Feb 2005) used national field data to determine enhanced service life of pavements containing polymer modified binders versus conventional binders. The data is from a variety of climates and traffic volumes within North America.

Direct Comparisons – Rutting

Distress Comparisons – Transverse Cracking

Distress Comparisons – Fatigue Cracking

MSCR Implementation

The use of polymer modified binders has grown tremendously over the past several years.

However, the most widely used binder specification in the U.S., AASHTO M 320, was based on a study of neat (unmodified) binders, and may not properly characterize polymer modified binders.

PG Grading Alone Does Not Always Predict Performance

- Study of the two mixes with the same aggregate structure, but different binders.

  - PG 63-22 modified, no rutting
  - PG 67-22 unmodified, 15mm rut
**Why doesn’t M 320 properly characterize polymer-modified binders?**

- Current spec, G* and δ are measured in the linear visco-elastic range.
- For neat binders, flow is linear (strain increases in a constant proportion to stress) and therefore not sensitive to the stress level of the test.
- For polymer-modified binders, the response is not linear and very sensitive to the stress level of the test. The polymer chains can be rearranged substantially as the stress increases.

**Why Do We Need New Binder Test?**

- **PG Binders**
  - Most Common “Neat” Binder Grades
    - PG 64-22
    - PG 67-22
    - Works OK for neat binders
  - Most Common “Modified” Binder Grade
    - PG 76-22
    - Doesn’t work as well for modified binders

**What happened as a result of M 320’s inability to fully characterize polymer-modified binders?**

- Most states began requiring additional tests to the ones required in AASHTO M 320
- These mostly empirical tests are commonly referred to as “PG Plus” tests
- These tests are not standard across the states – difficult for suppliers
- Even some of the tests that are the most common, e.g. Elastic Recovery, are not run the same way from state to state

**States with a “PG Plus” Specification**

- **ER Information and Test Time**
  - The Elastic Recovery Test is an excellent tool to establish the presence of polymer modification.
    - It takes about 4 hours to prepare and test samples for this information.
  - However, it is a poor tool to evaluate the rutting performance of polymer-modified binders.
    - The MSCR test can use the same sample already being run in the DSR to give more information in a few extra minutes.

- **Multiple Stress Creep Recovery Test**
  - Performed on RTFO-aged Binder
  - Test Temperature
    - Environmental Temperature
    - Not Grade-Bumped
  - 10 cycles per stress level
    - 1-second loading at specified shear stress
      - 0.1 kPa
      - 3.2 kPa
    - 9-second rest period
Multiple Stress Creep Recovery Test

- Calculate Recovery for each Cycle, Stress
  - Difference between strain at end of recovery period and peak strain after creep loading
- Calculate Non-recoverable Creep Compliance ($J_{nr}$)
  - Non-recoverable shear strain divided by applied shear stress
  - \( J = \) “compliance”
  - \( J_{nr} = \) “non-recoverable”

ALF Loading

- The pavement was heated to a constant 64ºC.
- The FHWA ALF uses an 18,000 lbs wheel load with no wheel wander.
- The speed is 12 MPH.
  - This is an extreme loading condition far more severe than any actual highway.

Relationship between $G^*/\sin\delta$ and ALF Rutting

- Existing SHRP specification has poor relationship to rutting for modified systems.

Relationship between $J_{nr}$ and ALF Rutting

- MSCR can adjust for field conditions and has excellent relations to performance.

New PG Grading System (MSCR)

**Requirements**

- **S = Standard:** $J_{nr} \leq 4.5 \text{ kPa}^{-1}$
- **H = Heavy:** $J_{nr} \leq 2.0 \text{ kPa}^{-1}$
- **V = Very Heavy:** $J_{nr} \leq 1.0 \text{ kPa}^{-1}$
- **E = Extreme:** $J_{nr} \leq 0.5 \text{ kPa}^{-1}$
**What is currently being supplied?**

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>64E</td>
</tr>
<tr>
<td>2</td>
<td>64V</td>
</tr>
<tr>
<td>3</td>
<td>64H</td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

**Modified Grades in the Northeast**

<table>
<thead>
<tr>
<th>Current Grade - M320</th>
<th>New Grade - M332</th>
</tr>
</thead>
<tbody>
<tr>
<td>PG 76-22</td>
<td>PG 64E-22</td>
</tr>
<tr>
<td>PG 76-28</td>
<td>PG 64E-28</td>
</tr>
<tr>
<td>PG 70-28</td>
<td>PG 64V-28</td>
</tr>
<tr>
<td>PG 64-22P</td>
<td>PG 64V-22</td>
</tr>
<tr>
<td>PG 58-34</td>
<td>PG 58H-34</td>
</tr>
</tbody>
</table>

**When would a polymer-modified asphalt typically be used?**

- **AASHTO M 323 - Table 1**

<table>
<thead>
<tr>
<th>Adjustment to High-Temp Grade</th>
<th>Traffic Load Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ESALs (M)</strong></td>
<td>Standing</td>
</tr>
<tr>
<td>&lt; 0.3</td>
<td>-</td>
</tr>
<tr>
<td>0.3 - &lt; 3</td>
<td>2</td>
</tr>
<tr>
<td>3 - &lt; 10</td>
<td>2</td>
</tr>
<tr>
<td>10 - &lt; 30</td>
<td>2</td>
</tr>
<tr>
<td>≥ 30</td>
<td>2</td>
</tr>
</tbody>
</table>
For More Binder Information

Asphalt Binder Testing

MS-25

MS-26