Polymer Modified Asphalts

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Outline

- Why Modify Asphalts
  - Common stresses
  - Specifications
- Existing modification methods and their influence on performance
- SB, SBS and Elvaloy Modified Asphalts
- Properties of polymer modified asphalt
- PMA handling during storage and transportation
Modified Asphalts Address Common Distresses in Pavements

- Rutting
Fatigue Cracking
Thermal Cracking
Stripping
PG 58-28 Sites
Taken from LTPP Bind Version 2.1

- PG 58-28
Low Temperature Grades (LTTPBIND 3.1)

-28
-34
-40

Low Pavement Temp
98% Rel.

-28
-34
-40
New Testing Protocols for Specifying AC

- Double Edge Notch Test (DENT) – Ontario only
- Extended Bending Beam Rheometer Test (XBBR) - Ontario only
- Multiple Stress Recovery Test (MSCR)
- Ash Test
Double-Edge Notched Tension Test (DENT) LS-299

- Notched samples of AC attached to load cells are stretched in a 15 °C bath of water until they break.
- Critical Crack Tip Opening Displacement (CTOD) determined
- CTOD is said to be related to fatigue cracking.
Extended Bending Beam Rheometer Protocol (LS-308)

- Determines how brittle an AC can get (physical hardening) when exposed to low temperatures over an extended period of time during winter.
- Modification of the current PGAC low temperature grade test with sample conditioning over 3 days at temperatures ranging from -8 to -30°C instead of just 1 hour.
Multiple Stress Creep Recovery Test

- The MSCR test is an improved test that captures the rutting resistance imparted to the ac by polymer modification.
- The % Recovery component was incorporated in jurisdictions such as Ontario to replace the elastic recovery test.
- Performed in DSR which is normally used to evaluate the PGAC high temperature grade.
- Multiple Stress Creep Recovery Test (MSCR) (AASHTO T350) was developed to replace heavy & slow traffic PG grade bumps.
MSCR % Recovery Requirement
Ash Content

- Ash Content (LS-227) measures the AC material that does not burn

- Used to quantify and limit modification of AC with recycled engine oil bottoms (REOB/VTAE)
Some Municipalities ban a variety of additives such as:

- Recycled Engine Oil Bottoms (REOB) - also called VTAE
- Air Blown Asphalt Cement
Petroleum Asphalts Grades

- PG grades (AASHTO M320)
  - PG 52-34
  - PG 58-28
Proliferation of Grades

Where PG 64-28 is required the following grades could be specified:

1. PG 64-28
2. PG 64-28 without REOB(VTAE) and other banned additives
3. PG 64-28DENT
4. PG 64-28DENT without REOB(VTAE) and other banned additives
5. PG 64-28DENT/xBBR
6. PG 64-28DENT/xBBR without REOB(VTAE) and other banned additives
7. PG 58H-28
Asphalt Modification

- Blending Asphalt Bases – With Additives
  - Polymers
    - SBS Family (Styrene-Butadiene-Styrene)
    - SBR (Styrene-Butadiene-Rubber)
    - Evaloy® (Dupont)
    - EVA (Ethylene-Vinyl-Acetate)
Asphalt Modification

- Rubber Asphalts
- Chemical modifications
  - PPA
  - Air blown
- Specialty Oils
  - Fluxing Oils (Aromatics)
  - Lube Bases (Aliphatics & Naphthenics)
- Chemical Additives
  - Anti-Stripping Agents
  - Warm Mix additives
# Influence of Modification on Performance

## Table

<table>
<thead>
<tr>
<th>PG Grade</th>
<th>Asphalt Bases</th>
<th>Polymers</th>
<th>Oils</th>
<th>Chemical Additives</th>
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<tbody>
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<td>Soft</td>
<td>Hard</td>
<td>SBS</td>
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What is a Polymer

The simplest definition of a polymer is a useful chemical made of many repeating units.

American Chemistry Council

Polybutadiene
Polybutadiene

- Rubber
- Glass transition $T$: -95 to -110 °C (-139 to -166 °F)
- Good performance up to -80 °C (-112 °F)
SB and SBS Copolymers

- **S**: Styrene
- **B**: Butadiene
SBR Copolymers

- Random, Alternating, Blocked, and Grafted
- Synthetic rubbers are often copolymers.
  e.g., automobile tires (SBR)

\[
\text{Styrene-Butadiene Rubber random polymer}
\]
Evaloy® (Dupont)

Ethylene backbone

n-Butyl Acrylate

Glycidyl Methacrylate
SBS and Elvaloy Copolymers

SBS

Elvaloy
Polymer Modification of Paving Asphalts

- Select the base asphalt according to the low temperature requirements
- Modify the base for the high temperature requirements by adding polymers
  - SB, SBS, Elvaloy, etc.
Typical Polymer Plant

SBS Blending System For Asphalt Terminals
Initial Mix
Cross-linker Added
Storage Tank
SBS Modification

Characteristics of PMA:

- Higher viscosities
  - PG 58-28: Vis @135°C ~ 0.290 Pa.s.
  - PG 64-28DENT/xBBR: Vis @135°C ~1.100 Pa.s.
- High elasticity
Consequence of Higher Viscosities

- Higher Mixing and Compaction Temperatures required
- Difficulty in estimating these temperatures for polymer modified asphalts
Mixing & Compaction Temperatures using Rotational Viscometer (RVM) and Steady Shear Flow (SSF) Methods for a PG 64-28DENT/xBBR

<table>
<thead>
<tr>
<th>Method</th>
<th>RVM</th>
<th>SSF</th>
<th>Supplier Recommendation</th>
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<tbody>
<tr>
<td>Mixing Temperature, $^\circ$C</td>
<td>190</td>
<td>154</td>
<td>160</td>
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<tr>
<td>Compaction Temperature, $^\circ$C</td>
<td>173</td>
<td>141</td>
<td>150</td>
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Factors Influencing Storage Properties

- Mixing
- Temperature: 150-175(max) °C
- Avoid direct fire heating: localized over heating
- Avoid extended period of heating
- Cross-contamination (leftovers):
  - Transportation truck
  - Storage tank
Cross-contamination Consequences

- PG 64-28DENT/xBBR contaminated by PG 58-28:
  - Decreased elastic recovery
  - Loss of flexibility
  - Rutting
Consequences of Over Heating or Extended Period of Heating

- Degradation of polymers and asphalt:
  - Increased stiffness
  - Fatigue cracking
  - Decreased flexibility
  - Fatigue cracking
  - Decreased low temperature performance
  - Thermal cracking
If the PMA has to be Stored for an Extended Period

- Lower the temperature
- Keep mixing / circulate (if possible)
Be Aware of Mixing Modified Asphalts from Different Suppliers

- Different Modification technologies
- Compatibility issues
- May cause separation