North Dakota ASPHALT conference
Binder Basics: Polymer Modified Asphalt and the Multiple Stress Creep Recovery (MSCR) Test

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AASHTO M320 (standard PG grading) was found to be inadequate for characterizing different types of modifications.

Lack of correlation between $G^*/\sin(\delta)$ and field performance for modified asphalt.

$G^*/\sin(\delta)$ stress level was too small.
MSCR Test Components

- Uses the DSR
- Increases the stress level to determine what traffic level the asphalt resists flow
- Measures two parameters
  - Jnr (non-recoverable creep compliance) which correlates with field rutting performance
  - Percent Recovery, which indicates the presence of sufficient and effective polymer modification
Dynamic Shear Rheometer (DSR)
Benefits of Modification

- The asphalt industry needs economical pavements that perform for a long time.
- Modification improves the glue that binds the aggregates together for better:
  - Resistance to permanent deformation
  - Reduction of large-scale aggregate movement
  - Adhesion
  - Fatigue life
  - Resistance to cracking
Elastomeric polymers stretch and elastically recover their shape when released.

A valuable property in:
- Running shoes
- Rubber bands
- Vehicle tires
- And asphalt pavement!
Engineered PMAC viewed under a Fluorescence Microscope

<table>
<thead>
<tr>
<th>State</th>
<th>% R</th>
<th>Jnr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unreacted</td>
<td>21.0</td>
<td>0.68 ( \text{Pa}^{-1} )</td>
</tr>
<tr>
<td>Partially Reacted</td>
<td>46.4</td>
<td>0.39 ( \text{Pa}^{-1} )</td>
</tr>
<tr>
<td>Fully Reacted</td>
<td>58.3</td>
<td>0.31 ( \text{Pa}^{-1} )</td>
</tr>
</tbody>
</table>
Past Asphalt Binder Grade

Grading System Based on Climate

PG 58 - 28

Performance Grade

Average 7-day max pavement design temp

Minimum pavement design temperature
MSCR Asphalt Binder Grade

Grading System Based on Climate and Traffic

PG 58H - 28

Performance Grade

Average 7-day max pavement design temp

Minimum pavement design temperature
Past Temperature Grade “Bumps”

58°C (136°F)  
PG 58-28  
- Standard traffic

64°C (147°F)  
PG 64-28  
1 “Bump”  
- Slow or heavy traffic

70°C (158°F)  
PG 70-28  
2 “Bumps”  
- Stationary or high volume traffic
MSCR Traffic “Bumping”

- **Standard traffic**
  - PG 58S-28
  - 1 “Bump”

- **Heavy traffic**
  - PG 58H-28
  - 2 “Bumps”

- **Very heavy traffic**
  - PG 58V-28
  - 3 “Bumps”

- **Extreme traffic**
  - PG 58E-28
1. Selecting a higher PG grade and/or mixture type (traffic level), for higher ESALs within the category, will provide better resistance to rutting.
2. New construction includes: reconstruction, rubblization, CIR, reclaiming (FDR)
3. For Non-Trunk Highways with traffic levels <3 million ESAL, consider modifying the “top 4” criteria to “top 3”.

<table>
<thead>
<tr>
<th>Type of Construction</th>
<th>Recommended Asphalt Binder for &lt;3 Million ESALs (20 yr)</th>
<th>Recommended Asphalt Binder for 3 - 10 Million ESALs (20 yr)</th>
<th>Recommended Asphalt Binder for &gt;10 Million ESALs (20 yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overlay</td>
<td>PG 58S-28</td>
<td>PG 58S-28¹</td>
<td>PG 58H-28¹</td>
</tr>
<tr>
<td>Wearing Mixture (Top 4”)³</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Construction²</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wearing Mixture (Top 4”)³</td>
<td>PG 58H-34</td>
<td>PG 58H-34¹</td>
<td>PG 58V-34¹</td>
</tr>
<tr>
<td>All Non-Wear Mixture (Below 4” from Surface)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PG 58S-28</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Asphalt that plots above the line indicates the presence of an elastomeric network.
PG 58-34 vs PG 58H-34

Percent Recovery vs Jnr

PG 58H-34
PG 58-34
AASHTO Recovery Curve
### FHR Production Samples 2013 - 2017

<table>
<thead>
<tr>
<th>Grade</th>
<th>High Performance Grade</th>
<th>% Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average</td>
<td>Lowest</td>
</tr>
<tr>
<td>PG 58-34</td>
<td>61.8</td>
<td>58.9</td>
</tr>
<tr>
<td>PG 58H-34</td>
<td>63.3</td>
<td>59.9</td>
</tr>
<tr>
<td>PG 64-34</td>
<td>66.6</td>
<td>64.4</td>
</tr>
<tr>
<td>PG 58V-34</td>
<td>67.3</td>
<td>64.0</td>
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<tr>
<td>PG 64-28</td>
<td>67.2</td>
<td>65.2</td>
</tr>
<tr>
<td>PG 58H-28</td>
<td>67.6</td>
<td>65.3</td>
</tr>
</tbody>
</table>

Red values plot below AASHTO Recovery Curve
Questions?

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"Dedicated to Quality Asphalt Paving Through Engineering, Research, and Education"

NDSU

UPPER GREAT PLAINS TRANSPORTATION INSTITUTE
NORTH DAKOTA LOCAL TECHNICAL ASSISTANCE PROGRAM

NDDOT

North Dakota Department of Transportation

U.S. Department of Transportation
Federal Highway Administration

North Dakota