Binder Grade Selection Using the MSCR Specification

John A. D’Angelo Ph.D. P.E.
8528 Canterbury Drive
Annandale, Virginia 22003
571-218-9733
johndangelo@dangeloconsultingllc.com
Modified Binders Affect Performance

- Study same mix different binders.

PG 63-22 mod. no rutting
PG 67-22 unmod. 15mm rutting
Test using the DSR applying a 1 sec creep stress followed by 9 sec recovery.
Multi Stress Creep and Recovery

- Sample prep is exactly the same as the existing RTFOT DSR.
Typical Plot of Creep and Recovery data
Determination of $J_{nr}$

$J_{nr} = \frac{\gamma_u}{\tau}$

- $\gamma_u$ = Avg. un-recovered strain mm/mm
- $\tau$ = applied stress during creep kPa
- $J_{nr}$ = non-recoverable compliance
What is % Recovered Strain

\( \gamma_p = \text{Peak strain} \)

\( \gamma_r = \text{recovered strain} \)

\( \%\text{ recovery} = \left( \frac{\gamma_r}{\gamma_p} \right) \times 100 \)

\( \gamma_u = \text{un-recovered strain} \)
Standard Method of Test for

Multiple Stress Creep Recovery (MSCR) Test of Asphalt Binder Using a Dynamic Shear Rheometer (DSR)

AASHTO Designation: TP 70-08
MSCR and Rutting

- Any new specification must be blind to modification.
- A new specification must identify the rutting potential of all binder types under multiple conditions.
Miss I55 6yr rut Jnr 3.2 kPa

\[
y = 0.2907x + 0.1297
\]

\[R^2 = 0.7499\]
Hamburg Rut testing  MINN Road mixes

![Graph showing rutting behavior of different asphalt mixes](image)

- **PG 58-28**
- **PG 58-34**
- **PG 58-40**

Equation of the line:

\[ y = 0.3976x - 0.2894 \]

Coefficient of determination:

\[ R^2 = 0.9646 \]
NUSTAR STUDY PG 64-22S, 64-22H, 64-22V BINDERS TESTED IN HAMBURG DRY AT ~ 64°C, 158# LOAD, E-10 FINE LIMESTONE BLEND

![Graph showing RUT depth in mm vs RUT passes at ~64°C & 158 LBS (703 N)]
New high Temp Spec

- PG 64 (Standard, Heavy, Very heavy) based on traffic.
  - PG 64S-XX $J_{nr} \leq 4.0$
  - PG 64H-XX $J_{nr} \leq 2.0$
  - PG 64V-XX $J_{nr} \leq 1.0$

  - Special Cases: Port Facilities, Quarry Entrances, etc. a PG 64E-XX $J_{nr} \leq 0.5$ can be considered.
Existing PG 76-22 4% SBS tested @ 4 temperatures 82, 76, 70 & 64
Compliance values increase with temperature and stress. The rate of increase with stress increases with increased temperature.
New MSCR Binder Spec
AASHTO M320 Table 3

<table>
<thead>
<tr>
<th></th>
<th>Original</th>
<th>RTFOT</th>
<th>PAV</th>
<th></th>
<th></th>
<th></th>
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<tbody>
<tr>
<td>DSR G*/sin δ</td>
<td>Min 1.0</td>
<td></td>
<td></td>
<td>64</td>
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<td>64</td>
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<td>RTFOT</td>
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<td>64 Standard</td>
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<td>MSCR3.2 &lt;4.0</td>
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<tr>
<td>64 Heavy</td>
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<td>64 Very heavy</td>
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<tr>
<td>MSCR3.2 &lt;1.0</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S grade</td>
<td>28</td>
<td>25</td>
<td>22</td>
<td>19</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>DSR G*/sin  δ</td>
<td>Max 5000</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>28</td>
<td>25</td>
<td>22</td>
<td>19</td>
<td>16</td>
<td></td>
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<tr>
<td>H &amp; V grade</td>
<td>28</td>
<td>25</td>
<td>22</td>
<td>19</td>
<td>16</td>
<td></td>
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<tr>
<td>DSR G*/sin  δ</td>
<td>Max 6000</td>
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</tbody>
</table>

Low temp BBR and DTT remain unchanged
Incompatible 67-22 base binder mixed with 4% linear SBS elemental sulfur as a cross linker.

<table>
<thead>
<tr>
<th>Blending Time, hours</th>
<th>2 h</th>
<th>4 h</th>
<th>6 h</th>
<th>6 h + x-linking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blending Temperature, °C</td>
<td>188</td>
<td>200</td>
<td>188</td>
<td>200</td>
</tr>
<tr>
<td>M320 High Temp DSR</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>UDOT' Elastic Recovery</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>MSCR Test</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>UV Microscopy</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
Changes in UDOT Elastic Recovery with Processing

AASHTO T301-mod
RTFO, 25°C, 20 cm pull and then cut

UDOT Elastic Recovery, %

60.0  65.0  70.0  75.0  80.0  85.0  90.0  95.0

188-2h  200-2h  188-4h  200-4h  188-6h  200-6h  188-6h+X  200-6h+X
Changes in % Recovery MSCR test with Processing

Recommended Min % Recovery PGXX V

Recommended Min % Recovery PGXX H
Fluorescence Micro-graphs at 250 magnification

- **Discrete polymer particles**
  - 188 2h

- **Polymer strands developing**
  - 188 4h

- **Polymer strands developing**
  - 200 2h

- **More uniform dispersion almost cross-linked**
  - 200 4h
Fluorescence Micro-graphs at 250 magnification

- Polymer strands developing
- More uniform dispersion almost cross-linked
- More uniform dispersion almost cross-linked
- Uniform dispersion cross-linked

188 6h + x-link
200 6h + x-link
## Table for MSCR % Recovery minimum values

<table>
<thead>
<tr>
<th>J\textsubscript{nr} @ 3.2 kPa</th>
<th>Minimum % Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0 - 1.01</td>
<td>30%</td>
</tr>
<tr>
<td>1.0 - 0.51</td>
<td>35%</td>
</tr>
<tr>
<td>0.50 - 0.251</td>
<td>45%</td>
</tr>
<tr>
<td>0.25 - 0.125</td>
<td>50%</td>
</tr>
</tbody>
</table>
Conclusions and Recommendations

- Mixing Temperature and X-linking effect the properties of polymer modified binders.
- The Elastic Recovery showed little difference between the different processing methods.
- Both SHRP $G^*/\sin \delta$ and MSCR indicated the differences between the different processing methods, but results are different for each.
- The MSCR both $J_{nr}$ and MSCR % Recovery indicated larger differences than the SHRP and ER tests.
- The Larger differences were verified by the Florencence Microscopy.
Implications

- MSCR test is more discriminating and a fundamental property test
- New practice for SBS blend optimization?
  - For research
  - For spec.
Implementation

- MSCR can replace the ER
  - Single protocol
  - Quick and easy
  - Fundamental property
New MSCR Specification

- New MP 19 accepted by AASHTO published Spring 2009.
Grade selection and Grade Bumping
With MP 19

- High Temperature Binder Grade Selected Based on Pavement High Temperature Grade LTPPBindv 3
- Without temperature bumping how is the binder grade adjusted for traffic?
- Can the existing LTPPBind software still be used for grade bumping?
LTPPBind v3 98% Reliability
High Temperature Grades
The MSCR gradings reflect the current grade bumping limits.

<table>
<thead>
<tr>
<th></th>
<th>Grade</th>
<th>Traffic Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>S</td>
<td>traffic &lt; 3 million ESAL’s</td>
</tr>
<tr>
<td>Heavy</td>
<td>H</td>
<td>traffic &gt; 3 million ESAL’s</td>
</tr>
<tr>
<td>Very Heavy</td>
<td>V</td>
<td>traffic &gt; 10 million ESAL’s</td>
</tr>
<tr>
<td>Extreme</td>
<td>E</td>
<td>traffic &gt; 30 million ESAL’s</td>
</tr>
</tbody>
</table>
LTPPBind 3.1 can still be used for binder selection.

The unadjusted grade is the New S grade. PG 58S
LTPPBind 3.1 can still be used for binder selection. As the temperature is adjusted for speed or traffic instead of bumping with temp bump to H, V, or E. In this case PG58H
LTPPBind 3.1 can still be used for binder selection.

As the temperature is adjusted for speed or traffic instead of bumping with temp bump to H, V, or E. In this case PG58V
LTPPBind 3.1 can still be used for binder selection.

As the temperature is adjusted for speed or traffic instead of bumping with temp bump to H, V, or E. In this case PG58E.
MSCR specification

- The binders properties may shift slightly.
- There will not be increase in the number of grades.
- We will see a shift in where materials are placed.
- We will have better control of what goes into the binder.
- There should be a more economical use of materials.
Thank You