Session W23 - Introduction to Modified Asphalt Binders (Part 2)
Visit our website…

http://www.modifiedasphalt.org

- Contact AMAP directly by:
  - Phone: (314) 843-2627
  - E-mail: amap@sbcglobal.net
Presenters:

- **Bob Kluttz**  
  Kraton Polymers  
  (281) 676-2426  
  Bob.Kluttz@kraton.com

- **Laurand Lewandowski**  
  Owens Corning  
  (740) 321-7663  
  Laurand.Lewandowski@owenscorning.com

- **Ron Corun**  
  Axeon Specialty Products  
  (410) 952-4020  
  Ronald.Corun@axeonsp.com
## Contributors:

<table>
<thead>
<tr>
<th>Name</th>
<th>Phone Number</th>
<th>Email Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gaylon Baumgardner</td>
<td>(601) 933-3217</td>
<td><a href="mailto:Gaylon.Baumgardner@ptsilab.com">Gaylon.Baumgardner@ptsilab.com</a></td>
</tr>
<tr>
<td>Paragon Technical Services</td>
<td></td>
<td></td>
</tr>
<tr>
<td>John Casola</td>
<td>(973) 740-1534</td>
<td><a href="mailto:John.Casola@malvern.com">John.Casola@malvern.com</a></td>
</tr>
<tr>
<td>Malvern Instruments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ron Corun</td>
<td>(410) 952-4020</td>
<td><a href="mailto:Ronald.Corun@nustarenergy.com">Ronald.Corun@nustarenergy.com</a></td>
</tr>
<tr>
<td>NuStar Energy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bob Kluttz</td>
<td>(281) 676-2426</td>
<td><a href="mailto:Bob.Kluttz@kraton.com">Bob.Kluttz@kraton.com</a></td>
</tr>
<tr>
<td>Kraton Polymers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laurand Lewandowski</td>
<td>(740) 321-7663</td>
<td><a href="mailto:Laurand.Lewandowski@owenscorning.com">Laurand.Lewandowski@owenscorning.com</a></td>
</tr>
<tr>
<td>Owens Corning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chris Lubbers</td>
<td>(936) 524-9262</td>
<td><a href="mailto:Chris.Lubbers@kraton.com">Chris.Lubbers@kraton.com</a></td>
</tr>
<tr>
<td>Kraton Polymers</td>
<td></td>
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Modified Asphalt Binders

The Basics covered include:

✓ PART 1
  ✓ Reasons for Modification
  ✓ Types of Modification
  ✓ Chemistry
  ✓ Polymer modification
  ✓ Modified Emulsions

✓ Part 2 (Session T23)
  ✓ Handling
  ✓ Lay down
  ✓ Field Experience
  ✓ Testing to AASHTO M320
  ✓ Testing for Modified Asphalt
Outline – Part 1 (Session T13)

• Section 1 - Introduction to Asphalt Modification
  ▪ Reasons for Modification
  ▪ Distresses in Asphalt Pavements
  ▪ Types of Modification
  ▪ Use of Modified Asphalt
  ▪ Chemistry of Asphalt Cements
  ▪ Chemistry/Macrostructure of Modified Asphalt Cements
  ▪ Compatibility (Microscopy)
Outline – Part 1 (Session T13)

• Section 2 – Introduction to Polymer Modification
  ▪ What are Polymers?
  ▪ Types of Polymers
  ▪ Compatibility of Polymers with Asphalt
  ▪ Effects of Polymers
  ▪ Analysis of polymers
  ▪ Recovery of PMA

• Section 3 - Emulsions of Modified Asphalt
  ▪ Asphalt emulsion formulation
  ▪ Modification of asphalt emulsions
  ▪ Impact on performance and performance parameters
Outline – Part 2

• Section 4 - Handling of Modified Asphalts
  ▪ Recommended Plant Operations
  ▪ Handling of Asphalt Binder at the Terminal
  ▪ Handling of Asphalt Binder at the HMA Plant
  ▪ Laydown of Modified Asphalt Mix
  ▪ Contractor Liquid Asphalt QC Plan

• Section 5 - Performance of Modified Asphalt Mixtures
  ▪ Life Cycle Cost Analysis
  ▪ Field Studies
Outline – Part 2

- Section 6 – Specifications and Testing
  - Pre-Superpave
  - Superpave
  - PG Specifications AASHTO M320
  - PG Testing Equipment
  - PG Plus Tests
  - MSCR Test
Section 4 - Handling Modified Binders (Contractor’s View)

Presented By:
Ron Corun

Prepared for the Association of Modified Asphalt Producers Training Program
Section 4 - Outline

• Section 4 - Handling of Modified Asphalts
  ▪ Handling of Asphalt Binder at the Terminal
  ▪ Handling of Asphalt Binder at the Hot Mix Asphalt Plant
  ▪ Recommended Plant Operations
  ▪ Laydown of Modified Asphalt Mix
  ▪ Contractor Liquid Asphalt QC Plan
Handling Modified Asphalts
Handling Modified Asphalts

- Between 5-20% of all asphalts are currently modified
- Most modified binders are in the PG 64-28 to 76-22 range
- Be safe and follow manufacturer’s recommendations
Handling Modified Asphalts

- Mixing PMA with other asphalts can cause the asphalt to fail to meet the PG grade requirements
- Reduce contamination at the terminal
  - Tanker truck empty before loading at terminal
  - Load from correct loading arm at terminal
Residue as % of Load

Inches of Residue

Percentage of Total Load

- 0.00%
- 2.00%
- 4.00%
- 6.00%
- 8.00%
- 10.00%

1 2 3 4 5 6
Handling PMA at the Plant

• Reduce contamination at the HMA plant
  ▪ Pump into correct tank at HMA plant
  ▪ Use dedicated tanks, if possible
  ▪ If dedicated tank is not available
    • Empty tank as much as possible if previous material was different
    • Add 2 or 3 full loads of PMA before testing and/or using the material in the tank

• Diluted PMA may fail PG grade!!!
Handling PMA at the Plant

• Vertical tanks
  ▪ Vertical tanks provide more efficient agitation
  ▪ Very few PMAs requires agitation to prevent separation
  ▪ Agitation is recommended for GTR modified asphalt
  ▪ Check with supplier

• Check and maintain proper temperatures
Handling PMA at the Plant

- Horizontal Tanks
  - Horizontal tanks work fine for most PMAs
  - Circulate to achieve uniform temperatures above and below heating coils
Proper Circulation in Horizontal Tanks

- Suction and return lines at opposite ends of tank to completely circulate material
- Return line near bottom of tank to prevent oxidation
Handling PMA at the Plant

- **BEWARE OF MIXING MODIFIED ASPHALTS FROM DIFFERENT SUPPLIERS!!!**
  - Different suppliers may use different polymer technologies
  - Differing technologies may not be compatible
  - Polymer separation may occur
Handling PMA at the Plant

• BEWARE OF USING DIRECT-FIRE HEATERS WITH MODIFIED ASPHALTS!!!
  - Direct-fire heat tubes may develop hot spots
  - Hot spots will immediately destroy the polymer network in the asphalt
Effect of Mixing Time and Temperature

Fluorescence micrographs showing the effect of time and temperature on the compatibility of a 10% SBS/10% Aromatic Oil/80% asphalt binder
(D) 430 °F 1 hour
(E) 430 °F 4 hours
(F) 430 °F 7 hours

Ref: B Brule, Y Brion and A. Tanguy, Asphalt Paving Technology 60, 43 (1991)
EC-101 Recommendations

![EC-101 Recommendations Diagram]

- **Grade**
  - Min EC101
  - Max EC101
  - Midpoint EC101

- **Mix Temperature**
  - 200
  - 220
  - 240
  - 260
  - 280
  - 300
  - 320
  - 340
## General Guidelines for Storage and Mixing Temperatures

<table>
<thead>
<tr>
<th>PG Binder</th>
<th>Storage Temperature (°F)</th>
<th>Mixing Temperature (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>64-22</td>
<td>285-315</td>
<td>265-320</td>
</tr>
<tr>
<td>70-22</td>
<td>300-325</td>
<td>280-330</td>
</tr>
<tr>
<td>76-22</td>
<td>315-340</td>
<td>285-335</td>
</tr>
<tr>
<td>Extended Storage</td>
<td>&lt;275 °F</td>
<td></td>
</tr>
</tbody>
</table>

Source: EC-101
Effect of Time and Temperature on Asphalt Properties

Long Term Storage of Modified Binders

- If storing PMA for longer than 60 days, turn heat down or off
- Lower temperatures minimize danger of damaging the PMA
Long Term Storage of Modified Binders

- Re-heating PMA binders
  - Bring temperature up slowly
  - If material has been held over the winter, heat incrementally 20 degrees increase at a time
  - Allow 3 or 4 days to get material up to circulation temperature
- As a precaution, you may want to test before using after winter shutdown
Mixing and Compaction Temperature Guidance

- Asphalt Institute developed procedure in 1970’s for determining laboratory mixing and compaction temperatures (MS-2)

- Equiviscous laboratory mixing and compaction temperatures
  - Viscosity at 135°C and 165°C
  - Lab mixing range of 150-190 centistokes
  - Lab compaction range of 250-310 centistokes

- **NOT FOR FIELD TEMPERATURES!!!**
Mixing and Compaction Temperature Guidance

• Superpave adopted AI procedure using rotational viscometer
• Equiviscous laboratory mixing and compaction temperatures
• Does not work for PMA
  ▪ Yields extremely high temperatures
  ▪ Use suppliers’ recommendations

• **Not For Field Temperatures for Unmodified or Modified Asphalts!!!**
# Field Mixing and Compaction Temperature Guidance

## Typical Asphalt Binder Temperatures

<table>
<thead>
<tr>
<th>Binder Grade</th>
<th>HMA Plant Asphalt Tank</th>
<th>HMA Plant Mixing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Storage Temperature (°F)</td>
<td>Temperature (°F)</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>Midpoint</td>
</tr>
<tr>
<td>PG 46-28</td>
<td>260 – 290</td>
<td>275</td>
</tr>
<tr>
<td>PG 46-34</td>
<td>260 – 290</td>
<td>275</td>
</tr>
<tr>
<td>PG 46-40</td>
<td>260 – 290</td>
<td>275</td>
</tr>
<tr>
<td>PG 52-28</td>
<td>260 – 295</td>
<td>278</td>
</tr>
<tr>
<td>PG 52-34</td>
<td>260 – 295</td>
<td>278</td>
</tr>
<tr>
<td>PG 52-40</td>
<td>260 – 295</td>
<td>278</td>
</tr>
<tr>
<td>PG 52-46</td>
<td>260 – 295</td>
<td>278</td>
</tr>
<tr>
<td>PG 58-34</td>
<td>280 – 305</td>
<td>292</td>
</tr>
<tr>
<td>PG 64-22</td>
<td>285 – 315</td>
<td>300</td>
</tr>
<tr>
<td>PG 64-28</td>
<td>285 – 315</td>
<td>300</td>
</tr>
<tr>
<td>PG 64-34</td>
<td>285 – 315</td>
<td>300</td>
</tr>
<tr>
<td>PG 67-22</td>
<td>295 – 320</td>
<td>308</td>
</tr>
<tr>
<td>PG 70-22</td>
<td>300 – 325</td>
<td>312</td>
</tr>
<tr>
<td>PG 70-28</td>
<td>295 – 320</td>
<td>308</td>
</tr>
<tr>
<td>PG 76-22</td>
<td>315 – 330</td>
<td>322</td>
</tr>
<tr>
<td>PG 76-28</td>
<td>310 – 325</td>
<td>318</td>
</tr>
<tr>
<td>PG 80-22</td>
<td>315 – 335</td>
<td>325</td>
</tr>
</tbody>
</table>

Use mid-point temperature for test strip construction.

**Asphalt Pavement Environmental Council (APEC)**

APEC is comprised of the following organizations: National Asphalt Pavement Association, Asphalt Institute, State Asphalt Pavement Associations.
HMA Plant Asphalt Pump

- Adequately sized AC pump
  - PMA will cause higher amperage draw
- AC pump in good condition
- Calibrated
- Strainer
  - Larger than standard holes – $\frac{1}{4}”$
  - Clean
HMA Plant Asphalt Pump Operation

- Circulate unmodified asphalt first before start-up
- Switch to PMA and circulate before start-up
- Switch to unmodified asphalt and circulate through pump after shutdown at end of shift
- Unmodified asphalt in AC pump, meter and strainer until next shift
HMA Plant Slat Conveyor

- Properly sized
- Good condition
- PMA will increase amperage draw on conveyor
  - Start at reduced tonnage rate
  - Start on unmodified mix to heat conveyor
Modified HMA Storage

• **DO NOT STORE OVERNIGHT!!!**
Transporting Modified HMA to Paver

- Clean, smooth truck beds
- Release agent
  - Type
  - Amount
  - Powdered Tide detergent
- Tarps

<table>
<thead>
<tr>
<th>Type</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powdered Tide</td>
<td>detergent</td>
</tr>
</tbody>
</table>
Placing Modified HMA

- No modifications to equipment
- Handwork is more difficult
- Attention to detail
- Weather Conditions – 50 °F minimum
Compacting Modified HMA

- Compaction Equipment
  - Number - 3 or 4
  - Type – high frequency
  - Size

- Mix temperature
  - Only high enough to allow proper compaction
  - Extra 10 °F doubles fumes
  - High temperatures can damage PMA

- Roller pattern
  - Front roller close to paver

- Field monitoring
  - Temp
  - Density
Compacting Modified HMA

• Compacting mixes with PMA may actually be easier than un-modified asphalt mixes
  ▪ Compaction requires confinement
  ▪ PMA may eliminate tender zone
Contractor QC Plan

- Contractors need to establish QC plan to prevent PG asphalt contamination and failing test results
  - Identify all hardware – label or number
    - Tanks
    - Pumps
    - Piping
    - Valves
    - Sample points
    - Heat system
  - Establish standard procedures and hardware settings for asphalt flow into storage and into HMA plant
Summary

• PMA improves the performance of HMA pavements
• Understand the product you are using and treat it with respect
  ▪ Follow suppliers recommendations
  ▪ Best Practices
Section 5 – Performance of Modified Binders

Presented By:
Laurand Lewandowski

Prepared for the Association of Modified Asphalt Producers Training Program
Section 5 - Outline

- Section 5 - Performance of Modified Asphalt Mixtures
  - Life Cycle Cost Analysis
  - Field Studies
Life Cycle Cost Analysis Studies
Design Life Stages of US Highways*

- Stage 1: Design - Formal planning of roadway to meet performance criteria
- Stage 2: Construction - Building of roadway (start with perfect pavement condition)
- Stage 3: Slow deterioration – Pavement weakens as result of traffic and climate
- Stage 4: Critical Structure Deterioration
- Stage 5: Total Destruction

*“At the Crossroads preserving our Highway Investment”
Life-Cycle Cost Analysis

PMA Pavement Performance

• Polymers have been used in asphalt pavements for over thirty years

• How have these pavements performed?

• Pavement field studies
  — Texas, Alabama and Utah
  — Asphalt Institute/AMAP Study
TXDOT Rating System

- The Condition Score and Distress Score are based on 0-100 scale.

- From our analysis the Distress and Condition Scores were found to be equal.

- A Score of 50 indicates the pavement requires some type of remedial attention.
LCCA - Texas*

Unmodified Asphalt Pavement (Atlanta District)

SBR Modified Pavement (Tyler District)

Poly. (Unmodified Asphalt Pavement (Atlanta District))

Poly. (SBR Modified Pavement (Tyler District))

*Ultrapave Study 1997-1998
AL DOT - PMIS

- Distress and Ride data are collected on a biannual basis.
- Information on cracking, rutting, patching, bleeding, etc. is gathered for the first 200 feet of each lane mile.
- The data is put into a statistical model to produce a rating from 0 to 95.
- AL DOT designs their pavements to last 28 years (12 years initially and then two 8 year overlays)
AL DOT Rating System

- 100  Perfect pavement
- 95   New pavement
- 76   Routine maintenance needed
- 57   Resurfacing needed
- 38   Major structural work needed
- 0    Totally unsuitable pavement
LCCA - Alabama*

*Ultrapave Study 1997-1998
Utah DOT Polymer Modified Asphalt Study

- UDOT has been using polymers since the late 1960s.
- In the past, UDOT has used low-temp ductilities, Toughness and Tenacity and Pen-Vis to flatten out the temperature susceptibility curve.
- Through field validation, determine the benefits of PMA.
- Examined 33 projects using AC-10, AC-20 and AC-20R along I-70.
Summary

• “The AC-20R asphalt concrete pavement sections constructed in 1989 are performing with virtually no thermal cracking.”*

• “Comparing the PMA to the conventional asphalt indicates a 76% reduction in incremental rating loss per year.”*

• “This justifies the use of polymerized asphalt for mitigating thermal cracking.”*

* Cameron Peterson, Interstate 70-Polymerized Asphalt Pavement Evaluation, Utah Department of Transportation, Materials Division, 1996.
Asphalt Institute PMA Performance Study

• Titled “PMA for Enhancing HMA Performance”
• Two objectives:
  – Quantify the effect of using PMA as compared to conventional mixtures in terms of increasing pavement life and reducing the occurrence of surface distress.
  – Identify the conditions or site features (for example, traffic levels, layer thickness, climate, etc..) that maximize the effect of PMA on performance
Modified versus Unmodified Performance

Polymer Modified HMA shows a substantially lower Rut Depth and less % Fatigue Cracking

*Harold von Quintus, “Polymer-Modified Asphalts- Enhancing HMA Performance,” AMAP Annual Meeting, February 10, 2004
Expected Service Life Increase for a 20-year Design*

*Harold von Quintus, “Polymer-Modified Asphalts- Enhancing HMA Performance,” AMAP Annual Meeting, February 10, 2004
## Expected Service Life Increase*

<table>
<thead>
<tr>
<th>Site Factor</th>
<th>Condition Description</th>
<th>Years</th>
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<tbody>
<tr>
<td><strong>Existing Pavement Condition</strong></td>
<td><strong>HMA</strong></td>
<td></td>
</tr>
<tr>
<td>Good Condition</td>
<td>Good Condition</td>
<td>5-10</td>
</tr>
<tr>
<td>Good Condition; Extensive cracking (1)</td>
<td></td>
<td>1-3</td>
</tr>
<tr>
<td><strong>PCC/ JPCP</strong></td>
<td>Good Condition</td>
<td>3-6</td>
</tr>
<tr>
<td>Poor Condition; Faulting &amp; mid-panel cracking (1)</td>
<td></td>
<td>0-2</td>
</tr>
</tbody>
</table>

(1) Without the use of any reflection cracking mitigation techniques

*Harold von Quintus, “Polymer-Modified Asphalts- Enhancing HMA Performance,” AMAP Annual Meeting, February 10, 2004*
Section 6 – Superpave Asphalt Binder Testing (Unmodified and Modified)

Presented By: Bob Kluttz

Prepared for the Association of Modified Asphalt Producers Training Program
Section 6 – Outline

• Specifications and Testing of Modified Asphalt Binders
  ▪ Pre-Superpave
  ▪ Superpave
  ▪ PG Specification AASHTO M320
  ▪ PG Testing Equipment
  ▪ PG Plus Tests
  ▪ MSCR Test
Pre-Superpave Shortcomings

- Viscosity Grading
  - Viscous effects only
- Penetration Grading
  - Empirical measure of viscous & elastic effects
- No low-temperature properties measured
- No consideration of long term aging
- Problems with modified asphalt characterization
- Specification proliferation
Pre-Superpave Asphalt Testing

Penetration

Viscosity

25°C

0 sec penetration

100 g

5 sec

100 g

Vacuum

Capillary Tube cs

60°C

100 A9
Consistency (pen or vis)

- Asphalts
  - A = C Pen Grade
  - B = C Visc Grad

Pre-Superpave Testing

Temperature, °C

-15  25  60  135

pen

viscosity

hard

soft

A  B  C
Performance

Rutting
Fatigue Cracking
Low-Temp Cracking
Superpave Binder Specification
AASHTO M320

- Framework was developed as part of the Strategic Highway Research Program (SHRP). Initially released as AASHTO MP1

- Performance-based specification for the purchase of asphalt binders used in hot-mix asphalt.

- Measure of the rheological properties of the binders over a wide range of temperatures, loading, and aging conditions.
Superpave Binder Specification

- Pavements see many temperatures and loads.
Superpave M320 Assumptions

- Rutting, Pushing, and Shoving Failures Occur in New Pavements

- Fatigue & Thermal Cracking Failures are the result of Old Pavements that become Brittle
Binder Grade is a function of environment and traffic level
Superpave Asphalt Binder Specification

- Grading System Based on Climate

**PG 64-22**

- Performance Grade
- Average 7-day max pavement design temp
- Min pavement design temp
Binder Equipment
Used to characterize material physical properties

Rotational Viscometer

Dynamic Shear

Direct Tension

Bending Beam
Superpave Binder Equipment

Asphalt Binder Aging:

- **Rolling Thin-Film Oven (RTFO)**
  - Short term aging
  - Simulates plant mixing and laydown

- **Pressure Aging Vessel (PAV)**
  - Long term aging
  - Simulates 5-7 years in use
Superpave Binder Equipment

Construction

Rutting

Fatigue Cracking

Low Temp Cracking

Pavement Age

No aging

RTFO - aging

PAV - aging

[RV]

[DSR]

[BBR]
DSR

Upper plate (oscillating)

Lower plate (fixed)

Report Values of $G^*$ & $\sin\delta$

Stress (normalized applied torque)

Strain (normalized measured deformation)

$\delta = $ phase angle

Applied Stress

Measured Strain
# M320 Binder Specification

<table>
<thead>
<tr>
<th>Performance Grade</th>
<th>PG 52</th>
<th>PG 58</th>
</tr>
</thead>
<tbody>
<tr>
<td>-10</td>
<td>-16</td>
<td>-16</td>
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<tr>
<td>-16</td>
<td>-22</td>
<td>-22</td>
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<tr>
<td>-22</td>
<td>-28</td>
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<tr>
<td>-40</td>
<td>-46</td>
<td>-46</td>
</tr>
<tr>
<td>-46</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Average 7-day Maximum Pavement Design Temp, C:**
- PG 52: <52
- PG 58: <58

**Minimum Pavement Design Temperature, C:**
- PG 52: >-10 >-16 >-22 >-28 >-34 >-40 >-46
- PG 58: >-16 >-22 >-28

**Original Binder:**
- Flash Point Temp, T48: Minimum, C: 230
- Viscosity, ASTM D 4402:
  - Maximum, 3 Pa-s (3000 cP)
  - Test Temp, C: 135
- Dynamic Shear, TP5:
  - G*/sinδ, Minimum, 1.00 kPa
  - Test Temp @ 10 rad/sec, C: 52

**Spec Requirement Remains Constant**

**Test Temperature Changes**
### M320 Binder Specification

<table>
<thead>
<tr>
<th>Performance Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</table>

- **Average 7-day Maximum Pavement Design Temperature, C**
- **Minimum Pavement Design Temperature, C**

- **Flash Point Temp, T48: minimum C**
- **Viscosity, ASTM D 4402:**
  - Maximum, 3 Pa-s (3000 cP),
  - Test Temp, C

- **Dynamic Shear, TP5:**
  - \( \frac{G^*}{\sin \delta} \), Minimum, 1.00 kPa
  - Test Temp @ 10 rad/s, C

- **Mass Loss, Maximum, %**
- **Dynamic Shear, TP5:**
  - \( \frac{G^*}{\sin \delta} \), Minimum, 2.20 kPa
  - Test Temp @ 10 rad/sec, C

---

**Spec Requirements to Control Rutting**
# M320 Binder Specification

<table>
<thead>
<tr>
<th>Specification Requirement to Control Fatigue Cracking</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PAV Aging Temp, C</strong></td>
</tr>
<tr>
<td><strong>Dynamic Shear, TP5:</strong></td>
</tr>
<tr>
<td>( G \times \sin \theta ), Maximum, 5000 kPa</td>
</tr>
<tr>
<td>Test Temp @ 10 rad/sec, C</td>
</tr>
<tr>
<td><strong>Physical Hardening</strong></td>
</tr>
<tr>
<td><strong>Creep Stiffness, TP1:</strong></td>
</tr>
<tr>
<td>( S ), Maximum, 300 MPa</td>
</tr>
<tr>
<td>m-value, Minimum, 0.300</td>
</tr>
<tr>
<td>Test Temp, @ 60 sec, C</td>
</tr>
<tr>
<td><strong>Direct Tension, TP3:</strong></td>
</tr>
<tr>
<td>Failure Strain, Minimum, 1.0%</td>
</tr>
<tr>
<td>Test Temp @ 1.0 mm/min, C</td>
</tr>
</tbody>
</table>
Bending Beam Rheometer, BBR

Load P

Deflection

P = 100g

Time, s

0 240

deflection
## M320 Binder Specification

<table>
<thead>
<tr>
<th>Specification</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAV Aging Temp, C</td>
<td></td>
</tr>
<tr>
<td>Dynamic Shear, TP5:</td>
<td>( G\sin\delta ), Maximum, 5000 kPa</td>
</tr>
<tr>
<td>Test Temp @ 10 rad/sec, C</td>
<td></td>
</tr>
<tr>
<td>Creep Stiffness, TP1:</td>
<td>( S ), Maximum, 300 MPa</td>
</tr>
<tr>
<td>m-value, Minimum, 0.300</td>
<td>Test Temp @ 60 sec, C</td>
</tr>
<tr>
<td>Direct Tension, TP3:</td>
<td>Failure Strain, Minimum, 1.0%</td>
</tr>
<tr>
<td>Test Temp @ 1.0 mm/min, C</td>
<td></td>
</tr>
</tbody>
</table>

Specification requirements to control low temperature cracking
Asphalt Testing with Modification in Mind

- PG Tests - AASHTO M320
- PG Plus Tests
  - Stability
    - Toothpaste Tube test
  - Identifying polymer modification
    - IR
    - NMR
    - GPC
  - Empirical tests
  - Engineering based testing
- Multiple Stress Creep Recovery Test (MSCR)
Stability (Separation) Test

- Vertical tube held at elevated temperature for extended time.
- Tube cooled
- Cut into thirds
- Tested top vs. bottom (ring & ball softening point or viscosity)
IR Analysis of Polymer in Asphalt

Absorbance / Wavenumber (cm⁻¹)
File #1: G4692C21
ASPHALT 20

Figure 4
**PG Plus Superpave Binder Specification**

- Used to ensure Modification to a Binder
  - Example: PG 76-22 Plus Minimum Elastic Recovery of 70% using AASHTO T301

- **Empirical tests**
  - Amount of stretch
  - Amount of elastic recovery
  - Temperature to cause flow

- **Engineering tests**
  - Phase Angle DSR
  - Passing G* increased
  - Strain to failure
Empirical Tests

- Used to identify qualities of specific modified asphalt binders
- All have a non-uniform stress/strain relationship which make it impossible for true comparisons or understanding of engineering material properties
- Commonly used empirical tests
  - Forced Ductility
  - Elastic Recovery
  - Toughness & Tenacity
- Specification proliferation
  - Many different procedures, temperatures, and loading times used across the country
Forced Ductility

- Unmodified PG 64-22
- Same 64-22 With SB Modification
Elastic Recovery

Neat doesn’t recover

Modified recovers
Toughness & Tenacity
Toughness & Tenacity

Stress

Toughness

Tenacity

Elongation, cm
Typical Results for Modified: PG 76-22

- Forced Ductility Ratio
  - Break stress / Maximum stress
  - Specification 0.30-0.35 minimum

- Elastic Recovery
  - Pull 10cm, cut, measure recovery after X time
  - Specification 65-75% minimum

- Toughness & Tenacity
  - Normally specified for SBR
  - Toughness, 110 minimum
  - Tenacity, 75 minimum

Source: Don Siler Marathon Ashland
New High Temp Specification

- **MSCR** – Multiple Stress Creep and Recovery (AASHTO TP70)
  - Linear binder tests will not correlate with high temperature mixture failure tests unless the binder is a viscous fluid at those temps.
  - To accurately address mix failure, non-linear binder properties have to be evaluated.
  - Creep and recovery testing of the binder at different stress levels is needed to describe binder properties in the non-linear range.
Accumulated Strain from Repeated Loading
Unmodified Binder
Accumulated Strain from Repeated Loading Elastomer Modified Binder
Multiple Stress Creep and Recovery

- MSCR identifies beneficial elastic properties.

- Rutting Performance
  - Direct measure of Non-recoverable compliance, $J_{nr}$
  - Goal is to quantify non-linear performance of the binder to predict rutting performance.
  - AASHTO MP19 high temperature specification criterion.

- Elastic Recovery Performance
  - Direct measure of recoverable compliance.
  - Surrogate for AASHTO T301
  - Not directly performance related
Multiple Stress Creep and Recovery

• If MSCR is implemented – PG grades will change!!!

• Example – PG 64-22 climate
  - PG 64-22 will become PG 64-22S (Standard traffic)
  - PG 70-22 will become PG 64-22H (Heavy traffic)
  - PG 76-22 will become PG 64-22V (Very heavy traffic)
  - PG 82-22 will become PG 64-22E (Extreme traffic)
Questions?
Thanks for your Participation

Please complete the evaluation to provide your feedback on this session and suggest topics for future events.

Remember to mark these upcoming events on your calendar!

March 7-11, 2017
www.conexpoconagg.com
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