Europe’s Modified Asphalt Binder Experiences

Jean-Pascal Planche, et al

AMAP 12th Annual Meeting
Kansas City, MO

February 17, 2011
Acknowledgements

- Elf, Elf Asphalt Inc. and Total
  - R&D, Projects and Marketing teams, worldwide
- Partners: polymer suppliers, customers – road contractors
- Road administrations – US and Europe
  - LCPC, FHWA and others
- University contacts – US and Europe
  - Subcontractors from both asphalt and polymer worlds
- Competitors‘ challenges
  - No improvement when no competition…!
• **Transportation Background**
• European Market of PmB’s
• Modification Techniques
• Application / PmB’s usage in Europe
• Regulations
• Summary
• Perspectives
Transportation Background

The Challenge for Transportation stakeholders:

- **To maintain the flow** of people, goods and services allowing the US to remain economically competitive in a rapidly changing global marketplace

- **A difficult challenge** due to the combined concurrent factors:
  - Increasing (heavy) traffic
  - Shrinking resources – aggregates, asphalts, oil…
  - Unstable economics – crisis…
  - Aging infrastructures – particularly in developed countries

- **Source:** *summary of NAPA / AI / DOT statements*

- **A worldwide challenge** - by definition
• Transportation Background
• **European Market of PmB’s**
• Modification Techniques
• Application / PmB’s usage in Europe
• Regulations
• Summary
• Perspectives
Bitumen worldwide Production
~ 2.5% total refining Prod.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>WORLD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total oil demand ( M tons )</td>
<td>3 288</td>
<td>3 509</td>
<td>3 581</td>
<td>3 651</td>
<td>3 931</td>
<td>4 273</td>
</tr>
<tr>
<td>therefrom ( M tons )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bunker</td>
<td>128,3</td>
<td>137,1</td>
<td>138,2</td>
<td>139,2</td>
<td>142,4</td>
<td>147,8</td>
</tr>
<tr>
<td>Fuel oil</td>
<td>476,5</td>
<td>446,5</td>
<td>445,0</td>
<td>441,0</td>
<td>424,0</td>
<td>417,1</td>
</tr>
<tr>
<td>Pet coke</td>
<td>35,8</td>
<td>40,3</td>
<td>40,9</td>
<td>41,9</td>
<td>45,3</td>
<td>48,3</td>
</tr>
<tr>
<td>Lubes</td>
<td>32,0</td>
<td>33,4</td>
<td>33,6</td>
<td>34,1</td>
<td>36,1</td>
<td>38,3</td>
</tr>
<tr>
<td>Bitumen</td>
<td>86,5</td>
<td>91,8</td>
<td>93,0</td>
<td>94,0</td>
<td>98,5</td>
<td>104,3</td>
</tr>
<tr>
<td>therefrom ( % )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bunker</td>
<td>3,90%</td>
<td>3,91%</td>
<td>3,86%</td>
<td>3,81%</td>
<td>3,62%</td>
<td>3,46%</td>
</tr>
<tr>
<td>Fuel oil</td>
<td>14,49%</td>
<td>12,72%</td>
<td>12,43%</td>
<td>12,08%</td>
<td>10,79%</td>
<td>9,76%</td>
</tr>
<tr>
<td>Pet coke</td>
<td>1,09%</td>
<td>1,15%</td>
<td>1,14%</td>
<td>1,15%</td>
<td>1,15%</td>
<td>1,13%</td>
</tr>
<tr>
<td>Lubes</td>
<td>0,97%</td>
<td>0,95%</td>
<td>0,94%</td>
<td>0,93%</td>
<td>0,92%</td>
<td>0,90%</td>
</tr>
<tr>
<td>Bitumen</td>
<td>2,63%</td>
<td>2,62%</td>
<td>2,60%</td>
<td>2,57%</td>
<td>2,51%</td>
<td>2,44%</td>
</tr>
</tbody>
</table>
Bitumen worldwide markets

Bitumen demand by region

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BITUMEN DEMAND</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>29.3</td>
<td>31.3</td>
<td>31.5</td>
<td>31.6</td>
<td>32</td>
<td>33</td>
</tr>
<tr>
<td>canada</td>
<td>2.9</td>
<td>3.3</td>
<td>3.4</td>
<td>3.4</td>
<td>3.7</td>
<td>4</td>
</tr>
<tr>
<td>latin america</td>
<td>4.6</td>
<td>5</td>
<td>5.1</td>
<td>5.2</td>
<td>5.7</td>
<td>6.3</td>
</tr>
<tr>
<td>western europe</td>
<td>18.2</td>
<td>18.8</td>
<td>18.9</td>
<td>18.8</td>
<td>18.9</td>
<td>19.2</td>
</tr>
<tr>
<td>eastern europe</td>
<td>1.8</td>
<td>2.1</td>
<td>2.1</td>
<td>2.1</td>
<td>2.3</td>
<td>2.5</td>
</tr>
<tr>
<td>former USSR</td>
<td>6.2</td>
<td>5.4</td>
<td>5.4</td>
<td>5.5</td>
<td>5.6</td>
<td>5.7</td>
</tr>
<tr>
<td>africa</td>
<td>1.9</td>
<td>2</td>
<td>2</td>
<td>2.1</td>
<td>2.2</td>
<td>2.4</td>
</tr>
<tr>
<td>middle east</td>
<td>4.5</td>
<td>5.2</td>
<td>5.3</td>
<td>5.3</td>
<td>5.6</td>
<td>5.9</td>
</tr>
<tr>
<td>japan</td>
<td>5.9</td>
<td>6.1</td>
<td>6.1</td>
<td>6.1</td>
<td>6.2</td>
<td>6.3</td>
</tr>
<tr>
<td>east asia</td>
<td>6.5</td>
<td>6.9</td>
<td>7.2</td>
<td>7.5</td>
<td>8.7</td>
<td>9.8</td>
</tr>
<tr>
<td>south asia / pacific</td>
<td>4.7</td>
<td>5.9</td>
<td>6.1</td>
<td>6.4</td>
<td>7.7</td>
<td>9.3</td>
</tr>
<tr>
<td><strong>total bitumen</strong></td>
<td>86.5</td>
<td>91.8</td>
<td>93.0</td>
<td>94.0</td>
<td>98.5</td>
<td>104.3</td>
</tr>
</tbody>
</table>

Current data (source Eurobitume)
- 2009 European Bitumen consumption = 16.6 Mt - Production = 17.4 Mt
- **Breakdown**
  - Normal paving grades: 13.8 Mt with: Softer 11.0 Mt / Harder 2.8 Mt
  - Paving PmB: 1.5 Mt
  - Industrial grades: 1.2 Mt
## PmB Market data

<table>
<thead>
<tr>
<th>Countries / years / info sources</th>
<th>1999 PIARC* (Kt)</th>
<th>2008 Eurobitume (kt)</th>
<th>2009 Eurobit. (kt)</th>
<th>% MS vs. Bitumen</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>251</td>
<td>34** (#300)</td>
<td>33**(300)</td>
<td>8</td>
</tr>
<tr>
<td>Germany</td>
<td>250</td>
<td>479</td>
<td>718</td>
<td>29</td>
</tr>
<tr>
<td>Czech Republic</td>
<td></td>
<td>40</td>
<td>34</td>
<td>10</td>
</tr>
<tr>
<td>Italy</td>
<td>80</td>
<td>153</td>
<td>113</td>
<td>9</td>
</tr>
<tr>
<td>Spain</td>
<td></td>
<td>152</td>
<td>153</td>
<td>8</td>
</tr>
<tr>
<td>Switzerland</td>
<td>36</td>
<td>24</td>
<td></td>
<td>11</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>66</td>
<td>123</td>
<td>78</td>
<td>6 (8 in 09)</td>
</tr>
<tr>
<td>Austria, Belgium, Luxembourg, Portugal, Greece, Hungary, Slovakia, Slovenia, Poland, Romania, Netherlands</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Denmark, Estonia, Finland, Norway, Sweden</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iceland, Latvia, Lithuania, Europe</td>
<td>647</td>
<td>1192</td>
<td>1497</td>
<td>10 (7 in 09)</td>
</tr>
</tbody>
</table>

* After PIARC Symposium on PmB’s, in Rome, Italy - Report N°303, 07/1999
European Market Summary

- According to available data sources
  - Warning: careful with exact values – numbers difficult to obtain – high uncertainty, based on voluntary info basis
  - Disclaimer: no official analysis – this is my own!
- European market of PmB’s still growing
  - Despite economic crisis – but UK badly hit in 2009
  - Average close to 10% in 2009 – 7% in 2008
  - EU Champion is Germany, approaching 30% market share
    - PmB = no longer a specialty product in Germany
  - Very low usage in Nordic countries – low traffic / perf issues?
  - Central & Eastern Europe fast growing
  - Mature countries steady - FR, SP, IT, CH… close to 10%
  - The French / German market paradox – see next slide
Focus on German and French Markets

• **France:**
  - The **oldest** PmB market in Europe - Most mature
  - Techniques validation by LCPC and ad-hoc committees
  - Main producers are road contractors – few being oil companies
    - Specialty mixes with little PmB usage like high modulus mixes
  - No specs until recent EN14023
  - Used to use 20% plastomer vs. 80% elastomer

• **Germany:**
  - Fast growing PmB market
  - Role of ARBIT: study in late1990’s to validate PmB performances
  - Producers: Mainly oil companies and few road contractors
  - Best bids vs. low bids country – long term performances considered
• Transportation Background
• European Market of PmB’s
• **Modification Techniques**
• Application / PmB’s usage in Europe
• Regulations
• Summary
• Perspectives
• **Binder**
  - Various asphalt modification techniques to meet new market demands and specifications - Superpave in the US, EN in Europe
    - From polymers to additives and combinations
    - New specifications more performance based
    - From Superpave to Superpave +, and now “Advanced specs” incl. MSCRT

• **Hot mix**
  - SMA, Porous asphalt, High modulus mixes and other new special mix designs
  - Perpetual pavements
  - New specifications, pavement and mix design guides (MEPDG)

• **Application**
  - Warm Mix Asphalts: abundance of new techniques – about 30!
    - Chemical additives, foaming, waxes…
  - Recycled Asphalt Pavements, towards higher recycling rates
  - WMA+RAP: the “green-green” combination

• **Combinations of new binders / mixes / applications**
Why modify binders?

- More Severe Constraints
  - Traffic volume
  - Aggressive heavy traffic
  - Challenging applications

- More Economic constraints
  - Oil and aggregate shortage threats
  - Durable Investments – longer life pavements
  - Thinner and thinner layers

- New environmental issues
  - Emissions
  - Energy consumption
  - LCCA = durability is a major driving force, together with recycling

- -> Need for modified binders!
Why use polymer modified binders?

- Recognized performance
  - Lower sensitivity to temperature
  - Improved cohesion
  - Improved elongation capability
  - Improved mechanical, viscoelastic properties
    - within and without the linear range
  - Better passive adhesion – water stripping resistance
- An essential contributor to the development of innovative products
Polymer used in Europe

- Mainly Elastomers
  - Mainly SBS types, typically 30% styrene, tribloc linear and/or radial
  - Used in Physical asphalt blends
  - Used in cross-linked asphalt blends - dynamic vulcanization – Growing use
  - Occasionally latex
  - PmB+PPA marginally used for the time being yet.

- Less and less Plastomers
  - Mainly EVA – typically Mass flow index, 5 to 50 and VA content, 15 to 35% (by weight)
  - Occasionally EBA or PE
  - Terpolymers not much used yet in Europe

- Back in business: rubber for CRMB
  - In Spain mainly but possibly in Germany and elsewhere
Production of Polymer Modified Binder

- Polymer
- Bitumen
- Premixing
- High shear Mixer
- Storage of PMB
- Reagent
  - Dosage
• Processes: Physical Blend vs. Cross-linked blend

**GENERAL CASE = SBS physical blend**

**Cross-linked in situ = SB(S) physical blend + reagent**

• Process Parameters: time, temperature, agitation system – speed and shear.
• Looking for a finished product ready-to-use, stable during storage and application
The compatibility issue

- How to get an homogenous material?
  - Physical blend – as a function of polymer content, and base and SBS origins (constant here)
    - Polymer < 3 %
      - Asphalt continuous phase
    - Polymer ~ 5 %
      - Two co-continuous phases
    - Polymer > 7 %
      - Polymer phase matrix

- Cross-linked blend
Why use cross-linked modified binders? 1/2

- Intrinsic characteristics of cross-linked elastomer modified binders
  - Exceptional elongation characteristics
  - Cohesion
  - Low and High temperature performance

Valais test section CH: No crack after 19 y
Dreessen et al, TRB 2010

Before / after aging:
Homogeneous polymer content of the in situ crosslinked SBS

Mouillet et al, Orgagec '02
Lausanne University (LAVOC) : Cracking index of mixes made with 16 different binders

- In 2009: Cross-linked PmB still showing no crack after 19y in service under cold climatic conditions (Swiss Alps)
- Correlation with m-value, remaining of elastomer properties

AG Dumont et al, E&E 2004, Dreessen et Al, TRB 2010, ISAP 2010
Why use cross-linked modified binders? 2/2

- **Words taken from Eurovia, a major European road contractor**
- Homogeneous product Advantages
  - Storage stability: a key asset for any user
  - No extra storage costs (no need for stirring)
  - No problem when delayed works
- “Rheological simple”
  - Easy to control
  - Quality control on physical blends is often controversial due to poor test reproducibility – particularly when highly modified

Homogeneous products create less problems to the user
Outline

- Transportation Background
- European Market of PmB’s
- Modification Techniques
- Application / PmB’s usage in Europe
- Regulations
- Summary
- Perspectives
Application of polymer modified binders in Europe

- For binder demanding applications
- Hot mix applications
  - To ensure durability of surface characteristics, resistance to permanent deformation, thermal cracking and raveling
  - Thin to ultra thin wearing courses
  - Heavy duty paving mixes
  - Porous draining & noiseless asphalt courses
  - Stone mastic asphalt
- Special mixes
  - Anti-cracking sand mixes (reflective cracking resistant)
  - Fuel resistant mixes
  - Waterproofing applications
Applications of polymer modified binders in Europe

• Surface dressing applications

• Heavy duty surface dressings
  • To improve thermal susceptibility, elongation properties and cohesion, adhesion & durability
  • In case of high traffic, winding road to reduce failure risk
  • Fluxed binders PmB (HC or bio flux) and PmB Emulsions

• Micro-surfacings
  • To improve cohesion
  • PmB emulsions

• High performance tack-coats
  • Elongation properties, cohesion and adhesion
  • PmB emulsions
Outline

- Transportation Background
- European Market of PmB’s
- Modification Techniques
- Application / PmB’s usage in Europe
- Regulations
- Summary
- Perspectives
**EN14023**

**Based on:**
- Consistency:
  - Pen
  - R&B
  - **Cohesion**
    - FD, DTT, Vialit
  - Durability (RTFOT)
  - Flash Point
- Brittleness (Fraass)
- Strain recovery (ER)

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>PROPERTY</th>
<th>TEST METHOD</th>
<th>UNIT</th>
<th>SELECTED CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consistency at intermediate service temperature</td>
<td>Penetration at 25 °C</td>
<td>EN 1426</td>
<td>0,1 mm</td>
<td>45-80 (Class 4)</td>
</tr>
<tr>
<td>Consistency at elevated service temperature</td>
<td>Softening point</td>
<td>EN 1427</td>
<td>°C</td>
<td>≥ 60 (Class 6)</td>
</tr>
</tbody>
</table>

**Cohesion**
- Force ductility (50 mm/min traction) or
- Tensile test (100 mm/min traction) or
- Vialit pendulum (Impact test)

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>TEST METHOD</th>
<th>UNIT</th>
<th>SELECTED CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force ductility</td>
<td>EN 13589 followed by EN 13703</td>
<td>J/cm²</td>
<td>≥ 2 (Class 3)</td>
</tr>
<tr>
<td>Tensile test</td>
<td>EN 13587 followed by EN 13703</td>
<td>J/cm²</td>
<td>-</td>
</tr>
<tr>
<td>Vialit pendulum</td>
<td>EN 13588</td>
<td>J/cm²</td>
<td>-</td>
</tr>
</tbody>
</table>

**Durability (Resistance to hardening, EN 12607-1)**
- Change of mass
- Retained penetration
- Increase in softening point

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>TEST METHOD</th>
<th>UNIT</th>
<th>SELECTED CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change of mass</td>
<td>EN 12607-1</td>
<td>%</td>
<td>≤ 0,5 (Class 3)</td>
</tr>
<tr>
<td>Retained penetration</td>
<td>EN 1426</td>
<td>%</td>
<td>≥ 50 (Class 5)</td>
</tr>
<tr>
<td>Increase in softening point</td>
<td>EN 1427</td>
<td>°C</td>
<td>≤ 8 (Class 2)</td>
</tr>
</tbody>
</table>

**Brittleness at low service temperature**
- Fraass breaking point
- Elastic recovery at 10 °C

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>TEST METHOD</th>
<th>UNIT</th>
<th>SELECTED CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fraass breaking point</td>
<td>EN 12593</td>
<td>°C</td>
<td>≤ - 10 (Class 5)</td>
</tr>
<tr>
<td>Elastic recovery at 10 °C</td>
<td>EN 13398</td>
<td>%</td>
<td>NR (Class 0)</td>
</tr>
</tbody>
</table>

**Strain recovery**
- Elastic recovery at 25 °C
- Elastic recovery at 10 °C

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>TEST METHOD</th>
<th>UNIT</th>
<th>SELECTED CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elastic recovery at 25 °C</td>
<td>EN 13398</td>
<td>%</td>
<td>≥ 50 (Class 5)</td>
</tr>
<tr>
<td>Elastic recovery at 10 °C</td>
<td>EN 13398</td>
<td>%</td>
<td>NR (Class 0)</td>
</tr>
</tbody>
</table>

**Additional characteristics**
- Flash Point
- Plasticity range
- Storage stability
- Difference in softening point
- Storage stability
- Difference in penetration
- Drop in softening point after EN 12607-1
- Elastic recovery at 25 °C after EN 12607-1
- Elastic recovery at 10 °C after EN 12607-1

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>TEST METHOD</th>
<th>UNIT</th>
<th>SELECTED CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flash Point</td>
<td>EN ISO 2592</td>
<td>°C</td>
<td>≥ 235 (Class 3)</td>
</tr>
<tr>
<td>Plasticity range</td>
<td>5.1.9</td>
<td>°C</td>
<td>TBR (Class 1)</td>
</tr>
<tr>
<td>Storage stability</td>
<td>EN 13399</td>
<td>°C</td>
<td>≤ 5 (Class 2)</td>
</tr>
<tr>
<td>Difference in softening point</td>
<td>EN 1427</td>
<td>°C</td>
<td>≤ 5 (Class 2)</td>
</tr>
<tr>
<td>Storage stability</td>
<td>EN 13399</td>
<td>°C</td>
<td>≤ 5 (Class 2)</td>
</tr>
<tr>
<td>Difference in penetration</td>
<td>EN 1426</td>
<td>0,1 mm</td>
<td>TBR (Class 1)</td>
</tr>
<tr>
<td>Drop in softening point after EN 12607-1</td>
<td>EN 1427</td>
<td>°C</td>
<td>NR (Class 0)</td>
</tr>
<tr>
<td>Elastic recovery at 25 °C after EN 12607-1</td>
<td>EN 13398</td>
<td>%</td>
<td>≥ 50 (Class 4)</td>
</tr>
<tr>
<td>Elastic recovery at 10 °C after EN 12607-1</td>
<td>EN 13398</td>
<td>%</td>
<td>NR (Class 0)</td>
</tr>
</tbody>
</table>
EN 14023 – all grades mandatory properties

- Grade selection upon classes, according to performance levels in Pen, R&B, Cohesion, Resistance to hardening, Flash Point

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>TEST METHOD</th>
<th>UNIT</th>
<th>Classes for all polymer modified bitumens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penetration at 25 °C</td>
<td>EN 1426</td>
<td>0.1 mm</td>
<td>10-40, 25-55, 45-80, 40-100, 65-105, 75-130, 90-150, 120-200, 200-300</td>
</tr>
<tr>
<td>Softening Point</td>
<td>EN 1427</td>
<td>°C</td>
<td>80, 75, 70, 65, 60, 55, 50, 45, 40</td>
</tr>
<tr>
<td>Force ductility * (50 mm/min traction) or Cohesion *</td>
<td>EN 13589 followed by EN 13703</td>
<td>J/cm²</td>
<td>3 at 5 °C, 2 at 5 °C, 1 at 5 °C, 2 at 10 °C, 3 at 15 °C, 0.5 at 20 °C</td>
</tr>
<tr>
<td>Tensile test * (100 mm/min traction) or Cohesion *</td>
<td>EN 13587 followed by EN 13703</td>
<td>J/cm²</td>
<td>3 at 5 °C, 2 at 5 °C, 1 at 5 °C, 3 at 10 °C</td>
</tr>
<tr>
<td>Vialit pendulum * (Impact test)</td>
<td>EN 13588</td>
<td>J/cm²</td>
<td>0.7</td>
</tr>
<tr>
<td>Retained Penetration</td>
<td>EN 12607-1</td>
<td>%</td>
<td>35, 40, 45, 50, 55, 60</td>
</tr>
<tr>
<td>Increase in Softening point</td>
<td></td>
<td>°C</td>
<td>8, 10, 12</td>
</tr>
<tr>
<td>Change of mass c</td>
<td></td>
<td>%</td>
<td>0.3, 0.5, 0.8, 1.0</td>
</tr>
<tr>
<td>Flash Point</td>
<td>EN ISO 2592</td>
<td>°C</td>
<td>250, 235, 220</td>
</tr>
</tbody>
</table>

- One cohesion method shall be chosen based on end application. Vialit cohesion (EN 13588) shall only be used for surface dressing binders.
- The main test is the RTFOT at 163 °C. For some highly viscous polymer modified bitumens where the viscosity is too high to provide a moving film it is not possible to carry out the RTFOT at the reference temperature of 163 °C. In such cases the procedure shall be carried out at 180 °C in accordance with EN 12607-1.
- Change of mass can be positive or negative.

The properties in Table 1 shall be specified for all polymer modified bitumens listed in this table. They are associated with regulatory or HSE requirements and shall be included in all specifications.
Regional requirements on Fraass breaking point and elastic recovery vs. climate, traffic and usage conditions

**EN 14023 – all grades optional properties**

### Table 2 — Framework specifications for polymer modified bitumens – Properties associated with regulatory or other regional requirements

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>TEST METHOD</th>
<th>UNIT</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fraass Breaking Point</td>
<td>EN 12593</td>
<td>°C</td>
<td>NR*</td>
<td>TBR</td>
<td>≤0</td>
<td>≤-5</td>
<td>≤-7</td>
<td>≤-10</td>
<td>≤-12</td>
<td>≤-15</td>
<td>≤-18</td>
<td>≤-20</td>
<td>≤-22</td>
</tr>
<tr>
<td>Elastic recovery</td>
<td>EN 13398</td>
<td>%</td>
<td>NR*</td>
<td>TBR</td>
<td>≥80</td>
<td>≥70</td>
<td>≥60</td>
<td>≥50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 °C or 10 °C</td>
<td>EN 13398</td>
<td>%</td>
<td>NR*</td>
<td>TBR</td>
<td>≥75</td>
<td>≥50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* NR. No Requirement may be used when there are no regulations or other regional requirements for the property in the territory of intended use.
* TBR. To Be Reported may be used when there are no regulations or other regional requirements for the property in the territory of intended use, but the property has been found useful to describe polymer modified bitumens.
* Where required, polymer modified bitumens shall conform to the requirements for elastic recovery at 25 °C or 10 °C.

The properties in Table 2 are required to meet specific regional conditions. They are associated with regulatory or other regional requirements.
EN 14023 – other properties

- Other properties: Plasticity range / R&B drop or ER after RTFOT / Storage stability (R&B, pen differences)

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>TEST METHOD</th>
<th>UNIT</th>
<th>Classes for the additional properties of polymer modified bitumens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasticity range</td>
<td>5.2.8.4</td>
<td>°C</td>
<td>0</td>
</tr>
<tr>
<td>Drop in softening point after EN 12607-1</td>
<td>EN 1427</td>
<td>°C</td>
<td>NR*</td>
</tr>
<tr>
<td>Elastic recovery at 25 °C after EN 12607-1</td>
<td>EN 13398</td>
<td>%</td>
<td>NR*</td>
</tr>
<tr>
<td>Elastic recovery at 10 °C after EN 12607-1</td>
<td>EN 13398</td>
<td>%</td>
<td>NR*</td>
</tr>
<tr>
<td>Storage stability b</td>
<td>EN 13399</td>
<td>°C</td>
<td>NR*</td>
</tr>
<tr>
<td>Difference in softening point</td>
<td>EN 1427</td>
<td>°C</td>
<td>NR*</td>
</tr>
<tr>
<td>Storage stability b</td>
<td>EN 13399</td>
<td>0,1 mm</td>
<td>NR*</td>
</tr>
<tr>
<td>Difference in penetration</td>
<td>EN 1426</td>
<td>0,1 mm</td>
<td>NR*</td>
</tr>
</tbody>
</table>

NR. No Requirement may be used when there are no requirements for the property in the territory of intended use.

Storage conditions of the polymer modified binder shall be given by the supplier. Homogeneity is necessary for polymer modified bitumens. The tendency of polymer modified bitumens to separate during storage may be assessed by the storage stability test (see EN 13399). If the product does not fulfill the properties in Table 3 Classes 2 to 5, information shall be given by the supplier regarding storage conditions for the polymer modified bitumen to avoid separation of the components and to ensure the homogeneity of the product.
Binder specifications in Europe – Perspectives

- **Towards performance based specifications**
- CEN working groups - WG1/TG5 & ad-hoc groups
- FEHRL (Highway research labs): “BitVal project”
  - Phase 1 - A review of existing data on bitumen tests used by TC336 WG1 – completed – see [http://bitval.fehrl.org/](http://bitval.fehrl.org/)
  - Phase 2 – Gap study in the knowledge identified in Phase 1
  - Phase 3 – Study of bitumen test methods missing from the original list
- Eurobitume – Task Force Performance
  - Goal: To develop a bitumen industry viewpoint on Performance Related Standards for bituminous binders for hot applied paving bitumen
  - Data collection including 146 binders (58 PmB’s, 4 Specials)
  - Lengthy process, constrained by CEN rules…
  - But proactive initiatives such as the push from highway
MSCRT: Asphalt concrete - binder correlation

- Fair correlation Jnr vs. rut depth @ 30000 cycles for a rut resist. mix
- Better correlation at higher stress levels at 60 °C
  - @ 100 Pa ⇒ $R^2=0.36$ / @ 3.2 kPa ⇒ 0.44 / @ 25.6 kPa ⇒ 0.77
- Validation of links between rutting and non linearity

Presented at IRF 2010
• Transportation Background
• European Market of PmB’s
• Modification Techniques
• Application / PmB’s usage in Europe
• Regulations
• Summary
• Perspectives
Polymer modified asphalt markets still growing in Europe but at different rates vs. countries # 10%
Mainly SBS elastomeric modifiers w or w/o cross-linking - Plastomers (EVA) occasionally used
Producers: generally oil companies, but road contractors very important in some countries
PmB’s used for appropriate applications – “European layer function concept”
EN specs soon to be in full force
  Still empirical in nature - cohesion used to differentiate with bitumen
  Possibly increasing PmB use?
Push towards PR specs – but lengthy process
Outline

• Transportation Background
• European Market of PmB’s
• Modification Techniques
• Application / PmB’s usage in Europe
• Regulations
• Summary
• Perspectives
Short - Mid term perspectives

- Recycling
  - of PmB’s RAP
  - RAP with PmB’s
- WMA with PmB’s
- Performance based
  - Test methods – promising: BBR, FT, DSR, MSCRT
  - Specs
- Tailored made polymers / additives – alloys / cocktails
  - More efficient
  - More cost effective
  - Easier to handle
Flexible, self-cleaning, instant crack repair — Forever open roads

http://www.fehrl.org/?m=251
Thank you!

Rendezvous in Laramie this July!

The 2011 Petersen Asphalt Research Conference
July 11 - July 13 Laramie, Wyoming
THE forum for current research
Abstracts due May 10

Pavement Performance Prediction Symposium
July 14, Laramie, Wyoming
Topic: The Effects of Asphalt Binder, Mix Design, and Construction on Pavement Durability

www.petersenasphaltconference.org

Questions?

jplancher@uwyo.edu