LABORATORY TESTING OF ORGANIC AND CHEMICAL WARM MIX MIX ASPHALT TECHNOLOGIES

Martins Zaumanis
St.Louis, Missouri, 12.10.2011
Acknowledgments

- Erik Nielsen
- Erik Olesen

- Juris Smirnovs

- Worcester Polytechnic University

- Technical University of Denmark

- Riga Technical University, Latvia
## WMA technologies

<table>
<thead>
<tr>
<th>Foaming</th>
<th>Organic or wax</th>
<th>Chemicalal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Energy asphalt</td>
<td>Sasobit</td>
<td>Evotherm ET</td>
</tr>
<tr>
<td>Low emission asphalt</td>
<td>Asphaltan A</td>
<td>Evotherm DAT</td>
</tr>
<tr>
<td>WAM®-Foam</td>
<td>Asphaltan B</td>
<td>Cecabase RT</td>
</tr>
<tr>
<td>LEAB</td>
<td>Licomont BS 100</td>
<td>Rediset WMX</td>
</tr>
<tr>
<td>LT asphalt</td>
<td></td>
<td>Warm Mix L</td>
</tr>
<tr>
<td>Advera</td>
<td></td>
<td></td>
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<tr>
<td>Aspha min</td>
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</tr>
</tbody>
</table>


Laboratory testing

Rediset WMX

Sasobit
**Sasobit (wax)**

**Principle**
- Fischer-Tropsch process wax
- Crystallization point ~90°C
- At production temperature reduces bitumen viscosity
- After crystallization hardens the bitumen

**Production**
- The specified dosage of additive can be introduced to binder or purchased in emulsion form
**Rediset WMX (chemical)**

**Principle**

- Melting point ~ 110°C
- Rheology modifier based on organic additives;
- Surface active formulation that allows the bitumen to disperse and coat the aggregates;
- Hydrophilic amine group absorbs on the aggregate surface, which prevents water from entering the aggregate and bitumen interface.

**Production**

- In form of flakes and granules
- Can be introduced in bitumen, in line with bitumen or directly to mixer
Bitumen testing

**Bitumen 40/60**
- Sasobit: 2%, 3%
- Rediset WMX: 1%, 2%

**Bitumen 50/70**
- Sasobit: 3%
- Rediset WMX: 2%

**Testing unaged**
- G* and δ (40/60 only)
- Dynamic viscosity
- Kinematic viscosity
- Softening point
- Penetration
- Fraass (50/70 only)
- Change in mass

**Testing after RTFOT @163°C**
Traditional test methods

Bitumen 50/70 test data chart

- Fraas breaking point, °C
- Softening point (ASTM), °C
- Compaction viscosity (1.7-25 Pa·s)
- Mixing viscosity (0.2-0.55 Pa·s)
# Traditional test methods

After RTFOT aging @ 163°C

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Bitumen 50/70</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ref. 50/70</td>
</tr>
<tr>
<td>Change in mass, %</td>
<td>-0,10</td>
</tr>
<tr>
<td>Retained penetration, %</td>
<td>70,8</td>
</tr>
<tr>
<td>Softening point, °C (change)</td>
<td>56,8 (+6,4)</td>
</tr>
<tr>
<td>Fraass breaking point, °C (change)</td>
<td>-20 (+5)</td>
</tr>
</tbody>
</table>
Rheology (DSR)

40/60 bitumen

**Test conditions:**
- *8* different temperatures
- *10* frequencies
- *2.5mm* plate

**G*** relative to pure bitumen as function of temperature and frequency

Increasing frequency from 0.01 Hz to 10 Hz within each temperature

- **2% Sasobit**
- **3% Sasobit**
- **1% Rediset WMX**
- **2% Rediset WMX**

**Pure bitumen**
Rheology (DSR)

40/60 bitumen

Test conditions:
* 8 different temperatures
* 10 frequencies
* 2.5mm plate

Difference in phase angle relative to 40/60 Bitumen

Increasing frequency from 0.01 Hz to 10 Hz within each temperature

Pure bitumen
2% Sasobit
3% Sasobit
1% Rediset WMX
2% Rediset WMX
# Mixture testing

## SMA-11 (40/60)

<table>
<thead>
<tr>
<th>Original</th>
<th>Sasobit 3%</th>
<th>Rediset WMX 2%</th>
</tr>
</thead>
</table>

### Compaction temperature

<table>
<thead>
<tr>
<th>155°C</th>
<th>135°C</th>
<th>125°C</th>
<th>115°C</th>
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### Aging

<table>
<thead>
<tr>
<th>0h</th>
<th>2h</th>
<th>4h</th>
<th>2h</th>
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### Compaction

- Marshall hummer
- Gyratory compactor

### Testing

<table>
<thead>
<tr>
<th>Density</th>
<th>Flow and stability</th>
<th>Dynamic creep</th>
<th>Stiffness modulus</th>
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<tr>
<td>EN12697-6 (method B)</td>
<td>EN12697-34 60°C</td>
<td>EN12697-25 40°C</td>
<td>EN12697-26 20°C</td>
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Asphalt aging

Indirect tensile test:
* @ 20°C
* 55 μm
* rise time of 124 ms

Graph showing comparison of stiffness (MPa) over different cure times (0h, 2h, 4h) for Reference, Sasobit, and Rediset WMX.
Indirect tensile test:
* IT CY
* @ 20°C
* 55 µm
* rise time of 124 ms

Gyratory specimens

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<tr>
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<tr>
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Reference
- Sasobit
- Rediset
- WMX

Marshall specimens

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Reference
- Sasobit
- Rediset
- WMX
Permanent deformations

Stability test results

Marshall test @ 60°C

Flow test results

Marshal quotient
Dynamic creep test:
* @40°C
* 3600 pulses
* 100 kPa stress
* 900s relaxation period

Maximum strain results

Marshall specimens

<table>
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<tr>
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<th>Rediset</th>
<th>WMX</th>
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<tbody>
<tr>
<td>155°C</td>
<td>2.1</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>125°C</td>
<td>2.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>125°C</td>
<td>2.3</td>
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Conclusions

• Addition of Sasobit® changes the bitumen viscosity and provides higher resistance to deformations and improved elasticity of bitumen;

• Addition of Rediset WMX® has minor effect on bitumen rheology;

• Addition of both additives increases the Fraas breaking point temperature; after RTFOT they are similar again;

• Asphalt aging should be performed before compaction;

• WMA has similar compaction characteristics and density as HMA at up to 30°C lower temperature;

• Similar mechanical performance at temperature 30°C lower than for HMA.

Future work:

• Building a WMA test section in Latvia