Warm Mix Asphalt Pavements based on the Fischer –Tropsch Wax Sasobit®

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Aims of WMA

- Political demands to decrease:
  - Binder fume/aerosol emissions
  - CO₂ emissions

- Reasons:
  - Worker's health protection
  - Protection of the environment und energy savings

- Solution: Reduction of temperature during asphalt mix production and paving
  - 10-15°C reduction halve the fume/aerosol emissions
  - Up to 40°C reduction are realized
Wax Additives

How does it work?

- Additives: Low-viscosity liquids at asphalt mixing and paving temperature
  - Viscosity reduction
  - Higher expansion coefficient → Temperature reduction
- Homogeneously soluble in asphalt binder
  - Hot storage stable
- Additives are deformation resistant solids at service temperature
  - Stiffening of binder → Deformation resistance of asphalt
**Wax Additives**

*How does it work?*

Solid wax particles create a branched and partly inter-linked stiffening elastic structure.

Scanning electron microscopy (SEM) image of 4% FT-wax in binder B 50/70.
**Wax Additives**

How can it be used?

- Pre-blending with binder
  - Stirred tank or pump circulation
  - Pre-blended binder from binder suppliers
- In-line blending at asphalt mixing plant
  - Liquid in-line dosage of molten additive
  - Solid in-line dosage (Ejector + static mixer)
- Direct addition into the asphalt mixer is not optimal
  - Risk of inhomogeneous distribution
- Dosage
  - $\approx 1.5\%$ for temperature reduction, $\approx 3\%$ for additional stiffness
**Wax Additives**

- **Additive types**
  - Montan wax (and wax blends)
    - Coal extract (fossil ester wax)
    - Melting temperature ≈ 75°C
  - Amide wax
    - Synthetic/oleochemic wax (fatty acid amide)
    - Melting temperature ≈ 140°C
  - Fischer-Tropsch (FT) wax “Sasobit®”
    - Synthetic hydrocarbon
**FT Wax Sasobit®**

- **Production**
  - *Fischer-Tropsch synthesis (catalyst, high pressure, high temperature)*
  - *Feed: Syngas (CO, H₂) from natural gas reforming*

- **Properties**
  - *Melting temperature ≈ 100°C*
  - *Needle penetration < 1 dmm*
  - *Viscosity @ 135°C ≈ 12 mPas (asphalt binder ≈ 300 – 3000)*

- **Chemistry**
  - *Pure hydrocarbon, no ageing sensitive groups*
  - *C₄₀-C₁₂₀, mainly linear structure*
Effects on Binder Properties

Viscosity of B 70/100 at 135°C

![Graph showing the relationship between Sasobit % and Dyn. Viscosity [mPas]. The viscosity decreases as the Sasobit % increases.]
Effects on Binder Properties

Viscosity of B 70/100

- B 50/70
- 1.5% Sasobit
- 3% Sasobit
- 1.5% Amide Wax
- 3% Amide Wax
Effects on Binder Properties

Needle penetration at 25°C
Effects on Binder Properties

DSR: Binder stiffness at elevated temperature

* Reference: Technical University Vienna
Effects on Binder Properties

Adhesion to aggregates (rhyolite) – Rolling bottle test

![Graph showing the relationship between surface area coated with binder (%) and rolling time (h) for B 50/70 and B 50/70 + 3% Sasobit. The graph indicates a decrease in surface area coated with binder as rolling time increases.](image-url)
**Effects on Asphalt Mix Properties**

**Effect on compaction resistance and air voids (SMA 11 S, B 50/70)**

\[
\frac{1}{d(S)} = a - b \, e^{-(S/D)}
\]

- \(d\): Height of Marshall test specimen
- \(a, b\): Regression coefficients
- \(S\): Number of compaction blows
- \(D\): Compaction resistance

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Sasol Wax

THE WAX COMPANY - more than just wax
Effects on Asphalt Mix Properties

Workability: Effect on stirring resistance of mastic asphalt (MA 11)
Effects on Asphalt Mix Properties

Effect on Hamburg wheel tracking test (water, 50°C); SMA 11 S
## Effects on Asphalt Mix Properties

**Low temperature properties: Tensile Stress Restrained Specimen Test (TSRST)**

<table>
<thead>
<tr>
<th></th>
<th>Max. Tension [N/mm²]</th>
<th>Breaking Temp. [°C]</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMA 11, 50/70</td>
<td>4.4</td>
<td>-25.0</td>
</tr>
<tr>
<td>SMA 11, 50/70 + 3% Sasobit</td>
<td>4.5</td>
<td>-24.5</td>
</tr>
<tr>
<td>Mastic asphalt, 30/45</td>
<td>6.0</td>
<td>-26.5</td>
</tr>
<tr>
<td>Mastic asphalt 30/45 + 3% Sasobit</td>
<td>5.9</td>
<td>-25.5</td>
</tr>
<tr>
<td>Mastic asphalt, PmB 45</td>
<td>6.8</td>
<td>-30.0</td>
</tr>
<tr>
<td>Mastic asphalt, PmB 45 + 3% Sasobit</td>
<td>7.0</td>
<td>-30.0</td>
</tr>
</tbody>
</table>
Field Experience

Field experience confirmed lab results with one exception:
- Better temperature reduction than in lab simulation

Binder fume/aerosol expositions at spreader bar of paver

<table>
<thead>
<tr>
<th></th>
<th>[mg/m³]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rolled asphalt</strong></td>
<td></td>
</tr>
<tr>
<td>Conventional (160-180°C)</td>
<td>10.4</td>
</tr>
<tr>
<td>WMA, average 130°C</td>
<td>0.6 - 6.9</td>
</tr>
<tr>
<td><strong>Mastic asphalt</strong></td>
<td></td>
</tr>
<tr>
<td>Conventional (240-250°C)</td>
<td>40.6</td>
</tr>
<tr>
<td>WMA 220-230°C</td>
<td>1.7 - 11.1</td>
</tr>
</tbody>
</table>

(95 percentile of all measurements, German worker protection agency)
Field Experience

Heating gas consumption in a mixing plant

- AC 22 B S: 778 m³/h Conventional asphalt, 493 m³/h Low Temperature
- SMA 8 S: 609 m³/h Conventional asphalt, 435 m³/h Low Temperature
Field Experience

Field evaluation of WMA technology, Massachusetts *
Gap Graded SMA, binder: PG 64-28 + 4 % latex w/wo 1.56 % Sasobit

Conventional (mat 289-325°F, 144-165°C) density 93.7-97.6 %

WMA (mat 241-305°F, 116-155°C) density 89.2-97.7 %

“…the WMA achieved the desired compaction with less effort at a reduced temperature“

*Reference: Laboratory and field evaluation of warm mix asphalt technology to determine its applicability for Massachusetts, W.S. Mogawer, A.J. Austermann, 2006
Conclusions and Outlook

- WMA is meanwhile a proven technology
- Especially wax additives are widely used because of additional benefits:
  - Paving temperature sensitive bridges
  - Earlier release to traffic
  - Paving at cold weather (longer season)
  - Long asphalt transport times
  - Deformation resistant heavy duty pavements
  - Better handling and rolling of stiff mixes (increased productivity)
- Additives open up new opportunities for the asphalt industry
  - versatile tool for the asphalt designer