Warm Mix Asphalt in Germany, a technology beyond reduced mixing and paving temperatures

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I´m coming from Germany, the mother country of warm mix asphalt

Sorry, but I have to destroy your hope quite at the beginning: we don´t use very often Asphalt with reduced mixing temperature

BUT THE TECHNOLOGY OF WARM MIX ASPHALT IS SINCE 5 YEARS A STANDARD TECHNOLOGY IN GERMANY
1997 I was contracted by the DOT of the Federal state Hamburg, Germany, to investigate new methods to minimize rutting of asphalt roads.

At that time: we had good results with polymer modified binders.

But the problem was: these modifications require a higher compaction effort and/or Higher temperatures for mixing and laying
Aim of research: find out modifications without the need of higher compaction effort or higher compaction temperature

Solution: Modification with different additives

Fischer Tropsch - Wax
Amide Wax
Romontan Wax
Zeolithe

{ Act as Bitumen-liquifier
Non negotiable: Reduction of asphalt quality

Technologies like foam asphalt or asphalt with Bitumen emulsion were eliminated right at the beginning, because the necessary asphalt Quality was not high enough:
- water susceptibility
- stability
- resistance against rutting
- fatigue behaviour.
The most effective modification was found to be Fischer-Tropsch Wax, known under the Trade name: SASOBIT.

It fully melts at temperatures above 105 °C (221 °F) and liquifies the binder in mixes above this temperature.

Below this temperature the wax particles crystallizes and makes the binder extremely stiffer.
Easy melting in bitumen
Wax content up to 2 %: effect mainly as liquifier

Wax content 2 to 4 %: effect also stiffness
Change of penetration with wax content
Hamburg wheel tracking tester

- Steel wheel
- Load
- Sample: 6 cm Asphalt concrete plate
- Moving force

Test conditions:
- Temperature: 50 C or 60 C
- Number of passes: 20000
- Result: rut depth
The graph illustrates the relationship between the number of passes and rutting depth for different asphalt mixtures. The x-axis represents the number of passes multiplied by 1000, and the y-axis shows the rutting depth in millimeters. The graph includes three lines:

- **Pen 50/70 +3% Sasobit**: The blue line represents this mixture, which shows a significant increase in rutting depth with an increase in passes, indicating lower rut resistance compared to other mixtures.
- **50/70**: The pink line represents this mixture, which shows a slight increase in rutting depth, indicating moderate rut resistance.

The red horizontal line represents the limit for rut resistance. The graph indicates that the Pen 50/70 +3% Sasobit mixture exceeds this limit at a lower number of passes compared to the 50/70 mixture.
Deep temperature susceptibility

A value of -8 °C is sufficient for winter temperature of -25 °C
What do above data have to do with warm mix asphalt or Temperature reduction of hot mix asphalt??

In 2000 started the discussion about emission of bitumen fumes and aerosols

German workers protection agency : Limiting value = 10 mg/m³
Asphalt operator : 6.5 to 9 mg/m³, Depending from weather conditions and asphalt temperature, normally 160-180°C
Screed operator: > 10 mg/m³
Hot mix asphalt

160°C
(320°F)

Warm mix asphalt

130°C
(266°F)
In principle: no need for temperature reduction of hot mix asphalt but for gussasphalt = asphalt mastix [operation at >230°C (446 °F)]

But the German workers protection agency announced a new value of 5 mg/m³

Ministry of Highways asked for proposals for a test Road
I proposed the use of waxes.
Test road Highway N° A7, North Germany

Realisation 2004

7500 heavy trucks /day or
18 Million trucks till now

7 test sections , 850 m length
Temperature reduced asphalt in 8 cm binder
and 4 cm surface course
Mixing temperature: 145 °C (293 °F)
Laying temperature: 135 °C (275 °F)
3 different polymer modified binder
With FT-wax, 135 °C (275 °F)

2 different polymer modified Binder with Amid wax, 135 °C (275 °F)

1 Binder pen 45 with FT-wax ,
135 °C(275 °F)

1 polymer modified binder pen 45 as Reference binder , 165 °C (329 °F)
<table>
<thead>
<tr>
<th></th>
<th>FT-wax</th>
<th>Amide wax</th>
<th>PmB Pen 45</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air void content of compacted layer [vol.-%]</td>
<td>4,2</td>
<td>4,7</td>
<td>6,2</td>
</tr>
<tr>
<td>Softening point [°C]</td>
<td>84,4</td>
<td>78</td>
<td>104,3</td>
</tr>
<tr>
<td>Penetration [1/10 mm]</td>
<td>30</td>
<td>16</td>
<td>33</td>
</tr>
<tr>
<td>$G^*, 60^\circ$ [Pa]</td>
<td>18300</td>
<td>22816</td>
<td>25400</td>
</tr>
<tr>
<td>$\delta, 60^\circ$ [° ]</td>
<td>73,8</td>
<td>73,3</td>
<td>68,5</td>
</tr>
<tr>
<td>Stiffness – 16°C [MPa]</td>
<td>212</td>
<td>252</td>
<td>182</td>
</tr>
<tr>
<td>m- value</td>
<td>0,38</td>
<td>0,29</td>
<td>0,32</td>
</tr>
</tbody>
</table>

Binder characteristics, surface layer
Bitumen fumes and aerosols

PmB Pen 45, T=170°C

Sasobit, T= 140°C
Phase angle 60 °C: bitumen pen 80 and pen 80 + 3% FT wax
Storage modulus $G'$, 60 °C: bitumen pen 80 and pen 80 + 3% FT wax
Temperatur [°C]

dyn. Viscosity [Pa.s]

Temperature reduction ~ 30 °C

viscosity range for asphalt mixing

- PmB Pen 45
- Pen 80 +3 % Sasobit

Viscosity
Energy saving

The reduced mixing temperature of 20 °C (68°F) leads to an energy save of about 10% (batch plant).

But: the production capacity dropped down by about 25% in order to achieve a good coating of chippings.
2006 guideline on temperature reduced asphalt mixes, published by FGSV: German research agency of the ministry of Highways

List of allowed additives

The aim: Hot mixed asphalt: temperature reduction from 165 °C (329 °F) down to 135 °C (275°F)
The asphalt industry in Germany doesn`t use viscosity reduced systems or “warm mix asphalt” primarily for temperature reduction of mixes. Especially the waxes are used for enhancing deformation resistance and/or for improved workability.

Reason: the highway authorities don`t ask for temperature reduced asphalt because it is more expensive
Main fields of application at normal mixing temperatures of 165 °C (329 °F) are:

- highways
- airports and container terminals: against rutting
- urban roads: longer compaction time
- bridge deck waterproofing and asphalt layers: mastic asphalt
- thin and ultra thin wearing courses: better compactibility
- cold weather conditions: laying even at temperatures around freezing
- early traffic release due to earlier curing
Asphalt work in winter
Foamed asphalt does not play any role in Germany because the asphalt quality isn´t equal to hot mix asphalt (more sensitive to water and deformation, Fatigue behaviour)

There is no acceptance for lower quality in view of higher requirements on Asphalt roads due to traffic increase
New field of application of waxes are:

Rubber asphalt: to improve the workability and to reduce the mixing temperature lower than 180 °C (356 °F)

A combination of FT-wax and rejuvenator oil for recycling of asphalt at very high quantities of 80-to 90% without quality loss. Mixing temperature: 135 °C (275 °F)
Thank you very much for your attention