Warm Mix Asphalt Technology

Northeast Asphalt User-Producer Group
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Wilkes-Barre, Pennsylvania
Advantages of Lower Temperatures

- Lower fumes
- Lower plant emissions
- Lower energy consumption
- Lower plant wear
- Decreased binder aging
Available Technologies

- Materials Processing
  - Foamed asphalt
- Additives
  - Mineral
  - Organic
Warm Asphalt Mix (WAM) Foam
What WAM Foam is NOT

- ‘New’ asphalt cement
- ‘Old’ foamed asphalt technology
- Emulsified asphalt cement system
- Base Layer Stabilization
- Miracle
What WAM Foam Is

• Joint Development between Shell and Kolo Veidekke a.s to produce asphalt pavements at lower operating temperature
aggregate addition sequence method

sand/filler

bitumen

mixer

crushed aggregates

Courtesy IFTA GmbH
Two phase bitumen mixing method

- Hard asphalt
- Mineral aggregates

Courtesy IFTA GmbH
Goals for Warm Asphalt Mix WAM

• Lower production temperatures of Hot Mix Asphalt
• Use existing Hot Mix Asphalt plants
• To meet existing standards for Hot Mix Asphalt specifications
• Focus on dense graded mixes for wearing courses
• WAM quality = Hot Mix Asphalt quality
Towards lower temperatures - asphalt cement rheology-

Hot mixtures

$\Delta T = 30 - 50 ^\circ F$ - workability - additives

or

colder Hot Mix

$\Delta T = 100 - 140 ^\circ F$ - WAM-Foam process

Cold mixtures - emulsions - foamed bitumen
WAM Positioning

![Diagram showing the relationship between production temperature, quality, and cost for different types of mixes: foam mix, cold emulsion mix, and hot mix. The diagram includes a color scale for production temperature (°F) from 50 to 350.](image-url)

- **Production Temperature (°F):**
  - Cold (50-110)
  - Warm (110-170)
  - Hot (170-230)
  - Very hot (230-290)
  - Extremely hot (290-350)

- **Quality:**
  - 1.0
  - 0.7

- **Cost:**
  - 1.3
  - 1.0
  - 0.7

- **Mix Types:**
  - Foamed mix
  - Cold emulsion mix
  - Hot mix

- **T Reducing Additives:**
Field trials in Norway 1996
WAM Emulsion Hunndalen after 6 years

DG 11 still in good condition after 6 years of service

High rate of studded tyres!
WAM Foam installation in an Asphalt Batch-Plant

2000
Road 120 Hobøl
Rut Depth

RV 120 Hobøl
Mean Rut Depth [mm]
HMA  vs.  WAM-Foam

Hot Mix Ska 11 (165 °C)
329 °F

WAb 11 (110 °C)
230 °F
WAM Foam in Drum Mix Plants 2001
WAM Foam, FV 82 Frogn – Nesodden
September 2001

• WAM Foam DG11, ADT 3600
What have we achieved with WAM Foam?

- 30 % reduction in energy consumption,
- 30 % reduction in CO$_2$-emissions,
- 50 – 60 % reduction in dust emission,
- Fume from WAM Foam is below detection limits
Additional Benefits

- Reduced energy consumption
- Reduced temperature => reduced binder oxidation
- Production rate is maintained
- No problems with humidity observed in drum mixer
  - some humidity in the stack of batch plant
- Reduced production temperature => reduced wear
Warm Asphalt Mixes by adding aspha-min®, a synthetic zeolite
Zeolite

Zeolites: crystalline hydrated aluminium silicates.

aspha-min®, is added (0.3%) to the HMA in the 100 to 200 °C (212 to 392 °F) temperature range
Granulated aspha-min®
Production of warm asphalt mix

No modifications to mix design are required.

Aspha-min® is considered as an additive to increase workability at low temperatures.

Mixing temperature of between 130 and 145°C (266 to 293°F) possible.
How zeolite works

Vapor is created by adding asphamin® to pre-heated mixture of sand and stone at the same time as asphalt is being introduced.
Adding aspha-min®
Manual Feed
Reduction of Emissions

Reduction of 30 – 35 °C (about 55 °F) the energy consumption was reduced by 30 %.

In Germany, 65 million tons of HMA are produced annually results in a reduction of 400,000 tons of CO$_2$. 
CO₂ Measurement at the plant
Reduction of Emissions

Using a 65 pen binder in the mix at a temperature of 168 °C (340 °F) an emission of 350 mg/ m³ fumes and aerosols was determined.

At a productions temperature of 142 °C (285 °F) where zeolite had been added, 90 mg/m³

Reducing temp by 26 °C (47 °F) created a reduction in fume emissions of 75 %.

At the application site a 35 °C reduction resulted in as low as 1/10 of the equivalent fume level.
Testing at Mixing Plant (1)
65 pen vs. 65 pen with aspha-min®

Temperature

- 287 °F
- 335 °F

Aerosols
Workability

All mixes produced at lower temperatures handled the same way as traditional mixes and obtained comparable density.
Organic Additives

Sasobit

Two classes:

• synthetic Fischer-Tropsch paraffin waxes

• low molecular weight ester compounds
Fischer-Tropsch paraffins are
- long-chained aliphatic hydrocarbons
- from coal gasification
- with the Fischer-Tropsch process

<table>
<thead>
<tr>
<th></th>
<th>Bitumen wax</th>
<th>Synthetic wax</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melting point, °C</td>
<td>70</td>
<td>100</td>
</tr>
<tr>
<td>Penetration at 25 °C, 0,1 mm</td>
<td>120</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Viscosity at 135 °C, mm² /s</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>Average molecular weight, g / mol</td>
<td>800</td>
<td>1600</td>
</tr>
<tr>
<td>n-paraffins, %</td>
<td>14</td>
<td>73</td>
</tr>
</tbody>
</table>
Ester additives are:

- Coal wax
- consists mainly of esters from fat acids and wax alcohols
- produced by toluene extraction of brown coal

Average molecular weight: 510 g /mol
How organic additives work

Organic additives

Temperature

Viscosity

Bitumen

Additive
Influence of organic additives (FT)

Penetration: „Viscosity at room temperature“
Softening point: „Melting point“

% of FT-paraffin in Bitumen 70/100
Influence of FT-Paraffin

Influence of organic additives (FT)

Fraass breaking point [°C]

% of FT-paraffin in Bitumen 70/100

Fraas Breaking Point: Low temperature behaviour
Influence of organic additives (FT)

Wheel tracking test (Hamburg device) with growing %-FT-paraffin

Organic additives
Experiences with organic additives

Up to 5 years experience:
Positive laboratory results coincide with field experience
Experiences with organic additives

Organic additives

Compaction of SMA can start at 130-120 °C ~ 265-250 °F

should be concluded at 90 °C ~ 195 °F
Conclusions

• Success in Europe = Success in U.S.?
• Long-Term Performance?
• Cost Benefit?
• Definite Reduction in Emissions
• Definite Reduction in Fumes
• Definite Reduction in Energy Consumption
Activities

• World of Asphalt Demo – Mar 2004

• NCAT Study