Foamed Bitumen

The innovative Binder for Cold Recycling in situ and in plant
What is Foamed Bitumen?

2 - 3% bitumen water in 180 °C hot bitumen:
The bitumen expands 15 to 20 times its original volume.

The increased surface area makes it possible to mix hot bitumen with cold and damp aggregates.
Quality of foamed bitumen: Expansion and Half-life
As the percentage of bitumen water is increased, the parameters “half-life” and “expansion” develop in opposite directions.
Quality of Foamed Bitumen

Effect on bitumen temperature

- 180 °C
- 170 °C
- 160 °C

Bitumen water-content
- 4%
- 3%
- 2%
- 1%
Plant for the production of foamed bitumen in laboratory conditions

Test of bitumen foaming properties and optimisation of bitumen water

Production of foamed bitumen mix design for optimisation of the foamed bitumen content

More than 100 plants: Customers are commercial laboratories, consultants, research institutes, universities and construction contractors
Spraybar with 16 nozzles where hot bitumen is foamed in expansion chambers.
Cold Recycling in-situ with Foamed Bitumen

Cement is pre-spread and consequently mixed with WR 2500 S under simultaneous injection of Foamed Bitumen and compaction water.

Cement pre-mixed in the slurry mixer WM 1000 which is injected into the Recycler 2200 CR together with the Foamed Bitumen.
Cold Recycling in-plant with Foamed Bitumen

Production of Foamed Bitumen Mixture and loading onto a stockpile

Production of Foamed Bitumen Mixture with the loading onto a tip truck
Cold Recycling in-plant with Foamed Bitumen

Storage capability up to 3 months
Storability of Foamed Bitumen treated mixes

Principle of Foamed Bitumen mixtures
Foamed Bitumen mix

Principle of Foamed Bitumen mixtures

42,5 cm
Mix Design Test for Foamed Bitumen

Milling of test pit

Samples of milled material of the existing pavement in the envisaged cold recycling thickness are taken

- normally between 15 and 25 cm -
Mix Design Test for Foamed Bitumen

Tests done on the milled sample:

- Grading analysis
- Water content
- Bitumen content
- Modified Proctor to determine the optimum water content (OMC) and maximum dry density (MDD)

Tests done on the bitumen sample:

- Optimisation of foaming properties – variation of bitumen temperature and bitumen water quantity
Aggregate up to 2.0 mm are usually coated in a Foamed Bitumen Mixture.
Mix design and manufacturing briquettes:

• Addition of cement (1.5 M.-%)

• Addition of water (80 - 90% of OMC)

• Addition of Foamed Bitumen (2; 3; 4; 5 M.-%): with WLB 10 directly into the laboratory mixer

• Production of briquettes by Marshall compaction – modified to 75 blows / briquette-side

• Storing for 72 hours at 40 °C (simulating 28 days)

• Indirect tensile strength on dry and soaked briquettes at 25 °C (5 °C)
Mix Design Test for Foamed Bitumen

Indirect Tensile Strength
by measuring the lateral strain the E-module can be calculated

\[ ITS = \frac{2 \times P}{\pi \times d \times l} \]

\[ E_{SZ} = \frac{P \times (0.274 + \mu)}{l \times u} \]

- ITS = Indirect tensile strength [N/mm²]
- \(E_{SZ}\) = Elasticity module [N/mm²]
- P = Tensile breaking strength [N]
- d = Briquette diameter [mm]
- l = Briquette height [mm]
- \(\mu\) = Poissons ratio [-]
- u = 45% of strain at break [mm]
Mix Design Test for Foamed Bitumen

Optimisation of Foamed Bitumen content

Indirect Tensile Strength [kPa]

Soaked ITS

Dry ITS

Foamed Bitumen content [% by mass]

Optimisation of Foamed Bitumen content
### Specification for Foamed Bitumen mixes

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mix design test (MDT)</th>
<th>Control test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Voids</td>
<td>8 – 15 Vol.-%</td>
<td>≤ value of MDT + 4 Vol.% / ≤ value of MDT + 2 Vol.-%</td>
</tr>
<tr>
<td>Indirect Tensile Strength at 25 °C</td>
<td>0,3 – 1,0 N/mm²</td>
<td>≥ value of MDT – 20 % / ≤ value of MDT + 30 %</td>
</tr>
<tr>
<td>Reduction of ITS after water storage</td>
<td>&lt; 30 %</td>
<td>&lt; 30 %</td>
</tr>
</tbody>
</table>

**Requirements on briquettes made of cold mix design**
### Specification for Foamed Bitumen mixes

#### Requirements on cold recycling layer

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Control test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness</td>
<td>&gt; nominal thickness - 10 %</td>
</tr>
<tr>
<td>Compaction</td>
<td>≥ 98 % mod. Proctor</td>
</tr>
<tr>
<td>Smoothness</td>
<td>1.5 cm / 4 m straight edge</td>
</tr>
<tr>
<td>Layer true to profile</td>
<td>nominal height ± 2 cm</td>
</tr>
</tbody>
</table>
Compaction measured in the field by replacement tests such as the Balloon- or Sand replacement test.

Compaction test of Foamed Bitumen layers

Density = Mass / Volume = $M_{\text{dry}} / V$

$M_{\text{dry}} = M_{\text{moist}} - M_{\text{water}}$

$V = L_1 - L_0$

$M_{\text{moist}}$

$M_{\text{water}}$

DIN 18 125 - 2
10 Liters

ASTM D 2167
1,5 Liters
less accurate!
Compaction test of Foamed Bitumen layers

Measuring with the HAMM Compactometer - HCM -

Works on the principle of accelerometer:
Stiffer ground gives greater accelerometer values which is shown by the Compactometer.

Various Specifications are specifying compaction to refusal in combination with documentation of the compactometer readings.
Compaction test of Foamed Bitumen layers

Documentation with the HAMM Compaction Navigator
- HCN = HCM + GPS -
Presumed economically not viable

Asphalt

Foamed bitumen or Bitumen emulsion treated material containing cement

Foamed bitumen and bitumen emulsion treated material without cement

Behavioural Characteristics of various Construction materials

Improved flexibility

Increasing permanent deformation resistance

Bituminous binder

High

Medium

Low

0%

7%

5%

0%

Strength

Cement

Catalyst

Unbound Material, Crushed Stone, Gravel, Soil

Stabilised

Lightly cemented

Strongly cemented

Presumed economically not viable

Asphalt
Behavioural Characteristics of various Construction materials

**Base bound with Cementitous binders**

- 30 cm Cementitous bound base
- 8 cm Asphalt base course
- 4 cm Asphalt wearing course

**Subgrade**

E-Modulus > 100 MPa

When cement is used as the stabilising agent, the recycled layer tends to be brittle, like a biscuit. It is therefore necessary to recycle a relatively thick layer.

**Base bound with Bituminous binders**

- 25 cm Bituminous bound base
- 5 cm Asphalt wearing course

**Subgrade**

E-Modulus > 100 MPa

When bitumen is used as the stabilising agent, the recycled layer tends to be flexible, like a pizza. A relatively thinner layer can therefore be recycled to produce the same strength.
Cold recycling in-situ with bitumen emulsion often results in the material being wetter than the OMC - Not compactable without drying out -
**Foamed Bitumen Projects in 1999**

<table>
<thead>
<tr>
<th>Land</th>
<th>Area [m²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle East</td>
<td>1,400,000</td>
</tr>
<tr>
<td>Mexico</td>
<td>980,000</td>
</tr>
<tr>
<td>Brasil</td>
<td>795,000</td>
</tr>
<tr>
<td>Bolivia</td>
<td>600,000</td>
</tr>
<tr>
<td>Finland</td>
<td>570,000</td>
</tr>
<tr>
<td>Norway</td>
<td>560,000</td>
</tr>
<tr>
<td>Sweden</td>
<td>330,000</td>
</tr>
<tr>
<td>Europe</td>
<td>150,000</td>
</tr>
<tr>
<td>Australia</td>
<td>300,000</td>
</tr>
<tr>
<td>Columbia</td>
<td>200,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5,885,000</strong></td>
</tr>
</tbody>
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Projects with Foamed Bitumen bounded Layers
Foamed Bitumen Projects
1998 to 2002

Area recycled in situ with Foamed Bitumen [million m²]

Year

Projects with Foamed Bitumen bounded Layers