What is Foamed Bitumen?

2 – 3 % 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.
Nature of Bitumen Dispersion

0.425mm

Key Characteristics

- Non-continuously bound (spot welds)
- Millions of elastic points
- Stress dependent behaviour (granular)
- Non temperature sensitive
Characteristics of Foamed Bitumen treated material

- **Bituminous binder**
  - Low
  - Medium
  - High

- **Cement**
  - Low
  - Medium
  - High

- **Increasing permanent deformation resistance**
  - Strongly cemented
  - Lightly cemented
  - Stabilised Modified
  - Unbound Material, Crushed Stone, Gravel, Soil
  - Foamed bitumen treated material containing cement
  - Foamed bitumen treated material without cement
  - HMA

**Soaked CBR value at Specified Density**

**AASHTO CLASSIFICATION OF NATURAL MATERIAL BEFORE STABILISATION**

**EXPECTED APPLICATION RATE OF FOAMED BITUMEN FOR STABILISATION (% by mass)**

**STRUCTURAL LAYER COEFFICIENTS AFTER STABILISATION**

**ANTICIPATED MATERIAL CHARACTERISTICS AFTER STABILISATION**

**SUGGESTED STRUCTURAL LAYER COEFFICIENTS FOR FOAMED BITUMEN STABILISED MATERIAL**

**INDICATIVE FIELD STIFFNESS**

For design traffic greater than 300 000 ESAL's the Indirect Tensile Strength (ITS) value should always be obtained from the foamed bitumen mix design. See table below for appropriate Tensile Strength Ratio (TSR).

1. **Initial Stiffness**
   - Phase 1 (MPa)
   - Phase 2 (MPa)
   - Indefinite range (MPa)

2. **Steady Stiffness**
   - Phase 1 (MPa)
   - Phase 2 (MPa)
   - Indefinite range (MPa)

3. **Indirect Tensile Strength (kPa)**

4. **Structural Layer Coefficients (per cm)**

5. **Nominal Size**

6. **Soaker CBR value at Specified Density**

7. **Material mixing percentages**

8. **Design traffic**

9. **Expected application rate**

10. **Structural layer coefficients**

11. **Soaked CBR value at Specified Density**
**Suggested Structural Layer Coefficients for Foamed Bitumen Stabilised Material**

<table>
<thead>
<tr>
<th>Indirect Tensile Strength (kPa)</th>
<th>0.051</th>
<th>0.063</th>
<th>0.063</th>
<th>0.103</th>
<th>0.120</th>
<th>0.140</th>
</tr>
</thead>
<tbody>
<tr>
<td>per cm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>per inch</td>
<td>0.13</td>
<td>0.16</td>
<td>0.21</td>
<td>0.26</td>
<td>0.30</td>
<td>0.35</td>
</tr>
</tbody>
</table>

**Structural Layer Coefficients After Stabilisation**

<table>
<thead>
<tr>
<th>Indirect Tensile Strength (kPa)</th>
<th>100</th>
<th>150</th>
<th>200</th>
<th>300</th>
<th>400</th>
<th>500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Stiffness Phase 1 (MPa)</td>
<td>500</td>
<td>750</td>
<td>1000</td>
<td>1500</td>
<td>2000</td>
<td>2500</td>
</tr>
<tr>
<td>Steady Stiffness Phase 2 (MPa)</td>
<td>250</td>
<td>450</td>
<td>600</td>
<td>800</td>
<td>950</td>
<td>1050</td>
</tr>
</tbody>
</table>

**Indicative Field Stiffness**

<table>
<thead>
<tr>
<th>CBR</th>
<th>10</th>
<th>20</th>
<th>40</th>
<th>60</th>
<th>80</th>
<th>CBR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SN</strong></td>
<td><strong>4.89</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Layer thickness x &quot;structural coefficient&quot; = SN</strong></td>
<td><strong>24 million</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Subgrade CBR</strong></td>
<td><strong>10</strong></td>
<td><strong>175 / 25.4 x 0.35</strong></td>
<td><strong>2.411</strong></td>
<td><strong>+</strong></td>
<td><strong>2.008</strong></td>
<td><strong>0.472</strong></td>
</tr>
<tr>
<td><strong>FC / GCS</strong></td>
<td><strong>SN</strong></td>
<td><strong>ACT = 4.891</strong></td>
<td></td>
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</tr>
</tbody>
</table>
N7 Rehabilitation project near Cape Town

2.3% foamed bitumen / 1% cement

After 10 million E80 load repetitions

- 19mm Novachip surfacing
- 35mm HMA binder layer
- 250mm foamed bitumen stabilised base
- 150mm crushed stone subbase
- Sand subgrade

NO CRACKING

6mm RUT (subbase)
Pavement Design

- Design as per "The Design and use of FB treated materials" September 2002, Asphalt Academy, South Africa – TG2 (currently under review but still conservative and only official design guide there is)

- Model the foamed bitumen layer in two phases
  - Phase 1: FB layer modelled as a asphalt layer with resilient modulus between 1800 and 2400 Mpa
    \[
    MR_{Phase1} = (\log(ITS_{equ}) \times 3950 - 7000) \times TSR \times F_{drainage}
    \]
  - Phase 2: FB layer modelled as a superior granular layer with resilient modulus between 800 and 1000 MPA
    \[
    MR_{Phase2} = \frac{M_{Phase1} \times TSR}{(0.5 \times UCS_{equ}) + 0.7}
    \]