High Modulus Asphalt (EME)
Warm mixes
Wearing Course - Thin and Very Thin Layer
EME - High Modulus Asphalt

- Pavement structure
- Mechanical Performances of EME
- Mix design of EME
- Effect on Pavement design
- Production / laying
- Recent development in Europe
- Conclusion
Pavement structure

- **Pavement layer functional dissociation**

<table>
<thead>
<tr>
<th>Wearing Course</th>
<th>Binder course</th>
<th>Base course</th>
<th>Sub base</th>
<th>Subgrade</th>
</tr>
</thead>
</table>

**Surface layers**
- Structural characteristics ➔ protection of the support
- (Thermical and Mechanical – stress distribution)

**Waterproofing**

**Surface Characteristics**

**BBTM, BBM, BBSG, BBDr, BBME**
- Skid resistance
- Noise
- Color
- Waterproofing

**GB EME**
- Roads bear traffic
- Materials bear stress

- Pavement design
  - Calculation of stresses and strains in layers
  - mechanical characteristics of asphalt mixes (including modulus)

- Mix design to make Asphalt that can bear traffic
History - Evolution of Base course mixes

<table>
<thead>
<tr>
<th>Year</th>
<th>GB</th>
<th>EME 2</th>
<th>EME 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>80/100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1976</td>
<td>Very hot summer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1978</td>
<td>60/70 or 35/50</td>
<td>10/20</td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>35/50</td>
<td>20/30</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>35/50 or 20/30</td>
<td>10/20 or 20/30 or 25/35</td>
<td></td>
</tr>
</tbody>
</table>
Evolution of Base course mixes

- **Performance improvements**
  - Stiffer
  - Improvement of fatigue behaviour
  - Higher rutting resistance

- **Technical Economic optimisation**
  - Thinner thickness
  - Better response to the increase of traffic aggressivity

- **Savings in raw materials, maintenance and related traffic disruption**
# Base course Asphalt Mixes

According to NF EN 13108-1 EB 14 Assise 35/50 (GB) and EB 14 Assise 10/20 (EME)

<table>
<thead>
<tr>
<th>Type</th>
<th>Max Aggr size</th>
<th>Binder</th>
<th>Binder Content (%)</th>
<th>Void content %</th>
<th>Thickness (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GB</td>
<td>14 et 20</td>
<td>35/50</td>
<td>4 to 5</td>
<td>6 to 8</td>
<td>8 to 16</td>
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<tr>
<td></td>
<td>20/30</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>EME</td>
<td>10-14-20</td>
<td>10/20</td>
<td>4.5 to 6.2</td>
<td>3 to 6</td>
<td>6 to 15</td>
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</tr>
</tbody>
</table>
**Base course mixes - Main properties**

According to NF EN 13108-1 EB 14 Assise 35/50 (GB) and EB 14 Assise 10/20 (EME)

<table>
<thead>
<tr>
<th>Type of mix</th>
<th>Giratory (Voids %)</th>
<th>C80 (D 10mm)</th>
<th>C100 (D 14mm)</th>
<th>C120 (D 20 mm)</th>
<th>Water sensitivity r/R ratio</th>
<th>Rut depth (60°C-100 mm) 10,000 cycles (%)</th>
<th>Rut depth ** 30,000 cycles (%)</th>
<th>Stiffness modulus (15°C-10Hz) in MPa</th>
<th>Fatigue – admissible strain (@ 1 million de cycles)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GB</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class 2</td>
<td>≤ 11</td>
<td>≥ 0.65</td>
<td></td>
<td></td>
<td>≤ 10*</td>
<td>≥ 9,000</td>
<td>≥ 80.10^-6</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>GB</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class 3</td>
<td>≤ 10</td>
<td>≥ 0.7</td>
<td></td>
<td></td>
<td>≤ 10*</td>
<td>≥ 9,000</td>
<td>≥ 90.10^-6</td>
<td></td>
<td></td>
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<tr>
<td><strong>GB</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class 4</td>
<td>≤ 9</td>
<td>≥ 0.7</td>
<td></td>
<td></td>
<td>≤ 10**</td>
<td>≥ 11,000</td>
<td>≥ 100.10^-6</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>EME</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class 1</td>
<td>≤ 10</td>
<td>≥ 0.7</td>
<td></td>
<td></td>
<td>≤ 7.5**</td>
<td>≥ 14,000</td>
<td>≥ 100.10^-6</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>EME</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>class 2</td>
<td>≤ 6</td>
<td>≥ 0.75</td>
<td></td>
<td></td>
<td>≤ 7.5**</td>
<td>≥ 14,000</td>
<td>≥ 130.10^-6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Mix design of EME

- Workability
- Water resistance
- Rutting resistance

Level 1

Level 2
- Level 3
- Modulus
- Fatigue resistance

Level 3 + Level 4

General requirement

Level 1 + Level 2

Fundamental Approach
In EN 13108-1

- >14000 MPa
- 15° C -10Hz
- >130 μdef (10° C 25Hz)
Mix design of EME

Mix design:
- Low void content (Laboratory study 3 to 6%)
- Use of hard binder (rutting + Modulus) 10/20 15/25 20/30
- Grading curve (D max 20 mm)
- High Binder content ~ 5.7% (fatigue)

Combination:
- High resistance to rutting
- High modulus 14000 MPa [15°C - 10Hz]
- High resistance to fatigue 130 µdefs [10°C 25Hz]

<table>
<thead>
<tr>
<th>National Road Network TC6 / PF3 30 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiche</td>
</tr>
<tr>
<td>BBTM</td>
</tr>
<tr>
<td>BBSG binder</td>
</tr>
<tr>
<td>Base</td>
</tr>
<tr>
<td>Foundation</td>
</tr>
<tr>
<td>Total thickness</td>
</tr>
</tbody>
</table>

Trafic : 20 Millions equivalent standard axle 130 kN, Support E = 120MPa
Results on Pavement design

Pavement design guide SCETAURROUTE for Motorways

<table>
<thead>
<tr>
<th>Motorway T0+ / PF3</th>
<th>GB3</th>
<th>EME 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comparison</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BBTM</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>BBME</td>
<td>5.0</td>
<td>-</td>
</tr>
<tr>
<td>Base</td>
<td>11.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Foundation</td>
<td>13.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Total thickness</td>
<td>31.5</td>
<td>22.5</td>
</tr>
</tbody>
</table>

Traffic: 20 millions equivalent standard axle 130 kN, Support E = 120MPa
Production - Laying

- **Hard binder (Higher viscosity)**
  - Mixing temperature 160-180 always < 190°C
  - Minimal temperature for laying 145°C

- **Production control**
  - Aggregates (grading curve)
  - Binder class and content

- **Compaction**
  - Quality of the sub base
  - Reach good in-place density
  - Warranty of Mechanical performances

- **Laying**
  - Bearing capacity of the sub base
  - Respect of thicknesses (Pavement Service Life)
  - Bonding between layers (tack coat)
Recent Development in Mauricius

- **EME 0/14**
  - Hard binder 20/30 (south africa)
  - Highway A13 10 cm on 6,9 km
  - Triolet 7cm on 5,6 km

- **25000 T of asphalt mix**
  - Improvement of performances allows significant thickness reduction without decrease of lifetime and also reduction of GHG
Conclusion

- **EME**: Now ~ 20 years of experience

- **Main steps for development are the followings**:  
  - Knowledge of existing Base course
  - « Fundamental approach » Modulus Fatigue → Benefit of EME

- **Available resources**:  
  - Hard binder
  - Aggregates (grading)
  - Eventually additives if no hard binder

- **Specific context**: for example, resistance to low temperature (ex Poland)

- **Selection of component for EME mix design**
- **Evaluation of Mechanical performances (Modulus + Fatigue)**