The development of EME in Europe requires an appropriate approach for the climate

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NCCA, Nynas NV
Introduction

- Growing and heavier traffic: roads stressed more
- “Enrobés a Module Elevé” – EME
  - Increased stiffness
  - But remains ‘flexible’
    - Bitumen – visco-elastic behaviour
    - Less prone to cracking in comparison to concrete
  - Bitumen: harder than normal ‘pen grade road bitumen’
    - Depending climate: 10/20 to 20/30
    - Optimisation bitumen/mix design: balance stiffness (rutting) and fatigue
Development and History

France – 2 classes - requirements:

- Performance of the asphalt mix:
  - Compaction – workability
    (voids by gyratory)
  - Resistance to rutting
    (French wheeltracking at 60°C – 30000 cycles)
  - Stiffness of the mix
    (2 point bending test, 15°C and 15 Hz)
  - Resistance to fatigue
    (2 point bending test, 10°C and 25 Hz)
  - Durability - water sensitivity
## Overview requirements EME

<table>
<thead>
<tr>
<th></th>
<th>EME class 1</th>
<th>EME class 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gyratory compaction</strong></td>
<td></td>
<td></td>
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<tr>
<td>% voids @ C80 (D 10 mm)</td>
<td>%</td>
<td>&lt;10</td>
</tr>
<tr>
<td>C100 (D 14 mm)</td>
<td></td>
<td>&lt;6</td>
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<tr>
<td>C120 (D 20 mm)</td>
<td></td>
<td></td>
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<tr>
<td><strong>Rutting resistance</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60°C &amp; 30000 cycles</td>
<td>%</td>
<td>7.5</td>
</tr>
<tr>
<td><strong>Dynamic modulus</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15°C &amp; 10 Hz</td>
<td>&quot;MPa&quot;</td>
<td>14000</td>
</tr>
<tr>
<td><strong>Fatigue resistance @ 1 million cycles</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10°C &amp; 25 Hz</td>
<td>µstrain</td>
<td>100</td>
</tr>
<tr>
<td><strong>Duriez (water sensitivity)</strong></td>
<td></td>
<td>&gt; 0.7</td>
</tr>
<tr>
<td>r/R ratio</td>
<td></td>
<td>&gt; 0.75</td>
</tr>
</tbody>
</table>

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**Note:**
- C: Coarse aggregate
- D: Fine aggregate
- %: Percentage
- "MPa": Megapascal
- µstrain: Micron strain
- r/R ratio: Radial to axial ratio
Requirements binder in EME

- Good quality mineral
- Hard bitumen: EN13924
  - + (new) rheological tests: DSR – BBR – DDT
- Bitumen film thickness – minimum percentage bitumen (assure durability)

**MODULE DE RICHESSE (Richness modulus)!**

- Measure for film thickness on the aggregate skeleton

\[ \% \text{ bitumen} = \alpha \times K \times \varepsilon^{1/5} \]
Module de Richesse

\[ K = "module de richesse" \text{ (Minimum 3.4 in France – EME 2 – advised 3.6)} \]

\[ \% \text{ bitumen} = \alpha \times K \times \varepsilon^{1/5} \]

\[ \alpha = \frac{2.65}{\gamma G} \]

\[ \gamma G = \text{apparent density of the aggregates mix} \]

\[ \varepsilon = \frac{0.25G + 2.3S + 12s + 135f}{\text{conventional specific surface}} \]

\[ G = \text{percentage on sieve 6.3 mm} \]

\[ S = \text{percentage of mineral through sieve of 6.3 mm and on sieve of 300 \( \mu m \)} \]

\[ s = \text{percentage of mineral through sieve of 300 \( \mu m \)} \]

\[ f = \text{percentage through sieve of 75 \( \mu m \)} \]
Module de Richesse (cont.)

• Bitumen amount also determined by the used aggregates/minerals!
  – Density
  – Specific surface
  – Gradation curve

• Changing film thickness can influence the durability of the road!

• **DANGER:** Fixing the bitumen percentage in the tender or specification standard!

• Prescribe the binder content in volume percent or use this *Module de Richesse* formula in the tender document!
# Effect changing parameters

<table>
<thead>
<tr>
<th>AGGREGATES</th>
<th>PORPHYRY TYPE</th>
<th>PORPHYRY TYPE</th>
<th>BASALT TYPE</th>
<th>BASALT TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gradation&gt; % passing sieve</td>
<td></td>
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<tr>
<td>• 31.500</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>• 6.300</td>
<td>55.4</td>
<td>55.4</td>
<td>55.4</td>
<td>57.5</td>
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<tr>
<td>• 0.315</td>
<td>12.6</td>
<td>12.6</td>
<td>12.6</td>
<td>18.7</td>
</tr>
<tr>
<td>• 0.080</td>
<td>7.6</td>
<td>7.6</td>
<td>7.6</td>
<td>8.2</td>
</tr>
<tr>
<td>Calculation G</td>
<td>45%</td>
<td>45%</td>
<td>45%</td>
<td>43%</td>
</tr>
<tr>
<td></td>
<td>S 43%</td>
<td>43%</td>
<td>43%</td>
<td>39%</td>
</tr>
<tr>
<td></td>
<td>s 5%</td>
<td>5%</td>
<td>5%</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>f 8%</td>
<td>8%</td>
<td>8%</td>
<td>8%</td>
</tr>
<tr>
<td>Eta Ε</td>
<td>11.96</td>
<td>11.96</td>
<td>11.96</td>
<td>13.38</td>
</tr>
<tr>
<td>Aggregate density (g/cm)</td>
<td>2.7</td>
<td>2.7</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Alpha = 2.65/ aggr.dens</td>
<td>0.9815</td>
<td>0.9815</td>
<td>0.8833</td>
<td>0.8833</td>
</tr>
<tr>
<td>BINDER</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Binder [ppc] - on aggregates</td>
<td>5.7</td>
<td>5.2</td>
<td>5.2</td>
<td>5.2</td>
</tr>
<tr>
<td>in mix</td>
<td>5.4%</td>
<td>4.9%</td>
<td>4.9%</td>
<td>4.9%</td>
</tr>
<tr>
<td>K (module de richesse &gt; 3.4)</td>
<td>3.67</td>
<td>3.23</td>
<td>3.58</td>
<td>3.5</td>
</tr>
</tbody>
</table>

- Change gradation
- Change mineral; other γ
- Go to min binder content
- www.irf2010.com
EME in Europe

U.K.

PL

BE
EME in Europe

Adaptation mix and/or bitumen type and performance requirements

• Depending country/climate/traffic loading/available minerals

U.K. • High Modulus base (3.5% bit) replaced by EME (M.R. = 3.6 (> 5.4% bit))

BE • EME class 2 – extra demands on the bitumen

NL • some test sections – French tests – 15/25 bitumen

Moderate climate (Oceanic climate): 10/20 or 15/25 bitumen
EME in Europe

**Poland**
- Combination requirements EME class 1 and 2
  - Climate more severe
  - Lower traffic load

**Finland**
- EME better than concrete

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**Continental and Nordic climate**
**20/30 bitumen**
**Other approach EME mix and binder design**
Nynas approach: Binder

- Not all hard binders fit for purpose
- Optimisation balance stiffness and fatigue
  - **Stiffness bitumen** ~ stiffness asphalt (high S)
    - Selection simple
  - **Fatigue**: Literature not unambiguous
    - Phase angle, p.i., m from BBR, ...
    - Nynas: alternative via fatigue measurements on the bitumen – rheometer
  - **Raw material**: selection and processing
    - Nypave FX 20 and Nypave FX 15
Nynas approach: Mix

- Demonstrate fit for EME class 2
- **Suspicion**: most critical = stiffness and fatigue
- **Attention**: despite stiff and hard bitumen, rutting because of high bitumen percentage
- **Optimisation** gradation curve needed!
  - Not decrease bitumen percentage
Optimisation mix

Mineral – Binder Mod.richesse

Fatigue $E^6$

Stiffness (MPa)

Rutting (%)

Durability ($r/R$)

Too much rutting

Red: Specification class 2
Blue: Nypave FX 15 test 2
Green: Nypave FX 15 test 1
Design calculation models

• Some ‘inexperienced’ users believe that road design calculation models predict reality

• Very high stiffness levels are used to calculate reductions of thickness of more than 50%

• This can result in exploding risk levels and early life failure

Do not apply thickness reduction of more that 20 to 25% versus the original structure!
EME = Optimization

Mix design • Not ‘standard’ Marshall thinking – change in mix design – performance testing

Binder • Not all hard bitumen are suitable
  – Balance between sufficient stiffness and resistance against fatigue remains the main challenge

Application • “Optimisation” compaction
Conclusions

• Binderfilm thickness is of utmost importance

• Neglecting this “law of nature” will cause early life damage

• Be careful with translating stiffness in thinner constructions
EME Technology needs a co-operation between Government, specifier, asphalt producer, contractor and bitumen supplier
EME requires as much ‘High tech‘ knowledge as a feel for the mix

Hope for more “EME believers” in Europe and to success for EME (BINDERS) in the future