Implementing High Modulus Asphalt (EME2) pavement and mix design in Queensland

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Presentation outline

- What is EME2 high modulus asphalt?
- Performance based mix design and Australian EME2 specification limits
- EME2 demonstration trials and ongoing monitoring
- EME2 pavement design within the Austroads framework
- Future directions.
What is High Modulus Asphalt (EME2)?

Properties:
- workable
- stiff
- rut resistant
- fatigue resistant
- moisture resistant

Achieved by:
- high binder content ≈ 6%
- hard binder: penetration 10-25 pu
- low air voids content < 6%
- performance based design method.
Volumetric properties of a typical AC20 mix

Volumetric properties of an EME2 mix
## EME2 mix design criteria

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Unit</th>
<th>Limit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air voids in specimens compacted by gyratory compactor at 100 cycles</td>
<td>EN 12697-31, AS/NZS 2891.2.2</td>
<td>%</td>
<td>Maximum</td>
<td>6</td>
</tr>
<tr>
<td>Water sensitivity</td>
<td>EN 12697-12, AG:PT/T232</td>
<td>%</td>
<td>Minimum</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>%</td>
<td>Minimum</td>
<td>80</td>
</tr>
<tr>
<td>Wheel tracking at 60°C and 30,000 cycles (60,000 passes)</td>
<td>EN 12697-22, AG:PT/231</td>
<td>%</td>
<td>Maximum</td>
<td>7.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>mm</td>
<td>Maximum</td>
<td>6.0</td>
</tr>
<tr>
<td>Minimum flexural stiffness at 50 ± 3 µε, 15°C and 10 Hz</td>
<td>EN 12697-26 method A, AG:PT/T274</td>
<td>MPa</td>
<td>Minimum</td>
<td>14,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MPa</td>
<td>Minimum</td>
<td>14,000</td>
</tr>
<tr>
<td>Fatigue resistance at 10°C, 25 Hz and 10⁶ cycles</td>
<td>EN 12697-24 method A, AG:PT/T274</td>
<td>µε</td>
<td>Minimum</td>
<td>130</td>
</tr>
<tr>
<td></td>
<td></td>
<td>µε</td>
<td>Minimum</td>
<td>150</td>
</tr>
<tr>
<td>Richness modulus</td>
<td>N/A</td>
<td>–</td>
<td>Minimum</td>
<td>3.4</td>
</tr>
</tbody>
</table>
Objectives of the trial(s)

• Construction and production
• Benchmarking/mix design specification
• Pavement design.
Activities around the trial(s)

Monitoring Cullen Avenue West, Queensland

- Ongoing FWD measurement at known pavement temperatures – capturing seasonal variation
- Monitoring pavement behaviour with different subgrade bearing capacity
- Back-calculation of in situ properties – cross validate with laboratory results
- Monitor functional performance, i.e. rutting, IRI
- *We know everything about the pavement structure and the materials*

Other trials/projects

- South Gippsland Highway (VIC)
- Sydney (NSW)
- Brisbane City Council (QLD)
- Gold Coast City Council (QLD)
- Perth (WA) – in preparation
Cullen Avenue West, Eagle Farm
Pavement design and mix design in France

\[ \varepsilon_{t,allow} = \varepsilon_6(10\degree C; 25\text{Hz}) \times \sqrt{\frac{E(10\degree C; 10\text{Hz})}{E(\theta_{eq}; 10\text{Hz})}} \times \left(\frac{NE}{10^6}\right)^b \times k_c \times k_r \times k_s \]

- Incorporates design option at any given temperature
- Considers risk and in situ performance of the different asphalt mixes
- Enables innovation, calls for improvement in the mix design, which can be realised in the pavement design
Austroads transfer function

\[ S_{mix} = f(S_{bitumen}; V_{bitumen}; V_{aggregate}) \]

\[ N = RF \left[ \frac{6918 \times (0.856 \times V_b + 1.08)}{E^{0.36} \times \mu \varepsilon} \right]^5 \]

This prediction works relatively well for the majority of mixes with plain binder. However, benefits from improvements in mix performance cannot be realised.

Two mixes may have the same binder content and perform differently
Transferring the French pavement design procedures to Queensland

<table>
<thead>
<tr>
<th>Option</th>
<th>Consistent with existing systems</th>
<th>Immediate adoption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved Austroads method</td>
<td>✓ (mostly)</td>
<td>x</td>
</tr>
<tr>
<td>The French method (in full)</td>
<td>x</td>
<td>✓ (maybe)</td>
</tr>
<tr>
<td>Existing Austroads method (benchmark against the French method)</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
Pavement thicknesses in France – High traffic volume

<table>
<thead>
<tr>
<th>Traffic category</th>
<th>Total pavement thickness (mm)</th>
<th>PF3, Ev2 = 120 MPa</th>
<th>PF4, Ev2 = 200 MPa</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GB3 pavement structure</td>
<td>EME2 pavement structure</td>
<td>GB3 pavement structure</td>
</tr>
<tr>
<td>TC8se</td>
<td>94 million HV (75 million ESA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>450</td>
<td>40/110/120</td>
<td>40/130/110</td>
</tr>
<tr>
<td>TC7se</td>
<td>38 million HV (30 million ESA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>410</td>
<td>40/100/110</td>
<td>40/110/140</td>
</tr>
</tbody>
</table>

- **Surface course + intermediate layer**
- **Base course, GB3, heavy duty DGA**
- **Base course, EME2, high modulus asphalt.**

AN INITIATIVE BY:
Presumptive values for elastic characterisation

<table>
<thead>
<tr>
<th>Asphalt mix type</th>
<th>Binder type</th>
<th>Volume of binder (%)</th>
<th>Asphalt modulus at heavy vehicle operating speed (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>10 km/h</td>
</tr>
<tr>
<td>EME2</td>
<td>EME binder (15/25 pen)</td>
<td>13.5</td>
<td>2000</td>
</tr>
<tr>
<td>AC20</td>
<td>C600</td>
<td>10.5</td>
<td>1500</td>
</tr>
</tbody>
</table>

- Austroads temperature correction suitable for EME2 mixes
Pavement thickness comparison

- EME2 (E=4200 MPa, Vb=13.5%)
- DG20 (C600) (E=3100 MPa, Vb=10.5%)
- DG20 (C320) (E=2600 MPa, Vb=10.5%)
Pavement support

**French method**
- Subgrade soil classification + long-term moisture condition
- Select treatment (material type and thickness)
- Achieve minimum platform (PF) category

**Queensland method**
- Subgrade strength at long-term moisture condition
- Select treatment (material type and thickness)
- Austroads sublayering to achieve minimum top modulus of 150 MPa
Case study – high traffic road in south east Queensland

Option 1 – DG20HM base

- 50mm SM14 asphalt
- 50mm DG14HS asphalt
- 250mm DG20HM asphalt (placed in 3 or 4 layers)

Option 2 – EME2 base

- 50mm SM14 asphalt
- 50mm DG14HS asphalt
- 190mm EME2 asphalt (placed in 2 layers)

150mm improved layer

Subgrade
(design CBR 7%)
Summary

Validation
- Extensive laboratory testing
- Production and demonstration trials
- Pavement design case studies

EME2/benefit
- Technology transfer, including mix design and pavement design
- Reduced pavement cost
- Less paving operations
- Better solution in constrained urban environment
Thank you for your attention!

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EME2 mix design – PSTS107:
http://www.aapaqmr.org/eme_ws1.html

EME2 pavement design – Technical Note TN142:

Mix design technical background:

Webinar: