Australian Asphalt Pavement Association

EME – long lasting structural layer

Robert Vos – State Executive Officer - Queensland
EME – long lasting structural layer

Robert Vos – State Executive Officer – Queensland
Trevor Distin – National Technology Manager – Boral Asphalt

Based on paper & presentation to:
Queensland Transport & Main Roads - Engineering Technology Forum 2014
Enrobés à Module Elevé (EME2)
High modulus asphalt
Outline

1. Introducing EME into Australia
2. EME principles & design
3. Performance benefits
4. Australian implementation
5. 1st demonstration project in Australia
6. Status of demonstration projects
7. Conclusions
1. Introducing EME into Australia

- 1980s French company mixes for “urban” use
- 1990’s Into state roads with standard specs
- Solutions $\rightarrow$ EME1 $\rightarrow$ EME2 modulus & fatigue
- Very hard binders | fatigue & modulus | thinner pavements
- 20+ years of experience $\rightarrow$ performance & 13t axle
- Airbus A380 very heavy loads $\rightarrow$ EME2 airports

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AAPA 2011 Study Tour to South Africa
South African EME demo
# Master Class – Premium Asphalt Bases 2012

## Programme

<table>
<thead>
<tr>
<th>Time</th>
<th>Presenter</th>
<th>Affiliation</th>
<th>Topic</th>
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<tbody>
<tr>
<td>9:30-10:00</td>
<td>REGISTRATION &amp; REFRESHMENTS</td>
<td>PREMIUM ASPHALT BASES (PAB)</td>
<td>Welcome &amp; Introduction</td>
</tr>
<tr>
<td>10:00-10:10</td>
<td>Warren Carter</td>
<td>National Tech Committee</td>
<td>Learnings from the Study Tours on PAB – EME2, HIMA, GB5</td>
</tr>
<tr>
<td>10:10-10:30</td>
<td>Rob Vos</td>
<td>AAPA</td>
<td>EME2 &amp; HiMA – understanding the performance requirements</td>
</tr>
<tr>
<td>10:30-11:15</td>
<td>Erik Denneman</td>
<td>ARRB</td>
<td>PAB - the role of the binder</td>
</tr>
<tr>
<td>11:15-12:00</td>
<td>Nigel Preston</td>
<td>Shell</td>
<td>PAB – design and manufacture in Australia</td>
</tr>
<tr>
<td>12:00-12:45</td>
<td>LUNCH BREAK</td>
<td></td>
<td>Update on AAPA Asphalt Long Life Pavement Design Project</td>
</tr>
<tr>
<td>12:45-1:30</td>
<td>Trevor Distin</td>
<td>Boral Consultant</td>
<td>EME, the French Experience</td>
</tr>
<tr>
<td>1:30-2:00</td>
<td>Ian Rickards</td>
<td>Colas International</td>
<td>GB5</td>
</tr>
<tr>
<td>2:00-2:45</td>
<td>Etienne le Bouteiller</td>
<td>Colas International</td>
<td>GB5</td>
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<tr>
<td>2:45-3:15</td>
<td>REFRESHMENT BREAK</td>
<td></td>
<td>GB5</td>
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<tr>
<td>3:15-4:00</td>
<td>Francois Olard</td>
<td>Eiffage Travaux Publics</td>
<td>GB5</td>
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<tr>
<td>4:00-4:30</td>
<td>Warren Carter / SRA representative</td>
<td>AAPA &amp; ARWG</td>
<td>Industry and SRA’s trialling PAB</td>
</tr>
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Master Class 2013

EME JOB MIX FORMULA

- Influence of aggregates / grading curve
  - Optimized curve needed
  - $E^*$ and $\varepsilon_0$ if % voids

- Influence of Bitumen characteristic
  - $G^*$ and PI value

- Influence of bitumen content
  - $\varepsilon_6$ if % bitumen
  - (but $E^*$ and Rut)

Binder content + 1% / formula

CONCLUSION

How to introduce EME:

- Local assessment needs to be made:
  - Pavement Design method
  - Climatic conditions
  - Testing methods / Performances

Then:

- Implement EME2 characteristics in Design Method
- Find the adequate binder (crucial)
- Perform comparative tests in Laboratory

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</thead>
<tbody>
<tr>
<td>1</td>
<td>08.00 – 08.15</td>
<td>Geoff Youdale</td>
<td>Facilitator</td>
<td>Introduction &amp; Objectives of today’s Master Class in Flexible Pavement design</td>
</tr>
<tr>
<td>2</td>
<td>08.15 – 09.45</td>
<td>Bevan Sullivan</td>
<td>AAPA NTC Fulton Hogan</td>
<td>The AAPA Asphalt Pavement Solutions – for Life Project : Development of a validated Mechanistic Design procedure for long life asphalt pavements in Australia</td>
</tr>
<tr>
<td></td>
<td>09.45 – 10.00</td>
<td>Morning Tea Break</td>
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<tr>
<td>3</td>
<td>10.00 – 11.00</td>
<td>Prof Martin van der Ven</td>
<td>TU Delft, Netherlands</td>
<td>From material fundamentals to field modelling of performance</td>
</tr>
<tr>
<td>4</td>
<td>11.00 – 12.00</td>
<td>Prof Kim Jenkins</td>
<td>Stellenbosch University, RSA</td>
<td>Fundamentals to theory – lessons to be learned from improving granular materials</td>
</tr>
<tr>
<td>5</td>
<td>12.00 – 12.30</td>
<td>Xavier Guyot</td>
<td>Colas Group</td>
<td>Application of design fundamentals in the Oceania Region in the introduction of EME</td>
</tr>
<tr>
<td>6</td>
<td>13.15 – 14.15</td>
<td>Prof David Timm</td>
<td>Auburn University, USA</td>
<td>Status review on NCAT test track performance data on material properties and pavement modelling for design</td>
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<tr>
<td>7</td>
<td>14.15 – 14.45</td>
<td>Dr Erik Denneman</td>
<td>ARRB Group</td>
<td>Australian update on pavement initiatives and future directions – Austroads and industry research</td>
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<tr>
<td>6</td>
<td>14.45 – 15.00</td>
<td>Geoff Youdale</td>
<td>Facilitator</td>
<td>Summary &amp; Conclusions drawn from the day and recommendations for going forwards in Australia</td>
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</table>
2. EME principles & design: French asphalt mix design

- Workability
- Moisture resistance
- Level 1

- Rut resistance
- Level 2

- Modulus
- Binder content
- Level 3

- Fatigue resistance
- Level 4

Bitumen properties
EME2 principles & design

- Increased fatigue life
- Increased modulus life
- Increased rut resistance
- Increased workability
- Decreased moisture sensitivity

<table>
<thead>
<tr>
<th>Performance Property</th>
<th>DG20</th>
<th>EME2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatigue @ 20°C, cycles to failure</td>
<td>40,000</td>
<td>270,000</td>
</tr>
<tr>
<td>Modulus @ 25°C</td>
<td>6.0 MPa</td>
<td>10.8 MPa</td>
</tr>
<tr>
<td>Rutting depth @ 60°C &amp; 60,000 passes</td>
<td>2.9 mm</td>
<td>1.2 mm</td>
</tr>
<tr>
<td>Tensile Strength Ratio and value</td>
<td>99%</td>
<td>101%</td>
</tr>
<tr>
<td></td>
<td>758kPa</td>
<td>1280kPa</td>
</tr>
</tbody>
</table>

Higher binder content
Harder binder
Low air voids
Performance related properties
3. Performance benefits

- Current Australian structural design for asphalt becomes uncompetitive for heavy duty pavements in hot climates
  - Reduce layer thickness of EME2 vs DG20 by 30% (heavy duty pavement 20 – 25% reduction)

- EME2 allows you to build road pavements that
  - can carry heavier axle loadings
  - reduce freight cost & GHG per tonne of freight
  - last longer without structural maintenance
  - reduced user delays during in-service life
  - are more sustainable
  - consume less non-renewable materials, transport and energy
  - performance not affected by global warming
Reduction in layer thickness

<table>
<thead>
<tr>
<th>Design</th>
<th>IDT Modulus @ 30°C &amp; RT = 0.04 sec</th>
<th>IDT Modulus @ 32°C &amp; RT = 0.04 sec</th>
<th>IDT Modulus @ 32°C &amp; 50 kmh</th>
<th>Binder Mass</th>
<th>Binder Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>EME&lt;sub&gt;BO&lt;/sub&gt;R(Q2)</td>
<td>8000</td>
<td>6817</td>
<td>7647</td>
<td>6%</td>
<td>13%</td>
</tr>
</tbody>
</table>

Typical reduction using CIRCLY of 30%

N = RF \[ \frac{6918(0.856 V_b + 1.08)}{S_{mix}^{0.36}} \]^{5} \[ \leq 7650 \text{ MPa} \]
Improved structural life

For the same thickness as dense graded asphalt the EME2 will provide a longer life

- Means less structural maintenance
- Lower life cycle costs
Increase in axle loading

Australian legal single axle quad tyres 9 t

In France legal axle 13 t equates to:

- Efficiencies in goods transport
- Reduction in cost freight per tonne
- More competitive goods for export
Reduction in construction costs

On new or distressed pavements:

- No kerb raising required / bridge clearances OK
- Remove need for waterproofing seals in layers
- Less excavation for new pavements
- Overall reduced pavement width & thickness
- Thinner layers, faster paving, quicker construction
Environmental benefits

Last longer, reduced thickness

- Reduced consumption on non-renewables
  - Bitumen, aggregates
  - Energy in manufacture & transport
- Less structural maintenance & traffic disruption
- Can carry heavier loads reduces GHG emissions per tonne/km of freight
- Pavements less susceptible to climate change
4. Australian implementation

Austroads → ARRB project

- Austroads & AAPA EME2 implementation team
- QTMR → National specification
- QTMR structural design
- Binders → local suppliers
- EME2 design → France
- Agree local test methods
- Performance based design!
EME binders

Fatigue resistance at 10 °C, µstrain vs Modulus at 15 °C, MPa.

- Source A
- Source B
- Source C
- Source D
- RAP
Local EME binders

Viscosity vs Temperature Chart

- C320
- C170
- C600
- AR450
- M1000/pen 43
- SAMI EME binder/pen 19
- Blown bitumen/pen 18

Compaction range
Mixing range

Mixing and compaction range are recommended by SP-2 and ASSHTO T312: as $0.17 \pm 0.02$ Pa.s and $0.28 \pm 0.03$ Pa.s.

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## EME2 test methods

<table>
<thead>
<tr>
<th>Property</th>
<th>French</th>
<th>Australia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workability</td>
<td>Gyro angle 0.85° loading 600 kPa</td>
<td>Gyro angle 2 - 3° loading 240kPa</td>
</tr>
<tr>
<td>Moisture sensitivity</td>
<td>Duriez test 10% air voids</td>
<td>TSR test 8 % air voids</td>
</tr>
<tr>
<td>Rut resistance</td>
<td>Large wheel 60,000 passes @ 50°C</td>
<td>Small wheel 10,000 passes @ 60°C</td>
</tr>
<tr>
<td>Modulus</td>
<td>Direct tensile 15°C @ 10Hz</td>
<td>Indirect tensile 25°C @ 10Hz</td>
</tr>
<tr>
<td>Fatigue</td>
<td>Trapezoidal beam 10°C @ 25Hz</td>
<td>4 point beam 20°C @ 25Hz</td>
</tr>
</tbody>
</table>
5. 1\textsuperscript{st} demonstration project in Australia
AAPA provides team support
Key EME delivery requirements

1. Commitment of all players
2. Goal: Demonstrating ability to deliver EME
3. Local EME quality binder must be available
4. Mix design to performance based standard
5. Current reliance on French specs & lab tests
6. Binder properties impact on fatigue & modulus
7. Australia test methods linked to French results
8. Manufacture & pave to achieve mix design properties
9. Placement & compaction higher temperatures / workable
10. Quality control / contamination prevention / attention to detail
EME placement

Placing of strain gauges in pavement

No natural sand, no lime
Standard paving equipment
Density easily achieved

EME2 being paved and compacted
Whinstanes, Brisbane

French EME2 specification
SAMI binder
Local aggregates & filler
315 tonnes of EME2
EME is now in Australia

First EME in Australia
6. Status of demonstration projects

- EME2 accepted as a viable solution
- Will reduce pavement thickness
- Cost effective & value-for-money alternative
- Additional demo projects on the way

- Master Classes planned for:
  - EME mix design – late 2014
  - EME structural design – early 2015

- Knowledge sessions for asset owners
  - Ports, airports & heavy freight routes
Austroads Project – ARRB EME Technology Transfer report

AAPA 2011 & 2012 Study Tour recommendations

AAPA Master Classes Melbourne → Brisbane & Sydney

AAPA members – binders & demonstration mix design

Demonstration projects – Qld, NSW + Vic??

Supplementary specification – Qld & NSW (French tests & mix design)

Testing using Australian test methods & equipment

Spec limits/values for Australian test methods & equipment

Draft-Interim design procedure / alternative

Introduction into SRA Pavement Design Supplements
EME status in NSW & Qld

- RMS specification for EME being incorporated into R116 based on Qld EME spec
- Fulton Hogan maintenance project imminent for RMS southern Region
- Princes Highway Gerringong off ramp later in 2014
- Berry Bypass pavement scheduled for 2015
- FH have mix designs completed and approved for both NSW and Qld
- FH progressing in Qld to Stage 2 development - translating from completed mix design to parameters for Austroads pavement design
- Projects under review in Gold Coast & North Queensland by Boral
- Toowoomba 2nd Range crossing & Brisbane Airport runway potential alternate pavements
Material Design

- Can take up to 4 months to complete a design
- Test houses can undertake initial mixture blend and PCG tests
  - We are purchasing:
    - French Slab Compactor
    - French Wheel tracker
    - French Gyratory / PCG
    - French Duriez (Water Sensitivity)
  - All available by end 2006
- Performance testing is undertaken by French Laboratories

Manufacturing

- No significant changes from High Modulus Base
- Mix temperatures; maximum 190°C
- Typical blend:
  - Coarse aggregate: 20mm, 14 or 10mm, 6mm
  - Fine aggregate: typically 30-34% on 2mm sieve
  - 6.5% filler content
  - Bitumen content minimums:
    - 0/20mm EME: 5.2%
    - 0/14mm EME: 5.4%
    - 0/10mm EME: 5.6%

Target binder content is set by Binder Richness Modulus with a minimum 3.4%
7. Conclusion

EME Technology Transfer to Australia

- Produced EME binder in Australia
- Designed local EME2 to French standards
- Demonstrated manufacture & paving
- Framework established for local test methods
- Pilot EME2 specification NSW & Qld
- Structural design out soon
- Ready for all the states in Australia