An Evaluation of the Use of WMA Wax Additives in the Production of Unconventional Bituminous Mixtures
Contents

• Literature Review

• Binder characterisation
  – General properties
  – Viscosity (temperature reduction)

• Performance of Mixtures
  – General properties; Water sensitivity
  – Permanent deformation
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• Conclusions
Literature review

• Several processes/products are available to reduce AC production temperatures
  – Physical-chemical means (usually additives, including paraffin waxes)
  – Two phase bitumen introduction
  – Foamed bitumens and emulsions

• These technologies are classified as:
  – WMA (slightly above 100 ºC)
  – Half-WMA (slightly below 100 ºC)
Literature review

• WMA technologies can reduce production temperatures
  – Reducing emissions, fumes and odours
  – Ensuring a cooler work environment and evident energy savings

• However, it is essential that the overall performance of WMA is as good as HMA
  – Otherwise, on a life-cycle basis, WMA will not have long term environmental benefits
Literature review

• The used WMA technology was the addition of a paraffin wax (Sasobit®) to the binder
  – Sasobit® is a Fischer-Tropsch or synthetic wax used as a compaction aid / temperature reducer
  – It melts at approximately 100 °C and changes the temperature-viscosity curve of the binder
  – It reduces by 10-30 °C the mixing temperatures
  – It improves the compactability and the resistance to deformation of WMAs and does not affect their resilient modulus
Objectives of the Study

• A high modulus bituminous mixture AC 20 Base (HMBM) and a high flexibility bituminous mixture AC 14 Surf (HFBM) were studied.

• These HMBMs were produced and compared:
  – with HMA technology (B10/20)
  – with WMA technology (B35/50 + wax)

• These HFBMs were produced and compared:
  – with HMA technology (B50/70)
  – with WMA technology (B160/220 + wax)
Binder Characterisation

- General properties:
  Penetration and Softening Point test results

<table>
<thead>
<tr>
<th>Mixture</th>
<th>HMBM</th>
<th>HFBM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bitumen</td>
<td>10/20</td>
<td>35/50</td>
</tr>
<tr>
<td>Additive</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Pen (0.1 mm)</td>
<td>16.4</td>
<td>37.9</td>
</tr>
<tr>
<td>R&amp;B (°C)</td>
<td>70</td>
<td>52</td>
</tr>
</tbody>
</table>

- 6% wax additive led to penetration values close to those of std binders and outperformed their R&B temperatures.
Binder Characterisation

- Viscosity results / Reduction of temperature

- Compactability test results allowed to increase the temperature reduction from 25 to 30°C and 35 to 40°C
Mixtures composition

Marshall mix design (gradation / binder content)

- The same binder content (HMBM = 5.3%; HFBM = 5.0%), aggregate type and gradation were used for both HMA and WMA mixtures
Water Sensitivity

Water sensitivity tests were carried out according to EN 12697-12 (Indirect Tensile Strength Ratio)

<table>
<thead>
<tr>
<th>Mixture</th>
<th>ITSR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HMBM-HMA (10/20)</td>
<td>85</td>
</tr>
<tr>
<td>HMBM-WMA (35/50+wax)</td>
<td>92</td>
</tr>
<tr>
<td>HFBM-HMA (50/70)</td>
<td>69</td>
</tr>
<tr>
<td>HFBM-WMA (160/220+wax)</td>
<td>72</td>
</tr>
</tbody>
</table>

- ITSR is slightly higher for WMAs (waxes + softer bitumens)
- The influence of the base bitumen penetration is higher than that of the wax additives

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Resistance to permanent deformation

- Wheel tracking test results at 50 °C

<table>
<thead>
<tr>
<th>Mixture</th>
<th>WTS_{AIR} (mm/10^3 cycles)</th>
<th>PRD_{AIR} (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HMBM HMA</td>
<td>0.07</td>
<td>5.13</td>
</tr>
<tr>
<td>WMA</td>
<td>0.06</td>
<td>6.16</td>
</tr>
<tr>
<td>HMBM HMA</td>
<td>0.24</td>
<td>13.55</td>
</tr>
<tr>
<td>WMA</td>
<td>0.25</td>
<td>15.60</td>
</tr>
</tbody>
</table>

- WMA mixtures showed resistance to permanent deformation similar to that of HMA mixtures
Stiffness modulus

4-point bending stiffness test results, carried out at 10, 20 and 30 °C

- Both WMAs have lower stiffness moduli than HMAs, especially at lower temperatures **(higher penetration)**
Fatigue cracking resistance

4-point bending fatigue test results, carried out at 20 °C and 10 Hz

- HMBMs showed similar fatigue performance
- HFBM WMA showed significantly higher fatigue resistance than HFBM HMA
Conclusions

• Softer base bitumens with synthetic wax additives are good to maximise WMA’s temperature reductions (40 ºC – HMBM; 30 ºC – HFBM)

• This additive significantly increases the resistance to permanent deformation of WMA mixtures

• The stiffness moduli of both WMAs was lower than those of corresponding HMAs (soft base bitumen)

• The fatigue resistance of the HFBM WMA was significantly higher than HFBM HMA, while the behaviour of both HMBMs was similar
Thank you for your attention