OUTLINE

1. CONTEXT
2. DEFINITIONS / PROCESSES
3. WARM MIX - DEVELOPMENT FOR COLAS
4. SPECIFICATIONS
5. LATEST DEVELOPMENTS
6. ENVIRONMENTAL ASPECT
7. CONCLUSION

- Greener solutions
- Cost of energy

DEFINITIONS

- HOT MIX > 160°C
- WARM 100°C – 140°C
- HALF WARM 60°C – 100°C
- COLD MIXES UP to 60°C
- Without H2O
- For a transient period

MORE THAN 8 SOLUTIONS

- WAM-Foam
- Sasobit
- Evotherm
- Aspha-Min
- Low Emission Asp
- Double barrel
- Rediset WMX
- Cecabase RT

WARM MIX - DEVELOPMENT FOR COLAS

- 2010
- 2002
- 2004
- 2007
- 2008
- 2010
- First Trial
- RN 157
- Colas Additive
- FOAM trials North America
SPECIFICATIONS FOR WARM MIXES

- Mechanical performances: Warm Mix ≥ Hot Mix
- Preference for solutions without water
- Ability to produce and pave any kind of Mixes
- Suitability for all kind of mixing plants
- Temperature reduction: 30 - 40°C

SINCE 2008
Development to Pmb, RAP

FOAM WMA Colas NA
Existing Foam production systems evaluation in progress

ASTEC Double Green
MAXAM Aquablack
GENCOR Ultra foam

Chemical Additives
Used From 2005 to 2007

Principle: Reduction of the viscosity of the binder

- Performance of Mixes → ok
- Effect of the additive on binders: Increase of TBA and G*
- Limits of this process:
  - Cost of the additive
  - Impact of the additive on the Environmental benefit of the process
Process stopped in 2007

Liquid Chemical Additives
Principle

Effect of the additive at the interface Bitumen/Aggregate

- Performance of Mixes → ok
- No modification of the binder
- Investment reduced
- Solution adapted for all kind of mixes
- Cost of the additive reduced compared to solid additives
- First trial in 2007. Now more than 1 000 000 t of Warm mix paved

Liquid Chemical Additives Mechanical Performances

<table>
<thead>
<tr>
<th>EME CCB</th>
<th>EME 3E CCB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Binder Content</td>
<td>5.21 %</td>
</tr>
<tr>
<td>% RAP</td>
<td>25 %</td>
</tr>
<tr>
<td>Temp (°C)</td>
<td>180°C</td>
</tr>
<tr>
<td>Complex modulus % voids</td>
<td>3.3</td>
</tr>
<tr>
<td>5°-15°C 5Hz (MPa)</td>
<td>16220</td>
</tr>
<tr>
<td>Fatigue</td>
<td>3.3</td>
</tr>
<tr>
<td>% voids at 15°C 23Hz</td>
<td>130</td>
</tr>
</tbody>
</table>

No difference between Warm and Hot
Liquid Chemical Additives

**A75 New Motorway**

- RAP 25% in base course / 20% in surface layer
- Very Thin Asphalt Layer
  - Rugosoft on 225,000 m²
- Warm High Modulus Asphalt
  - RAP 25%
- Last Trials: High RAP content. 2009 RN 2 LAON
  - Base course: 40% RAP / Batch Plant
  - Hot Mix
  - Warm Mix
  - RAP 40%
  - Binder content (%): 4.4
  - Temp (°C): 160, 160, 120
  - % voids at 105°C: 4.1, 5, 4.6
  - Water Resistance: 0.75, 0.86, 0.95
  - Rutting % void content:
    - 1°C: 7.3, 7, 6.7
    - 6°C: 4.2, 3.1, 4.1
  - Modulus (MPa):
    - 15°C: 10852, 12114, 12187
  - Fatigue resistance:
    - ε: 6 µd efs
      - 89, 95, 91
  - On site: No difference in void content and in mechanical performances.

**Liquid Chemical Additives Racing track**

- Warm mixes in base and binder courses
  - RAP 20%

**Energy saving**

- Continuous warm mix production for 1 week
- Measurements 2007 - 2008

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<tr>
<th>Material</th>
<th>Energy saving measured</th>
<th>RD 906 Ecological M DB</th>
<th>17%</th>
<th>51 MJ/t</th>
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Results coherent with previous ones and with Ecologiel

Environmental Aspect

- Improvement of working conditions: significant fumes reduction
- Temperature reduced - less steam
- Also for inhabitants

Energy saving measured

- RD 906 Ecological M DB: 17% 51 MJ/t
- Malalat: 18% 64 MJ/t
- RN 333: -15 to -20% 31 to 40 MJ/t
- A75: -1.1 to 1 ton 81 MJ/t

Results coherent with previous ones and with Ecologiel

Environmental Aspects

- Campaigns conducted with external partners
- Significant measurement point selected
- Difficult to give a precise figure for reduction
  - quantities detected extremely low in control mixes
  - sometimes under detection threshold of available equipment
  - sensitivity to environment
  - influence of worksite, cigarette smoke

Measurements 2007 - 2008

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Also for inhabitants
International Development
- 2008 Romania, UK, Czech Republic, Belgium
- 2009 Poland, Denmark, Hungary, Croatia, Canada (Alberta, Alaska...)
- 2009 Morocco, Réunion Island.

Other Benefit
- Improvement of workability - facilitate specific jobs (bridges)
- Ability to haul the mix on longer distances and still have workability to place and compact (example Nouvelle Caledoine).

Conclusion
- Now more than 1,500,000 t for COLAS
- Spreading of our solutions
  - All products
  - All kind of Jobs
  - All countries
- No failure up to now
  (Respect of manufacturing temperatures, compaction procedure...)
- ... But we still have a look to other possible solutions.