VERY HIGH RECYCLING RATE
(UP TO 70%) IN HMAs & WMAs
FOR SUSTAINABLE ROAD CONSTRUCTION

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- Determining the performances of a typical base course high-modulus asphalt produced at either 95°C (LEA®) or 170°C (HMA), depending upon 2 factors:
  - factor A: % RAP (from 30 to 70%)
  - factor B: fresh binder penetration (from 18 to 61 1/10mm)

- Underlying question:

  *Can we still use high RAP contents in LEA® mixes (<100°C)?
Equipments for recycling at strong rate in plant

‘Double Barrel’ or ‘Double RAP’ drum mix plants
- virgin aggregates (250-300°C)
- up to 50% RAP at ambient T°C in the recycling ring
Parallel drum dryers

- the 1\textsuperscript{st} one for virgin aggregates (200-250°C)
- the 2\textsuperscript{nd} one for RAP (110-150°C)
Energetic & environmental stakes

- Hot Mix Asphalt
- Warm Mix Asphalt
- Half-Warm Mix Asphalt
- Cold Mix Asphalt

**HWMA_LEA® mixes (50% energy savings)**

**kg CO₂ /T**

**L Fuel /T**

- Heating
- Vaporization
- Drying

www.irf2010.com
Traditional HMA production

- **Total drying**: 180°C
- **Coating**: 160°C
- **Stockage**: 150°C
- **Application**: 130-140°C

**LEA® process (90°C, covered by 3 patents)**

- Matching any asphalt plant configuration
- Enabling energy savings up to 50% ($\approx 3L_{fuel/ton \ of \ mix}$)
- Enabling a reduction in CO$_2$ emissions to the same extent ($\approx 9kg \ CO_2/\ ton \ of \ mix$)

[www.irf2010.com](http://www.irf2010.com)
Below 100°C, the residual humidity of aggregates makes the bitumen foam.
Same aggregate squeleton

Graph showing the cumulative proportions of different sieve sizes for R30, R50, and R70, with passing fraction (%) on the y-axis and sieve size (mm) on the x-axis.

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### Same total binder content
(assumption of 100% working RAP binder)

<table>
<thead>
<tr>
<th>RAP content</th>
<th>30 %</th>
<th>50 %*</th>
<th>70 %*</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/20 Haut-Lieu</td>
<td>23,0 %</td>
<td>25,0 %</td>
<td>14,5 %</td>
</tr>
<tr>
<td>6/10 Haut-Lieu</td>
<td>21,0 %</td>
<td>6,0 %</td>
<td></td>
</tr>
<tr>
<td>4/6 Haut-Lieu</td>
<td></td>
<td>5,0 %</td>
<td>6,0 %</td>
</tr>
<tr>
<td>0/4 Haut-Lieu</td>
<td>26,0 %</td>
<td>14,0 %</td>
<td>9,5 %</td>
</tr>
<tr>
<td>0/10 RAP Voglans</td>
<td>30,0 %</td>
<td>50,0 %</td>
<td>70,0 %</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fresh binder content</th>
<th>3,87 (pph)</th>
<th>2,80 (pph)</th>
<th>2,24 (pph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total binder content</td>
<td>5,53 (pph)</td>
<td>5,60 (pph)</td>
<td>5,67 (pph)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sieve</th>
<th>6,3 mm</th>
<th>48,1 %</th>
<th>49,8 %</th>
<th>46,5 %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 mm</td>
<td>28,2 %</td>
<td>27,3 %</td>
<td>26,0 %</td>
</tr>
<tr>
<td></td>
<td>0,25 mm</td>
<td>13,1 %</td>
<td>12,9 %</td>
<td>12,9 %</td>
</tr>
<tr>
<td></td>
<td>0,063 mm</td>
<td>7,9 %</td>
<td>8,2 %</td>
<td>8,4 %</td>
</tr>
</tbody>
</table>
- Laboratory tests used:
  - Gyratory shear compacting press (compactability)
  - Duriez test (water resistance)
  - Complex modulus test (stiffness modulus)
HMAs: Evolution of the compacting ability (%voids at the shear compacting press)
HMAs: Evolution of the moisture resistance (r/R Duriez ratio)
**HMAs**: Complex modulus $E^* @ 15^\circ C - 10Hz$
LEAs: Evolution of the compacting ability (%voids at the shear compacting press)

0.2% additive

1% additive
LEAs: Evolution of the moisture resistance (r/R Duriez ratio)

- **0.2% additive**
  - Pen
  - %RAP

- **1% additive**
  - Pen
  - %RAP
LEAs: Complex modulus $E^*@15\degree C-10Hz$

$Z1 = 0.011 \%R\text{AP} -0.010 \text{Pen} +1.000 \%\text{add}$
$Z2 = 0.046 \%R\text{AP} +0.999 \text{Pen} +0.009 \%\text{add}$
$Z3 = 0.999 \%R\text{AP} -0.046 \text{Pen} -0.012 \%\text{add}$

$E^*(15\degree C,10Hz) = 14467 -788 Z1 -1687 Z2 +560 Z3 +1614 Z1^2 -433 Z2^2 -4371 Z3^2$
Some of our past road works with very high RAP%...
10,000 T of high-modulus HMA (65% RAP) on the French A26 toll highway near Arras
4000-ton LEA® roadwork near Toulouse with up to 50% RAP

⇒ RAP capability with LEA® technique
Conclusions on HMA & LEA® with RAP

- Gyratory compactor: the higher the RAP content (range 30-70%), the more difficult the mix compaction

- Duriez ratio:
  - Hard virgin bitumen & high RAP content may lead to poor moisture resistance
  - For LEA®, the vegetable additive acts as a “compatibilizer”

- Stiffness value:
  - HMA: satisfying high modulus asphalt up to 70% RAP
  - LEA: satisfying high modulus asphalt up to 60% RAP

- On site: 40,000 tons were laid off with very high RAP content
Thank you for your attention!

http://www.lea-co.com