RAP for a sustainable development

Overview: figures (2010 EAPA)

<table>
<thead>
<tr>
<th></th>
<th>RA available</th>
<th>recycled in HWMA</th>
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<tbody>
<tr>
<td>EU</td>
<td>50 Mt</td>
<td>24 Mt</td>
</tr>
<tr>
<td>France</td>
<td>7 Mt</td>
<td>3 Mt</td>
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</tbody>
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<table>
<thead>
<tr>
<th></th>
<th>HWMA production</th>
<th>avail. RA / HWMA prod.</th>
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<tbody>
<tr>
<td>EU</td>
<td>300 Mt</td>
<td>17%</td>
</tr>
<tr>
<td>France</td>
<td>40 Mt</td>
<td>18%</td>
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Overview: different practises in EU

Different local trade-off between:
- RA availability
- Supply of aggregate
- Environmental legislation
- Incentive policies
- Landfill dumping fees
- Hauling costs
- Plants fit for recycling

Overview: RA recycling trends

Percent of available RA recycled

<table>
<thead>
<tr>
<th>Year</th>
<th>Germany</th>
<th>Netherlands</th>
<th>France</th>
<th>Italy</th>
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<tbody>
<tr>
<td>2006</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>2007</td>
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<td>2008</td>
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<td>2009</td>
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<tr>
<td>2010</td>
<td></td>
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Mixing plant fittings

France = 500 mixing plants (< 180 fit for hot recycling)

Max RA content < 30%
Limitation: RA water content

Some plants fit for high RA content

Parallel drum
Max. RA content = 60%
RA : product specifications (EN 13108-8)

Delivery ticket and product sheet shall contain:

- Identification
  supplier, designation (U RA d/D), date time of delivery
- Presence of foreign matter
  F1 = cement, cinder, brick, metal ≤ 1%
synthetic materials, wood, plastics ≤ 0.1%
- Max. size of the RA particles (U)
- Binder content
- Binder type and properties
  paving grade, modified, hard grade, with additive
  mean softening point (R&B) or Penetration (Viscosity at 60°C for soft asphalt)
- Aggregate grading, d and D(max)
- Feedstock quantity

If required:

- Source
  Mix type (EB...)
- Type and properties of aggregate
- Homogeneity of the feedstock

Recycling rate / RA properties

Recommended use of RA in HMA

Assessment of the resulting binder

Combination laws

\[ \log \left( \frac{\lambda_1}{100} \right) - \frac{\lambda_2}{100} - \frac{\lambda_3}{100} \]

\[ \log(\log C_1) = \frac{\lambda_1}{100} - \log(\log C_2) + \frac{\lambda_2}{100} - \log(\log C_3) \]

\[ \lambda_1 + \lambda_2 = 100 \]

Preliminary study in lab

- Assess the sources / homogeneity of RA
- Identification of components (on different road sections and pavement layers):
  binder content and residual properties, granularity of milling, EN 13108-8 requirements
- Formula of new mix with RA (rate of recycling, nature of bitumen or rejuvenator added, aggregates properties)
- Performances must be equal to those of new AC
- Traditional pavement design method

Policy to promote recycling:

in France no new study needed if the rate of recycling is ≤ 15% in binder, base, sub-base courses
Research example: compatibility new-old binder

- Assess degree of heterogeneity RAP bitumen and new binder
- Ageing and mixing simulation in laboratory
- Observation of the distribution of chosen tracers within recycled asphalts by microscopic techniques

*PhD work of Laëtita El Bèze*

<table>
<thead>
<tr>
<th>Aged binder</th>
<th>RAP</th>
<th>New binder</th>
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<tr>
<td>Aggregate</td>
<td></td>
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<tr>
<td>Simulated ageing in laboratory</td>
<td>Aged HMA</td>
<td>Artificial RAP</td>
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<tr>
<td>Multilayer system</td>
<td>Homogeneous mix.</td>
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**Spatial repartition of sulfates**

- Follow up of the spatial repartition of sulfates by X-rays Fluorescence microscopy and XANES microscopy in a synchrotron
- Proposed model: mobilization of the aged bitumen layer leading to partial homogeneity between aged and new binder
- To be confirmed on more realistic RAP

Assessment after 30 years of experience in RAP

- Recycling rate RA in new HMA: 10 to 70%
  - Current average near 20 to 25%
- Global behavior: without major problem, even with PmB excepted on specific sites:
  - Degradations with cracks, fatigue, but also rutting sometimes observed
  - Due to hazardous parameters from RAP (hardening binder, heterogeneity…) or higher rate recycling
- Maintenance study and mix design very important
- Difficulties to take into account the wear of old aggregates on the surface friction properties

Tendencies et evolutions

- WMA techniques (but <2 or 3% of total HMA production)
- Recycling essential to respect the topics of sustainable development
- European know-how sharing:
  - Harmonization of practices in Europe (Direct Mat project – RILEM BIB TSG)
  - Recommendation guide: state of the art, practical advises, specifications, prescriptions,…
- Researches:
  - Accelerated ageing, to predict and anticipate the behaviors on field
  - Recycling with high rate, reach near 100%
  - Performances of binder after recycling: compatibility, homogeneity of mix, influential factors governing binder’s mixing, healing
  - Definition of damage criteria on old AC, to assess the “level of recyclability”
  - Fast RA characterization
  - Inventory and monitoring of existing sites, long term performances survey

Conclusion

- The in plant recycling of RA in HMA is a competitive solution in term of:
  - Environment
  - Technique
  - Economy
  - Energy
  - Sustainable development
- But researches still needed:
  - to improve the whole performances of material, essentially for the prediction of ageing and medium and long time performances
  - to assess the criteria regarding Sustainable Development (LCA)