Cold and Semi-Hot Recycling of Asphalt Pavement in Sweden

by
Torbjörn Jacobson

VTI

Swedish National Road and Transport Research Institute

Asphalt pavements in Sweden

Asphalt production:
- 7 million tons of hot mix
- 1 million tons of cold or semi-hot mix
- 1 million tons of recycled asphalt

Wearing course:
- Surface dressing (30%)
- Cold and semi-hot mix (20%)
- Hot mix (50%)

Recycling of Asphalt Pavement

- Cold recycling: 40%
- Semi-hot recycling: 35%
- Hot recycling: 25%

- Mix in plant
- Mix in place

Reclaimed Asphalt Pavement (Asphalt Granulate)

Asphalt granulate
- Crushed or milled and sorted asphalt pavements
- 0-16 mm for wearing course
- 0-22 mm for road base
- Binder content: 3.0-6.0%
Cold Recycling in Plant

- Bitumen emulsion: 2,0-4,0%
- Aggregate: 10-20%
- Asphalt granulate: 80-100%
- Optimal water content: 6-7%
- Total binder content: 4,5-7,5%

Cold Recycling in Plant

- Easy to move
- Close location to the job site
- Continuous or batch mixer
- Modern control systems
- 100-150 ton per hour

Cold Recycling in Plant - new binder

**Standard**
- BE60M/1500
- BE60M/6000
- BE60M/12000
- BE 60M/160/220

**Special**
- Nyrec 240/pen.330/430
- Nyrec 630/pen.160/220

Semi-Hot Recycling in Plant

- Temperature: 50-80°C
- Batch mixing: 100-150 ton per hour
- Soft bitumen: 1,2-1,8%
- Asphalt granulate: 80-100%
- Aggregate: 0-20%
**Semi-Hot Recycling - new binder**

- Soft bitumen
- 0.8-1.4 % adhesion agent (amin)
- V1500
- V3000
- V6000
- V12000

**Cold Recycling - Mix in Place**

- Bitumen emulsion
  - BE60M/160/220 and 330/430
  - 1.5-4.0% emulsion
- Foamed bitumen
  - 1.0-2.5% bitumen
  - adhesion agent (1%)
- 1-2% cement improve water sensitivity and stability

**Laying and Compaction**

- Cold mix is relatively slow to lay
- Compaction with both steel and rubber tyre roller
- Newly laid pavements can be sensitive to mechanical stresses
Semi-Hot Recycling - Mix in Place

- Temperature: 50-80°C
- For soft bitumen asphalt pavement
- New binder, mix or aggregate is added
- Depth: 0-8 cm

Laboratory tests - step 1

- Sampling
- Characterising old pavement material
  - Binder content, grading of extracted material
  - Compaction curve
  - Grading and moisture content of granulate
  - Penetration, softening point or viscosity of recycled binder

Laboratory tests - step 2

Mix design system for cold or semi-hot asphalt:

- Preparation
  - Sampling composition
  - Mechanical properties
  - Durability

Laboratory tests - step 2

Mix design
- Preparation of specimens
  - Mixing, compaction, curing
- Mechanical properties
  - Stability, Ind. Tensile test, Resilient modulus + air void content
- Durability
  - Water sensitivity

Laboratory tests - step 2

Preparation of test specimen

- Suitable particle grading for granulate:
Laboratory tests - step 3

Quality control

With low traffic volume
- Binder content and grading of mix

With higher traffic volume
- Preparation of specimens from mix, then:
  - Mechanical properties
  - Durability

Test equipment

Laboratory test - requirements for Cold Mix

<table>
<thead>
<tr>
<th>Method</th>
<th>Road base</th>
<th>Wearing course</th>
</tr>
</thead>
<tbody>
<tr>
<td>Void content, volume %:</td>
<td>6-14</td>
<td>4-12</td>
</tr>
<tr>
<td>Marshall stability, 25°C kN:</td>
<td>&gt;7</td>
<td>&gt;5</td>
</tr>
<tr>
<td>Stiffness modulus 1), 10°C, MPa:</td>
<td>&gt;2000</td>
<td>-</td>
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<tr>
<td>Ind. tensile strength, 10°C, kPa:</td>
<td>-</td>
<td>&gt;300</td>
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<tr>
<td>Water sensitivity, %:</td>
<td>&gt;50</td>
<td>&gt;60</td>
</tr>
</tbody>
</table>

Laboratory test - requirements for Semi-Hot Mix

<table>
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<tr>
<th>Method</th>
<th>Road base</th>
<th>Wearing course</th>
</tr>
</thead>
<tbody>
<tr>
<td>Void content, volume %:</td>
<td>5-10</td>
<td>3-8</td>
</tr>
<tr>
<td>Marshall stability, 25°C kN:</td>
<td>&gt;10</td>
<td>&gt;8</td>
</tr>
<tr>
<td>Stiffness modulus, 10°C, MPa:</td>
<td>2000-5000</td>
<td>-</td>
</tr>
<tr>
<td>Ind. tensile strength, 10°C, kPa:</td>
<td>-</td>
<td>&gt;500</td>
</tr>
<tr>
<td>Water sensitivity, %:</td>
<td>&gt;60</td>
<td>&gt;70</td>
</tr>
</tbody>
</table>

Asphalt Pavement is 100% Recyclable.

Thank you!