High RAP Recycling
(In Practice)

Ton Eijkenboom (NL)

Dutch Market

Current Dutch Recycle Market

- Production: 8.0 million MT/Y total
- RAP: 6.0 million MT/Y total
- RAP recycled: 2.8 million MT/Y (35% overall)
- Virgin materials: 5.2 million MT/Y
  - 2.3 million MT stones
  - 2.3 million MT sand
  - 0.3 million MT filler
  - 0.3 million MT bitumen

Starting Point

- Rasenberg / Strukton (Breda NL)
- >50% RAP
- Problem: Bitumen Behavior

Processing RAP as Primary

Urban Mining

- Course Aggregate 10/20
- Fine Aggregate 3/10
- Sand 0/3
- Bitumen

Virgin Bitumen

What is this black stuff?
### Virgin Bitumen

<table>
<thead>
<tr>
<th>Source</th>
<th>Range</th>
<th>S.A.R.A. in w/w %</th>
<th>Saturates</th>
<th>Aromats</th>
<th>Resins</th>
<th>Asphaltenes</th>
<th>Use Temperature Interval (UTI)</th>
<th>Melt Temperature (Psh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PADD II US Gulf</td>
<td>65.0</td>
<td>-20.5</td>
<td>12.7</td>
<td>7.6</td>
<td>3.3</td>
<td>15.2</td>
<td>58.2</td>
<td>8.1</td>
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<td>Sweden Nynas</td>
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<tr>
<td>PADD V US Rocky Mountain</td>
<td>66.7</td>
<td>-24.9</td>
<td>4.6</td>
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<td>PADD V US California Valley</td>
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### Crystallization Process

#### Steric Hindrance Slows Down Crystallisation

- Old Bitumen: asphaltene form rigid structures
- Re-heated Bitumen: break down the structure
- Rejuvenated Bitumen: steric hindrance prevents structures

### The Road to Rejuvenation

#### Chemical Composition Old vs. New Bitumen (2007)

- Tests Rejuvenated Bitumen in Mastic
- DSR Comparison Old vs. Virgin Bitumen
- Market introduction (2013)
- YTD > 250,000 MT asphalt produced with RheoFalt® HP-EM
The Road to Rejuvenation

Iatroscan Chromatogram, Virgin 70/100 Bitumen

Iatroscan Chromatogram, Flux Oil

Iatroscan Chromatogram, RheoFalt® HP-EM

The Products Should be:
- In The Malthene phase
- Temperature Stable
- Non Toxic
- Compatible with bitumen
- Hydrophobic
- Readily Available
- Cost Effective
- Environmental friendly

Search for Chemo-Mechanical Bitumen Identical Rejuvenators
Search for Chemo-Mechanical Bitumen
Identical Rejuvenators

DSR Comparison Old Rejuvenated Bitumen vs. Virgin Bitumen

DSR Comparison Old Rejuvenated Bitumen vs. Virgin Bitumen

Tests Rejuvenated Bitumen in Mastic

Virgin 80/100 Bitumen (Binder of Current RAP)

Old Data 1990

Old Data 1990
Tests Rejuvenated Bitumen in Mastic

Four point bending and Europe Type Test on Rejuvenated Asphalt (Plant Mixed)

2.5 MT Laboratory Mixer

Type testing:
According to European Standards

- Asphalt Plant Mixed Material
- Best Correlation with Production
- Optimal Homogeneity
The Road to Rejuvenation

Fatigue

Resultaat van mengsel:

\[ \text{Hars} \quad 101 \, \mu m/m \]

\[ \text{Vermoeiingslijn} \quad \ln(N) = A_0 + A_1 \cdot \ln(\varepsilon) \]

\[ \text{Vermoeiingslijn} \quad N = k_1 \cdot \varepsilon^{k_2} \]

Kenmerken:

\[ q = A_0: \quad 38,408 \]

\[ \log_{10} k_1: \quad 16,680 \]

\[ \text{Aantal proeven: } 18 \]

\[ p = A_1: \quad -5,326 \]

\[ k_2: \quad -5,326 \]

\[ \text{t.b.v. rek-karakter.: } 1000000 \]

\[ R^2: 0,842 \]

\[ \text{gemiddelde } E_{\text{ini}} \quad [\text{MPa}]: 18131 \]

\[ \text{sx/y: } 0,706 \]

\[ \text{rek-karakter.} \quad [\mu m/m]: 101,2 \]

Resultaat van mengsel: DL4303 86 µm/m

Vermoeiingslijn \ln(N) = A_0 + A_1 \cdot \ln(\varepsilon)

Vermoeiingslijn \[ N = k_1 \cdot \varepsilon^{k_2} \]

Kenmerken:

\[ q = A_0: \quad 36,342 \]

\[ \log_{10} k_1: \quad 15,783 \]

\[ \text{Aantal proeven: } 18 \]

\[ p = A_1: \quad -5,061 \]

\[ k_2: \quad -5,061 \]

\[ \text{t.b.v. rek-karakter.: } 1000000 \]

\[ R^2: 0,937 \]

\[ \text{gemiddelde } E_{\text{ini}} \quad [\text{MPa}]: 13101 \]

\[ \text{sx/y: } 0,617 \]

\[ \text{rek-karakter.} \quad [\mu m/m]: 85,7 \]

Virgin Bitumen

Mean results

\[ T \quad [^\circ C]: 20,0 \]

\[ f \quad [\varepsilon]: 2036 \]

\[ E^*: 2036 \quad [\mu m/m] \]

\[ \phi \quad [^\circ]: 45,8 \]

\[ 0,1 \]

\[ 0,2 \]

\[ 0,5 \]

\[ 1,0 \]

\[ 2,0 \]

\[ 5,0 \]

\[ 8,0 \]

\[ 10,0 \]

\[ 20,0 \]

\[ 30,0 \]

\[ 0,1 \]

\[ 0,2 \]

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\[ 8,0 \]

\[ 10,0 \]

\[ 20,0 \]

\[ 30,0 \]

\[ 0.1 \]

\[ 1.0 \]

\[ 10.0 \]

\[ 100.0 \]

\[ 0.1 \]

\[ 1.0 \]

\[ 10.0 \]

\[ 100.0 \]

\[ 0.1 \]

\[ 1.0 \]

\[ 10.0 \]

\[ 100.0 \]

\[ 0.1 \]

\[ 1.0 \]

\[ 10.0 \]

\[ 100.0 \]

\[ 0.1 \]

\[ 1.0 \]

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\[ 100.0 \]
The Road to Rejuvenation

Pilot Production and test phase 100%
Recycled Asphalt (2010)

Breda NL
Dinteloord NL
Swiss Denmark Dordrecht NL LT – 100% RAP

Market introduction (2012) YTD > 200,000 MT Asphalt produced with RheoFalt® HP-EM

100% Recycling

Market introduction (2012) YTD > 200,000 MT Asphalt produced with RheoFalt® HP-EM

The Final Result...

RAP
Thermal Cleaned Sand
RheoFalt HP-EM

95
4.8
0.2
The Balance

A year production of 100,000 ton:
A savings of 31,200,000 MJoule!

This means saving 8,400 ton CO₂

This stands for the energy need of 2000 households

Calculated By Royal Haskoning (NL)

Conclusion

- 100% Recycled asphalt is possible with this Resin
- The Recycled asphalt has comparable characteristics and can be used in regular asphalt
- The influence of the Resin shows clearly improved results
- The characteristics are controlled by the amount of Resin
  - (Via LogPen calculation)

RheoFalt® HP-EM

Thank you for your attention

100% Asphalt Recycling starts now