Maintenance methods for Porous Asphalt

Jan Voskuilen
Advisor/Specialist Asphalt mixtures
Centre for Transport and Navigation
Ministry of Infrastructure and Environment

Topics

• Background Porous Asphalt in the Netherlands

• Traditional maintenance techniques for Porous Asphalt
  – Spraying rejuvenators
  – Open emulsion sand asphalt mixture
  – Thin inlay
  – Inlay Porous Asphalt or remix

• Innovative maintenance techniques for Porous Asphalt
  – Capsule approach
  – Induction heating approach
POROUS ASPHALT in the Netherlands

Since 1987 PA is laid on Dutch motorways, first for safety reasons, later-on for noise reduction.

Now 90% of our motorways has Porous Asphalt as wearing course (7% TLPA).

Mix composition of single-layer PA 16+
(standard wearing course for motorways since 2007)

<table>
<thead>
<tr>
<th>Passing sieve</th>
<th>desired</th>
<th>min.</th>
<th>max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.0 mm</td>
<td></td>
<td>93</td>
<td>100</td>
</tr>
<tr>
<td>11.2 mm</td>
<td></td>
<td>70</td>
<td>85</td>
</tr>
<tr>
<td>2.0 mm</td>
<td></td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>0.063 mm</td>
<td></td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Bitumen</td>
<td></td>
<td>5.2</td>
<td></td>
</tr>
</tbody>
</table>

Target air void content mix design is >20%
Layer thickness is 50 mm
Guarantee period is 7 years
PA 16+ consists of:

- stones 6 to 16 mm (PSV >58)
- crusher sand between 2 and 0.063 mm
- filler < 0.063 mm containing >25% hydrated lime
- pen grade bitumen 70/100
- RAP is not allowed

Damage pattern of PA 16

- ravelling
- cracks
- rutting
- transversal evenness
- longitudinal evenness
- skidding resistance
- bearing capacity
Performance model for SLPA

Between the red lines the ravelling process really takes place (slow lane)

When which technique?

a. Spraying rejuvenators (preventive method)

b. Porous Emulsion Sand Asphalt mixture (voids content 25%)

c. Thin inlay 2 cm

d. Inlay PA or Remix PA

tensile strength
Spraying rejuvenator on Porous Asphalt

- Lane width →

- Bitumen emulsion containing a rejuvenator is sprayed on the PA surface

- Aged PA after cleaning
- Covered stones after spraying rejuvenator
- Improve early life skid resistance by sanding

Spraying rejuvenator on Porous Asphalt

- 3 to 4 years before normative ravelling
- Good skid resistance of PA before application is needed
- Always post-laying treatment with sowing sand
- 2 to 3 years profit
- Also good experiences with Two-layer Porous Asphalt in Denmark (Øster Søgade Copenhagen)
Inlay PA: Spraying rejuvenator on surrounding old PA

- Prevent ravelling on the edges of the surrounding old PA

Lane width 0,5 m
Driving direction
Section

Replacement PA
Sealing old PA

Open Emulsion Sand Asphalt mixture

- aging of the binder
- stripping
- loss of stones from the surface

- filling holes and voids in situ with an Open Emulsion Sand Asphalt mixture
Open Emulsion Sand Asphalt mixture

History

- 2001: first test section VIA-RAL (A76)
- 2003: 70 km VIA-RAL lane width (3,50 meter)
- 2004: 100 km VIA-RAL lane width (3,50 meter)
- 2004/05: first test sections Drainway
- 2006: Two-layer PA test sections on the A8 with VIA-RAL, Drainway and ESHA PP

OESA is an accepted maintenance measure in the Netherlands

Application of Open Emulsion Sand Asphalt mixture
Application of Open Emulsion Sand Asphalt mixture
Application of Open Emulsion Sand Asphalt mixture

Ministerie van Verkeer en Waterstaat
EPFL 23 November 2010

Application of Open Emulsion Sand Asphalt mixture

Ministerie van Verkeer en Waterstaat
EPFL 23 November 2010
Application of Open Emulsion Sand Asphalt mixture
Application of Open Emulsion Sand Asphalt mixture

Application at night

- After one day the emergency lane has to be cleaned
- No rolling, so no rolling damage

Requirement for application of Open Emulsion Sand Asphalt mixture

**Yes**
- Beginning of ravelling Porous Asphalt

**NO**
- Rut depth more than 10 mm
- Cracks
- Cold asphalt repairs
- Too much ravelling
- Bad weather conditions
  (temperature below 5°C and humidity above 85%)
Application of Open Emulsion Sand Asphalt mixture

- Can not be used on “bad surface”

Results OESA mixture

- Noise:
  - Reduction 2 to 3 dBA (in comparison with before treatment)
- Skidding resistance:
  - Increasing from 0.42 to 0.52
- Braking deceleration:
  - 6.5 m/s²
- Drainability properties:
  - Drainability the same as clogged Porous Asphalt
Conclusions Open Emulsion Sand Asphalt

- Properties positive
- Reduction of maintenance costs
- Good maintenance strategy
- Enlarging of service life of ravelled Porous Asphalt of about 4 years

Open Emulsion Sand Asphalt is not nice to see, but it is very functional and cost-effective

Thin inlay (only slow lane)

If old Porous Asphalt is too much ravelled, it can not be treated a rejuvenator. Also an open emulsion sand asphalt mixture is not possible.

In this case a 2 centimeter thin inlay is a possibility.

Thin inlay:
milling of 2 cm old Porous Asphalt and bring back 2 cm Porous Asphalt 0/6 or 0/8.
COST EFFECTIVE?

Service life PA slow lane: 10 years
Service life PA fast way: 14 years
Service life Spraying rejuvenator: 3 years
Service life Open Emulsion Sand Asphalt: 4 years
Service life of Thin inlay

Laying speed

- Inlay Porous Asphalt: 200 m/h
- Spraying rejuvenator: 3000 m/h
- Open Emulsion Sand Asphalt mixture: 800 m/h
- Thin inlay: 350 m/h
Innovative maintenance techniques for Porous Asphalt

1. Capsule approach – only laboratory study

2. Induction heating approach – test site planned in December 2010

Ravelling process
Two approaches:

1. Embedded encapsulated chemicals will be used in the binder to decrease stiffness and repair bond.

Photo courtesy University of Illinois

Two approaches:

2. Local heating inside the material with induction energy will be used to repair the binder and to improve the properties again.
Capsules approach

Asphalt rejuvenated by diffusion

Capsules approach

Porous core
Capsules approach

Induction heating approach

- Conductive fibers
- Bitumen
- Aggregates
- Microcack

Opening of microcacks

Induction heating

Melted bitumen

Crack closed

Zoom
Induction heating approach

Conductive fillers

Steel wool → Graphite

Mortar with sand-bitumen ratio 2.25

Optimum of fibers

Asymptote

Volume resistivity in log (ohm.m)

Conductive additives content (Vol %)

Graphite
Steel wool
5.83% steel wool + graphite
6.54% steel wool + graphite

Optimum

Alternating magnetic field

Coil

Induced currents

Fibers
Aggregates
Bitumen
Induction heating approach

Advances. Induction approach (Heating)

Conductive fillers: Steel wool, Graphite

6.54% steel wool

Minimum resistivity

Maximum heating

Graph showing the relationship between Sand-bitumen ratio (volume) and Volume resistivity in log (ohm.m).

Graph showing the relationship between Sand/bitumen ratio (volume) and Temperature (ºC).

Minimum resistivity

Maximum heating

Graph showing the relationship between Sand/bitumen ratio (volume) and G.J. instanteen.
Induction heating approach

1. 

2. -20 °C

3. Induction

4.
Experiments

**Induction heating approach**

- Steel fiber
- Steel wool (chopped by hand)
- Sample: φ100mm×50mm (PA 0/16, air void :22%)

\[ \rho = \frac{RS}{L} \]

\[ ITS = \frac{2F}{\pi DH} \]

Summary & Conclusions

- Maintenance techniques are successful to enlarge the service life of Porous Asphalt.

- Self Healing Asphalt works at the laboratory. The next step is to prove it in a real field test site.