A sustainable maintenance method for cracked pavements using polyester asphalt reinforcement. Increase pavement life, reduce maintenance and create sustainable pavements.

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Asphalt reinforcement
- Basics -
Cracks develop ...

Crack development due to:

- Aging of the Bitumen
- Temperature differences
- Dynamic loads (Traffic)
Wearing course
Binder course
Bearing course

‡ situation after years
Conventional rehabilitation

Option 1: conventional rehabilitation

After short time: Reflective cracks
Rehabilitation

Option 2: reinforced rehabilitation

Durability of the pavement will be significantly increased!
What is HaTelit® C 40/17

- Flexible reinforcement grid out of high modulus Polyester with a mesh size of 4 cm
- Ultralight non-woven serves as installation aid
- Grid is heat resistant up to 250°C
- Grid and non-woven are bituminous coated (excellent interlayer bonding)
Why Polyester?

• polyester is flexible and yet robust enough to withstand forces induced by supply traffic, installation of asphalt and compaction

• high modulus polyester is well compatible with the characteristics of the asphalt

• polyester can withstand cyclic loading much better than brittle materials such as glass
Installation of reinforcement...
Why Polyester

... paving ...
Why Polyester

... traffic ...
... compaction ...
Compatibility of asphalt and polyester

- Coefficient of thermal expansion -
1. Ratio of the coefficient of thermal expansion $\alpha$ [1/K]:

*Example reinforced concrete:*

- $\alpha$-Concrete: $\sim 1.3 \times 10^{-3}$
- $\alpha$-Steel: $\sim 1.0 \times 10^{-3}$  ‡ Ratio: $\sim 1 / 1$
- $\alpha$-Asphalt: $\sim 6.0 \times 10^{-4}$
- $\alpha$-Polyester: $\sim 8.0 \times 10^{-5}$  ‡ Ratio: $\sim 1 / 7$
- $\alpha$-Asphalt: $\sim 6.0 \times 10^{-4}$
- $\alpha$-Glassfibre: $\sim 4.5 \times 10^{-6}$  ‡ Ratio: $\sim 1 / 133$

‡ Polyester does not act as a foreign material!
Results of Performance Tests
Critical load situations in a cracked pavement
Critical load situations in a cracked pavement

Shear mode (+)
Critical load situations in a cracked pavement

Bending mode
Critical load situations in a cracked pavement

Shear mode (-)
Critical load situations in a cracked pavement
Critical load situations in a cracked pavement
Dynamic fatigue tests

Tests to determine the effect of HaTelit® in anti reflective cracking applications in Asphalt overlays
Test set up, dynamic fatigue
- Material: HaTelit® C 40/17
- Precrack: 3 mm, 6mm, 9 mm
- HaTelit position: directly above the crack tip
- Load position: Bending and shear mode
- Contact pressure: 560 kN/m²
Typical crack (without reinforcement)

N=79,884
Typical crack (with HaTelit)
Bending mode without HaTelit
Bending mode with HaTelit
“Improvement factor”

\[ V_f = \frac{N_f(\text{with Hatelit})}{N_f(\text{without Hatelit})} \]

\[ N_f = \frac{1}{c_{f1}} \]

\[ c_{f1} = \frac{1}{N_f (B)} + \frac{2}{N_f (S)} \]

\[ 4.60 < V_f < 6.14 \]
Research results and FEM Simulation

Without HaTelit

With HaTelit
Proof of the effectiveness
by project experience
Project Report
Rehabilitation of Corso Giovanni Agnelli, Torino - Italy
Background:

• 2005 parts of the Corso Giovanni Agnelli in Torino had to be rehabilitated

• Existing pavement: Asphalt layer on concrete slabs
Corso Giovanni Agnelli, Torino
Design

Section 1:
- HaTelit C 40/17
- Concrete slabs
- Joint sealing with bitumen
- Levelling course
- 4 cm of asphalt wearing course

Section 2:
- Concrete slabs
- Joint sealing with bitumen
- 5 cm of asphalt wearing course
June 2005:
Rehabilitation of Section 1
June 2005: Installation of HaTelit®

Corso Giovanni Agnelli, Torino
June 2005: Installation of 4 cm asphalt wearing course
July 2005, two weeks later: Rehabilitation of Section 2
Section 2: Installation of only 5 cm asphalt wearing course
May 2006,
Ten month after the rehabilitation
May 2006: Cracks start to develop in unreinforced section
Condition in July 2009,
4 years after the rehabilitation
Section 1: July 2009 - 4 years after rehabilitation
Section 1: July 2009 - still in excellent condition - no cracks
Section 2:  July 2009 - 4 years after rehabilitation
August 2010 - 5 years after rehabilitation

Severe cracking and damages in the unreinforced section were full overlay replacement done in August 2010.

Note: First cracks reflected already after 1 year

**Reinforced section:**

Excellent condition after 5 years !!!
The research and project examples presented confirm that the lifetime of the reinforced pavements can be extended by a factor of 3 to 4.
COMPARISON OF EMBODIED ENERGY FOR REINFORCED AND UNREINFORCED ASPHALT OVERLAYS
DATA SOURCE

Inventory of Carbon & Energy (ICE) by the University of Bath, UK

Database which is continuously updated for embodied energy and carbon coefficients for building materials.
## Examples of Embodied Carbon Dioxide ECO₂

<table>
<thead>
<tr>
<th>Material</th>
<th>kg ECO₂ / kg of material</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate</td>
<td>0.0052</td>
<td>gravel or crushed rock</td>
</tr>
<tr>
<td>Aluminium</td>
<td>9.16</td>
<td>-</td>
</tr>
<tr>
<td>Asphalt</td>
<td>0.076</td>
<td>6% binder content</td>
</tr>
<tr>
<td>Bitumen</td>
<td>0.55</td>
<td>-</td>
</tr>
<tr>
<td>Cement</td>
<td>0.74</td>
<td>UK weighted average</td>
</tr>
<tr>
<td>Concrete 16/20</td>
<td>0.10</td>
<td>unreinforced</td>
</tr>
<tr>
<td>Reinforced Concrete RC 40/50</td>
<td>0.188</td>
<td>high strength applications / precast</td>
</tr>
<tr>
<td>PVC General</td>
<td>3.10</td>
<td>-</td>
</tr>
<tr>
<td>Polyester</td>
<td>1.93</td>
<td>derived from HDPE</td>
</tr>
<tr>
<td>Steel</td>
<td>1.46</td>
<td>average UK recycled content</td>
</tr>
<tr>
<td>Steel</td>
<td>2.89</td>
<td>Virgin steel</td>
</tr>
</tbody>
</table>

Source: ICE Inventory of Carbon & Energy V2.0
ECO$_2$ in kg per kg of material

- Aggregate: 0.0052
- Cement: 0.74
- Steel: 2.89
- RC 40/50: 0.188
- Bitumen: 0.55
- Asphalt: 0.076
- Polyester: 1.93
Comparative calculation of ECO\textsubscript{2} for reinforced and unreinforced asphalt overlays based on materials used

<table>
<thead>
<tr>
<th>Material</th>
<th>Material consumption</th>
<th>kg embodied CO\textsubscript{2} per kg of material</th>
<th>embodied CO\textsubscript{2} in kg / m\textsuperscript{2}</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>unreinforced</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>HaTelit\textsuperscript{®} reinforced</td>
</tr>
</tbody>
</table>
Conclusions

• PES asphalt reinforcement grids with bituminous coating significantly delay reflective cracking

• Project experience and research presented shows that pavement life can be increased by a factor of 3 - 4 by using HaTelit® asphalt reinforcement

• Unreinforced pavement rehabilitation: 1.93 kg ECO₂ / m² / year design life

• HaTelit® reinforced pavement rehabilitation: 0.71 kg ECO₂ / m² / year design life
Conclusions

• Significant saving in Embodied Carbon Dioxide of 63% based on material consumption

• The application of HaTelit® asphalt reinforcement saves resources by extending pavement life and thus is a key to sustainable maintenance methods