Performance testing anti-cracking interlayers

Frederik Vervaecke
This document remains the exclusive property of NV Bekaert SA.

Communication thereof is wholly confidential and does not extend beyond the technical staff of the addressee, who is not authorized to duplicate this document nor to make known to a third party any contents thereof.

NV Bekaert SA is exclusively entitled to apply for a patent for any patentable element contained in this document.

NV Bekaert SA disclaims all liability which may arise out of the putting into use of the information contained in this document, provided it did not assume control thereof. It also disclaims all liability for infringements of industrial property rights which may arise out of the putting into use of the information contained in this document.

All the information contained in this document is based on reasonable research, but does not guarantee any result.
Standardized testing of anti-cracking interlayers for asphalt:

Properties interlayer

- Tensile testing
- Bitumen retention test

Performance anti-cracking interlayer

Nothing standardized
Laboratory testing

Big variety of performance tests of anti-cracking interlayers:

1. Static testing: 3- or 4-pt bending test:

**Pro:**
- Fast test;
- Simple setup;
- Relative large samples;

**Contra:**
- Relevant for reality?
- Not straight forward interpretation;

A.G. Kneepkens, M Verweij, 2015, “Gewapende feiten over asfaltwapening”, Civielm techniek Nr, 30-33
E. Pasquini, M. Bocci, G. Ferrotti, & F. Canestrari, éà&”, “Laboratory characterisation and field validation of geogrid-reinforced asphalt pavements”, Road Mat. & Pav. Design, 14:1, 17-35.

Only first part of the curve was recorded & investigated
Laboratory testing

Big variety of performance tests of anti-cracking interlayers:

2. Cyclic bending tests:
   Several setups and research groups have their own test (Nottingham, Santander, Teheran, Italy,…)

Laboratory testing

Big variety of performance tests of anti-cracking interlayers:

2. Cyclic bending tests:
   Several setups and research groups have their own test (Nottingham, Santander, Teheran, Italy, …)

Example:

Pro:
- Relative simple test setup;
- Relative large samples;

Contra:
- Long test
- Spread on results (fatigue)
- Not straightforward interpretation
Laboratory testing

Big variety of performance tests of anti-cracking interlayers:

3. Thermal movement test:
   Several setups and research groups have their own test (Nottingham, Texas, Belgium, ...)
   Example:

   ![Diagram of thermal movement test]

   Contra:
   - Long test
   - Spread on results (fatigue)
   - Special setup is needed

   Pro:
   - Realistic seasonal movement;
   - Relative large samples are possible;

L.F. Walubita, A.N.M. Faruk, J. Zhang, X. Hu, “Characterizing the cracking & fracture properties of geosynthetic interlayer reinforced HMA samples using the Overlay Tester (OT)”, Con. & Build, mat. 93 (2015), 695-702;
Laboratory testing

Big variety of performance tests of anti-cracking interlayers:

4. Large scale fatigue testing:
   Several setups and research groups have their own test (France, Spain, Switzerland, Netherlands, ...)
   Example:

   ![Photo of a test track]

   **Contra:**
   - Long test
   - Spread on results (fatigue)
   - Special setup is needed
   - Complete road structure not only the asphalt/interlayer composite
   - Very expensive

   **Pro:**
   - Realistic situation
   - Entire road structure

Important parameters for testing anti-cracking interlayers:

- Testing the composite (interlayer, tack coat & asphalt) as it is used in the application;

- As reflective cracking is a fatigue behavior, it is important to perform cyclic testing;

- Sample dimensions must be adapted to the dimensions of the anti-cracking interlayer;

- Details of asphalt, tack coat, base layer need to be kept unchanged;
Thermal plate test:

- Specimen on bed of steel balls for free horizontal displacement;
- Climate chamber conditioned at -10°C;
- Slow cyclic opening & closing joint (1mm) by contraction & expansion of loading frame;
- Observations:
  - Crack initiation & development (by pictures);
  - Applied force;
  - Opening joint (0-1mm);
  - Relative displacement in overlay (2cm above joint).

Interlayer system: reinforcement + bitumen layer
Thermal plate test:

- **Reference - no interlayer**
  - + 300g/m² tack coat

- **Fortifix® 1-O**
  - (38x50)kN/m
  - (3100x4400)kN/m
  - + 300g/m² tack coat

- **Glas grid 35x35**
  - (70x100)kN/m
  - (2800x4000)kN/m
  - + 300g/m² tack coat

*All tests were done in the same period to make sure there are no differences in used materials.*
## Thermal plate test:

#### Performance testing Fortifix®

**Graph:**
- F (kN) vs. Number of cycles
- Δ F_COD=0

**Table:**

<table>
<thead>
<tr>
<th>Reference</th>
<th>F_{max} (kN)</th>
<th>Crack initiation</th>
<th>End of test</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>cycles</td>
<td>time (h)</td>
<td>cycles</td>
</tr>
<tr>
<td>Reference</td>
<td>8</td>
<td>1</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Fortifix</td>
<td>9</td>
<td>Na</td>
<td>Na</td>
<td>Na</td>
</tr>
<tr>
<td></td>
<td>8.7</td>
<td>35</td>
<td>126</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>9.5</td>
<td>15</td>
<td>42</td>
<td>24</td>
</tr>
<tr>
<td>Glas grid</td>
<td>9.6</td>
<td>8</td>
<td>32</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>9.3</td>
<td>28</td>
<td>108</td>
<td>28</td>
</tr>
</tbody>
</table>
Thermal plate test:

\[ \text{strength new steel grid} = \frac{1}{2} \times \text{glas grid} \quad \Rightarrow \text{similar/better performance (15-50\%)} \]
### What about FF1 & carbophalt?

<table>
<thead>
<tr>
<th>Material</th>
<th>Interlayer</th>
<th>Tackcoat</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reference</strong></td>
<td>no interlayer</td>
<td>300g/m²</td>
</tr>
<tr>
<td><strong>SAMI</strong></td>
<td>SAMI</td>
<td>2kg/m²</td>
</tr>
<tr>
<td><strong>Carbon/glas grid</strong></td>
<td>(120x200)kN/m</td>
<td>300g/m²</td>
</tr>
<tr>
<td></td>
<td>(4 000x12 000)kN/m</td>
<td></td>
</tr>
<tr>
<td><strong>FF1-C</strong></td>
<td>(42x54)kN/m</td>
<td>500g/m²</td>
</tr>
<tr>
<td></td>
<td>(3 000x4 400)kN/m</td>
<td>700g/m²</td>
</tr>
</tbody>
</table>

To be submitted for publication in 2019
## What about FF1 & carbophalt?

<table>
<thead>
<tr>
<th>Tack coat</th>
<th>$F_{\text{max}}$</th>
<th>Crack initiation</th>
<th>Crack @ top asphalt</th>
<th>$F_{\text{end}}$</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>g/m²</td>
<td>(kN)</td>
<td>cycles</td>
<td>cycles</td>
<td>(kN)</td>
<td></td>
</tr>
<tr>
<td><strong>Reference</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>300</td>
<td>8</td>
<td>1</td>
<td>5</td>
<td>0,04</td>
<td>crack</td>
</tr>
<tr>
<td><strong>SAMI</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>7</td>
<td>1</td>
<td>2</td>
<td>0,04</td>
<td>cracks</td>
</tr>
<tr>
<td>2000</td>
<td>9</td>
<td>1</td>
<td>3</td>
<td>0,08</td>
<td>delamination + crack</td>
</tr>
<tr>
<td><strong>Carbon/glas</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>300</td>
<td>10,5</td>
<td>2</td>
<td>5</td>
<td>2,6</td>
<td>delamination + crack</td>
</tr>
<tr>
<td>300</td>
<td>10</td>
<td>1</td>
<td>5</td>
<td>4,2</td>
<td>crack</td>
</tr>
<tr>
<td><strong>FF1-C</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>11,4</td>
<td>2</td>
<td>30</td>
<td>3,7</td>
<td>crack</td>
</tr>
<tr>
<td>700</td>
<td>11,9</td>
<td>1</td>
<td>20</td>
<td>2,8</td>
<td>crack</td>
</tr>
<tr>
<td>700</td>
<td>12</td>
<td>10</td>
<td>50</td>
<td>5,5</td>
<td>crack (not @surface yet)</td>
</tr>
</tbody>
</table>

To be submitted for publication in 2019
What about FF1 & carbophalt?

Performance testing Fortifix®

To be submitted for publication in 2019
What about FF1 & carbophalt?

Both the number of cycles before the end of the test as the maximum force & the force at the end of the test show a significant effect on preventing crack initiation and crack growth.

To be submitted for publication in 2019
What about FF1 & carbophalt?

Although FF = $1/4 \times$ carbon grid & EA FF = $1/3 \times$ carbon grid

⇒ better performance based on crack propagation & Force take-up

To be submitted for publication in 2019
How can this be explained?

1. Adhesion to overlay:

Interlocking 3D structure ensures anchorage;

2. Adhesion existing surface & overlay:

Shear test:
limited reduction surface by steel compared to glass

⇒ adhesion interface is less influenced

To be submitted for publication in 2019