Assessment of Interlayer Bonding Properties with Dynamic Testing

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Introduction

Water from coring

Shear

Bohrkern 27, Sanierung 92
Debonding Mechanisms

Construction Paving

Climate & Environment

Traffic & Climate

Steel Roller
Surface Cracks
Joint

Water

Temp

Crack/Joint

Particle Loss

Pressure

Shear

Tension

Local Settlement

Asphalt

Steel Roller
Crack
• Leutner shear device (static)

\[ T = 20^\circ C \]
\[ v = 50 \text{mm/min} \]
\[ \sigma_n = 0 \text{MPa} \]
\[ \varnothing = 150 \text{mm} \]
Leutner shear evaluation

\[ \tau = \frac{F}{A} \]

\[ K = \frac{\tau}{s} \]
• Dynamic Shear Device (Dresden)
Dynamic shear evaluation

\[ \tau = \frac{F}{A} \]

\[ K = \frac{\tau}{s} \]

s: amplitude of relative displacement [mm]
## Testing Sequence

<table>
<thead>
<tr>
<th>Start Temperature (Deform. Amplitude)</th>
<th>Normal Force</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>-10°C (0.03 mm)</td>
<td>0.9 MPa</td>
<td>0.1 Hz</td>
</tr>
<tr>
<td>10°C (0.07 mm)</td>
<td>0.6 MPa</td>
<td>1 Hz</td>
</tr>
<tr>
<td>30°C (0.11 mm)</td>
<td>0.3 MPa</td>
<td>5 Hz</td>
</tr>
<tr>
<td>50°C (0.15 mm)</td>
<td>0.0 MPa</td>
<td>10 Hz</td>
</tr>
<tr>
<td>-10°C (0.03 mm)</td>
<td>0.9 MPa</td>
<td>0.1 Hz</td>
</tr>
</tbody>
</table>

Bituminous mixtures — Test methods for hot mix asphalt — Part 48: Interlayer Bonding
<table>
<thead>
<tr>
<th>Layer No.</th>
<th>SMA/AC</th>
<th>MA/MA</th>
<th>PA/AC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Mix type</td>
<td>SMA 11</td>
<td>AC 22</td>
<td>MA 11</td>
</tr>
<tr>
<td>Binder Content [%]</td>
<td>3.2</td>
<td>3.2</td>
<td>7.8</td>
</tr>
<tr>
<td>Air void Content [%]</td>
<td>5.8</td>
<td>4.8</td>
<td>1.2</td>
</tr>
</tbody>
</table>
Results Static Testing

Findings

- Shear stiffness highly temperature dependent
- Decreasing from 5 MPa/mm at -10°C to 0.25 MPa/mm at 50°C for SMA/AC
- Comparison at 20°C shows very similar shear stiffness around 1 MPa/mm for MA/MA and PA/AC
- Slightly higher shear stiffness for SMA/AC with 1.5 MPa/mm
Results Dynamic Testing

SMA/AC_2_1 / 1 Hz

MA/MA_1_2 / 1 Hz

SMA/AC_4_1 / 1 Hz

MA/MA_2_1 / 1 Hz

Shear stiffness (MPa/mm)

Normal stress (MPa)

-10°C
10°C
30°C
50°C
-10°C
Shear stiffness decreases with increasing temperature, but values are different than for static testing.

Decrease of stiffness of 96% comparing stiffness values of SMA/AC at -10°C and 50°C.

Stiffness increases with increasing normal stress.

Difference between the first and the last shear stiffness test result at -10°C is due to damage of specimen: often appears at temperature of 50°C.

Comparison of 2 specimens of same material show big scattering between 17% and 50%.

Ranking difficult. Here: MA/MA > SMA/AC > PA/AC.
Dynamic testing allows applying the time (frequency) and temperature relationship which enables to construct the Master curve for shear stiffness K with the help of the time-temperature-superposition principal.

The shear stiffness Master curve for MA/MA, different normal stresses and a reference temperature of 20°C shows the dependency on normal stress.
Conclusions

- Shear stress and shear stiffness are temperature dependent.
- Static and dynamic testing show similar trends, but values are different for the same test conditions (temperature and normal load).
Conclusions

- Static and dynamic tests do not have the same goal and output:
  - Static testing gives interlayer bond properties at failure and is used for quality assessment
  - Dynamic testing aims at the interlayer bond properties during the service life of pavement
Conclusions

• Results from dynamic testing are promising, but method still needs evaluation before adopting for standardization:
  - Proposed deformation amplitudes and temperatures have to be modified according to the tested material combination
  - Number of test specimens per material has to be increased
First Announcement

9th International Conference on Maintenance and Rehabilitation of Pavements
July 1st – July 3rd, 2020

Call for Abstracts: Spring 2019
Reserve date now! More details will be announced later.
Chair: Christiane Raab, Empa, Dübendorf, Switzerland

mairepav2020.empa.ch
See you 2020 in Switzerland