Älvsbacka Bridge – A Bridge in Cold Climate

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Älvsbacka Bridge

• Span 130 m, main beams 1100 x 645 mm.
• 23 m high pylon towers, 900 x 900 mm.
• Untreated spruce and protective cladding.
• The deck is built in five sections, and assembled on site.
• The bridge deck has a 1 m camber.
Health monitoring system

• GNSS for Displacement and vibration.
• 3-axis accelerometers for vibration.
• Load cells for cable tensions.
• Weather station for temperature and RH.
• MC-sensors for determining MC.
• Web camera to differentiate traffic and weather loads.
Engineered woods

- Glulam
- CLT
- LSL
- PSL
- We know the properties of wood in elevated temperatures.
Engineered woods in cold climate

- Nordic countries, Russia, USA, Canada etc.
- 17 January 2013 -23°C, but it gets colder!
Specimens

• Specimens cut to 150mm x 20mm x 10 mm
• Six types of adhesive:
  – One-component polyurethane (PUR)
  – Polyvinyl acetate (PVAc)
  – Emulsion-polymer-isocyanate (EPI)
  – Melamine-formaldehyde resin (MF)
  – Melamine-urea- formaldehyde resin (MUF)
  – Phenol-resorcinol-formaldehyde resin (PRF)
Glue line stability in cold climate

- Universal testing machine in climate chamber
- Temperatures from 20° C to -60° C
- Tested according to EN 302-1
Shear strengths of wood and adhesives bonds at different temperatures

<table>
<thead>
<tr>
<th>Temp./Glue</th>
<th>1-PUR</th>
<th>2-PVAc</th>
<th>3-EPI</th>
<th>4-MF</th>
<th>5-PRF</th>
<th>6-MUF</th>
<th>7-Wood</th>
</tr>
</thead>
<tbody>
<tr>
<td>20°C</td>
<td>10.9 (1.0)</td>
<td>9.6 (0.6)</td>
<td>10.0 (1.1)</td>
<td>9.8 (0.9)</td>
<td>9.8 (1.0)</td>
<td>8.7 (0.7)</td>
<td>10.1 (0.9)</td>
</tr>
<tr>
<td></td>
<td>A^2</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>-20°C</td>
<td>10.8 (2.3)</td>
<td>8.1 (1.2)</td>
<td>8.3 (1.6)</td>
<td>9.4 (2.3)</td>
<td>9.7 (1.8)</td>
<td>7.9 (1.1)</td>
<td>9.5 (1.1)</td>
</tr>
<tr>
<td></td>
<td>A,B</td>
<td>B</td>
<td>B</td>
<td>A</td>
<td>A</td>
<td>A,B</td>
<td>A,B</td>
</tr>
<tr>
<td>-30°C</td>
<td>10.2 (2.9)</td>
<td>8.2 (1.2)</td>
<td>8.3 (2.0)</td>
<td>8.1 (2.5)</td>
<td>9.2 (2.0)</td>
<td>7.2 (1.9)</td>
<td>9.0 (0.9)</td>
</tr>
<tr>
<td>-40°C</td>
<td>9.9 (1.5)</td>
<td>7.9 (1.9)</td>
<td>7.3 (1.5)</td>
<td>7.7 (1.4)</td>
<td>9.3 (1.4)</td>
<td>7.2 (1.3)</td>
<td>8.7 (1.3)</td>
</tr>
<tr>
<td></td>
<td>A,B</td>
<td>B</td>
<td>B</td>
<td>A,B</td>
<td>A,B</td>
<td>B,C</td>
<td>B,C</td>
</tr>
<tr>
<td>-50°C</td>
<td>9.2 (1.3)</td>
<td>7.9 (1.8)</td>
<td>7.8 (1.4)</td>
<td>7.5 (1.2)</td>
<td>8.4 (1.7)</td>
<td>6.6 (0.9)</td>
<td>8.8 (1.5)</td>
</tr>
<tr>
<td></td>
<td>B,C</td>
<td>B</td>
<td>B</td>
<td>A,B</td>
<td>C</td>
<td>B,C</td>
<td>B,C</td>
</tr>
<tr>
<td>-60°C</td>
<td>7.9 (1.4)</td>
<td>7.7 (1.1)</td>
<td>7.2 (1.5)</td>
<td>7.3 (1.7)</td>
<td>8.0 (1.4)</td>
<td>6.6 (1.3)</td>
<td>8.0 (0.9)</td>
</tr>
<tr>
<td>Total shear strength change (%)^3</td>
<td>27.1</td>
<td>19.3</td>
<td>27.5</td>
<td>25.0</td>
<td>18.7</td>
<td>24.5</td>
<td>27.1</td>
</tr>
</tbody>
</table>

^1 Values in parentheses are standard deviations based on 15 specimens.

^2 Values in the same capital letter in each column are not statistically different at the 0.05 significance level.

^3 Total shear strength change (%)=(Shear Strength_{20°C} - Shear Strength_{-60°C})/ Shear Strength_{20°C}*100.
Conclusions

• As temperature is lowered the shear strength is reduced.
• Except for PUR have a shear strength below 10 MPa already at -20°C, not meeting the EU requirement.
• MUF showed the lowest shear strength of the tested adhesives.