European round robin tests for the Multiple Stress Creep Recovery Test and contribution to the development of the European standard test method

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CEN/TC336/WG1/TG1: High service temperature properties

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Context

Development of the European standard test method by TG1:
EN 16659: “Bitumen and Bituminous Binders - Multiple Stress Creep and Recovery Test (MSCRT)”

TG1 objectives:

- To evaluate and possibly improve the test method
- To offer European labs the opportunity to gain expertise and know-how, and to contribute to the European standard
- To determine the precision of the test results

⇒ Round Robin Tests (+ surveys)
Multiple Stress Creep Recovery Test

Procedure:

10 creep/recovery cycles at constant stress level repeated at multiple constant stress levels (in increasing order)
Multiple Stress Creep Recovery Test

Test results:

At each stress level (average results of 10 cycles):

\[ J_{nr} = \frac{\varepsilon_{nr}}{\sigma} \quad \text{in } 1/\text{kPa} \]

% Recovery

\[ \%R = 100 \left( \frac{\varepsilon_{r}}{\varepsilon_{tot}} \right) \quad \text{in } \% \]
## TG1 Round Robin tests overview

<table>
<thead>
<tr>
<th>1st RRT (2012)</th>
<th>2nd RRT (2014)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 paving grade (30/45)</td>
<td>2 paving grade (15/25 and 70/100)</td>
</tr>
<tr>
<td>2 polymer modified (25/55-55, 45/80-75)</td>
<td>3 polymer modified (25/55-60, 45/80-75, 90/150-75)</td>
</tr>
<tr>
<td>1 paving grade (50/70 with 3 % wax)</td>
<td>1 paving grade (70/100 with 3 % wax)</td>
</tr>
<tr>
<td></td>
<td>1 EVA polymer modified</td>
</tr>
<tr>
<td>before/after short term ageing (RTFOT)</td>
<td>fresh binders</td>
</tr>
<tr>
<td>2 stress levels: 0.1 and 3.2 kPa</td>
<td>3 stress levels: 0.1, 3.2 and 6.4 kPa</td>
</tr>
<tr>
<td>1 temperature: 60 °C</td>
<td>2 temperatures: 60 °C and 70 °C</td>
</tr>
<tr>
<td>31 (26 labs returned results in time)</td>
<td>28 (23 labs returned results in time)</td>
</tr>
<tr>
<td>3 repeated tests</td>
<td>3 repeated tests</td>
</tr>
</tbody>
</table>
Test results $J_{nr}$ (mean values of RRT)

Paving grade bitumens

- 15/25@60°C
- 15/25@70°C
- 30/45@60°C
- 70/100@60°C
- 70/100@70°C

Polymer modified bitumens

- 25/55-55@60°C
- 25/55-60@60°C
- 25/55-60@70°C
- 45/80-75(1)@60°C
- 45/80-75(2)@60°C
- 45/80-75(2)@70°C
- 90/150-75@60°C
- 90/150-75@70°C
Test results %R (mean values of RRT)

Paving grade bitumens

Polymer modified bitumens

Stress (kPa) vs. %R (%) for various bitumen grades and temperatures.
Precision of test results

Tables (mean values, repeatability ‘r’ and reproducibility ‘R’): see paper

Observations:

- Ranges of r and R are very different depending on binder type (paving grade versus polymer modified binders)
  - analysed separately
- Special binder results showed poor precision (specimen preparation?)
  - not included for overall estimation of r and R
Paving grade bitumens: estimation of r and R

\[ y = 0.055x \]

\[ y = 0.323x \]

\[ r/J_{nr} \text{ (in %)} = 5.5 \% \]
\[ R/J_{nr} \text{ (in %)} = 32.3 \% \]

\[ r = 0.6 \% \]
\[ R = 4.4 \% \]
Polymer modified bitumen: estimation of r and R

\[ y = 0.081x \]
\[ y = 0.430x \]

Note: excluded from this analysis
- Results at 70 °C and 6.4 kPa for all binders
- All results for the very soft PMB90/150-75 excessively high compared to other data!
### Precision data proposed for EN 16659

<table>
<thead>
<tr>
<th></th>
<th>J_{nr} (in % of J_{nr})</th>
<th>%R (in %)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Paving grade bitumens</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r</td>
<td>6 %</td>
<td>1 %</td>
</tr>
<tr>
<td>R</td>
<td>33 %</td>
<td>5 %</td>
</tr>
<tr>
<td><strong>Polymer modified bitumens</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r</td>
<td>9 %</td>
<td>2 %</td>
</tr>
<tr>
<td>R</td>
<td>43 %</td>
<td>12 %</td>
</tr>
</tbody>
</table>
Conclusions on precision of MSCR test

- Precision was estimated for paving grade bitumens and for polymer modified bitumens.
- Compared to precision data reported in the ASTM standard: r and R values from the European RRTs are equal or smaller.
- Precision is negatively affected by:
  - Testing binders after RTFOT (short term ageing)
  - Increasing the test temperature from 60 °C to 70 °C
  - Increasing stress level from 3.2 to 6.4 kPa
General conclusions on MSCR test

- The two parameters identified are relevant:
  - $J_{nr}$ shows the sensitivity to permanent deformation
  - %R distinguishes PMBs from non modified bitumens and also distinguishes between PMBs with different levels of modification
- The test method is relatively fast and simple, only a few grams of binder are needed (DSR based test)
- A lot of European laboratories have now acquired practical experience and are capable of performing the test
- Precision data have now been established for Europe
THANK YOU FOR YOUR ATTENTION