High-temperature properties of bituminous binders and asphalt mixtures

mgr inż. Marta Wójcik-Wiśniewska
dr inż. Krzysztof Błażejowski

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Motto: Asfaltové vozovky – bezpečná cesta k prosperitě
Agenda

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   acc. to European Standard
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Introduction
INTRODUCTION

Resistance to rutting is one of the main performance indicators of the asphalt mixes at high temperatures. Even though the role of bitumen is not dominantly responsible for the mix resistance to permanent deformations, however properly selected type of bitumen can support the aggregate skeleton.

This presentation describes methods, which are used to test the high-temperature properties of bitumen. It presents also test results of high-temperatures properties of bituminous binders and asphalt mixtures, obtained correlations and conclusions.

We are looking for an answer on the question:

What is the contribution of bitumen in preventing the high-temperature deformations of pavement surface?
The following types of bitumens were used in the test program conducted by ORLEN Asfalt:

**PAVING GRADE BITUMEN:**
- 20/30
- 35/50
- 50/70
- 70/100

**POLYMER MODIFIED BITUMEN:**
- PMB 25/55-60
- PMB 45/80-55
- PMB 45/80-65

**HIGHLY POLYMER MODIFIED BITUMEN:**
- PMB 25/55-80 HiMA
- PMB 45/80-80 HiMA
- PMB 65/105-80 HiMA
High-temperature properties of bitumen acc. to EN standard
BITUMEN TESTING.
SOFTENING POINT

In Europe, Softening Point (R&B) test is a standard method used for assessment of the bitumens’ properties at high operation temperatures. The Softening Point indicates approximately the upper limit of bitumen’s viscoelastic behavior. Softening point test was carried out in accordance with EN 1427.

General view of the automatic R&B softening point test equipment with a bitumen sample

View of a bitumen sample after R&B test

Fot: ORLEN Asfalt Sp. z o.o.
Softening point test results, acc. to EN 1427
High-temperature properties of bitumen acc. to Superpave system

MSCR method
The MSCR test (*Multiple Stress Creep Recovery test*) has been performed in the USA since 2010 as a part of the Performacne Grade classification system of bituminous binders.

The MSCR test is performed according to the following standards:

- **in the USA:**
  - AASHTO TP 70: *Standard Method of Test for Multiple Stress Creep Recovery (MSCR) Test of Asphalt Binder Using a Dynamic Shear Rheometer (DSR)*

- **in Europe:**
  - EN 16659:2015 „*Bitumen and Bituminous Binders – Multiple Stress Creep and Recovery Test (MSCRT)*“. 
BITUMEN TESTING.
MSCR METHOD DESCRIPTION.

- **MSCR test** is one of the methods used to assess bitumen properties at high temperatures.

- **The main feature of the MSCR test** is to be able to measure the bitumen properties at the highest expected field temperature (USA) or user selected equivalent temperature (Europe).

As a result of such comparison it is possible to evaluate whether pavement will resist rutting under extreme high-temperature conditions.
The MSCR test is performed using the Dynamic Shear Rheometer

General view of the Dynamic Shear Rheometer (DSR)

General view of the system components – cone

General view of the system components – plate

Fot: ORLEN Asfalt Sp. z o.o.
BITUMEN TESTING.
MSCR METHOD DESCRIPTION.

As a result of MSCR test, two parameters are calculated:

- \( J_{nr} \) in \([kPa^{-1}]\) - non-recoverable creep compliance determined at two stress levels 100 Pa and 3200 Pa; it is a direct measure of bitumen resistance to rutting.
- \( R \) in \[%\] - percent recovery - also determined at two stress levels (100 Pa and 3200 Pa); this parameter specifies the elastic properties of bitumen at a given temperature thus it can be interpreted as effective indicator of polymer modification (in case of polymer-modified bitumens).

The \( J_{nr}3.2 \) kPa is the most relevant parameter used to classify bitumen binder’s resistance to permanent deformations.

The lesser the \( J_{nr}3.2 \) kPa value, the higher resistance to rutting for the corresponding asphalt mixtures.
MSCR test results
The following types of binders were used in the MSCR test:

- **Paving grade bitumen**: 20/30, 35/50, 50/70, 70/100.
- **Highly polymer modified bitumen**: PMB 25/55-80 HiMA, PMB 45/80-80 HiMA, PMB 65/105-80 HiMA.

**Test conditions:**
- The tests were performed acc. to the US standard: ASTM D 7405-10a.
- All tested bitumen samples were aged by RTFOT method.
- **Test temperatures**: 64°C, 70°C.
BITUMEN TESTING.
MSCR TEST RESULTS.

MSCR test results
Jnr 3.2 [kPa⁻¹], temperature: 64°C and 70°C

graph interpretation: less = better
Classification of bitumens and traffic load characteristics requirements
based on the *Superpave* system

<table>
<thead>
<tr>
<th>Letter Class (letter code)</th>
<th>Number of equivalent standard axle loadings and traffic conditions</th>
<th>Requirements for bitumen in higher boundary temperature for PG Jnr3.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>S – Standard</td>
<td>&lt; 10 mln axles standard traffic</td>
<td>≤ 4,0</td>
</tr>
<tr>
<td>H – Heavy</td>
<td>10-30 mln axles or slow traffic</td>
<td>≤ 2,0</td>
</tr>
<tr>
<td>V – Very Heavy</td>
<td>&gt;30 mln axles or fully stop traffic</td>
<td>≤ 1,0</td>
</tr>
<tr>
<td>E – Extreme</td>
<td>&gt;30 mln axles and fully stop traffic</td>
<td>≤ 0,5</td>
</tr>
</tbody>
</table>
### Classification of bitumens based on MSCR test

<table>
<thead>
<tr>
<th>Binder type</th>
<th>Class in temperature 64°C and 70°C, acc. to PG Jnr 3.2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>64°C</td>
</tr>
<tr>
<td>Paving grade bitumen 20/30</td>
<td>E</td>
</tr>
<tr>
<td>Paving grade bitumen 35/50</td>
<td>E</td>
</tr>
<tr>
<td>Paving grade bitumen 50/70</td>
<td>S</td>
</tr>
<tr>
<td>Paving grade bitumen 70/100</td>
<td>*</td>
</tr>
<tr>
<td>Polymer modified bitumen PMB 25/55-60</td>
<td>E</td>
</tr>
<tr>
<td>Polymer modified bitumen PMB 45/80-55</td>
<td>E</td>
</tr>
<tr>
<td>Polymer modified bitumen PMB 45/80-65</td>
<td>E</td>
</tr>
<tr>
<td>Polymer highly modified bitumen PMB 25/55-80 HiMA</td>
<td>E</td>
</tr>
<tr>
<td>Polymer highly modified bitumen PMB 45/80-80 HiMA</td>
<td>E</td>
</tr>
<tr>
<td>Polymer highly modified bitumen PMB 65/105-80 HiMA</td>
<td>E</td>
</tr>
</tbody>
</table>
High-temperature properties of asphalt mixtures
Rutting resistance test
The following types of binders were used in the rutting resistance test:

- **Paving grade bitumen**: 20/30, 35/50, 50/70.
- **Highly polymer modified bitumen**: PMB 25/55-80 HiMA, PMB 45/80-80 HiMA, PMB 65/105-80 HiMA.

**Test conditions:**

- Rutting resistance was evaluated using the small wheel tracker acc. to method B, in the air, described in EN 12697-22
- The bituminous mix AC16 for the wearing course was used
- **Test temperatures**: 60°C and 70°C
- Bitumen content - 5,6% (the same amount in all mixes regardless of bitumen type)
ASPHALT MIXTURES TESTING.

Rutting resistance test results
Wheel-Tracking Slope WTS\textsubscript{AIR} [mm/10 000 cycles],
AC16 mix at 60°C and 70°C

Graph interpretation: less = better
Correlation between bitumen and asphalt mixtures
## Correlation Between Bitumen and Asphalt Mixtures

The table below shows the correlation R² between bitumen and asphalt mixtures. R² more = better.

<table>
<thead>
<tr>
<th>Tested property of bitumen</th>
<th>Tested property of asphalt mixtures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Proportional Rut Depth (PRD&lt;sub&gt;AIR&lt;/sub&gt; T = 60°C)</td>
</tr>
<tr>
<td>Softening Point (R&amp;B)</td>
<td>R² = 0.59</td>
</tr>
<tr>
<td>Jnr, 3.2 kPa, Temp = 64°C</td>
<td>R² = 0.95</td>
</tr>
<tr>
<td>Jnr, 3.2 kPa, Temp = 70°C</td>
<td>---</td>
</tr>
</tbody>
</table>
Summary and conclusions
SUMMARY AND CONCLUSIONS

- European standards for bitumens at high temperatures provide only fairly limited information related to rutting resistance of the associated asphalt mixes. There is no significant correlation between the softening point and rutting results.

- US standards (MSCR after RTFOT) seems to provide more efficient methods for evaluation the consequences of using a specific bitumen at high temperature conditions.

- Polymer modified bitumens exhibit significantly better properties at the high temperatures than regular unmodified bitumens. All highly modified bitumens (HiMA) showed the highest resistance to rutting.

- The results of the MSCR test and the rutting test of asphalt mixes at different temperatures demonstrate intrinsic sensitivity of bitumens to high temperatures. Temperature range used in this study as well as good correlation with Jnr3.2 rutting resistance parameter provide very promising tools to determine performance of bitumens in high temperature conditions. Taking occurrence of more hot temperature periods into consideration, it can also have a practical dimension rather than only scientific.
THANK YOU FOR ATTENTION