

# AV '17 KONFERENCE ASFALTOVÉ VOZOVKY 2017

## High-temperature properties of bituminous binders and asphalt mixtures

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**Motto: Asfaltové vozovky – bezpečná cesta k prosperitě**

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### 02 High-temperature properties of bitumen

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acc. to European Standard

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acc. to Superpave system

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## Introduction

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## 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?***

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## INTRODUCTION – THE TEST PROGRAMME

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

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## High-temperature properties of bitumen acc. to EN standard

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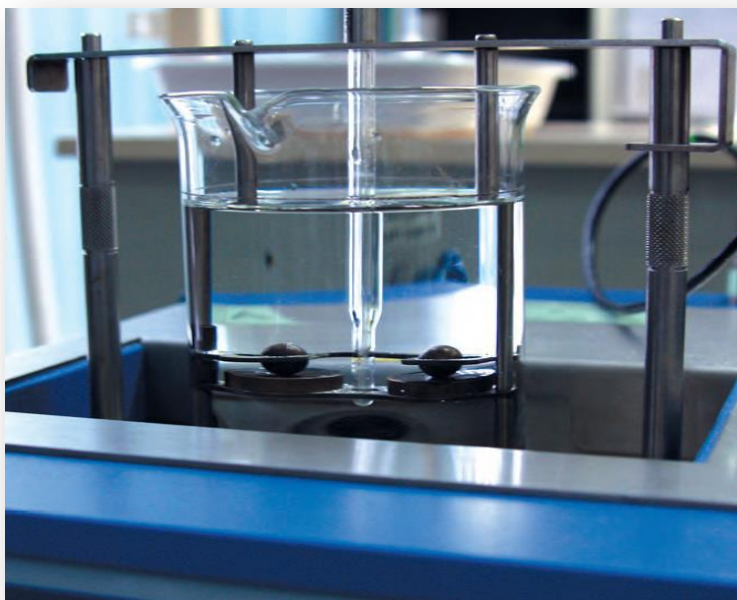
  
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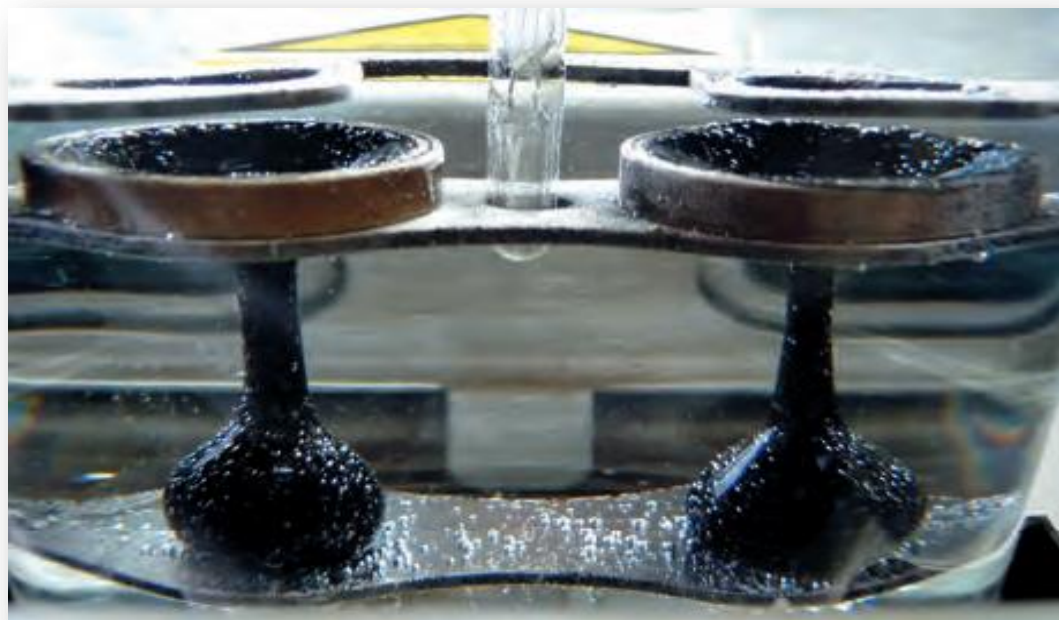
## BITUMEN TESTING. SOFTENING POINT

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*



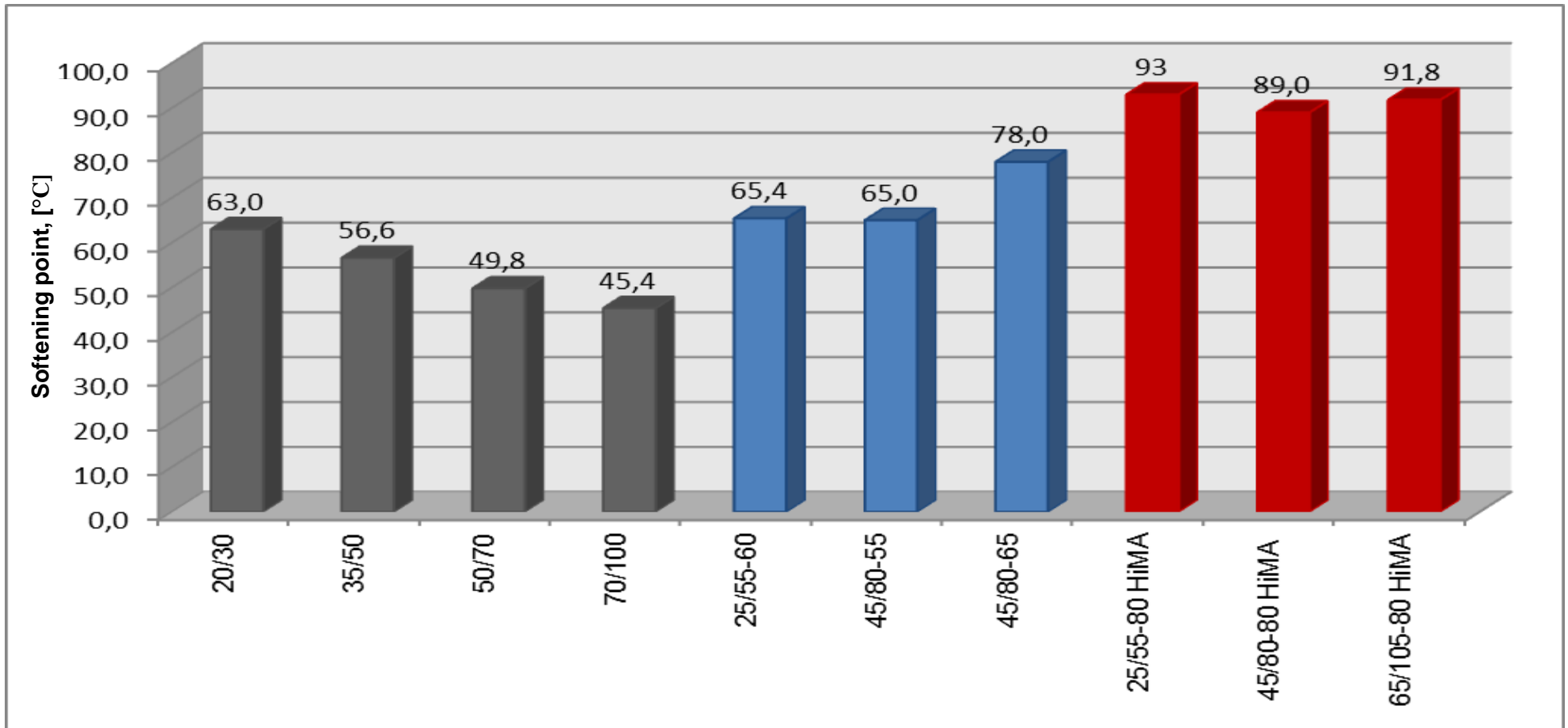
*View of a bitumen sample after R&B test*

*Fot: ORLEN Asphalt Sp. z o.o.*

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## BITUMEN TESTING. RESULTS OF SOFTENING POINT

Softening point test results, acc. to EN 1427





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## High-temperature properties of bitumen acc. to Superpave system

### MSCR method

## BITUMEN TESTING. MSCR METHOD DESCRIPTION.

- **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)*
    - **ASTM D7405:** *Standard Test Method for Multiple Stress Creep and Recovery (MSCR) of Asphalt Binder Using a Dynamic Shear Rheometer.*
  - 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.**

## BITUMEN TESTING. MSCR METHOD DESCRIPTION.

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*

## 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  $J_{nr3.2}$  kPa is the most relevant parameter used to classify bitumen binder's resistance to permanent deformations.**

**The lesser the  $J_{nr3.2}$  kPa value, the higher resistance to rutting for the corresponding asphalt mixtures.**

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## MSCR test results

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## BITUMEN TESTING. 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.
  - **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.
  
- **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**

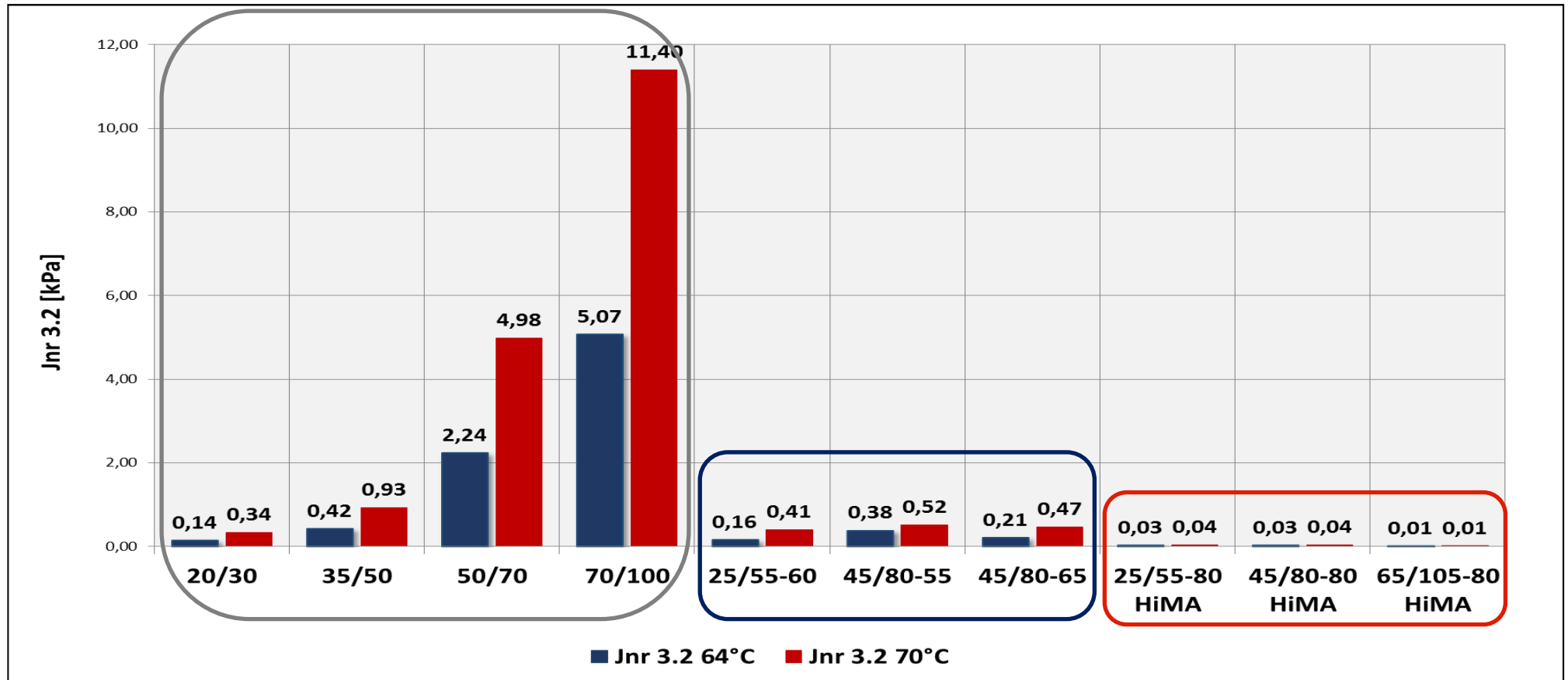
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## BITUMEN TESTING. MSCR TEST RESULTS.

### MSCR test results

Jnr 3.2 [kPa<sup>-1</sup>], temperature: 64°C and 70°C

graph interpretation: **less = better**





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## BITUMEN TESTING. MSCR TEST RESULTS.

Classification of bitumens and traffic load characteristics requirements  
based on the *Superpave* system

Letter Class (letter code)	Number of equivalent standard axle loadings and traffic conditions	Requirements for bitumen in higher boundary temperature for PG Jnr3.2
<b>S – Standard</b>	< 10 mln axles standard traffic	<b>≤ 4,0</b>
<b>H – Heavy</b>	10-30 mln axles or slow traffic	<b>≤ 2,0</b>
<b>V – Very Heavy</b>	>30 mln axles or fully stop traffic	<b>≤ 1,0</b>
<b>E – Extreme</b>	>30 mln axles and fully stop traffic	<b>≤ 0,5</b>

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## BITUMEN TESTING. MSCR TEST RESULTS.

### Classification of bitumens based on MSCR test

Binder type	Class in temperature 64°C and 70°C, acc. to PG Jnr 3.2	
	64°C	70°C
Paving grade bitumen 20/30	E	E
Paving grade bitumen 35/50	E	V
Paving grade bitumen 50/70	S	*
Paving grade bitumen 70/100	*	*
Polymer modified bitumen PMB 25/55-60	E	E
Polymer modified bitumen PMB 45/80-55	E	V
Polymer modified bitumen PMB 45/80-65	E	E
Polymer highly modified bitumen PMB 25/55-80 HiMA	E	E
Polymer highly modified bitumen PMB 45/80-80 HiMA	E	E
Polymer highly modified bitumen PMB 65/105-80 HiMA	E	E

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## High-temperature properties of asphalt mixtures Rutting resistance test

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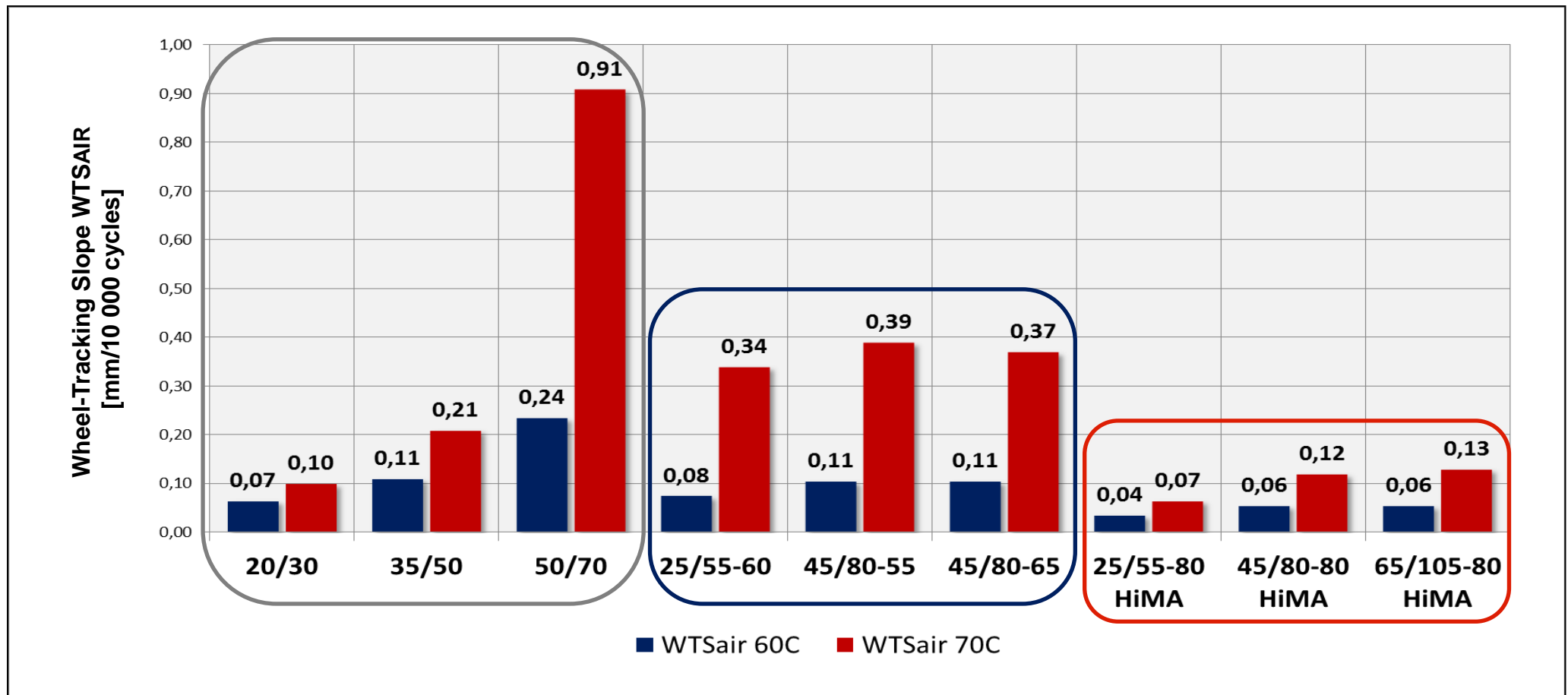
## ASPHALT MIXTURES TESTING.

- The following types of binders were used in the rutting resistance test:
  - **Paving grade bitumen:** 20/30, 35/50, 50/70.
  - **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.
  
- **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)

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## ASPHALT MIXTURES TESTING.

Rotting resistance test results  
Wheel-Tracking Slope WTS<sub>AIR</sub> [mm/10 000 cycles],  
AC16 mix at 60°C and 70°C



graph interpretation: **less = better**

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## Correlation between bitumen and asphalt mixtures

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## CORRELATION BETWEEN BITUMEN AND ASPHALT MIXTURES

Correlation  $R^2$  between bitumen and asphalt mixtures:

$R^2$  more = better

Tested property of bitumen	Tested property of asphalt mixtures			
	Proportional Rut Depth $PRD_{AIR}$ $T = 60^\circ C$	Wheel-Tracking Slope $WTS_{AIR}$ $T = 60^\circ C$	Proportional Rut Depth $PRD_{AIR}$ $T = 70^\circ C$	Wheel-Tracking Slope $WTS_{AIR}$ $T = 70^\circ C$
Softening Point R&B	$R^2 = 0,59$	$R^2 = 0,56$	$R^2 = 0,42$	$R^2 = 0,43$
Jnr, 3.2 kPa, $Temp = 64^\circ C$	$R^2 = 0,95$	$R^2 = 0,92$	---	---
Jnr, 3.2 kPa, $Temp = 70^\circ C$	---	---	$R^2 = 0,84$	$R^2 = 0,84$

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## Summary and conclusions

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## 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.

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