Alternative usage of MSCR test for evaluation of type and content of polymer in bitumen

Petr Jíša[a], Radek Černý[a]

[a]Orlen UniCRE a.s.. Revoluční 1521/84. 400 01 Ústí nad Labem

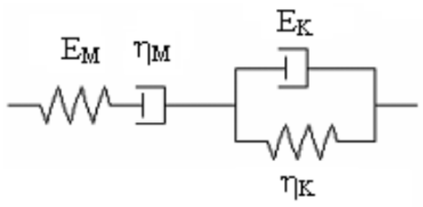
Introduction

Results from MSCR creep and recovery tests can be evaluated by rheological models
The obtained model parameters can refer to the type and content of the used polymer
The goal of our work was deeper evaluation of results from MSCR using Burgers model

Materials and methods

Burgers model

Combines elements from Maxwell model (index M) and Kelvin-Voigt model (index K)



Deformation curve from MSCR can be fitted by Burgers model by constitutive equations

$$\varepsilon(t) = \begin{cases} \frac{\sigma_0}{E_M} + \frac{\sigma_0 t}{\eta_M} + \frac{\sigma_0}{E_K}\left(1 - e^{-\frac{E_K}{\eta_K} t}\right) & (t < t_1) \\ \frac{\sigma_0 t_1}{\eta_M} + \frac{\sigma_0}{E_K}\left(1 - e^{-\frac{E_K}{\eta_K} t_1}\right) e^{-\frac{E_K}{\eta_K}(t - t_1)} & (t \geq t_1) \end{cases}$$

- t_1 time at which recovery begins
- $\varepsilon(t)$ strain at given time
- σ_0 shear stress in creep phase

Evaluated bitumen samples

Acronym	Characteristic
REF	Base bitumen (no polymers)
1 % SBSL	1 wt % of linear SBS
5 % SBSL	5 wt % of linear SBS
1 % SBSR	1 wt % of radial SBS
5 % SBSR	5 wt % of radial SBS
0.5 % RET	0.5 wt % of reactive terpolymer
2.5 % RET	2.5 wt % of reactive terpolymer

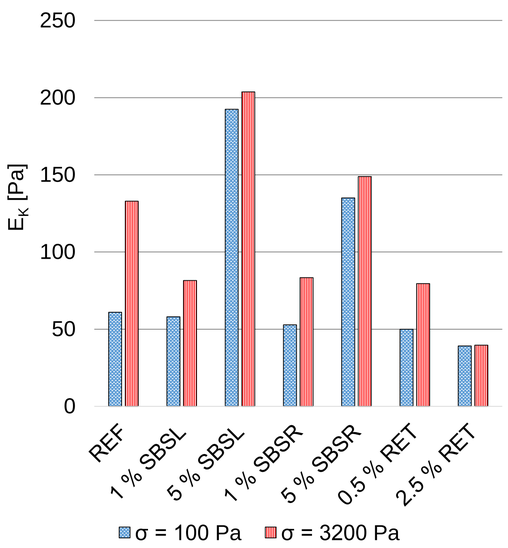
Results and discussion

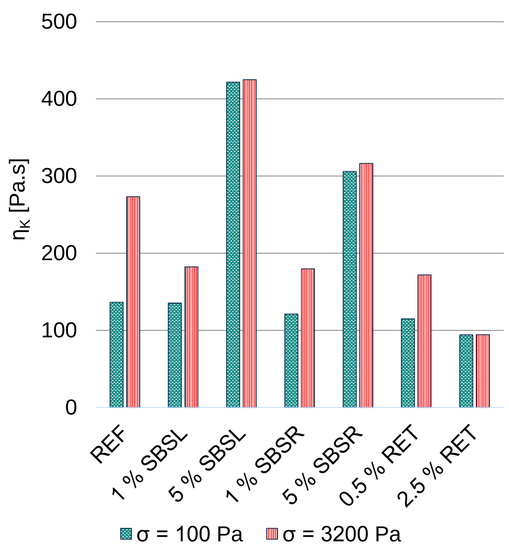
Kelvin-Voigt model elements

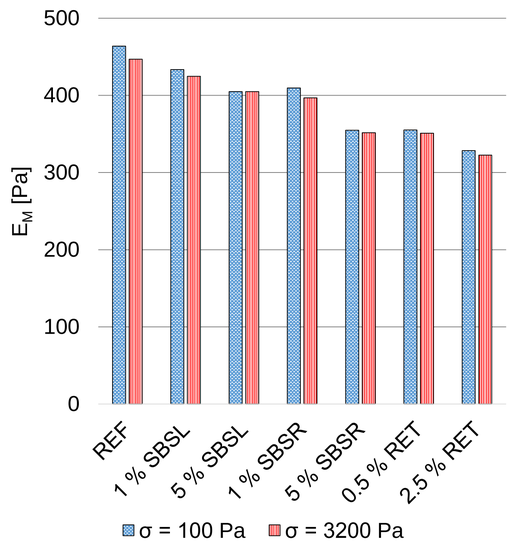
- High sensitivity to shear stress
- Low sensitivity to low polymer contents
+ For high contents of polymers, sensitivity to shear stress is lower (possible indicator of high polymer content)

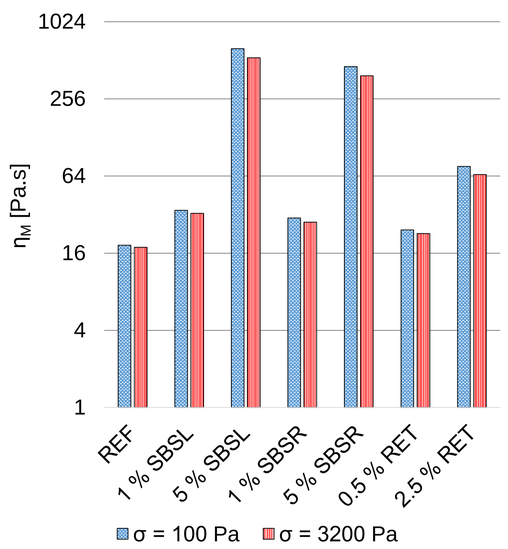
Maxwell model elements

+ Low sensitivity to shear stress
+ High sensitivity to polymer content
+ Different dependency on polymer content for different polymers









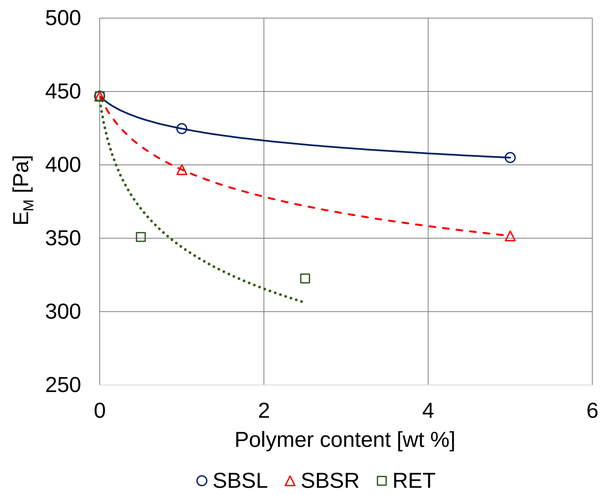
Conclusions

- From MSCR results, it is possible to calculate rheological elements of Burgers model
- Among the Burgers model elements, the Maxwell elements (E_M, η_M) particularly appear to have a potential for distinguishing between polymers and their different contents in bitumen
- Dependency of E_M on polymer content differs depending on used polymer

Dependency of E_M on polymer content can be fitted by logarithmic function

$$E_M = a \cdot \ln(b \cdot x + c) + d$$

	SBSL	SBSR	RET
a	-13.7	-31.5	-44.3
b	21.4	22.6	30.0
c	5.3	5.8	3.8
d	469.8	502.2	502.5



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