CETRA[2018]

5th International Conference on Road and Rail Infrastructure
17–19 May 2018, Zadar, Croatia

Road and Rail Infrastructure V

Stjepan Lakušić – EDITOR

IRF GLOBAL

FEHRL

Organizer
University of Zagreb
Faculty of Civil Engineering
Department of Transportation

CETRA[2018]
5th International Conference on Road and Rail Infrastructure
17–19 May 2018, Zadar, Croatia

TITLE
Road and Rail Infrastructure V, Proceedings of the Conference CETRA 2018

EDITED BY
Stjepan Lakušić

ISSN
1848-9850

ISBN
978-953-8168-25-3

DOI
10.5592/CO/CETRA.2018

PUBLISHED BY
Department of Transportation
Faculty of Civil Engineering
University of Zagreb
Kačićeva 26, 10000 Zagreb, Croatia

DESIGN, LAYOUT & COVER PAGE
minimum d.o.o.
Marko Uremović · Matej Korlaet

PRINTED IN ZAGREB, CROATIA BY
"Tiskara Zelina", May 2018

COPIES
500

Zagreb, May 2018.

Proceedings of the
5th International Conference on Road and Rail Infrastructures – CETRA 2018
17–19 May 2018, Zadar, Croatia

Road and Rail Infrastructure V

EDITOR
Stjepan Lakušić
Department of Transportation
Faculty of Civil Engineering
University of Zagreb
Zagreb, Croatia

CETRA[2018]
5th International Conference on Road and Rail Infrastructure
17–19 May 2018, Zadar, Croatia

ORGANISATION

CHAIRMEN

Prof. **Stjepan Lakušić**, University of Zagreb, Faculty of Civil Engineering
Prof. emer. **Željko Korlaet**, University of Zagreb, Faculty of Civil Engineering

ORGANIZING COMMITTEE

Prof. **Stjepan Lakušić**
Prof. emer. **Željko Korlaet**
Prof. **Vesna Dragčević**
Prof. **Tatjana Rukavina**
Assist. Prof. **Ivica Stančerić**
Assist. Prof. **Maja Ahac**
Assist. Prof. **Saša Ahac**
Assist. Prof. **Ivo Haladin**
Assist. Prof. **Josipa Domitrović**
Tamara Džambas
Viktorija Grgić
Šime Bezina
Katarina Vranešić
Željko Stepan
Prof. **Rudolf Eger**
Prof. **Kenneth Gavin**
Prof. **Janusz Madejski**
Prof. **Nencho Nenov**
Prof. **Andrei Petriaev**
Prof. **Otto Plašek**
Assist. Prof. **Andreas Schoebel**
Prof. **Adam Szeląg**
Brendan Halleman

INTERNATIONAL ACADEMIC SCIENTIFIC COMMITTEE

Stjepan Lakušić, University of Zagreb, president
Borna Abramović, University of Zagreb
Maja Ahac, University of Zagreb
Saša Ahac, University of Zagreb
Darko Babić, University of Zagreb
Danijela Barić, University of Zagreb
Davor Brčić, University of Zagreb
Domagoj Damjanović, University of Zagreb
Sanja Dimter, J. J. Strossmayer University of Osijek
Aleksandra Deluka Tibljaš, University of Rijeka
Josipa Domitrović, University of Zagreb
Vesna Dragčević, University of Zagreb
Rudolf Eger, RheinMain Univ. of App. Sciences, Wiesbaden
Adelino Ferreira, University of Coimbra
Makoto Fujiu, Kanazawa University
Laszlo Gaspar, Széchenyi István University in Győr
Kenneth Gavin, Delft University of Technology
Nenad Gucunski, Rutgers University
Ivo Haladin, University of Zagreb
Staša Jovanović, University of Novi Sad
Lajos Kisgyörgy, Budapest Univ. of Tech. and Economics
Anastasia Konon, St. Petersburg State Transport Univ.
Željko Korlaet, University of Zagreb
Meho Saša Kovačević, University of Zagreb
Zoran Krakutovski, Ss. Cyril and Methodius Univ. in Skopje
Dirk Lauwers, Ghent University
Janusz Madejski, Silesian University of Technology
Goran Mladenović, University of Belgrade
Tomislav Josip Mlinarić, University of Zagreb
Nencho Nenov, University of Transport in Sofia
Mladen Nikšić, University of Zagreb
Andrei Petriaev, St. Petersburg State Transport University
Otto Plašek, Brno University of Technology
Mauricio Pradena, University of Concepcion
Carmen Racanel, Tech. Univ. of Civil Eng. Bucharest
Tatjana Rukavina, University of Zagreb
Andreas Schoebel, Vienna University of Technology
Ivica Stančerić, University of Zagreb
Adam Szeląg, Warsaw University of Technology
Marjan Tušar, National Institute of Chemistry, Ljubljana
Audrius Vaitkus, Vilnius Gediminas Technical University
Andrei Zaitsev, Russian University of transport, Moscow

CETRA[2018] 17–19 May 2018, Zadar, Croatia
5th International Conference on Road and Rail Infrastructure

IMPROVEMENT IN PROPERTIES OF BITUMEN USING SELECTED ADDITIVES

Eva Remišová
University of Zilina, Faculty of Civil Engineering, Department of Highway Engineering, Slovak Republic

Abstract

The properties of bituminous binders should meet specific requirements resulting from the load in the road pavement construction. The bituminous binder is expected to have the properties to ensure the durability of the asphalt mixture, the resistance of the asphalt mixture to permanent deformations at high temperatures (elastoplastic behaviour, stiffness) and at low temperatures to sufficiently stiffness and relaxation properties to resist low temperature cracking (cohesion and tensile strength of the binder). In order to improve the qualitative properties of bitumen and/or asphalt mixtures, additives and modifiers are applied e.g. to increase elasticity, improve adhesion to aggregate, reduce viscosity, increase ageing process resistance, prevent binder drainage from the surface of aggregate, etc. In some cases, the required properties can be modified by adding "natural" bitumen. Additives to improve adhesion are surfactants that reduce surface tension at the bitumen/aggregate phase and thus improve wetting. The results of the tested additives show their positive effect on the adhesion of bitumen to the aggregate determined according EN 12697-11 after 6 and 24 hours rolling in particular on the adhesion of paving grade bitumen to acidic and neutral aggregates (granodiorite, andesite, melaphyre). However, the results show that these additives also affect basic properties of bitumen binder as penetration, softening point, viscosity. The most significant changes have been made with the use of the Licomont BS100 and Sasobit wax additives (increase in the softening point of 13 to 43 °C) which move the bitumen to the values typical for the modified bitumen. By adding CWM and Wetfix BE additives, the bitumen became softer. In most cases, the additive has reduced the bitumen viscosity, the bitumen was less viscous, that allow better workability of the mixture and the possibility of lowering the working temperatures.

Keywords: bitumen, additive, affinity to aggregate, penetration, viscosity

1 Introduction

Bitumen binders are used in road construction to produce the various structural layers of the road pavement. The top layer pavement construction are most common produced from asphalt mixtures. Continuous obtaining of knowledge about the impact on development of bitumen parameters in the production, laying and durability of asphalt mixtures in the pavement, allows us to choose the most suitable for the using purpose. The bitumen for asphalt pavements has not always all the required parameters, such as adhesion, increased elasticity, resistance to ageing, to heat effect, workability of the mixture, etc. To improve the performance of bitumen properties and then asphalt mixtures, the different types of additives are used. In the production of low temperature asphalt mixtures (WMA), organic compound as amide waxes, montan waxes, low Fischer-Tropsch (FT) paraffin, zeolites are used as additives [1-4].

DOI: https://doi.org/10.5592/CO/CETRA.2018.737

Each of them has different characteristics and other influences the asphalt production process. Waxes and paraffins also influence by physico-mechanical properties and zeolites act to improve workability for example. The type of additive must be selected carefully so that the melting point of the additive is higher than expected in-service temperatures and to reduce the risk of permanent deformation and to minimize cracking of asphalt at low temperatures. Adhesion promoters, surfactants, reduce the surface tension on the bitumen / aggregates contact, and so improve the wetting. They're polar substances which are able to absorb on the aggregate surface (hydrophobization) and at the same time to attach in the bitumen. Chemically they are esters of fatty acids, their non-metallic salts, amines, amides, etc. Modifiers, unlike additives, enter to the bitumen structure and create a 3-D network. Bitumen modified by the addition of macromolecular substances such as synthetic polymers, change the thermo-viscous and elastic-viscous properties of bitumen [5]. The quality level is dependent on the type of modifier and its quantity in the bitumen, type of bitumen and chemical composition, and the technology mainly homogenisation method. In some cases, you can modify the properties by adding "natural bitumen" e.g. the adhesion, elasticity, heat sensitivity, resistance to ageing.
The choice of suitable additives is influenced by the additive properties and structure, bitumen chemical composition and physical properties, and the requirements for the quality of bitumen and asphalt mixtures. In work [6] the effect of selected additives on the adhesion between three types of aggregate and bitumen (50/70, 35/50) and on the water sensitivity was studied. Therefore four additives used in [6] were selected for verification of the influence on bitumen basic properties as penetration, softening point and dynamic viscosity.

2 Experimental program

The aim of the program is to monitor the change of properties of bitumen binders in laboratory conditions using selected additives. In order to meet the objectives of the work, experimental measurements of bituminous binders' properties were performed on samples of paving grade binders 50/70, 35/50 and polymer modified bitumen 45/80-75. The binders were tested on basic properties as penetration according to EN 1426, softening point according to EN 1427, dynamic viscosity determined using spindle viscometer (Brookfield model DV/II Pro) according to EN 13302 and the affinity to acid and intermediate aggregates (granodiorite, andesite, melaphyre) according to EN 12697-11 after 6 and 24 hours rolling (Fig. 1).

Figure 1 Performed tests of experiment

The binders were mixed with common used additives as Sasobit, FT-paraffin, additive based on synthetic waxes; Licomont BS100, additive based on derivate of fatty amines; Wetfix BE adhesion promoter based on derivate of fatty amines; and CWM surface active additive (Fig. 2). The additives were applied in amounts that are recommended by their producers, additives Sasobit and Licomont BS100 in amount of 3.0 % by weight of binder and Wetfix BE and CWM in amount of 0.4 % by weight of binder.

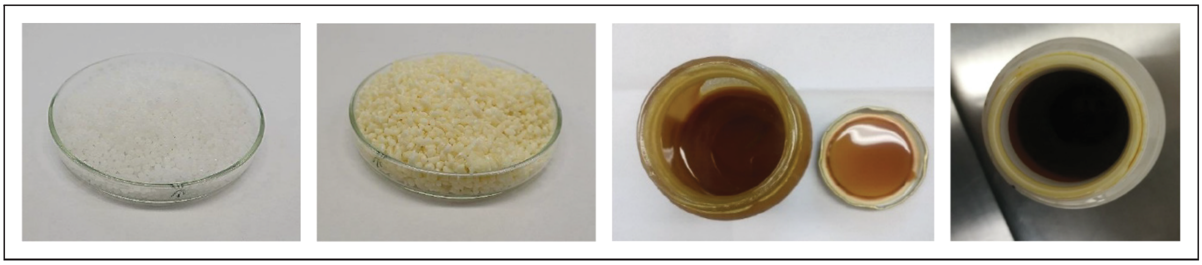

Figure 2 Used promoters – Sasobit, Licomont BS100, Wetfix BE, CWM

3 Test results and analysis

Tested additives have been verified in terms of their influence on adhesion between bitumen and aggregate. In the context of the experimental measurements the affinity 35/50 and 50/70 bitumen to neutral and alkaline aggregate by the rolling bottle method according to EN 12697-11 was determined (Fig. 3). In all cases, the positive effects of the additives used after 6 and 24 hours rolling was recorded. The determination of adhesion between polymer modified bitumen and the acidic, neutral and alkaline aggregate showed satisfactory results without the addition of additives (degree of bitumen coverage over 60 % for acidic and neutral stone, over 70 % for limestone).
The results of measurements of bitumen basic properties as penetration and softening point showed the different changes compared to the reference samples without additives. The changes of parameter (values increase or decrease) are influenced by the type of bitumen and additive. In Figure 4 there are the results of penetration of bitumen and bitumen with additives. Addition of Sasobit caused a percentage decrease in penetration for all binders, while CWM in all cases caused an increase in penetration. The largest decrease occurred with PmB 45/80-75 after the addition of Sasobit by up to 28.5 % compared to the reference penetration. The smallest decrease was only 0.4 % after the addition of Licomont BS100 to binder 35/50. The CWM addition in PmB 45/80-75 increased by 11.2 % and at least by 0.1 % at least CWM in 35/50. Overall we can evaluate PmB 45/80-75 as a bitumen, at which the greatest percentage changes in penetration values occurred after the addition of additives.

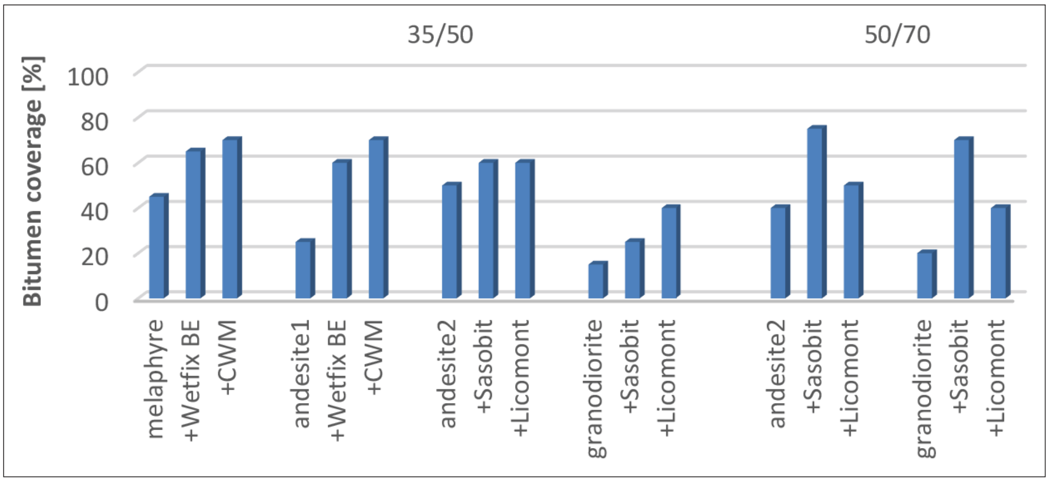

Figure 3 The results of the affinity between 35/50 and 50/70 bitumen and aggregates

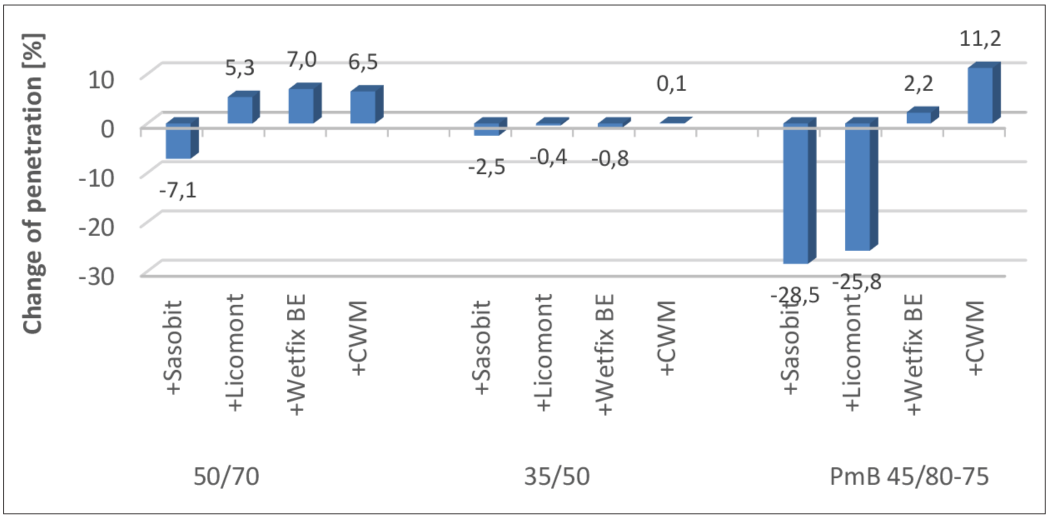

Figure 4 The change of penetration of bitumen binders by application of additives

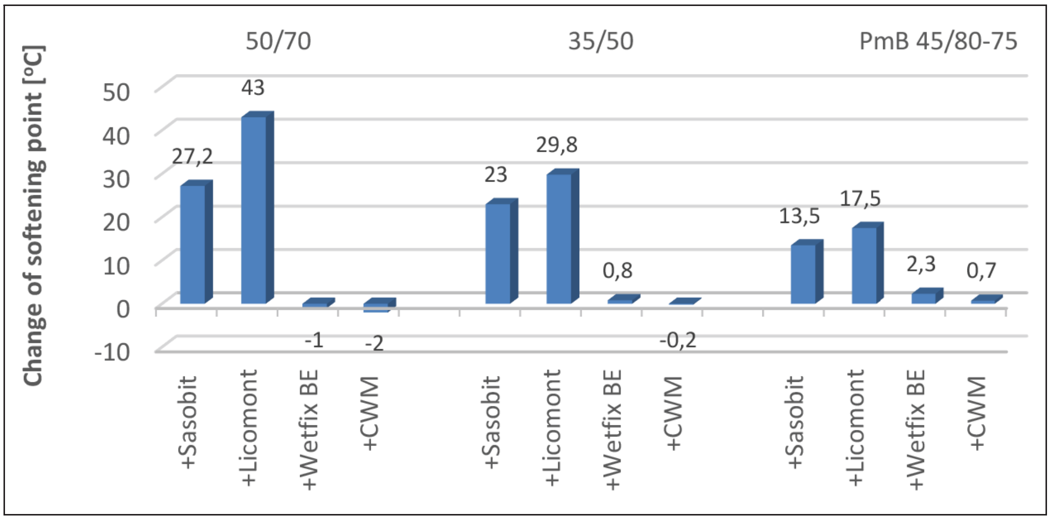

Figure 5 The change of softening point of bitumen binders by addition additives

The softening point of bitumen indicates the temperature at which the bitumen loses its stiffness and it may cause pavement deformation. The additives Sasobit and Licomont BS100 caused an increase for all bitumens´ softening point (Fig. 5). The biggest increase of +43 °C occurred after the addition of Licomont BS100 to 50/70. The smallest increase was caused by the adding the CWM additive to PmB 45/80-75 (+0.7 °C). The lowest effect on the bitumen softening point showed additive Wetfix BE and CWM, the changes are negligible from -2 °C to +2.3 °C.

The dynamic viscosity of tested bituminous binders, determined in the temperature range of 120 °C to 190 °C, was reduced by the addition of additives, more markedly for 35/50 and 50/70 bitumen and Sasobit and Licomont BS100 additive (Fig. 6, 7, 8). The additives influenced the viscosity significantly in the temperature range from 120 °C to 150 °C. The use of Wetfix BE and CWM additive in bitumen 35/50 showed almost no change in bitumen viscosity. The effect of Wetfix BE and CWM additives on polymer modified bitumen viscosity in temperature range of 160 °C to 190 °C is approximately the same. The Licomont BS100 and Sasobite additives significantly changed the thermo-viscous properties of tested binders.

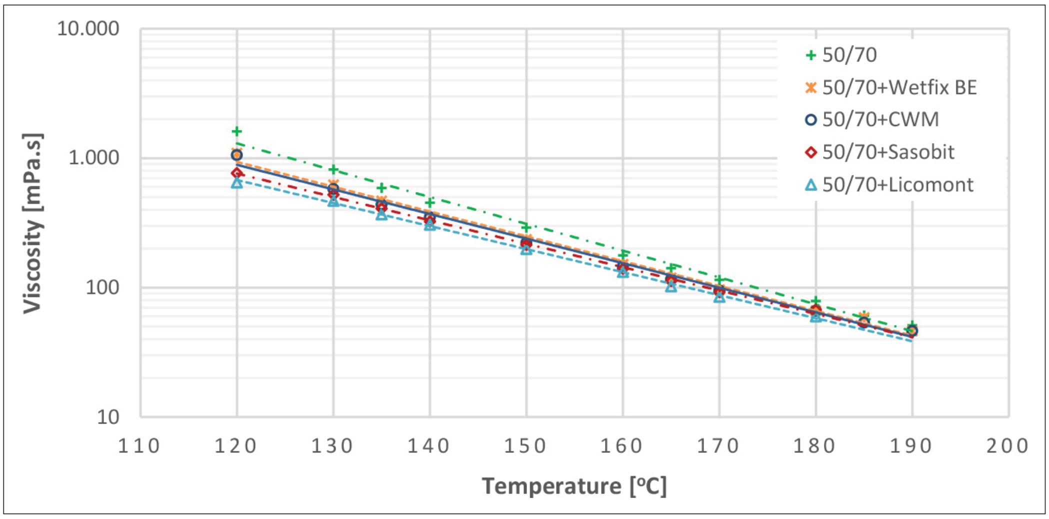

Figure 6 The results of dynamic viscosity of 50/70 bitumen with additives

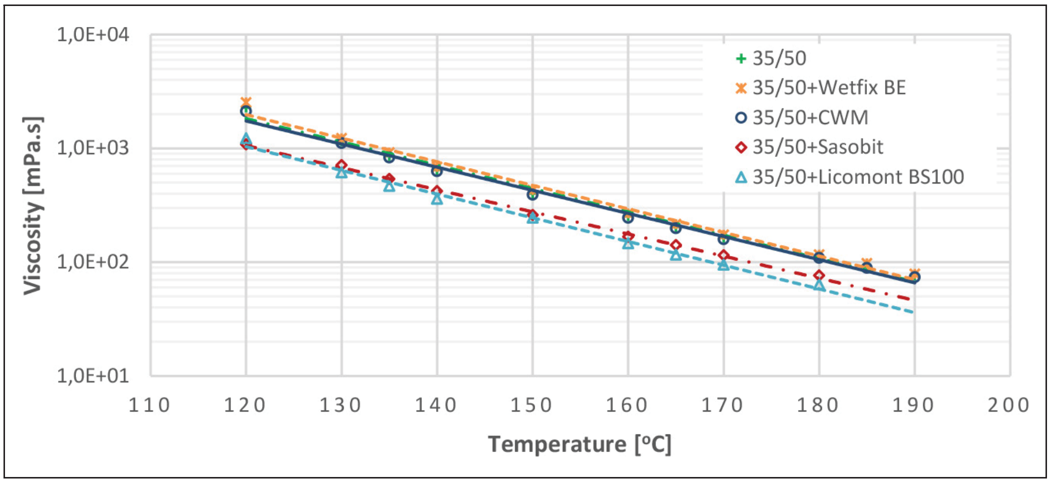

Figure 7 The results of dynamic viscosity of 35/50 bitumen with additives

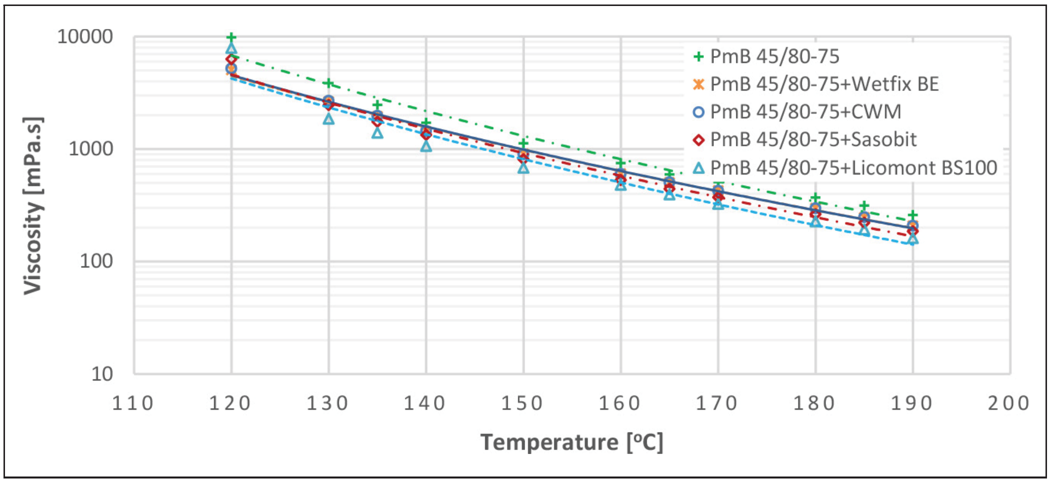

Figure 8 The results of dynamic viscosity of PmB 45/80-75 with additives

4 Conclusions

The use of tested additives, in principle, does not change the gradation of bitumen. Overall, the bitumen penetration due to the additives does not change significantly compared to the values for bitumen without additives. The major changes in values were observed for PmB 45/80-75 bitumen. The Licomont BS100 additive, among all tested additives, most influences the parameter values for all three binders. The Sasobit and Licomont BS100 additives caused the significant increase in the softening point of tested binders, the lowest influence on the softening point being with Wetfix BE and CWM additives. By adding additives the viscosity of all bitumen in temperatures in the range of 120 °C to 190 °C were reduced, excepting Wetfix BE additive and 35/50 bitumen.
It has been confirmed that Wetfix BE and CWM additives, improving the adhesion between bitumen and aggregate, only minimally influenced bitumen tested properties. The additives Sasobit and Licomont BS100, bitumen-modifying waxes, have increased the softening point and have reduced the viscosity which allows to reduce the working temperature during the production and spreading of the asphalt mixture.

Acknowledgments

The research is supported by the project VEGA 1/0300/17 Research of performance related and rheological properties of bituminous binders.

References

[1] Chomicz-Kowalska, A., Mrugala, J., Maciejewski, K.: Evaluation of Foaming Performance of Bitumen Modified with the Addition of Surface Active Agent, WMCAUS, 245 (2017), pp.1-11, doi:10.1088/1757-899X/245/3/032086.

[2] Asphalt additives market – Global forecast to 2026, brochure, Copyright © 2016 MarketsandMarkets, 2016.

[3] Remišová, E.: Ako zmenia prísady vlastnosti asfaltov, in Výstavba a rehabilitácia asfaltových vozoviek, SAAV International Conference, Vysoké Tatry, in Slovak, ISBN 978-80-232-0333-2, 2017, pp. 44-48, 2017.

[4] Iwanski, M., Chomicz-Kowalska, A., Maciejewski, K.: Application of synthetic wax for improvement of foamed bitumen parameters, Construction and Building Materials 83 (2015), pp.62-69, 2015.

[5] McNally, T.: Polymer Modified Bitumen. Properties and Characterisation, 1st edition, Woodhead Publishing Limited, ISBN 9780857090485, 2011.

[6] Hušlová, K.: Porovnania výsledkov skúšok priľnavosti asfaltu ku kamenivu z rôznych skúšobných metód, in Slovak, University of Zilina, pp.78, 2016.

[7] EN 1426 Bitumen and bituminous binders. Determination of needle penetration.

[8] EN 1427 Bitumen and bituminous binders. Determination of the softening point. Ring and Ball method.

[9] EN 13302 Bitumen and bituminous binders – Determination of dynamic viscosity of bituminous binder using a rotating spindle apparatus.

[10] EN 12697-11 Bituminous mixtures. Test methods for hot mix asphalt. Part 11:Determination of the affinity between aggregate and bitumen.