

Physico-mechanical properties of asphalt concrete based on road bitumen modified by rapeseed oil epoxide

Mykhailo Nykypanchuk¹,
Yurii Hrynychuk¹ and Mykola Olchovyk²

1. Lviv Polytechnic National University, 12, Bandery str., 9013 Lviv, UKRAINE; E-mail: yura_gym@ukr.net
2. Road Service in Lviv region, 54, V. Velykoho str., 79053 Lviv, UKRAINE; E-mail: dorogalviv@ukr.net

Abstract – the investigation results of type B fine asphalt concrete and its form modified by rapeseed oil epoxide are represented. The efficiency of ERO addition and its positive effect on the physico-mechanical properties of asphalt concrete has been established.

Key words: asphalt concrete, modifier, epoxide, bitumen, strength, water resistance.

I. Introduction

Since the quality of asphalt concretes depends on the quality of bitumen, which is the basis for AC production, it is necessary to pay attention to the properties of asphalt concrete based on modified bitumen. Polymers and latexes of different types, synthetic waxes (low-molecular modifiers), natural asphalt, fiberglass and others are among the additives that improve the quality of asphalt and may be introduced into the bitumen composition or fed directly to the asphalt mixer. Thus, the guarantee of AC quality is one of the priorities in the road industry [1].

However, despite the relative simplicity of AC application, the behavior of modified asphalt layers has not been sufficiently investigated. Regardless of the fact that they are widely used in Ukraine, their application is based on some physical and mechanical properties that do not allow to verify the feasibility of their use [1].

According to the literature data analysis, the modification of bitumen by polymers has been studied quite thoroughly. The use of epoxy compounds is the most promising direction. Previously we determined that bitumen modification by epoxy rapeseed oil (ERO) improves bitumen qualitative characteristics, such as penetration, softening temperature, ductility, adhesion, etc. [2]. EPO is produced *via* rapeseed oil epoxidation.

Therefore, the aim of this work was to study the effect of bitumen modified by ERO on the physico-mechanical properties of asphalt concrete.

II. Experimental

Pure road bitumen BND 90/130 and bitumen modified by ERO in the amount of 3 wt % were used as initial materials at 463 K for 300 min. Such a choice should demonstrate a clear difference between non-modified and modified bitumen and ERO effect on the improvement of AC characteristics. The ERO effect on bitumen properties is represented in Table 1.

TABLE 1

PHYSICO-MECHANICAL PROPERTIES OF BITUMEN MODIFIED BY ERO

Index	BND 90/130	BND 90/130 + 3 wt % ERO
Softening temperature by "rig and ball" method, K	318	322
Penetration at 298 K, $m \cdot 10^{-4}$ (0.1 mm)	95	85
Ductility at 298 K, $m \cdot 10^{-2}$ (cm)	133	132
Adherence with glass, adhesion, %	95	92

The mineral part of AC mixture corresponds to the B25 grading. In accordance with [3] it is hot, fine-grain, dense mixture of B type with continuous grading, I type, based on BND 90/130.

To study the efficiency of ERO addition we selected two AC mixtures similar by grain size (Fig. 1) with the maximum size of aggregates 20 mm according to [4].

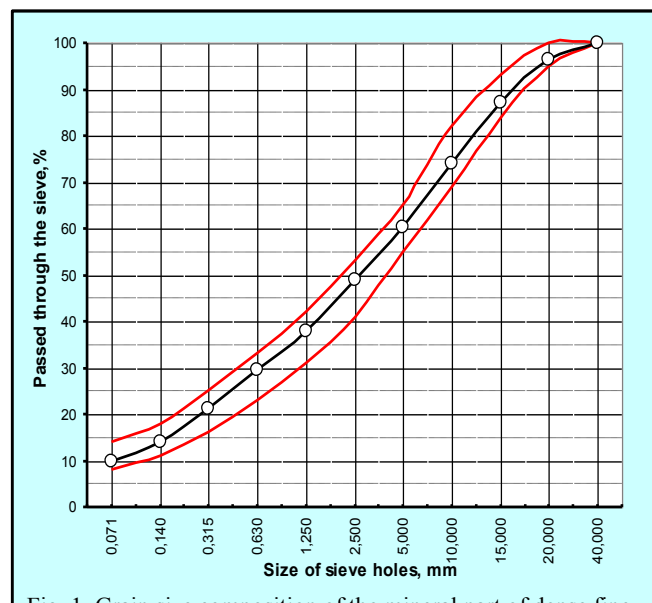


Fig. 1. Grain size composition of the mineral part of dense fine asphalt concrete of B25 type with continuous grading



Fig. 2. Photograph of the samples

Physico-chemical properties of AC mixture were determined using cylindrical samples ($D = 71.4$ mm, $h = 71.4 \pm 1.5$ mm) obtained under the laboratory conditions by means of mixtures compaction in the standard form (Fig. 2).

After samples formation on the basis of standard and modified bitumen we determined their physico-mechanical characteristics in order to study the change in properties of AC modified by ERO. All investigations were carried out according to the standards.

The results demonstrate that ERO is suitable for use as bitumen modifier. It improves the AC properties and meets the demands for petroleum viscous modified bitumen BMP-90/130-49 [4]. The introduction of 3 % modifier into bitumen increases the AC strength by half at 293 K and doubles it – at 323 K compared with the non-modified AC (Table 2). This fact indicates that they are characterized by higher thermal stability and coatings on their basis will have higher track stability under working conditions. The AC water resistance factor is equal to 0.97.

TABLE 2

PHYSICO-MECHANICAL PROPERTIES
OF FINE ASPHALT CONCRETE

Index	For asphalt concrete based on:	
	BND 90/130	BND 90/130 modified by ERO
Bitumen content, %	6.2	6.2
Water saturation, vol %	0.49	0.51
Average density, g/cm ³	2.4	2.4
Ultimate strength, MPa, at		
293 K	5.2	8.1
323 K	1.8	3.8
Water resistance factor	0.91	0.97

The bitumen modification by ERO is technologically simple process and needs the same equipment and technology necessary while using other modifiers (Elvaloi, Kraton D, *etc.*), i.e.:

1. Bitumen heating to 453–463 K.

2. Gradual and regular introduction of 2–5 % of ERO under constant stirring of the binding agent.

3. After the additive introduction, the intensive mixing of bitumen with ERO for a definite time.

Conclusions

The experimental results show high efficiency of ERO additive and its essential effect on the ultimate strength and durability of road coatings on the basis of modified AC. The comparison of different asphalt concretes with various additives indicates high efficiency of the bitumen modified by ERO.

Such bitumen meets all standards [5] and its characteristics (especially strength and water resistance) are better as compared to the non-modified ones.

References

- [1] Zhdanyuk V.K., Costin D., and Volovyk O.O., „Rezultaty porivnyalunykhn doslidzhen vlastyvostei asfal'tobetoniv z dobavkoyu “trinidadepure/z 0/8” [Results of comparative studies of the properties of asphalt concrete with the addition of "trinidadepure / z 0/8"], *Naukovo-vyrobnychiy zhurnal № 5 – Scientific and Production magazine number 5*, 2011, 223, 38. *Scientific and Production magazine number 5 (223) September – October 2011 p – S. 38-43.*
- [2] Grynchuk Yu. and Nykypanchuk M., „Epoksydni spoluky na osnovi ripakovo oli yak modyfikatory dlya dorozhnikh bitumiv” [Epoxides from rapeseed oil as a modifier for road bitumen]: *Visnyk Nats. Univ. Lviv. Polytechn. – Proceedings of the National University "Lviv Polytechnic". Chemistry, technology materials and their applications.*, 2011, 700, 474.
- [3] „Sumishi Asphaltbetonni i Asphaltobeton Dorogniy i Aerodromnyi.” [Sumishi asfal'tobetonni i asfal'tobeton dorozhnii ta aerodromnyi.] *Technichni Umovy – Specifications, DSTU B V.2.7-119-2011.* Kyiv 2012.
- [4] „Budivelni Materialy. Bitumy Dorogni Modifikovani Polimeramy.” [Building materials. Bitumen modified with polymers.] *Technichni Umovy – Specifications, DSTU B V.2.7-135:2007.*