Ing. Marián Dubravský, Assoc. Prof. Dr. Ján Mandula
Technical university of Košice
Civil Engineering faculty

WARM MIX ASPHALT WITH NATURAL ZEOLITE FOR ROAD PAVEMENTS

The paper deals with a method to reduce temperature of asphalt mix using the ingredients of natural zeolite. In this article we discuss a proposal of the warm mix asphalt mixtures based on natural zeolite and determine the density, maximum density and sensitivity of asphalt test specimens on water. The results are compared with the reference hot mix asphalt.

Key words: warm mix asphalt, natural zeolite, temperature reduction.

Розглядається метод зменшення температури асфальтових сумішей з використанням природного цеоліту. Обговорений підбір складу низькотемпературних (теплих) асфальтових сумішей на основі природного цеоліту та визначена об'ємна вага, максимальна об'ємна вага та вплив води на асфальтові зразки. Результати порівнюються з еталонними гарячими асфальтовими сумішами.

Ключове слова: теплі асфальтові суміші, природний цеоліт, зниження температури.

Introduction

Asphalt is a mixture of aggregates, binder and filler, used for constructing and maintaining all kind of roads, parking areas but also play- and sport areas. Aggregates used for asphalt mixtures could be crushed rock, sand, gravel or slags. In order to bind the aggregates into a cohesive mixture a binder is used. Most commonly, bitumen is used as a binder. An average asphalt pavement consists of the road structure above the formation level which includes unbound and bituminous-bound materials. This gives the pavement the ability to distribute the loads of the traffic before it arrives at the formation level. Normally, pavements are made of different layers (see Figure 1).

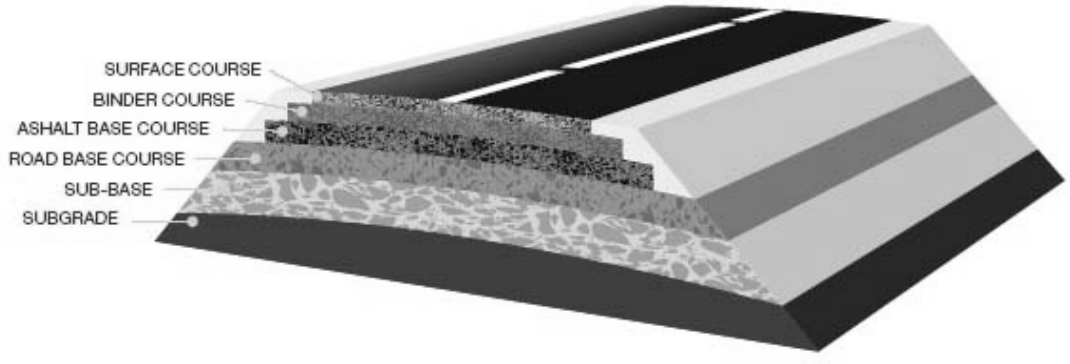

Fig. 1. Structural design of asphalt pavement

A typical asphalt road construction is multi-layered in form, comprising bitumen-bound and unbound materials. Essentially, the lower indigenous subgrade layer is covered by a bound or unbound sub-base, providing drainage and frost protection for the subgrade, and a road base layer upon which the asphalt layers are laid as a final surface coating. The structural design of a pavement relates to the ability of the road to carry the imposed loads without the need for excessive maintenance.

Warm Mix Asphalt

Warm mix asphalts are compounds that are produced and transported at lower temperature than asphalt mix produced at hot. The drop in temperature of 20 – 40 °C led to the following classification of asphalt by temperature:

- Hot Mix Asphalt (HMA) – (150 – 190 °C),
- Warm Mix Asphalt (WMA) – (100 – 140 °C),
- Half Warm Mix Asphalt (HWMA) – (60 – 100 °C),
- Cold Mix – (0 – 40 °C) [1-3].

Warm mix asphalt concrete (WMA) is produced by adding zeolites, waxes, asphalt emulsions, or sometimes even water to the asphalt binder prior to mixing. This allows significantly lower mixing and laying temperatures and results in lower consumption of fossil fuels, thus releasing less carbon dioxide, aerosols and vapors. Not only are working conditions improved, but the lower laying-temperature also leads to more rapid availability of the surface for use, which is important for construction sites with critical time schedules. The usage of these additives in hot mixed asphalt (above) may afford easier compaction and allow cold weather paving or longer hauls.

Experience from abroad highlights the following advantages of WMA:

a) reduction of emissions,
b) better working conditions in the absence of noxious gases,
c) less energy consumption,
d) rapid introduction into service,
e) possibility distribution of asphalt mix for longer distances,
f) longer period of compaction.

Natural zeolite

Zeolites are microporous, aluminosilicate minerals commonly used as commercial adsorbents. The term zeolite was originally coined in 1756 by Swedish mineralogist Axel Fredrik Cronstedt, who observed that upon rapidly heating the material stilbite, it produced large amounts of steam from water that had been adsorbed by the material [4].

Zeolite is also being used as an additive in the production process of warm mix asphalt concrete. The development of this application started in Germany in the 1990s. The structure of zeolite contains 20 % of water that is released from the structure of zeolite at higher temperature (see figure 2). This effect causes micro-foaming of asphalt mixture.

The extensive uses of zeolites are mainly due to the specific physic-mechanical properties:

- high selectivity and ion exchange,
- reversible hydration and dehydration,
- high gas sorption capacity,
- high thermo stability,
- resistance to aggressive media [5].

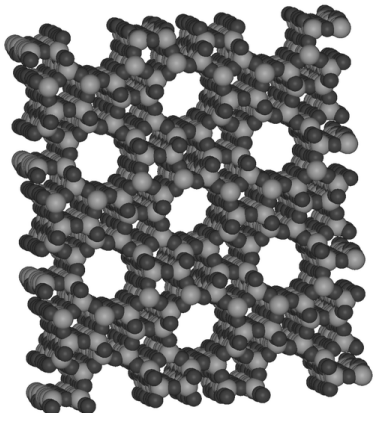

Fig. 2. Spatial structure of Clinoptilotite

As an ingredient in asphalt mixtures of natural zeolite was used product ZeoCem 200, the manufacturer is the company Zeocem a.s. Bystré (location Nižný Hrabovec). Zeolite is suitable on use in industry, households, the liquidation of oil spills in agriculture, forestry, chemicals in the brain. It has a maximum chemical stability, ability to maintain sorbed material and absorbs odors, [2]. Chemical composition of the natural zeolite used in experiment is shown in table 1.

Table 1

Chemical composition of the natural zeolite

Oxide	**SiO_2**	**Al_2O_3**	**TiO_2**	**Fe_2O_3**	**MnO**	**CaO**	**MgO**	**K_2O**	**Na_2O**
Quantity (%)	66,97	10,61	0,24	1,72	0,03	2,90	0,73	2,96	0,68

Propose and analysis

To verify the basic features of asphalt mixtures produced by foaming technology of WMA were proposed WMA designated AC surf 11 and AC bin 16 produced at 130 °C with addition of 0.3 % of natural zeolite. These mixtures were compared with reference mixture AC surf 11 and AC bin 16 produced at 160 °C. Composition of asphalt mixtures used in experiment is shown in table 2.

Table 2

Composition of asphalt mixtures

Mixture/Mark	**Gravel – fraction**			**Stone meal**	**Additive**	**Binder**
Type of gravel	Hradová	Hradová	Hradová	Hosťovce	Natural zeolite	MOL
Mark	fr. 8/11	fr. 4/8	fr. 0/4	VJM	Zeolite	50/70
Quantity (%) AC bin 16	**34.5**	**19.0**	**37.3**	**4.7**	**0**	**4.5**
Quantity (%) WMA AC bin 16	**34.5**	**19.0**	**37.3**	**4.4**	**0.3**	**4.5**
Quantity (%) AC surf 11	**19.0**	**21.0**	**52.0**	**7.0**	**0**	**6.0**
Quantity (%) WMA AC surf 11	**19.0**	**21.0**	**52.0**	**6.7**	**0.3**	**6.0**

Resulting particle size distribution curves of aggregate for asphalt mixture WMA AC bin 16, which comply with the limits (see Figure 3).

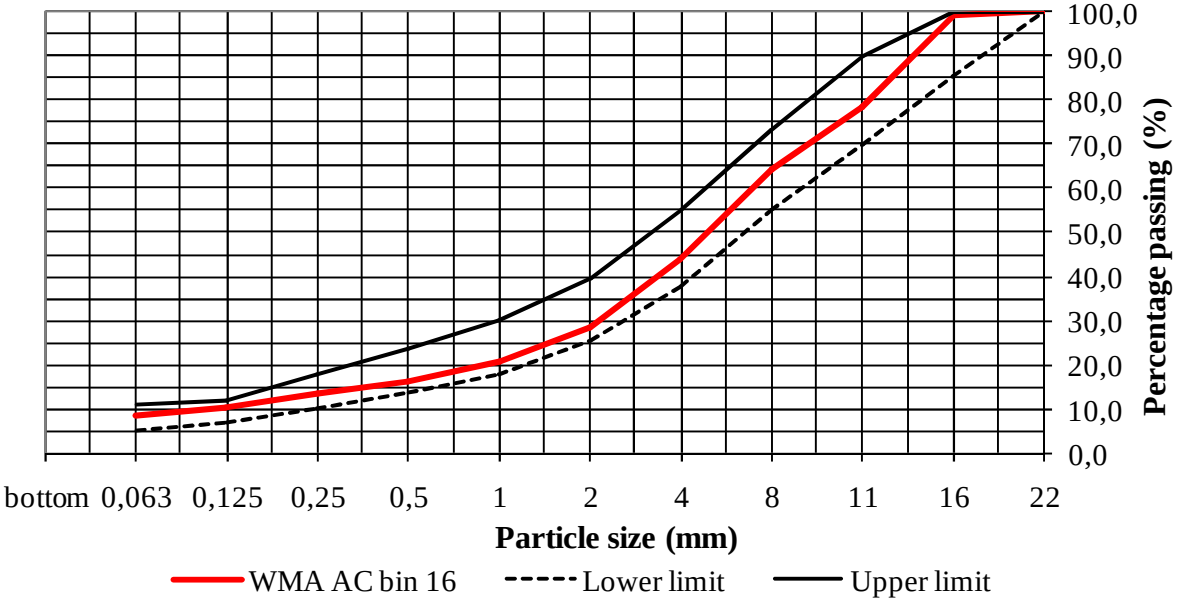

Fig. 3. Determination of particle size distribution of AC bin 16 (STN EN 12697-2)

Resulting particle size distribution curves of aggregate for asphalt mixture WMA AC surf 11, which comply with the limit curves (see Figure 4).

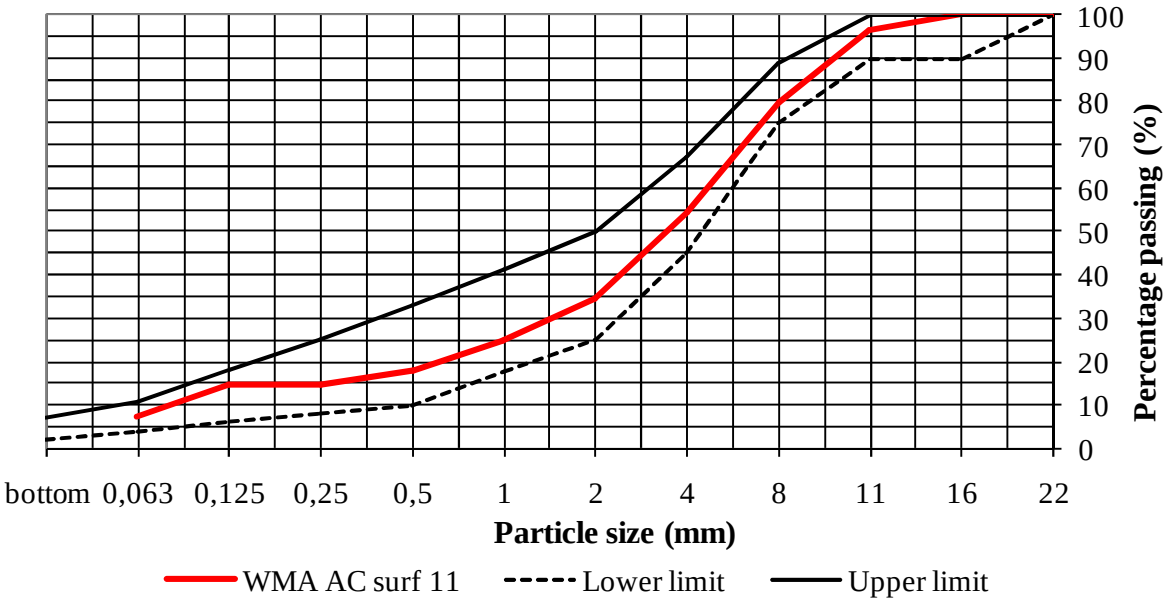

Fig. 4. Determination of particle size distribution of AC surf 11 (STN EN 12697-2)

Experiment and assessment

Addition of natural zeolite in WMA for surface and binder course allowed compaction at lower temperature while retaining air void content. The results of measured values are shown in Figure 5 and Figure 6. The results are compared with the desired value under the Asphalt datasheet I/2 and I/3. Figure 5 graphically shows the results of the density, maximum density and air void content of asphalt test specimens [6].

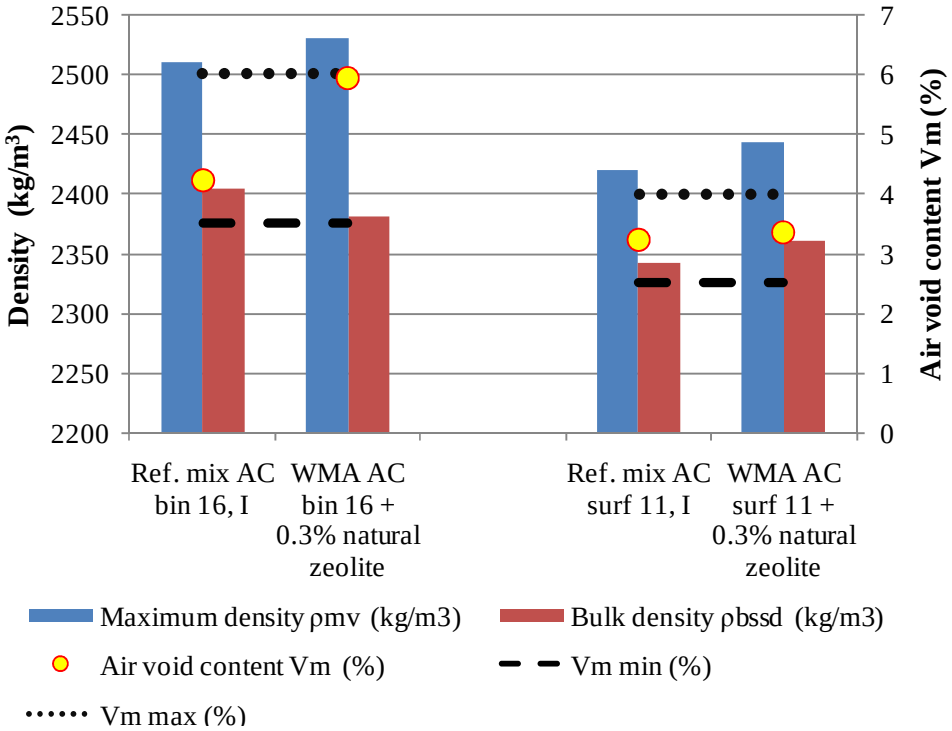

Fig. 5. Density and air void content of asphalt mixtures

Figure 6 graphically shows the results of the indirect tensile strength for each asphalt mixtures, and consequently calculated sensitivity to water ITSR (indirect tensile strength ratio – %) [7]. Water sensitivity of asphalt specimens is comparable with reference mixture.

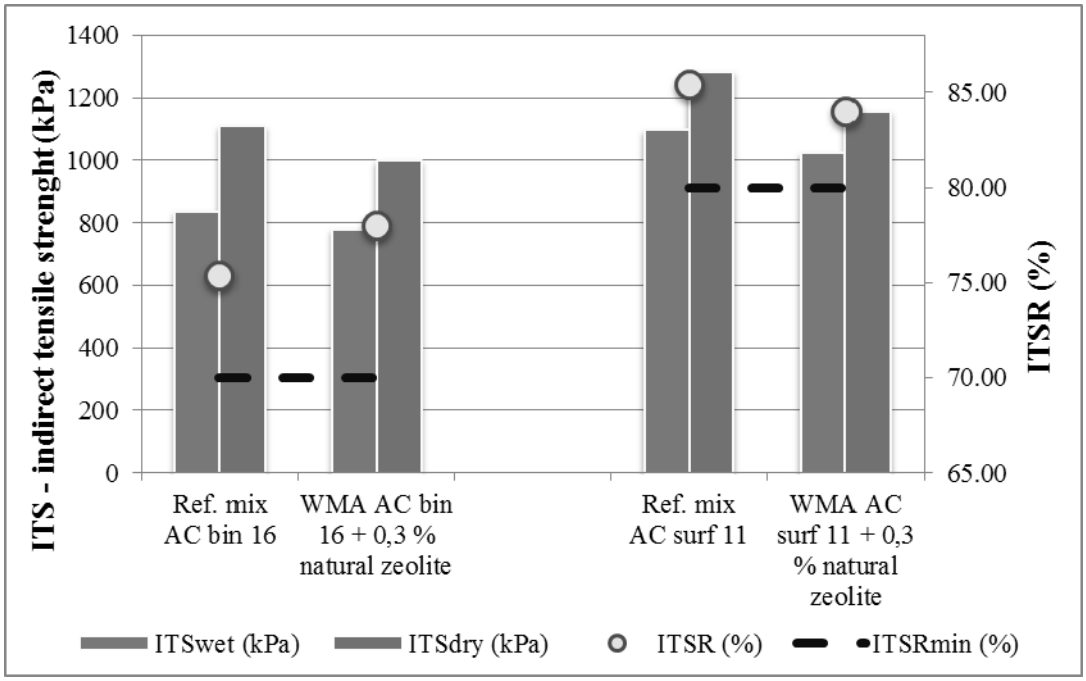

Fig. 6. Indirect tensile strength of asphalt mixtures

Conclusion

Warm mix asphalt is possible for asphalt industry to improve performance of their products, efficiency of construction and admit environmental benefits. Results of studies show that mechanical properties of WMA are comparable to conventional asphalt mixtures. The challenge is to demonstrate that the overall performance of WMA is really as good as that conventional asphalt. Reduce the production of $C0_2$ as a result of reduction in consumption of fuels in the production of asphalt mixtures. Less fumes, aerosols and odor in the production and laying of warm mix asphalt. The ultimate aim is further study and then freely implements this technology in order to promote innovation and competition.

Acknowledgments

The research has been carried out within the project NFP 26220220051 Development of progressive technologies for utilization of selected waste materials in road construction engineering, supported by the European Union Structural Funds.

The paper presents results of the research activities of the Centre „Progressive Constructions and Technologies in Transportation Engineering“. The Centre was supported by the Slovak Research and Development Agency under the contract No. SUSPP-0013-09 and the companies Inžinierske stavby and EUROVIA SK.

1. Rubio M. C., Martínez G., Baena L., Moreno F.: Warm mix asphalt: an overview. Journal of Cleaner Production Volume 24, March 2012, pp. 76–84. 2. Vaitkus, A., Cygas, A., Laurinavicius, A., Perveneckas, Z.: Analysis and evaluation of possibilities for the use of warm mix asphalt in Lithuania. The Baltic Journal of Road and Bridge Engineering 4, 2009, pp. 80-86. 3. Vaitkus, A., Vorobjovas, V., Ziliut, L.: The Research on the Use of Warm Mix Asphalt for Asphalt Pavement Structures. Road Department, Vilnius Gediminas Technical University, 2009, Vilnius, Lithuania. 4. W. R. Grace & Co. Enriching Lives, Everywhere. – Zeolite Structure. Grace.com. Retrieved on 2010-12-09. 5. http://www.zeocem.com/sk/. 6. Dubravský, M., Mandula, J.: Objemové hmotnosti nízkoteplotných asfaltových zmesí na báze zeolitu. In: Vedecko-výskumná činnosť ÚIS. Herľany 6.-7. december 2011. Košice: TU, SvF, 2011, s. 29-32. ISBN 978-80-553-0821-0. 7. Mandula, J., Dubravský, M.: Warm mix asphalt based on natural zeolites. In.: Pozemné komunikácie a dráhy. Vol. 7/issue 2, 2011, pp. 21-30. ISSN 1336-7501.