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ScienceDirect

Procedia Engineering 172 (2017) 441 – 448

Procedia Engineering

www.elsevier.com/locate/procedia

Modern Building Materials, Structures and Techniques, MBMST 2016

Effect of polymer fibres reinforcement on selected properties of asphalt mixtures

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Abstract

The paper presents selected results of the research program concerning fibre reinforced asphalt concrete. Aramid-polyalphaolefin fibres was used in this study. Selected properties responsible for low temperature cracking and resistance to permanent deformation are presented in this paper. Low temperature cracking susceptibility was evaluated with the results obtained from bending test of rectangular beams with constant rate of deformation and semi-circular bending test based on fracture mechanics theory. Performance in high temperatures was assessed by master curves of dynamic modulus. Obtained results indicated that evaluated fibres can improve low temperature pavement performance.

Peer-review under responsibility of the organizing committee of MBMST 2016

Keywords: fibres reinformcement; asphalt mixture; low-temperature cracking; dynamic modulus, SPT, fracture mechanics; SCB test.

1. Introduction

In recent years, different ways of improving asphalt pavements performance are gaining more and more popularity. One of such technologies is using fibres as a reinforcement in asphalt mixtures, which derives from cement concrete fibre reinforcement. Various types of fibres are known to be used in this application. These include both synthetic (glass, carbon, polymer) and natural (hemp, coir, jute, sisal, flax) fibres [1]. Main function of fibres incorporated into asphalt mixture is to increase tensile strength which can result in higher strain energy responsible for fracture characteristics [2]. As a result, asphalt mixtures with fibres addition tend to be more resistant to

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Peer-review under responsibility of the organizing committee of MBMST 2016
doi:10.1016/j.proeng.2017.02.026

permanent deformation and have higher tensile strength [3] what is important for resistance to low temperature cracking.

It should be noted that the idea of using fibres in asphalt mixtures is not a new concept. In 1984 Button and Hunter [4] published a report concerning usage of synthetic fibres in asphalt mixtures. Ten different fibres types (both synthetic and organic) were tested in terms of Hveem and Marshall stability, resilient modulus, indirect tension, fatigue, creep and resistance to moisture damage. Field trials and observations were also conducted. In general, slight overall improvement was noticed (e.g. susceptibility to moisture damage) but some positive effects were attributed to higher binder content of mixtures with fibre additions. Clear potential in extending fatigue life and reducing crack propagation (partly confirmed by field trials) was also observed, but the cost effectiveness of evaluated technologies was considered as questionable. Since then a number of other experiments with using fibres in asphalt mixtures were carried out [3,5,6].

Recently, a composition of aramid-polyalphaolefin fibres has gained significant attention. It was originally developed in 1982 [7] as an additive to extend fatigue life of asphalt pavement. Present version of polymer fibres tested in this research was introduced in 2008 and since then was a subject of a several research programs.

An extensive testing of aramid-polyalphaolefin fibres was done by Kaloush et al. [8]. Subjected fibres were evaluated in terms of their influence on triaxial shear strength, resistance to permanent deformation measured by the results of dynamic creep test, dynamic modulus, fatigue life, thermal cracking and crack propagation. Two different fibres contents were tested – 0.45 kg and 0.9 kg per ton of asphalt mixture. In overall, mixtures with the addition of fibres showed better characteristics than reference mixtures, but fibre content was also a factor that affected final results. For dynamic modulus test, mixture with 0.45 kg fibre content presented higher moduli than reference mixture while adding 0.9 kg fibre content resulted in worse (i.e. lower modulus) characteristics. Flexural strength was also affected by fibres content in the same manner and it can be concluded that for certain properties there is an optimum fibre content after which adding more fibres can lead to unsatisfactory results. Kaloush also concluded that better performance of asphalt mixtures with discussed fibres can be also incorporated in pavement design process and pavement overall thickness can be reduced by using fibres [9,10]. Stempihar et al. [11] described the use of aramid fibres in open graded asphalt mixtures used for airfields pavements. According to his findings fibre-reinforced asphalt concrete improves dynamic modulus especially at higher temperatures and although the initial cost of the mixture is slightly higher than traditional mix, in overall this extra cost can be overcome by a minimal increase of pavement service life [11].

2. Experimental details

2.1. Methodology

The objective of the experiment was to determine the influence of polymer fibres addition on the selected properties of asphalt mixtures for wearing and binder course. The research program was defined to identify eventual differences between asphalt mixtures with and without reinforcing fibres. It included evaluation of parameters responsible for pavement behaviour in low temperatures and high temperatures.

2.2. Materials

Three different asphalt mixtures were tested, all based on Polish requirements described in document WT:2-2014 [12] according to PN-EN 13108-1 [13]: asphalt concrete for wearing course AC 11 S obtained by mixing granite and limestone aggregate with 5.6% (by weight) of neat bitumen 50/70 for medium traffic load category, asphalt concrete for binder course AC 16 W obtained by mixing granite aggregate with 4.6% (by weight) of neat bitumen 35/50 and polymer modified bitumen PmB 25/55-60 for medium and heavy traffic load category. Due to the character of the research, it was decided not to implement anti-striping agent in composition of used asphalt concretes, in order to avoid any possible influence of its presence on test results. Volumetric properties, water sensitivity according to the standard PN-EN 12697-12 [14] and Appendix 1 of the document WT-2 2014 [12] and rutting resistance according to the standard PN-EN 12697-22 [15] of used asphalt mixtures are presented in Table 1, both for reference mixtures and for mixtures with fibres.