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Viscoelastic properties of polymer modified bitumen in Warm Mix Asphalt technology in terms of ageing

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Abstract

The paper presents the influence of ageing on the viscoelastic properties of the polymer modified bitumen (PMB) in WMA technology. The base bitumen was PMB 45/80-65. Fischer-Tropsch synthetic wax (SW) and the liquid surface active agent (FA) ware used as a bitumen viscosity-reducing modifiers. All properties of binders have been determined before ageing (NEAT) and after long-term ageing (RTFOT+PAV). The research area includes the study basic properties (softening point and Fraass breaking point) and rheological characteristics (zero shear viscosity ZSV, complex viscosity η_0 and rutting factor G*/sinδ). It was found that fatty amine additive works as a ageing inhibitor. The ageing process revealed degradation process in polymer. This phenomenon is more explicit in the bitumen modified with wax than the fatty amine.

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Keywords: ageing; modified RTFOT; PAV; WMA; synthetic wax; fatty amine.

1. Introduction

Warm Mix Asphalt (WMA) technologies are gaining attention all over the world. The key elements of warm asphalt mixes include modifiers added to reduce the mix production and compaction temperatures [1,2]. Developed in response to the Kyoto Protocol setting global emission reduction targets [3]. WMAs can be produced and placed at temperatures approximately 20ºC – 40ºC lower than those of conventional hot mix asphalt [4,5] but higher than the temperature of boiling water [6]. To ensure that effect, certain organic additives have to be used, such as

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synthetic waxes [7] or chemical compounds (surfactants) [8]. The effective temperature range for the use of surfactants is 85ºC to 140°C. Above this range, in extreme cases up to 180ºC, disintegration of surfactants is initiated [9] along with polymer degradation [10] which reduces effectiveness of the modification. The Polish standard PN-EN 12591:2009 requires that simulation of short-term ageing be conducted at a temperature of 163ºC. However, modified WMAs reach the equivalent viscosity at temperatures lower [11] than those used in the RTFOT methodology (0.17 ÷ 0.28 Pas). This means that ageing simulation is conducted at lower viscosity and temperatures that do not correspond to real field conditions.

Considering the limited number of studies devoted to the impact of the modified RTFOT temperature on WMAs modified with polymers and additives, the ageing simulation tests in the RTFOT short-term ageing phase were performed at temperatures 28ºC lower.

2. Materials and test methods

The base bitumen used in the tests was PMB 45/80-65. The mixing additives used to lower viscosity included the synthetic wax produced by the Fischer-Tropsh process (synthetic wax - SW) [12,13] and the liquid surface active agent (fatty amine – FA) [14].

The reference bitumen was modified with the addition of 0.3% and 0.6% surface active agent and with the addition of 1.5%, 2.5% and 3.5% synthetic wax. The following samples were prepared:

- PMB (polymer modified bitumen 45/80-65)
- PMB + 0.3% FA(bitumen 45-80/65 and the addition of 0.3% fatty amine FA)
- PMB + 0.6% FA (bitumen 45-80/65 and the addition of 0.6% fatty amine FA)
- PMB + 1.5% SW (bitumen 45 -80/65 and the addition of 1.5% synthetic wax SW)
- PMB + 2.5% SW (bitumen 45-80/65 and the addition of 2.5% synthetic wax SW)
- PMB + 3.5% SW (bitumen 45-80/65 and the addition of 3.5% synthetic wax SW)

All parameters studied were determined before and after long-term ageing. Prior to subjecting the samples to the long-term ageing, short-term ageing was performed using the RTFOT (Rolling Thin Film Oven Test). Since the low viscosity modifiers were used to enable the asphalt mix production at lower temperatures, the samples were conditioned at 135°C (instead of 163°C – as specified in PN-EN 12607-1). The PAV (Pressure Ageing Vessel) was used for the long-term ageing process.

Dynamic tests for viscosity, complex modulus G* and phase angle δ were performed using the cone-plate rheometer. The plate was 25 mm in diameter. Each test was conducted to PN-EN 14770.

3. Results and discussion

3.1. Softening Point and Fraass Breaking Point temperature

Tests for the softening point and breaking point of the binder were conducted as preparatory evaluations. These two characteristic temperatures define the range of bitumen flow and the approximate range of the bitumen viscoelastic behaviour. Figures 1 and 2 show the results from the tests.