ABSTRACT

Asphalt mix design is a procedure where the type of bitumen and optimum content for a particular aggregate blend is determined. Designed proportions of these materials with suitable physical characteristics must ensure mechanical stability and durability of pavement. Waste utilization in asphalt mixtures may considerably contribute to enhancement of asphalt mixture's performance when all components are carefully selected. Herein below, modification of asphalt mixtures with waste composite powder PMMA/ATH (poly-methyl methacrylate filled with aluminium trihydrate) was investigated. PMMA/ATH waste powder is generated in large amounts during the shaping process of acrylic sheets.

In the first part of the dissertation, comprehensive mechanical and rheological study of PMMA/ATH modified paving bitumen in a broad temperature range is reported. The addition of Fischer-Tropsch paraffin wax to bitumen enabled temperature reduction for 20 °C during preparation of modified bitumen. The effect of primary ageing and long-term oxidative ageing of modified bitumen was studied. Besides oscillatory shear measurements, viscoelastic behaviour of modified bitumen was thoroughly examined with static and dynamic creep and recovery experiments. In the existing literature, creep and recovery tests are less frequently employed for examination of viscoelastic behaviour than measurements under oscillatory shear conditions. The findings in this study, therefore, contribute to the development of test methods and conditions for the characterization of bitumen viscoelastic properties. Repeated creep and recovery tests simulate accumulated deformation in the asphalt layer during traffic loading. Contrary to some literature report, the results of my research revealed that the frequency of loading and unloading was an important factor affecting accumulation of deformation at elevated temperatures. The time stability of examined bitumen was investigated with two important material functions – tensile E(t) and shear G(t) relaxation modulus. A calculation of relaxation moduli from experimental data was performed using the Hopkins and Hamming approach and Schwarzl method. It was found that, although the relaxation process of the modified binder is delayed, the differences in viscoelastic properties from un-aged to aged state are smaller compared to the base bitumen.

In the second part of the dissertation, the performance characteristics of asphalt mixtures prepared with waste PMMA/ATH were evaluated. The results clearly show that the addition of waste PMMA/ATH to asphalt concrete AC 8 surf (type of mixture) contributes to a higher mechanical stability of this three phase system (aggregate, bitumen, air voids). The most notable effect of PMMA/ATH in the asphalt mixture was observed when the "wet" modification technique was employed.

The doctoral dissertation represents original research on bituminous binders. Namely, in the existing literature review, time-dependent viscoelastic and fatigue behaviour of modified bitumen with selected experimental techniques and mathematical procedures (interconversions of material functions) was not found.

Keywords: PMMA/ATH, bitumen, asphalt mixture, viscoelasticity, mechanical properties