Nano-scale properties of warm-modified bituminous binders determined with atomic force microscopy

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Abstract

The use of additives to prepare warm asphalt has been a topic of intensive study recently; however, their effect on the nano-mechanical properties of binder material has yet to be studied. This study presents an investigation into the impact of warm additives Sasobit (Flakes, Organic) and Rediset WMX (Pastilles, Organic-Chemical) and LQ (Liquid, Chemical) on topography, modulus and adhesion of warm-modified bituminous binders using atomic force microscopy (AFM) with the PeakForce Quantitative Nanomechanical Mapping (PFQNM) mode. In this study, the warm additives were incorporated into two binder grades, namely 40/60 and 100/150 Pen. PFQNM results show that Sasobit significantly increased the modulus of the binders at the nano-scale by approximately seven times and five times for 40/60 and 100/150 Pen, respectively. Surprisingly, Sasobit also improved the adhesion properties of the bitumen, with the adhesion force increasing from 17.7 to 35.26 nN and from 21.56 to 59.01 nN for 40/60 and 100/150 Pen, respectively. Both Rediset WMX and LQ also improved the adhesion characterisations of warm-modified bituminous binders by around 110% and 50%, respectively. However, the elastic modulus only increased using Rediset WMX because Rediset LQ did not alter the binder properties of net bitumen as it has no effect on the morphological structure of bitumen. In summary, this study provides new insight into the behaviour and response of virgin and modified bitumen, with particular reference to adhesion and modulus.