Phase behaviour study of epoxy asphalt binders with differential scanning calorimetry

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Presented by:
Western Research Institute

Session 4: Asphalt Material Modification – Polymer, Rubber, Reactive Chemistry

Modification of asphalt by reactive polymer systems: mechanisms and development of thermo-rheological properties

Brett Lambden | *Cenovus Energy*

The new class of reactive polymers was developed to modify asphalts through chemical reactions with asphalt components. Due to the complexity of such systems, and the long experience with "classical" thermoplastic elastomer SBS, the introduction of the new modification systems is slow. Moreover, the present specifications were designed around SBS. In case of reactive polymers, it will have to be accepted that we are dealing with entirely different modification systems and materials, possibly new emerging asphalt paving technologies.
Presented work attempts to compare two different reactive polymer systems with the "classical" system using SBS. The impact of reactive polymers and SBS was studied through material properties manifested by specification tests and through their thermo-rheological properties in linear and non-linear viscoelastic region. As expected, the behavior of reactive polymeric systems with different chemistries also differed among themselves. The available results show that the reactive polymers react with polar components of asphalt which leads to higher stiffness at elevated pavement temperatures and differing impact on low temperature behavior. The data point to a significantly improved resistance to plastic deformation of pavement, despite the fact, that elastic recovery-based specification tests fail in its prediction.

Phase behaviour study of epoxy asphalt binders with differential scanning calorimetry

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The glass transition parameters are used to study the miscibility, or lack of it, in polymer modified asphalt binders. In this study, a quantitative assessment of the contribution of thermodynamics of mixing to glass transition was conducted in a differential scanning calorimetry for four asphalt binders modified with an elastomeric epoxy system. Especially, the values of heat capacity (Cp) and subsequently the glass transition temperature (Tg) of all binders were determined to quantify the miscibility based on the entropic changes. Emphasis was also given on examining the enthalpy of mixing as a function of the composition of epoxy asphalt binders during curing to ensure that these binders were completely crosslinked for further analyses. In all cases, the positive deviations of Tg,mix obtained from the ideal mixing rule, or ΔT_(g,mix), led to negative values of the entropy of mixing (ΔS_mix^c), dictating the presence of internal repulsive forces between the asphalt and epoxy components. The soft in properties and sol type base binders are also associated with epoxy asphalt binders of low ΔT_(g,mix) values. Overall, the incorporation of the epoxy system in asphalt binders increases the Tg and decreases the amount of ΔS_mix^c, and such performance imposes the formation of phase-separated binders.

Determining Optimal Mixing for Reduced Reaction Time of Reactive-Isocyanate-Based Asphalt Modifiers with Computational Fluid Dynamics

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With the functional improvements reactive-isocyanate-based modifiers provide to asphalt mixes alongside the developing knowledge of the kinetics of liquid asphalt binders, it is important to understand the functional variables in the modification reaction process. Improving the processing time of the modification step is key. Unlike polymer modified asphalts, reactive-isocyanate-based modifiers exhibit mass transfer limitations which increases the importance of well-developed mixing profiles. Shorter residence times allow for uninterrupted loading schedules at asphalt terminals and reduction in cost. Computational fluid dynamics (CFD) models were used to understand flow patterns, mixing power, shear rate, and mixing time for different impellers in a commercial scale molten asphalt reactor. For asphalt modification, pitched blade turbine (PBT) impellers are typically used. By analyzing quantitative mixing behaviors in the simulations, key performance differences were identified between the following impeller arrangements: a single PBT, two PBT's, a flat blade turbine and PBT, a ribbon, and an anchor. These attributes show how a ribbon impeller can reduce the reaction time to 3 hours versus 12 hours with a PBT impeller. Ultimately, the interplay between axial and radial flow patterns and shear rate gradients proved to be most critical to optimizing reaction time with the best impeller arrangement.