Micromechanical Modeling of Fracture in Asphalt Concrete Using a Clustered DEM Approach

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Abstract

Cracks in asphalt pavements often create irreversible structural and functional deficiencies that increase maintenance costs and decrease lifespan. The understanding of fracture behavior in asphalt concrete laboratory specimens is currently an open research area that comprises a vital link in the ability to design asphalt concrete paving mixtures and flexible pavement structures that resist cracking. Towards this end, a micro-fabric distinct element modeling (MDEM) approach was implemented in the two-dimensional particle flow software package (PFC-2D) to study the complex crack behavior observed in asphalt concrete fracture tests. This behavior was simulated with an MDEM model having complex morphological features, but relatively simple constitutive models in both the bulk material regions and at the material interfaces. A double-cantilever beam (DCB) test was used to verify the implementation of bilinear cohesive zone model (CZM) in PFC-2D, which yielded a favorable comparison between MDEM results and the closed-form reference solution. The MDEM approach was then employed to investigate the fracture behavior of asphalt concrete in a new disk-shaped compact tension test (DC(T)). Both homogeneous and heterogeneous models were successfully calibrated to experimental data and new insights towards crack propagation in asphalt mixtures were revealed. More recently, true viscoelastic material modeling has been employed to improve model predictions. New work is underway to utilize this analysis technique in the study of size effect in asphalt concrete. Early findings of this testing and analysis program will be presented. These and other related micromechanical modeling efforts being conducted around the world represent the early stages towards a "virtual asphalt laboratory," where simulations of laboratory tests and eventually field response and distress predictions can be made to enhance understanding of pavement distress mechanisms, such as thermal fracture, reflective cracking, and with considerable further extension, fatigue cracking.

Key Words: Fracture, DEM, MDEM, CZM, Double-Cantilever Beam, Bilinear cohesive model, Disk-Shaped Compact Tension, Fracture Energy, Asphalt Concrete, Crack Propagation, Crack Path, Fracture Process Zone, Homogeneous, Heterogeneous, Microstructure.

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