MEASUREMENT AND PREDICTION OF FUNDAMENTAL TENSILE FAILURE LIMITS OF HOT MIX ASPHALT (HMA)



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The purpose of this dissertation was to provide insight into key mechanisms and asphalt mixture properties that control fracture in asphalt concrete. A Digital Image Correlation (DIC) (non contact, full-field, surface displacement/strain measurement technique) was developed to more accurately capture localized or non-uniform stress distributions in asphalt mixtures and as a tool for detecting first fracture.
The experimental analysis of asphalt mixture cracking behavior was based on the Hot Mix Asphalt (HMA) Fracture Mechanics visco-elastic crack growth law. Asphalt mixture cracking mechanism and fundamental tensile failure limits were investigated using multiple laboratory test configurations, namely the Superpave Indirect Tensile (IDT) test, the Semi-Circular Bending (SCB) test and the Three-Point Bending Beam (3PB) test. Both unmodified and polymer modified mixtures were tested.
Results show that the DIC method could be used to reliably identify first fracture and to determine asphalt tensile failure limits. It was found that these failure limits are independent of the specimen geometry and of the test configuration. Also, importantly the tensile failure limits were shown to be sensitive to both presence and level of polymer modification.
Results also show that first fracture and crack growth in asphalt mixtures can be predicted effectively using a Displacement Discontinuity (DD) boundary element method, for various different boundary condition problems, and not just for the calibrated laboratory test conditions.
The numerical simulations and the DIC results showed that significant damage, stress redistribution and other changes after initial fracture make the analysis after peak load difficult to interpret meaningfully. The effect of polymer modification on crack localization was also investigated using horizontal full-field strain maps obtained from the DIC. Polymer modified mixtures showed high strains only up to the location of impending fracture, while unmodified mixtures showed highly distributed damage in both the critical area and around the point of fracture.

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