ABSTRACT

The objective of this research study was to develop a fatigue cracking characterization process for asphalt mixtures in order to evaluate fracture-fatigue performance using a laboratory test technique: dynamic Semi-Circular Bending (SCB) test, and assess: (i) crack initiation, (ii) crack propagation, (iii) fatigue failure, and (iv) residual materials properties at any stage of the progressive fatigue process. The major scope of the research included: formulation of dynamic SCB test; and assessment of fatigue performance using crack initiation and propagation properties of three major types of asphalt mixtures. Static SCB test results showed that plane strain condition could be achieved when specimen thickness varied within the range of 40-50 mm. In addition, fracture resistance Optimization showed that higher fracture resistance could be obtained when asphalt content was at the intermediate level considered in this study. Also, aggregate gradation showed a pronounced impact on K_{IC} of asphalt mixtures.

Dynamic SCB test was devised, formulated, and programmed in order to estimate the fatigue performance of eighteen asphalt mixtures at three temperatures. Next, dynamic SCB tests were conducted on 648 SCB specimens at 5, 15, and 25 ^{o}C. Fatigue lives of dense-graded asphalt mixes were characterized by higher crack initiation phase and brief crack propagation time. In contrast, modified asphalt mixtures resulted in early crack initiation time entailed by a prolonged crack propagation phase. Dense-graded asphalt mixes resulted in a stable crack growth for comparatively shorter time than the modified ones. Further, crack growth rate estimated using Paris' law parameters indicated that the gap-graded asphalt mixtures resulted in higher crack growth than dense-graded mixes for stable crack growth condition. Predictive models were established to estimate the number of cycles to crack initiation, propagation, and fatigue failure encompassing 648 data points that showed good to fair fit between the observed and predicted values. Overall, this research synergized static and dynamic fracture-fatigue responses of asphalt mixtures in a concurrent manner for fatigue cracking characterization. The developed dynamic SCB test integrated various fundamental fracture-fatigue properties to explain fatigue process and set a strong venue to advancing the state-of-the-art pertaining to fatigue cracking evaluation of asphalt mixtures.

KEYWORDS: Asphalt mixture, polymer-modified asphalt, asphalt-rubber, fatigue cracking, fracture toughness, crack initiation, crack propagation, dynamic SCB test, fracture mechanics, predictive models.