Title: Investigation of Fracture Properties of California Asphalt Concrete Mixtures

PI: Shadi Saadeh, Ph.D.
Department of Civil Engineering and Construction Management
California State University, Long Beach
Long Beach, CA 90840
Email: Shadi.Saadeh@csulb.edu

Project Objective

The objective of this study is to investigate the use of the semi-circular bend (SCB) test as a QA/QC measure for field construction and to investigate the feasibility of using SCB test results as a trigger for further investigation using beam-fatigue test (BFT). This objective was achieved by testing seven asphalt mixtures including mixtures with recycled asphalt pavement (RAP), warm mix asphalt (WMA), lime, and polymer modified asphalt. Parts of the experimental program results were used to develop and calibrate a finite element (FE) model of the SCB test. The model was then used to investigate crack propagation in SCB and to predict SCB simulations for experimental results not used in the calibration process.

Problem Statement

Fatigue life resistance of asphalt concrete (AC) is defined as AC's ability to resist repeated traffic loading without significant cracking or failure. Fatigue cracking is a primary distress in asphalt concrete that is caused by the repetitive stresses and strains due to traffic loading and environmental factors such as temperature differences. The fatigue resistance of AC is investigated by a number of fatigue tests.

Fatigue cracking occurs when the pavement has been stressed to the limit of its fatigue life by a repetitive axial load. Fatigue cracking is often associated with loads that are too heavy for pavement structure or more repetitions of a given load, which is provided for the design.

In California, the Asphalt Research Program performed a five-year study on the fatigue performance of AC mixtures. To predict fatigue performance of asphalt mixtures, BFT was developed during this study. BFT requires long testing period and can't be run on the field, which makes BFT impractical for QC/QA testing.

A previous study investigated the influence of moisture on fracture properties of asphalt mixtures. Twenty-four SCB tests were conducted on two California asphalt mixtures in dry and wet conditions. In addition, 16 BFT were conducted on the same HMA mixtures in dry and wet conditions. The results of these two tests were compared. The data analysis showed that there is a good relation between BFT and SCB however; they recommended more tests should be done on more AC mixtures in order to get reliable results.

In this study, an experimental and numerical evaluation of the SCB test is conducted. A comprehensive comparison of BFT and SCB test parameters was conducted. In addition, an

advanced FE modeling approach called extended finite element method (XFEM) is used to numerically simulate the SCB test process. This study, to the best knowledge of the authors, is the first to investigate the SCB test using XFEM. The SCB test and modeling results of this study are being considered for use as a QC/QA test for construction projects incorporating performance-related materials specifications based on designs performed using a mechanistic empirical pavement design method called CalME that is currently being developed by Caltrans and the University of California Pavement Research Center (UCPRC).

Research Methodology

In this study, the use of SCB test as QA/QC test to trigger further investigation of the fracture properties of asphalt mixtures using BFT is investigated. To achieve this goal, six different AC mixtures used in California and one from MnROAD are selected. Various asphalt mixtures with various gradation and mixture designs were selected to achieve a comprehensive comparison and evaluation. A total of 42 SCB cross head movement (CHM) method tests and 21 BFTs were conducted on seven asphalt mixtures (PG64-10RAP [LIME], PG64-28PM [LIME], 710P4-AR, AN-HMA, AN-WMA, MnROAD, WMA-ADVERA) that are used in California. In addition 18 SCB camera-method tests were conducted on the same mixtures (with the exception of MnROAD). Figures 1 and 2 show the SCB test Cross-Head Movement and Non-Contact camera Methods.

Figure1, SCB test, Cross head Movement Method

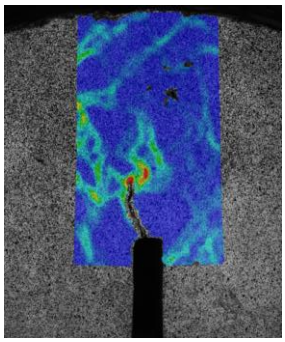

Figure 2, SCB test, Non-Contact Camera method

Results

Comparison of fracture properties of seven AC mixtures from the SCB CHM method and the beam-fatigue test (BFT) is made. This has indicated that the initial stiffness is not a good representative of the fracture properties of AC while J_c, N_f and PV are better indicators. In addition, a comparison of the results of two method of measuring SCB test parameters on six AC mixtures indicated that there is a good relation between SCB CHM and Camera methods; hence, SCB CHM can be used as a reliable test for QA/QC measures. In addition, a part of the experimental program results were used to develop and calibrate an FE model of the SCB test, and the model was then used to investigate crack propagation in SCB and to predict SCB simulations for experimental results not used in the calibration process. Based on the modeling results of this study, the results of this study indicate that the SCB test holds great potential for measuring the fracture properties of asphalt mixtures.