Fatigue performance characterization and prediction of asphalt binders using the linear amplitude sweep based viscoelastic continuum damage approach

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Abstract

This study assessed the fatigue performance of asphalt binders modified with crumb rubber, waste cooking oil (WCO), and Styrene-Butadiene-Styrene (SBS). The experimental program included linear amplitude sweep (LAS) and time sweep (TS) tests with different loading profiles under various test temperatures. The objective was to compare the fatigue analyses based on the recently proposed G^R and W^R_{sum} failure criteria within the viscoelastic continuum damage (VECD) modeling framework. Simulation algorithms were developed for the two criteria which allowed for fatigue performance evaluation. The results indicated that the damage characteristic relationship was slightly dependent on test method and strain profile, and the degree of dependence was material specific. The two failure criteria appeared to be fundamental material functions; the G^R criterion was temperature dependent but was able to unify both LAS and TS tests, while the W^R_{sum} criterion unified both test methods under all temperatures. With respect to modification, an optimum WCO dosage of 3% was identified according to the W^R_{sum} criterion for the best fatigue performance. Both the SBS and crumb rubber modifications were observed to significantly improve the fatigue resistance based on the two failure criteria.

Keywords: fatigue performance; failure criterion; waste cooking oil; crumb rubber; linear amplitude sweep

1. Introduction

With the increasing emphasis of sustainability in pavement industry, a variety of materials have been recycled and processed to modify or as a partial replacement of the virgin asphalt, such as crumb rubber from used tires, bio-binders, and re-refined engine oil bottoms (REOB) [1-4]. While achieving significant environmental, social, and economic benefits, asphalt mixtures with such recycled materials should be carefully designed and evaluated to ensure equivalent or even better performance as compared to virgin materials. On the other hand,