Sensitivity Analysis of Tensile Strength and Creep Compliance on the Thermal Crack Growth with Prediction Model of Fiber Modified Asphalt Concrete

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Abstract

Thermal cracking is one of the significant forms of asphalt pavement deterioration that can occur in cold climates or where large daily temperature cycles occur. Thermal cracking is mainly driven by mechanical and thermal properties of the asphalt concrete mixture such as creep compliance, fracture properties and thermal coefficient. In this paper, in order to investigate the effect of tensile strength and creep compliance of the fiber reinforced asphalt concrete on the amount of crack propagation induced by thermal cycle, two sets of Marshall and Indirect Tension Creep Tests were implemented using 8 specimens. The crack growth prediction model was developed using Stress Distribution Model (SDM), Stress Intensity Factor (SIF) Model, and Paris Model. The sensitivity analysis of the crack growth prediction model was done using the fracture parameters related to tensile strength of the mixture and creep compliance which were obtained from the tests. The results show that the fiber reinforcement has a great effect on the enhancement of fracture behavior of HMA asphalt concrete due to its tensile strength against crack propagation.

Keywords: Sensitivity analysis, Thermal cracking, Crack growth prediction model, Asphalt concrete, Fiber reinforced

1. INTRODUCTION

Cracking is one of the significant forms of asphalt pavement deterioration that can occur in cold climates or where large daily temperature cycles occur.

The cracking that results from cold climates is generally referred to as “Low Temperature Cracking”, and the cracking that results from daily temperature cycles is usually referred to as “Thermal Fatigue Cracking”. Low temperature cracking in Iran usually occurs in north-western provinces. Thermal fatigue cracking is associated with areas that experience large extremes in diurnal temperatures, such as Khorasan, Qom or other central provinces [1]. Therefore, it is important to find solutions in our country for reducing the thermal cracking in winter or cold climate provinces, in order to reduce maintenance costs.

Thermal cracking is associated with the volumetric contraction that occurs as a material experiences a temperature drop. If a material is restrained, which is the case for asphalt concrete in a pavement structure, the tendency to shorten will result in the development of thermal stresses [2]. Cracking will develop when the induced stress equals to or is greater than the tensile strength of the material.

Many additives such as polymer, lime, styrene, fibers and rubber were used previously by many researchers to improve the properties of hot-mix asphalt [3].

The inclusion of polymer to asphalt showed to improve the performance of asphalt mixtures. Polymer modified pavement exhibited higher resistance to rutting and thermal cracking, and reduced fatigue damage, stripping, and temperature susceptibility. Polymer-modified asphalt binders showed high performance at critical locations such as intersections of busy streets, airports, vehicle weigh stations and race tracks [4].

The scope of this research is to investigate the effect of fracture parameters of fiber-modified and non-modified asphalt concretes on the low thermal crack growth. For this purpose, temperature-induced stresses at each nodes of the Finite Element (FE) model of the asphalt layer were firstly calculated by means of