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Simulating the Visco- Elasto Plastic Behavior of Glasphalt Mixtures by Using of Modified Burgers Model

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Abstract

Analogous to most visco-elastoplastic materials, the creep curve of asphalt mixture can be generally divided into three-stages: decelerated creep, equi-velocity creep and accelerated creep. The Burgers model which can exhibit linear visco-elastic behavior is suitable to describe the first two stages of creep process and is not enough to represent the third stage. The aim of this study is simulating the visco-elastoplastic behavior of glasphalt mixtures under dynamic loading conditions by using the modified Burgers model. In this model a viscoplastic string is added to the Burgers model to predict visco-elastoplastic behavior of glasphalt mixtures at higher strain and high temperature. In this research the creep constitutive equation of the modified Burgers model is established for test conditions. Then the model parameters are solved by mathematical methods and also, predictions from the proposed model are compared with the experimental results. The results show that the modified Burgers model constitutes a very good fitting with the experimental data for each of the separately analyzed level of applied stress and testing temperature.

Keywords: Visco Elasto Plastic, Glasphalt, Repeated Loading, Model Parameters.

1. INTRODUCTION

Rutting is defined as the formation of twin longitudinal depression along the wheel paths mainly caused by progressive movement of materials due to repeated loading [1]. Rutting has long been recognized as a problem in flexible pavements, with the increase in the tire pressures, permanent deformation potential in hot mix asphalt layers has also increased. This type of deformation does not generally cause surface cracks but provides some riding discomfort, creates a traffic hazard, permits water to accumulate and create steering difficulty. The general cause of rutting is instability. One of the reasons of instability rutting is the creep formation. Creep is the continuous time-dependent deformation under constant or repeated stress or load. The creep phenomenon was first reported in 1834 by Vicat. As shown in Fig. 1, the curve was made of three major parts: primary stage with relatively large deformation during a short number of cycles; secondary stage which the rate of accumulation of permanent deformation remains constant; and tertiary stage, the final stage that the rate of deformation accelerates until complete failure takes place. Under the application of an initial and relatively small load, material behaves as elastic. There occurs a sudden deformation as soon as the initial load is applied. The strains are fully recoverable, which can be explained by the behavior of a Hooken spring. In other words, no permanent strain is generated during a loading and unloading cycle. Additionally, this phenomenon is independent of the rate of loading [2]. If the load is continuously applied, the material continues to deform with a decreasing rate. In other words, the permanent strain rate slows down with time. The deformation characteristic can be simply explained by the Kelvin model. The behavior is that after unloading the material, a part of deformation is recoverable. The physical damage process during the primary stage is called strain hardening. This damage occurs due to the movement of dislocations in asphalt concrete under repeated traffic loading. This results in increase in the plastic strain. On the contrary, the dislocation intersections decrease the movement in the body, which causes a permanent strain rate reduction. Secondary creep, also known as steady- state creep, is the part when the microcracks are initialized. Microcracing is the damage process during the secondary stage. At the point where microcracking initiates, the decrease in the permanent stain ends [3]. During this stage, the slope of deformation is nearly linear. At this stage, the strain rate eventually reaches a minimum and becomes nearly constant. The "creep strain rate" is typically the rate in this secondary stage. The stress dependence of this rate is related to the creep mechanism. The deformation