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Simple Methodology to Create Master Curves for Stiffness of Asphalt Mixtures

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Abstract

In road engineering, most of the mechanistic design methodologies for asphalt pavements are based on estimating the structural response of the pavement, i.e. the critical stresses/strains due to a certain design load. The critical strains, which are generally considered, are the horizontal flexural tensile strain at the bottom of the asphalt layer and the vertical compressive strain at the top of the subgrade. For the calculation of the stresses/strains, use is made of linear elastic multi-layer program like BISAR or visco-elastic multi-layer programs e.g. Kenlayer and VEROAD. Typically the stiffness modulus of asphalt concrete increases with decreasing temperature and increasing loading frequency. By shifting the stiffness modulus versus loading time relationship for various temperatures horizontally with respect to the curve chosen as reference, a complete modulus-time behavior curve at a constant, arbitrary chosen, reference temperature T_{ref} can be assembled. This Paper describes a methodology to construct the stiffness master curves for Asphalt Mixture. The model described is based on physical observations and it is believed to give 'reasonable' estimates for the mix stiffness at any arbitrary loading frequency. The technique of the determination of the master curve is based on the principle of time-temperature correspondence, or thermo-rheological simplicity. The experimental (stiffness) data are plotted versus log frequency or log loading time and by choosing a reference temperature the data of the other temperatures are shifted horizontally until they fit the curve for the reference temperature. Then the data obtained at the other temperatures are shifted until they fix the extended reference curve. Master curve can be constructed by fitting a sigmoid function using non-linear least square regression techniques. The shifting will be done using an experimental approach by solving shift factors simultaneously with the parameters of the model without the need to assume any functional form for the shift factor equation. Based on the material presented in this paper, has been founded that a sigmoid model can best describe the master curve of mix stiffness of asphalt concrete. This model also can explain the physical behavior of asphalt concrete.

Key word: Stiffness, Master Curve, Non Linear Visco-Elastic Behavior, Asphalt Mixture

1. INTRODUCTION

Most of the mechanistic design methodologies for asphalt pavements are based on estimating the structural response of the pavement, i.e. the critical stresses/strains due to a certain design load. The critical strains, which are generally considered, are the horizontal flexural tensile strain at the bottom of the asphalt layer and the vertical compressive strain at the top of the subgrade. For the calculation of the stresses/strains, use is made of linear elastic multi-layer program like BISAR [1] or visco-elastic multi-layer programs e.g. Kenlayer [2] and VEROAD [3].

Bituminous mixture stiffness needs to be determined in order to evaluate both the load induced and thermal stress and strain distribution in asphalt pavements. Stiffness has been used as an indicator of mixture quality for pavements and mixture design to evaluate damage and age-hardening trends of bituminous mixtures both in laboratory and the field [4]. The mix stiffness is generally estimated from the so-called master curves i.e. the relationship between the mix stiffness, loading time (or frequency) and temperature. In practice, the indirect tensile test or the four-point bending test is used to determine this relationship. This is done by measuring the stiffness of an asphalt concrete at different temperatures and frequencies. Typically the stiffness modulus of asphalt mixes increases with decreasing temperature and increasing loading frequency. By shifting the stiffness modulus versus loading time relationship for various temperatures horizontally with respect to the curve chosen as reference, a complete modulus-time behavior curve at a constant, arbitrary chosen, reference temperature T_{ref} can be assembled. This Study describes a methodology to construct the stiffness master curves for asphalt concrete. The model described is based on physical