

ABSTRACT

Song, Jiansheng, Ph.D., Purdue University, August 2005. Mechanical Behavior of Hot Mix Asphalt with Varying Volumetric Composition. Major Professor: Terhi K. Pellinen, Ph.D., Eur. Ing.

In this research, triaxial shear strength test was utilized to investigate the mechanical behavior of Hot Mix Asphalt with varying volumetric composition. The stress-strain responses under investigation included the pre-peak behavior represented by nonlinear strain stiffness, the at-peak behavior represented by shear strength, and the post-peak behavior represented by dilation phenomenon and these three stages were analyzed by Puzrin-Burland model, Mohr-Coulomb and Drucker-Prager failure theories, and Critical State Soil Mechanics theory, respectively. The Hierarchical Single Surface model was used to predict the permanent deformation (rutting) in the asphalt concrete layer. The purposes of the research were to compare the mechanical responses of dense graded mixture and Stone Mastics Asphalt with respect to the sensitivity to air voids, loading rate dependency, and stress dependency.

According to this research, rut depth was found to be proportional to the displacement of asphalt mixture and therefore mix more dilative has higher rutting potential. The asphalt mixture with refusal density was found to have higher stiffness and strength but was more dilative than the mix with 7.0-8.5% air voids. Stone Mastics Asphalt was found to be less dilative than dense graded mixture and it had higher nonlinear strain stiffness especially when sufficiently compacted. Hierarchical Single Surface model is promising in predicting rut depth because it reasonably and mechanistically differentiated the rutting potentials of mixes that differed only in the magnitude of dilation. This research also proved the existence of critical state for asphalt mixture and laid down a foundation for the future development of critical state mechanics for asphalt mixture, which can be another powerful tool to investigate the deformation phenomenon.

Based on the analyses of the test results, the requirements on VMA in Superpave mix design system were recommended to be modified for the design of the coarse, dense graded mixture because they produced mixes with excessively high film thicknesses and excessively low strength/stability. The loading rate of 1.25 mm/min, the air voids in test specimen of 0 to 3%, and the normal stresses of 300 kPa and -100 kPa were recommended for the triaxial shear strength testing and evaluation of asphalt mixture. The as-built air voids in asphalt concrete was recommended to be as low as 5% (leaving some space for densification). It was especially suggested Stone Mastics Asphalt mixture be compacted to higher density to fully take advantage of its mechanical properties.