Three-Dimensional Discrete Element Models for Asphalt Mixtures

Zhanping You, Ph.D., P.E.[1]; Sanjeev Adhikari [2]; Qingli Dai, Ph.D.[3]

[1]Donald and Rose Ann Tomasini Asst. Prof., Dept. of Civ. and Envir. Engrg., Michigan Technological Univ., 1400 Townsend Dr., Houghton, MI 49931-1295

[2]Grad. Res. Asst., Dept. of Civ. and Envir. Engrg., Michigan Technological Univ., 1400 Townsend Dr., Houghton, MI 49931-1295

[3]Res. Asst. Prof., Dept. of Mech. Engrg.-Engrg. Mech., Michigan Technological Univ., 1400 Townsend Dr., Houghton, MI 49931-1295

Abstract

The main objective of this paper is to develop three-dimensional (3D) microstructure-based discrete element models of asphalt mixtures to study the dynamic modulus from the stress-strain response under compressive loads. The 3D microstructure of the asphalt mixture was obtained from a number of two-dimensional (2D) images. In the 2D discrete element model, the aggregate and mastic were simulated with the captured aggregate and mastic images. The 3D models were reconstructed with a number of 2D models. This stress-strain response of the 3D model was computed under the loading cycles. The stress-strain response was used to predict the asphalt mixture's stiffness (modulus) by using the aggregate and mastic stiffness. The moduli of the 3D models were compared with the experimental measurements. It was found that the 3D discrete element models were able to predict the mixture moduli across a range of temperatures and loading frequencies. The 3D model prediction was found to be better than that of the 2D model. In addition, the effects of different air void percentages and aggregate moduli to the mixture moduli were investigated and discussed.