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Analytical Derivation and Numerical Simulation of Permeability and Fluid Flow Patterns in Hot Mix Asphalt

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Abstract: Permeability is an important property that influences the performance of hot-mix asphalt (HMA). It is a function of compaction effort, and several properties of HMA such as asphalt content, and the shape and size distribution of aggregates. Due to the different laboratory and field methods for measuring permeability, and the interaction among the factors that influence its value, it would be difficult to develop an analytical equation that accurately relates permeability to all factors contributing to HMA permeability. This paper presents a simple equation for approximating the permeability of asphalt mixes. It utilizes the percent air voids and surface area of aggregates. The equation is empirical but it is derived based on the well-known Kozeny?Carman equation for calculating the permeability of granular materials. The developed equation was used successfully to fit permeability data collected from several studies that carried field and laboratory measurements of HMA permeability. A finite element model was developed to investigate the influence of the gradient of percent air voids in HMA on water flow patterns. The x-ray computed tomography was used to measure the percent air void gradients among sublayers of the asphalt mix. The permeability of these sublayers was calculated using the developed equation, and used as an input to the finite element model. The simulation results show that air void gradients in HMA encourage lateral flow in the horizontal direction and reduce the flow in the vertical direction. Keywords: asphalt, numerical analysis, simulation, permittivity, aggregates (materials)