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Predictions for the porosity dependence of elastic properties and ultrasound wave velocities in isotropic porous media

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Ultrasound wave velocities of porous media are uniquely determined by their elastic properties. In particular, in statistically iosotropic porous media the velocities of the transverse and longitudinal waves can be used to determine the effective elastic moduli and the Possion ratio. On the other hand, many model-based relations have been proposed in the literature to predict the porosity dependence of elastic moduli [1-3], while such relations for predicting the wave velocities themselves are relatively scarce. Especially tricky is the prediction of the longitudinal wave velocity, which is caused by the fact that the porosity dependence of the Poisson ratio is highly non-trivial [4]. In this contribution we present six different model-based predictions for the velocities of transverse waves that can be derived from well-known model predictions for elastic moduli, including the numerical benchmark solutions recently obtained by Pabst and Uhlířová for computer-generated model materials with random microstructure and isometric grains obtained by virtual partial sintering (overlap) of monosized spherical particles [3]. Moreover, we show that a recently introduced velocity ratio function [5] can be used to obtain predictions for the velocity of longitudinal waves as well. It is shown that all these model relations predict a decrease of the wave velocities with increasing porosity, with those based on the Maxwell-Mori-Tanaka model / MMT model being typically highest, followed by those based on the differential, exponential and self-consistent model and those based on the numerical benchmark solution [3] and the Pabst-Gregorová percolation relation [2] being lowest. A comparison with experimental data published in the literature shows that the vast majority of data is between the differential prediction and the aforementioned numerical benchmark solution. Moreover, for all experimental data the correlation between the longitudinal and transverse velocities (both normalized with respect to the transverse velocity of the dense material) is below the MMT prediction and above a straight line with a slope equal to the square root of 7/3.

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Participation

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