

Insights on ultrasonic dispersion in concrete

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Abstract:

Ultrasonic interrogation is among the most commonly used nondestructive evaluation technique used for concrete structures. In practical applications, however, ultrasonic inspections are founded primarily on purely empirical relationships between properties of interest (e.g. strength) and the associated ultrasonic parameter (e.g. pulse velocity). The goal here was to improve our understanding of the microstructural basis for how the heterogeneous, porous concrete medium affects the propagation of elastic waves. Concrete specimens were prepared with similar aggregate contents, but water-to-cement ratios ranging from 0.40 to 0.90, creating a wide range of different cement paste porosities. In order to quantify internal structure, specimens were first subjected to x-ray CT scans. From the resulting 3D images, porosity and pore size distribution, density of the cement paste phase, and number of internal interfaces were all measured. The same specimens were subsequently subjected to ultrasonic interrogation using a through-transmission configuration. In addition to pulse and phase velocity measurements, the ultrasonic signals were evaluated using a diffusion model to separate absorption attenuation from scattering attenuation. The results showed that ultrasonic dissipation rate correlated weakly with paste density, while diffusivity correlated well with number of interfaces, but only if entrained air is considered separately. The somewhat surprising find was that the CT-based measurement of cement paste porosity, which is perhaps the single best predictor of concrete strength, correlated very well with ultrasonic diffusivity. As illustrated in Fig. 1, this suggests that an ultrasonic diffusivity measurement could provide a more fundamental basis for predicting concrete strength.

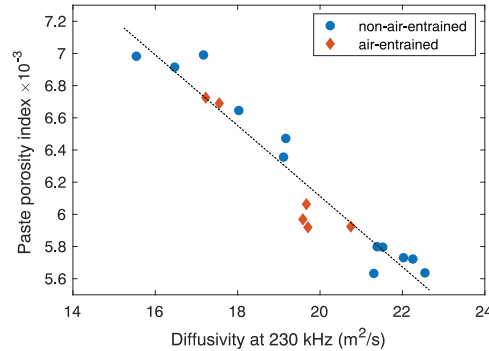


Figure 1: Index of cement paste porosity plotted against ultrasonic diffusivity.