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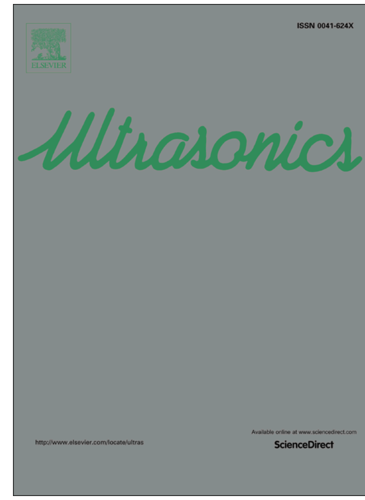

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A contactless ultrasonic surface wave approach to characterize distributed cracking damage in concrete

Suyun Ham[1,4], Homin Song[1], Michael L. Oelze[2], and John S. Popovics[1, 3]

[1] The Department of Civil and Environmental Engineering, The University of Illinois, Urbana, IL 61801

[2] The Department of Electrical and Computer Engineering, The University of Illinois, Urbana, IL 61801

[3] Corresponding author: 205 N. Mathews St. Urbana, IL 61801; johnpop@illinois.edu

[4] Present address: Department of Civil Engineering, The University of Texas at Arlington, Arlington TX 76019

Abstract

We describe an approach that utilizes ultrasonic surface wave backscatter measurements to characterize the volume content of relatively small distributed defects (microcrack networks) in concrete. A simplified weak scattering model is used to demonstrate that the scattered wave field projected in the direction of the surface wave propagation is relatively insensitive to scatters that are smaller than the propagating wavelength, while the scattered field projected in the opposite direction is more sensitive to sub-wavelength scatterers. Distributed microcracks in the concrete serve as the small scatterers that interact with a propagating surface wave. Data from a finite element simulation were used to demonstrate the viability of the proposed approach, and also to optimize a testing configuration to collect data. Simulations were validated through experimental measurements of ultrasonic backscattered surface waves from test samples of concrete constructed with different concentrations of fiber filler (0.0, 0.3 and 0.6 %) to mimic increasing microcrack volume density and then samples with actual cracking induced by controlled thermal cycles. A surface wave was induced in the concrete samples by a 50 kHz ultrasonic source operating 10 mm above the surface at an angle of incidence of 9º. Silicon-based miniature MEMS acoustic sensors located a few millimeters above the concrete surface both behind and in front of the sender were used to detect leaky ultrasonic surface waves emanating from concrete. A normalized backscattered energy parameter was calculated from the signals. Statistically significant differences in the normalized backscattered energy were observed between concrete samples with varying levels of simulated and actual cracking damage volume.

Keywords: Air-coupled, Backscatter, Incoherent, In situ characterization, MEMs, Microcracking, Non-Destructive Evaluation (NDE)