Multiscale modelling of load induced distributed damage for early identification of concrete damage

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Identifying and preventing damage in concrete structures at an early stage of material degradation can significantly reduce costs associated with the maintenance and repair of concrete infrastructure. Visible deterioration of concrete subjected to mechanical loadings is always preceded by weak microstructural degradation (i.e., due to initiation and propagation of microcracks) that cannot be detected by optical inspection. Such weak changes can be detected by means of the multiple-scattered late-arriving diffuse ultrasonic signals, also called coda-waves [1], as the later part of the wave has already repeatedly sampled the concrete microstructure. However, a methodology to reliably identify, quantify, and classify the variations to the coda waves with the corresponding level of damage is not yet established.

In this contribution, a virtual methodology for damage identification using scale-bridging simulations, forward wave propagation simulations, and machine learning based damage classification is presented. First, load-induced material changes of concrete have been modelled using a Reduced Order Multiscale Simulation [2]. Afterward, simulated coda waves are obtained by sampling the mesostructures via Computational Ultrasonic Wave Propagation Simulations [3]. It is followed by the classification of damage based on the simulated coda signals using a combination of Convolutional Neural Network and Feature Engineering. The methodology has been validated thoroughly with the experimental data. Finally, the potential of this technology and its limitations for practical applications (e.g., at the structural level) will be discussed.

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