Concrete Damage Assessment by Coda Waves: Wave propagation simulations to support experimental investigations

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Concrete is a strongly heterogeneous and densely packed composite material. Due to the high density of scattering constituents and inclusions, ultrasonic wave propagation in this material consists of a complex mixture of multiple scattering, mode conversion and diffusive energy transport. For a better understanding of the effect of aggregates, porosity and of crack distribution on elastic wave propagation in concrete and to optimize inverse techniques it is useful to simulate the wave propagation and scattering process explicitly in the time domain. For this purpose, we use the rotated staggered grid (RSG) finite-difference technique for solving the wave equations for elastic, anisotropic and/or viscoelastic media. This study is part of the CoDA project (DFG project 398216472, FOR 2825), which aims to develop a novel method based on ultrasonic coda wave interferometry (CWI) for the assessment of safety and durability of reinforced concrete structures. For this purpose, the coda technique is a suitable method to detect small changes in concrete members. In order to distinguish changes in the coda signal in terms of their origin (i.e. mechanical load, temperature, moisture), wave propagation simulations are performed to support the experimental investigations within the project. The idea is to create realistic digital twins for the experiments on two different scales: The specimen scale and the structural scale. In this study, high-performance simulations of ultrasonic wave propagation within concrete structures on the specimen scale were performed and evaluated using coda wave interferometry (CWI).