Numerical simulation of nonlinear elastic wave propagation in locally damaged reinforced concretes

Benjamin Ankay[1,*] and Chuanzeng Zhang[1]

[1]Department of Civil Engineering, University of Siegen, Germany

*Presenting & Corresponding author: ankay@bau.uni-siegen.de

Abstract

During the service-life, cyclic loading and corrosion can cause some defects or damages in the interfacial bonding zone of reinforced concretes, resulting in a reduced load-carrying capacity of the composite structures. At an early stage of debonding the interfacial zone will be progressively degraded and small-scale defects occur (microcracking) leading to a nonlinearity in the elastic behavior of the concrete structures.
To assess the potential of using nonlinear ultrasonic elastic waves for the detection of debonding or damages in reinforced concrete structures, numerical simulations play an important role.

In this paper, the two-dimensional ultrasonic wave propagation in a nonlinear elastic half-space is numerically simulated by a mapped Chebyshev pseudo-spectral method [1]. In particular a steel rebar embedded in a concrete matrix is modelled. To investigate the effect of the localized damage in the bonding zone, an additional interfacial zone with adjusted nonlinear elastic parameters is incorporated. To simulate the semi-infinite elastic half-space, the Convolutional Perfectly Matched Layers (CPML's) are implemented. The underlying constitutive equations are based on the nonlinear elastic theory of Murnaghan [2]. The received time signals are transformed to and evaluated in the frequency domain at different damage stages. The application of the nonlinear ultrasonic technique is discussed based on the numerical results.

Keywords: Ultrasonic nondestructive testing, Nonlinear elastic wave propagation, Reinforced concretes, Interface debonding, Microcracks and damages, Chebyshev pseudo-spectral method

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