Damage detection in concrete with coda wave interferometry using a 60 kHz ultrasonic signal

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Abstract

Coda wave interferometry is an ultrasound-based possible candidate for structural health monitoring of concrete structures. It is based on a correlation evaluation of two ultrasonic signals. A perturbation, e.g., cracks in the medium are causing changes in the signal. The correlation development over the signal's length is very characteristic for the position of the crack relative to source and receiver. This development can be modeled and allows to state an inverse problem whose solution localizes a new perturbation, e.g., crack in the medium.

An application at a four-point bending test of a reinforced concrete specimen with a span of 3.5 m and 25 ultrasonic transducers with a used central frequency of 60 kHz shows promising results for damage detection. The coda technology can successfully distinguish multiple developing cracks and results are compared to fiber optic sensor measurements. Some problems like cracks that develop into the installation position of the ultrasonic transducers are also found and solutions are proposed.

Keywords: diffuse ultrasound; coda wave interferometry; structural health monitoring; cracks in concrete; damage detection

1 Introduction

Coda wave interferometry (CWI) is a rather novel ultrasound-based monitoring and damage detection technique applicable to concrete. The ultrasound sensors are embedded into the concrete and regularly send ultrasound signals from a source transducer to a receiver transducer. It can thus be referred to as a permanent, active structural health monitoring technology.

The high heterogeneity of the concrete creates scattering that increases the area to which a signal is sensitive and additionally increases the sensitivity to very small changes. In general, signals with their diffuse tail created by the scattering can be reproduced. When evaluating a signal, it is compared to a reference signal. As soon as small perturbations appear in the medium, the signal undergoes small changes. An evaluation of these changes in the signal subsequently allows a