Concepts from seismic interferometry transferred to sonic and ultrasonic concrete inspection and monitoring

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Abstract

Seismic interferometry (SI) deals either with the sensible detection of changes in the subsurface or with the reconstruction of virtual signals between two receivers by cross-correlation of signals from diffuse sources. These concepts can be applied in NDT in civil engineering for various purposes, e. g. to detect changes in bridges. Here it is demonstrated using data from a reference structure on our test site. Practical applications can be expected in the very near future.

1. Seismic Interferometry

“Analogues to optical interferometry, seismic interferometry estimates the detailed properties of the earth by analysing the interference patterns of seismic waves” (1). This is done by cross-correlating seismic receiver traces (in ultrasound: “A-scans”). If the traces are from different receivers having recorded signals from the same (lot of) sources at the same time, the result can be used to reconstruct the Greens function between the receivers and thus travel times of various waves. If the traces are from the same receiver, recording signals from the same source but at different points in time we can retrieve indications of subtle changes in material of the subsurface. The latter version is known as coda wave interferometry (CWI) (2).

2. Applications in civil engineering

2.1 The BLEIB reference structure

The BLEIB reference structure is a 24 m long post-tensioned concrete beam on three supports built to allow research and validation of advanced testing and monitoring concepts (Fig.1). It was built on the BAM test site technical safety close to Berlin. Static and dynamic load can be applied. Tension can be adjusted. One span was intentionally damaged.

Figure 1. The BLEIB reference structure at the BAM test site.

2.2 Detection of subtle changes

The reference structure contains 14 embedded ultrasonic transducers (3) connected to a multiplexer and a data acquisition system. Active transmission measurements have been performed during adjustment of the tension forces and evaluated by CWI. The retrieved velocity changes (Fig. 2 left) can e.g. be used to estimate changes of elastic moduli.

2.3 Passive bridge monitoring

A linear array of accelerometers was placed on top of the structure to record environmental vibrational noise. These signals were used to reconstruct "virtual" active measurements between the receivers (Fig. 2 right). The wave velocity calculated from this experiment matched the one retrieved by active measurements. This approach will allow to set up bridge passive monitoring systems, which has been demonstrated in (4).

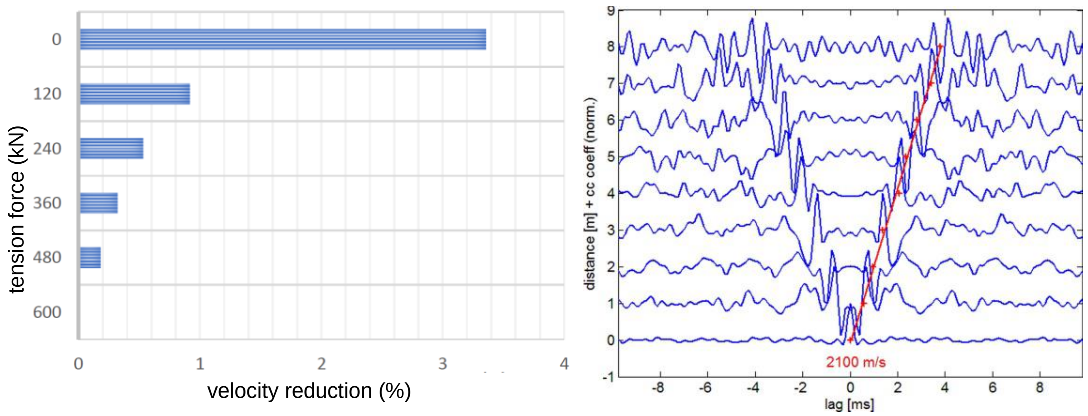

Figure 2. Left: Velocity changes from active experiment and CWI depending on structural tension. Right: Virtual signals and wave velocity retrieved by passive recordings and SI.

2.4 Other applications

Examples for applications of interferometric concepts is the interpolation of missing A-scans in ultrasonic imaging experiments or the reconstructions of the true source signal. This has been demonstrated by simulations and low frequency ultrasonic shear wave measurements on a polyamide test model (5).

References

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