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Frequency analysis and data correlation for beam displacement measurements based on the ISTIMES campaign in Montagnole

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Time-frequency analysis is an interdisciplinary subject, which originates from mathematics, signal analysis and physics (Grochenig, 2001). From a signal theoretical and mathematical point of view the primary purpose has been to understand how signals, operators and other mathematical objects can be understood simultaneously in the time and frequency variables, which correspond to the phase space variables in physics (Grochenig, 2001; Claasen, 1980). Perhaps the most popular time-frequency representations are the short-time Fourier transform (STFT) and the Wigner distribution (Grochenig, 2001). Their common feature is to localize a function before taking the Fourier transform, thereby obtaining a time-frequency representation. Here, we employ the classical Kaiser window (Kaiser and Schafer, 1980) which is well known in spectrum analysis, since it provides a flexible approach to control the frequency resolution as well as the amplitude dynamics (sidelobe rejection) for a given measurement interval (or resolution) in time.

In this contribution, we employ frequency analysis and data correlation for beam displacement measurements based on the ISTIMES campaign (Proto et al., 2010) conducted at the rock fall test center in Montagnole, France, on October 14, 2010. Several test cases are considered based on direct and indirect impact from a steel sphere dropped on a reinforced concrete beam. Several measurement technologies were used to measure the deformation of the beam based on IRT (InfraRed Thermography), GBSAR (Ground Based Synthetic Aperture Radar), and ODM (Optical Diode Measurements).

A time-frequency analysis was used to analyze the evolution of the resonance frequencies of the beam. A short-time cross-correlation followed by Fourier transformation was used to integrate data based on two different signal sources (sensor technologies). The results were compared to a frequency analysis based on video data and image processing to yield a high-accuracy reference measurement.

Even though the time-frequency analysis and data correlation techniques are able to indicate a certain time-dependent behavior of the beam resonances, these results are difficult to interpret due to several uncertainties that are detected in the measurement data. On the other hand, all measurement techniques were consistent and agreed with the reference measurement on a slight decrease in the beam resonant frequency for consecutive drops with the steel sphere.

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