Analysis of the Repeatability of the Pencil Lead Break in Comparison to the Ball Impact and Electromagnetic Body-Noise Actuator

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Acoustic emission testing is used to monitor the structural health by recording and analyzing sound signals originating from within a structure. Usually, a set of sensors is attached at key positions on a structure under test to record and analyze these acoustic signals. For reliable measurements, prior to a measurement campaign, the coupling of the sensors has to be assessed as the coupling can have significant impact on the effective sensitivity of the sensor. For this purpose, artificial sound sources are commonly used which induce signals in the form of elastic waves into a structure. By comparing the expected characteristics of these induced signals to observed characteristics in a measured signal, the frequency response function of the sensor coupling can be approximately assessed and proper coupling can be verified. To assess the coupling of sensors reliably by means of an artificial sound source, it has to exhibit high repeatability, i.e. small relative standard deviation (RSTD) with respect to some characteristic of interest. In this work, the repeatability of the pencil lead break, ball impact and a electromagnetic body-noise actuator is assessed across several repetitions. Through controlled and repeated excitation of the respective artificial sound sources on a concrete girder, the RSTD of the magnitude spectra of the artificial sound sources across frequency is assessed in the frequency range of about 0 kHz to 650 kHz. The ball impact and the actuator exhibited a RSTD of below 5 % of their magnitude spectra for frequencies below about 20 kHz, the maximum frequency for the actuator, whereas for the pencil lead break a RSTD of above 11 % was observed across the entire frequency range. An increase of the RSTD with increasing frequency was observed for the ball impact and the pencil lead break. The repeatability of the pencil lead break, for which a RSTD between 15 % to 40 % was observed for a broad frequency range of its amplitude spectrum, usually achieved a lower relative standard deviation than the ball impacts with 4 mm and 5 mm balls above a frequency of about 60 kHz. A significant increase of the relative standard deviation for the 4 mm and 5 mm ball was observed starting at about 20 kHz. Above about 60 kHz, the relative standard deviation of the 5 mm ball impact had risen to 30 % and more oscillating between about 30 - 50 %. At 200 kHz and more all signals were attenuated to background noise level by the concrete girder. It is concluded, that the pencil lead break is inferior with respect to repeatability below 40 kHz compared to the 4 mm and 5 mm ball impact and electromagnetic body-noise actuator, but performs equally well or better above 60 kHz. The repeatability of the investigated artificial sound sources depends on the investigated frequency range with no unique best. The most important finding is the increasing relative standard deviation of the ball impact with increasing frequency. As a result, the repeatability of the ball impact is questionable and not generally certain and should be investigated before using it in high precision experiments.