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Electro-mechanical impedance-based damage detection of concrete beam under impact loading

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Ship and vehicle collision with pier can trigger catastrophic calamity on bridge structures. It is essential to quantify the collision damage degree of pier after collision and to take steps for preventing the full structural failure. The novelty in this paper is the development of a relationship of the root-mean-square deviation (RMSD) index and the damage volume ratio of bridge pier after collision that allows for the quantification of damage degree of concrete based on the observed impedance signatures. The bridge pier is simplified to a concrete beam subjected to continuous impact loading by a freefalling steel ball. The concrete damaged plasticity constitutive model is utilized in numerical analysis to simulate the damage development of concrete beam under impact loading. The RMSD is used as a damage index to quantify and evaluate the variations in admittance signals measured by lead-zirconate-titanate (PZT) patches and compared to the damage volume ratio computed by numerical analysis. The results demonstrate that the RMSD index and the damage ratio of concrete have good agreement. The Electro-mechanical impedance (EMI) technique based on PZT patches can keenly detect the impact damage of concrete and the RMSD index can effectively quantify the damage degree of concrete caused by impact loading.

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