Non-Linear Damping Identification for Damage Prediction of Concrete Beams

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Damping behavior has been proven sensitive to even small, visually undetectable damages. It is known that when a concrete structure is undamaged, damping behavior is modelled by constant damping model. When the structure is damaged, the damping behavior is best described by nonlinear damping model. Thus, by identifying the presence of nonlinearity in damping behavior could reveal the presence of damage in structure. Damping behavior is identified by studying the decay envelope of free vibration in Log-Amplitude scale. Where, constant damping model should best fit to a straight line and common nonlinear damping models, Coulomb and Quadratic damping models, should resemble to concave and convex lines respectively. This decay curve shape characteristic is used to distinguish the nonlinearity in damping behavior of reinforced concrete beam and predict the existence of damage. The experimental study was conducted using flexural free vibration of simply supported reinforced concrete beam. The beam was 200x150mm in cross section and 2700mm in length. The damping behavior of free vibration of beam was investigated at undamaged state (D0) and after different level of flexural damage by loading in four-point bending configuration. Damage states D1-appearance of first crack, D2-appearance of five cracks, D3-appearance of seven cracks, D4-appearance of thirteen cracks, D5-appearance of fifteen cracks. The acceleration time history obtained from the tests were processed using Fast Fourier Analysis and band pass filtering. Then the oscillation peaks were extracted to obtain the decay envelopes and plotted in Log amplitude scale. Then the results were compared with decay curves of ideal damping models described above. It was observed that the constant damping model describes the undamaged beam (D0 state) very well. The decay envelope comparison after each damage states D1, D2, D3, D4, D5 are resembled to convex line depicting quadratic damping behavior. It is seen that rate of decay has significantly increased after the appearance of first crack (D1 state) indicating the potential of damping in portraying even a small damage. This will lead to the suggestion that the damping behavior of the undamaged RCC beam is resemble to constant damping model, and after damage, the damping behavior become nonlinear and distinguishing nonlinearity in decay envelope could portray the existence if damage. It is also important to note that this method is applicable when a single dominant mode is activated, and modes are well separated. Severity of damage in RCC beam may not be characterized by identifying the nonlinearity.

Keywords: Damping, Nonlinear damping, Damage detection, Reinforced concrete beam