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Evaluation Of Stiffness Reduction Of RC Columns During Earthquakes Based On Acceleration Measurements

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ABSTRACT
This research aims at evaluating structural degradation of an RC viaduct during earthquakes through the identification of time-varying equivalent linear stiffness of its columns using acceleration measurement data. Two existing methods for the identification of physical model, i.e. $M^{-1}C$ and $M^{-1}K$ are discussed first. These include a method which identifies physical model by way of state-space model and a method which directly identifies physical model using acceleration, velocity and displacement time history. The latter method does not explicitly use modal information and generates comparatively stable results even when it is difficult to identify sufficient number of modes accurately. On the other hand, the method needs integration and double integration of measured acceleration data in order to obtain velocity and displacement data leading to severe error accumulation. This research develops an improved version of the direct identification method which effectively suppresses error accumulation through the integration process by considering equation of motion during each time step independently.

This improved method and the two existing methods are tested using numerical data generated by simple linear models and a three-dimensional linear RC viaduct model. The performance comparisons of the methods by noise-corrupted data show that the improved method yields accurate results for a wide range of the systems' natural frequencies and noise conditions. The performance of the methods is also tested by simple nonlinear models and the improved method successfully identifies their equivalent linear stiffness under various conditions on the systems' natural frequencies and noise levels.

This improved method is applied to the excitation and the response acceleration time histories generated by nonlinear dynamic analyses of an RC viaduct model with different seismic excitations. The time-varying equivalent linear stiffness of the columns of the viaduct model thus obtained shows the declining behavior as the columns experience large nonlinear deformation. Finally, this method is applied to real-scale experiment data of an RC column and the time-varying declining behavior of the mass-normalized equivalent linear stiffness is observed. These results indicate that the proposed method enables quick and reliable evaluation of the extent of nonlinearity of RC columns of viaducts without a priori knowledge about structural properties.

KEYWORDS: *System identification, Earthquakes, Acceleration measurement, RC columns, Physical model, Equivalent linear stiffness*