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Combining Stockwell Transform and deconvolution interferometry to detect the non-linear response of instrumented buildings during an earthquake

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A new method for the assessment of non-linear dynamic structural behavior, influenced by soil-structure interactions, is proposed in this study, based on the analysis of earthquake records. The approach evaluates instantaneous impulse response functions, by combining two reliable techniques, the use of which is becoming more widespread in the fields of engineering and seismology: the Stockwell Transform (S-Transform, Stockwell et al., 1996) and the deconvolution interferometry (Snieder and Safak, 2006). The new method aims to detect, from the recorded structural response, the degradation of its stiffness based on the estimated changes in the fixed-base frequency during an earthquake event.

First, travel times of seismic waves are estimated by the deconvolution of the spectra of the recordings made at each level with respect to the building's roof obtained by S-Transform. Since changes in the shear wave velocity (v_s) inside the building depend only on the variations in its physical properties, v_s is computed at each instant of time, through the arrival times of the deconvolved waves at each floor. An average value of v_s is considered, obtained by a weighted average of the arrival times at the different levels. Subsequently, approaching the dynamic response of structure by a shear model, therefore considering the building floors sufficiently rigid with respect to the columns, the fixed-base frequency during the earthquake is evaluated as the ratio between the instantaneous average v_s and four times the building height. The time variation of this frequency is associated with the degradation of the building's structural stiffness as a consequence of its non-linear response.

The proposed technique was applied to a 14-story concrete building (Jalapa building) located in the central area of Mexico City, Mexico. Both soil-structure interaction effects and structural and non-structural damage affected the structure during several small and moderate size earthquakes that occurred over 1990's, recorded by a network of 14 accelerometers installed inside the building (Meli et al., 1998). Considering the extended range of the linear response of the foundation soil of Mexico City, which consists of highly plastic clays, it was believed that the observed non-linear behavior was limited to the structural response.

The results of the proposed technique allow one to detect the different phases of the non-linear response of the Jalapa building during the various recorded events, with reasonable agreement with the observed status of the building after each event.

Reference:

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