System Identification of Multi-story Buildings with a Pair of Seismic Recordings

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Summary

This study presents system identification of ten-story Millikan Library in Pasadena, California with a pair of the Yorba Linda earthquake of September 3, 2002. The fundamental of the proposed approach is based on wave features of generalized impulse and frequency response function (GIRF or GFRF), i.e., wave response at one structural response location to an impulsive motion at another reference location in time and frequency domains respectively. With a pair of seismic recordings at the two locations, GIRF/GFRF is obtainable. With a continuous-discrete model for the structure, a closed-form solution of GFRF, and subsequent GIRF with Fourier transformation of GFRF, can also be found in terms of structural physical properties above the impulse location. Matching the two sets of GIRF/GFRF from recordings and the model helps identify system parameters such as wave velocity or shear modulus.

Keywords: Continuous-discrete modeling; Seismic structural responses; System identification.

1. Introduction

For seismic design, vibration control, and damage diagnosis of multi-story buildings, such as ten-story Millikan Library building located in Pasadena California, response characterization and system identification are fundamental and typically carried out with a discrete, multi-degree-of-freedom (MDOF) model. As far as one-dimensional (1D) horizontal motion is concerned, the Millikan Library building as shown in Fig. 1a can be modeled as a 10-DOF system with each floor mass and inter-story stiffness (i.e., physical parameters) calculable based on design configuration and materials. These physical parameters can also be calibrated in terms of identified vibratory features (i.e., modal frequencies, damping, and shapes—a function of physical parameters), through Fourier spectral analysis of 11-set acceleration recordings of the Yorba Linda earthquake of September 3, 2002.

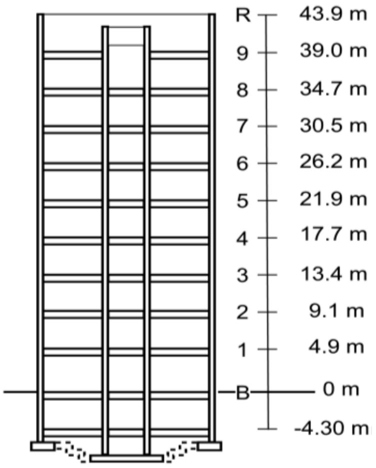

Fig. 1a: Vertical cross-section of 10-story Millikan Library, Pasadena, California.

While the aforementioned discrete modeling is overwhelmingly used in structural engineering (e.g. [1,2]), it has limitation in characterizing comprehensive seismic motion in structures with a finite number DOF modeling in general, and distorting time-space or wave features of seismic motion in buildings in particular. Misrepresenting the seismic responses in structures would falsely predict, likely underestimate, the maximum inter-story drift, a key index of seismic demand for structural design. This is due to the fact that time-delay peak waves at two neighboring floors would have the drift calculated as difference between one peak amplitude and one non-peak value, which is typically larger than the difference between two peak values without time-delay effect. This time-delay

https://doi.org/10.2749/222137813807018845
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