ABSTRACT

Cheng, Li-Hui Ph.D., Purdue University, October 2017. Phase Difference Index: A Frequency-domain Analysis Tool for Structural Mode Identification. Major Professor: Ayhan Irfanoglu.

A new structural mode-identification approach, called phase difference index plot (PDI plot), to identify the natural modes in a building from its acceleration records response to earthquake ground motion. The phase difference index of a response record obtained in a building can be calculated by Hilbert transform of displacement response curves obtained (derived from acceleration records) at two different floors in the building. The torsional mode can also be identified if two accelerometers were installed on opposite sides in a floor. To demonstrate the power of the new approach, earthquake acceleration records from ten buildings in Taiwan and US are collected. After applying narrow band-pass filter to the acceleration records, and then using Hilbert transform on pairs of displacement records in chosen floors, (obtained from the acceleration records) the phase difference between the corresponding pair of designated floors can be calculated. Cosine of phase difference angle of the two displacement curves is defined as the phase difference index. Phase difference index versus frequency graph forms a PDI plot. Structural behavior at corresponding floors under various frequency bands can be found by studying PDI plot. From comparison of PDI plot and normal building mode shapes obtained based on estimated stiffness and mass distribution, the natural modes can be identified. The method has been tested for accuracy and limitations by applying it to data obtained from numerical simulations. Response of ten actual buildings in US and Taiwan have been studied using the proposed method. It is shown that using PDI plot method more modes of a

building can be identified confidently compared to traditional frequency-domain and time-domain based methods.