

Nonlinear vibration analysis and dynamic identification of progressive damage in a reinforced concrete structure

Key words: SHM, damage detection, nonlinear dynamic, rc structure, Wavelet Transform, effective stiffness.

Abstract

This thesis presents a non-linear vibration analysis and dynamic identification of a reinforced concrete structure under progressive damage. For this purpose results of an experiment carried out for two reinforced concrete frames under progressive damage on a shake table were used.

Initial analyses focused on the force-displacement relationship of successive damage states of the reinforced concrete frame. For this purpose, the intensity of the horizontal seismic forces and respected relative displacement responses were investigated. Part of this research was devoted to numerical modeling using nonlinear finite element software - *SeismoStruct*. A decrease of effective stiffness was observed as a change of the slope a_{stf} from linear approximation of the damage “hysteresis loop”. Additional measure of cumulative damage, a standard deviation of displacements σ_{dmg} coefficient was also proposed to describe the course of damage with values increasing with the damage progresses.

In the second part of the thesis Continuous Wavelet Transform (with Morlet wavelets) was applied for response signal to study progressive damage of the analyzed structures. Wavelet scalograms of response for the different stages of damage accumulation were acquired and damage-related indices were selected. Due to the use of the Morlet wavelet, the wavelet scalograms of dynamic response are dominated by the image of the waveform of frame vibration frequencies. This waveform is directly related with decrease in stiffness as the damage progresses in the structures. Therefore, the change in the spatial image of the coefficients could be related with the damage progress. The differences in respective images of the wavelet coefficients for individual states of the structure were used to select the best indicators of the actual damage.