Reduction of structural stiffness due to damage leads to increase in travel time of seismic waves propagating through the damaged part. Wave travel times through the structure can be effectively measured by tracing a pulse radiated from a virtual source, generated by deconvolution of the recorded vibrational response to earthquake shaking at different points in the structure (e.g. on different floors of a building [1]). These pulse responses are in fact the impulse response functions of the structure and can be obtained by inverse Fourier transform of the transfer functions of the response with respect to the base or roof responses. Such analyses of earthquake records in selected damaged buildings have shown that the measured increases in wave travel times are consistent with the level and spatial distribution of the observed damage [2,3]. Further, it was shown that the measured wave travel times are not affected by the soil-structure interaction, and can be used to estimate the building fixed-base frequency, which is a major advantage over the Fourier methods [4,5].

The authors are currently performing impulse response analyses of many instrumented buildings that have recorded multiple earthquakes and have been or could have been damaged, and further developing this structural health monitoring method for automated use during an earthquake and implementation in early warning systems [6]. To facilitate the interpretation of the impulse response functions obtained from real data, and as part of the further development of the method, impulse response is computed and analyzed of models of buildings represented by a set of horizontal layers. This paper presents the derivation of the impulse response functions for general layered medium (parallel layers over a half-space), and numerical results and analysis for different layer properties corresponding to buildings. Propagator matrix is used to compute the model transfer-functions (relative to the base or roof) and FFT or analytical integration to obtain the impulse responses.

References

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