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Wave Propagationin High-Rise Buildings Viewed as Metamaterials

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The repeatability of the floors in a high-rise building, which have very similar structural properties, make it a nearly periodic one-dimensional structure, which may behave as an elastic metamaterial. To get an insight into such behavior, a simple model of a of a high-rise building is used, in which the floor slabs are represented as rigid lumped masses, while the structural elements between the slabs (shear walls and columns) are represented collectively as segments of a Timoshenko beam. The propagator of the composite beam is presented and the derivation of the dispersion assuming Bragg scattering from the slabs in an infinite, periodic beam. Results are presented for the dispersion and beam transfer-functions and impulse response functions for properties typical for buildings. The results, extrapolated for illustrative purposes beyond the range of validity of simple beam models, reveal banded nature of the dispersion and response, and mechanical filter properties. While real structures would have more complex banded spectra, the selective nature of the filtering could be exploited for passive higher frequency vibration control to protect sensitive equipment from vibrations created, e.g., by high-speed trains, traffic, explosions or smaller but near seismic events.