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Multiple, Three-Dimensional Interactions between the Ground and a Group of Structures Subjected to Seismic Impact

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In our earlier study, using a fully coupled, two-dimensional ground-structure model, we have investigated the dynamic interactions between a set of identical buildings in a town and shown the collective behavior of the buildings during a seismic excitation: Due to the multiple interactions through (the waves in) the ground, the eigenfrequencies of the collective building system, i.e., town, become lower than the resonant frequency of a single building. This shift of eigenfrequencies may be called the ”town effect” (or ”city effect”). Our analysis is different from the conventional ones where each structure is handled individually, and the frequency shifts and ”unexpected” structural behavior may be recognized only if the mechanical movement of the structural group is analyzed jointly. In the study, however, we have just considered the anti-plane shearing of a linear elastic half space on which identical buildings, each consisting of an elastic spring that connects a concentrated mass at the top and the rigid foundation at the bottom, stand. In this contribution, we shall briefly summarize some quantitative information about the two-dimensional anti-plane town effect and show its significance by investigating the actual structural damage patterns found on the occasions of several earthquakes in Europe and Japan. Then, we shall further consider the in-plane and three-dimensional cases and generalize the mathematical statement of the related problems. Since the ”town effect” may be induced by dynamic structural impact in general (e.g., blasting), the simple analytical models handled here may contain the essential features that will play an important role in evaluating the dynamic performance of a group of structures in urban environments around the world.

Keywords: earthquake hazard, collective behavior, city effect, town effect, dynamic ground-structure interaction