

Improved seismic analysis of unreinforced masonry buildings with flexible diaphragms

by

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Abstract

The presence of flexible timber diaphragms in many existing unreinforced masonry buildings poses a significant challenge for the assessment of their seismic vulnerability. When diaphragms are flexible, different parts of a structure can interact with each other dynamically, in a way not typically encountered in modern structures with rigid diaphragms. As a result, the seismic analysis methods developed for buildings with rigid diaphragms, as well as our basic understanding of the dynamic behaviours of buildings under earthquake excitations, cannot be applied directly for buildings with flexible diaphragms. This thesis addresses two issues that require immediate attention in improving the seismic analysis of unreinforced masonry buildings with flexible diaphragms, namely (1) to enhance our understanding of the dynamic response characteristics of low-rise buildings with flexible diaphragms, and (2) to investigate the applicability of an array of existing analysis methods developed for rigid diaphragm structures.

The research work presented in this thesis begins with a basic analysis of the elastic behaviour of symmetric buildings with flexible diaphragms. Through an analytical study of their modal properties, it is shown that at least two dominant modes are present in the dynamic responses of buildings with flexible diaphragms. Using the results of modal analysis, an improvement to the linear static analysis method is proposed.

The inelastic behaviours of symmetric- and asymmetric-plan building systems with flexible diaphragms are then investigated through a systematic parametric analysis. It is shown that the effect of diaphragm flexibility varies depending on the level of stiffness- and strength-eccentricity of the system. A general diaphragm classification is developed to explain the influence of diaphragm flexibility on the global building response.

A simple numerical modelling technique to incorporate the dynamic behaviours of flexible diaphragms in a three-dimensional equivalent frame modelling approach is also investigated, and validated against shake table test data.

Finally, the applicability of nonlinear static procedures utilising single-mode, multi-mode and adaptive pushover analyses are investigated. Practical recommendations are provided for the use of various pushover analysis methods for unreinforced masonry buildings with flexible diaphragms.

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List of Publications

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Nakamura, Y., Derakhshan, H., Ingham, J.M. and Griffith, M.C. (2014) “Seismic analysis of in-plane loaded walls in unreinforced masonry buildings with flexible diaphragms”, *Bulletin of New Zealand Society for Earthquake Engineering*, 47(4), 275 – 289.

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Statement of Original Authorship

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