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Ductility Demand Distribution of Asymmetric Multi-Story R/C Buildings

Amir M. Halabian[1], Mohammad S. Birzhandi[2]

1- Faculty of Civil Engineering, Isfahan University of Technology
2- Master of Science in Structure

ms_birzhandi@yahoo.com

Abstract

To evaluate the influences of the number of stories on the torsional response and ductility demand distribution in the plan and the height of plan asymmetric RC dual lateral load resistant multi-story buildings, three categories of structural models that contain 8-, 14- and 20-stories buildings (with the wide range of eccentricity values) are subjected to an assemblage of ordinary and near-fault ground motions. The approach of modeling has been used, is more accurate for multi-storey R/C structures, because it redefines the stiffness from the strength in each time step. According to the findings, the torsional effects, decreases for high-rise structures where the lateral natural period increases.

Keywords: Ductility demand, Torsional response, Asymmetric structures, R/C dual systems.

1. INTRODUCTION

In many buildings, the centers of resistance do not coincide with the centers of mass, resulting even for a purely translational excitation; the resultants of the stories resisting forces do not pass through the stories centers of mass. When these structures, so-called asymmetric buildings, are subjected to earthquake ground motion, they undergo both translational and rotational motion even though the earthquake excitation is purely uni-direction translational. Most of the conducted work on inelastic seismic response of asymmetric buildings are performed on simplified, highly idealized, one-storey models, with simple shear-beam elements (mostly three) designed for lateral load resistance. Tso and Sadek (1985) [1] employing such a models resulted that while the inelastic response is not mainly translational, the ductility demand of the edge lateral resisting elements could be increased up to twice of similar elements in the symmetric building. Effect of torsion on the stiff and flexible sides is a serious discrepancy in the pervious studies; some researches such as Tso and Ying (1990) [2] and Mittal and Jain (1995) [3] stated the inelastic torsional effects could lead to critical response in the flexible edge and are not important in the stiff edge, while Chandler and Duan (1991) [4] explained that for the models they studied, a critical circumstance would occur in the stiff edge. Tso and Zhu (1992) [5] in a separate study showed that these contradictory conclusions could be upon the type of models and assumptions used for their design and the type of eccentricity.

As it was mentioned, the numerous early publications on the problem of inelastic torsion, practically used very simplified, highly idealized, one-story, shear-beam type systems with bi-linear force-displacement relationship. Duan and Chandler (1993) [6] showed these simplified models are not adequate for the evaluation of additional ductility demand caused by torsion in the multi-story frame structures. Employing single story frame buildings whose inelastic behavior can be predicted with more advanced models instead of bi-linear relations, Stathopoulos and Anagnostopoulos (2003) [7] concluded that for single story frame buildings with plastic hinge model the ductility demands in flexible edge and stiff side are increased and decreased, respectively, when compared to the shear-beam type model. To extent the adequacy of code provisions for torsion which is mostly based on studies conducted on single story, shear-beam type systems Stathopoulos and Anagnostopoulos (2005) [8] used multi-story frame systems with plastic hinge model.

The shear-beam type models and multi-story moment resisting frame systems are separately used in most of the researches conducted in the area of torsional responses of asymmetric buildings. To the best knowledge of the authors, unfortunately, little attention has been paid to the most practical but most complex case which is multi-storey dual lateral load resisting buildings. In the past studies, the traditional simple bi-linear force–displacement relationship of shear walls was independent of strength and therefore there was an inevitable need to consider the strength as antiseptic parameter, introducing the strength eccentricity along with the mass and stiffness eccentricities to study the seismic response of asymmetric systems. However, for shear RC walls with given length and given reinforcement yield strain, the stiffness depends on the strength