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Effect of Modeling Floor Diaphragm Flexural Rigidity on Seismic Design of Steel Buildings with RC Shear Walls

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ABSTRACT

Inaccurate modeling of flexural rigidity of floor diaphragms leads to incorrect estimation of building seismic response and uneconomical or unsafe seismic design of floors and vertical lateral load resisting elements like shear walls. Through a thorough parametric study 144 simply-framed steel building with intermediate RC shear walls are modeled, analyzed, and designed. Varied modeling parameters are: (a) floor diaphragm type (deck or slab), (b) floor thickness, (c) number of building stories, and (d) planar layout of shear walls. Response and design measures for models with deck diaphragms (rigid membrane without flexural rigidity) and slab diaphragms (with membrane and flexural rigidities) are compared and their sensitivities with respect to varied modeling parameters are estimated.

1. INTRODUCTION

Building floors are primary structural members and their main functions are transferring floor vertical loads to columns and shear walls and transferring lateral loads to vertical lateral load resistance system [1]. For building structures, the effects of modeling floor diaphragms on building seismic behavior and its structural design have not been thoroughly studied especially for low-rise and medium-rise buildings. Furthermore, inaccurate modeling of flexural rigidity of floor diaphragms leads to misestimating of building seismic response and uneconomical or unsafe seismic design of floors and vertical lateral load resisting elements like shear walls. The stiffness of floor diaphragms and shear walls significantly influence building seismic response. Structural parameters affecting such stiffness are namely thickness of floor diaphragm, layout of shear walls in plan, opening in floor diaphragm, irregularity of structure in plan, thickness of shear walls, change of shear wall stiffness at story levels, discontinuity of shear walls, story heights, and flexural rigidity of floor diaphragm. Floor diaphragm structural behavior and transfer of lateral loads to vertical lateral load resistance system and the error resulted by rigid diaphragm assumption are studied in previous investigations [2, 3, 4].

In this study for measuring the effect of floor diaphragm out-of-plane flexural rigidity, similar building models are modeled with (1) floor diaphragms having only membrane stiffness called deck diaphragms and (2) floor diaphragms having in-plane and out-of-plane stiffness called slab diaphragms. In order to study the effect of such different floor models, a parametric study of steel building with shear walls is used. In the following, developed models and selected parameters are explained and then results from analyses and design are presented for main response and design measures.

2. PARAMETRIC STUDY

The developed building models consist of simple steel 3-D frames carrying vertical loads and shear walls resisting lateral loads. Shear walls are continuous along building height and connected to frames whose columns are continuous and beams are simply supported. All beams spans are 4 m and shear walls thickness varies from 25 cm to 10 cm from bottom to top. The assumed design properties for concrete are cylindrical