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Comparison between the Dynamic Responses of Steel Buildings with Medium and Deep Columns under Several Seismic Intensities

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Abstract: Structural engineers often use deep columns in high seismic areas to reduce drifts, yet this somehow contradicts what is stated in some tests in the sense that even though deep columns may satisfy current seismic provisions, they can suffer premature twisting; this is an indication that a lot of research is needed in this area. Numerical and experimental studies have been conducted to estimate the response of steel buildings with medium and deep columns under the action of static and cyclic loading; however, studies accounting for the dynamic characteristics of buildings and strong motions are not common. In addition, responses in terms of local parameters have not been considered either. In this study, the nonlinear seismic responses of steel buildings with perimeter moment-resisting frames and medium (W14) columns are numerically calculated and compared to those of similar steel buildings with equivalent deep columns in terms of cost (W27 and larger). Low-, mid-, and high-rise steel building models with different dynamic characteristics, as well as several strong motions with different frequency contents, are considered. Results indicate that the drifts of the models with medium columns may be up to 140% greater than those of the models with deep columns. Significant reductions are also observed for top displacements, normalized interstory shears, and combined normalized axial loads and bending moments. Hence, the seismic demands of the buildings with deep columns may be much smaller than those of the buildings with medium columns and, therefore, the buildings with deep columns exhibit a superior behavior, which results in more economical designs. The reduction is greater for the case of low- and mid-rise buildings than for high-rise buildings. One of the reasons for this is that as medium columns are replaced by deep columns, the stiffness and the strength increase, which are lower in the tallest model.

Keywords: moment-resisting steel frames; deep columns; low-, mid-, and high-rise buildings; seismic loading; local and global response

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1. Introduction and Literature Review

Different arrangements of structural members are continuously studied with the aim of improving the structural behavior of buildings subjected to the action of various types of loads. In the case of steel buildings under the action of severe seismic loads, moment-resisting frames (MRF) are widely used due to their great ductility capacity. In some developed countries, like the United States of America, the common practice is to use in these buildings two MRF in each direction, usually located at the perimeter (PMRF) and gravity frames (GF) at the interior. The first are designed to resist the total seismic load and the second to resist the gravity loads. Hence, for seismic design purposes, the buildings are usually modeled as two-dimensional (2D) structures.