Journal of Constructional Steel Research 72 (2012) 51–60

Contents lists available at SciVerse ScienceDirect

Journal of Constructional Steel Research

Seismic performance of steel special moment resisting frames with different span arrangements

Devrim Özhendekci *, Nuri Özhendekci

Department of Civil Engineering, Yıldız Technical University, Faculty of Civil Engineering, Davutpasa Campus, 34210, Esenler, Istanbul, Turkey

ARTICLE INFO

Article history:
Received 4 June 2011
Accepted 5 October 2011
Available online 28 October 2011

Keywords:
Steel special moment resisting frames
Seismic performance assessment
Collapse performance
Span arrangement

ABSTRACT

Span arrangement is a crucial parameter from the designer's perspective, since it directly affects the seismic performance and economy of design. However, previous studies have not paid sufficient attention to the evaluation of its effects. Thus three 10-story steel special moment resisting frames with different span arrangements are designed according to the procedures of Turkish seismic design codes which are very similar to allowable stress design and capacity design procedures provided in AISC Manual and Seismic Provisions for Structural Steel Buildings. With the chosen geometric properties, design earthquake load and seismic effective mass is kept constant for model frames which is thought to be convenient for comparison purposes. The buildings are analyzed with OPENSEES under 15 simulated ground motion records and seismic performance assessment is carried out for collapse prevention performance level according to nonlinear dynamic procedure of FEMA 356. SIMQKE program is utilized to simulate ground motions, mean spectrum of whose matches to 1.5 times the design spectrum resulting in an earthquake hazard level of 2% probability of exceedance in 50 years. The entire model frames are found to satisfy the acceptance criteria for collapse prevention performance level. Based on the results of the structural systems used in this study, model frame with span length to story height ratio of approximately 2 seems to maintain both performance and economy, while the ratio higher than 2.5 can result in relatively high deflections and high element plastic rotations in lower stories under infrequent earthquake loads which render the frame seismically vulnerable.

1. Introduction

Moment resisting steel frames tend to develop high lateral deflections under infrequent seismic events. This flexibility may lead to superior inelastic behavior by providing high global ductility on condition that lateral deflections are limited and the energy dissipation is provided via some manipulation on the proportioning and detailing of structural elements. The lateral deflections are aimed to be controlled during the design procedure for mainly preserving the stable, non-deteriorating hysteretic behavior of beam-to-column connections and limiting the P-delta effects in inelastic behavior range. Strong column/weak beam (SCWB) condition is also necessary in order to prevent the formation of weak story mechanisms. These frames also require special attention to prevent damage to nonstructural components. Though controlling drift requires driving up the section sizes, the resultant frames provide high reliability in terms of collapse prevention under infrequent seismic actions. Furthermore, these frames do not have diagonal braces or structural walls which may render architectural freedom possible.

For high seismic zones, long-span moment resisting frames necessitate to increase the section sizes in order to control drift. Controlling the lateral deflection of a structural system is provided via the flexural rigidities of the beams and columns, but generally contribution of the beams are more efficient especially if the columns are not extremely oversized. On the other hand, increasing the beam sizes for controlling the drift ratios may sometimes lead to additional increase in column sizes in order to realize strong column/weak beam condition. Besides, high axial forces developing especially in the first story columns of long-span frames lead to the use of heavier column sections both because of strength considerations and SCWB condition. For the upper stories, vertical loads may cause further increase in beam sections because of strength considerations. It should also be noted that long-span beams also require more concern about bracing against lateral torsional buckling. Despite these economical disadvantages of long-span frames, number of columns and beam-to-column connections are fewer in such frames which may lead to comparable design solutions to the frames with higher number of spans.

Generally, excessively short-spanned frames are also avoided, because their behavior can be dominated by shear yielding in inelastic range. Rigid beam-to-column connections, prequalified for providing enough inter story drift capacity, have limitations on beam span to depth ratio which yields a lower limit for span width.

* Corresponding author. Tel.: +90 212 383 5215; fax: +90 212 383 5102.
E-mail address: devrimozhen@yahoo.com (D. Özhendekci).

0143-974X/$ – see front matter
doi:10.1016/j.jcsr.2011.10.002