Journal of Constructional Steel Research 71 (2012) 162–170

Contents lists available at SciVerse ScienceDirect

Journal of Constructional Steel Research

Evaluating response modification factors of TADAS frames

Mussa Mahmoudi *, Mohammad Ghasem Abdi

Department of Civil Engineering, Shahid Rajaee Teacher Training University, Tehran, Iran

ARTICLE INFO

Article history:
Received 30 April 2011
Accepted 10 October 2011
Available online 9 November 2011

Keywords:
Hysteretic dampers
Moment resisting frames
Ductility factor
Overstrength factor
Response modification factor

ABSTRACT

The current paper tries to evaluate overstrength, ductility and response modification factors in special moment resisting frames with TADAS (triangular-plate added damping and stiffness) devices. For that matter, multi-story buildings were considered during the course of study. Further, OpenSees Software was applied to perform the static pushover analysis, the nonlinear incremental dynamic analysis as well as the linear dynamic analysis. In this research, seismic response modification factor for special moment resisting frames (SMRFs) with TADAS devices (T-SMRFs) and without them has been determined separately. The results showed that the response modification factors for T-SMRFs were higher than the SMRFs ones. It was also found that the number of stories of buildings has had greater effect on the response modification factors.

1. Introduction

The moment resisting frames are one of the most commonly used methods to resist lateral loads especially during an earthquake [1]. Recently, much emphasis has been put on developing various damping mechanisms in order to provide positive control of structural vibration in the wake of earthquakes. One of these mechanisms is hysteretic dampers which through their hysteresis dissipate the energy exerted into a structure. The TADAS (triangular-plate added damping and stiffness) device is one of the examples of the hysteretic dampers with elasto-plastic behavior [2].

In fact, the energy input during an earthquake is relatively independent of restoring force characteristics of the structural system. This suggests that damage to the main frame could effectively be reduced by adequately incorporating hysteretic dampers into the structure. Here, the major consideration is the selection of strength and stiffness of hysteretic dampers for maximizing the damping effect as well as minimizing the damage to the main frame.

With regard to TADAS dampers with elasto-plastic behavior, Tsai et al. [3] numerically examined its strength and stiffness on earthquake response and hence; obtained optimal combination of strength and stiffness. The above outcome although provided important background for the structural design combined with TADAS dampers, however, it remained empirical because the finding was only based on the numerical parametric analysis.

Seismic design codes consider a reduction in design loads, taking advantage of the fact that the structures possess significant reserve strength and capacity to dissipate energy which called overstrength and ductility respectively. These two factors are incorporated in structural design through a force reduction or a response modification factor. This factor represents ratio of maximum seismic force on a structure during specified ground motion if it was to remain elastic to the design seismic force. Consequently, to obtain design forces, the actual seismic forces are reduced by the factor "R". The basic flaw in code procedures is that they use the linear method while relying on the nonlinear behavior [1].

The response modification factors were first proposed in ATC3-06 [4]. The product of three factors i.e. Overstrength, Ductility, and Redundancy were calculated in ATC-19 [5] and ATC-34 [6]. The response modification factor for special moment resisting frames with TADAS devices (T-SMRFs) should be computed relatively, defining the system according to its ductility and performance in a manner consistent with factors already established for other structural systems, such as ordinary moment resisting frames (OMRFs) and special moment resisting frames (SMRFs). The present study focuses on overstrength evaluation, force reduction due to ductility and response modification factors of SMRFs and T-SMRFs. These were designed in accordance with the Iranian Earthquake Resistant Design Codes [7] (BHRC, 2005) and the Iranian National Building Code (part 10) for Structural Steel Design [8].

To obtain the proposed factors, nonlinear static analyses, nonlinear incremental dynamic analysis and linear dynamic analysis were carried out.

* Corresponding author at: Department of Civil Engineering, Shahid Rajaee Teacher Training University, P.O. Box 16785/163, Postal code 16788, Lavizan, Tehran, I.R. Iran. Tel.: +98 21 22970070x22970060/69; fax: +98 21 22970033.
E-mail addresses: m.mahmoudi@srttu.edu (M. Mahmoudi), abdi_mg@yahoo.com (M.G. Abdi).

0143-974X/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jcsr.2011.10.015