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Seismic assessment of steel moment frame-rocking walls

Mahya S. MOGHADASI[1], Mark GRIGORIAN[2], Abdoreza S. MOGHADAM[3]
Zeynab moradi[4]
[1] MSc Graduate- International Institute of Earthquake Engineering and Seismology, Tehran, Iran
[2] Senior Struct. Eng. MGA Struct. Eng. Inc., 111 N. Jackson St. Glendale, CA 91206, US
[3] Associate Professor, International Institute of Earthquake Engineering and Seismology, Tehran, Iran
[4] MSc Graduate- International Institute of Earthquake Engineering and Seismology, Tehran, Iran

ABSTRACT

Rocking system is one of the recent developments devised to improve the seismic behavior of structures. This paper introduces a special type of Rocking Wall-Moment Frame (RWMF) combination that consists of a Grade Beam Restrained Moment Frame, (GBRMF) attached to a co-planar, post tensioned (PT) pin supported Rigid Rocking Core (RRC) by means of Gap Opening link beams (GOLBs) and supplementary devices. It compares a 4-storey and an 8-storey steel moment frame with Fixed base Shear Walls (FSW) with the proposed alternative. Simulation and numerical analysis are carried out using SAP2000 software. Time history analysis of the subject systems is conducted using 7 earthquake records on soil types C defined by USGS. Seismic responses of the RWMFs are presented. The results illustrate that RWMFs can be treated as repairable structures because plastic hinges are well distributed and prevent sever damage to columns and footings. Furthermore, RWMFs prevent soft storey failure by imposing uniform drift along the height of the structure. RWMFs lend themselves well to self- alignment and post-earthquake repairs by using post tensioned cables and known supplementary devices.

Keywords: *Rocking wall-moment frames, Reparability, Self- alignment, time history analysis*

1. INTRODUCTION

While fixed base moment frame–rigid core combinations are the most popular earthquake resisting systems worldwide, they are not free from technical flaws and economic drawbacks. Conventional fixed-base moment frame–shear wall or braced frame combinations rely on uncontrolled inelastic responses of their members to absorb seismic energy. These systems have served their functions rather well in the past. However, they are practically un-repairable and are prone to catastrophic collapse due to major seismic events. Here, a relatively new, dual earthquake resisting system consisting of ductile moment frames (MFs) with rotationally controllable column supports in combination with post-tensioned RRCs is introduced, see Fig.1. The proposed configuration is capable of damage control, collapse prevention and self centering due to strong ground motion. The idea that rocking motions may reduce damage to MFs during earthquakes in not new, and was originally recognized by MacRae et al.[1, 2] Ajrab et al. [3], Panian et al. [4], Ji, et al. [5] and Wada et al.[6]. The pioneering effort in developing design concepts for controlled rocking of self-centering cores are due to Christopoulos et al. [7,8], Deierlein et al.[9], Eatherton et al.[10,11] , Takeuchi et al. [12], Janhunen et al. [13] and Grigorian et al. [14]. The focus of the present paper is on the global response of the RWMF rather than member design. GOLBs are used to connect the MF to the RRC; [15, 16]. Further research has shown that while these connections display excellent realignment abilities in laboratory testing, they tend to damage the adjoining columns and diaphragms in assembled systems; [17, 18]. [10 and 19] have both proposed innovative detailing methods to prevent damage due to rocking. The interested reader in rocking frame innovations is referred to two well documented bibliographies [20 and 21]. The full introduction of RWMF system and its formulas have been described by Grigorian and Moghadasi[22]. ASCE 41[23] defines specific performance levels for immediate occupancy, life safety, and collapse prevention, where collapse prevention, is defined as "the post-earthquake damage state in which the building is on the verge of partial or total collapse". A well-designed RWMF can be expected to provide reliable support for the gravity system, facilitate the rescue/evacuation effort and improve the reparability of the frame after a major seismic event [22]. The present article focuses on collapse prevention employing RWMF technologies for new structures. This leads to the notion that if collapse prevention is feasible through reliable technologies, then life safety and immediate occupancy can also be achieved through similar strategies. To ensure that near perfect self-centering is