Seismic performance of semi-rigid frames with connection dampers

Reza Attarnejad[1], Milad Roohi Ghareshiran[2], Akbar Pirmoz [3]

1- Associate Professor, Department of Civil Engineering, University of Tehran, Tehran, Iran
2- MSc student in Earthquake engineering, University of Tehran, Tehran, Iran
3- PHD candidate in Earthquake engineering, University of Tehran, Tehran, Iran

E-mail**:** Milad_Roohi@ut.ac.ir

Abstract

To reduce dynamic response of a semi-rigid frame with bolted connections, energy dissipation materials may be placed at a connection between the end plate and column flange or between the angle and member flange. In this article a three-span three bay frame with semi-rigid connections having three different capacities and energy dissipation materials analytically modeled by idealizing semi-rigid connection and energy dissipation materials as rotational spring and damper, respectively. The numerical model included nonlinear connection behavior, member yielding and geometrical nonlinearity of the structure. The pushover and dynamic analyses of the frames were performed using OPENSEES analysis program and dynamic analyses of frames with and without connection dampers show that there is an optimal damper damping coefficient by which the seismic responses of semi-rigid frame, including lateral displacements can be significantly reduced.

Keywords: Semi-rigid frame, Semi-rigid connection, bolted connection, Damper, Seismic response

1. INTRODUCTION

Moment resisting steel frames, especially their fully welded connections, were heavily damaged during the 1994 Northridge and 1995 Kobe earthquakes. After these earthquakes, the scientists and engineers considered frames with semi-rigid bolted connections as one of the alternatives of rigid welded connections. Semi-rigid connections don't have the brittle behavior of rigid welded joints and have a good ductility and energy dissipation capacity. On the other hand, in these systems, by limiting energy absorbing zones to semi-rigid connections, the need for strong-column weak-beam (SCWB) philosophy can be eliminated by only designing the columns to be stronger than the connections. As a result, the problem of non-economical columns can be easily solved. Some of the previous works [1-4] investigating the seismic behavior of frames with semi-rigid connection showed that semi-rigid frames can exhibit ductile and hysteretic behavior. In addition, when the connection stiffness increased the base shear consequently increased, but the lateral drift did not decrease in a similar manner. Consequently, it was pointed out that the optimum system should be searched for in order to develop least possible base shear with acceptable lateral deformations. Finally, using semi-rigid systems can ultimately lead to lighter structures with sufficient reliability and be considered as an option for industrial and building uses. But the complexity of the behavior of semi-rigid connections and a wide range of levels of connections rigidity makes it difficult to seismic design these semi-rigid frames. Currently Design criteria's of the regulations limited semi-rigid systems to low or moderate ductility or like our design codes, the design is generally not permitted.

To reduce the seismic response of a steel frame with bolted connections, Hsu and Fafitis [5] proposed the elastomeric bolted connections by using two elastomeric pads and a shear pin as shown in Fig. 1(a). [6] Some others just placed viscoelastic materials between the angles and beam flanges to remain the original bolted connection configuration unchanged [see Fig. 1(b)]. Such a bolted connection is usually modeled as a rotational spring and a rotational dashpot in parallel [5].