Amirkabir University of Technology
(Tehran Polytechnic)

Amirkabir Jounrnal of Science and Research
Civil and Enviromental Engineering
(AJSR-CEE)
Vol. 48, No. 4, Winter 2016, pp. 175-177

Evaluation of the Effect of Connection Fracture and Configuration of Fracturing Connections on Seismic Performance of Steel Moment Frames

B. Mohebi*

Assistant Professor, Faculty of Civil Engineering, Imam Khomeini International University

(Received: 14 October 2014, Accepted: 4 July 2015)

ABSTRACT

Provision of ductility has always been of concern in seismic design of structures. However, large variability in connection performance is observed during the recent earthquakes, due to brittle fracture of steel moment frame connections. In this study, distribution of early fracturing pre-Northridge connections is optimized by genetic algorithm tool to quantify the sensitivity of seismic response of the structures to spatial variation of early fracturing connections for two hazard levels. Also, a non-degrading ductile connection is modeled to compare the seismic performance of the structures. Probability assessment is carried out by implementation of incremental dynamic analysis to find the reliability of structures under this condition. Results show that configuration of fracturing connections in beams, in contrast to columns, can significantly affect the collapse capacity of structures.

KEYWORDS:

Pre-Northridge, Connection Fracture, Steel Moment Frame, IDA, Performance Based Evaluation

* Corresponding Author, Email: mohebi@eng.ikiu.ac.ir

1- Introduction

Reduction of structural building damage to prevent loss of lives, is a goal that seismic engineering has always been following. For this reason, seismic building codes have been promoted over the years to provide sufficient ductility of structural members due to intensive seismic actions. However, Northridge earthquake revealed defective performance of welded steel moment connections. Spread losses were observed in steel moment frames in a wide range of building heights and over the vast geotechnical areas. Field observations reported damages mainly due to brittle fracture of beam-column connections and also local buckling and yielding of panel zones [1]. Large dispersion that observed in connection resistance was attributed to variability in material as well as manufacturing parameters [2]. Roeder [3] tried to find solutions for pre-Northridge connections problem through recognition of yield mechanisms, failure modes and issues influencing connection performance. Mele [4] focused on American, Japanese and European welded connection design details to find parameters that affect connection performance. Bernuzzi et al. [5] tried to predict ductility and dynamic load capacity of steel moment connections and proposed approaches for design of SMFs. Foutch and Yun [6] presented analytical models to predict performance of steel moment frames with pre-Northridge connections under seismic loads. However, large dispersion is observed in experimental results which makes post fracture behavior of steel moment connections and also the effect of fracture parameters on the structures response complicated. For this reason, the influence of unanticipated character of these connection failures on local and global response of steel moment frame buildings is still associated with ambiguities. Therefore, a more detailed investigation is needed for rehabilitation purpose to better understand the response of SMF structures under probable patterns of fracture.

2- Methodology

In this study, two special moment frames, 5-storey and 9-storey buildings are designed according to Iranian building codes. Fracture in beam and column elements are modeled, separately. A nonlinear spring is placed at each member end at beam-column connection face to characterize brittle behavior of connection. Every connection is assumed to be able to fracture whenever plastic rotations are sufficiently high. It is assumed that 25% of all connections experience early fracture and the remaining 75% fracture at a pre-specified rotation. In addition, connections with no degrading bilinear hysteresis rule are modeled to provide an ability to investigate brittle connection fracture effects on structures response.

As mentioned before, early fracture is considered to be distributed randomly due to large dispersion of pre-Northridge connections performance and limited experimental data. Thus, a study is conducted initially to quantify the sensitivity of drift results to spatial distribution of early fracturing connections using SGA. The objective is to find an early fracture configuration that yields the median maximum peak drift response, while the total number of early fractures remains constant (25% of total number of connections).

The capacities for the structures are calculated through the use of incremental dynamic analysis [7]. A more detailed investigation is achieved by comparison of probabilistic assessment results of brittle models and a model with modified non-degrading connections. Also, a reliability analysis is carried out to investigate performance of the structures under this condition. The summery of reliability level of structures is shown in Fig. 1.

3- Conclusions

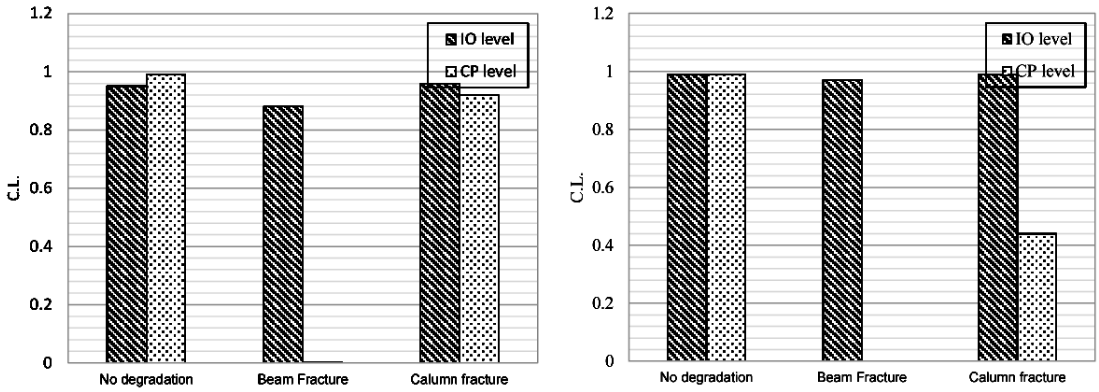
Based on the analysis results, the following conclusions can be drawn:

• Nonlinear dynamic analysis results indicate that optimization of early fracture distribution results in more drift responses. Beam fracture resulted in median values of maximum and average peak interstory drift increase up to about 60%. However, column fracture has a slight effect on drift results.

• Results of IDA analyses show considerable drop in structure capacity (θ_{max} and S_a) due to connection fracture. Also drift demands are increased by fracture of connections. The effect of fracture on demands and capacities is intensified by increase in ground motion intensity.

• In general, the structure is more affected by beam fracture than column fracture. Column fracture has almost no effect on confidence level for IO level against 50/50% probability level. In contrast, fracture in beams yields much lower structure confidence level.

• Comparison of probability assessment results



b) 9 Story Structure a) Five story structure

Fig. 1. Summary of reliability of structures

shows that utilization of only randomness of the variable parameters yields slightly less conservative results.

4- References

[1] Bonowitz, D. and Youssef, N.; "SAC Survey of Steel Moment-resisting Frame Buildings Affected by the 1994 Northridge Earthquake," *Technical Report 95–06: Surveys and Assessment of Damage to Buildings Affected by the Northridge Earthquake, SAC Joint Venture*, pp. 2–1 to 2–169, 1995.

[2] Kaufmann, E. J.; Fisher, J. W.; Di-Julio-Jr, R. M. and Gross, J. L.; "Failure Analysis of Welded Steel Moment Resisting Frames Damaged in the Northridge Earthquake," *Tech. Rept. 5625, NIST*, 1995.

[3] Roeder, C. W.; "Connection Performance for Seismic Design of Steel Moment Frames," *Journal of Structural Engineering*, Vol. 128, No. 4, pp. 517–525, 2002.

[4] Mele, E.; "Moment Resisting Welded Connections: An Extensive Review of Design Practice and Experimental Research in USA, Japan and Europe," *Journal of Earthquake Engineering*, Vol. 6, No. 1, pp. 111–145, 2002.

[5] Bernuzzi, C.; Calado, L. and Castiglioni, C.; "Ductility and Load Carrying Capacity Prediction of Steel Beam-to-Column Connections under Cyclic Reversal Loading," *Journal of Earthquake Engineering*, Vol. 1, No. 2, pp. 401–432, 1997.

[6] Foutch, D. A. and Yun, S.; "Modeling of Steel Moment Frames for Seismic Loads," *Journal of Constructional Steel Research*, Vol. 58, No. 5, pp. 529–564, 2002.

[7] Vamvatsikos, D. and Cornell, C. A.; "Incremental Dynamic Analysis," *Earthquake Engineering and Structural Dynamics*, Vol. 31, No. 3, pp. 491–514, 2002.