RIGID CONNECTION FOR STEEL STRUCTURE UNDER LATERAL FORCE

H. Khatibi[1*], F.Hejazi[2], A. Fateh[3] , M.S. Jaafar [4]

[1] *Master of Structural Engineering and Construction, Civil Eng. Department, Faculty of Engineering, University Putra Malaysia (UPM)*
[2] *Senior Lecturer, PhD, Civil Eng. Department, Faculty of Engineering University Putra Malaysia (UPM)*
[3] *PhD Candidate of Structural Engineering, Civil Eng. Department, Faculty of Engineering, University Putra Malaysia (UPM)*
[4] *Professor, Civil Eng. Department, Faculty of Engineering University Putra Malaysia (UPM)*
Email: Hamed.Khatibi@icloud.com

ABSTRACT:

Earthquake retrofitting insufficiency as well as architectural circumscription of ordinary X-braced techniques turns out to be controversial issue in engineering studies during last decades. Moreover removal of brace without deliberation of safety and structural stability is reasonably perilous and may lead to structural collapse. In this study an attempt has been made to implement rigid plates in beam columns connection to provide enough lateral resistance stiffness for structure against earthquake as shear frames to fulfill the architectural and the structural demand. The suggested connection includes of rigid plate which is welded to the flanges of column and beam to improve stiffness trait of beam- column joint. Rigid plate connection is appropriate in steel moment resistance frame that acts as supplementary gird element. By other words, ordinary beam column connection is strengthening by installation of stiffed rigid steel plate to beam and column flanges.
In order to evaluate the seismic performance of structure with rigid plate in connections, the finite element simulation is made and push over analysis is performed. The results indicated that the rigid plate application in steel frame increases the failure capacity compare with bare frame. So it can be used as an alternative technique for rehabilitation of existing steel structures. Briefly the results demonstrate the seismic performance of steel structure equipped by rigid plate connection is improved.

KEYWORDS: Rigid Plate Connection, Steel Shear Frame, Finite Element Simulation, Retrofitting Method, Beam-Column Connection

1. INTRODUCTION

Architecture constraint and low seismic performance of X-brace elements in steel structures captured a lot of researcher's interest to rectify these shortages. In two last decades, a lot of different connection's configurations as well as novel braces components were recommended. Bagheri Sabbagh et al. (2012) worked on development of cold formed steel elements for earthquake resistant moment frame buildings.
Tagawa and Gurel (2005) proposed a stiffening method to meet architectural needs. Application of steel channels as stiffeners in bolted moment used as an alternatives to both continuity and double plates in bolted moment-resistant beam-to-column connections.
Furthermore, Mashaly et al. (2011) performed a study related to behaviour of four-bolt extended end-plate connection subjected to lateral loading and the results verify that the chosen parameters such as material and section geometry of joint, played effective roles on the energy dissipation of the connection.

In 2007, Mirghaderi and Dehghani (2008) worked on a new rigid connection with some specific features for earthquake-resistant steel structures. Chen et al. (2003) presented a study of flange rib moment connections applicable in steel moment-resisting frames. The connections were strengthened by welding vertical rib to the beam flange and the column flange.
Through the existing technology of constructions, making full rigid connections for steel structures is tough issue, very costly and uneconomical approach. Low performance of shear frame connections does not provide enough rigidity to resist the lateral load properly leading to find a new alternative for increasing rigidity and lateral resistance of frame.
From the architecture point of the view is required to replace the educate resistance system for frame substituted by bracing system. Through the review of previous studies there is little information about application of Rigid Plate (RP) connection in steel structure and effect of them in seismic response of structure. In current study the assessment of rigid plate connection in maximum failure force under push over displacement is studied in shear frame by aid of finite element modeling.

2. MATERIAL AND METHODS

2-D models includes steel shear bare frame and frame equipped by rigid plate connections are consisted of five stories with 3m height and 6m bay as shown in figure 1. It assumed that free edges of the rigid plates are cut. 2D frame equipped with different geometry configuration by optimum thickness that was found from parametric study, subjected to push over displacement.
Dimension of rigid plate connection 30cm x 30cm x 1.5cm is considered. Column's sections were selected as same section of UC 305x305x283 from ground to the top level. Furthermore all the beams were chosen as same section with UB 457x152x60.All materials for beams columns and plates considered as normal steel with yield strength at of 460 and 600MPa at zero and 0.2 plastic strain respectively. Meshing for all members is used by solid 8 -nodes elements.

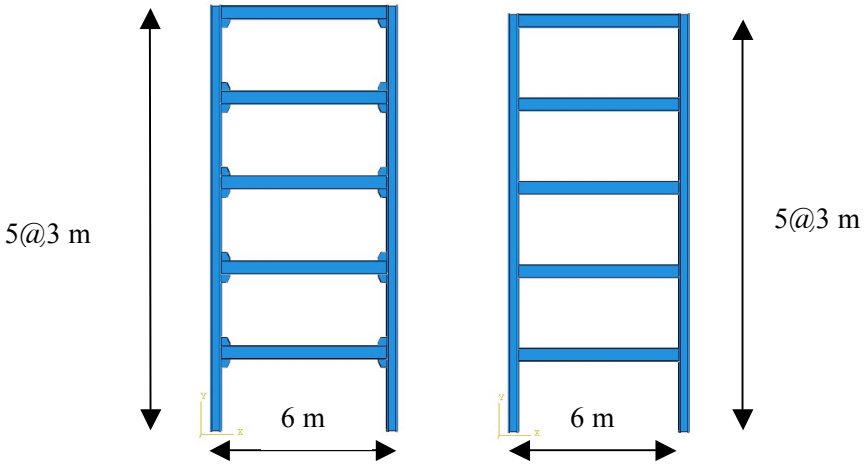

Figure 1. 2D Models-Bare Frame and Frame with Rigid Plate

The location of displacement which is applied in this study is shown in figure 2.

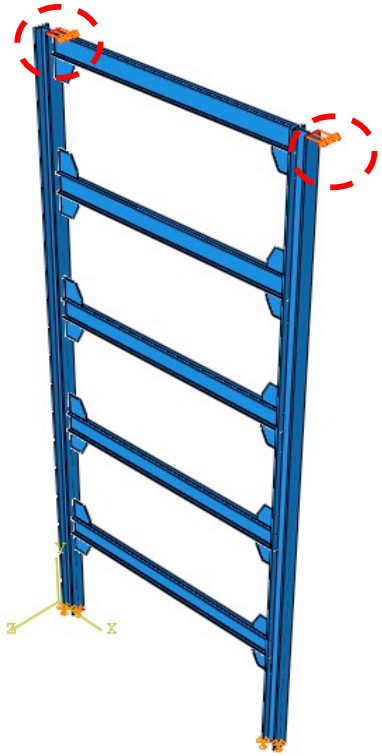

Figure 2. Push over Analysis Description and Location in Finite Element Simulation

3. RESULTS AND DISCUSSION

Push over analysis was performed with the mentioned size and dimension of rigid plate and frames sections. Figure3 illustrates the maximum failure force of rigid plates with thickness of 15mm, under push over analysis. As can be found, maximum failure force in model furnished by rigid plate compared with bare frame were increased, which is one of the most crucial demand in earthquake engineering enhanced. With meticulous investigation, the results reveal that, maximum failure load for plate with dimension of 30cm x 30cm x 1.5cm increased approximately 11 percent compared with bare frame (as shown in Table 1).
It is observed that in this case rigid plates are failed sooner than beams and plastic hinges are occurred in rigid plate components which are the most important expedition in current study. Figure 4 shows the stress distribution at rigid plate connection and it proved the performance of rigid plate in the frame to bear lateral loads.

Table 1: Efficiency of different sizes of Rigid Plate under Push over Analysis in 2D model

Plate Dimension (cm)	*Maximum Failure Force (N)*	*Increase %*
No Plate (Bare Frame)	493862	----
30x30x1.5	547146	10.79

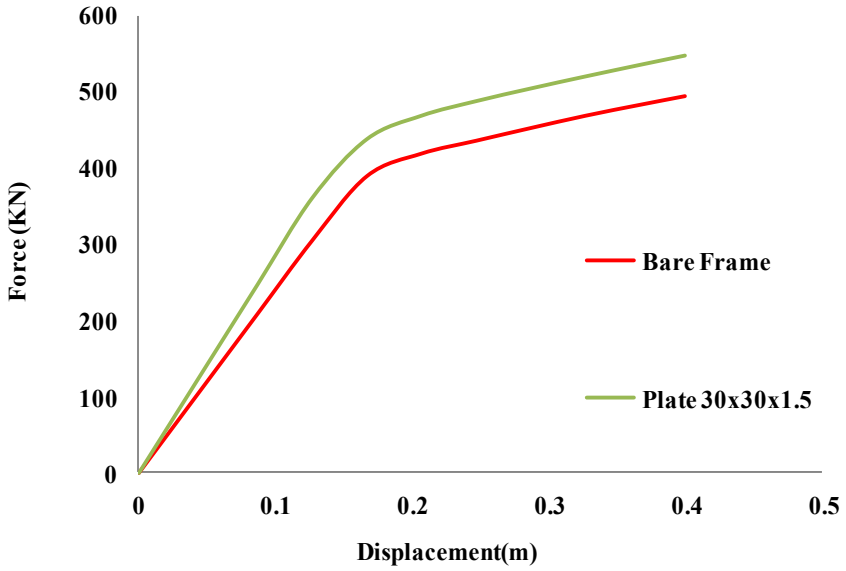

Figure 3. Compare Failure force under Push over Analysis

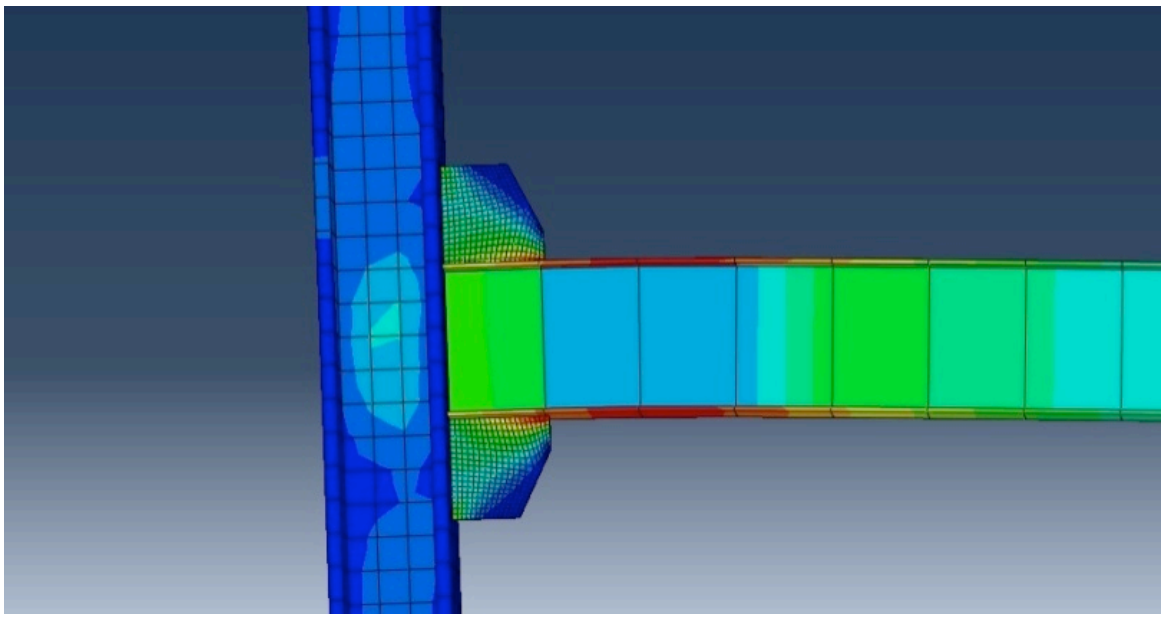

Figure 4. Stress Distribution at Rigid Plate in Frame

4. CONCLUSION

In this study, the effect of rigid plate application in steel shear frame under push over displacement is evaluated. The plate with dimension of 30cm x 30cm x 1.5cm is opted to analysis by aid of finite element simulation.

Results shows that application of Rigid Plate Connection in steel frame leads to increase the overall failure capacity whereas the ratio of plate dimension over thickness stands between 13 to 27, the formation of plastic hinge occurred in Rigid Plate. But whenever the ratio exceeds these ranges, the maximum failure capacity is also increased but, the plastic hinge formation happened in the other structural components which are out of design expeditions. Application of various rigid plates' materials can be recommended as future research interest.

REFERENCES

Bagheri Sabbagh, A., Petkovski, M., Pilakoutas, K., & Mirghaderi, R. (2012). Development of cold-formed steel elements for earthquake resistant moment frame buildings. *Thin-Walled Structures*, *53*, 99–108. doi:10.1016/j.tws.2012.01.004

Chen, C.-C., Lee, J.-M., & Lin, M.-C. (2003). Behaviour of steel moment connections with a single flange rib. *Engineering Structures*, *25*(11), 1419–1428. doi:10.1016/S0141-0296(03)00104-4

Mashaly, E., El-Heweity, M., Abou-Elfath, H., & Osman, M. (2011). Behavior of four-bolt extended end-plate connection subjected to lateral loading. *Alexandria Engineering Journal*, *50*(1), 79–90. doi:10.1016/j.aej.2011.01.011

Mirghaderi, S. R., & Dehghani Renani, M. (2008). The rigid seismic connection of continuous beams to column. *Journal of Constructional Steel Research*, *64*(12), 1516–1529. doi:10.1016/j.jcsr.2008.01.015

Tagawa, H., & Gurel, S. (2005). Application of steel channels as stiffeners in bolted moment connections. *Journal of Constructional Steel Research*, *61*(12), 1650–1671. doi:10.1016/j.jcsr.2005.04.004

Rubin, H., Wang, A. M., Nickbarg, E. B., McLarney, S., & Naidoo, N.. Schoenberger, 0. L., Johnson, JL & Cooperman, BS (1990) .