engineering proceedings

MDPI

Proceeding Paper

Comparison of Two Novel HBS and SC-PC-FD Steel Beam–Column Connections †

Arash Akbari Hamed *,‡, Mahsa Saeidzadeh ‡ and Mohammad Reza Chenaghlou ‡

Faculty of Civil Engineering, Sahand University of Technology, Tabriz, Iran; mahsa.saeidzadeh@yahoo.com (M.S.); mrchenaghlou@sut.ac.ir (M.R.C.)

* Correspondence: akbarihamed.a@sut.ac.ir

† Presented at the 1st International Online Conference on Buildings, 24–26 October 2023; Available online: https://iocbd2023.sciforum.net/.

‡ These authors contributed equally to this work.

Abstract: This study presents a comparative analysis of the structural performance of two innovative steel beam-column connections, namely a self-centering pinned connection with friction damper (SC-PC-FD) and a heat-treated beam section (HBS). The findings indicate that the SC-PC-FD connection exhibits a stable flag-shaped behavior, while the HBS connection can withstand applied loadings up to a rotation of 6% without any occurrence of lateral-torsional buckling. Upon comparison of these connections, it is evident that the SC-PC-FD connection can eliminate residual drifts and provide higher ductility up to a rotation of 7%, while maintaining the main members within the elastic range.

Keywords: self-centering connection; beam-column connection; heat-treated connection

Citation: Hamed, A.A.; Saeidzadeh, M.; Chenaghlou, M.R. Comparison of Two Novel HBS and SC-PC-FD Steel Beam–Column Connections. *Eng. Proc.* **2023**, *53*, x. https://doi.org/10.3390/xxxxx

Academic Editor(s): Name

Published: 24 October 2023

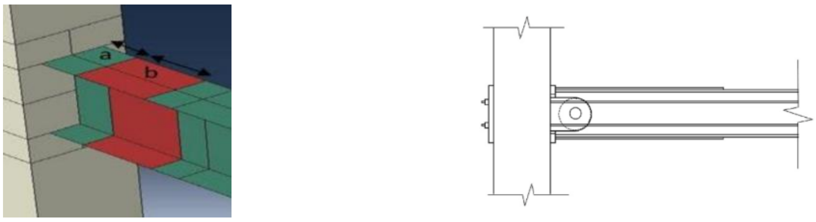
Copyright: © 2023 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

In light of the experiences gained from the Northridge 1994 and Kobe 1995 earthquakes, two approaches have been employed to relocate the plastic hinges away from the column face. The first approach involves strengthening the connection through the installation of haunches, brackets, and cover plates. The second approach entails weakening a beam in a zone far from the column face, such as the reduced beam section (RBS). However, it should be noted that while RBS connections offer certain advantages, but they reduces the elastic stiffness of the beam and also exhibit decreased resistance against local buckling of the web and lateral-torsional buckling [1]. Research has shown that a decrease of 40% to 50% in the flange area of the RBS leads to an increase of 4.5% to 8% in drift [2]. Therefore, despite the significant improvements in the seismic performance of beam-column connections, it is crucial to introduce a new connection that offers enhanced ductility, eliminates residual deformations, and effectively dissipates seismic energy. This new connection should also maintain simple constructional details. In order to achieve these objectives, the seismic performance of two novel connections, namely SC-PC-FD [3] and HBS [4,5], are compared to each other.

2. Materials and Methods

To establish a connection with the HBS approach, it was necessary to subject the flanges and web of a steel I-shaped IPE140 section to heat treatment using the heating protocol proposed by Morrison et al. [5] (Figure 1a). It was considered that $a = 0.6b_f$ and $b = 0.75d_b$, where b_f represents the flange width and d_b represents the section height. It is important to note that only the strength of the steel material is reduced through the heat treatment process, while the other material characteristics remain constant. Based on the findings of the experimental study conducted by Akbari Hamed and Basim [4], it was assumed that the heat-treated steel strength was reduced to 68% of its initial value for the ST37 steel grade. Figure 1b shows a 4-strand SC-PC-FD connection using the same steel beam section. It is worth emphasizing that both models had a beam length of 1.7 m and a column length of 3 m. The column of the models was assigned a rectangular hollow structural section with the dimensions of 160 × 160 × 12. To compare the cyclic performance of these innovative beam-column connections, an incrementally quasi-static loading history was applied to the tip of the beams.

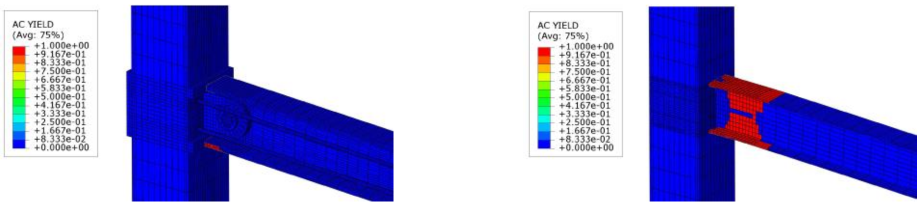


(**a**) (**b**)

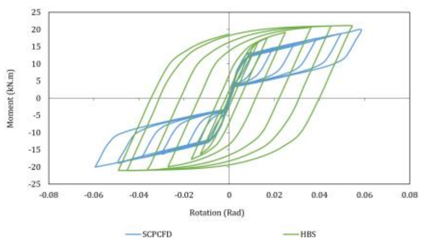
Figure 1. (**a**) The HBS connection, (**b**) The SC-PC-FD connection.

3. Results and Discussion

According to Figure 2a,b, it can be observed that the protected zone of the SCPCFD connection and strands remained within the elastic range. Consequently, the yield of the main members was prevented, and the induced energy was dissipated solely by the disposable friction dampers. In the HBS connection, only the weakened region experienced yielding, and at a rotation of 0.06 rad, the yielding extended towards the vicinity of the column. Furthermore, the numerical study revealed that the HBS connection exhibited maximum strength, ductility, and initial stiffness values of 21.10 kN.m, 4.03, and 2604.87 kN.m/rad, respectively. On the other hand, the corresponding values for the examined 4-strand SC-PC-FD connection were 20.41 kN.m, 14.67, and 2585.89 kN.m/rad, respectively. Therefore, the ratio of strength, ductility, and initial stiffness parameters of the HBS connection compared to the SC-PC-FD connection were 1.03, 0.27, and 1.01, respectively. Based on these findings, it can be concluded that although the HBS connection exhibits slightly higher strength and initial stiffness compared to the SC-PC-FD connection, the latter demonstrates a significant increase in ductility along with its flag-shaped hysteretic curve (Figure 2c) and simple constructional details. Additionally, the SC-PC-FD connection ensures that the main members remain within the elastic behavior range.



(**a**) (**b**)



(**c**)

Figure 2. (**a**) The yielding status of SC-PC-FD connection, (**b**) The yielding status of HBS connection, (**c**) The hysteretic curves obtained for the SC-PC-FD and HBS connections.

4. Conclusions

The analysis of the obtained results led to the conclusion that the novel SC-PC-FD connection exhibits a substantial enhancement in ductility, thanks to its straightforward constructional details. Additionally, it effectively eliminates residual drifts through its stable flag-shaped self-centering performance. Consequently, structures equipped with SC-PC-FD connections can be considered a dependable substitute for conventional moment-resisting frames in regions prone to seismic activity.

Author Contributions: A.A.H.: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing—Original Draft, Writing—Review & Editing, Visualization, Supervision. M.S.: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing—Original Draft, Writing—Review & Editing, Visualization. M.R.C.: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing—Original Draft, Writing—Review & Editing, Visualization, Supervision. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data available on request from the authors.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Jin, J.; El-Tawil, S. Seismic performance of steel frames with reduced beam section connections. *J. Constr. Steel Res.* **2005**, *61*, 453–471.
2. Kim, K.D.; Engelhardt, M.D. Nonprismatic beam element for beams with RBS connections in steel moment frames. *J. Struct. Eng.* **2007**, *133*, 176–184.
3. Saeidzadeh, M.; Chenaghlou, M.R.; Hamed, A.A. Experimental and numerical study on the performance of a novel self-centering beam-column connection equipped with friction dampers. *J. Build. Eng.* **2022**, *52*, 104338.
4. Hamed, A.A.; Basim, M.C. Experimental-numerical study on weakened HSS-to-HSS connections using HBS and RBS approaches. In *Structures*; Elsevier: Amsterdam, The Netherlands, 2020; Volume 28, pp. 1449–1465.
5. Morrison, M.; Schweizer, D.; Hassan, T. An innovative seismic performance enhancement technique for steel building moment resisting connections. *J. Constr. Steel Res.* **2015**, *109*, 34–46.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.