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EXTENDED ABSTRACTS

Evaluation of the Structural Behavior of a Novel Self-Centering Beam-Column Connection with Friction Damper In Comparison To Existing Connections

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Self-centering connection, Friction damper, Metallic yielding damper, Welded moment connection, Residual drift.

1. Introduction

Due to the disadvantages of some existing connections such as the lateral-torsional buckling of RBS connections (Akbari Hamed and Basim, 2020; Akbari Hamed and Bafandeh Nobari, 2021), Saeidzadeh et al. (2022) proposed a novel partial-strength and semi-rigid (Chenaghlou and Akbari Hamed, 2017; Eurocode3, 2005) self-centering connection which eliminates residual drifts and provides more ductility in comparison with existing connections. Considering the stable cycle behavior and the advantages of this connection, in this paper, the structural cyclic behavior of this novel connection was compared with existing connections under the applied quasi-static loading. To this aim, the verified finite element models of four connections including welded moment connection (WMC), post-tensioned strand connection (PTSC), friction damper connection (FDC) and metallic yielding damper connection (MYDC) were considered.

2. Methodology

To ensure the accuracy of the modeling procedure used in this paper, the results of numerical modeling by ABAQUS software were compared with the results of experimental studies performed for WMC (Chen et al., 2005), PTSC (Kailai et al., 2013), FDC (Latour et al., 2018), MYDC (Oh et al., 2009) and the novel beam-column connection which is called self-centering pinned connection with friction damper (SCPCFD) (Saeidzadeh et al., 2022).

In order to investigate the behavior of SCPCFD connection with existing connections, the aforementioned four types of beam-column connections with 3D deformable solid elements were considered which had a beam length of 1.7m and a column height of 3m. It should be noted that in all models, IPE140 and Box160×160×12 were assigned to the beams and columns, respectively and they were kept constant to have a better comparison. Then, the considered quasi-static cyclic loading protocol was applied to the beam end of models using the Static/General approach.

3. Results and discussion

Fig. 1. shows the yielding status for the WMC, PTSC, FDC, MYDC and SCPCFD models at the rotation of 0.06 Rad. According to Fig. 1. the connection area at the vicinity of column (i.e. the protected zone) in the WMC model, and the angles in the PTSC model exceeded the elastic range. In the FDC and MYDC models, a significant

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part of the beam as a main member showed inelastic behavior. According to the results of Von Mises stress of the SCPCFD model, the protected zone of the connection and strands remained in the elastic range, and as a result, the yield of the main members was prevented.

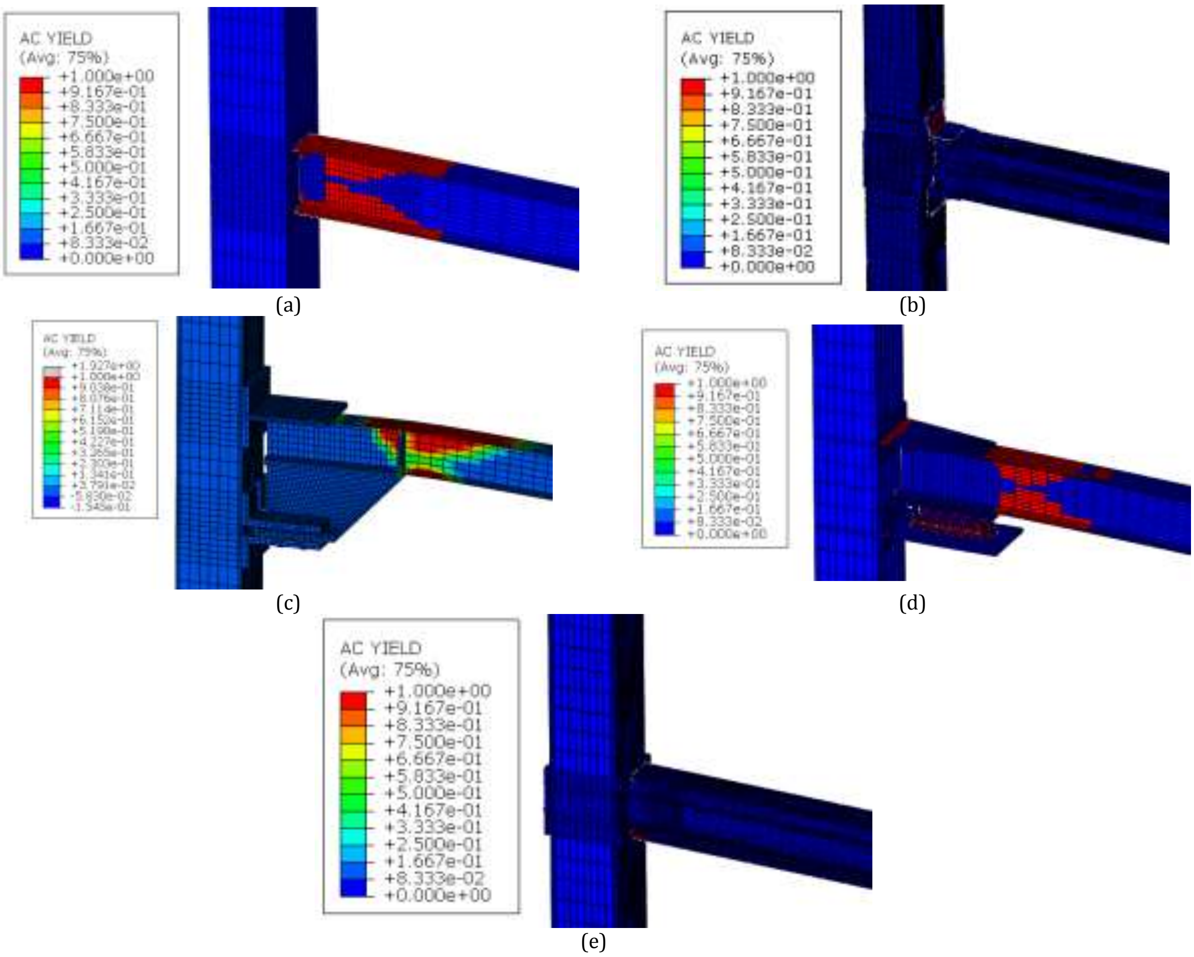

Fig. 1. Yielding status of the models at the rotation of 0.06 Rad: a) WMC, b) PTSC, c) FDC, d) MYDC, e) SCPCFD

Fig. 2. shows the cyclic curves of the WMC, PTSC, FDC, MYDC and SCPCFD models. According to Fig. 2. it can be seen that the SCPCFD connection has a negligible residual drift and while providing simpler constructional details than other connections, it has a flag-shaped and completely stable self-centering behavior. Moreover, WMC, FDC and MYDC connections have a remarkable yielding in the beam as a main member, especially in WMC connection, which results in the residual drift and damage of the connection.

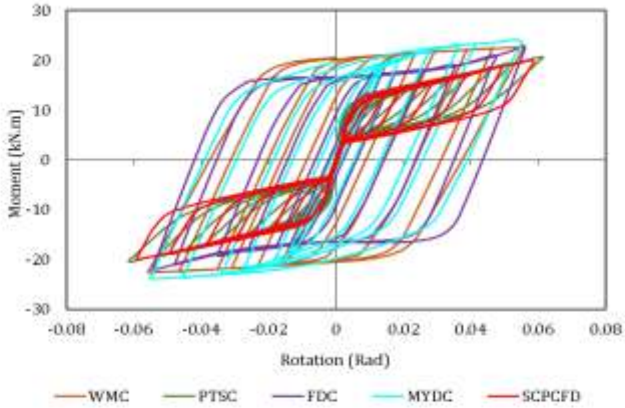

Fig. 2. Cyclic behavior of the considered models

Table 1 shows the estimated values for some of the structural parameters including strength, initial stiffness and ductility of the considered connections. Also, the ratio of these parameters for WMC, PTSC, FDC and MYDC models with respect to the corresponding values of the SCPCFD model is given in Table 2. According to Tables 1 and 2, despite the slightly higher initial stiffness and strength of the considered existing connections, they have significant residual drift as a result of experiencing severe nonlinearity along with complex constructional details which is associated with higher required cost. Moreover, it is observed that the proposed connection can provide more ductility comparing to the other connections in addition to its ability to completely eliminate the residual drift; therefore, it is required to further study the performance of this novel connection in more critical situations such as the skewed beam-column connections (Hoseinzadeh and Saeidzadeh, 2019; Hoseinzadeh et al, 2019).

Table 1. The calculated structural parameters of the models

Model	Strength (kN)	Initial stiffness (kN.m/Rad)	Ductility
WMC	22.62	2617.95	4.13
PTSC	20.64	2599.85	11.76
FDC	22.79	2669.93	5.17
MYDC	23.90	2681.30	4.61
SCPCFD	20.41	2585.89	14.67

Table 2. The ratio of the calculated parameters of the existing connection models with respect to the SCPCFD model

Model	Strength (kN)	Initial stiffness (kN.m/Rad)	Ductility
WMC	1.108	1.012	0.282
PTSC	1.011	1.005	0.801
FDC	1.116	1.032	0.352
MYDC	1.171	1.036	0.314

4. Conclusions

The obtained results show that the SCPCFD connection provides full self-centering action and elastic behavior of the main members which results in elimination of the residual drifts. These desirable performance characteristics along with the considerable reduced constructional details, higher ductility, and providing energy dissipation by replaceable friction pads approve the superiority of the SCPCFD connection with respect to the considered existing connections.

5. References

Akbari Hamed A, Bafandeh Nobari H, “Numerical Investigation on Seismic Behavior of Novel Moment Connections with Heat-Treated Beam Sections”, Journal of Civil and Environmental Engineering, 2021 May 22, 51 (102), 1-3.

Akbari Hamed A, Basim M C, “Experimental-numerical study on weakened HSS-to-HSS connections using HBS and RBS approaches”, Structures, 2020, 28, 1449-1465.

Chen CC, Chen SW, Chung MD, Lin MC, “Cyclic behaviour of unreinforced and rib-reinforced moment connections”, Journal of Constructional Steel Research, 2005, 61 (1), 1-21.

Chenaghlou MR, Akbari Hamed A, “Connection classification for a space structure jointing system”, ce/papers, 1 (2-3), 746-755, 2017.

Eurocode3, “Design of steel structures-Part1-8: Design of joints”, 2005.

Hoseinzadeh AM, Saeidzadeh M, “Study of the effect of skewed beam-to-column connections on loss of strength in endplate moment connections”, 2018, 205-219.

Hoseinzadeh Asl M, Saeidzadeh M, Momenzadeh S, “Evaluation of Friction Strength Loss in Endplate Moment Connections with Skewed Beam”, International Journal of Steel Structures, 2019, 19 (6), 1767-1784.

Kailai D, Peng P, Alexandre L, Zhenhua P, Lieping Y, “Test and simulation of full-scale self-centering beam-to-column connection”, Earthquake Engineering and Engineering Vibration, 2013, 12 (4), 599-607.

Latour M, D’Aniello M, Zimbru M, Rizzano G, Piluso V, Landolfo R, “Removable friction dampers for low-damage steel beam-to-column joints”, Soil Dynamics and Earthquake Engineering, 2018, 115, 66-81.

Oh SH, Kim YJ, Ryu HS, “Seismic performance of steel structures with slit dampers”, Engineering Structures, 2009, 31, 1997-2008.

Saeidzadeh M, Chenaghlou MR, Akbari Hamed A, "Experimental and numerical study on the performance of a novel self-centering beam-column connection equipped with friction dampers", Journal of Building Engineering, 2022, 52, 104338.