Amirkabir Journal of Civil Engineering

Amirkabir J. Civil Eng., 53(4) (2021) 373-376
DOI: 10.22060/ceej.2020.17081.6454

Performance Assessment of the Coupled Steel Shear Wall with Two-Side Connection and Self-Centering

R. Motamedi, M. Gholami*

Reza motammedi Master graduate, Yasouj University, Iran

ABSTRACT: Coupled shear wall with two-side connection and self-centering is a dual System, Including shear wall with Coupling and self-centering Which are joined together by truss elements in the alignment of the floors. In this dual system, beams coupling and plates have the function of energy dissipation and the self-centering frame has the function of reversibility. The result is a reduction in post-earthquake structural repairs and, consequently, a reduction in economic damage, correction, and recovery of damages following a seismic event. In this study, we investigate numerical studies on seismic performance of coupled shear wall and self-centering Primary pre-tensioning force and without pre-tensioning force with the post-yield hardness under 12, 16, and 20% slope in ABAQUS software discussed. Therefore, 9 samples of 6 story and 3 samples of 12 story coupled shear wall and self-centering Primary pre-tensioning force and without pre-tensioning force are designed in way performance-based plastic seismic design and these samples have been subjected to and analyzed with push-over, cyclic, and time history analyzes. The results show that the coupled shear wall with two-side connection and self-centering Primary pre-tensioning force state with 20% stiffness compared to post-yield hardness, less residual drift, less relative lateral displacement distribution, Self-centering Better, less energy dissipation.

Review History:

Received: Aug. 20, 2019
Revised: Feb. 01, 2020
Accepted: Feb. 02, 2020
Available Online: Feb. 08, 2020

Keywords:

Ductile Member
Self-Centering Frame
Post-yield Hardness
Pushover Analysis
Performance-Based Plastic Seismic Design
Steel Shear Wall

1. Introduction

In the last decade, several Experimental and a numerical study has been performed on the B-SPSW system to investigate its seismic behavior [1–14]. These studies show that this system exhibits good seismic performance, but although the B-SPSW system exhibits good seismic behavior, There are two major disadvantages One is that the amount of residual relative displacement in this system is significant after a severe earthquake and as a result, the cost of repairing the system is high, and another that the use of this system due to architectural requirements may be limited. Consequently, in the present study, to eliminate the two disadvantages of relative Residual displacement and architectural constraints in the B-SPSW system, coupled steel shear wall self-centering System SC-BSPSW–CB, is proposed. In this regard, First the 6 and 12 story models were designed using the Performance-Based Design method (PBPD) proposed by Qiu et al [15] and then the behavior of these models has been investigated using push-over, cyclic, and time history analyzes. Note that time history analyzes were performed with 4 earthquake records at MCE hazard level.

2. Numerical modeling framework

The ABAQUS finite element program was used to develop models of the self-centering SPSW with beam-connected web plates. The models use various nonlinear elements to capture important SC-MRF limit states, including gap opening of the SC-WFD connections, yielding of the PT strands, yielding and inelastic deformations in the members (beams, columns, braces, and panel zones). The models include second-order (P-delta) effects due to gravity loads imposed on the gravity load frames in the prototype buildings.

To develop a computationally efficient model for nonlinear time history analysis, a stress-resultant beam-column element (element B32OS from the ABAQUS element library) is used for modeling the columns and the beams. The web plates were modeled using shell elements. The PT strands are modeled as a truss element with bilinear elastoplastic hysteresis material that aligns with the centroid of each PT group on each side of the beam or column web. To account for post-tensioning, an initial strain equal to T0/(APT·EPT) is imposed on the truss element. Post-tensioning results in axial shortening of the beams and column deflections which decrease the post-tensioning force. To avoid this decrease, the

*Corresponding author's email: m.gholami@yu.ac.ir

initial strain in the truss element is increased to ensure that the post-tensioning force in the PT strands is equal to T0 after beam shortening.

in the PT connection model, rigid link elements are used to model the beam–column interface. To capture the gap opening mechanism in the beam-column interface, three zero-length compression-only axial springs are placed at equal spaces along with the beam flange thickness. A leaning column was included in the model to simulate the gravity loads that would contribute to p-delta effects on the frame. Diaphragm action is modeled with truss elements connecting the lean-on columns to the SC-MRF at each floor level. These trusses have a stiffness of 100 times the axial beam stiffness. The seismic mass attributed to the wall was modeled as lumped masses at the lean on columns nodes at each story.

3. Results

3.1. Pushover analysis

There is little difference between the results of the models with different β parameter values in terms of primary stiffness and secondary stiffness and final capacity. This difference is small due to the different cross-sections in these models, not due to the β parameter. In general, it is clear that the beta parameter does not affect the results of the model analysis. On the other, for models with different α value, the initial stiffness of the models are equal but there is a significant difference in the secondary stiffness of the models. Also, the capacity of these models in The 2% drifts is also different.

The reason is that with the increase of cable Cross-sectional area, The fixity of PTF frame connection increases after opening. As a result, k_2increases, and as k_2increases, the model capacity Increases 2% in drift.

3.2. cyclic analysis

Generally, flag-shape (FS) hysteresis Curves exhibit pinching behavior. Clearly, the β parameter has a significant impact on the energy dissipation of the models. For example, the energy dissipation capacity of the models with β=0.91 , β=1.08 and β=0 are 5810000 (NM), 5470000 (NM), and 4950000 (NM) respectively. That is, with the increase in β, the amount of energy dissipation decreases. But with increasing the α parameter, there is no change in the energy dissipation of the models and the energy dissipation in all of these models is equal to about 5230000 (NM). The reason is that in these models, The energy dissipation is carried by the shear wall. The shear wall specifications are the same in all these models.

3.3. Result of response history analysis

As the β value increases, the average maximum story displacement increases. The reason for this is that the increase in the β value causes a reduction in energy dissipation in the system and thus as a result, the demand for ductility of the system increases. Also, by increasing the β value and as a result of increasing the amount of self-centering force, the amount of residual displacement decreases. By increasing the α parameter the story displacement and maximum residual displacement decreased. This result is reasonable because the analysis results showed that with increasing α, the model's secondary stiffness increased and Clayton [13] reported that with increasing secondary stiffness, the story displacement and the residual drift decreased.

4. Conclusions

The main results are as follows:

- By increasing the α parameter both the maximum stories displacement and the maximum residual displacement decrease.
- As the β value increases, The average maximum stories displacement increases. But the amount of residual displacement is reduced.

References

[1] Thorburn, L. J., et al. (1983). "Analysis of steel plate shear walls."

[2] Vatansever, C. and N. Yardimci (2011). "Experimental investigation of thin steel plate shear walls with different infill-to-boundary frame connections." Steel and Composite Structures 11(3): 251-271.

[3] Xue, M. (1996). "Behavior of steel shear wall panels and frame-wall systems."

[4] Shishkin, J. J., et al. (2009). "Analysis of steel plate shear walls using the modified strip model." Journal of structural engineering 135(11): 1357-1366.

[5] Guo, L., et al. (2011). "Behavior of steel plate shear wall connected to frame beams only." International Journal of Steel Structures 11(4): 467-479.

[6] Ozcelik, Y. and P. M. Clayton (2017). "Strip model for steel plate shear walls with beam-connected web plates." Engineering Structures 136: 369-379.

[7] Choi, I.-R. and H.-G. Park (2009). "Steel plate shear walls with various infill plate designs." Journal of structural engineering 135(7): 785-796.

[8] Ozcelik, Y. and P. M. Clayton (2018). "Seismic design and performance of SPSWs with beam-connected web plates." Journal of Constructional Steel Research 142: 55-67

[9] Ozcelik, Y. and P. M. Clayton (2018). "Behavior of columns of steel plate shear walls with beam-connected web plates." Engineering Structures 172: 820-832.

[10] Clayton, P. M., et al. (2015). "Seismic performance of self-centering steel plate shear walls with beam-only-connected web plates." Journal of Constructional Steel Research 106: 198-208.

[11] Clayton, P. M., et al. (2012). "Seismic design and performance of self-centering steel plate shear walls." Journal of structural engineering 138(1): 22-30.

[12] Clayton, P. M., et al. (2012). "Experimental investigation of self-centering steel plate shear walls." Journal of structural engineering 138(7): 952-960

[13] Li, C. H., et al. (2012). "Cyclic test of a coupled steel

plate shear wall substructure." Earthquake engineering & structural dynamics 41(9): 1277-1299.

[14] Borello, D. J. and L. A. Fahnestock (2012). "Behavior and mechanisms of steel plate shear walls with coupling." Journal of Constructional Steel Research 74: 8-16.

[15] Qiu, C.-X. and S. Zhu (2017). "Performance-based seismic design of self-centering steel frames with SMA-based braces." Engineering Structures 130: 67-82.

HOW TO CITE THIS ARTICLE:

R. Motamedi, M. Gholami, Performance Assessment of the Coupled Steel Shear Wall with Two-Side Connection and Self-Centering, Amirkabir J. Civil Eng., 53(4) (2021): 373-376.

DOI: 10.22060/ceej.2020.17081.6454