

# Performance assessment of the coupled steel shear wall with two-side connection and self-centering

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## 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 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 pushover, 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.

## 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, in order 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

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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) are used for modeling of 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 align 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  $T_0/(A_{PT} \cdot E_{PT})$  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 initial strain in the truss element is increased to ensure that the post-tensioning force in the PT strands is equal to  $T_0$  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 the beam flange thickness. A leaning column were 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 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  $\beta$  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  $\beta$  parameter. In general, it is clear that the beta parameter does not affect the results of the models analysis. On the other, for models with different  $\alpha$  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 are 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,  $k_2$  increases, and as  $k_2$  increases, the model capacity Increases 2% in drift .

### 3-2- cyclic analysis

Generally, flag-shape (FS) hysteresis Curves exhibite pinching behavior. Clearly, the  $\beta$  parameter has a significant impact on the energy dissipation of the models. For example, the energy dissipation capacity of the models with  $\beta = 0.91$  ,  $\beta = 1.08$  and  $\beta = 0$  are 5810000 (NM), 5470000 (NM) and 4950000 (NM) respectively. That is, with the increase in  $\beta$ , the amount of energy dissipation decreases. But with increasing the  $\alpha$  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  $\beta$  value increases, the average maximum story displacement increases. The reason for this is that the increase in the  $\beta$  value causes a reduction in energy dissipation in the system and thus as a result, the demand for ductility of system increases. Also, by increasing the  $\beta$  value and as a result of increasing the amount of self-centering force, the amount of residual displacement decreases. By increasing the  $\alpha$  parameter the story displacement and maximum residual displacement decreased. This result is reasonable because the analysis

results showed that with increasing  $\alpha$ , 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  $\alpha$  parameter both the maximum stories displacement and the maximum residual displacement decreases.
- As the  $\beta$  value increases, The average maximum stories displacement increases. But the amount of residual displacement is reduced.

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