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Structural Analysis of Steel Plate Shear Wall using ANSYS

Research Scholar Piyush Kumar Jaiswal, Asst. Prof. Rahul Sharma
Department of Civil Engineering,
Prashanti Institute of technology & Science,
Ujjain (M.P.) India
Piyushjswl231091@gmail.com

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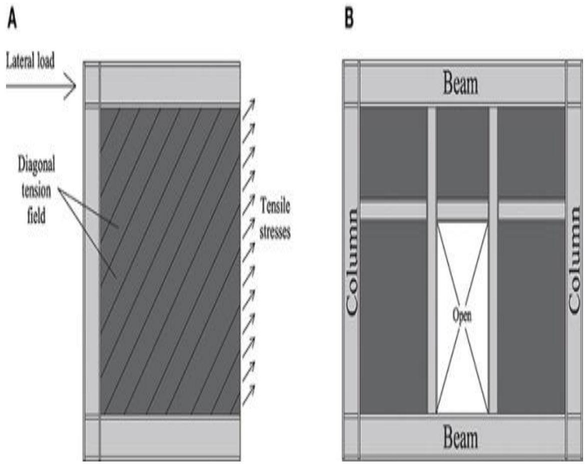
Abstract- The SPSW structures are used as lateral load resisting structure in various countries like Japan, USA. Due to architectural or other requirements, it becomes essential to incorporate opening on SPSW. The incorporation of SPSW affects its strength. The objective of current research is to investigate the effect of circular opening on lateral load resisting behavior of SPSW using techniques of Finite Element Analysis. The modeling and structural FEA analysis is conducted using ANSYS simulation package. The strength of SPSW with and without opening is evaluated in the basis of stress and deformation. The FEA results have shown that incorporation of any opening in SPSW increases stress and deformation. The lateral deformation found to increase with increase in lateral load. The maximum distortion is obtained at this critical zone. The deformation of SPSW with circular opening is 31.2% higher than SPSW without opening.

Keywords- SPSW, deformation, stress.

I. INTRODUCTION

A typical steel plate shear wall (SPSW) consists of an unstiffened thin infill plate connected to vertical and horizontal boundary frame members, i.e., columns and beams, respectively. The lateral load is transferred through the infill plate by the principal tension stresses, as shown in Figure 1.



(a) (b)

Fig 1. (A) Diagonal tension field of a typical SPSW, (B) Fully-stiffened SPSW with door opening.

The infill plate is allowed to buckle in shear and consequently forms a diagonal tension field during an earthquake. Previous studies, both experimentally and numerically, have shown that this system exhibits a high ductility and hysteretic energy dissipation capacity compared with conventional braced frames and concrete shear walls.

Structural characteristics of steel plate shear walls include high initial stiffness, high ductility, high dissipation of energy, and good resistance to degradation when subjected to cyclic loading. These are all positive traits for a lateral load resisting system for seismic design.

The use of thin steel plates also increases the amount of usable floor space. Since the amount of steel needed to resist design forces weighs considerably less than that of reinforced concrete, dead loads are decreased as well, leading to a decrease in foundation costs and seismic loads.

Construction time is also reduced due to the elimination of the curing period involved with reinforced concrete.

II. LITERATURE REVIEW

Yamaguchi et al (1), Conducted monotonic, cyclic tests with various loading rates, pseudo dynamic test, El Centro shake table tests for wood framed shear walls, the tests with more load cycling and high amplitudes corresponded together post peak strength degradation. The fast reversed cyclic test results are close to shake table tests. Compared with pseudo dynamic tests and shake table test, similar amplitudes load cycles were observed but results were different.

Mc Mullin and Merrick (2), conducted force controlled cyclic tests on walls sheathed on both sides with oriented strand board (OSB), 3 ply plywood, 4 ply plywood, gypsum wall board (GWB). The stiffness of GWB was found to be greater than OSB and ply wood.

Salenikovich and Dolan (3), tested walls by various aspect ratios and overturning restraints with both statically and cyclically. Walls ductility and wall stiffness were same as result of two protocols. Capacity and corresponding displacement were 13% and greater than 30% respectively were found for walls tested monotonically and having aspect ratios less than or equal to 2:1.

Ni and Karacabeyli (4) studied the performance of shear walls anchored with hold downs, without hold downs and with dead loads and no hold downs. Static and reverse cyclic loading as per ISO (1998) protocols were used. Comparison to displacement of walls without hold downs to with hold downs and no vertical load were observed 50% corresponding displacement of walls without hold down or vertical load was found to that of walls with hold downs and no vertical load.

Venkatasai ram kumar.N et al (5) analyzed the reinforced concrete shear walls in multistory buildings with effect of lateral loads under flat terrain with varying seismic zones as per IS : 1893 : 2002 and wind loads as per IS : 875 : 1987 (Part : 3). In all the considered G + 2, G + 4, G + 6, building frames, the base moment varied in power equation pattern and for base shear the graphs varied linearly. With increase in base area the stability of building increased and minimum thickness to prevent buckling of shear wall also decreased as the stability increased.

Venkata Sai Ram Kumar N et al (6) analyzed behavior of reinforced concrete shear4 walls by considering increase of height of buildings from ground level to G+7 of height of each floor as 3.5m. The analysis involved in developing of capacity curves which relates wind drift, shear wall length, wind drift, wind shear, wind moment, seismic drift, seismic shear, seismic moment, base moment and base shear with increase in height the base shear of medium and soft soils have no change and varied linearly, but for rocky soils there is a slight decrease in base shear after 20mts of building height.

Ugale Ashish B. and Raut Harshalata R. (7) consider a building frame with(G+6) storey situated in seismic zone III as per Indian code 1893:2002, steel plate shear wall behavior was analyzed using STAAD PRO software, with shear wall and without shear wall also. Found steel plate shear wall enhances the stiffness of the structure.

Compared without SPSW building, building with SPSW has very less deflection, bending moment, shear force, deflection and also quantity of steel is also reduced. SPSW occupies less space compared to RC shear wall which have economical and architectural aspect

III. OBJECTIVES

The objective of current research is to investigate the effect of circular opening on lateral load resisting behavior of SPSW using techniques of Finite Element Analysis. The modeling and structural FEA analysis is conducted using ANSYS simulation package.

The strength of SPSW with and without opening is evaluated in the basis of stress and deformation.

IV. METHODOLOGY

The structural analysis of SPSW is conducted using techniques of FEM. The model of SPSW is developed as shown in figure 2 below. The SPSW is made of steel wall and concrete columns/beams.

The SPSW model is meshed using brick elements. The brick element comprises of 8 nodes with 3DOF/node. The sizing for meshing is set to fine type and transition set to fast. The meshed model of SPSW is shown in figure 3 below.

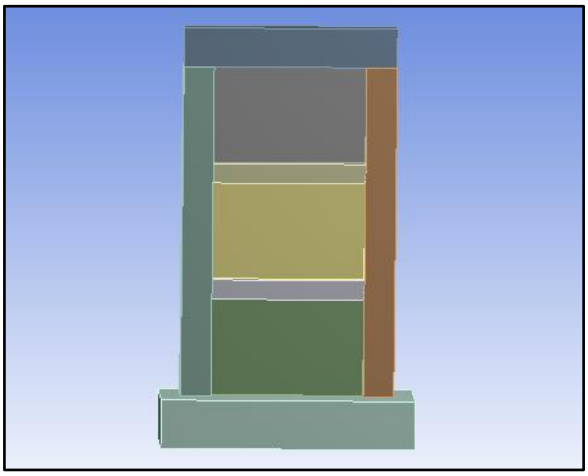


Fig 2. SPSW design without opening.

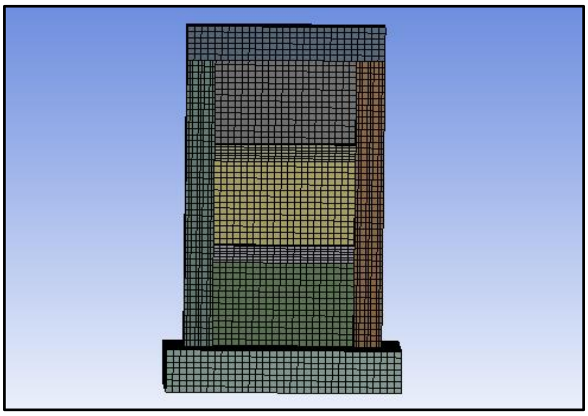


Fig 3. SPSW meshed model.

The next step after meshing is applying structural loads and boundary conditions. The base of SPSW structure is applied with fixed support and top face of the structure is applied with force as shown in Fig 4 below.

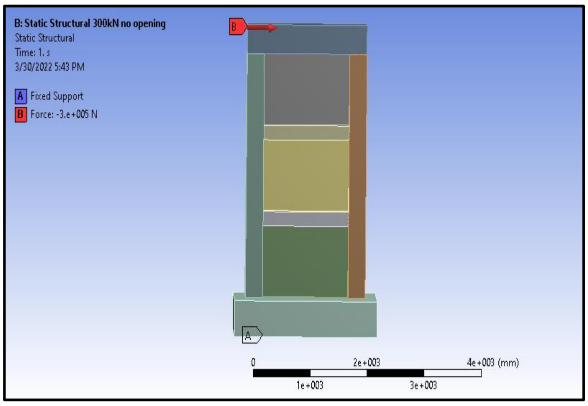


Fig 4. SPSW loads and boundary condition.

The applied loads are successively increased in 100kN and maximum load of 600kN is applied. The applied loads and boundary condition is shown in Fig 5 above.

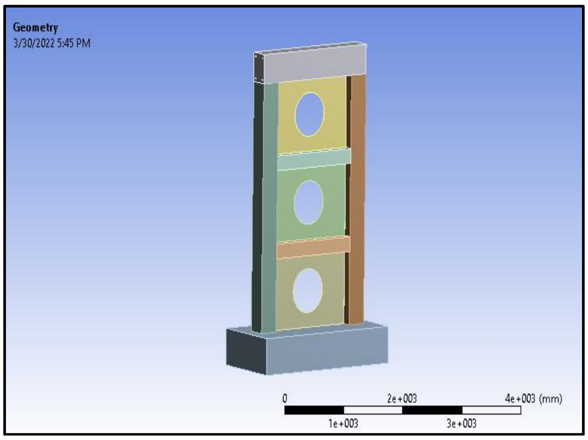


Fig 5. SPSW with circular opening.

The SPSW with circular opening is also modeled and applied with same loading conditions as for SPSW without opening.

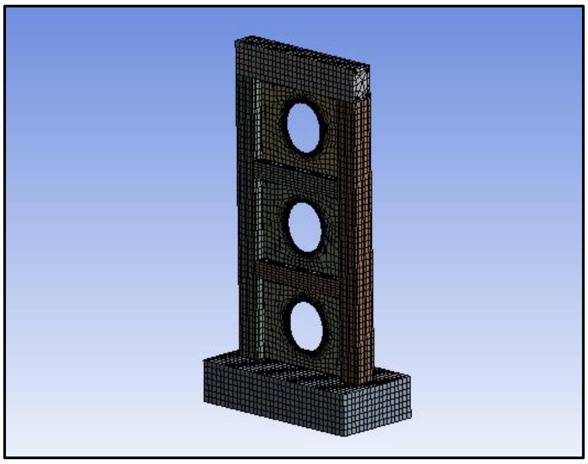


Fig 6. Meshed model of SPSW with circular opening.

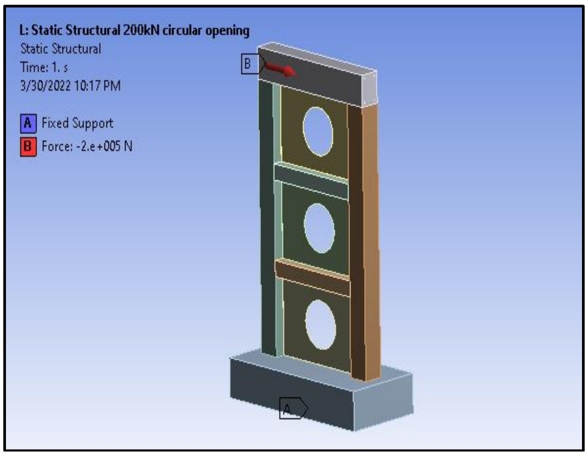


Fig 7. Loads of SPSW with circular opening.

The loading condition applied on SPSW with circular opening is similar to SPSW without opening. The loads are applied in steps of 100kN up to 600kN. The simulation solver is then run.

V. RESULTS AND DISCUSSION

The structural analysis results are obtained for SPSW with and without opening. The maximum deformation is obtained at the top most zone of SPSW i.e. near the zone of load application. The deformation obtained is more than 3.0425mm.

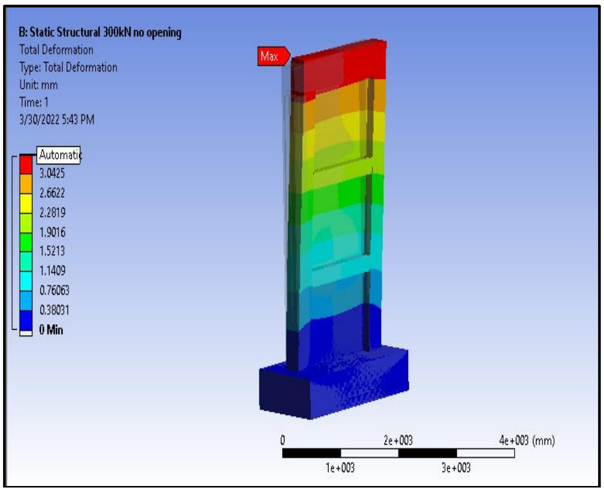


Fig 8. Deformation of SPSW without opening.

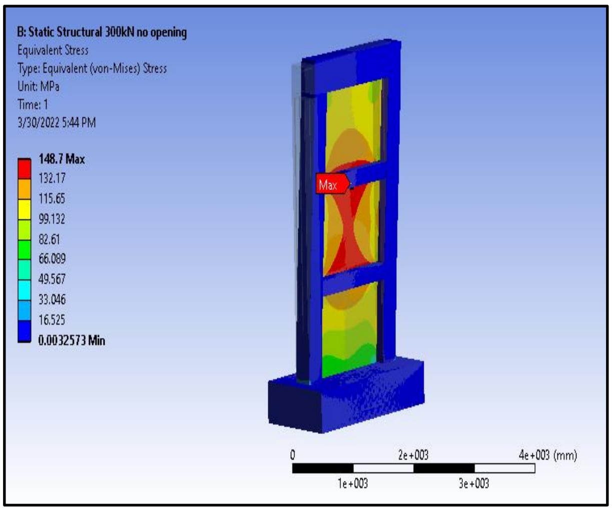


Fig 9. Equivalent stress of SPSW without opening.

The equivalent stress plot of SPSW is obtained for SPSW and the maximum equivalent stress is observed at the central zone. The equivalent stress at this zone of more than 132.1MPa. The equivalent stress is lower at the bottommost region and top corner region of SPSW.

The equivalent stress plot is obtained for SPSW with circular opening. The equivalent stress is maximum near the opening i.e. at the diametrically opposite regions is circular opening. The equivalent stress obtained is higher than 202.95MPa.

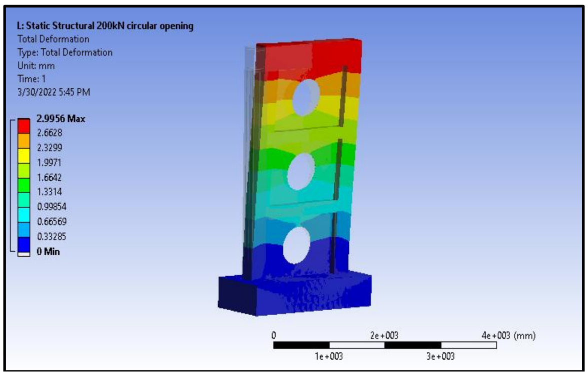


Fig 10. Deformation of SPSW with opening.

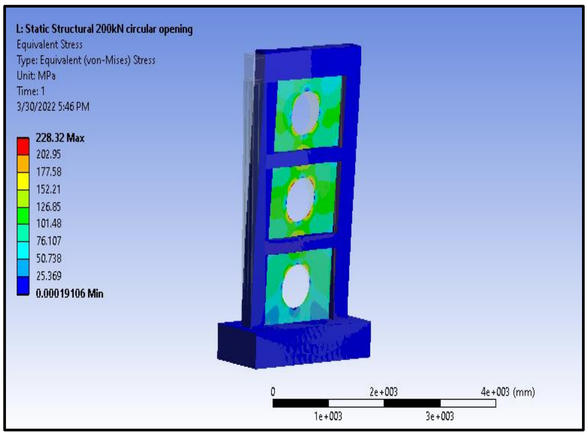


Fig 11. Equivalent stress of SPSW with opening.

The equivalent stress at the bottom and topside regions is nearly 50MPa. The equivalent stress observed for SPSW with opening is much higher than SPSW without opening.

Table 1. Response Spectrum Analysis Results

Design Type	Deformation (mm)	Equivalent Stress (Mpa)
SPSW without opening	0.000161	0.001335
SPSW with circular opening	0.000238	0.001361
SPSW with square opening	0.000277	0.001407

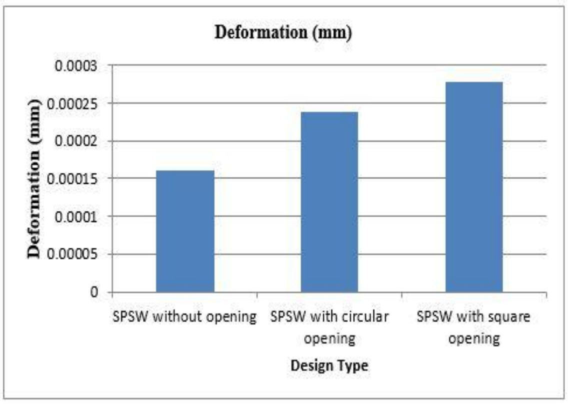


Fig 12. Equivalent stress comparison from RSM

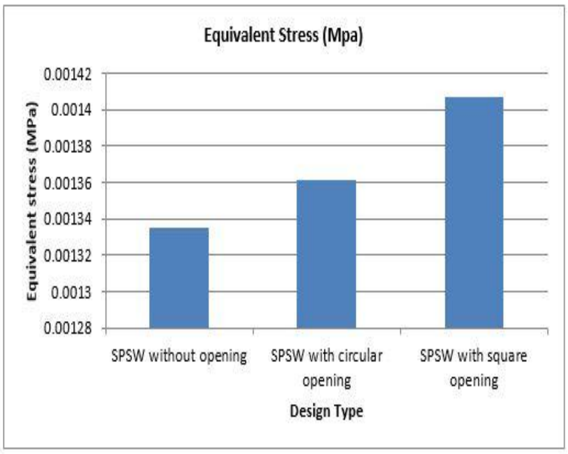


Fig 13. Deformation comparison from RSM.

Table 2. Modal Analysis Results.

Natural Frequency	1st Natural Frequency	2nd Natural Frequency	3rd Natural Frequency	4th Natural Frequency	5th Natural Frequency
SPSW without opening	8.7394	13.048	13.092	13.166	20.195
SPSW with circular opening	8.7712	18.318	18.352	18.474	19.222
SPSW with square opening	8.7764	18.774	18.815	18.852	18.944

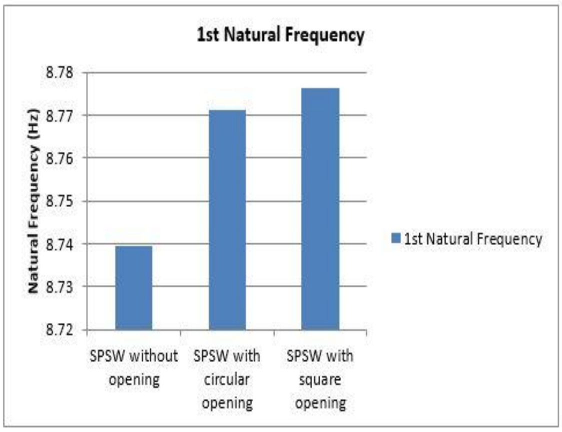


Fig 14. 1st natural frequency comparison.

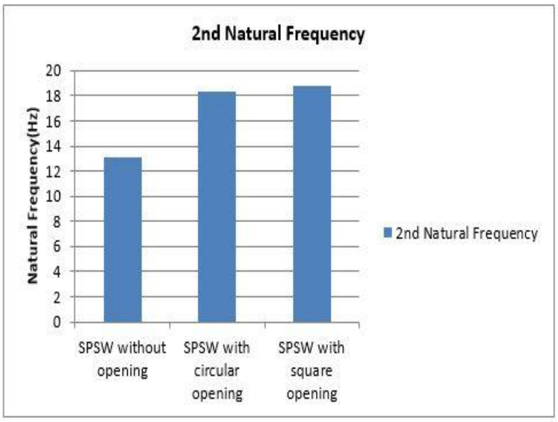


Fig 15. 2nd natural frequency comparison.

Table 3. Comparison of deformation for several SPSW types.

Loads	SPSW without opening	SPSW with circular opening	SPSW with square opening
200kN	2.2819	2.9956	2.5436
300kN	3.4228	4.4934	3.8155
400kN	4.5638	5.9912	5.0873
500kN	5.7047	7.489	6.3591
600kN	6.8456	8.986	7.6309

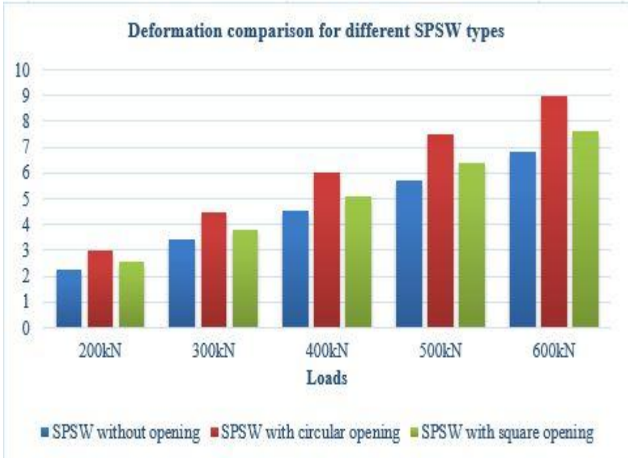


Fig 16. Comparison of deformation for several SPSW types.

VI. CONCLUSION

The SPSW's should possess strong lateral load resisting behavior. The research has shown that incorporation of any opening in SPSW would increase stresses and deformation generated. The lateral deformation found to increase with increase in lateral load. The critical region which is subjected to crack initiation is obtained and is found to be at the central region of steel plate. The maximum distortion is obtained at this critical zone. The deformation of SPSW with circular opening is 31.2% higher than SPSW without opening.

REFERENCES

[1] Yamaguchi N.Karacabeyli E. Minowa c, KAWAI N, Watanabe K, Nakamura I seismic performance of nailed wood frame walls. Paper No 8-1-1 in Proc World Conf. on Timber Eng, , Whistler, BC, 31 July to 3 Aug 2000.

[2] Mc Mullin KM, Merrick DS (2000) Seismic testing of light frame shear walls. Paper No 5-4-1 in Proc 6th World Conf on Timber Eng, , Whistler, BC, 31 July to 3 Aug, 2000.

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[3] Salenikovich AJ, Dolan JD, The racking performance of shear walls with various aspect ratios, part1,2 cyclic tests of fully anchored walls.Forest Prod J.53 (11-12), 10, 37-45, 65-73, 2003a, 2003b.
[4] Ni C, Karacabeyli E, Capacity of shear wall segments without hold-downs. Wood Design Focus 12(2):10-17,2002Eftychios A. Pnevmatikakis, Petros Maragos "An Inpainting System For Automatic Image Structure-Texture Restoration With Text Removal", IEEE trans. 978-1-4244- 1764, 2008.
[5] Venkata Sairam Kumar.N, P.V.S.Maruthi Krishna, "Utilization of reinforced concrete flexural (shear) Wals in multistorey buildings with effect of lateral loads under flat terrain". IJESRT, Vol.2, Issue 9, pp-2467-2471, 2013.
[6] S.V.Venkatesh, H.Sharada Bai, "Effect of internal & External shear wall on performance of buildings frame subjected to lateral load", International journal of earth science and engineering, Vol.4, No.6, SPL, (Oct, 2011), pp 571-576,2011
[7] Ugale Ashish B. Raut Harshalata R. "Effect of steel plate shear wall on behaviour of structure". International journal of civil engineering research, Vol.5, Number 3, PP-295-300, 2014.