Seismic Behavior of SPSW Steel Framed Buildings

Mohammed Abdul Rizwan[1], Tejas D. Doshi[2]

[1] M.Tech Student in Dept. of Civil Engineering , KLE Dr. MSSCET, Belagavi-590008(Karnataka).
[2] Assistant Professor, Dept. of Civil Engineering, KLE Dr. MSSCET, Belagavi-590008(Karnataka).

Abstract- *The present paper describes the analysis and design of steel frame building with Steel plate shear wall (SPSW). For present work equivalent static analysis and response spectrum analysis is carried out for steel moment resisting building frame having (G+6) storey situated in zone III. Modelling will be done by using mesh and strip modelling. The analysis of steel plate shear wall and the building are carried out using software STAAD.Pro V8i. The main parameters consider in this paper to compare the seismic performance of buildings are displacement, axial force bending moment and maximum stresses. The models are analyzed as per IS 1893:2002 and IS 800-2007.*

Key Words: Steel plate shear wall (SPSW), strip frame model, mesh frame model, ESM and RSM.

1. INTRODUCTION

Construction of shear walls are to with stand lateral loads acting on a structure, since shear walls can carries large earthquake forces, and they are able to resist large overturning effects on them. Their foundations should be properly designed and some special attention should be given. If possible shear walls should be provided along both length and width. However, if they are provided only in one direction, then to resist strong earthquake motions a proper grid of beams and columns in the vertical plane called a moment resistant frame must be provided along the other direction.

In horizontal load resisting system we generally provide shear wall as vertical members. It consists of a boundary columns and horizontal floor beams. The SPSW and boundary columns together act as a vertical plate girder. The columns act as flanges and the steel plate wall acts as web of the vertical plate girder. In a plate girder beams act as transverse stiffeners. In recent years steel plate shear wall systems has been used in many highly seismic areas to resist lateral loads. In a steel building frames, steel system is used to resist lateral loads which results in cost savings in comparison to that uses a steel frame in combination with concrete, as practiced in Canada. This is due to less materials required on construction site. Schedule of construction also shortens which is good for cost reduction, in high rise buildings. Other advantages of SPSW due to their relative simplicity and light weight are repetition during fabrication of SPSW. To reduce the cost of field fabrication, steel shear walls can be pre-fabricated and then can be assembled as per requirement on site.

Many of the existing SPSW buildings are designed with stiffened shear panels to avoid out of plane buckling. At the point where buckling takes place, the load resisting system changes from in-plane shear to inclined tension field that forms along the elongated diagonal. When thin panels are used, buckling takes place at very low loads and the panel is resisted mostly by tension field action.

1.1 Reasons behind erection of steel plate shear wall

Steel plate shear wall offers high stiffness and high strength which can be used to resist large horizontal loads and to withstand gravity loads. Shear walls are designed to resist lateral loads due to wind and earthquakes. Steel plate shear wall system became an effective alternative for other lateral load resisting systems, such as RC shear walls, various types of braced frames etc. SPSWs are widely used across the world because of the various advantages over other types of load resisting systems, because of large ductility and high stiffness, speed of construction, light weight, offers more space due to minimum thickness which is good from an architect view and to reduce the seismic load.

I.2 Modelling of steel plate shear walls

I.2.1 Strip Modelling:

The building is modelled using the finite element software *STAAD.Pro V8i*. The strip modelling is purely based on the diagonal tension field action developed immediately after the buckling of the plate. This type of modelling is recommended by the code of Canada, the CAN/CSAS- 16-01 in the analysis and design procedure of the SPSWs. In the analysis software the steel plate in the wall panel is to be replaced by a series of truss members (struts) or the strips along the tension field. There are two ways of modelling by the method. The first one is the strips inclined at uniform angle with the horizontal and the other is the multi-angle strip model as shown in Figures.

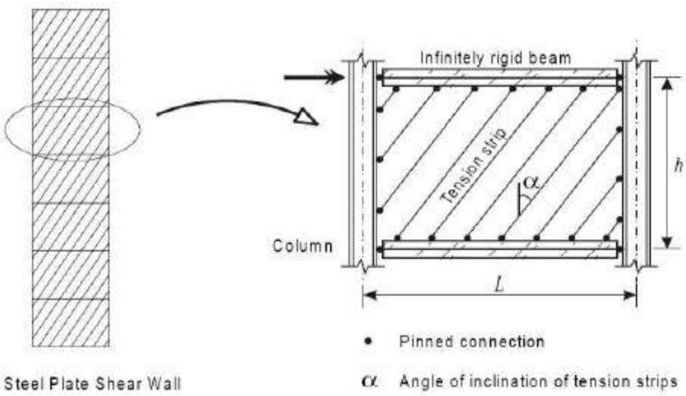

Fig -1: Uniform angle strip model

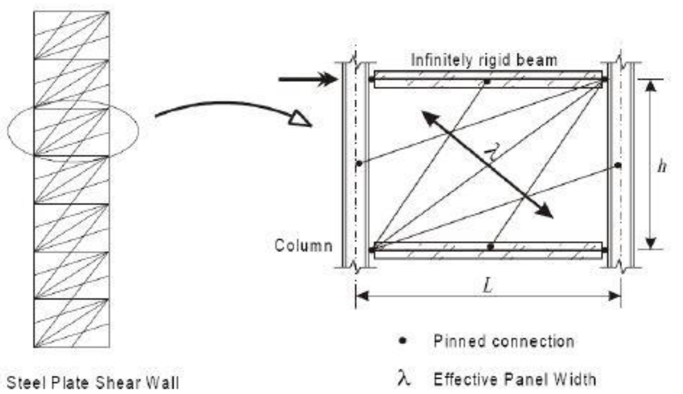

Fig -2: Multi-angle strip model

I.2.2 Mesh Modelling:
To provide meshing of plates select a bay or panel of one storey or of a full height as per requirement, for better and accurate results adopt smaller sections instead of bigger sections.

To provide a plate and generate a mesh for a plate in STAAD.Pro V8i we have adopted these steps. Select Add 4-noded plate command in STAAD pro and select 4 points where you wish to provide a plate. After assigning of plates is done, then generate the mesh to the assign plates by selecting command generate surface meshing and click at all 4 points of a desired plate to generate type of meshing. In this study we have considered quadrilateral type of meshing. For fine and smooth meshing divide the whole plate into finer elements of same size or divisions. The smaller the mesh size the greater would be the results accuracy. In this study we have considered a plates of 3mX3m size and meshing of 0.6mX0.6m size.

2. Method of Analysis.

The seismic analysis of a structure involves evaluation of the earthquake forces acting at various level of the structure during an earthquake and the effect of such forces on the behaviour of the overall structure. According to IS 1893-(2002) following methods have been recommended to determine the design lateral loads they are:

a) Equivalent Static Method
b) Response Spectrum Method

2.1 Seismic Analysis Using IS 1893 (Part 1): 2002

2.1.1 Load Factor: In the design of steel structure, following load combinations as given in the IS 1893 (Part1): 2002 are.

1.7(DL) + 1.7(LL)
1.7(DL) + 1.7(ELX)
1.7(DL) - 1.7(ELX)
1.7(DL) + 1.7(ELZ)
1.7(DL) - 1.7(ELZ)
1.3(DL) + 1.3(LL) + 1.3(ELX)
1.3(DL) + 1.3(LL) - 1.3(ELX)
1.3(DL) + 1.3(LL) + 1.3(ELZ)
1.3(DL) + 1.3(LL) - 1.3(ELZ)

3. Structural Planning(Models)

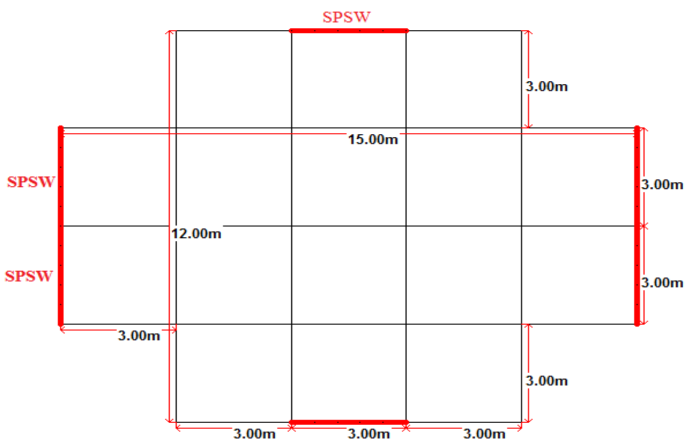

Fig -3: Plan of a steel frame buildings with SPSW(Strip and Mesh frame model)

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 02 Issue: 03 | June-2015 www.irjet.net p-ISSN: 2395-0072

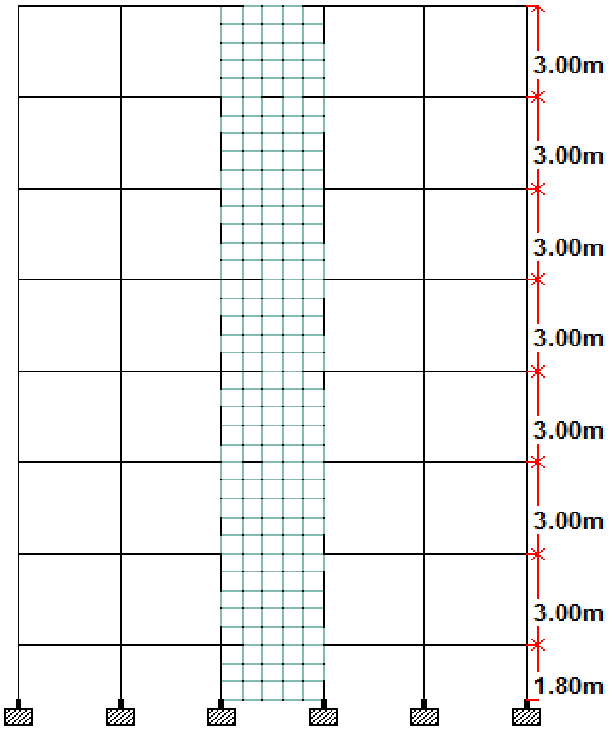

Fig -4: Elevation of a steel frame building with SPSW(Mesh frame model)

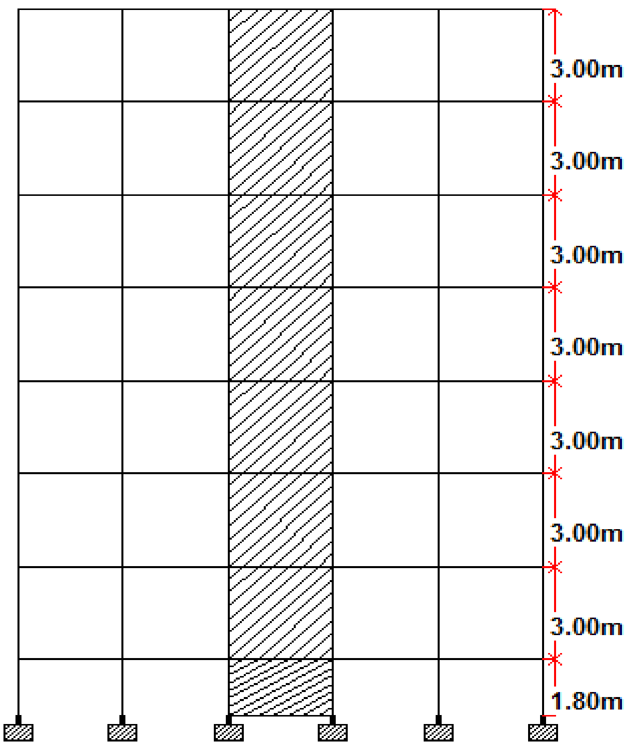

Fig -5: Elevation of a steel frame building with SPSW(Strip frame model)

3.1 Data assumed for the Structure

The building considered having G+6 stories. Height of each storey is 3 m. The building has plan dimensions 15mX12m. It is considered that building is located in seismic zone III. Thickness of slab is 150mm. Live load intensity is taken as 4 kN/m² at intermediate floors and 1.5 kN/m² at roof. Weight of floor finish is considered as 1 kN/m². Type of soil is Medium soil. Thickness of wall is 230 mm. Shear wall thickness is 8mm. Width of strips is 350mm. Angle of inclination of strips with vertical(α) 45^0. Beam size ISHB 300 and Column size ISWB 600H.

The results found are shown with the help of graph for the parameters considered below

1. Displacement
2.Axial force
3.Bending moment
4.Maximum stresses

3.2 COMPARISON OF RESULTS

3.2.1 Displacement result

Table 1: Displacement for Mesh and Strip frame.

Type of frame	Displacement in mm	
	ESM	RSM
Mesh frame	2.766	2.661
Strip frame	2.901	2.823

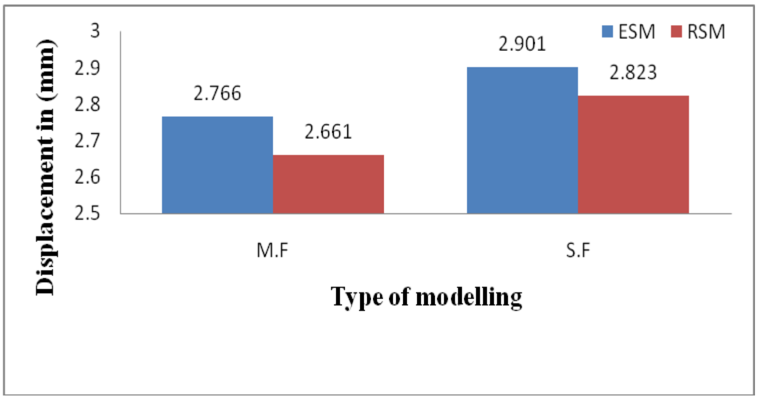

Chart -1: Displacement of buildings

The value of displacement is less in mesh model when compared to strip model because of smaller element size in mesh model which gives more accurate results.

3.2.2 Axial force result

Table 2: Axial force for Mesh and Strip frame.

Type of frame	Axial force in kN	
	ESM	RSM
Mesh frame	14.458	10.356
Strip frame	17.282	13.576

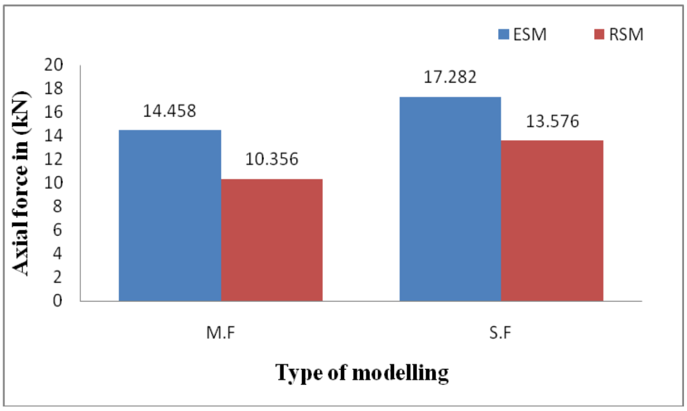

Chart -2: Axial force of buildings

Smaller element size in mesh model gives more accurate results, Because of which the value of Axial force is less in mesh model when compared to strip model.

3.2.3 Bending moment result

Table 3: Bending moment for Mesh and Strip frame.

Type of frame	Bending moment in kNm	
	ESM	RSM
Mesh frame	45.235	28.355
Strip frame	45.677	28.457

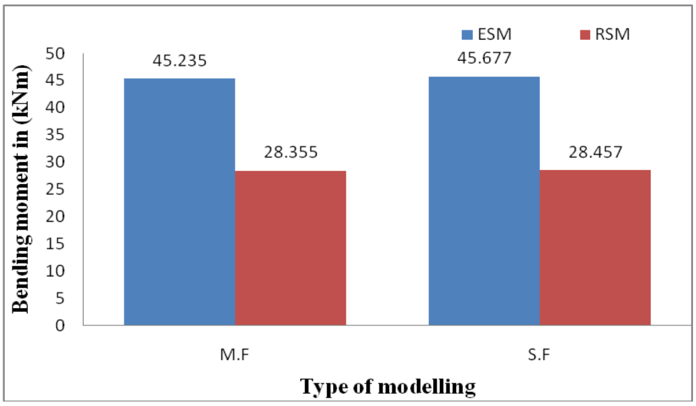

Chart -3: Bending moment of the buildings

The value of Bending moment is less in mesh model when compared to strip model because of smaller element size in mesh model which gives more accurate results.

3.2.5.1 Maximum compressive stresses result

Table 4:Max. compressive stress for Mesh and Strip frame.

Type of frame	Maximum compressive stresses in kN	
	ESM	RSM
Mesh frame	85.065	52.172
Strip frame	90.634	53.421

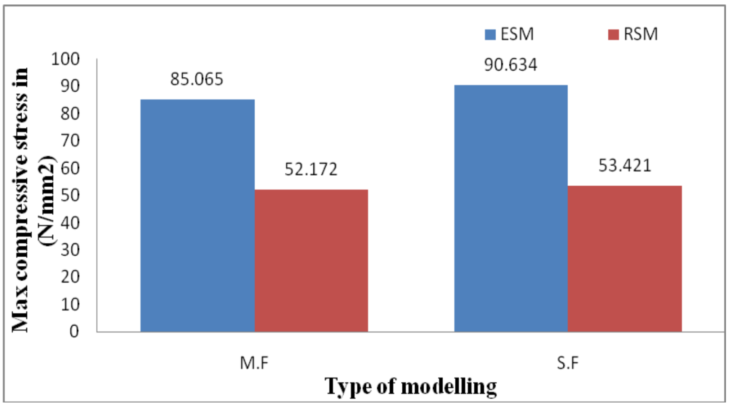

Chart -4: Maximum compressive stresses of the buildings

In mesh model element size is small, which gives more accurate results, the value of Maximum compressive stresses is less in mesh model when compared to strip model.

3.2.5.2 Maximum tensile stresses result

Table 4: Max. tensile stresses for Mesh and Strip frame.

Type of frame	Maximum tensile stresses in kN	
	ESM	RSM
Mesh frame	84.325	49.403
Strip frame	86.899	50.121

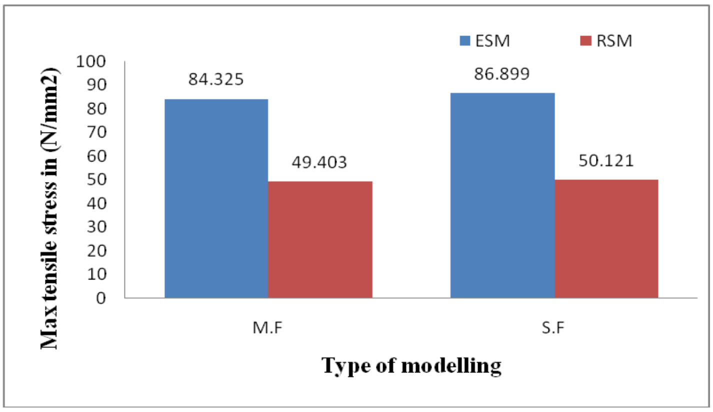

Chart -5:Maximum tensile stresses of the buildings

The value of Maximum tensile stresses is less in mesh model when compared to strip model because in mesh model element size is small which gives more accurate results.

4. CONCLUSIONS

[1] Displacement in case of SPSW strip frame is very large and in case of SPSW mesh frame is very less. The addition of SPSW significantly reduces the displacement in the structures.

[2] With the addition of SPSW, load carrying capacity of the structure increases.

[3] SPSW increases the stiffness of the structure.

[4] With the use of SPSW mesh frame in the buildings, the Bending moment, Axial force and stresses are less compared to buildings with SPSW strip frame.

[5] From the results building with SPSW mesh frame is preferred over buildings with SPSW strip frame.

REFERENCES

[1] Thorburn, L.J., Kulak, G.L., (1983). Analysis of steel plate shear walls. Structural Engineering Report No. 107, Department of Civil Engineering, University of Alberta, Edmonton, Alberta, Canada.

[2] Timler, P.A. and Kulak, G.L. (1983) , "Experimental Study of Steel Plate Shear Walls", Structural Engineering Report No. 114, Department of Civil Engineering, University of Alberta, Edmonton, Alberta, Canada.

[3] Tromposch, E.W. and Kulak, G.L.(1987) Cyclic and static behaviour of thin panel steel plate shear walls. Structural Engineering Report No. 145, Department of Civil Engineering, University of Alberta, Edmonton, AB.

[4] Rezai, M. (1999) . “Seismic Behaviour of Steel Plate Shear Walls by Shake Table Testing,” PhD Dissertation, Department of Civil Engineering, University of British Columbia, Vancouver, Canada.

[5] L. J. Thorburn, Kulak G.L., and Montgomery C.J. (1983). “Analysis of steel plate shear walls”, Structural Engineering Report No.107, Department of Civil Engineering, The University of Alberta Edmonton, Alberta, pp 1-167.

[6] Mahmoud REZAI, Carlos E VENTURA And Helmut G L PRION(2000), “NUMERICAL INVESTIGATION OF THIN UNSTIFFENED STEEL PLATE SHEAR WALLS”,12th World Conference on Earthquake Engineering 2000 pp 1-4.

[7] Ms Deepika C. Hiwrale Prof. P.S. Pajgade (2012) “Analysis and Design of steel framed buildings with and without Steel Plate Shear Walls” International Journal of Scientific & Engineering Research Volume 3, Issue 6, June-2012

[8] Pundkar R. S, Alandkar P. M “Influence of steel plate shear wall on multi storey steel building” International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com Vol. 3, Issue 4, Jul-Aug 2013, pp.1940-1945

[9] IS 1893 (Part 1):2002, Indian Standard, “CRITERIA FOR EARTHQUAKE RESISTANT DESIGN OF STRUCTURES”, PART 1 GENERAL PROVISIONS AND BUILDINGS.(Fifth Revision).

[10] IS 800:2007, Code of practice for general construction in steel, BUREAU OF INDIAN STANDARDS, NEW DELHI.

BIOGRAPHIES

Mohammed Abdul Rizwan is M.Tech Student in Department of Civil Engineering, KLE Dr. M. S. Sheshigiri College of Engineering and Technology, Belagavi, 590008 Karnataka.

Prof. Tejas D. Doshi is working as Assistant Professor in Department of Civil Engineering, KLE Dr. M. S. Sheshigiri College of Engineering and Technology, Belagavi, 590008 Karnataka.

