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Parametric Study of Steel Frame Building with and without Steel Plate Shear Wall

Prof. Prashant Topalakatti[1] Prabhu M. Kinagi[2]
1.Professor, Dept. of Civil Engg., BLDEA'S PGHCET, Bijapur – 586103 (Karnataka)
2.M-Tech Student in Structural engineering in Dept. of Civil Engg., BLDEA'S PGHCET
Bijapur – 586103 (Karnataka).India
email: prashant.topalakattii@gmail.com, prabhukinagi@gmail.com

Abstract
The present paper describes the analysis of high-rise steel buildings frames with and without Steel plate shear walls (SPSWs) by using STAAD PRO V8i FEA programme. The primary variable in the analysis were presence of steel plate shear walls thickness of plate (6 mm to 18 mm). The main parameters are consider deflection, shear force, bending moment, axial force. The models are analyze by equivalent static analysis as per IS 1893:2002.
Keywords: steel plate shear wall(SPSW), staad pro V8i, IS 1893:2002.

1. Introduction

Recently, many high-rise apartment buildings have been constructed in the Asian region's using the frame-slab system, which consists only of reinforced concrete columns, beams and slabs. As the height of building increases the lateral loads as well as the vertical loads tends to control the design. The rigidity and stability requirements become more important than the strength requirement. The first way to satisfy these requirements is to increase the size of the members which may lead to either impractical or uneconomical members. The second is to change the form of the structure into something more rigid and stable to confine the displacements and increase stability. The shear wall-frame system is a frequently used structural scheme in moderately tall buildings (e.g. 20-40 stories). A shear wall structure is considered to be one whose resistance to horizontal loading is provided entirely by shear walls. An introduction of shear wall represents a structurally efficient solution to stiffen a building structural system because the main function of a shear wall is to increase the rigidity for lateral load resistance. Sometimes it is inevitable to have openings such as doors, windows and other types of openings in shear wall.

Shear walls are vertical elements of the horizontal force resisting system. Shear walls are constructed to counter the effects of lateral load acting on a structure. In residential construction, shear walls are straight external walls that typically form a box which provides all of the lateral support for the building. When shear walls are designed and constructed properly, and they will have the strength and stiffness to resist the horizontal forces [5].

2. Modeling of steel plate shear walls

2.1 Strip Modeling

This is the most popular way of modeling thin, non-compact shear walls. It is purely based on the diagonal tension field action developed immediately after the buckling of the plate. This type of modeling is recommended by the code of Canada, the CAN/CSA-S16-01 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 modeling by this method. The first one is the strips inclined at uniform angle with the horizontal and the other is the multi-strip model as shown in the following figures. The two models of the SPSWs are as shown in following figures

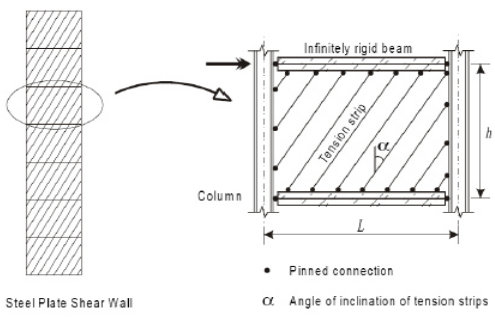

Figure 1. Strip Model Representation of a SPSW

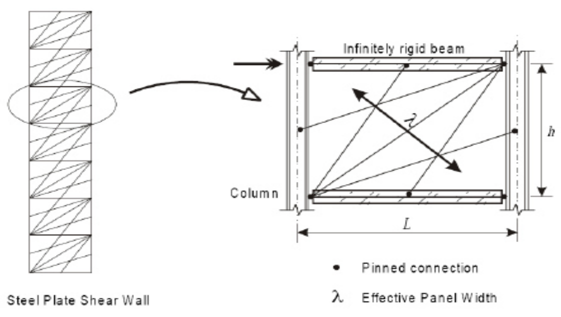

Figure 2. Multi-angle strip model of a SPSW

2.2 Modeling guide lines for Strip Model

- A minimum of ten strips are to be provided per wall panel.
- Each strip is pinned at both of its ends to the surrounding beams or columns as per its location in the wall panel.
- Each strip has the width equal to the centre to centre spacing of the consecutive strips.
- Thickness of the strips is kept same as that of the plate.
- The strips are normally inclined at 45 degree with the horizontal. The angle of inclination shall be in the range of 38 to 45 degrees with the horizontal. Slight variation in the angle does not affect the behavior of the model.
- The connection of the beams of that panel with the columns shall be kept pinned or hinged.

3. 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 behavior 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
c) Time History Method

In the present study Equivalent Static Method is used.

3.1 Equivalent Static Method

Equivalent lateral force method is the simplest method of analysis and requires less computational efforts because the forces depend on the code based fundamental period of structure with some empirical modifier. The design base shear shall first be computed as a whole, and then be distributed along the height of the building based on simple formulas appropriate for building with regular distribution of mass and stiffness. The design lateral force obtained at each floor level shall then be distributed to individual lateral load resisting elements depending upon floor diaphragm action. In case of rigid diaphragm (reinforced concrete monolithic slab-beam floors or those consists of prefabricated/precast elements with topping reinforced screed can be taken as rigid diaphragm) action. The total shear in horizontal plane shall be distributed to the various elements of lateral force resisting system on the basis of relative rigidity.

3.2 Static analysis load factors

In the design of steel structure, following load combinations as given in the IS 1893 (Part1): 2002 and IS 800-2007 are:

1.5 DL+1.5 LL+ 1.5RLL
1.2 DL+0.6 LL+1.2 EL
1.2 DL+0.6 LL-1.2 EL
1.5 DL+1.5 EL
1.5 DL-1.5 EL
0.9 DL+1.5 EL
0.9 DL-1.5 EL

4. Structural details

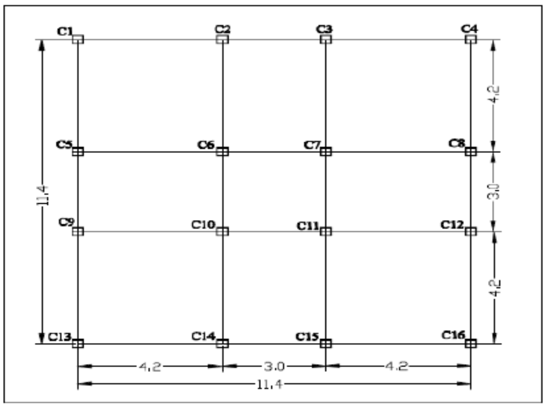

Fig 3. Plan of a G+6 story steel building

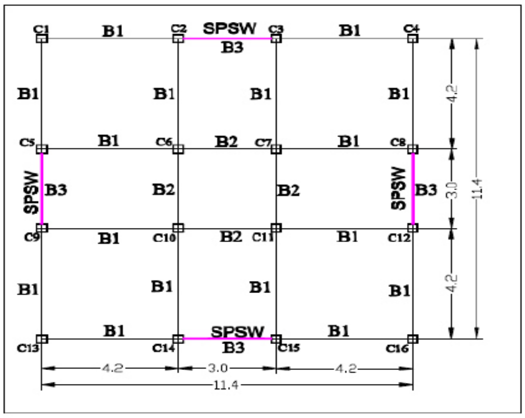

Fig 4. Plan of a G+6 story steel building with SPSW

4.1 Description of building

Table 1 Details of building consideration

1	Type of structure	M.R.S.F
2	Zone	III
3	No. of stories	G+6
4	Lateral load resisting system	Steel plate shear wall
5	Height of each storey	3m
6	Depth of foundation	3m
7	Thickness of slab	150mm
8	External wall thickness	230mm
9	Internal wall thickness	150mm
10	Shear wall thickness	6mm
11	Width of strips	350mm
12	Angle of inclination of strips with vertical(α)	45^0
13	Unit weight of masonry	20 kN/m3
14	Floor finish	2 kN/m2
15	Live load	4 kN/m2 4 kN/m2 at intermediate
15	Type of soil	medium
16	Seismic analysis	Seismic co-efficient method (IS 1893-2002)

4.2 Member specification

Table 3.2 Beam specifications

Beam Specifications	For steel building	For SPSWs building
B1	ISHB 225	ISWB 300
B2	ISHB 350	ISHB 200
B3	ISHB 225	ISWB 150

Table 3.3 Column specifications

Column Specifications	For steel building	For SPSWs building
C1, C4, C13, C16	TUBE 330 X 330 X 8	TUBE 330 X 330 X 8
C2, C3, C5, C6, C7, C8, C9, C10, C11, C12, C14, C15	TUBE 330 X 330 X 10	TUBE 330 X 330 X 10

The above mentioned both the frame has been analyses by using STAAD-PRO V8i SELECT SERIES 2 software. For getting results column No.1 has been selected. The results found to be are shown with the help of graph.

5. Comparison of results

In this chapter the results obtained for steel frame building with and without SPSW and varying thickness of SPSWs analysis carried out by Equivalent Static Analysis (ESA). The analysis is carried out in STAAD Pro software. For getting results column No.1 has been selected.

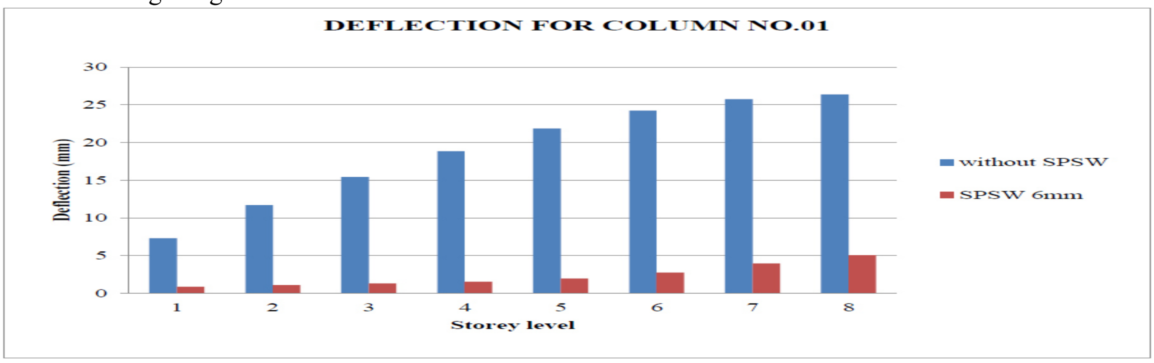

Fig 5.1 Deflection

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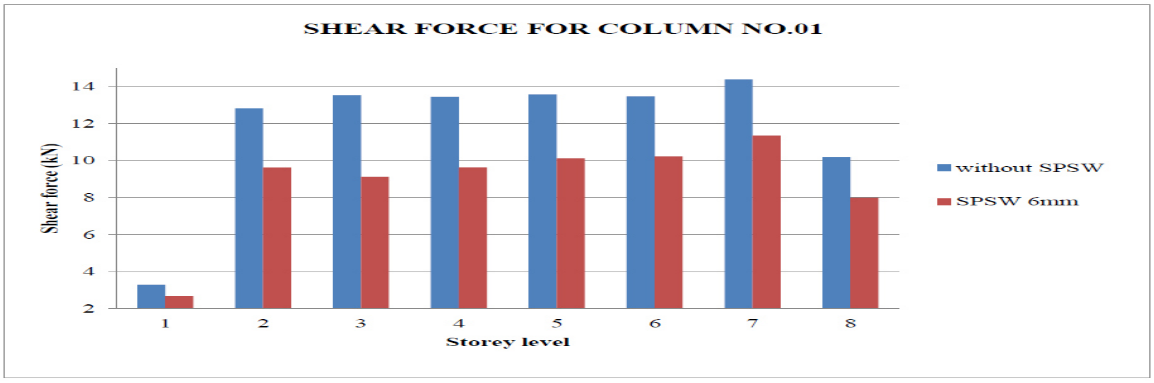

Fig 5.2 Shear Force

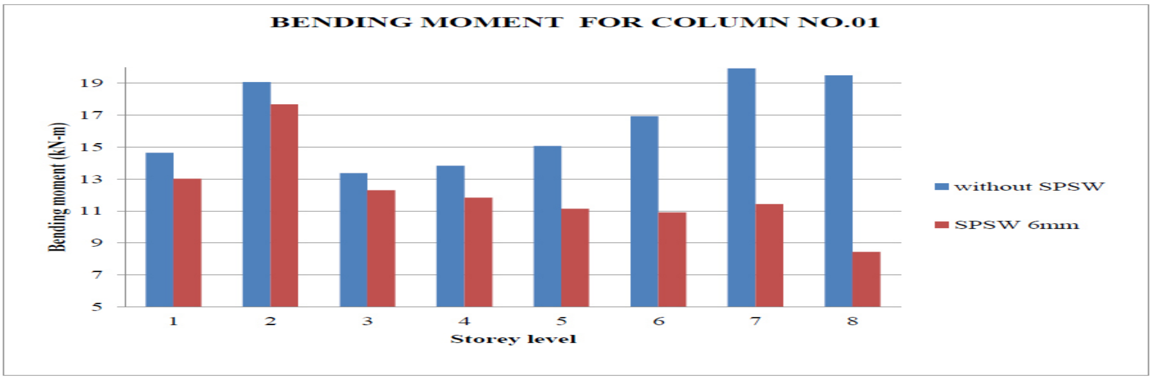

Fig 5.3 Bending Moment

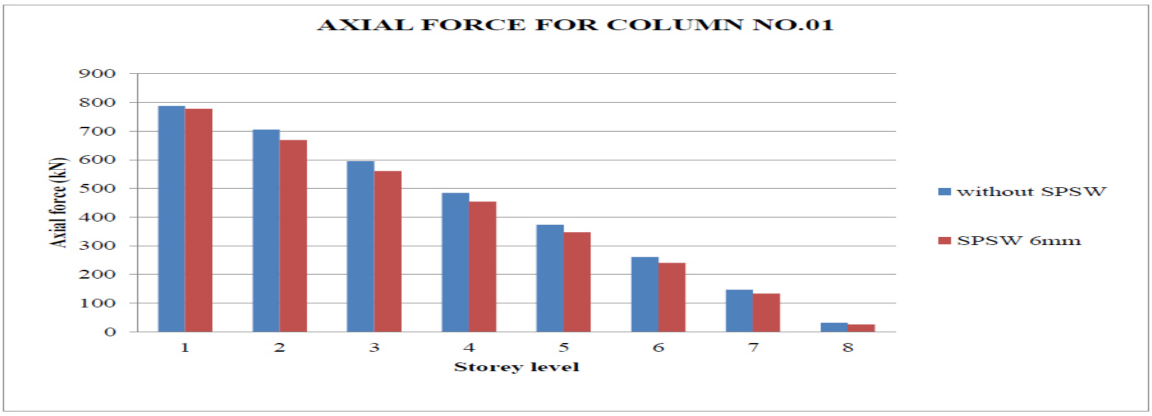

Fig 5.4 Axial Force

5.1 Effect of varying thickness of SPSW:

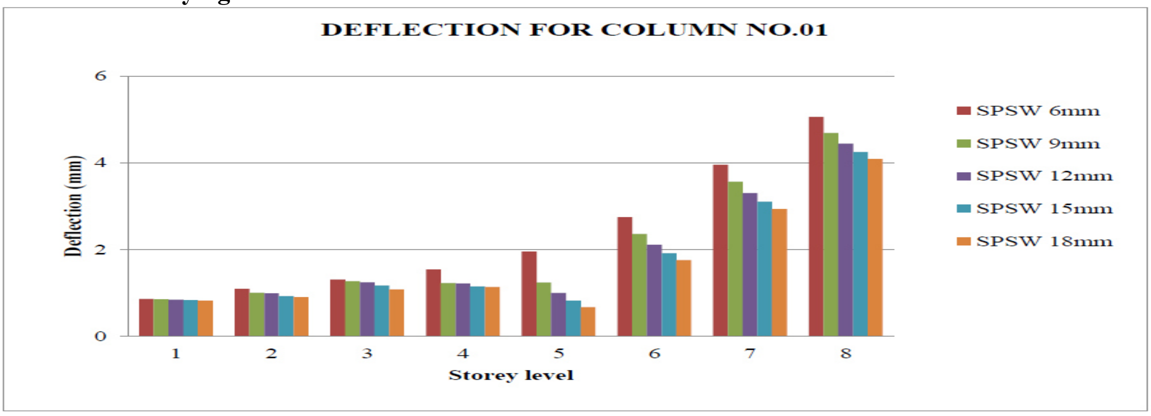

Fig 5.5 Deflection

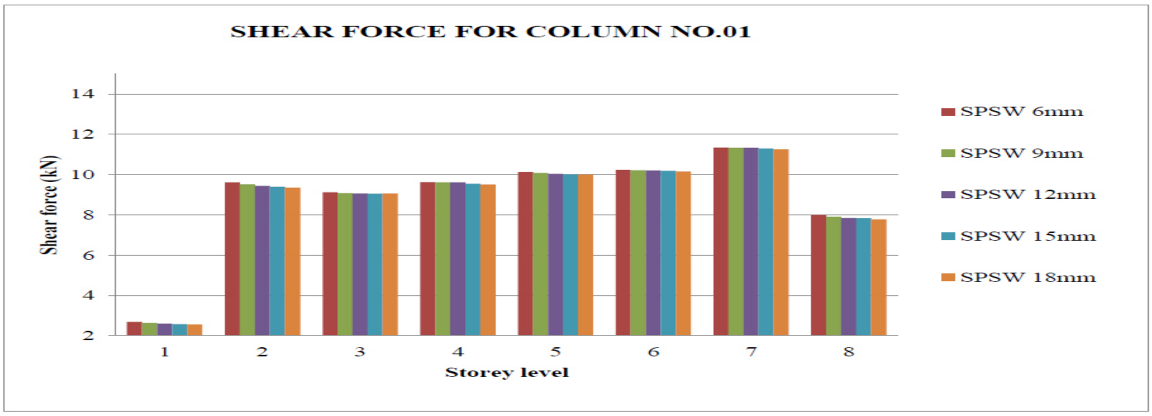

Fig 5.6 Shear Force

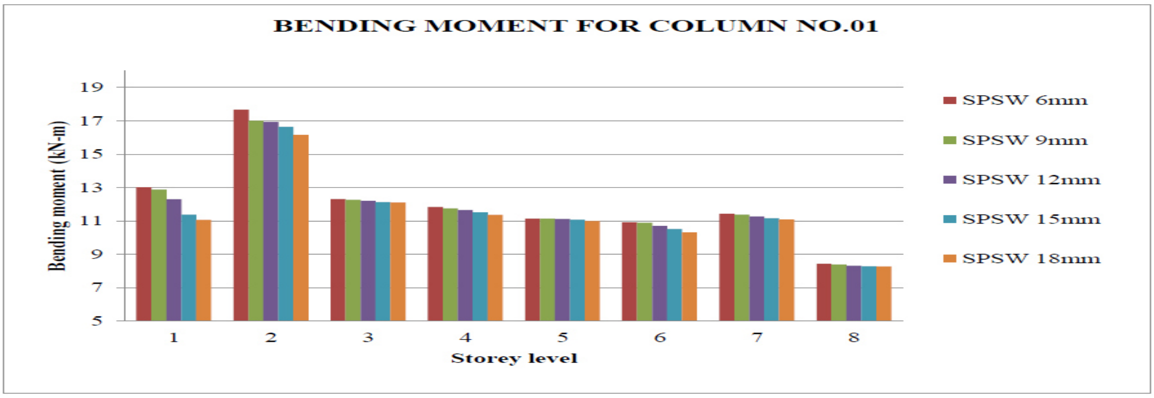

Fig 5.7 Bending Moment

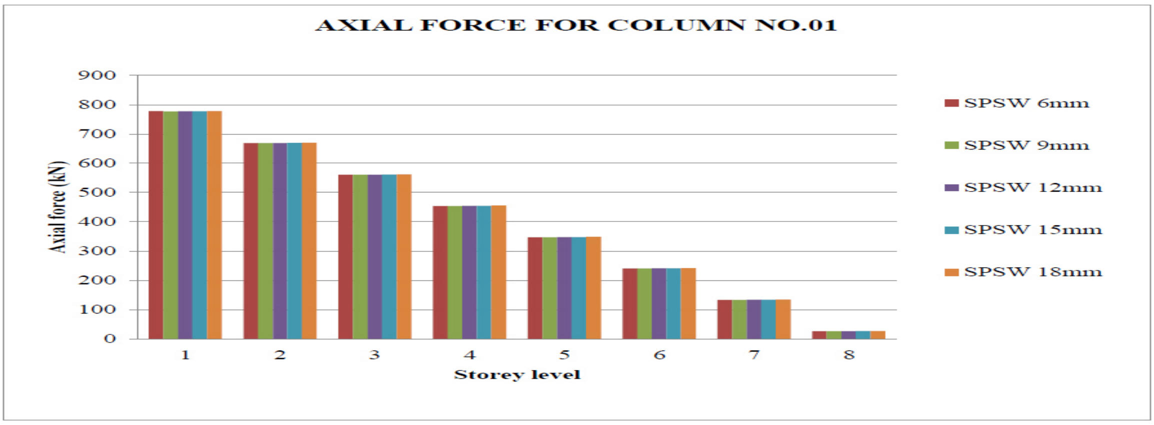

Fig 5.8 Axial Force

6. Conclusion

1. From results it is concluded that steel frame building with SPSW has lesser deflection, shear force, bending moment and axial force values compared to steel frame building without SPSW.
2. It is found that as the thickness of the steel plate shear wall increases deflection, shear force, bending moment and axial force decreases.
3. From results of present study conclude that steel plate shear walls have a large effect on the behavior of frames under earthquake excitation. In general, infill steel plate shear wall increases stiffness of the structure.
4. Steel plate shear wall occupy much less space due to relatively small thickness of SPSW compared to reinforced concrete shear walls and aesthetic good from architectural point of view. Therefore steel plate shear walls are preferred over reinforced concreted shear wall.

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