Analysis of Steel Frame Building With Steel Plate Shear Wall

Manoj B Poojar [1], Mamata B Mogali [2]
[1]Dept of Civil Engineering
[2]Assistant Professor, Dept of Civil Engineering
[1, 2]SDM College of Engineering and Technology Dharwad-580002

Abstract- *Now a day's Steel Structures are commonly used in construction field and are very important in strength considerations. The Steel plate shear wall is a lateral load resisting system. In High-rise structures with steel plate shear wall is very effective in earthquake forces. In this study, High-rise steel structure of (G+15) are analysed with and without SPSW and considering the varying thickness of plate are used, they are 8mm, 16mm, 24mm, 25mm, 26mm, 27mm, 28mm, 29mm, 30mm and 35mm. These models are analysed in software ETABS especially for linear static analysis and non-linear static analysis (Push over analysis) for 5thearthquake zone and medium soil type is adopted for an analysis purpose. The analysis results are maximum storey displacement, maximum storey drift, storey shear and storey stiffness. The SPSW has high strength than the normal conventional building. The lateral forces are transferred to the foundation because of these reason, structural members get increased in conventional building system but in SPSW system are greatly reduced. For steel structure IS-800-2007, for earthquake analysis IS-1893-2002 code books are used.*

Keywords- SPSW, Steel Frame Building, Varying Thickness of SPSW, Linear Static, Non-Linear Static analysis.

I. INTRODUCTION

In RCC Structures as the height of the building increases, the requirements for stiffness and stability increases due to the lateral loads and vertical loads and it becomes more important because there will be increase in the dimensions of the elements due to heavy load in the high rise buildings. The Steel Structures are more subsequently used now a day. The High-rise steel structures are designed without shear wall, the structural parts become little heavy but with shear wall, the structural parts like beams and column sizes are reduced and also load carrying capacity is increased.

Steel plate shear wall: The main aim of steel plate shear wall is to resist lateral loads. This system is very ductile. This system has large stiffness and it limits the storey drift. The steel plate shear wall is lighter as compared to the concrete shear walls and hence results in lower weight and the loads transferred to foundation is less; due to this reduction in the total weight of the structure. The speed of the work increases due to the use of welding and bolted connections and hence reduces the construction cost and time their increases the quality of work in the system and hence work progress is efficient. As compare to the concrete shear walls, the steel plate shear wall has relatively less thickness and requires less space hence utilization of room space increases.

II. METHODOLOGY

1. The steel framed structure of G+15 is taken into consideration.
2. The modelling is carried out by the Software ETABS.
3. The analysis is carried out using linear static and non-linear static techniques for varying plate thickness.
4. Parametric studies are done for maximum storey displacement, max storey drift, storey shear and storey stiffness for the above results obtained.

III. ANALYSIS PROBLEM

The parameters considered for the analysis as shown in below table.

Table-3.0 Parameters considered for Analysis

Sl.No.	Parameter	Value
1.	Number of Storey	G+15
2.	Seismic Zone	V
3.	Zone Factor	0.36
4.	Floor Area	3600 Sq ft
5.	Height of Building	44.2
6.	Each Floor Height	3.05m
7.	Column Section	ISHB 400-1 Double
8.	Beam Section	ISMB 600
9.	Slab	150mm
10.	Shear Wall	Steel Plate Shear Wall
11.	Live Load	4 kN/m^2
12.	Floor Finish	1 kN/m^2
13.	Grade of Concrete	M30
14.	Grade of Steel	Fe345
15.	Unit Weight of Masonry	20 kN/m^3
16.	Seismic Analysis	IS 1893:2002
17.	Design Philosophy	IS: 800-2007

Load Combinations:

The loads are to be taken for the analysis as per the IS: 800-2007 and IS: 1893(part-1)-2002. The following load combination is as follows.

For Deflection:

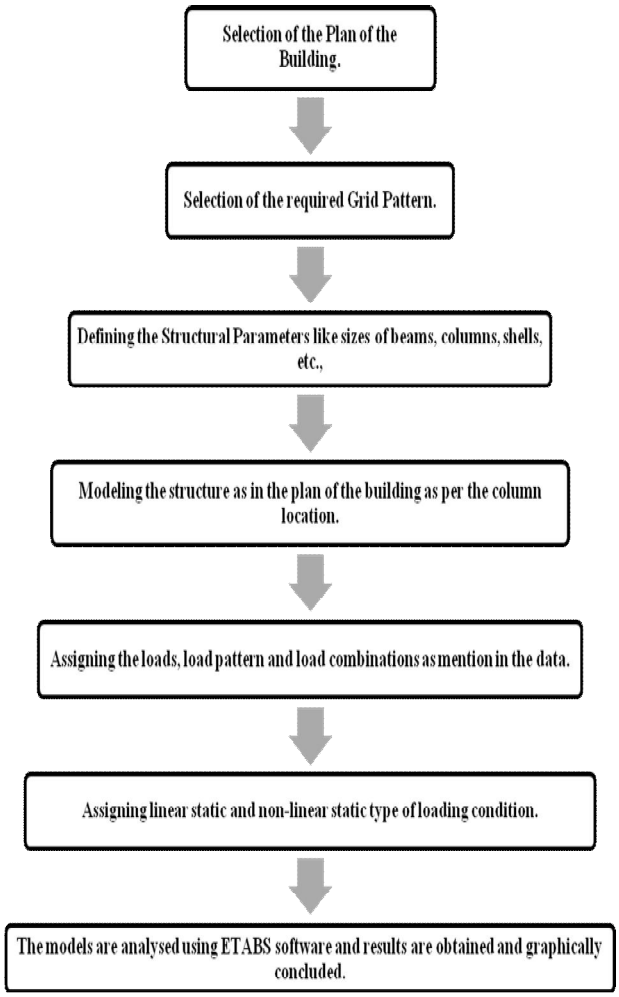
1. (DL + S-Dead)
2. (DL + LL + S-Dead)

For Strength:

3. 1.5 (DL + S-Dead)
4. 1.5 (DL + LL + S-Dead)
5. 1.2 (DL + LL + S-Dead + E-X)
6. 1.2 (DL + LL + S-Dead - E-X)
7. 1.2 (DL + LL + S-Dead + E-Y)
8. 1.2 (DL + LL + S-Dead - E-Y)
9. 1.5 (DL + S-Dead + E-X)
10. 1.5 (DL + S-Dead - E-X)
11. 1.5 (DL + S-Dead + E-Y)
12. 1.5 (DL + S-Dead - E-Y)
13. 0.9 (DL + S-Dead) + (1.5 E-X)
14. 0.9 (DL + S-Dead) - (1.5 E-X)
15. 0.9 (DL + S-Dead) + (1.5 E-Y)
16. 0.9 (DL + S-Dead) - (1.5 E-Y)

Procedure for Structural Analysis Using ETABS:

Modelling and analysis of the building is done in ETABS Software with the following steps:



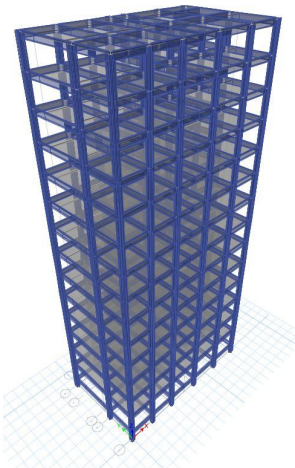


Fig-3.1 Without Steel Plate

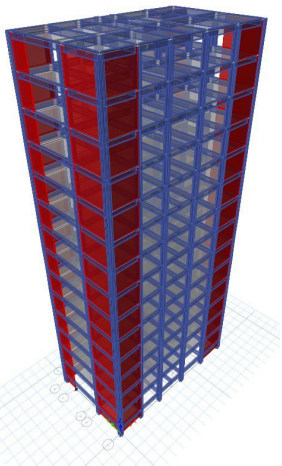


Fig-3.2 With Steel Plate of 25mm Thick

IV. RESULTS AND DISCUSSION

Linear static analysis

Maximum storey displacement:

Table-4.0 Percentage Reduction for Maximum Storey Displacement

Type of SPSW	Max Storey Displacement (mm)	Percentage Reduction
Without Steel Plate	42.512	
8 mm Steel Plate	29.807	29.88%
16 mm Steel Plate	28.489	32.98%
24 mm Steel Plate	28.045	34.03%
25 mm Steel Plate	28.013	34.10%
26 mm Steel Plate	27.984	34.17%
27 mm Steel Plate	27.957	34.23%
28 mm Steel Plate	27.934	34.29%
29 mm Steel Plate	27.912	34.34%
30 mm Steel Plate	27.892	34.39%
35 mm Steel Plate	27.818	34.56%

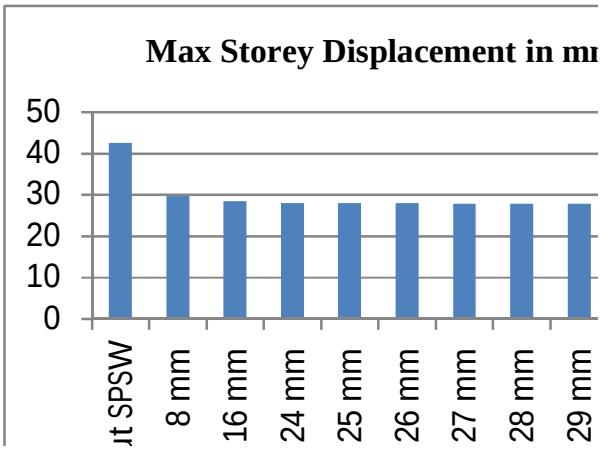


Fig-4.0 Maximum Storey Displacement in mm

DISCUSSION: As the thickness of the plate increases the maximum storey displacement decreases. From the above fig-4.0 and table-4.0, the percentage reduction for 35mm thick steel plate is 34.56%.

Maximum storey drift:

Table-4.1 Percentage Reduction for Max Storey Drift

Type of SPSW	Max Storey Drift (mm)	Percentage Reduction
Without Steel Plate	0.001246	
8 mm Steel Plate	0.000344	72.39%
16 mm Steel Plate	0.000286	77.04%
24 mm Steel Plate	0.000262	78.97%
25 mm Steel Plate	0.000259	79.21%
26 mm Steel Plate	0.000257	79.37%
27 mm Steel Plate	0.000255	79.53%
28 mm Steel Plate	0.000253	79.69%
29 mm Steel Plate	0.000252	79.77%
30 mm Steel Plate	0.000250	79.93%
35 mm Steel Plate	0.000242	80.57%

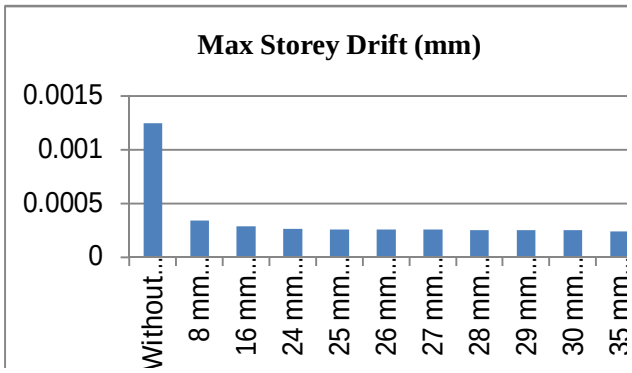


Fig-4.1 Max Storey Drift in mm

DISCUSSION: As the thickness of the plate increases the maximum storey drift decreases. From the above fig-4.1 and table-4.1, the percentage reduction for 35mm thick steel plate is 80.57%.

Storey shear:

Table-4.2 Percentage Reduction for Storey Shear

Type of SPSW	Storey Shear (kN)	Percentage Reduction
Without Steel Plate	2005.3520	
8 mm Steel Plate	1930.5041	3.73%
16 mm Steel Plate	1915.1100	4.50%
24 mm Steel Plate	1899.5506	5.27%
25 mm Steel Plate	1883.8135	6.06%
26 mm Steel Plate	1867.8850	6.85%
27 mm Steel Plate	1851.7494	7.65%
28 mm Steel Plate	1835.3896	8.47%
29 mm Steel Plate	1693.3991	15.55%
30 mm Steel Plate	1510.9115	24.65%
35 mm Steel Plate	940.9763	53.07%

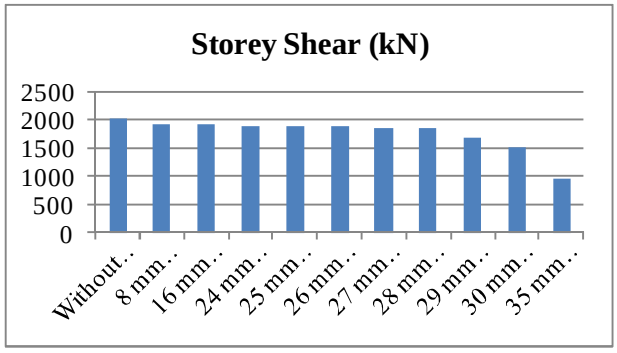


Fig-4.2 Storey Shear in Kn

DISCUSSION: As the thickness of the plate increases the storey shear decreases. From the above fig-4.2 and table-4.2, the percentage reduction for 35mm thick steel plate is 53.07%.

Storey stiffness:

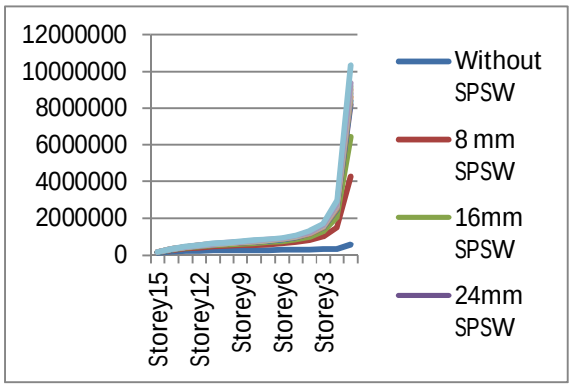


Fig-4.3 Storey Stiffness in kN/m

DISCUSSION: As the thickness of the plate increases the storey stiffness increases as shown in fig-4.3.

Base shear:

Table-4.3 Percentage Reduction for Base Shear

Type of SPSW	Base Shear (kN)
Without Steel Plate	627.3176
8 mm Steel Plate	1007.2744
16 mm Steel Plate	1128.9328
24 mm Steel Plate	1223.5931
25 mm Steel Plate	1234.4996
26 mm Steel Plate	1245.2566
27 mm Steel Plate	1255.8757
28 mm Steel Plate	1266.3671
29 mm Steel Plate	1276.74
30 mm Steel Plate	1287.0027
35 mm Steel Plate	1336.9014

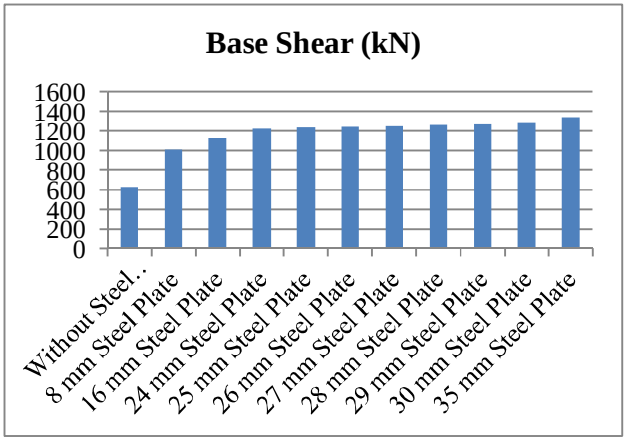


Fig-4.4 Base Shear in kN

DISCUSSION: As the thickness of the plate increases the base shear increases as shown in table-4.3.

PUSH OVER ANALYSIS

Maximum storey displacement:

Table-4.4 Percentage Reduction for Maximum Storey Displacement

Type of SPSW	Max Storey Displacement (mm)	Percentage Reduction
Without Steel Plate	42.321	
8 mm Steel Plate	29.637	29.97%
16 mm Steel Plate	28.322	33.07%
24 mm Steel Plate	27.881	34.12%
25 mm Steel Plate	27.849	34.19%
26 mm Steel Plate	27.820	34.26%
27 mm Steel Plate	27.794	34.32%
28 mm Steel Plate	27.771	34.38%
29 mm Steel Plate	27.750	34.43%
30 mm Steel Plate	27.731	34.47%
35 mm Steel Plate	27.659	34.64%

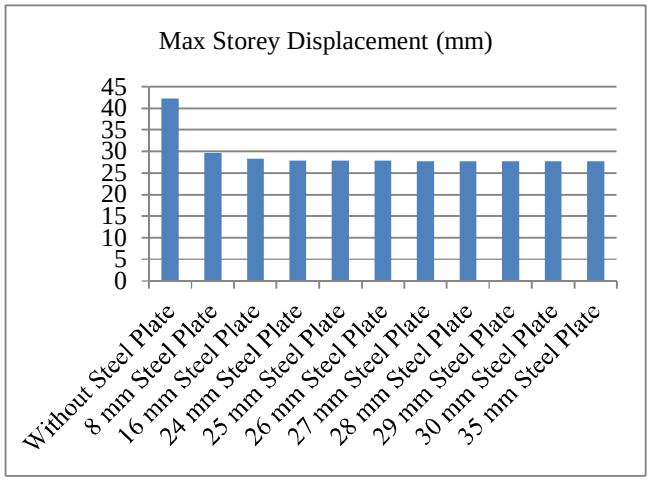


Fig-4.5 Maximum storey displacement in mm

DISCUSSION: As the thickness of the plate increases the maximum storey displacement decreases. From the above fig-4.5 and table-4.4, the percentage reduction for 35mm thick steel plate is 34.64%.

Maximum storey drift:

Table-4.5 Percentage Reduction for Max Storey Drift

Type of SPSW	Max Storey Drift (mm)	Percentage Reduction
Without Steel Plate	0.001247	
8 mm Steel Plate	0.000345	72.39%
16 mm Steel Plate	0.000288	76.96%
24 mm Steel Plate	0.000264	78.89%
25 mm Steel Plate	0.000261	79.13%
26 mm Steel Plate	0.000259	79.29%
27 mm Steel Plate	0.000257	79.45%
28 mm Steel Plate	0.000255	79.61%
29 mm Steel Plate	0.000253	79.77%
30 mm Steel Plate	0.000252	79.85%
35 mm Steel Plate	0.000244	80.49%

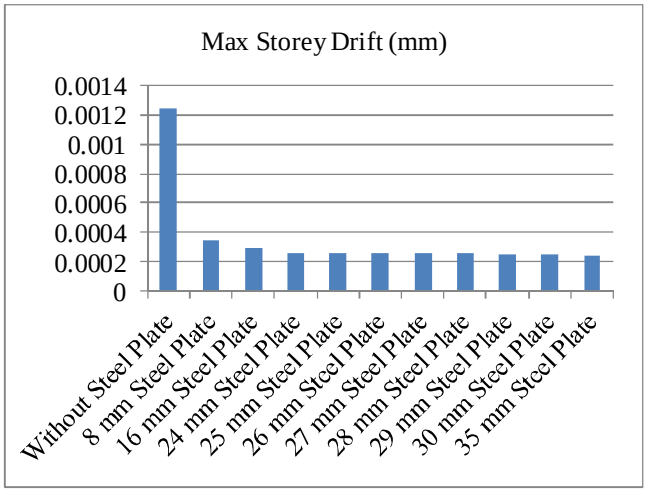


Fig-4.6 Max Storey Drift in mm

DISCUSSION: As the thickness of the plate increases the maximum storey drift decreases. From the above fig-4.6 and table-4.5, the percentage reduction for 35mm thick steel plate is 80.49%.

Storey shear:

Table-4.6 Percentage Reduction for Storey Shear

Type of SPSW	Storey Shear (kN)	Percentage Reduction
Without Steel Plate	2013.8828	
8 mm Steel Plate	1938.7900	3.72%
16 mm Steel Plate	1923.3426	4.49%
24 mm Steel Plate	1907.7283	5.27%
25 mm Steel Plate	1891.9345	6.05%
26 mm Steel Plate	1875.9473	6.85%
27 mm Steel Plate	1859.7511	7.65%
28 mm Steel Plate	1843.3284	8.46%
29 mm Steel Plate	1700.7291	15.54%
30 mm Steel Plate	1517.2799	24.65%
35 mm Steel Plate	945.6871	53.04%

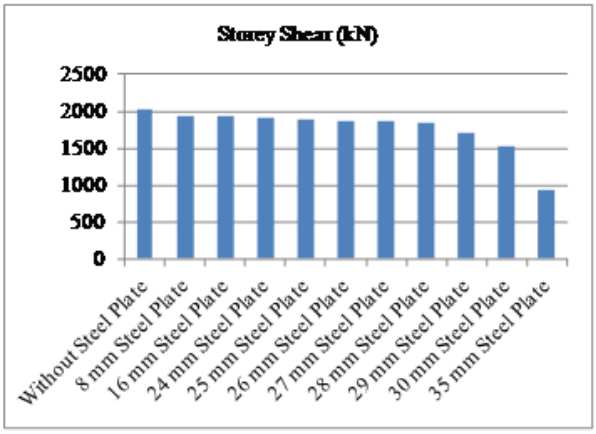


Fig-4.7 Storey Shear in Kn

DISCUSSION: As the thickness of the plate increases the storey shear decreases. From the above fig-4.7 and table-4.6, the percentage reduction for 35mm thick steel plate is 53.04%.

Storey Stiffness:

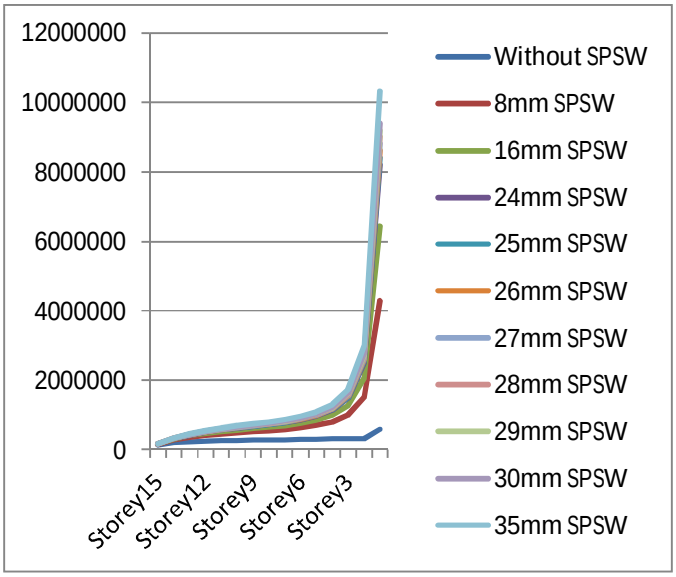


Fig-4.8 Storey Stiffness in kN/m

DISCUSSION: As the thickness of the plate increases the storey stiffness increases as shown in fig-4.8.

Base shear:

Table-4.7 Percentage Reduction for Base Shear

Type of SPSW	Base Shear (kN)
Without Steel Plate	630.4581
8 mm Steel Plate	1011.5199
16 mm Steel Plate	1133.8194
24 mm Steel Plate	1228.8856
25 mm Steel Plate	1239.834
26 mm Steel Plate	1250.6315
27 mm Steel Plate	1261.2897
28 mm Steel Plate	1271.8189
29 mm Steel Plate	1282.2284
30 mm Steel Plate	1292.5267
35 mm Steel Plate	1342.5885

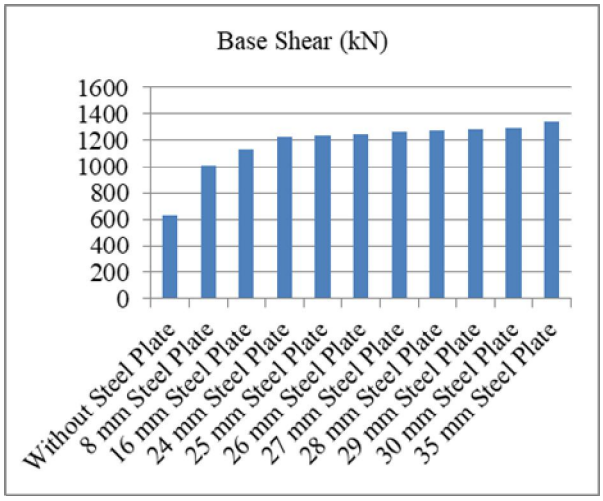


Fig-4.9 Base Shear in kN

DISCUSSION: As the thickness of the plate increases the base shear increases as shown in table-4.7.

V. CONCLUSIONS

From the linear static and non-linear static analysis results, it is concluded that

1. At the top storey the displacement is maximum and decreases with increase in the thickness of the steel plate shear wall.
2. Maximum storey drift is maximum at 1st storey for all the thickness of steel plate and decreases with increase in the thickness of steel plate.
3. Storey shear is maximum at 1st storey for all the thickness of steel plate and decreases with increase in the thickness of steel plate and remains zero at the base.
4. Stiffness of the structure increases with increase in the thickness of the steel plate.

REFERENCES

[1] Prof. Prashant Topalkatti, Prabhu M. Kinagi, "Parametric Study of Steel Frame Building with and Without Steel Plate Shear Wall", Civil and Environmental Research, ISSN 2224-5790 (Paper), ISSN 2225-0514 (Online), Vol. 6, No. 10, 2014.

[2] Anjana R.K. Unnithan, Dr. S. Karthiyaini, "Design and Analysis of High Rise Building with Steel Plate Shear Wall", International Journal of Civil Engineering and Technology (IJCIET) ISSN Print: 0976-6308 and ISSN Online: 0976-6316, Vol. 8, Issue 4, April 2017.

[3] Ms. Deepika C. Hiwrale, Prof. P.S. Pajgade, "Analysis and Design of steel framed building with and without steel plate shear walls", International Journal of Scientific and Engineering Research, ISSN 2229-5518, Vol. 3, Issue 6, June 2012.

[4] Vaobhao V. Maind, Prof. Mohd. Shahezad, "Review on Seismic Response of Multi-storied Steel Building by using Steel Plate Shear Wall and Steel Braced System", International Journal of Research in Engineering, Science and Technology(IJRESTs), ISSN 2395-6453(online), Vol. 1, No 8, Dec 2015.

[5] 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.

[6] Zirakian T, Boyajian D, "Recent Studies on Steel Plate Shear Wall Systems", Journal of Steel Structures &Construction, ISSN: 2472-0437, Volume 2, Issue 1, 1000e104.

[7] Bing Qu M.ASCE, Michel Bruneau M.ASCE, "Design of Steel Plate Shear Walls Considering Boundary Frame Moment Resisting Action", JOURNAL OF STRUCTURAL ENGINEERING © ASCE, DECEMBER 2009.

[8] Fatemeh Esfandi, Amin Honarbakhsh, "Nonlinear Dynamic Analysis Of The Steel Shear Walls Affected By An Earthquake In The Near And Far Area To Retrofit The Metal Buildings",Scinzer Journal of Engineering, ISSN 2415-105X, Vol 3, Issue 2, 2017.

[9] S. P. Sharma, J. P. Bhandari, "Literature Review on the Seismic Performance of Multi-Storey Building with Different Locations of Shear Wall and Diagrid", International Journal of Science and Research (IJSR), ISSN (Online): 2319-7064, Volume 6 Issue 6, June 2017.

[10] Mr. Rohit V. Mashalkar, Mrs. Trupti Narkhede, "Review on Dynamic Evaluation of Wind and Earthquake Forces Resisting Systems for Tall Building", International Journal of Science Technology & Engineering, ISSN (online): 2349-784X, Volume 3, Issue 08, February 2017.

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

[12] IS 1893(part 1):2002, Indian Standard, "Criteria for Earthquake Resistant Design of Structures", General Provisions and Buildings (Fifth Revision).

[13] IS 1893(part 2):1987, Code of Practice for Design Loads (other than earthquake) for buildings and structure, Part 2, imposed loads (second revision).