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ANALYSIS OF MULTI-STORIED BUILDINGS WITH STEEL PLATE SHEAR WALL

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Abstract: In current century, most of the multistory construction project is going through financial crisis. In majority, this problem arises due to huge earthquake resistance structural technique adopted in the framing system. As a result, the consumption of conventional construction material like concrete and steel goes on increasing day by day in the structures. On the other hand time delay is the key factor that will affect overall growth of such project. Hence in order to overcome these constraints, economical construction methodology and optimization techniques should be used. Hence the aim of present study is to compare seismic performance of 8 storey & 16 storey multistoried buildings with shear wall situated in earthquake zone III. Seismic coefficient method is used for seismic analysis. The analysis has been done with reinforced concrete shear wall and steel plate shear and results are compared. RC shear wall is changed with Steel plate shear wall for all building models. This study concludes that changing the position of shear wall of reinforced concrete with steel plate in buildings is economical. The response of multistoried structure is very good with the provision of steel plate shear wall in the building. Also alteration in thickness of steel plate gives effective results for various locations of shear wall. There is reduction in axial force and bending moment in columns by 20 % for 20 mm thick steel plate and by 35% for 50 mm steel plate as compared to RC shear wall with shear wall at central location. The displacement in top column is reduced by 15 % in case of 20 mm thick steel plate shear wall where as 45% reduction in case of 50 mm SPSW. As thickness of steel plate increases the displacement reduces but base shear increases.

Index Terms **- Steel plate shear wall (SPSW), Seismic Response, Economy, STAAD Pro.**

I. INTRODUCTION

Reinforced concrete multi-storey building is adequate for resisting both the vertical and horizontal load. When such building is designed without steel plate shear wall, the beam and column sizes are quite heavy, steel quantity is also required in large amount. Thus, 2 there is lot of congestion at these joints and it is difficult to place and vibrate concrete at these places and displacement is quite heavy and which induces heavy forces in member. The building with steel plate shear wall and greater lateral load resisting capacity, uniformly distributed mass and stiffness in plan as well as in elevation suffer much less damage compared to building without steel plate shear wall or any lateral load resisting system. But now days need and damage of latest generation and growing population has made the architect or engineer in inevitable towards planning of different type of soil. Hence earthquake engineering has developed the key issues in understanding the role of behavior of different type of building on different type of soil conditions.

An introduction of steel plate shear wall represents structurally sufficient solution to stiffen a building structural system, because the main function of steel plate shear wall is to increase rigidity for lateral load resistance. Steel plate shear wall allows less structural wall thickness in comparison to the thickness of concrete shear wall. The study of project indicated the average wall thickness, including the furring, of 18 inch these result in saving approximately 2%in gross square footage. Steel plate shear wall results in lesser building weight in comparison to building that uses concrete shear wall .A study perform for the project indicate that total weight of building as design using SPSW was approximately 18%less than that of building design using concrete shear wall core system, which results in reduction of foundation load due to gravity and overall building seismic load. The use of SPSW system reduces the construction time not only it is fast to erect, but there also is number curing period reduction.

II. LITERATURE REVIEW

A lot of investigators have been worked on the seismic response of multistoried buildings with steel plate shear wall, (SPSW). Some of them are mentioned below:-

Vijit Sahu, Dr. G.P. Khare, Mr. Dushyant Kumar Sahu(2018)-In this project main aim was to compare the effect of shear wall at different location of multi-storey frame. And the parameters for the comparison were storey drift, base shear, maximum nodal displacement and maximum nodal reaction. It has been found that the storey drift increases with increase in number of storeys. Storey drift decreases with the provision of shear walls.

Mr. Archin A Shah, MS. Megha Thomas. Dr.V .R. Patel(2017) Steel plate shear wall is a Special Structural System which is used to resist the lateral load but its use in construction is limited to an extent compared to R.C.C shear wall. The steel plate shear wall system consists of Vertical steel plate which is connected to the Horizontal Boundary element (HBE) and Vertical Boundary element (VBE). SPSWs have high elastic stiffness, large displacement ductility, and stable hysteretic behavior and high energy dissipating capacity.

III METHODOLOGY

The high-rise buildings are different in shape, height and functions. This makes each building characteristics different form each other's. There are some standards for each kind of high rise buildings, such as residential, official and commercial. However, for model designing, main factor such as floor shape, floor height and column section were considered. Building with 8 Storey having same floor plan of 22m X 13m dimensions were considered for this study. The floor height of the building was assumed as 3.1 meters for all floors. Mostly in apartment buildings, floor plan will be same for all floors. So the building was considered with same floor plan in all floors having shear walls at different location. The detailed features of building given in table no 1. The following methodology will be adopted for this work.

IV PROBLEM STATEMENT

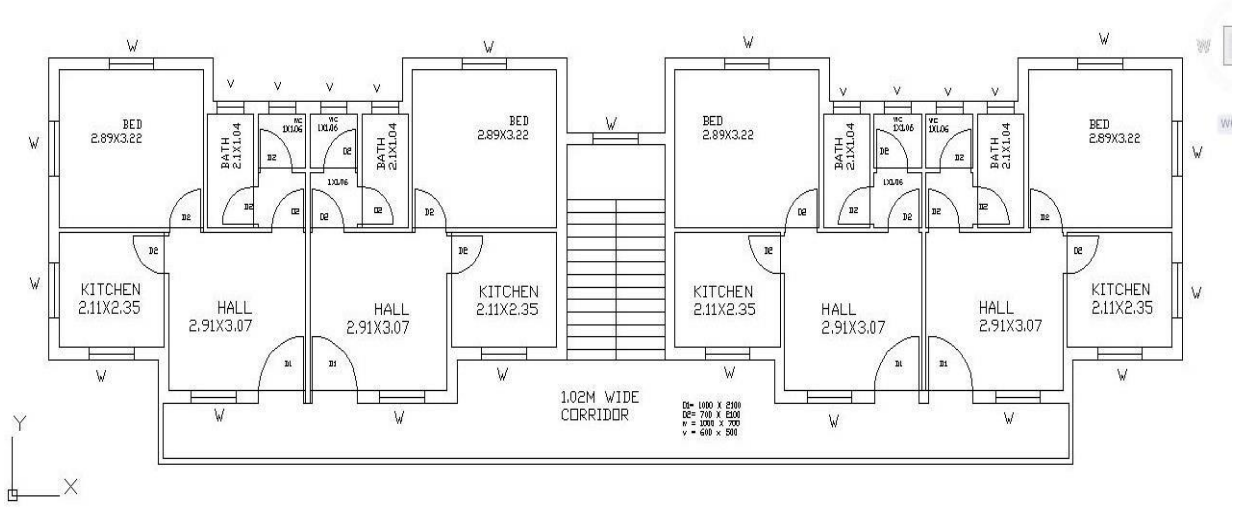
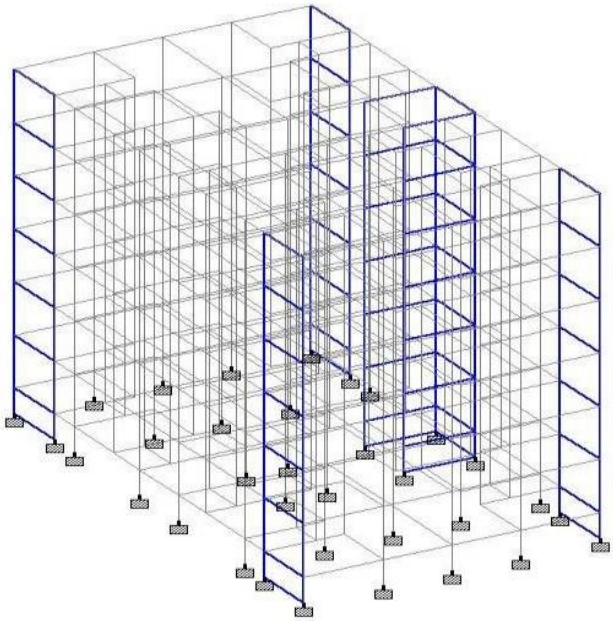


Figure 1 : Plan of Building

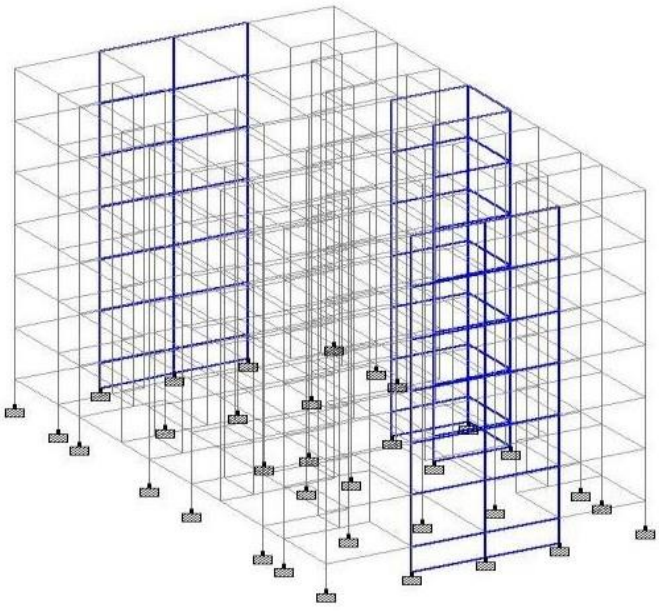
Table 1– Detailed Features of Building

Sr no.	Parameters	Values
1	Residential apartment	
2	Height of storey	3.1
3	Density of concrete	25 KN/m^3
4	Poisson ratio	0.2
5	Density of brick masonry	20 KN/m^3
6	Damping	5%
7	Seismic zone	III
8	Importance factor	1.5
9	Response reduction factor	5
10	Foundation soil	Hard
11	Size of beam	300X450mm
12	Size of column	300X600mm
13	Thickness of walls	0.230m
14	Thickness of slab	0.150m
15	Thickness of shear wall	0.23m
16	Thickness of steel plate shear wall	0.150m
17	Earthquake load	As per IS-1893-2002 Part-I
18	Live load	3 KN/m^2

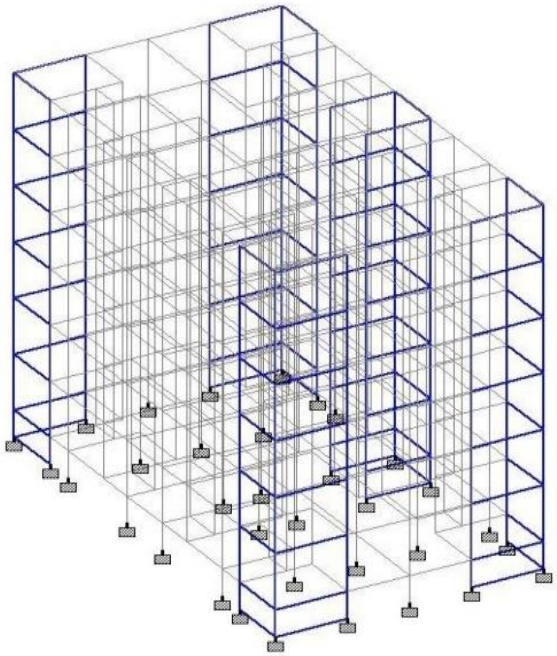
Figure 2: Building Plan in STAAD Pro.



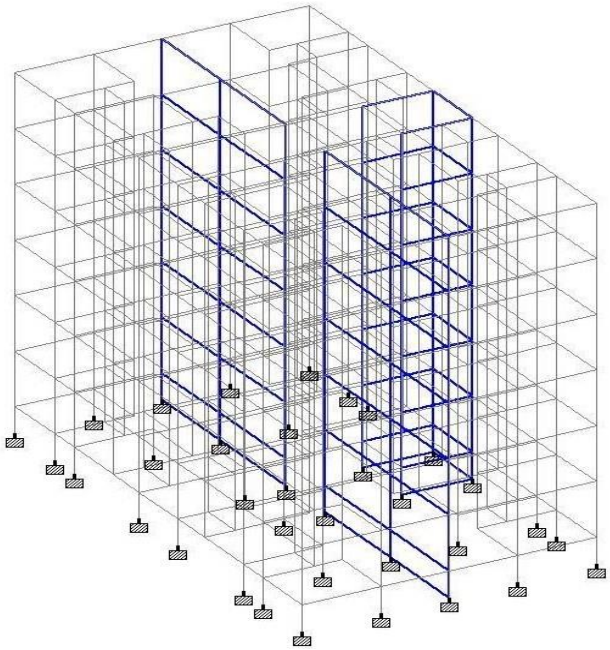
(a) SPSW at Z-Direction with Core



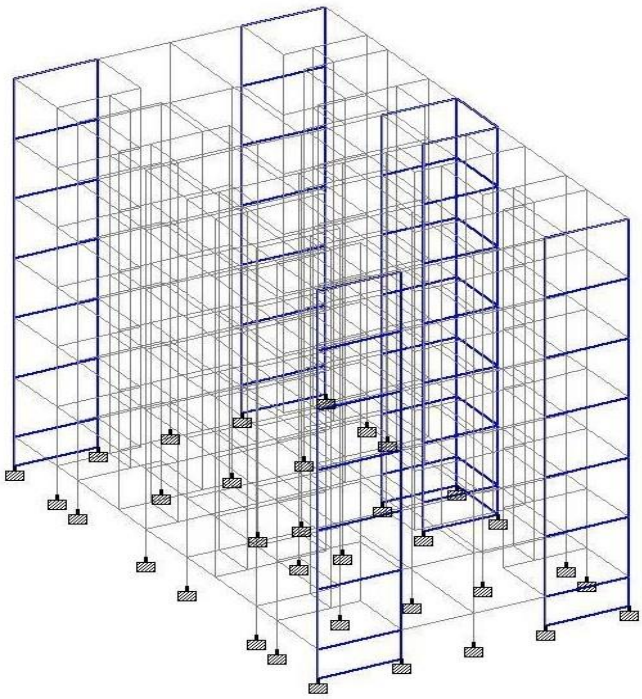
(b) SPSW in Z-dir. central wall with Core



(c) SPSW at Corner (L Shape) with Core



(d) SPSW at Central wall with Core



(e) SPSW at Z-Direction with Core

Figure 3: Various positions of SPSW in Building

Figure 1 shows the plan of building considered for analysis and figure 2 shows the various positions of steel plate shear wall in the building STAAD Pro. The steel plate shear wall is provided at various locations as specified earlier with variations in thickness of plate from 20 mm to 50 mm. The results have been presented in section 5 for all locations of SPSW with variations in thickness for (G+7) and (G+15) structure with the same plan. A variation in thickness of steel plates is used to achieve an economy.

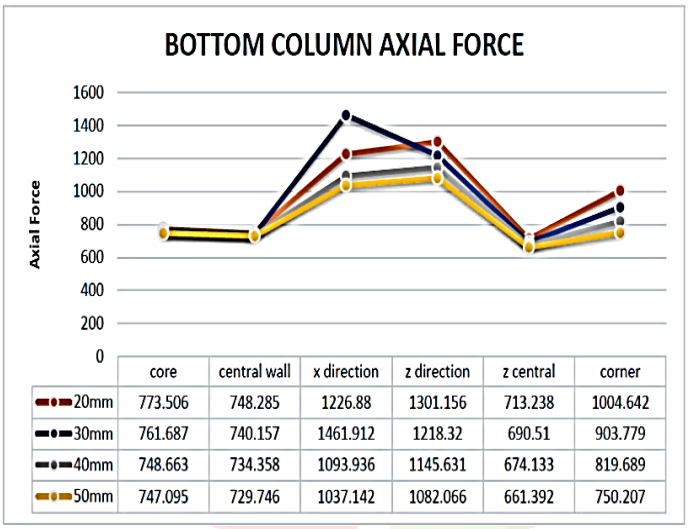
Table 2– Various Thickness of Steel Plate for G+7 & G+15 Structure

No.	Plate thickness (mm)
1	20
2	30
3	40
4	50

The structure with SPSW at all locations with various thicknesses of steel plate is analyzed and the various parameters like axial forces in columns, storey displacements and base shear have studied. The comparison between all models has been done for optimum results.

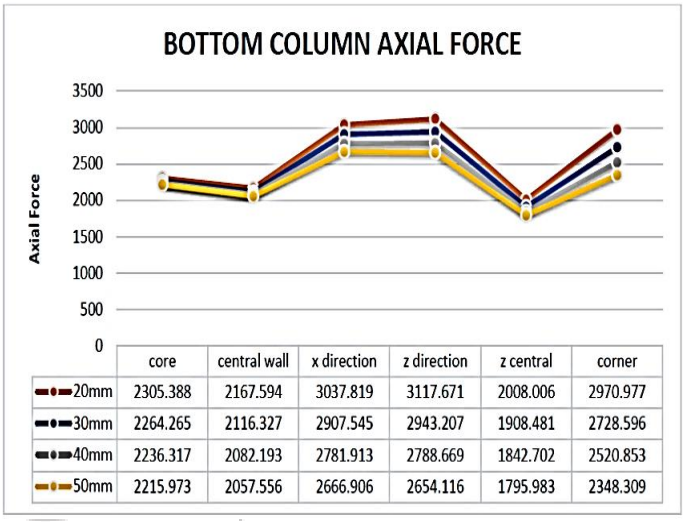
V RESULTS:

After analyzing the structure by STAAD Pro. software, the comparative study of SPSW with various thickness at various positions of (G+7) and (G+15) building. The design parameters such as Axial force in columns, Displacements, Base shear, etc. have been studied for SPSW.



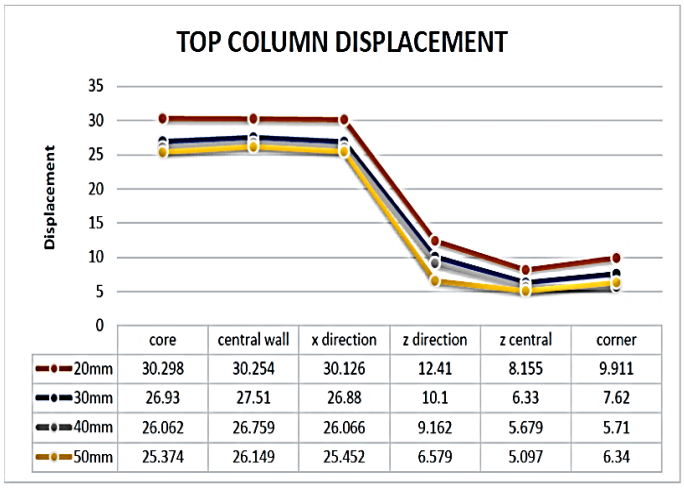
	core	central wall	x direction	z direction	z central	corner
20mm	773.506	748.285	1226.88	1301.156	713.238	1004.642
30mm	761.687	740.157	1461.912	1218.32	690.51	903.779
40mm	748.663	734.358	1093.936	1145.631	674.133	819.689
50mm	747.095	729.746	1037.142	1082.066	661.392	750.207

Figure 4: Bottom Column Axial Force for (G+7) Structure



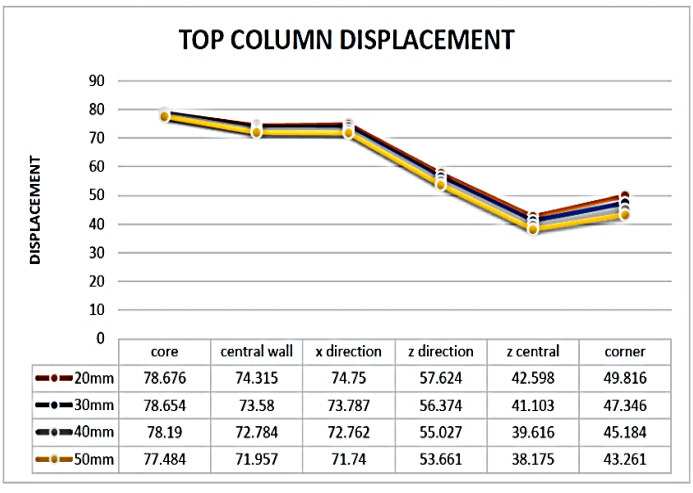
	core	central wall	x direction	z direction	z central	corner
20mm	2305.388	2167.594	3037.819	3117.671	2008.006	2970.977
30mm	2264.265	2116.327	2907.545	2943.207	1908.481	2728.596
40mm	2236.317	2082.193	2781.913	2788.669	1842.702	2520.853
50mm	2215.973	2057.556	2666.906	2654.116	1795.983	2348.309

Figure 5: Bottom Column Axial Force for (G+15) Structure



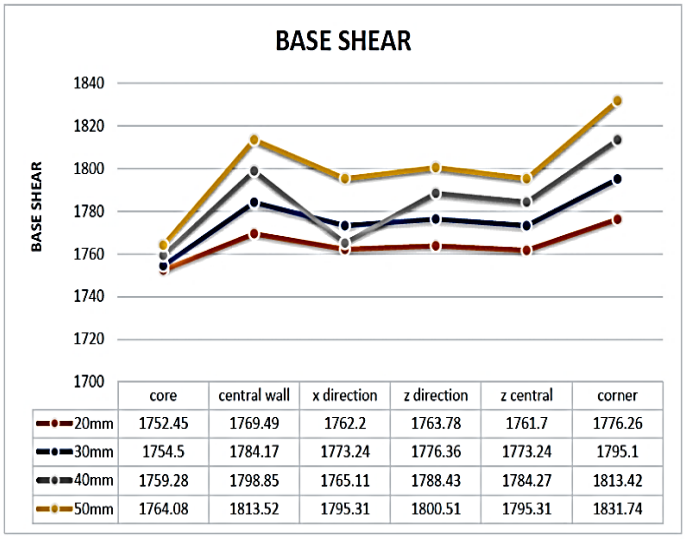
	core	central wall	x direction	z direction	z central	corner
20mm	30.298	30.254	30.126	12.41	8.155	9.911
30mm	26.93	27.51	26.88	10.1	6.33	7.62
40mm	26.062	26.759	26.066	9.162	5.679	5.71
50mm	25.374	26.149	25.452	6.579	5.097	6.34

Figure 6: Top Column Displacement for (G+7) Structure



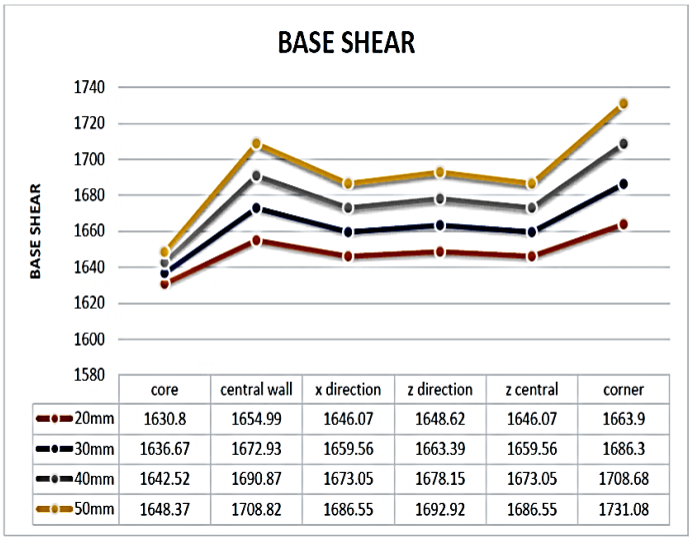
	core	central wall	x direction	z direction	z central	corner
20mm	78.676	74.315	74.75	57.624	42.598	49.816
30mm	78.654	73.58	73.787	56.374	41.103	47.346
40mm	78.19	72.784	72.762	55.027	39.616	45.184
50mm	77.484	71.957	71.74	53.661	38.175	43.261

Figure 7: Top Column Displacement for (G+15) Structure



	core	central wall	x direction	z direction	z central	corner
20mm	1752.45	1769.49	1762.2	1763.78	1761.7	1776.26
30mm	1754.5	1784.17	1773.24	1776.36	1773.24	1795.1
40mm	1759.28	1798.85	1765.11	1788.43	1784.27	1813.42
50mm	1764.08	1813.52	1795.31	1800.51	1795.31	1831.74

Figure 8: Base Shear for (G+7) Structure



	core	central wall	x direction	z direction	z central	corner
20mm	1630.8	1654.99	1646.07	1648.62	1646.07	1663.9
30mm	1636.67	1672.93	1659.56	1663.39	1659.56	1686.3
40mm	1642.52	1690.87	1673.05	1678.15	1673.05	1708.68
50mm	1648.37	1708.82	1686.55	1692.92	1686.55	1731.08

Figure 9: Base Shear for (G+15) Structure

Concluding Remarks for G+15 Structure:

1. There is reduction in axial force in columns by 20 % for 20 mm thick steel plate and by 35% for 50 mm steel plate.
2. As thickness of steel plate increases the displacement reduces but base shear increases.

VI CONCLUSIONS

1. Presence of Steel Plate Shear Wall at corner (L shape) with core reduces axial forces in column as compared to other cases for larger thickness of wall.
2. The Steel Plate Shear Wall in z-direction at central wall with core reduces more displacement as compared to other cases.
3. The provision of steel plate shear wall at central wall location in Z direction is effective position of shear wall as compared to other positions.
4. In SPSW, axial force and displacement in column reduce by 20 % to 35 % as thickness of Steel Plate increases in all positions of shear wall.
5. Base shear increases as thickness of steel plate increases.
6. Due to relatively small thickness of SPSW, steel shear wall occupy much less space than equivalent reinforced concrete shear wall.
7. Steel plate shear walls also provide major stiffness against building drift for the hi- rise buildings.

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