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Comparative Study of RCC Building Considering Effect of Braced Wall Line

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***Abstract* – The effects of the introduction of steel plate shear walls in buildings, on the bending moments, the shear forces, axial loads of the beams and columns and the story drifts are mainly observed. This is because of the fact that the mechanism of shear resistance by the steel shear walls is entirely different than that of the RCC shear walls. Some multistory buildings with SPSWs are analyzed by the equivalent static method as given by the IS 1893 (Part 1): 2002. The strip model as suggested by the code of Canada and the researchers is used to model the steel shear wall using the popular FEA software, the SAP 2000. The strips in the strip model are modeled using the frame element.**

***Keywords* – Steel plate shear walls (SPSW); steel building; equivalent static method; IS-1893: 2002**

I.INTRODUCTION

As compared to the RCC the steel has got some important physical properties like the high strength per unit weight and ductility. The high yield and ultimate strength result in slender sections. Being ductile the steel structures give sufficient advance warning before failure by way of excessive deformations. These properties of steel are of very much vital in case of the seismic resistance design.

The ductility of steel is a unique property of steel that no other building material exhibits in quite the same way. Through ductility steel is able to undergo large deformations beyond the elastic limit without danger of fracture. Thus the ultimate capacity is far in excess of that estimated by the elastic design. These desirable properties of steel are made use of in the high rise structures by using steel as the structural elements.

In low, medium and high-rise structures the loads acting on the structures mainly consist of the gravity loads and the lateral loads. The gravity loads which include the self-weight of the structure and the part of the live load that remains constant. The lateral loads are due to wind, blast and earthquake etc. and are very severe due to earthquake. So the structure should have sufficient stiffness and strength laterally to perform satisfactorily to these occasional loads.

The structural system consists of horizontal framing system (beams and slab) and the other is the vertical framing system made of walls and columns. Horizontal system transfers the vertical loads and tensional loads to the vertical framing system, which is responsible for transfer of vertical loads and lateral loads to the footing.

1.1. Shear resistance by compact steel shear walls

In compact steel shear walls under the action of external shear force, shear stresses are generated as shown in the Fig. 4.1 below. Thus in-plane shear stresses are responsible for the external shear resistance. This nature of stresses is due to relatively higher thickness of the steel plate.

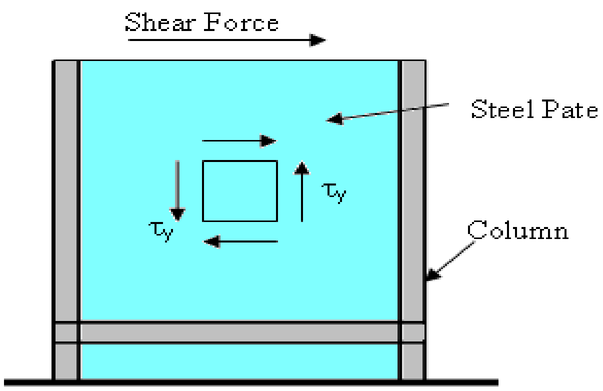

Fig.1. Shear resistance by Compact Shear Walls.

1.2. Shear resistance by thin, non-compact SPSWs

The beams and columns which constitute the steel plate shear wall system play an important role in the mechanism of shear resistance by SPSWs. Only the steel plate which is thin and slender is unable to resist the shear without the presence of the beams and columns. The beams, columns and the steel plate together form a system and assist in external shear resistance as shown in the following fig.

Due to the external shear force the frame tries to deform the way shown in the fig. but the steel plate being attached to the frame, does not allow the deformation because of the principal tensile stresses formed along one of the diagonal of the panel and the shear gets resisted. Being thin the plate has a small resistance against the diagonal compressive stresses along the other diagonal. So the plate buckles along that diagonal when a strong earthquake hits the structure.

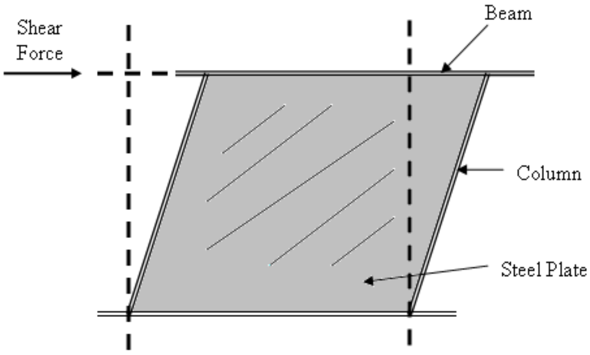

Fig.2. Shear resistance by thin steel shear walls.

But small buckling due to the normal wind loads etc are recoverable as the plate deformations are within elastic limit. As there are number of advantages in using the steel shear walls as mentioned, slight buckling of the steel plate has to be allowed.

II. EFFECT OF STEEL SHEAR WALLS

The mechanism of shear resistance and hence the behavior of steel plate shear walls is quite different from that of the RCC shear walls. This is because of the fact that the SPSW system consists of not only the steel plate but along with that the columns and the beams to which steel plate is connected. So the beams and columns affect the overall behavior of the SPSW and vice-versa.

The effect of the introduction of steel shear walls on the behavior of related different structural components, like beams and columns, a G+6 story building is analyzed for without and with steel shear wall conditions.

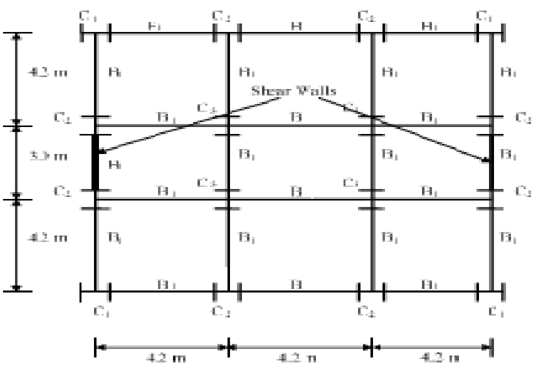

Fig.3. Plan of a G+6 story building with steel Shear walls

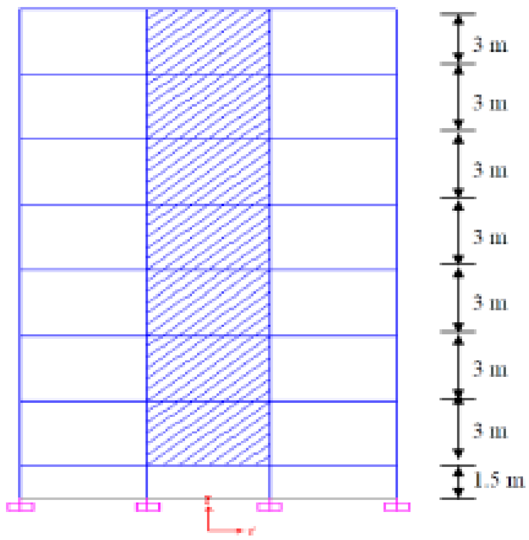

Fig.4. Elevation of a building frame with the steel shear walls.

III. DATA ASSUMED FOR THE STRUCTURE

The building considered having G+6 stories. Height of each storey is 3.0m. Steel plate shear wall for lateral Load resisting system. The building has plan dimensions 12.6mX11.4m for Figure 3. It is considered to be located in seismic zone IV. Thickness of slab is 150mm. The unit weights of brick masonry are taken as 19 KN/m3. Live load intensity is taken as 4KN/m2. Weight of floor finish is considered as 2.0 KN/m2. Type of soil is Medium soil. Response reduction factor 5.

Importance factor 1.5. Zone IV. Zone factor 0.24. Thickness of external and internal wall is 230 mm and 150 mm. Shear wall thicknesses for Figure 1 (Model 1) is 6mm. Total Length of shear wall is 6m. Total Length of beam in plan 96m. Total c/s area of columns in plan is 0.14m2.

Following are the load combinations as given in the IS1893 (Part1):2002 and are used here in the analysis of the structure.

- 1.7DL+1.7IL
- 1.7DL+1.7EL
- 1.7DL-1.7EL
- 1.3DL+1.3IL+1.3EL
- 1.3DL+1.3IL-1.3EL

Following table shows the calculation of the seismic weight of the building at different floor levels.

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Table.1.Calculation of seismic weight of the building

Level	Parapet Wall (kN)	Walls (kN)	Slab + FF (kN)	Beams (kN)	Columns (kN)	Live load (kN)	Total Load (kN)
Roof	232	487	682	60	14.8	0	1475
6	0	974	825	60	29.5	287	2176
5	0	974	825	60	29.5	287	2176
4	0	974	825	60	29.5	287	2176
3	0	974	825	60	29.5	287	2176
2	0	974	825	60	29.5	287	2176
1	0	974	825	60	29.5	287	2176
plinth	0	487	0	60	29.5	0	576
Σ	232	6818	5637	480	221	1722	15107

$$T = \frac{0.09h}{\sqrt{d}} = 0.599 \text{ sec.}$$

$$Ah = \frac{Sa}{g}\frac{Z}{2}\frac{I}{R} = 0.076$$

$$Vb = Ah\ W = 0.076 \times 15107 = 1149\text{kN}$$

Comparison of results

Table 2.Variation of bending moments in beams.

S.N.	Building level	Beam No.	With shear walls	Without shear walls
1	1st	233	444	93.6
2	2nd	234	208	77
3	3rd	235	157	84
4	4th	236	103	89
5	5th	237	72.2	92
6	6th	238	54.5	94
7	7th	239	45.6	95
8	8th	240	81.3	97

Table 3. Variation of shear forces in beams

S.N.	Building level	Beam No.	With shear walls	Without Shear walls
1	1st	233	756	112
2	2nd	234	473	193
3	3rd	235	320	200
4	4th	236	214	194
5	5th	237	153	178
6	6th	238	117	155
7	7th	239	97.6	126
8	8th	240	163	89

Table. 4. Variation of shear forces in beams.

S.N.	Storey level	Column No.	With shear walls	Without shear walls
1	Bottom	113	4894	3066
2	Ground	447	4510	2925
3	1st	453	3663	2475
4	2nd	459	2570	2032
5	3rd	465	1798	1591
6	4th	471	1320	1152
7	5th	477	903	715
8	Top	483	445	279

Variation of bending moments of beams to which the steel plates of the shear walls are connected for with and

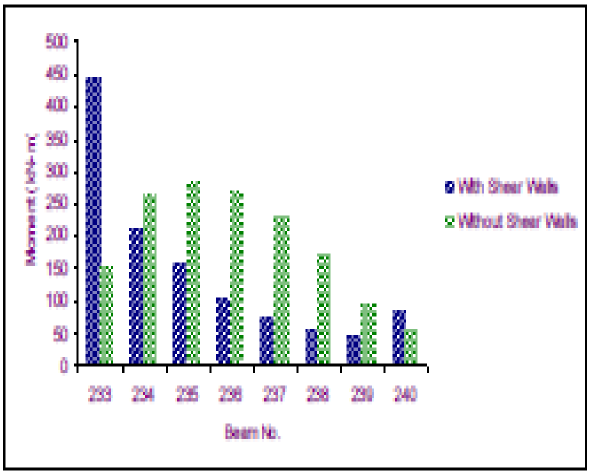
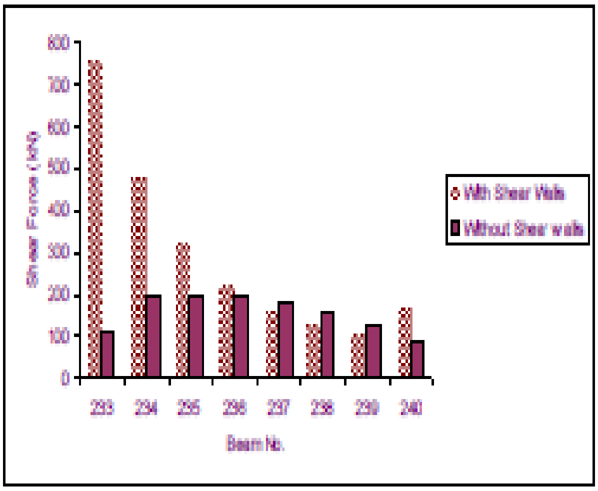


Fig.5.Variation of bending moments of beams.

Variation of shear forces of beams for with and without Shear wall effect is plotted below.



Effect of presence of the shear walls on the variation of axial forces in the columns.

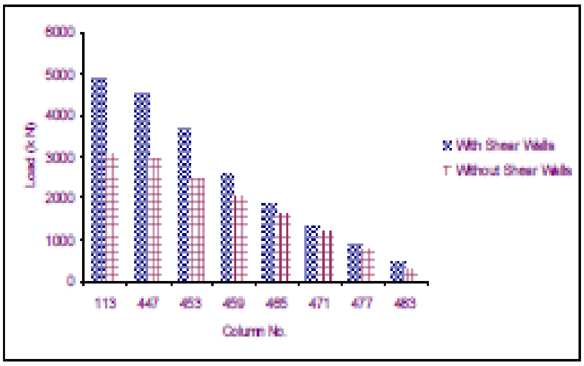


Fig.7.Variation of axial loads of Columns.

IV. DISCUSSION OF THE RESULTS

From above analysis it is found that, for figure 5 the B.M. values are higher for the bottom and top beams and are quite less for intermediate beams in a building with steel shear walls. For Figure 6 the shear force values are higher for beams towards the bottom of the building for with shear wall effect. And For Figure 7 lower columns the axial load values are higher for building with steel shear walls.

V. CONCLUSION

With the use of steel shear walls in the buildings, the bending moments in the beams are observed to reduce due to the nearly equal and opposite pull exerted by the vertical components of diagonal tension of the SPSWs present on both sides (lower and upper) of the beams. For topmost and bottommost (plinth beam) beams, the bending moments are observed to be higher comparatively because of the pull exerted by the shear walls present on only one side of the beams (i.e. on upper side of bottom beam and lower side of top beam). The shear forces on topmost and bottommost beams are also higher comparatively due to the presence of the SPSWs on only one side of the beams. The shear force and bending moment values for the plinth beam are very high comparatively when the shear wall is present, so it needs to be anchored properly to the foundation. The presence of steel shear walls significant increase in the column loads particularly in some of the lower columns.

APPENDIX

Response Spectra: -The spectra as per IS1893 (part1): 2002 for different soil type has been given as
For rock, or hard soil sites

$$\frac{S_a}{g} = \begin{cases} 1+15T, & 0.00 \le T \le 0.10 \\ 2.50 & 0.10 \le T \le 0.4 \\ 1.00/T & 0.40 \le T \le 4.0 \end{cases}$$

For medium soil sites

$$\frac{S_a}{g} = \begin{cases} 1+15T, & 0.00 \le T \le 0.10 \\ 2.50 & 0.10 \le T \le 0.55 \\ 1.36/T & 0.55 \le T \le 4.0 \end{cases}$$

For soft soil sites

$$\frac{S_a}{g} = \begin{cases} 1+15T, & 0.00 \le T \le 0.10 \\ 2.50 & 0.10 \le T \le 0.67 \\ 1.67/T & 0.67 \le T \le 4.0 \end{cases}$$

Zone factor:
Based on the seismic intensity the whole country is divided into four zones and each zone is given a Zone Factor based on the Maximum Considered Earthquake.

Seismic Zone	II	III	IV	V
Seismic Intensity	low	Moderate	Severe	Very Severe
Z	0.1	0.16	0.24	0.36

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