Parametric Study of High Rise Building Structure with Respect To Positioning of Shear Walls

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Abstract— High rise buildings are becoming need of today's situation with the population increasing day by day. A trend to high rise building is being seen in the developing cities of India to meet the housing demand. The buildings and infrastructures are necessary for the development and day-to-day activities of human beings. The loss of lives observed during earthquakes is directly related to the number of damaged and collapsed buildings during the event. The buildings become more and more susceptible to the earthquake loads with increase in height. Earthquake load can develop high stresses, produce sway movement or even may cause vibration in the structure. Thus, it is very much important for the structure to have enough strength against vertical loads collectively with satisfactory stiffness to resist earthquake load. Shear walls are among the most common lateral load resisting systems. The usefulness of the shear walls in the structural planning of the multistory buildings has long been recognized. But there are many factors such as placement of shear walls, its length, its thickness, aspect ratio, plan of the building which affects the response of the building towards lateral loads. In the present study an attempt is made to study the effect of the position of shear walls on bending moment, shear force, axial force and torsional force. Also the effect on storey drift, storey displacement and base shear is studied by changing the shear wall position. The complete study is carried out for zone II as per IS 1893 (part 1):2002, considering primary loads (dead, live and seismic loads) and their combinations with proper load factor using Staad-Pro.

Key words: High Rise Building Structure, Shear Walls

I. INTRODUCTION

The use of shear walls started in 1940. They are deep, vertically cantilevered, reinforced concrete beams. Their primary function is to resist the combined effect of vertical and lateral forces due to gravity loads and wind or earthquake forces. Shear walls are among the most common lateral load resisting systems. This is due to their ability in providing lateral stiffness and strength for the structure. It is observed that the buildings with shear walls have performed well as compared to bare frames in the past earthquakes.

The shear walls require special detailing in the high seismic regions. They are commonly located along the lift, staircase and core regions. They are built in wood, concrete, masonry or steel. The walls are very stiff, with considerable depth in the direction of lateral loads. These shear walls are provided at selected bays in both the orthogonal directions based on the feasibility considerations and are integrated with columns of the frame such that there is no physical separation between the columns and the walls. The buildings incorporated with properly designed and detailed shear walls increases the life safety and lowers the property damage during earthquakes. In addition to considerable strength, structural walls can dissipate a great deal of energy if detailed properly. Shear Walls are an invaluable structural element when protecting buildings from seismic events.

II. SCOPE & OBJECTIVE

The broad objective of the present study is to critically study the utility of the presence and placement of shear wall in high rise building structure including the parametric study to improve the overall response and effectiveness of the structure for earthquake loadings. The response of the structure is to be seen in terms of deflections, axial force, torsional force, shear force, bending moment and base shear. The analytical models are developed in Staad-Pro software. The overall specific objectives of this study are:

- To accurately simulate the behavior of frame wall structure in the software.
- To find the best suitable positioning of shear walls for building.
- To study the effect of shear wall positioning on bending moment, shear force, axial force and torsional force.

III. GENERAL DETAILS

Type of Building	Residential building
Type of frame	Ordinary moment resisting frame
Seismic Zone	II
Importance Factor	1
Floor to floor height	3m
Number of Storey	G+10, G+5 & G+3
Assumed Beam Size	600 X 450 mm , 600 X 500 mm
Assumed Column Size	600 X 450 mm , 600 X 500 mm
Thickness of Slab	100mm
Density of Concrete	30 kN/m^3
Grade of Steel	Fe500
Type of Soil	Medium
Damping of Structure	5%
Live Load	4.5 kN/m^2
Floor finish load	2.25KN/m^2
Plinth height	1m
Depth of foundation	3m
Density of Brick	20 kN/m^3
Thickness of wall	230mm
Parapet wall height	1m
Size of Building	40m x 50m, 20m x 25m & 12m x 15m

Table 1:

A R.C.C. building of G+10 storey with floor height 3m constructed on medium soil subjected to earthquake loadings in Zone II has been considered. In this regard, STAAD.Pro

V8i software has been considered as a tool to perform. Effect of Earthquake Forces on R.C.C. structure is analyzed. Deflection, axial forces, torsion, bending moments and shear force along X and Z directions are calculated. Maximum base shear along X and Z directions is also calculated. Modelling of plan in STAAD.Pro software indicated for further study. The plan of building as shown in Figure has been considered to carry out the study. The structural configuration and dimensions of the building structure are 40 x 50m. In this case the earthquake force is predominant. Hence, the structure is analyzed for the seismic loading only.

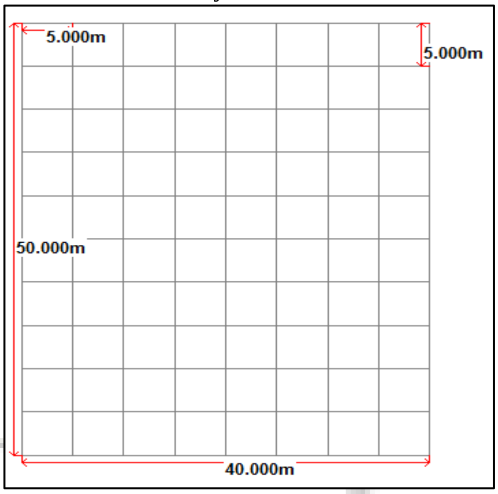

Fig. 1: Plan of building Different Positions of Shear Wall

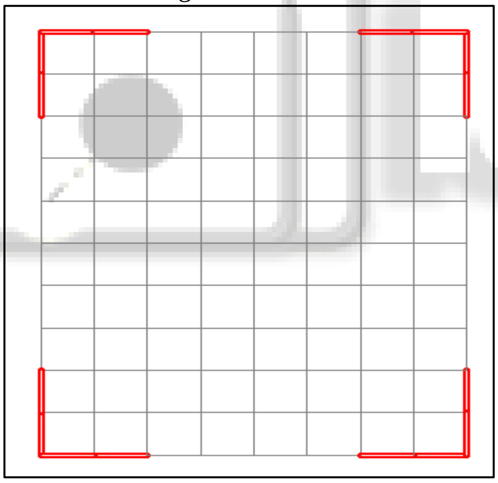

Fig. 2: Position A

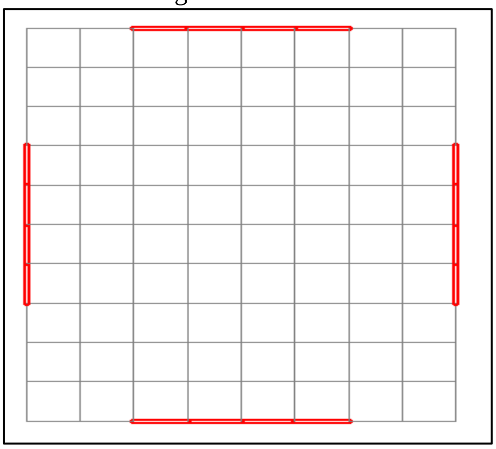

Fig. 3: Position B

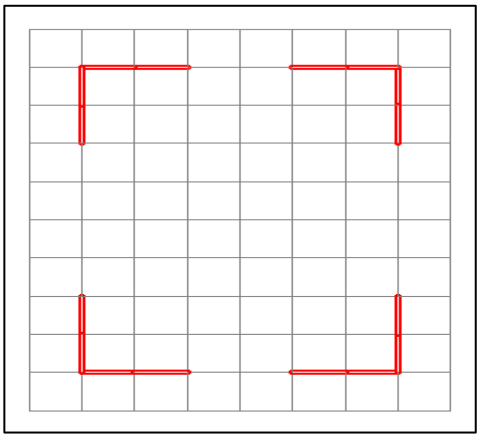

Fig. 4: Position C

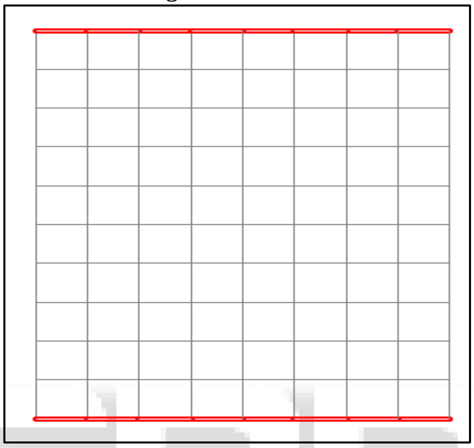

Fig. 5: Position D

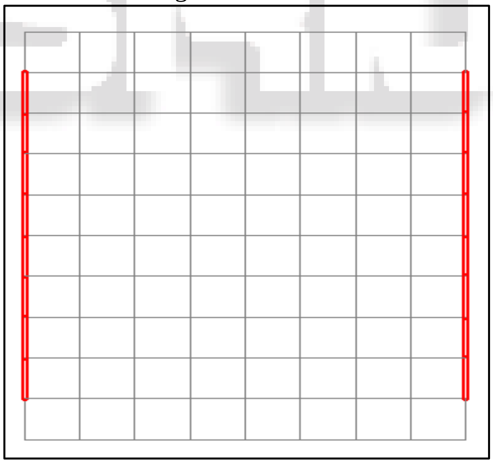

Fig. 6: Position E

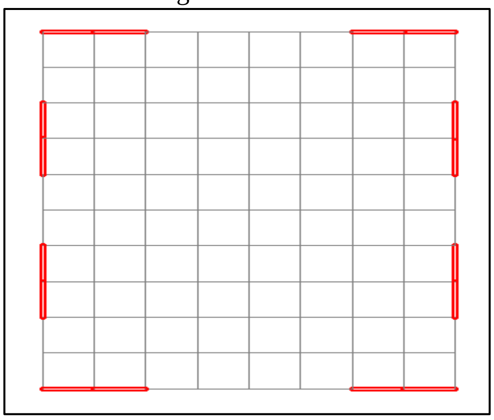

Fig. 7: Position F

IV. RESULTS & COMPARISON

R.C.C. buildings of G+10 storeys with floor height 3m constructed on medium soil subjected to earthquake loadings in Zone II has been considered.

Sr. No.	Structure	Height m	Allowable Deflection Mm.	Maximum Deflection Mm
1	Bay Frame	36	108	25.439
2	Position A	36	108	18.21
3	Position B	36	108	17.79
4	Position C	36	108	17.53
5	Position D	36	108	25.86
6	Position E	36	108	22.17
7	Position F	36	108	18.68

Table 2: Deflection Criteria

Structure Name	Axial Force
Axial Force Of Bay Frame	5770.682
Axial Force Of Position A	3296.998
Axial Force Of Position B	3582.555
Axial Force Of Position C	4906.572
Axial Force Of Position D	3157.205
Axial Force Of Position E	3413.407
Axial Force Of Position F	3764.177

Table 3: Maximum Axial Force

Structure Name	Max Torsion kN-m
Torsional Force of Bay Frame	1.996
Torsional Force of Position A	14.238
Torsional Force of Position B	0.841
Torsional Force of Position C	6.424
Torsional Force of Position D	6.327
Torsional Force of Position E	1.626
Torsional Force of Position F	8.093

Table 4: Maximum Torsional Force

Structure	Maximum Shear Force	Seismic Along X-Direction	Seismic Along Z-Direction
Position F, Position F	Max Fx	5773.325	5773.326
Position F, Position F	Max Fy	256.661	217.43
Position F , Position F	Max Fz	116.289	221.109

Table 5: Maximum Shear Force

Structure	Maximum Bending Moment	Seismic Along X-Direction	Seismic Along Z-Direction
Position A, Position F	Max Mx	14.238	14.238
Position D, Position F	Max My	178.606	178.606
Position E , Position F	Max Mz	352.725	352.725

Table 6: Maximum Bending Moment

A. Comparison of G+10, G+5 & G+3 Buildings

R.C.C. buildings of G+10, G+5 and G+3 storeys with same configurations of shear walls and floor height 3m constructed on medium soil subjected to earthquake loadings in Zone II has been considered.

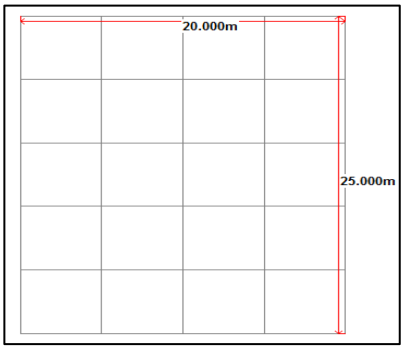

Fig. 8: Plan of G+5 Building

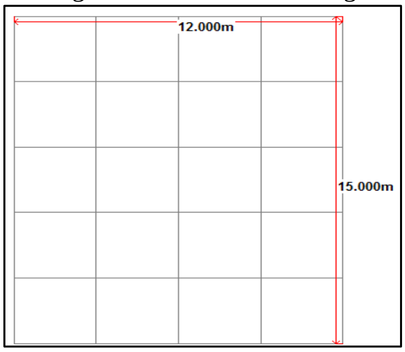

Fig. 8: Plan of G+5 Building

Sr. No.	Structure	Height m	Allowable Deflection mm.	Maximum Deflection mm
1	Bay Frame			
	G+10	36	108	25.439
	G+5	21	63	27.472
	G+3	15	45	16.507
2	Position A			
	G+10	36	108	18.21
	G+5	21	63	21.998
	G+3	15	45	10.207
3	Position B			
	G+10	36	108	17.79
	G+5	21	63	21.59
	G+3	15	45	9.191
4	Position C			
	G+10	36	108	17.53
	G+5	21	63	15.658
	G+3	15	45	5.86
5	Position D			
	G+10	36	108	25.86
	G+5	21	63	24.822
	G+3	15	45	16.616
6	Position E			
	G+10	36	108	22.17
	G+5	21	63	23.148
	G+3	15	45	16.814
7	Position F			
	G+10	36	108	18.68
	G+5	21	63	22.305
	G+3	15	45	11.715

Table 7: Comparison of G+10, G+5 & G+3 Building with Respect To Deflection Criteria

Axial Force			
Structure Name	G + 10	G + 05	G + 03
Axial Force Of Bay Frame	5770.682	2934.263	1017.484
Axial Force Of Position A	3296.998	1371.177	386.769
Axial Force Of Position B	3582.555	1504.284	429.979
Axial Force Of Position C	4906.572	2046.563	544.372
Axial Force Of Position D	3157.205	1245.586	337.764
Axial Force Of Position E	3413.407	1487.804	421.983
Axial Force Of Position F	3764.177	1559.907	447.501

Table 8: Comparison of G+10, G+5 & G+3 Building with Respect to Axial Force

Max Torsion kN-m			
Structure Name	G + 10	G + 5	G + 3
Bay Frame	1.996	0.997	0.621
Position A	14.238	6.068	1.179
Position B	0.841	0.406	1.179
Position C	6.424	1.608	1.933
Position D	6.327	1.938	2.051
Position E	1.626	1.378	1.905
Position F	8.093	3.622	4.412

Table 8: Comparison of G+10, G+5 & G+3 Building with Respect to Torsional Force

Structure	Maximum Shear Force	Seismic Along X-Direction	Seismic Along Z-Direction
Position F , Position F	Max Fx	5773.325	5773.326
Position F , Position F	Max Fy	256.661	217.43
Position F , Position F	Max Fz	116.289	221.109

Table 9: Comparison of G+10, G+5 & G+3 building with Respect to Shear Force for G+10

Structure	Maximum Shear Force	Seismic Along X-Direction	Seismic Along Z-Direction
Position A , Position D	Max Fx	3109.081	5772.679
Position E , Position D	Max Fy	137.467	207.589
Position A , Position D	Max Fz	42	109.098

For G+5

Structure	Maximum Shear Force	Seismic Along X-Direction	Seismic Along Z-Direction
Position B , Position B	Max Fx	1036.142	1036.142
Position C , Position C	Max Fy	80.581	80.581
Position D , Position D	Max Fz	22.543	26.443

For G+3

Structure	Maximum Bending Moment	Seismic Along X-Direction	Seismic Along Z-Direction
Position A, Position F	Max Mx	14.238	14.238
Position D, Position F	Max My	178.606	178.606
Position E, Position F	Max Mz	352.725	352.725

Table 10: Comparison of G+10, G+5 and G+3 building with respect to Bending Moment For G+10

Structure	Maximum Bending Moment	Seismic Along X-Direction	Seismic Along Z-Direction
Position A , Position D	Max Mx	6.068	6.327
Position A , Position D	Max My	67.952	178.606
Position E , Position D	Max Mz	204.651	324.505

For G+5

Structure	Maximum Bending Moment	Seismic Along X-Direction	Seismic Along Z-Direction
Position F , Position A	Max Mx	7.411	6.115
Position D , Position D	Max My	35.207	40.168
Position E , Position D	Max Mz	85.51	85.289

For G+3

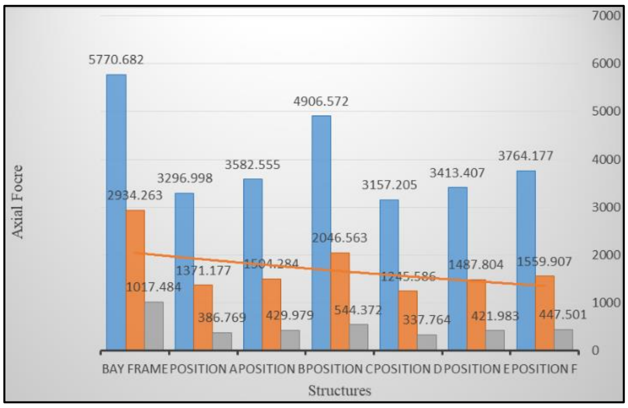

Fig. 9: Comparison of Maximum Axial Forces for G+10, G+5 & G+3

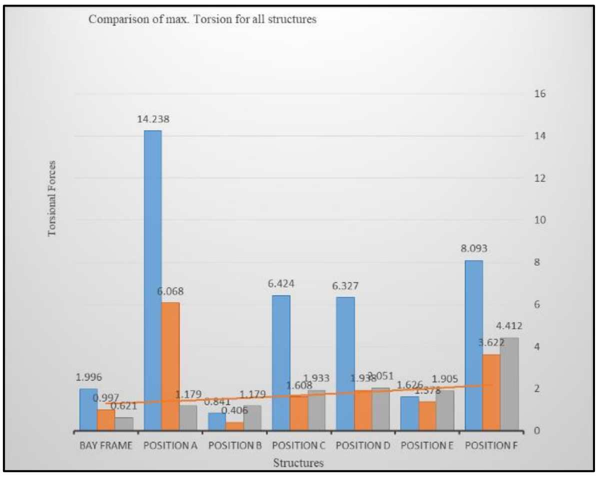

Fig. 10: Comparison of Maximum Torsional Forces for G+10, G+5 & G+3

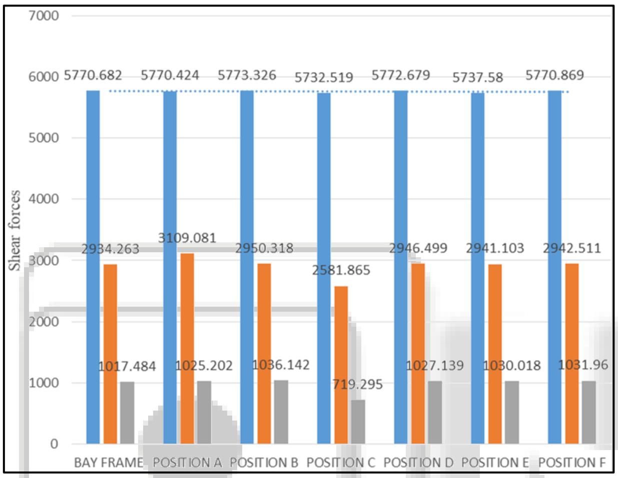

Fig. 11: Comparison of Shear Force (Fx) For G+10, G+5 & G+3

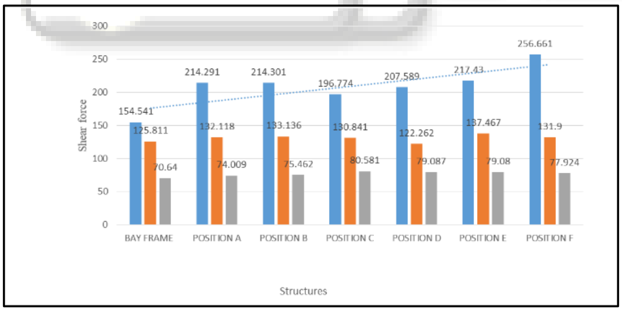

Fig. 12: Comparison of Shear Force (Fy) For G+10, G+5 & G+3

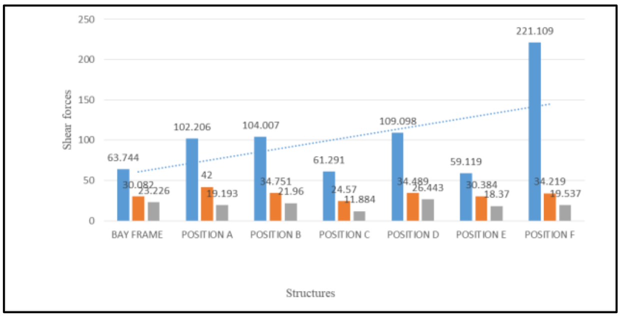

Fig. 13: Comparison of Shear Force (Fz) For G+10, G+5 & G+3

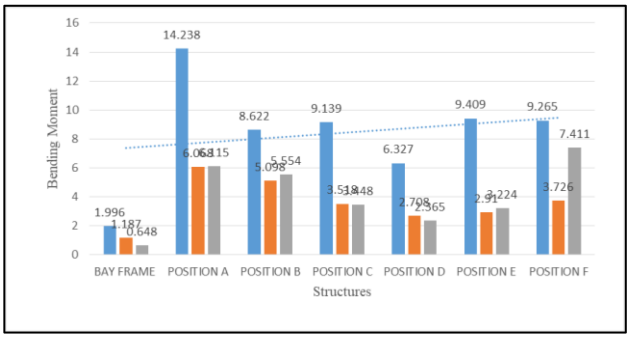

Fig. 14: Comparison of Bending Moment (Mx) For G+10, G+5 & G+3

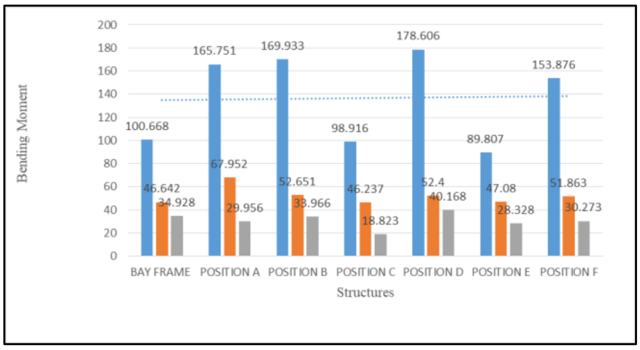

Fig. 15: Comparison of Bending Moment (My) For G+10, G+5 & G+3

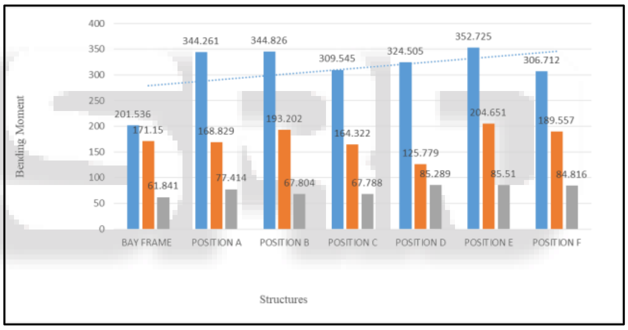

Fig. 16: Comparison of Bending Moment (Mz) For G+10, G+5 & G+3

V. CONCLUSION

In the present study seven models of G+10, G+5 & G+3 storey structure is considered in which one of model is bay frame and other models with shear wall in different positions in seismic zone II. It is concluded that:

- There is significant improvement observed in seismic performance of building by providing shear walls with different configurations since lateral displacement and member forces reduces considerably in building due to provision of shear walls.
- As per observation position C of shear wall have minimum deflection and bending moment.
- The L-shape shear walls configuration is effective during seismic activity because the member forces developed in this configuration are less as compared to other configurations.
- The average position of structures are position A, position B and position F.
- As per deflection criterion position E and position D have maximum deflection.

- By providing shear wall along four edges we can increase strength and of the structure.
- Shear walls are one of the most effective building elements in resisting lateral forces during earthquake. By providing shear walls in proper position can be minimized effect and damages due to earthquake.

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