RESEARCH ARTICLE OPEN ACCESS

Study of Strength of RC Shear Wall at Different Location on Multi-Storied Residential Building

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Abstract
Shear wall systems are one of the most commonly used lateral load resisting systems in high-rise buildings. Shear walls have very high in plane stiffness and strength, which can be used to simultaneously resist large horizontal loads and support gravity loads, making them quite advantageous in many structural engineering applications. There are lots of literatures available to design and analyze the shear wall. However, the decision about the location of shear wall in multi-storey building is not much discussed in any literatures. In this paper, therefore, main focus is to determine the solution for shear wall location in multi-storey building. A RCC building of six storey placed in HYDERABAD subjected to earthquake loading in zone-II is considered. An earthquake load is calculated by seismic coefficient method using IS 1893 (PART–I):2002. These analyses were performed using ETABS.
Keywords: Multi-storey, RC structure, seismic analysis, RC shear wall, ETABS.

I. Introduction

Generally shear wall can be defined as structural vertical member that is able to resist combination of shear, moment and axial load induced by lateral load and gravity load transfer to the wall from other structural member. Reinforced concrete walls, which include lift wells or shear walls, are the usual requirements of Multi Storey Buildings. Design by coinciding centroid and mass center of the building is the ideal for a Structure. 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.

In modern tall buildings, shear walls are commonly used as a vertical structural element for resisting the lateral loads that may be induced by the effect of wind and earthquakes which cause the failure of structure as shown in figure Shear walls of varying cross sections i.e. rectangular shapes to more irregular cores such as channel, T, L, barbell shape, box etc. can be used. Provision of walls helps to divide an enclose space, whereas of cores to contain and convey services such as elevator. Wall openings are inevitably required for windows in external walls and for doors or corridors in inner walls or in lift cores. The size and location of openings may vary from architectural and functional point of view.

The use of shear wall structure has gained popularity in high rise building structure, especially in the construction of service apartment or office/ commercial tower. It has been proven that this system provides efficient structural system for multi storey building in the range of 30-35 storey's (MARSONO & SUBEDI, 2000). In the past 30 years of the record service history of tall building containing shear wall element, none has collapsed during strong winds and earthquakes (FINTEL, 1995).

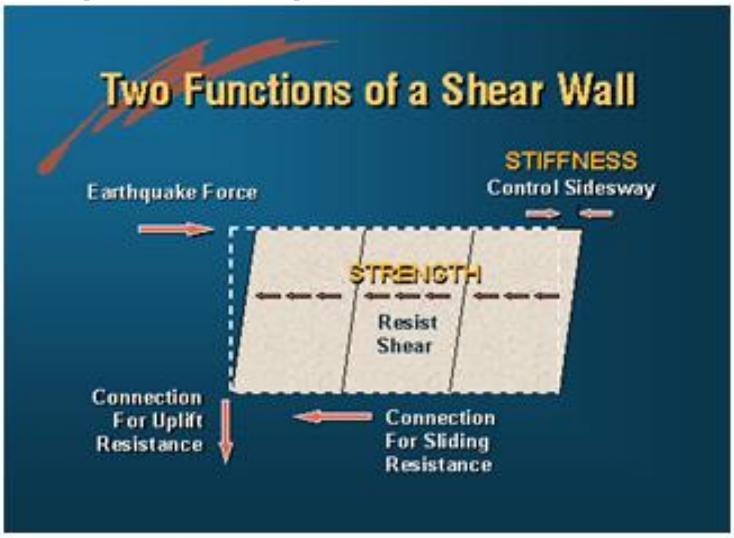
1.1 RC Shear Wall

Reinforced concrete (RC) buildings often have vertical plate-like RC walls called Shear Walls in addition to slabs, beams and columns. These walls generally start at foundation level and are continuous throughout the building height. Their thickness can be as low as 150mm, or as high as 400mm in high rise buildings. The overwhelming success of buildings with shear walls in resisting strong earthquakes is summarized in the quote, "We cannot afford to build concrete buildings meant to resist severe earthquakes without shear walls." as said by Mark Fintel, a noted consulting engineer in USA.

RC shear walls provide large strength and stiffness to buildings in the direction of their orientation, which significantly reduces lateral sway of the building and thereby reduces damage to structure and its contents. Since shear walls carry large horizontal earthquake forces, the overturning effects on them are large. Shear walls in buildings must be symmetrically located in plan to reduce ill-effects of twist in buildings. They could be placed symmetrically along one or both directions in plan. Shear walls are more effective when located along exterior perimeter of the building such a layout increases resistance of the building to twisting.

1.2 Function of Shear Wall

Shear walls must provide the necessary lateral strength to resist horizontal earthquake forces. When shear walls are strong enough, they will transfer these horizontal forces to the next element in the load path below them. These other components in the load path may be other shear walls, floors, foundation walls, slabs or footings. Shear walls also provide lateral stiffness to prevent the roof or floor above from excessive side-sway. When shear walls are stiff enough, they will prevent floor and roof framing members from moving off their supports. Also, buildings that are sufficiently stiff will usually suffer less non-structural damage.



II. Analysis

Analysis of building is done using ETABS. The models were prepared in the ETABS. Software by using different cross sections of RC shear wall viz. Box type, L type and cross type shear wall and these are located at different location such as along periphery, at corner and at middle positions.

2.1 Problem Statement

For the analysis purpose, the model of RC building G+ 5 storey's and 16mx16m plan area has selected which is located in Hyderabad City. The ground storey height is 3.5m and floor to floor height is 3m. Spacing of frame is 4m. Concrete used is M20 and structural steel is Fe415.

Structural properties of RC Building

Shear wall thickness	:	200 mm
Total depth of slab	:	120 mm
External wall thickness	:	250 mm including plaster
Internal wall thickness	:	150 mm including plaster
Size of external column	:	300x530 mm
Size of internal column	:	300x300 mm
Size of beam in longitudinal and transverse direction	:	300x450 mm
Zone factor (Z)	:	0.1
Importance factor (I)	:	1
Response reduction factor (R)	:	5

Following figure (1) shows the plan and figure (2) elevation of different models of the above multi-storeyed RC building in that column along X-direction shows in alphabets i.e. A, B, C, D and E and column along Z-direction shows with the numbers i.e. 1,2,3,4 and 5.

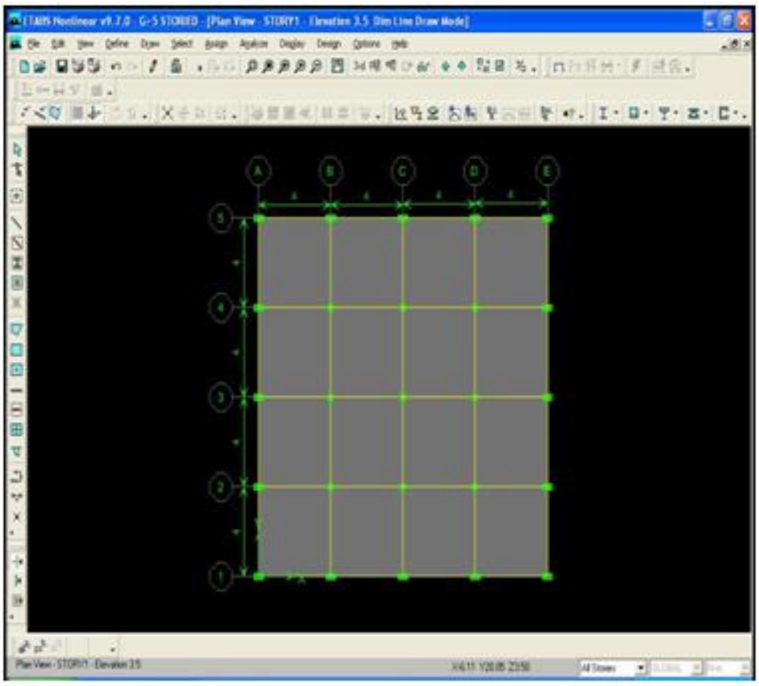
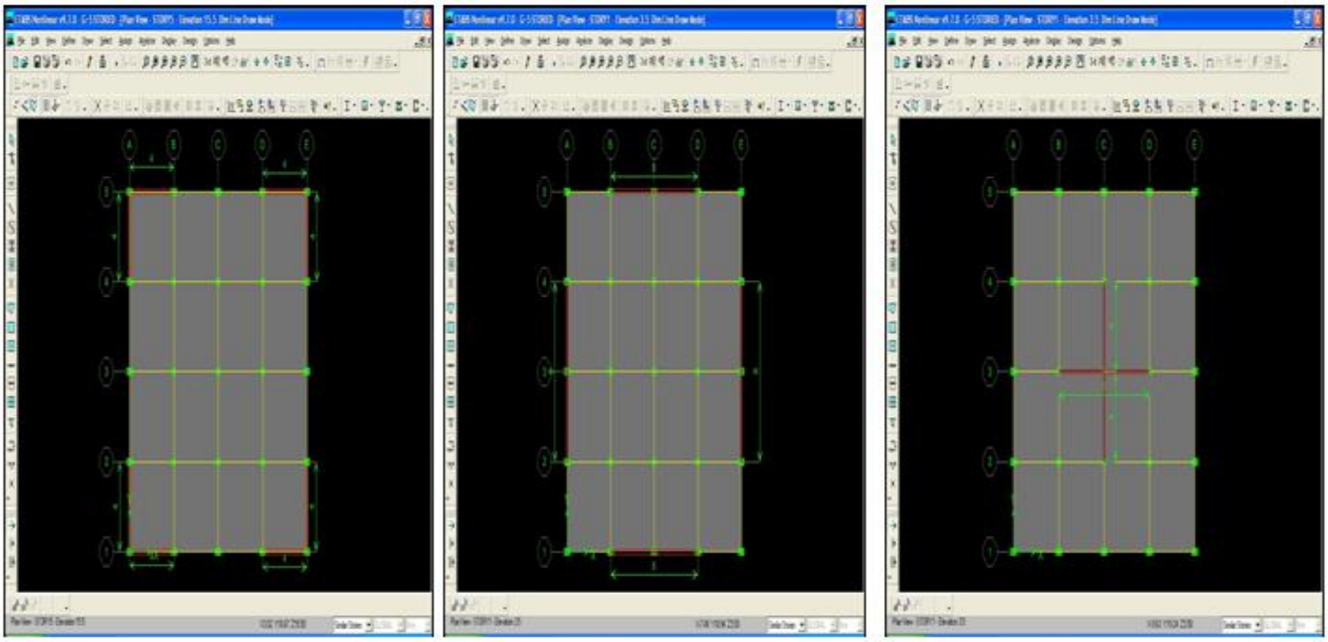


Fig. 1 Model of Building without shear wall

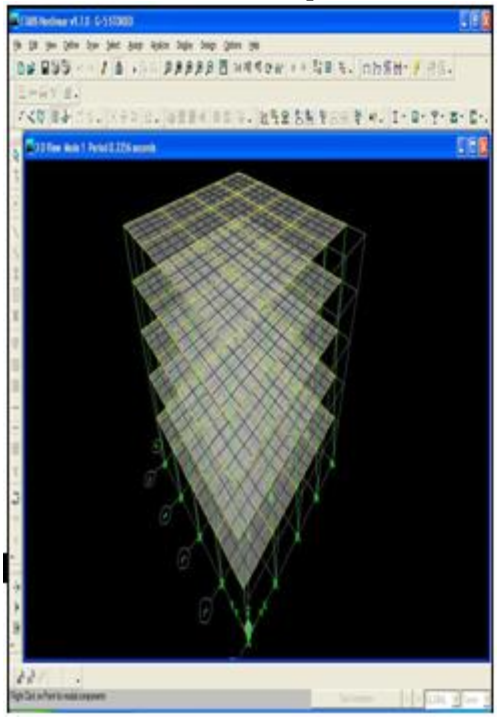


Figs: Different models of building with different types of shear wall

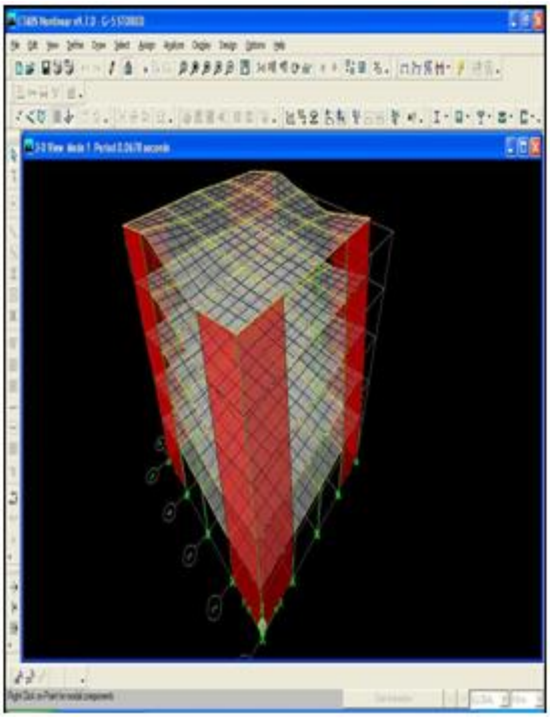
Table 1: Computation of lateral forces at each floor of building.

Sr. No.	Level	Lateral Force			
		Model I	**Model II**	**Model III**	**Model IV**
1	Roof	253.3	237.431	237.431	251.502
2	5th Floor	280.2	269.539	269.539	289.498
3	4th Floor	180.3	174.905	174.905	188.174
4	3rd Floor	105.4	101.394	101.394	108.562
5	2nd Floor	50.60	47.317	47.317	50.662
6	1st Floor	15.32	13.519	13.519	15.38

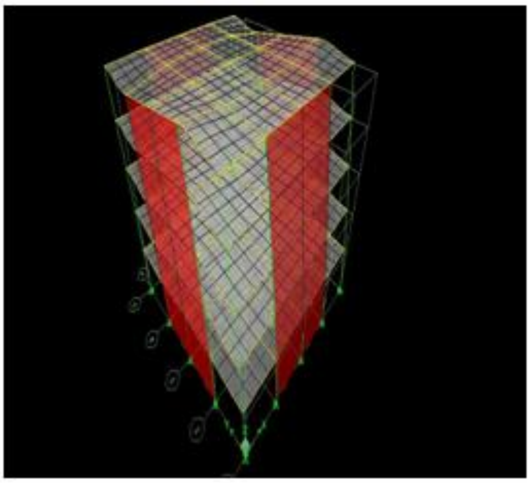
Deflected shape of a structure for 1.5DL+1.5EQX



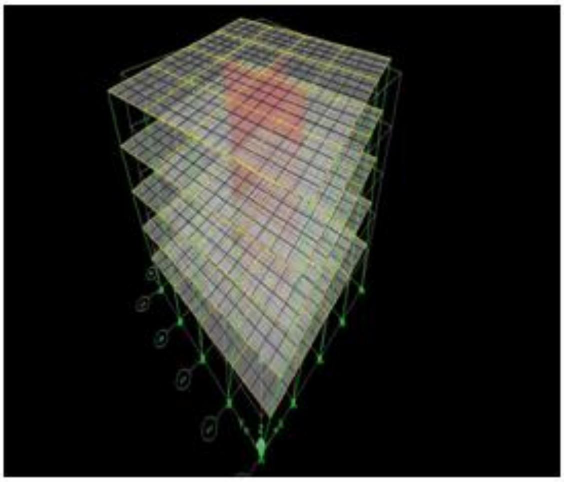
Model I: Structure without shear wall



Model II: Structure with L type shear wall



Model III: Structure with shear wall along periphery



Model IV: Structure with cross type shear wall

III. Result Summary

Table 4.1: Maximum Deflection at the Roof without Shear Wall.

software	Load combination	Calculated deflection (mm)
ETABS	1.5DL+1.5EQX	51
	1.2DL+1.2LL+1.2EQX	40
	1.5DL+1.5EQZ	37

Table 4.2: Comparison of drift (mm) between shear wall and Without shear wall of a structure.

	No shear wall			Shear wall 1			Shear wall 2			Shear wall 3		
Node no.	1.5DL+1.5EQX	1.2DL+1.2LL+1.2EQX	1.5DL+1.5EQZ	1.5DL+1.5EQX	1.2DL+1.2LL+1.2EQX	1.5DL+1.5EQZ	1.5DL+1.5EQX	1.2DL+1.2LL+1.2EQX	1.5DL+1.5EQZ	1.5DL+1.5EQX	1.2DL+1.2LL+1.2EQX	1.5DL+1.5EQZ
At 20m												
1	52.69	42.16	37.855	13.529	10.829	12.842	9.821	7.896	9.525	14.648	11.748	12.93
2	52.739	42.217	37.92	13.924	11.187	12.891	9.781	7.795	9.465	14.767	11.899	13.029
3	52.734	42.213	37.948	14.074	11.402	13.402	9.708	7.785	9.493	14.74	11.869	12.997
7	52.838	42.366	38.06	15.202	12.755	14.584	10.195	8.6	9.928	14.714	11.919	13.039
8	52.832	42.37	38.119	15.418	12.998	14.872	10.372	8.839	10.162	14.599	11.711	12.981
13	52.948	42.491	38.172	15.838	13.469	15.241	10.655	9.197	10.391	14.723	11.806	13.027

Table 4.3: Maximum Bending Moment of Various Models.

LEVEL	Bending Moment (kN.M)			
	MODEL I	MODEL II	MODEL III	MODEL IV
AT 20m	-7.896	-10.607	17.207	-12.129
AT 8m	-2.365	-2.132	12.412	-5.204
AT 3.5m	-0.315	1.119	3.321	-0.363

Table 4.4: Comparison of Shear forces-Y (KN) for Beam of different models.

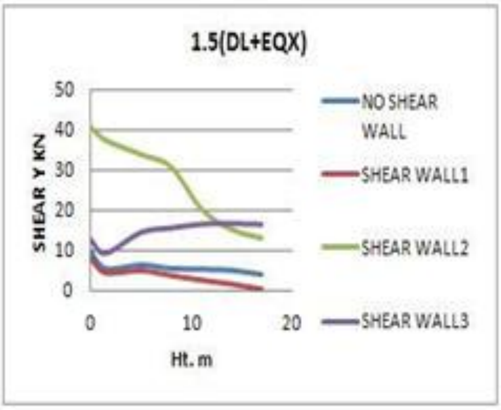
COMPARISON OF SHEAR FORCE FOR BEAM					
BEAM NO.	LOAD COMBINATION	SHEAR FORCE (KN)			
		NO SHEAR WALL	SHEAR WALL 1	SHEAR WALL 2	SHEAR WALL 3
7	1.5DL+1.5EQX	10.007	8.221	40.717	12.735
72	1.5DL+1.5EQX	5.424	4.508	37.386	9.332
417	1.5DL+1.5EQX	6.336	5.045	33.784	14.451
1784	1.5DL+1.5EQX	5.406	3.813	30.739	15.561
1849	1.5DL+1.5EQX	5.221	2.638	20.287	16.508
1914	1.5DL+1.5EQX	4.969	1.623	15.156	16.664
1979	1.5DL+1.5EQX	3.866	0.343	12.987	10.438

Table 4.5: Maximum Drift in Frame X-direction.

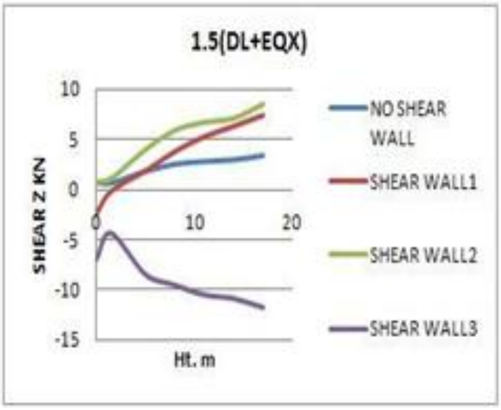
Load Combination	Displacement 'mm'				Allowable Displacement in mm
	MODE L I	MODE L II	MODE L III	MODE L IV	
(1)	(2)	(3)	(4)	(5)	(6)
1.2DL+1.2LL+1.2EQX	42.215	11.187	9.798	11.892	80
1.5DL+1.5EQX	52.737	13.924	7.785	14.76	80
1.5DL+1.5EQZ	38.005	13.559	9.488	13.18	80

Table 4.6: Maximum Drift in Frame Y-direction.

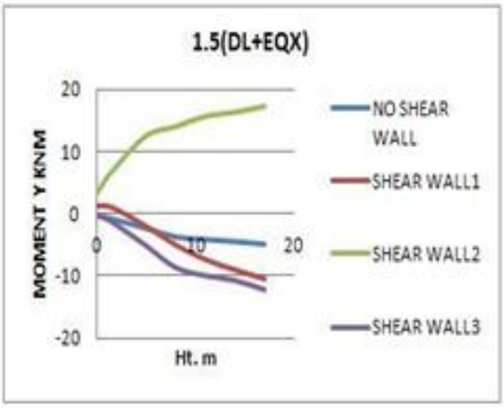
Load Combination	Displacement 'mm'				Allowable Displacement in mm
	MODE L I	MODE L II	MODE L III	MODEL IV	
(1)	(2)	(3)	(4)	(5)	(6)
1.2DL+1.2LL+1.2EQX	42.215	11.187	9.798	11.892	80
1.5DL+1.5EQX	52.737	13.924	7.785	14.76	80
1.5DL+1.5EQZ	38.005	13.559	9.488	13.18	80



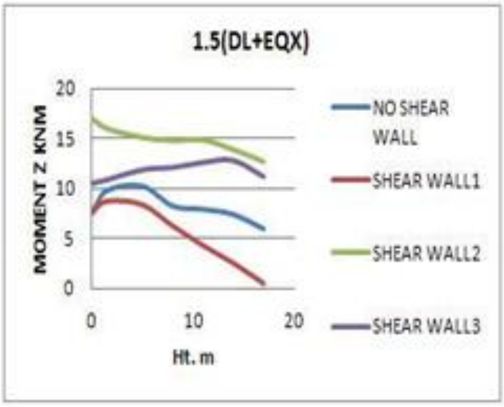
4.1. a: Graph of Shear Force Y



4.2.b: Graph of Shear Force Z



4.3. c: Graph of Bending Moment Y



4.4.d: Graph of Bending Moment Z

IV. Discussion

4.1 Maximum Deflection

The lateral deflection of column in the model of shear wall provided along periphery is reduced as compared to other two models. It reduces up to 33.31% and 32.03% as compared to models with L type shear wall and cross type shear wall respectively.

Maximum Shear Force in Beams

The effect of earthquake for model III at ground storey is more as compare to top storey and middle level. e.g. for a particular beam at ground storey increases shear force up to 21.20% compared to shear wall at middle storey.

Maximum Bending Moment in Beams

The effect of earthquake for model III at top storey is more as compare to middle storey and ground level. e.g. for a particular beam at top storey increases bending moment up to 41.60% compared to bending moment at middle store.

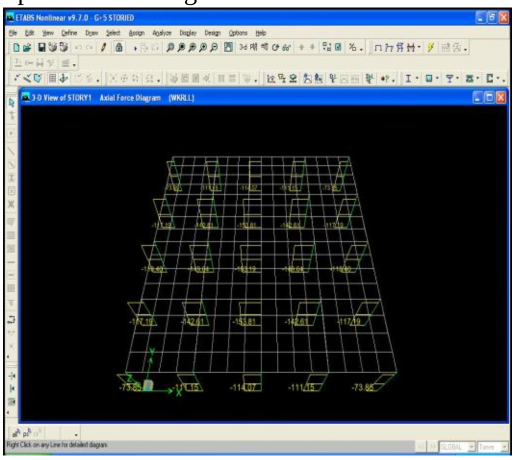


Fig: Plan of Building With Axial load on Columns

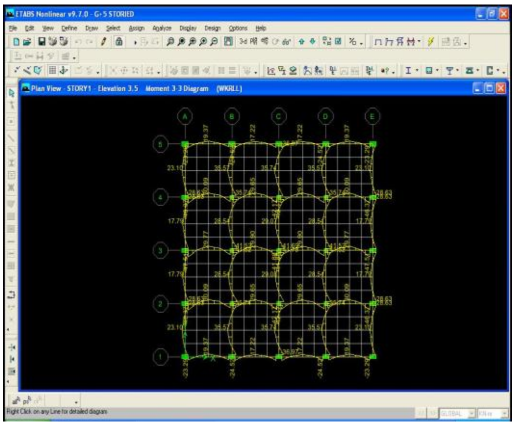


Fig: Plan of Building with Max Bending Moment in Beam.

V. Conclusion

(i) Among all the load combination, the load combination of 1.5DL+1.5EQX is found to be more critical combination for all the models.

(ii) The lateral deflection of column for building with type 2 shear wall is reduced as compared to all models.

(iii) The shear force is maximum at the ground level for model III as compared to model II and IV.

(iv) The shear force of model IV at middle level is more as compared to model III.

(v) The bending moment is maximum at roof level for model III.

(vi) It has been observed that the top deflection is reduced after providing type 2 shear wall of the frame in X-direction as well as in Y-direction.

(vii) More than model III for the load 1.5DL+1.5 EQX of the frame in Y-direction. Hence, it can be said that building with type 2 shear wall is more efficient than all other types of shear wall.

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