

## **Lateral Load Analysis of Shear Wall Framed Multistory Structures For Achieving More Safety Towards Earth Quakes**



**Pillutla Ranga Sai Praneeth**

**M.Tech (Structural Engineering),  
Department of Civil Engineering**

**Aurora's Scientific Technological and Research  
Academy, Bandlaguda, Hyderabad,  
Telangana – 500005.**



**S.Uttam Raj**

**Assistant Professor,**

**Department of Civil Engineering  
Aurora's Scientific Technological and Research  
Academy, Bandlaguda, Hyderabad,  
Telangana – 500005.**

### **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 multistory 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. The shear walls will be introduced in the framed structure at suitable locations and the analysis is made for both for static and dynamic loads caused due to earthquakes. A RCC building of 6 storey placed 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 STAAD Pro. A study has been carried out to determine the strength of RC shear wall of a multistoried building by changing shear wall location. The proposed six storey building is first analyzed without shear walls. The three different cases of shear wall position for a 6 storey building have been analyzed later. The results of the above four analysis will be compared and optimize the shear wall frame structure i.e. (shear walls and frames) will be suggested for the building considered for the analysis. This analysis will help in achieving safety against earthquakes as well as keeping the flexibility of the frame structure intact. It is concluded that incorporation of shear wall has become inevitable in multistory buildings to resist lateral forces.

The type II shear wall proposed in this analysis proves to be more efficient and will achieve maximum safety towards earthquakes in zone-II.

### **Key words:**

Multi-storey, RC structure, seismic analysis, RC shear wall, STAAD Pro.

### **INTRODUCTION:**

The primary purpose of all kinds of structural systems used in the building type of structures is to support gravity loads. The most common loads resulting from the effect of gravity are dead load, live load and snow load. Besides these vertical loads, buildings are also subjected to lateral loads caused by wind, blasting or earthquake. Lateral loads can develop high stresses, produce sway movement or cause vibration. Therefore, it is very important for the structure to have sufficient strength against vertical loads together with adequate stiffness to resist lateral forces.

1. Structural Frame Systems: The structural system consists of frames. Floor slabs, beams and columns are the basic elements of the structural system. Such frames can carry gravity loads while providing adequate stiffness.

2. Structural wall systems: In this type of structures, all the vertical members are made of structural walls, generally called shear walls.

3. Shear wall –Frame systems (Dual Systems): The system consists of reinforced concrete frames interacting with reinforced concrete shear walls.

## **EARTHQUAKE RESISTANCE WITH PROVISION OF SHEAR WALLS:**

Means of providing earthquake resistance to multistoried reinforced concrete building. The structure is still damaged due to some or the other reason during earthquakes. Behavior of structure during earthquake motion depends on distribution of weight, stiffness and strength in both horizontal and planes of building. To reduce the effect of earthquake reinforced concrete shear walls are used in the building. These can be used for improving seismic response of buildings. Structural design of buildings for seismic loading is primarily concerned with structural safety during major Earthquakes, in tall buildings, it is very important to ensure adequate lateral stiffness to resist lateral load. The provision of shear wall in building to achieve rigidity has been found effective and economical. When buildings are tall, beam, column sizes are quite heavy and steel required is large. So there is lot of congestion at these joint and it is difficult to place and vibrate concrete at these place and displacement is quite heavy. Shear walls are usually used in tall building to avoid collapse of buildings.

When shear walls are situated in advantageous positions in the building, they can form an efficient lateral force resisting system. 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.

## **RC SHEAR WALL:**

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 building must be symmetrically located in plan to reduce ill-effects of twist in buildings.

This 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. 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. Shear walls are usually provided along both length and width of buildings. Shear walls are like vertically-oriented wide beams that carry earthquake loads downwards to the foundation.

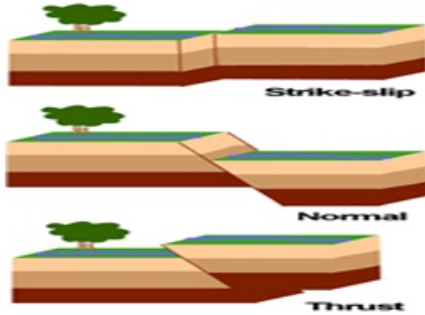
## **FUNCTION OF SHEAR WALL :**

Shear walls must provide the necessary lateral strength to resist horizontal forces. When shear walls are strong enough, they will transfer these horizontal forces to the next element in the load path. These components in the path may be other shear walls, floors, foundation walls, slabs or footings. Shear walls also prevent excessive roof sway. They will also prevent roof framing members like beams, from moving of their supports. These walls will result in less damage than compared to a framed structure without shear walls.

## **EARTHQUAKES:**

An earthquake (also known as a quake, tremor or temblor) is the result of a sudden release of energy in the Earth's crust that creates seismic waves. The seismicity, seismism or seismic activity of an area refers to the frequency, type and size of earthquakes experienced over a period of time. Earthquakes are measured using observations from seismometers. The moment magnitude is the most common scale on which earthquakes larger than approximately 5 are reported for the entire globe. The more numerous earthquakes smaller than magnitude 5 reported by national seismological observatories are measured mostly on the local magnitude scale, also referred to as the Richter scale. These two scales are numerically similar over their range of validity. Magnitude 3 or lower earthquakes are mostly almost imperceptible or weak and magnitude 7 and over potentially causes serious damage over larger areas, depending on their depth. The largest earthquakes in historic times have been of magnitude slightly over 9, Effectiveness of shear wall has been studied with the help of four different models.

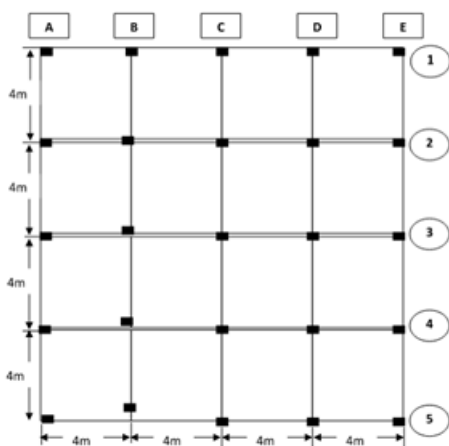
Model one is bare frame structural system and other three models are dual type structural system. An earthquake load is applied to a building of ten stories located in zone II, zone III, zone IV and zone V. Parameters like Lateral displacement, story drift and total cost required for ground floor are calculated in both the cases replacing column with shear wall.



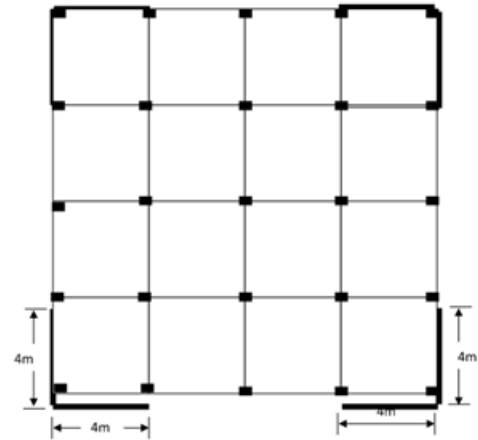
**FIG. 2.1 TYPES OF FAULTS**

**PROBLEM STATEMENT AND ANALYSIS:**

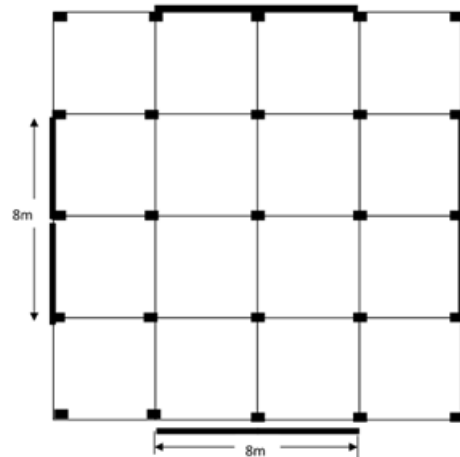
For the study proposed in multistoried building of six storey's with four bays in longitudinal direction and four bays in lateral direction was considered for analysis. As a first step the analysis will be done without any shear walls (framed structure) for lateral loads including earthquakes. Shear walls are introduced at three locations and the study is conducted using STAAD PRO. The plan of the building is shown in the figure 5.1. The location of shear walls proposed in the three cases i.e. (Type-I, Type-II, Type-III) shown in the figure 5.2.



**FIGURE 5.1 MODEL OF BUILDING WITHOUT SHEAR WALL**



**FIGURE 5.2 a) TYPE I (SHEAR WALL AT CORNERS)**



**FIGURE 5.2 c) TYPE III (SHEAR WALL IN MIDDLE)**

**5.2 Problem statement:**

The RCC building which is G+5 considered in the analysis is 16m×16m in plan. The ground storey height is 3.5m and floor to floor height is 3m. The spacing of the frame in lateral direction is 4m. Concrete used is M20 and structural steel used is Fe415. The size of the external column is proposed as 300mm×530mm whereas all the internal columns are proposed with dimensions of 300mm×300mm. The size of the beam in the longitudinal direction is taken as 300mm×450mm. In the transverse direction the beams are also proposed with same size i.e. 300mm×450mm. The slab thickness for all the slabs is considered as 120mm. The external wall thickness for the building is 250mm including plaster. The internal wall thickness is 150mm including plaster.

In the present analysis shear walls proposed with 200mm thick for all the shear walls in the locations indicated in the figure. The zone factor  $z$  is considered as 0.1, the importance factor is considered as 1 and the response reduction factor is considered for the earthquake resistant analysis (lateral load analysis). The nomenclature for the building frame is A B C D E in the longitudinal direction and 1 2 3 4 5 in the lateral direction as shown in the fig 5.1. The loads considered are dead, live and earthquake loads in X&Z directions. The load combinations are  $1.5DL+1.5EQX$ ,  $1.2DL+1.2LL+1.2EQX$  and  $1.5DL+1.5EQZ$  were considered in the study.

### 5.3. Analysis:

Using STAAD PRO for the four cases indicated above the computation of lateral forces at each floor of the building are calculated. Similarly drift of the building between shear walls and without shear walls are also calculated. The maximum Bending moment and shear forces are also analyzed using STAAD PRO. The maximum drift of the frame in X&Y directions are also studied using STAAD PRO lateral load analysis package.

## Results & Conclusions

### 6.1. Lateral forces :

The study indicated for the lateral forces have reduced by the provision of shear walls in case of TYPE-I and TYPE-II compared to know shear wall condition, whereas the TYPE-III model has not shown much change as compared to no shear wall condition. The computation of lateral force at each floor of the building arrived from the analysis each shown in the Table-6.1.

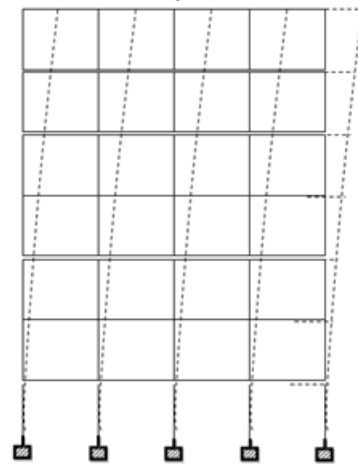
**Table 6.1: COMPUTATION of LATERAL FORCES AT EACH FLOOR of BUILDING.**

Sr.no	Level	Lateral Force (KN)			
		Without Shear Wall	Type I	Type II	Type III
1	Roof	253.05	237.431	237.431	251.502
2	5 <sup>th</sup> floor	289.18	269.539	269.539	289.498
3	4 <sup>th</sup> floor	187.06	174.905	174.905	188.174
4	3 <sup>rd</sup> floor	108.44	101.394	101.394	108.562
5	2 <sup>nd</sup> floor	50.60	47.317	47.317	50.662
6	1 <sup>st</sup> Floor	15.36	13.519	13.519	15.38

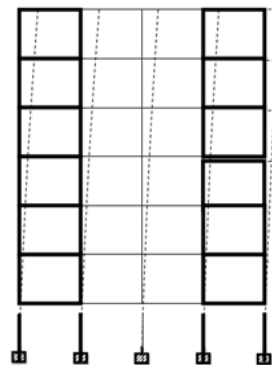
### 6.2. Deflected shape:

The deflected shape of the structure is obtained from  $1.5DL+1.5EQX$  is shown in the figure 6.1.

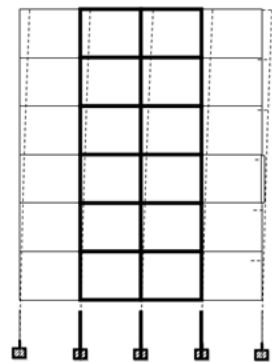
From this figure it could be seen that the maximum deflection has reduced from 52.69mm to 9.821mm in TYPE-II. The comparison of drift between shear wall and without shear wall for all the three load conditions and for all the three types considered is given in Table 6.2.



**FIGURE 6.1 RESPONSE OF STRUCTURE WITHOUT SHEAR WALL**



**FIGURE 6.1 a) RESPONSE OF TYPE I: STRUCTURE WITH L TYPE SHEAR WALL**



**FIGURE 6.1 b) RESPONSE OF TYPE II: STRUCTURE WITH SHEAR WALL ALONG PERIPHERY**

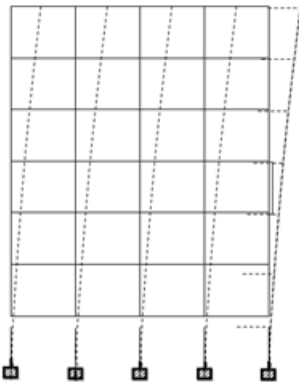


FIGURE 6.1c) RESPONSE OF TYPE III: STRUCTURE WITH CROSS TYPE SHEAR WALL

### 6.3. Bending moment:

The maximum bending moment with TYPE-II has become positive from a value of 7.207KN-m as compared to a negative moment of 7.896KN-m without shear wall. The maximum bending moment of various types studied are given in table 6.3. The graphs of bending moment are shown in z and y- directions for all the four cases considered are shown in the figure 6.2 and 6.3.

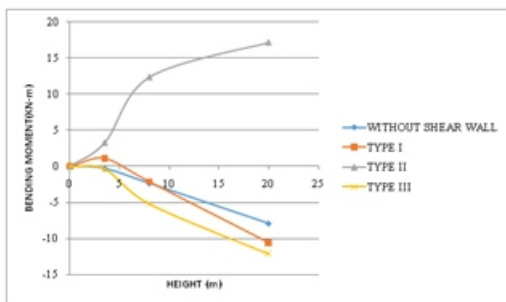


FIGURE 6.3 VARIATION OF BENDING MOMENT IN Y-DIRECTION W.R.T HEIGHT FOR DIFFERENT CASES

Table 6.3: MAXIMUM BENDING MOMENT OF VARIOUS MODELS.

LEVEL	Bending Moment (KN-m)			
	WITHOUT SHEAR WALL	TYPE I	TYPE II	TYPE III
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

### 6.4 Shear Force;

The shear force has increased in TYPE-II wall compared to no shear wall condition. However, the beams and the walls would be able to resist the shear forces as the shear resistance of the beams is very high. The comparison of the shear forces for beams of different types is given in table 6.4. The graphs showing the shear force in z and y- directions for all the four cases is given in figure 6.4 and 6.5.

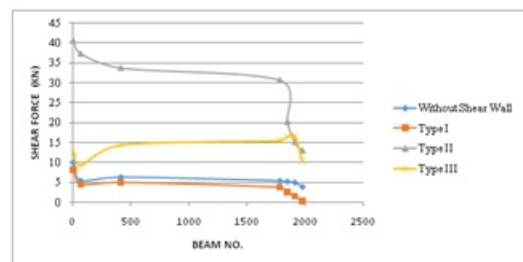


FIGURE 6.4: COMPARISON OF SHEAR FORCES – Y (KN) FOR BEAM OF DIFFERENT MODELS.

### 6.5 Maximum Drift in x and y-directions:

The maximum drift in x- direction is reduced to 9.798 mm from 42.215mm. For load condition 1(1.2 DL+1.2LL+1.2EQ<sub>L</sub>) for load conditions of (1.5 DL+1.5EQ<sub>x</sub>) reduces to 7.785mm from 52.737mm. The maximum drift in x- direction for all types and all load combinations is shown in table 6.5. The maximum drift in y-direction is also reduced to 7.785mm from 52.737mm.

Table 6.5: MAXIMUM DRIFT IN FRAME X-DIRECTION.

Load Combination	Displacement'mm'				Allowable Displacement mm
	WITHOUT SHEAR WALL	TYPE I	TYPE II	TYPE III	
(I)	(2)	(3)	(4)	(5)	(6)
1.2DL+1.2LL+ 1.2EQ <sub>X</sub>	42.215	11.187	9.798	11.892	80
1.5DL+1.5EQ <sub>X</sub>	52.737	13.924	7.785	14.76	80
1.5DL+1.5EQ <sub>Z</sub>	38.005	13.559	9.488	13.18	80

Table 6.6: MAXIMUM DRIFT IN FRAME Y DIRECTION.

Load Combination	Displacement'mm'				Allowable Displacement mm
	WITHOUT SHEAR WALL	TYPE I	TYPE II	TYPE III	
(I)	(2)	(3)	(4)	(5)	(6)
1.2DL+1.2LL+ 1.2EQ <sub>X</sub>	42.215	11.187	9.798	11.892	80
1.5DL+1.5EQ <sub>X</sub>	52.737	13.924	7.785	14.76	80
1.5DL+1.5EQ <sub>Z</sub>	38.005	13.559	9.488	13.18	80

## 6.6 Conclusions:

- (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-II shear wall is reduced as compared to all models.
- (iii) The shear force is maximum at the ground level for TYPE-II as compared to TYPE-I and III.
- (iv) The shear force of model IV at middle level is more as compared to TYPE-II.
- (v) The bending moment is maximum at roof level for TYPE-II among all the models.
- (vi) It has been observed that the top deflection is reduced after providing TYPE-II shear wall of the frame in X-direction as well as in Y-direction.
- (vii) For the load 1.5DL+ 1.5EQZ, both the shear force and bending moment is maximum for TYPE-II of the frame in X-direction.
- (viii) It has also been observed that for the load 1.5DL+ 1.5 EQX, the shear force is more for TYPE-II as compared to TYPE-I of the frame of Y-direction.
- (ix) The bending moment of TYPE-III is more than TYPE-II for the load 1.5DL+1.5 EQX of the frame in Y-direction. Hence, it can be said that building with TYPE-II shear wall is more efficient than all other types of shear wall.

## REFERENCES:

- [1] Solution of shear wall in multi-storey building”, Anshuman, Dipendu Bhunia, Bhavin Ramjiyani, International journal of civil and structural engineering, Volume 2, no.2, 2011.
- [2] “Review on Shear wall for soft storey high rise building, Misam Abidi and Mangulkar Madhuri N. ,International Journal of Civil and Advance Technology, ISSN 2249-8958, Volume-1 ,Issue-6, August 2012.
- [3] “Effect of change in shear wall location on storey drift of multi-storey residential building subjected to lateral load”, Ashish S. Agrawal and S. D. Charkha, International journal of Engineering Research and Applications, Volume 2, Issue 3, may-june 2012, pp.1786-1793.
- [4] “Configuration of multi-storey building subjected to lateral forces”, M Ashraf, Z. A. Siddiqui, M. A. Javed, Asian journal of civil engineering ,vol. 9,no.5, pp. 525-535, 2008.
- [5] IS 1893(part 1) : 2002, “Criteria for earthquake resistant design of structures, part 1, general provisions and buildings “, Fifth revision, Bureau of Indian Standards, Manak Bhavan, Bahadur Shah Zafar Marg, New Delhi 110002.
- [6] IS: 875 (Part 2) - 1987 (Reaffirmed 2008), “Code of practice for design loads for buildings and structures. Part 2- Imposed load”.
- [7] Shrikhande Manish, Agrawal Pankaj (2010).” Earthquake Resistant Design of Structures.” PH I Learning Private Limited New Delhi.