BEHAVIOUR OF G+10 BUILDING WITH SHEAR-WALLS AT DIFFERENT POSITIONS

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Abstract - *Nowadays shear wall as structural element in high rise buildings has become a common practice. It has become the most common way to form the Lateral load resisting system in High rise structures. Very high strength and stiffness of the shear walls can be used to resist large horizontal loads and supporting Gravity loads. This makes them advantageous in many structural applications. The main focus of this project is to determine the most suitable location or position for the shear wall. A G+10 RCC building subjected to earthquake loading located in zone IV is considered in this project. The equivalent Lateral force method or static method is used to calculate the Earthquake load using IS1893 (Part I):2002. Analyses were performed on ETABS. This research focuses on determining strength of shear walls in different locations. We have tried to place shear walls at different locations and an attempt has been made to check the best position for shear walls in a building. Six different cases of shear wall position for a G+10 building have been analyzed. This project aims to analyze the response of structure using by static method.*

Key Words: Shear wall, ETABS

1. INTRODUCTION

Earthquake in general has long devastating history in the past. Earthquakes are most distressing and a threat to human civilization, devastating man-made structures, and human lives. It is such an unpredictable calamity that survival must ensure the strength of the structures against seismic forces(13). Therefore, a lot of research works are going on around the globe for the development of better techniques that can be incorporated into structures for better resistance against earthquakes (13). A shear wall is a structural component located in a building right from foundation level to top parapet level at various locations. Shear walls are used to defend against lateral forces. Structural members which are used to resist lateral forces due to earthquakes and wind are the Shear walls.

There are many different methods of seismic analysis like the time history method, response spectrum method seismic coefficient method, etc. (13). A study has been carried out to determine the best possible orientation of the RC shear wall of a multistoried building by trying out different possible orientations. And parameters like storey drift, base shear, nodal displacement are observed and compared.

The six different types of models are as follows (Fig:4-9)

1. Without a Shear wall
2. Shear wall at the Centre – For Lift cores only
3. Shear walls at Periphery
4. Shear walls at Corners
5. Shear wall along both Longitudinal faces & Lift cores
6. Shear wall along with both Lateral faces & Lift cores

1.1 Concept

In this project, different position of shear wall is given. Shear wall gives more stability to the building's than normal wall. This building is located in Delhi, zone IV. This project give idea about shear wall location. This is also show that the behavior of shear wall in the buildings at different location. This project gives idea about displacement, drift, shear.

The location of the shear walls depends on the plan of structure, core location, the symmetry of the building, and the lateral force experienced by the structure. Mostly, shear walls should be placed around the outer walls of the building in a symmetrical form. It is usually very difficult to find a suitable location for the shear wall in the structure. However, the ideal place is the center of the building. Sometimes, structural analysis is performed to identify the ideal location in the structure.

1.3 Properties of shear wall

Shear wall is a structural member positioned at different places in a building from foundation level to top parapet level, used to resist lateral forces i.e parallel to the plane of the wall. There are different materials by which shear wall can be constructed, but reinforced concrete (RC) buildings often have vertical plate-like Reinforced concrete walls (Figure 1) in addition to slabs, beams and columns. 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.

1.2 Flow chart

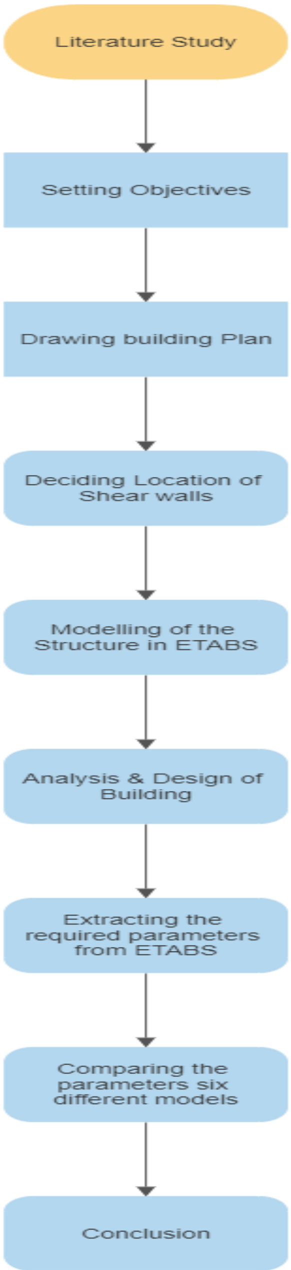

Fig -1: Flow Chart

1.4 Functions of Shear Walls

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 (13). These other components in the load path may be other shear walls, floors, foundation walls, slabs or footings.

2 MODELING AND ANALYSIS

2.1 Building Description

The modeling and analysis is done using ETABS software. The building considered for the analysis is a Residential G+10 building. The typical floor plan and elevation of the residential building is as shown in the figure 2 and figure 3.

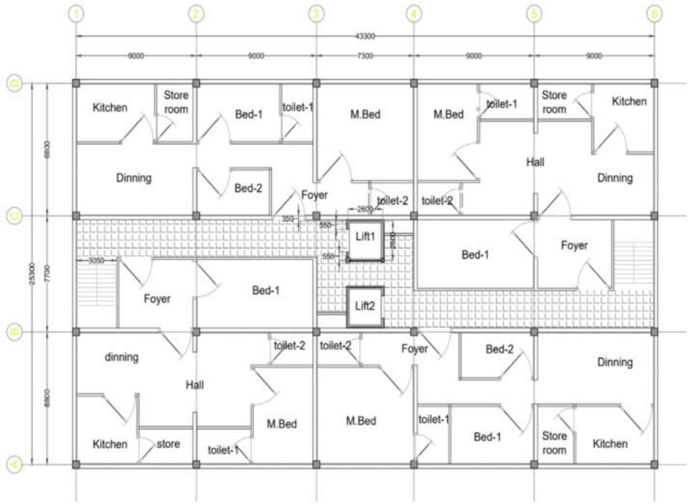

Fig -2: Typical floor plan

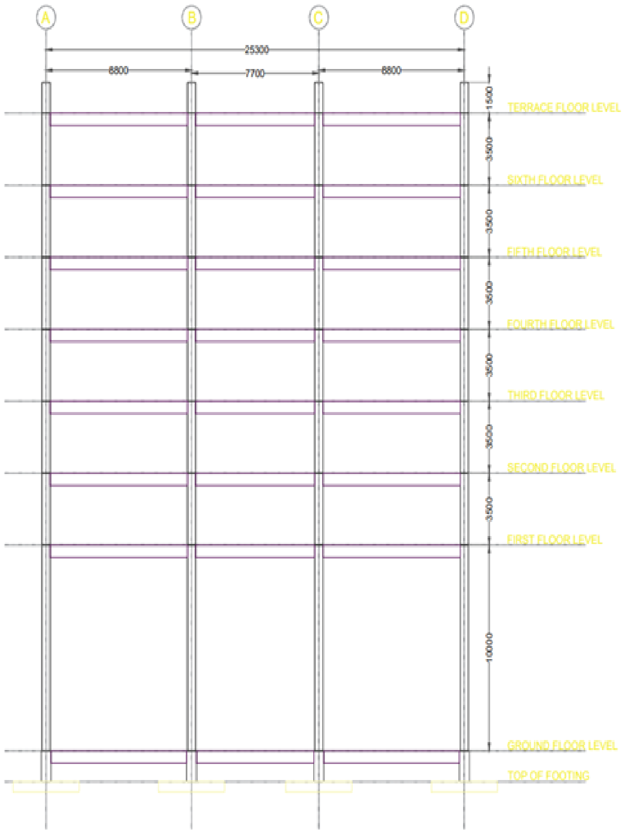

Fig -3: Elevation of the buildin

2.2 Design Criteria

The loading combinations considered, and the other parameter considered are tabulated in Table-1 to Table-7.

No.	Load Combination
1.	$1.5\ (DL + LL)$
2.	$1.5\ (DL \pm ELX)$
3.	$1.5\ (DL \pm ELY)$
4.	$1.2\ (DL + LL \pm ELX)$
5.	$1.2\ (DL + LL \pm ELY)$
6.	$0.9DL \pm 1.5ELX$
7.	$0.9DL \pm 1.5ELY$
8.	$1.5\ (DL \pm WX)$
9.	$1.5\ (DL \pm WY)$
10.	$1.2\ (DL + LL \pm WX)$
11.	$1.2\ (DL + LL \pm WY)$
12.	$0.9DL \pm 1.5WX$
13.	$0.9DL \pm 1.5WY$

Table -1: Ultimate Load combinations

No.	Load Combination
1.	$DL + LL$
2.	$DL \pm ELX$
3.	$DL \pm ELY$
4.	$DL + LL \pm ELX$
5.	$DL + LL \pm ELY$
6.	$DL \pm WX$
7.	$DL \pm WY$
8.	$DL + LL \pm WX$
9.	$DL + LL \pm WY$

Table -2: Service Load combinations

The building was idealized into a structural frame and modeled in ETABS by generating the grids. The six different models were modeled and analyzed separately. These models are as follows:

BUILDING DESCRIPTION	
Number of Stories	G+10
Location of Building	Delhi
Purpose	Residential Occupancy
Sub-Structure	In-Situ Raft Foundation
Super-Structure	Ordinary Moment Resisting Frames
Floor Slab Type	Two-Way slab system
Lateral Load resisting system	Rigid Floor Diaphragm and OMRF with Shear Walls

Table -3: Building description

MATERIAL SPECIFICATIONS	
Elastic Modulus of M30 concrete	27386.12 MPa
Elastic Modulus of M40 concrete	31622.77 MPa
Poissons Ratio of Concrete	0.2
Elastic Modulus of Steel	200000 MPa

Table 4: Material specification

TYPE OF LOADING	CODE
Dead Load	IS 875 (Part 1): 1987
Live Load	IS 875 (Part 2):1987
Wind Load	IS 875 (Part 3): 1987
Seismic Load	IS 1893 (Part 1): 2016

Table -5: IS Codes used

DESCRIPTION		VALUE
Zone Factor	IV	0.1
Soil Type	Medium	II
Importance Factor	I	1
Response Reduction Factor	R	3

Table -6: Seismic parameters

DESCRIPTION	VALUE
Basic Wind Speed	44m/s
Design life of Structure (50 years)	1
Topography factor	1
Terrain Category	2
Importance Factor	1
Pressure Coefficient Positive	1.2
Pressure Coefficient Negative	0.001

Table -7: Wind load parameters

4. RESULTS

All the six models were analyzed, and the results were generated from ETABS. Before running the analysis, the model has been checked for any warnings.

Storey displacements plotted when Earthquake hits in X direction. Significant storey displacements are observed.

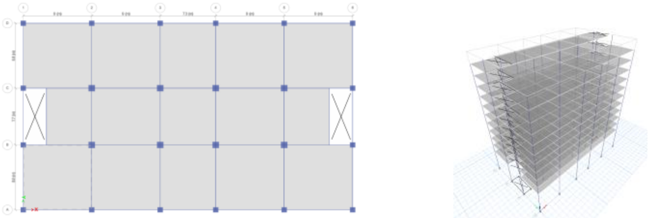

Fig -4: Model case 1

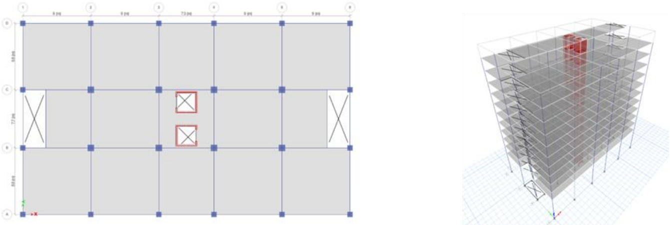

Fig -5: Model case 2

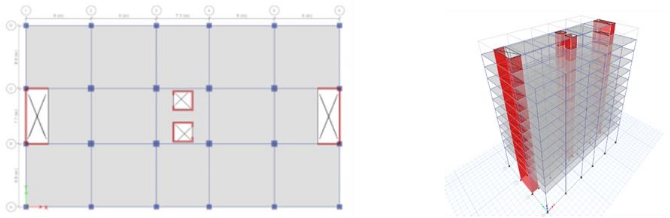

Fig -6: Model case 3

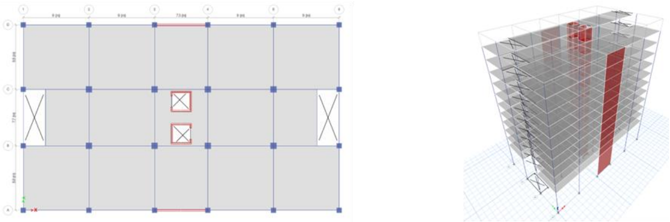

Fig -7: Model case 4

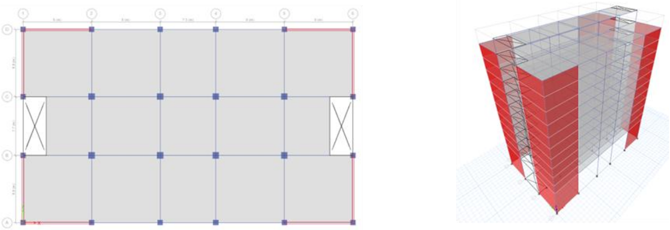

Fig -8: Model case 5

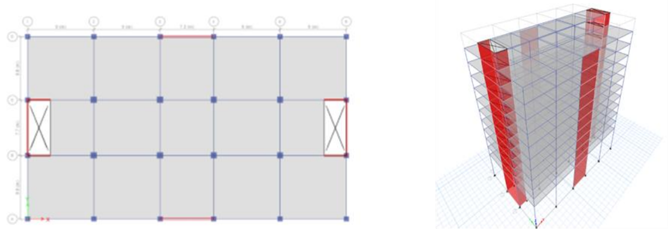

Fig -9: Model case 6

Model 1 having No shear walls tend to show very large displacements. Very small displacements are observed in Model 5 (Shear walls at corners). Model 2 & 4 are showing almost same storey displacements in Y direction. Similarly, Model 3 & 6. This shows that the contribution of the shear wall along X – direction is very less.

The max storey displacement is observed to be significantly reduced when compared with the building without shear wall. More than 50% reduction in displacements was noticed just by providing shear walls at the lift cores. Maximum of about 90% reduction in displacement was observed when the shear walls were located at the corners of the building. Different orientations of shear wall have been studied and the respective reduction was noted and can be seen in the bar graph. Although we have got 90% reduction with one of the orientations, we need to check whether it is optimum/ economical or not? To know that I have calculated the efficiency of every model considered. The efficiency was calculated by Max storey displacement divided by the length of shear wall provided. Calculations show that the maximum efficiency is shown by thr model with the shear walls at the Lift cores only

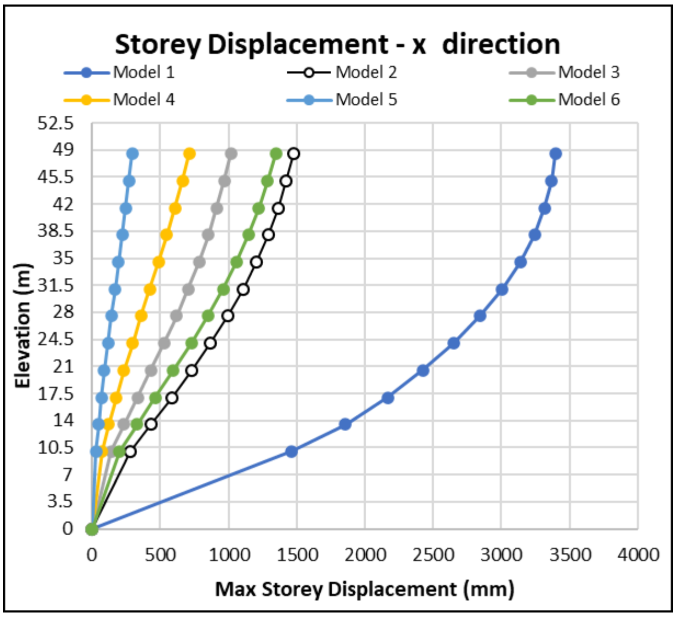

Fig -10: Storey displacement in x-direction

Model 1 give more displacement as compared to other Model, because the model doesn't have shear walls. Model 5 give very less displacement, because shear walls are provided at the corners. This configuration is restraining the displacement in all directions making the structure very stiff. The displacements are reduced by almost 50% just by providing shear walls at the lift cores.

Whereas providing shear walls along longer side of the structure is observed to be not very efficient. The reason is quiet obvious that the Moment of Inertia and so the stiffness of the structure is already higher along longer side, providing shear walls along this direction may be of no use and only increasing the cost of the structure.

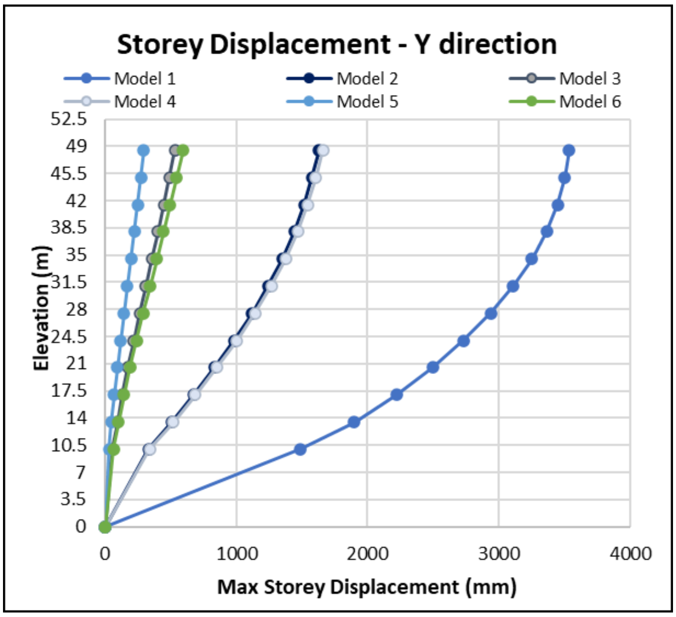

Fig -11: Storey displacement in y-direction

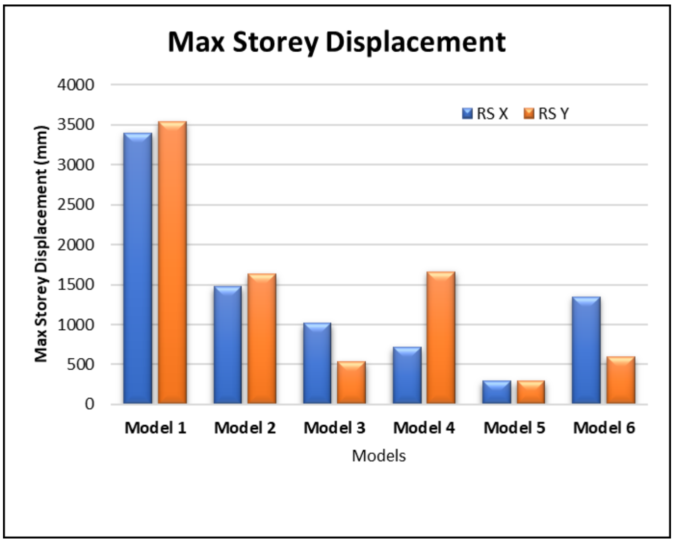

Fig -12: Maximum storey displacement

In figure 13, reduction of storey displacement with respect to Model 1 is given. Model 5 has shown the maximum about 90% reduction when shear wall is provided at the corners. Reduction in displacement may be a fascinating number but a good structural design can be identified by the efficiency of the structural components we are providing. And hence plotting the efficiency of each and every configuration considered is very important.

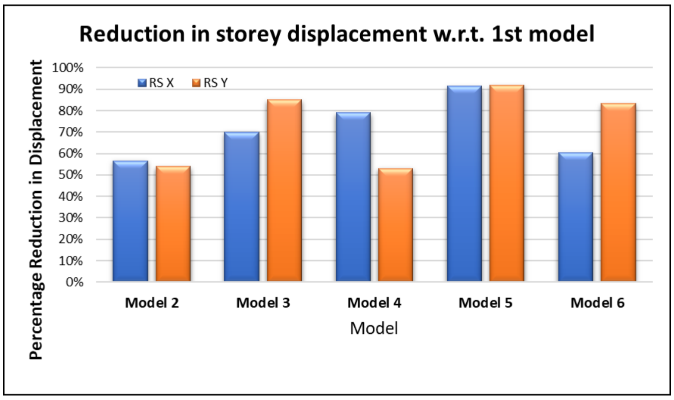

Fig -13: Reduction in storey displacement w.r.t. first model

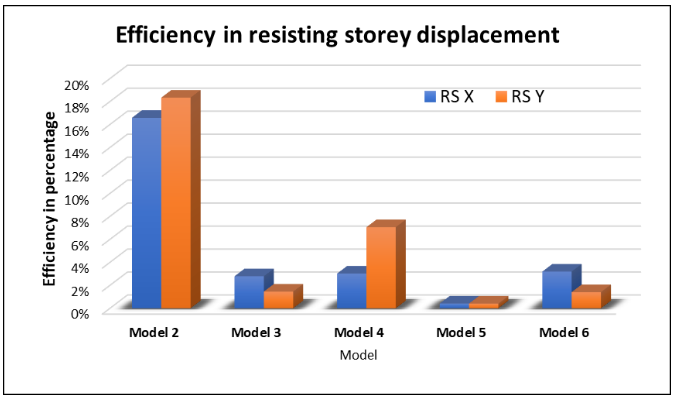

Fig -14: Efficiency in resisting storey displacement

4. CONCLUSIONS

Shear wall is become an important structural component when it comes to High-rise buildings. Provision of shear walls in high-rise structures significantly reduce the displacements and suppress the effect of seismic forces too. But, just providing the shear walls is not enough. The location where shear walls have to be provided and the configuration is of importance. As a structural engineer, we should always try to make the designs such that we are using lowest possible quantity of concrete and steel in the structure. Not only that but utilizing their strengths and capacities to the fullest.

1. Displacements of the structure can be reduced by around 50% just by providing shear wall at the center of the building.

2. Providing shear walls at the corner can be the best option when it is not possible to provide shear walls at the center.

3. Shear wall shall be provided along the shorter edge of the structure.

4. Providing shear walls along longer side of the structure may not be useful as structure already has higher stiffness along longer direction.

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