ANALYSIS OF SHEAR WALL LOCATION DUE TO EARTHQUAKE EFFECT IN HIGH RISE RCC STRUCTURES

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Abstract - Major hazards from earthquake, storms, tsunami in recent decades have brought increasing awareness among structural engineers. Earthquake produces large amount of lateral forces. Shear walls in building are better solution to counteract these forces. Our primary goal is to identify the best location of shear wall to generate minimum deflection. To achieve this goal a 25storeyed commercial cum residential building has been analyzed and the results of deflections for various loads and location cases have been compared for minimum deflection.The general definition of shear wall, their need, scope and objective of this study have been stated. The definition of shear wall is elaborately and briefly described here. Various types of shear walls, their common behavior, the loads they are subjected to are also described here. The most common and usual trend of shear wall location and shape havealso been discussed here.Methodology is mainly concerned with the defining of the different location cases for shear wall and their model generation. For this study 5 different location cases for a shear wall while keeping all the other structural element unchanged. The cases include Case1: the original plan, Case2: moving the shear wall 35 inch inward, Case3: moving the shear wall 70 inch inward, Case4: moving the shear wall 105 inch inward, Case5: moving the shear wall 140 inch inward. The model generation process of these 5 cases considering the loads such as Dead, Live, Wind, Earthquake have been developed by software ETABS9.The comparative results have showed that shear walls are more effective at the outer periphery and near columns. The structure has analyzed without basements. So their responses to loads are not included in the paper.

Index Terms - Shear Wall, Shear Wall Location,High Rise RCC Building, Earthquake.

I. INTRODUCTION

The reinforced concrete shear walls are important structural elements placed in multi storeyed buildings which are situated in seismic zones because they have a high resistance to lateral earthquake loads.Shear walls are introduced into modern tall buildings to make the structural system more efficient in resisting the horizontal and gravity loads, ground motions as well as thereby causing less damages to the structure during earthquake. One of the adverse effects for tall buildings is the high lateral load due to earthquake. The structure is still damaged due to some of the other reasons during earthquake. Behaviors of structure during earthquake motion depend on the distribution of weight, stiffness and strength in both horizontal and vertical planes of building. When buildings are tall, beam and column size needs to be quite heavy and steel requirement is also large. So there area lot of congestions at those joint and it is difficult to place and vibrate concrete at these place and displacement is quite heavy. When shear walls are situated in advantageous positions in building, they can form an efficient lateral force system. The provision of shear wall in building to achieve rigidity has been found effectively and economical.
In this paper five models for RCC frame type buildings with shear walls in different arrangements are generated with the help of ETABS9 and effectiveness has been checked.

II. LITERATURE REVIEW

It has always been a human desire to create taller and taller structures. So in recent days there is a considerable increase in the high rise buildings and the modern development is heading towards taller and slender structures. Every structural engineer is familiar with the problem of giving sufficient strength and stability of these tall buildings against lateral loads thus the effect of lateral loads like wind load,earthquake loads, blast forces and attaining escalating importance. The major types of loads are dead load, live load, cyclic load, seismic load etc.

Reinforced concrete buildings often have vertical plate like RC walls, called shear walls. Shear walls are like vertically oriented wide beams that carry earth quake loadsand transfer them downwards to the foundation. These walls start at foundation level and are continuous throughout the building height. Their thickness can be as low as 150 mm or as high as 400 mm in high rise building. Shear walls are usually provided along both length and width also have columns. These columns primarily carry gravity loads.Lateral loads serve sever damage to the existing building that are poorly designed for seismic and lateral loads.The designs of these kinds of buildings are quite complex and difficult. Shear walls can be classified in different aspects like height consideration, consideration of section properties and

the number of shear walls to be connected. Monolithic shear walls are classified as short, squat or cantilever according to their height to depth ratio.

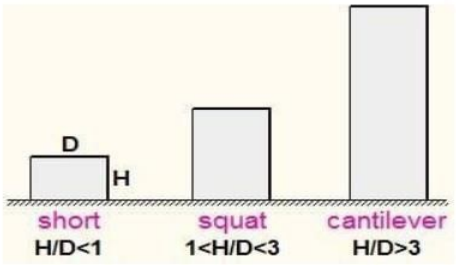


Fig. 1: Classification on the Basis of Height.

Generally shear walls are either plane or flanged in section, while core walls consist of channel sections.

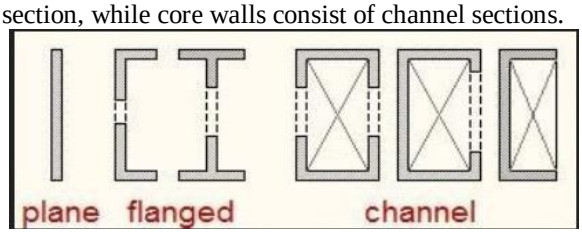


Fig. 2: Classification on the Basis of Sections.

Normally the walls are connected directly to the foundations. However, in a few cases where the lateral loads are relatively small and there are no appreciable dynamic effects, then they can be supported on columns connected by a transfer beam to provide clear space. In many cases, the wall is pierced by openings. These are called coupled shear walls because they behave as individual continuous wall sections coupled by the connecting beams or slabs. In the first case the shear walls are connected by beams and in the second case the shear walls are connected with slabs.

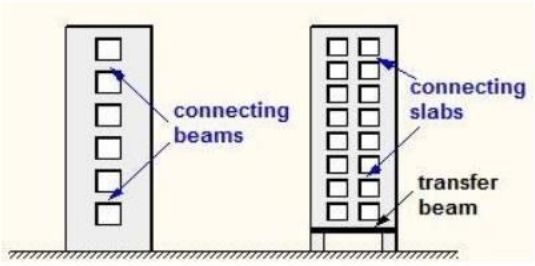


Fig. 3: Classification on the Basis of Connection.

The purpose of this study is to investigate the best location of shear wall in high rise buildings. Large horizontal stiffness difference between the side frames is caused by the shear wall location.

Table 1: Material Properties

Compressive Strength of Concrete, f'_C	4 ksi
Elastic Modulus of Concrete , E_c	3600 ksi
Poison Ratio of Concrete	0.2
Yield Stress of Steel, F_Y	60 ksi
Elastic Modulus of Steel, E_s	29000 ksi
Poison Ratio of Steel	0.3

III. METHODOLOGY

In this current state we don't have much option for horizontal expansion of buildings due to the constraint of land. So vertical expansion is done and high rise buildings are built. These structures are more sophisticate and are subjected to have more loads in addition to their dead & live loads such as earthquake and seismic loads. So their modeling, design, detailing and construction are done more carefully and precisely. For more design accuracy and time consumption issue, softwares are used. The two most important factors in the analysis and design of building structures are choosing an appropriate structural modeling method which reflects the actual behavior of the system and deciding on the analyzing technique to be performed on the structure. In methodology the design perimeters, standards, material properties, different sections, section properties, modeling process and the whole making of the models will be described.

The purpose of this paper is to locate the position of a shear wall, where it will provide maximum stiffness and less deflection and less lateral sway when all the other shear walls and structural elements are unchanged. For this, original model has been prepared. Then the position of a shear wall has changed four times to compare the deflection.



Fig. 4: Plan of the Column and Shear Wall Layout.

The paper has a total of five cases. In 1st case, the original plan of the building has generated and analyzed. In the 2nd case, the shear wall of the section T-1 has moved 35 in. inward and the model has generated according to it and it has analyzed. In the 3rd case, the same shear wall of T-1 section has moved 70 in. inward and the model has analyzed

according to it. In the 4th case, the shear wall of T-1 section has moved 104 in. inward and has analyzed. In the 5th case, the model has analyzed by moving the shear wall 140in. inward.

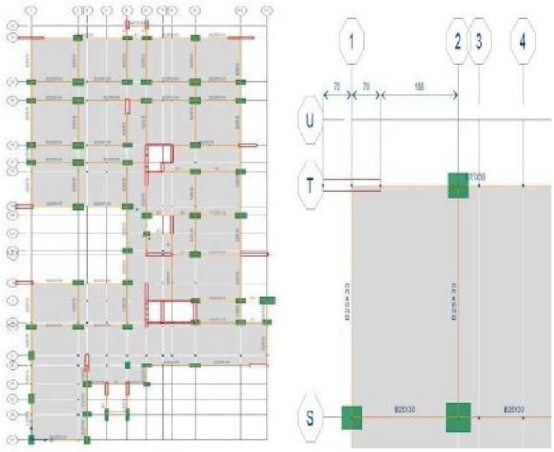


Fig. 5: Plan and Zoomed View of Case 1.

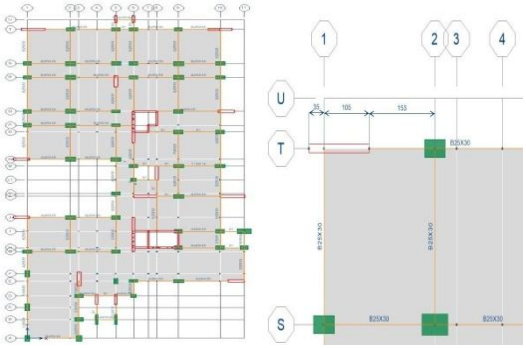


Fig. 6: Plan and Zoomed View of Case 2.

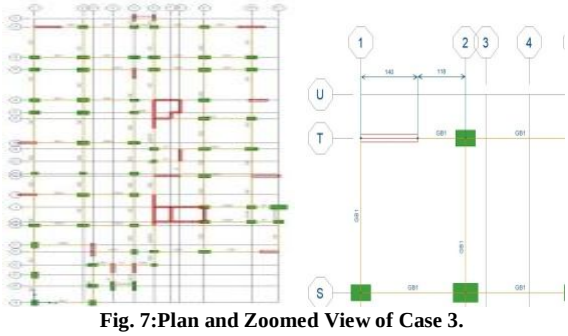


Fig. 7:Plan and Zoomed View of Case 3.

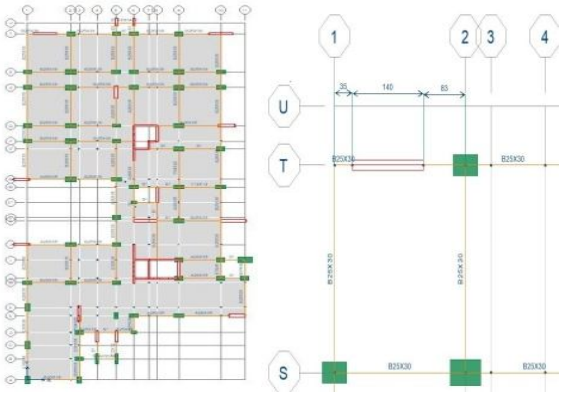


Fig. 8:Plan and Zoomed View of Case 4



Fig. 9:Plan and Zoomed View of Case 5.

After defining the material properties comethe section properties. Here the dimensions of the different structural members has provided and also defined their categories. For beams a clear cover of 2.5 in. has considered. The slabs are taken as shells and are provided with same thickness for both membrane and bending. The following tables shows the frame dimensions of the building.

Table 2: Frame Sections and Shear Wall Dimensions.

Beam (In^2)	Transfer Beam (In^2)	Column (In^2)	Shear Wall (In^2)
28x35	30x48	15x84	15x140
15x30	35x40	24x30	15x84
30x36	38x42	24x48	20x116
25x20	40x48	30x48	20x140
25x15	40x54	30x54	20x95
24x20		30x60	20x96
20x15		36x60	24x150
12x12		40x84	24x96

Table 3: Applied Loads on the Structures.

Types of loads	Value	Unit
Floor Finish (Super Dead)	5.57	psf
Partition Wall & Shear Wall	As per plan	psf
Live Load	42	psf
Wind Load	As per BNBC	
Earth Loading	As per UBC 94	

The applied loads on the structure are given in the table 3.Height of shear wall is as height of building. The shear walls are modeled as reinforced concrete for all structures. Auto mesh has been used both in slab and shear walls.

IV. RESULT AND DISCUSSION

This paper is concerned with the location of shear wall where it will provide less lateral deflection due to lateral forces such as earthquake load. In this paper results of deflection for the 5 varying positions of shear wall of grid T-1; when all the other structural

members remained in the same position will be discussed and compared. This paper has been written considering the analysis result of the models generated in ETABS9 for the five varied shear wall positions. In this paper a comparison is made between deflection resulted from the analysis for the five different cases and the best position of shear wall for that specific load is determined.

Table 4: Maximum Deflection for EQX.

Case Name	Deflection in X direction (in.)	Deflection in Y direction (in.)
case 1	3.186046	0.194729
case 2	3.192242	0.201156
case 3	3.201015	0.208364
case 4	3.194149	0.205072
case 5	3.178726	0.196366

The maximum permissible computed deflection for high storeyed building is $\frac{1}{480}$ according to BNBC 2006(chapter 6,table 6.6.4). The height of the building is 289ft. and the permissible deflection for it's top storey is 7.225 in. Here all the deflection values for EQX of different cases are within the limit. A bar chart has been created for both X & Y direction taking the above values to identify the maximum deflection.

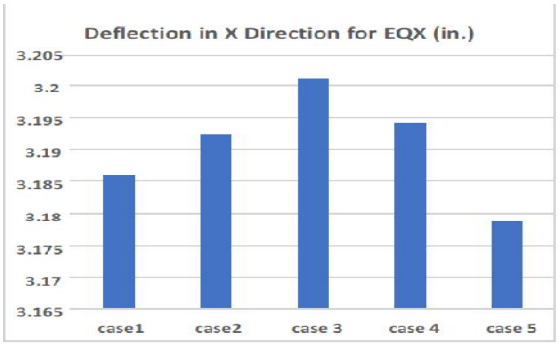


Fig. 10: Bar Chart Showing Comparative Deflection.

From the above bar chart of Fig. 10it is stated that the deflection is maximum for case 3 and it reduces gradually towards both case 1 and case 5. The minimum deflection is found for case 5 and then for case 1. So it can be said that the shear walls provide more resistance towards deflection due to EQX in the out most periphery and near the column.

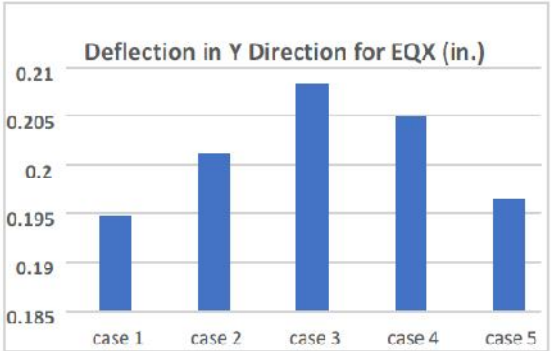


Fig. 11: Bar Chart Showing Comparative Deflection.

From the above bar chart of Fig.11 it can be stated that the deflection is maximum for case 3 and it reduces gradually towards both case 1 and case 5. The minimum deflection is found for case 1 and then for case 5. So it can be said that the shear walls provide more resistance towards deflection due to EQX in the out most periphery and near the column.

Table 5: Maximum Deflection for EQY.

Case Name	Deflection in X direction (in.)	Deflection in Y direction (in.)
case 1	0.177221	3.429296
case 2	0.19066	3.426937
case 3	0.187278	3.428149
case 4	0.192984	3.432434
case 5	0.198217	3.436181

The maximum permissible computed deflection for high storeyed building is $\frac{1}{480}$ according to BNBC 2006(chapter 6,table 6.6.4). The height of the building is 289ft. and the permissible deflection for it's top storey is 7.225inch. Here all the deflection values for EQY for different cases are within the limit. A bar chart has been created for both X & Y direction taking the above values to identify the maximum deflection.

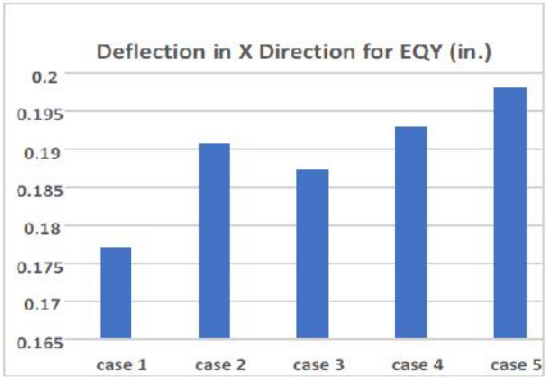


Fig. 12: Bar Chart Showing Comparative Deflection.

From the above bar chart of Fig.12 it can be stated that the deflection is minimum for case 1 and it increases in a nonlinear pattern toward the other cases. So it can be said that the outer most position is the best position for shear wall for resisting EQY in short direction.

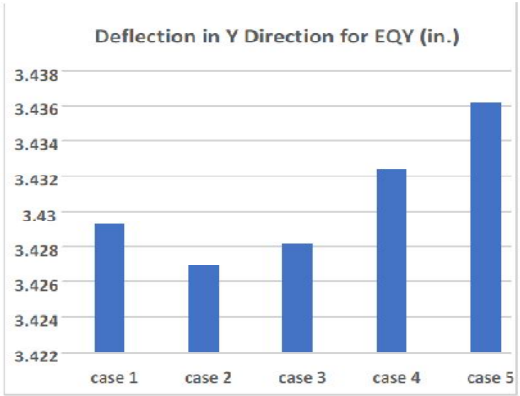


Fig. 13: Bar Chart Showing Comparative Deflection.

From the above bar chart of Fig.13 it can be stated that the deflection is maximum for case 5 and minimum for case 2. So it can be said that the shear walls are the most effective in the outer periphery for resisting EQY in long direction.

In the analysis of the model of the paper it has been found that the maximum deflection has caused due to earthquake load is 3.44inch. The maximum allowable limit for the deflection is 7.225inch according to BNBC 2006. The deflection is 47.65% of the allowable maximum deflection. So it is within the deflection limit of BNBC 2006. And the deflection result shows that the shear walls are more effective in the outmost periphery with greater depth of shear wall in the load direction.

CONCLUSIONS

From this paper work a few conclusions can be drawn -

- Lateral displacement is greater for high storey buildings.
- The maximum deflection has found 3.44 inch It is 47.65 percent of the allowable limit of 7.225inch according to BNBC 2006.
- The shear walls are more effective in the direction where the depth are greater. The shear wall of T-1 section has greater depth along X axis. The maximum deflection along this axis is 3.20 inch it is within the allowable deflection limit of 7.225inch according to BNBC 2006.
- Besides dead & live loads, the other loads also effect the lateral displacement of building.
- In a frame structure all the frames are subjected to additional moments and deflections due to earthquake loads.
- Shear walls can reduce the deflection of a building.
- Shear walls that are placed at the outer edge portion, periphery and near the column provide more stiffness to the structure resulting in less deflection.

RECOMMENDATIONS

Due to our confinement and our specific paper work we could not focus on many cases. So for future work a few directions can be given -

- The dimension of the shear wall should be changed and investigated for minimum deflections.
- Various type of shear walls such as L shaped, O shaped, I shaped shear walls should be tested for their performances.
- Effect of core shear walls should be investigated.
- The structure has analyzed without the basements. So their response to loads are not included in the paper. The structure can be analyzed with the basements and a real scenario of the structure can be created.

REFERENCES

[1] Varsha R. Rawnuck et al ,2014. Comparative study of strength of R.C shear wall at different location on multi storied building. International Journal of Civil Engineering Research. ISSN 2278-3652.

[2] shwinkumar Balaso Karnale et al,2015.IJIRSET-Comparative Seismic Analysis of High rise RCC building.

[3] P. V. Sumanth Chowdary et al,2014. Comparative Study on RCC Structure with and without Shear Wall". IJSRD - International Journal for Scientific Research & Development| Vol. 2, Issue 02, | ISSN (online): 2321-0613.

[4] Dhiraj.V.Narkhede et al,2016.Performance of Shear Wall Building at Various Positions.

[5] International Journal of Research in Advent Technology (IJRAT) (E-ISSN: 2321-9637).

[6] Mahdi Hosseini1,2016. Earthquakes Analysis of High Rise Buildings with Shear Walls at the Center Core and Center of Each Side of the External Perimeter with Opening.

[7] Rakshit Patil et al,2016.Optimal location of shear wall in high rise building subjected to seismic loading. International Journal For Technological Research In Engineering Volume 3, Issue 10.

[8] Bryan Stafford Smith & Alex Coull,2013.Tall building Structures: Analysis & Design.

[9] J. Penzien .2015."Earthquake Engineering and Structural Dynamics,vol 3".

[10] 9th world conference on Earthquake engineering,1988."Shear wall behavior of different size, Institute of technology IT pasadena".

[11] Bangladsh National Building Code, BNBC 2006.Loading chapter, zone coefficient for earthquake and wind.

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