EFFECTIVE LOCATION OF SHEAR WALL ON PERFORMANCE OF BUILDING FRAME SUBJECTED TO LATERAL LOADING

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Abstract - Shear wall systems are one of the most commonly used lateral load resisting systems in high-rise buildings. It is very necessary to determine effective, efficient and ideal location of shear wall. In this paper focuses to see the effect of shear wall location in multi-storied building. A residential building of G+15(16 Story) structure having base dimension of plan 49.25ft X 49.25ft with typical floor height of 10ft is considered. In this paper, 8, 10, 12, 14 and 16 storied buildings were modeled using software and three different models were studied with different location of shear wall in building frame for critical parameters like displacement and base shear under lateral loading. The analysis has been carried out using the software ETABS 9.6.0 and for analysis equivalent static method is used here. Three types of models (one without any shear wall, one with shear wall placed at middle of 4 periphery sides, one with shear wall placed at 4 corners in L shape) have been analyzed. It is found from this study that Model 2 (one with shear wall placed at middle of 4 periphery sides) shows best performance as far as top displacement and base shear are concerned.

Keywords - Shear wall system, Shear Wall Location, RCC Structure, Tall building, Soft storey, Lateral loading, and Equivalent static method.

I. INTRODUCTION

Tall buildings are the most complex built structures since there are many conflicting requirements and complex building systems to integrate.Today's tall buildings are becoming more and more slender, leading to the possibility of more sway in comparison with earlier high-rise buildings. Thus the impact of wind and seismic forces acting on them becomes an important aspect for the design. Reinforced concrete framed buildings are adequate for resisting both vertical and horizontal loads acting on them. Lateral forces like wind and seismic forces can be resisted by the use of a shear wall system which is one of the most efficient methods of ensuring the lateral stability of tall buildings.

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. An introduction of shear wall represents a structurally efficient solution to stiffen a structural system because the main function of a shear wall is to increase the rigidity against lateral load.

When a building has a story without shear wall, or with poorly placed shear walls, it is known as a soft story building. 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. The size and location may vary from architectural and functional point of view.Shear walls in buildings must be symmetrically located in plan to reduce ill-effects of twist in buildings. When shear walls are situated in advantageous positions in the building, they can form an efficient lateral force resisting system by reducing lateral displacements under earthquake loads. Therefore it is very necessary to determine effective, efficient and ideal location of shear wall. In this paper effort has been made to investigate the effect of Shear Wall position on lateral displacement and Base Shear in RCC Frames.

II. LITERATURE REVIEW

In modern civilization tall buildings have rapidly developed worldwide. Tall buildings are symbols of civilized, congested and populated society. It certainly resembles the economic growth, the force and the image of a civilization. A Tremendous variety of field of study shapes and complicated structural layouts are designed. The design of tall buildings essentially involves an approximate analysis, conceptual design, preliminary design and what's more, advancement, to securely convey gravity and horizontal burdens. The design criterion is strength, serviceability, stability and also human comfort. The strength is satisfies by limit stresses, while serviceability is satisfies by drift limits in the range of H/300 to H/500. Stability is satisfied by sufficient safety factor against buckling and P-Delta effects. The safety factor is around 1.67 to 1.92. The human comfort aspects are satisfied by accelerations are in the range of 10 -25 mg, where, g-acceleration due to gravity=981cms/sec^2.

High-rise buildings are constructed everywhere in the world. The structural design of high-rise buildings depends on dynamic analysis for winds and earthquakes. Now a day's performance of computer progresses remarkably, almost structural designers use the software of computer for the structural design of high-rise buildings. 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 willprevent floor and roof framing members from moving off their supports. Also,buildings that are sufficiently stiff will usually suffer less non-structural damage.

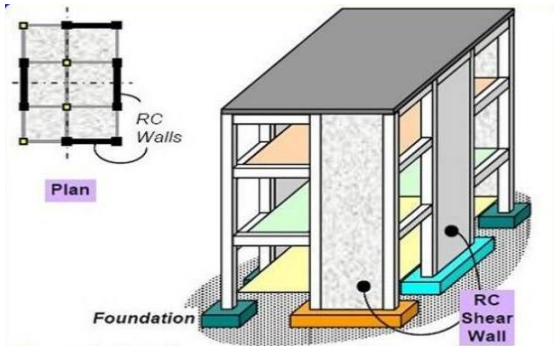


Fig 1:Reinforced concrete Shear wall in buildings – an excellent structural system earthquake resistance

The purpose of this study is to investigate the effect of shear wall location in rigid frames. Large horizontal stiffness difference between the side frames is caused by the shear wall location.

compressive strength of concrete, f'c	4 ksi
Elastic modulus of concrete , E	3600 ksi
Poison ratio of concrete	0.2
Yield stress of steel, Fy	36 ksi
elastic modulus of steel, E	29000 ksi
poison ratio of steel	0.3

Table 1: Material properties

III. METHODOLOGY

A residential building of G+15(16 Storey) structure having base dimension of plan 2425.6 square feet with typical floor height 10ft is considered for the analysis.The slab thickness is 5 inch.These buildings were designed in compliance to the Bangladesh National Building Code for Seismic Resistant Design of Buildings (BNBC 2006) under gravity loading.

The study is carried out on the same plan with three different shear wall location i.e. without shear wall (Model -1), shear wall at middle along periphery (Model -2), and another is shear wall at Corner along periphery (Model -3). The shear wall thickness is 10inch. The plinth height is 6ft above from foundation base. The typical plans are shown in figure respectively.

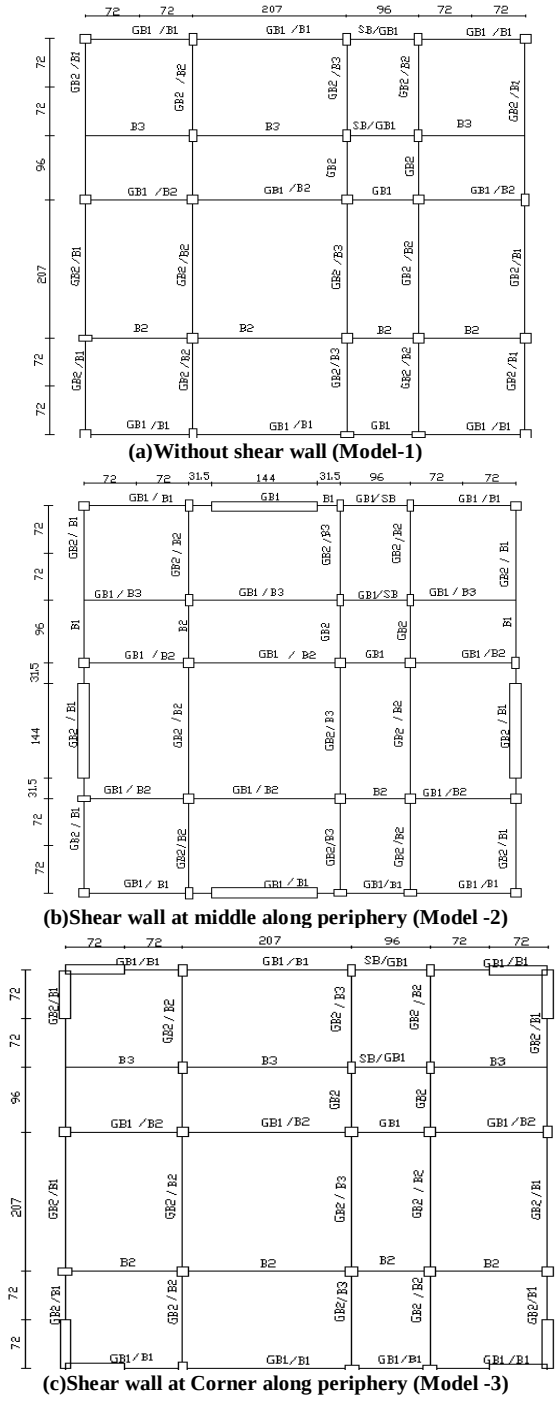


Fig. 2: Typical building plan of (a) Without shear wall (Model-1), (b) Shear wall at middle along periphery (Model-2) and (c) Shear wall at Corner along periphery (Model -3)

While modeling the beams and columns, the properties to be assigned are cross sectional dimensions, reinforcement details and the type of material used.

Section Name	Dimension(Inch)
B1	15X10
B2	18X10
B3	21X10

GB1	12X10
GB2	15X10
SB	18X10

Table 2: Beam dimensions

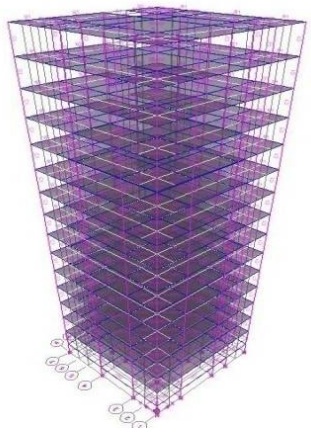
Section Name	Dimension(Inch)
C1	15X12
C2	18X12
C3	18X12
C4	21X12

Table 2: Column dimension

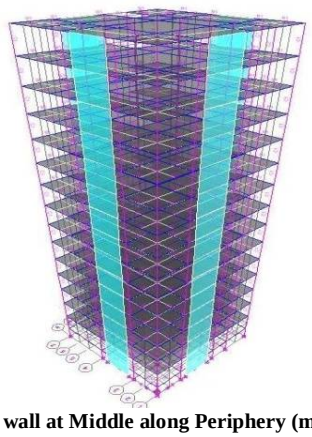
Types of load	Value	Unit
Floor Finish(Super Dead)	5.63	psf
Partition Wall & Shear Wall	As per plan	psf
Live Load	42	psf
Wind Load	As per BNBC	
Earthquake loading	As per UBC 94	

Table 3: Applied loading on the structures.

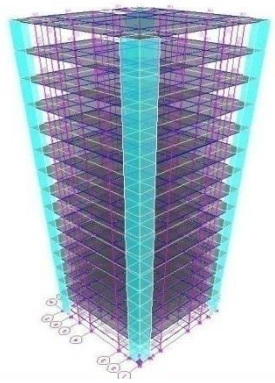
The applied loads on the structure are given in the table 3. Dimensions of shear walls are same in all models. Height of shear wall is as height of building.



(a) Without Shear Wall (Model -1)



(b) Shear wall at Middle along Periphery (model -2)



(c) Shear Wall at Corner along Periphery (Model -3)

Fig. 3: Three Dimensional View of Building (a) Without shear wall (Model-1), (b) Shear wall at middle along periphery (Model-2) and (c) Shear wall at Corner along periphery (Model -3)

First model is without shear wall (Model-1), second one is shear wall at middle along periphery (Model-2), and other one is shear wall at corner along periphery (Model -3). The shear walls are modeled as reinforced concrete for all structures. Auto mesh has been used both in slab and shear walls.

RESULT AND DISCUSSION

The model analysis is done by using various parameters and with the some relationship by comparing with the pattern of identical parameters. It should also be noticed that the area of shear wall in all models is same. The area is (144×10) =1440 in^2.

The parameters for this analysis are-

- Structural Displacement
- Base Shear

4.1Displacement

From this study, we saw that the displacements of three different models. Displacement of Model -1 is highest than the other structures.

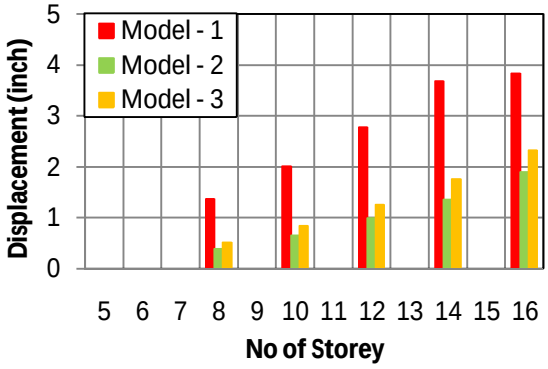


Fig 4: Structural Displacement due to Earthquake Loading

When the shear wall is located at the middle of periphery (Model -2), top displacement of the structure is lowest than two other models. So Model -2 is more efficient than others. Model -3has lower

displacementthan Model -1 but little bit higher than Model -2.

4.2 Base shear

Base shear is the maximum expected lateral force that will occur due to seismic ground motion at the base of the structure. Figure 5 compares the base shear values of the models in X-direction using equivalent static method.

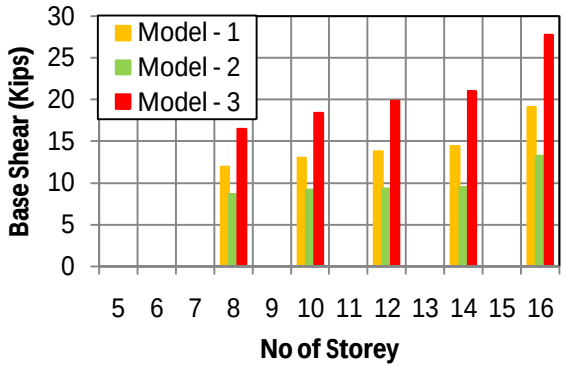


Fig 5:Base Shear due to Seismic Ground Motion

From the above figure it is found that Model -3 has maximum base shear in all 8,10,12,14 and 16 storeys (16.47, 18.44, 19.89, 21.03 and 27.78 Kips).It is also found that the base shear of Model -1 is higher for all structures than the base shear of Model-2.

Lesser value of base shear indicates higher seismic weight of the structure. The base shear variation for earthquake forces in all directions shows that the base shear for shear wall at middle of periphery structure is lesser than the other two structures. Hence the shear wall at middle along periphery (model -2) shows best performance as far as base shear values is of concern.

CONCLUSIONS

This study concludes that that Reinforced concrete frame building without shear wall will exhibit a poor performance to resist any type of lateral load. In medium high rise buildings (i.e. greater than 10 storeys) provision of shear walls is found to be effective in enhancing the overall seismic capacity of the structure.

Among three models, Model 1 (Building without shear wall) shows the maximum top displacement value, whereas Model2 (Building with shear wall placed at middle of 4 periphery sides) shows the minimum top displacement value.

The shear force at ground level of model3 (building with shear wall placed at 4 corner in L shape)is larger compared to model 2.Hence, it can be said that building with shear wall placed at middle along the 4 periphery (Model 2) is more efficient than shear wall in other positions. To make comprehensive comments more buildings with different shear wall positions need to be analysed.

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