# NUMERICAL ANALYSIS OF HIGH RISE RCC BUILDINGS WITH SHEAR WALLS HAVING OPENING OF DIFFERENT SHAPES

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**Abstract -** Shear walls are provided in high rise structures and structures located in higher seismic vulnerability areas. The primary purpose of shear wall is to resist lateral forces arising due to earthquake or wind. This project aims to study effect of various types of openings and without openings in shear wall on behavior of structural frames. In this study different storied RCC buildings with shear wall have been analyzed using finite element software ETABS9. The same buildings have analyzed having openings of different shapes (Rectangular, Triangular) and without openings in shear wall. The structures are analyzed with equivalent static method. Non Llinearity is not considered here. Deflection, axialforce, shearforce, bending moment of column of buildings having shear wall with opening and without opening have been obtained. Deflection, axialforce, shearforce, bending moment increase with number of stories. Buildings having 8,10,12,15 stories have been analyzed. The longest span in X direction is 22 ft. and in Y direction is 20 ft. Total length in X direction is 110 ft. and in Y direction is 60 ft. The comparative results have showed that the deflection, axial force, shear force and bending moment at bottom column depend on the shapes of openings with different number of stories of structures.

**Index Terms -** Shear Wall,Shear Wall Opening, High Rise RCC Building,Soft Storey.

## I. INTRODUCTION

RCC Multi Storeyed Buildings are adequate for resisting both the vertical and horizontal load. When such building is designed without shear wall, the beam and column sizes are quite heavy, steel quantity is also required in large amount thus there is a lot of congestion at these joint and it is difficult to place and vibrate concrete at these places and deflection is quiteheavy which induces heavyforcesin member. Shear wall may become imperative from the point of view of economy and control of lateral deflection.

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 storeyed buildings. Design by coinciding center of mass and stiffness of the building is the ideal for a Structure. Providing 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. The use of shear wall structure has gained popularity in high rise building structure, especially in the construction of service of apartment,office, commercial tower. It is very important to note that shear walls meant to resist earthquake should be designed for ductility.

When there is a storey in a building without shear wall or shear wall with improper openings, it is known as a soft storeybuilding.The opening area percentage in a shear wall should be less than or equal to 30 percent of the total area of that particular shear wall in a RCC building to reduce ill-effects of twist in buildings. When shear walls are situated with proper opening in the building, they can form an efficient lateral force resisting system by reducing lateral displacements under earthquake.

## II. LITERATURE REVIEW

Tall towers and multi storeyed buildings have fascinated mankind from the beginning of civilization, their construction being initially for defense and subsequently for ecclesiastical purposes. These tall buildings because of its height, are affected by lateral forces due to wind or earthquake actions tends to snap the building in shear and push it over in bending. In general, the rigidity (i.e. Resistance to lateral deflection) and stability (i.e. Resistance to overturning moments) requirement become more important. Shear walls (Structural walls) contribute significant lateral stiffness, strength, and overall ductility and energy dissipation capacity. In many structural walls a regular pattern of openings has to be provided due to various functional requirements such as to accommodate doors, windows and service ducts. Such type of openings reduces the stiffness of the shear wall to some extent depending on the shape of the opening. In the present parametric study, efforts are made to investigate and critically assess the effects of various shapes of openings in shear walls on the responses and behaviors of multi storeybuildings.The 8,10,12&15 storey prototype

buildings with different types of openings and without openings in shear wall have analyzed using software ETABS9.

The design criterions are 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=981 cm/sec$^2$.

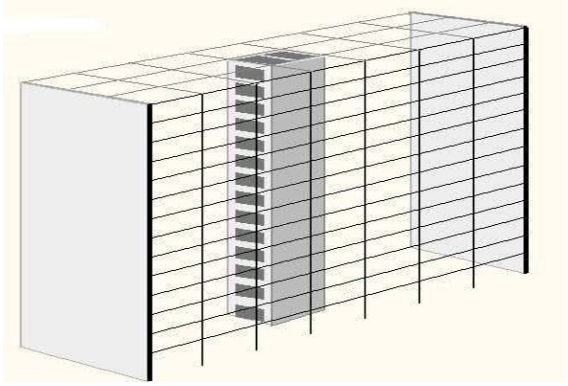


**Figure 1: RCC Shear Wall in Lift Well.**

The purpose of this study is to investigate the effect of shear walls having openings of different shapes and without openings in rigid frames. Large horizontal deflection difference between the side frames is caused by the shear wall opening shapes.

**Table 1: Material Properties**

| | |
|---|---|
| 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, $F_Y$ | 36 ksi |
| Elastic Modulus of Steel, E | 29000 ksi |
| Poison Ratio of Steel | 0.3 |

## III. METHODOLOGY

Three residential buildings of 8,10,12,15 storeyed having base dimension of plan 8400 square feet with typical floor height 12ft. 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 two different shaped openings in shear wall and also a solid shear wall i.e. without opening in shear wall, shear wall with rectangular opening and another shear wall with triangular opening. The shear wall thickness is 10 inch. The plinth height is 7ft above from foundation base. The typical plans are shown in figure respectively.

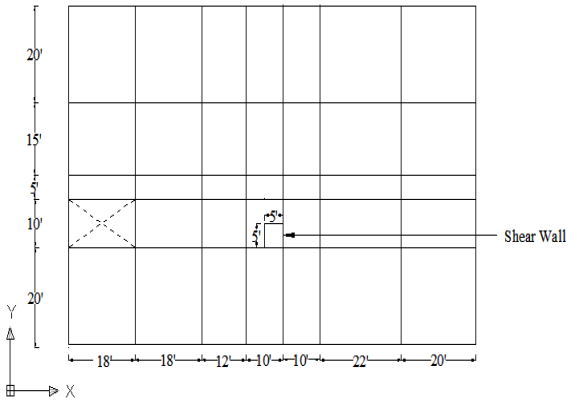



**Figure 2: Same Plan of All Analyzed Buildings.**

We have analyzed the no. 10 column of ground floor for all the structures to observe the effects for having no opening in shear wall and having rectangular and triangular shaped opening in shear wall with various storied buildings.

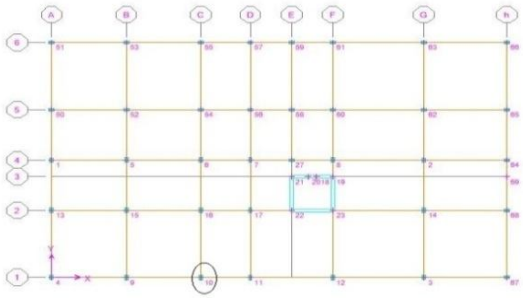


**Figure 3: Column Numbering in Plan View.**

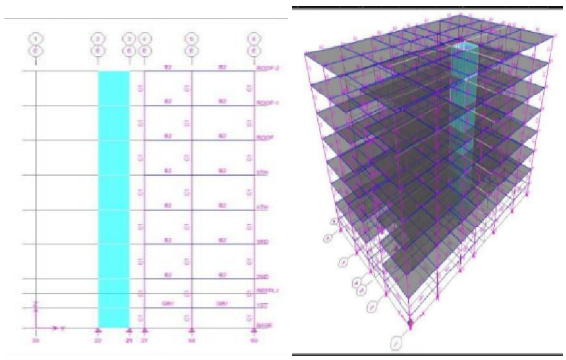


**Figure 4: Shear Wall Without Opening (Basic).**

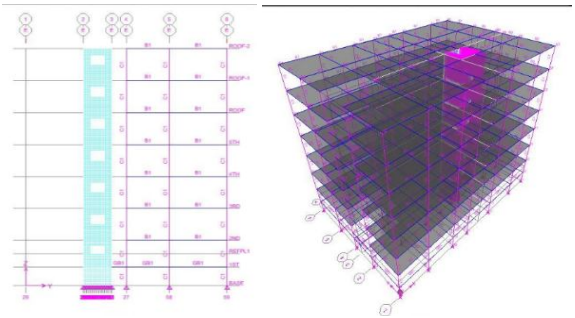


**Figure 5: Shear Wall With Rectangular Opening.**

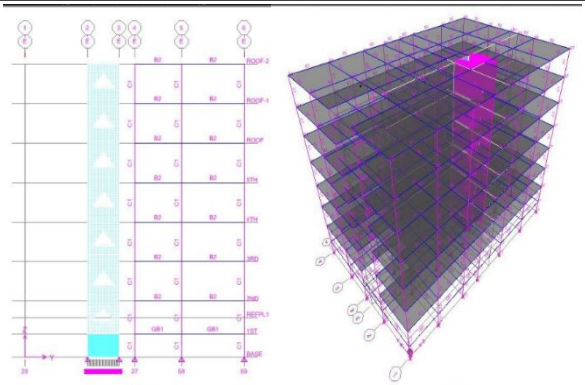


**Figure 6: Shear Wall With Triangular Opening.**

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

**Table 2: Beam Dimensions**

| Section Name | Dimension (inch) |
|---|---|
| B1 | 15x12 |
| B2 | 18x12 |
| B3 | 21x12 |
| GB1 | 12x10 |
| GB2 | 15x12 |
| SB | 18x12 |

**Table 3: Column Dimensions**

| Section Name | Dimension (inch) |
|---|---|
| C1 | 15x10 |
| C2 | 18x10 |

**Table 4: 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 4. Dimensions of shear walls are same in all models. 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

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 noted that the area of shear wall of all models is same and the area is (144×10) =1440 $in^2$.The opening area of both rectangular and triangular opening in shear wall is same and the value is 432 $in^2$ which is 30% of the total area of the shear wall in both the opening cases.So that, we can compare the models effectively and canfind outwhich one can give better performance. The parameters for this analysis are-

- Comparison of Structural Deflection
- Comparison of Axial Force
- Comparison of Shear Force
- Compare of Bending Moment

### Deflection

**Table 5: Deflection (in.) of Column 10 at Ground Floor.**

| Types of Opening | Storey | | | |
|---|---|---|---|---|
| | 8th | 10th | 12th | 15th |
| Basic | 0.412 | 0.432 | 0.451 | 0.480 |
| Rectangle | 0.635 | 0.649 | 0.663 | 0.672 |
| Triangle | 0.465 | 0.479 | 0.492 | 0.519 |

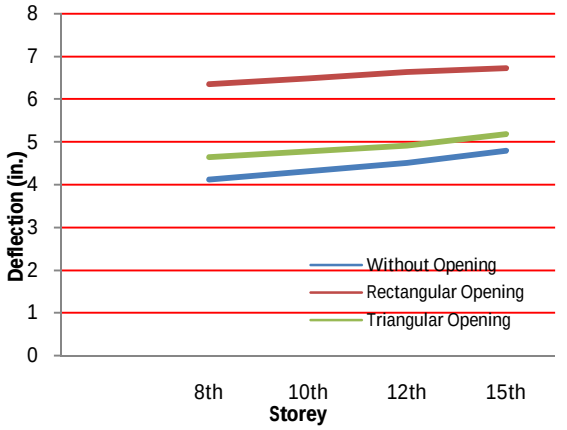



**Figure 7: Deflection vs. Storey Graph.**

From fig. 7 it can be stated that for all the three types of models deflection values gradually increase with the increase of the number of stories of the building.It is observed that the deflection values for the column 10 of GF are maximum in the building where we took 30% rectangular opening in shear wall.The values in the 'Y' axis of the graph is multiplied by 10 with the column values.

The deflection values for column 10 of GF in the buildings where we took 30% triangular opening in shear wall are less than the rectangular opening model. The minimum values of deflection are seen in the basic models of the buildings without opening in shear wall. From the graph (fig. 7) it is seen that themagnitude between basic & rectangle curve is higher than the other.

## Axial Force

**Table 6: Axial Force (kip) of Column 10 at Ground Floor.**

| Types of Opening | Storey | | | |
|---|---|---|---|---|
| | 8th | 10th | 12th | 15th |
| Basic | 613.5 | 790.9 | 964.8 | 1212.8 |
| Rectangle | 703.2 | 909.6 | 1113.0 | 1406.4 |
| Triangle | 614.4 | 791.2 | 966.28 | 1379.5 |

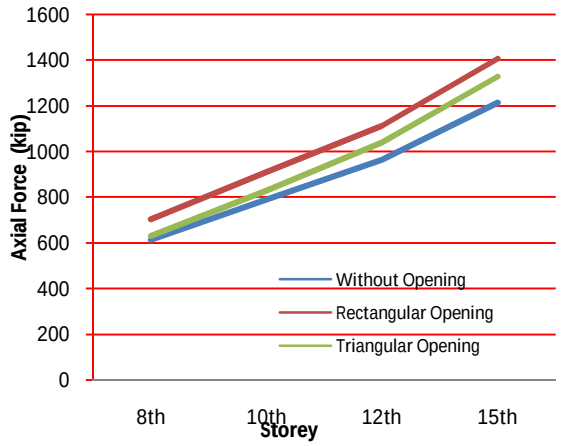



**Figure 8: Axial Force vs. Storey Graph.**

From fig. 8 it can be stated that for all the three types of models axial force values gradually increase with the increase of the number of stories of the building. It is observed that the axial force values for the column 10 of GF are maximum in the building where we took 30% rectangular opening in shear wall. The axial force values for column 10 of ground floor in the buildings where 30% triangular opening in shear wall are less than the rectangular opening model is found.

The minimum values of axial force are seen in the basic models of the buildings without opening in shear wall.It can be seen that the values of basic & triangular model are very close to each other. That means the behavior for shear wall with triangular opening and without opening is quite similar in terms of axial force.From the graph (fig. 8) it is found that there is a jump at 12$^{th}$ floor. It may be the change of the height of the building non-uniformly. There, the difference is 3 whereas the previous difference is 2.

## Shear Force

**Table 7: Shear Force (kip) of Column 10 at Ground Floor.**

| Types of Opening | Storey | | | |
|---|---|---|---|---|
| | 8th | 10th | 12th | 15th |
| Basic | 1.67 | 1.68 | 1.70 | 1.71 |
| Rectangle | 1.70 | 1.73 | 1.76 | 1.80 |
| Triangle | 1.79 | 1.81 | 1.83 | 1.88 |

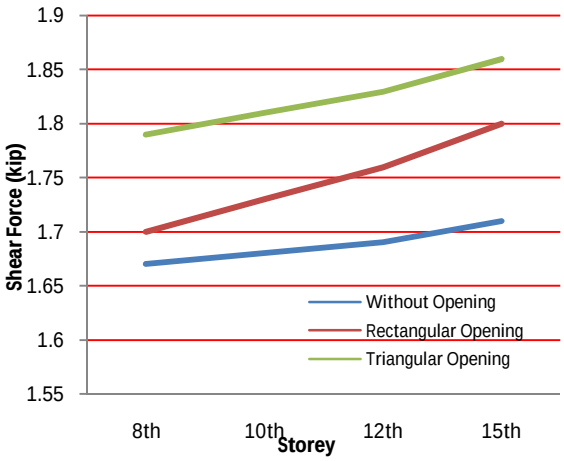



**Figure 9: Shear Force vs. Storey Graph.**

From fig. 9 it can be stated that for all the three types of models shear force values gradually increase with the increase of the number of stories of the building. But the values are too small as compared to bending moment and axial force but greater than deflection.It is observed that the shear force values for the column 10 of ground floor are maximum in the building where we took 30% triangular opening in shear wall. The shear force values for column 10 of ground floor in the buildings where we took 30% rectangular opening in shear wall are less than the triangular opening model. The minimum values of shear force are seen in the basic models of the buildings without opening in shear wall.The difference of shear force values for different storied building is very small.

## Bending Moment

**Table 8: Bending Moment (kip-ft) of Column 10 at Ground Floor.**

| Types of Opening | Storey | | | |
|---|---|---|---|---|
| | 8th | 10th | 12th | 15th |
| Basic | 114.99 | 116.06 | 117.01 | 118.29 |
| Rectangle | 117.53 | 119.50 | 121.32 | 123.89 |
| Triangle | 123.41 | 124.93 | 126.35 | 129.90 |

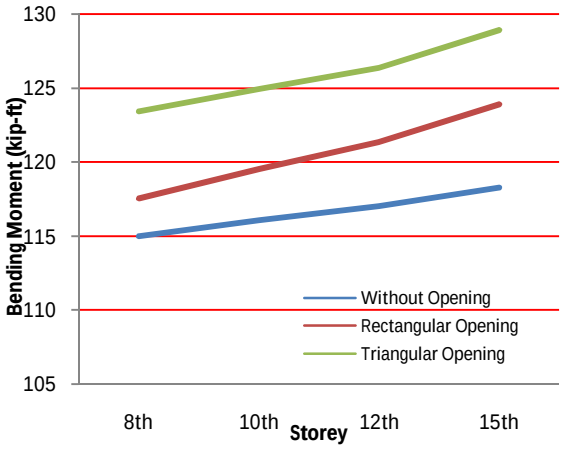



**Figure 10: Bending Moment vs. Storey Graph.**

From fig. 10 it can be stated that for all the three types of models bending moment values gradually increase with the increase of the number of stories of the building.It is observed that the bending moment values for the column 10 of ground floor are maximum in the building where we took 30% triangular opening in shear wall.
The bending moment values for column 10 of ground floor in the buildings where we took 30% rectangular opening in shear wall are less than the triangular opening model. The minimum values of bending moment are seen in the basic models of the buildings without opening in shear wall.

## CONCLUSIONS

In the present study, linear finite elements have analyzed with reinforced concrete buildings by changing shapes of openings and without openings in shear walls are carried out for different number of stories. The shapes of openings in shear walls vary as well as having no opening in shear walls along with the number of stories. The buildings are analyzed for severe earthquake load in Dhaka (seismic zone II). Comparisons are made between variousparameters such as deflection,axialforce,shearforce,bending moment. Some prominent conclusions for shear wall with and without opening are as follow:

**1)** The bending moment and axial force values vary as shapes of opening vary because stiffness of shear wall vary in terms of different shapes of openings.
**2)** For all the three types of the models deflection, axial force, shear force and bending moment values gradually increase with the increase of number of stories of the building.
**3)** The maximum deflection values and axial force values are found in the building having rectangular opening in shear wall.
**4)** The minimum values of deflection, axial force, shear force and bending moment are found in basic model in the building without opening in shear wall.
**5)** The magnitude of deflection between basic (without opening) and rectangular opening curve is higher than the triangular opening curve.
**6)** The values of axial force are very close to building without opening and having triangular opening in shear wall.
**7)** The maximum shear force and bending moment values are found in the building having triangular opening in shear wall.
**8)** The values of shear force are too small as compared to bending moment and axial force but greater than deflection values.

## RECOMMENDATIONS

The following recommendations are suggested for the future researches which are not covered in this study.The recommendations are as follow:

- We are unable to do experiment due to the lacks of building materials and time.But itwill be the best if we can do it practically.
- Additional steel reinforcement around the opening can be investigated and simulated by finite element software.
- The ill effects of shear walls caused by the openings can be improved by increasing the thickness of the shear wall.

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