International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 06 | June 2021 www.irjet.net p-ISSN: 2395-0072

EFFECT OF OPENING IN SHEAR WALL ON THE COLUMNS OF BUILDING

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Abstract - *In recent years mid-rise buildings are become very popular for the residential purpose. According to the recent construction norms Shear walls are the compulsory and important structural element in the RC framed building for fulfilling the criteria of the earthquake resistant structures. Shear walls resists the lateral loads coming on the structure which may be earthquake or wind forces. Sometimes due to the architectural or functional requirements such as doors, windows etc. openings have to be provided to the shear wall which can affects the structural elements of the structure. Therefore, this paper studies the effect of different sizes and arrangements of openings in shear wall on the columns of the structure. The study is carried out on the G+10 mid-rise structure using finite element software ETABS for analysis. Analysis is done by a linear static response spectrum method. Parameters studying are bending moments in the columns and axial forces developed on the columns.*

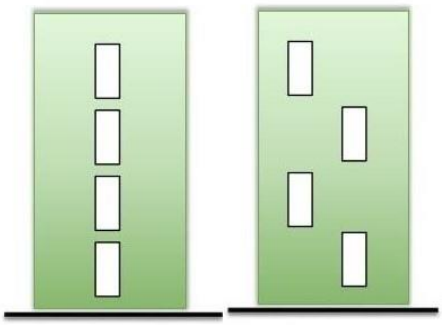
Key Words: **Shear wall with openings, ETABS, Response spectrum method, opening percentage, Column Moments, Axial Forces.**

1. INTRODUCTION

Finite Element Shear walls are the vertical structural element resist the lateral load arrived due to the earthquake or wind forces. The location of shear wall governs the important role in the resisting the lateral load. Sometimes shear walls are situated at locations where the openings are required for fulfilling the functional or architectural requirements. The opening in shear wall affects the seismic performance of the structure. It may reduce the lateral stiffness also. Therefore in this kind of cases design of shear wall has to follow in such way that it doesn't reduce or affects the stability of the shear wall. A different code from different countries provides some special arrangements of reinforcement for designing the shear wall with opening.
For studying the effects of opening, analysis of shear wall have to be perform. The non-linear dynamic analysis is important to understand the changes in the seismic parameters. For this finite element analysis, special software or programs are designed to perform this kind of non-linear dynamic analysis most precisely. For performing non-linear analysis, time history method and pushover analysis method are the well-known methods used at the field. Also ETABS, Staad.Pro, SAP, Ansys are the some commonly used finite element based software's in India.

1.1 Shear wall with openings

Shear wall with openings are mostly dependent on the functional and architectural requirement. In most of the cases the openings are given foe the window purposes in shear wall. Otherwise it may require for the door purpose for the core wall of the lifts. The sizes of openings may vary as per the requirements but theses openings may causes serious damage to the performance of the building. The openings can affects the seismic performance of the building as well as it also affects the frame of the structure. These openings can be arranged in two ways. (a)regular arrangement and (b)irregular arrangement.



(a) (b)

1.2 Aim

To make a comparative study of the different models of same building structure having a shear wall with different sizes and arrangements of opening in it for the window purposes.

1.3 Objectives

1. To study the effect of different sizes and arrangements of openings on the bending moments developed on the columns.
2. To study the effect of different sizes and arrangements of openings on the axial forces developed on the columns.

2. MODELING

We are preparing one structural plan of residential building which having shear walls at 2 locations. The following structural plan shows the location and detailing of the structural plan.

1.	Plan dimension	19030X8810
2.	Beam size	230X450
3.	Column sizes	
	C1 to C6	230X450
	C13 to C18	230X450
	C7 to C12	230X600
4.	Thickness of slabs	
	S1	125
	S2	125
	S3	150
	S4	125
	Sunk slab	300
5.	Thickness of Shear wall	
	SW1	230
6.	Thickness of wall	150
7.	Floor to floor height	3000
All Dimensions are in mm		

Table -1: detailing of structural plan

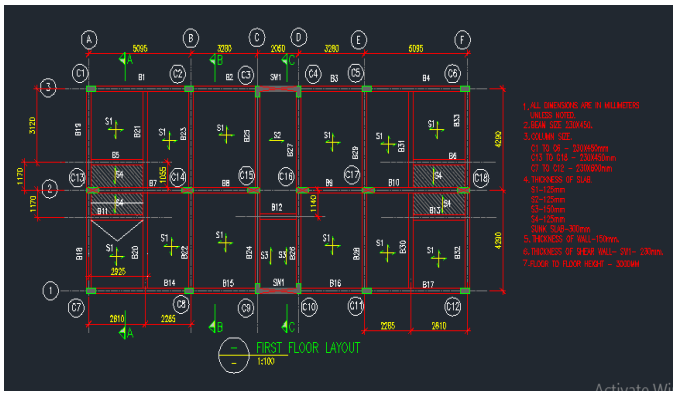


Fig -1 Structural plan of a proposed building

For study the effect of openings due to its size and position at shear wall the dimensions of openings have to be decided. Therefore as per the recommended sizes of opening on the actual field, some following general openings sizes are considered for the study.

As the width of the shear wall is 1820mm and floor to floor height is 3000mm, the dimension of the bay for shear wall is 1820X3000 mm.

Sr. no.	Dimensions of opening	Percentage of opening
1.	600X600	6.6%
2.	600X900	9.9%
3.	450X900	7.4%
4.	900X1200	19.8%
5.	1200X1200	26.4%
All Dimensions are in mm		

Table -2: proposed opening sizes

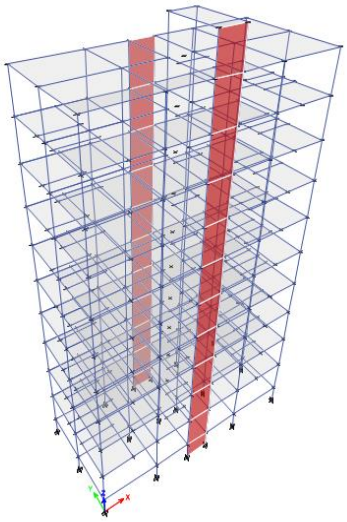
According to the opening arrangements and opening sizes, following combinations are decided for the preparing the models-

No. of Models	Cases	% opening
1.	Shear wall without opening	_
2.	Shear wall with regular opening of 600X600mm	6.60%
3.	Shear wall with regular opening of 450X900mm	7.40%
4.	Shear wall with regular opening of 600X900mm	9.90%
5.	Shear wall with regular opening of 900X1200mm	19.8%
6.	Shear wall with regular opening of 1200X1200mm	26.40%
7.	Shear wall with irregular opening of 600X600mm	6.60%
8.	Shear wall with irregular opening of 450X900mm	7.40%
9.	Shear wall with irregular opening of 600X900mm	9.90%
10.	Shear wall with irregular opening of 900X1200mm	19.8%
11.	Shear wall with irregular opening of 1200X1200mm	26.40%

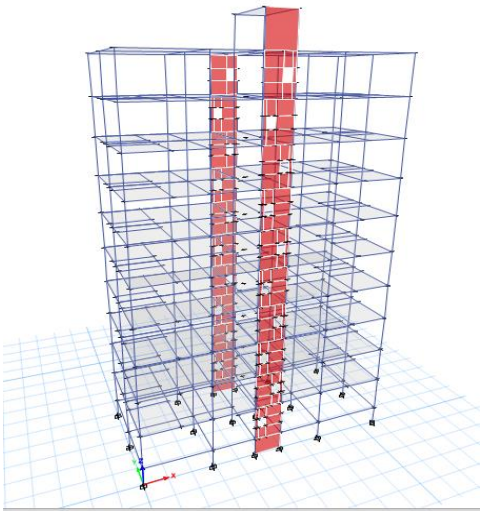
Table -3: Cases for preparing model

The maximum eccentricity or irregularity in opening arrangements is shown for the opening size 450x900mm which is 570mm.

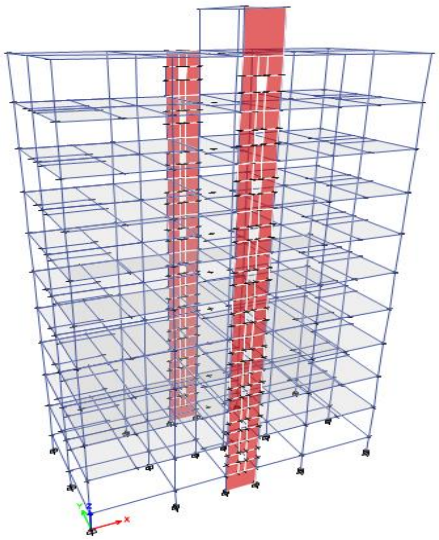
Therefore total 11 no. of models have to be preparing on the ETABS for the analysis and comparison.



Model 1



Model 9



Model 3

3. ANALYSIS

The Method of analysis used in this study is linear static response spectrum method. And the Finite element software used for the analysis is ETABS. All the 11 models are analyzed by response spectrum method on the ETABS. Following are the inputs and the functions defined for the analysis.

1. Diaphragm- Rigid Diaphragm
2. Function- Response spectrum function (for zone II)
3. Modal case- Eigen (with 12 no. of modes)
4. Loads-

   SDL= Floor finish- 1.5kn/m^2 (for room floors)

   Staircase load- 5.5kn/m^2

   Live load= For room floors- 2kn/m^2

   For passage- 3kn/m^2

   For staircase- 3kn/m^2

   For balcony- 3kn/m^2

   For terrace- 2kn/m^2

   Unit Wt. of concrete- 25kn/m^3

   Unit Wt. of Brick material- 20kn/m^3
5. Seismic data-

   Seismic Zone- III

   Zone factor- 0.16

   Soil type- Medium

   Importance factor- 1

   Response reduction factor- 5

3.1 Response spectrum analysis

Response spectrum method is also known as Mode Super-Position Method. Generally, this method is used for dynamic analysis of the structures, which may be asymmetrical or have geometrical areas of discontinuity or irregularity. It is applicable to analysis of forces and deformation in multi-story buildings due to intensity of ground shaking. For certain range of damping which are reasonable models for many buildings the response in each natural mode of vibration can be measured independently of the others and the modal responses can be combined to determine the total response. Each mode responds with its own particular pattern of deformation which is known as mode shape and the frequency is known as the modal frequency, having its own modal damping.

4. RESULTS

This paper studies the effect of different sizes and arrangements of openings in shear wall on the columns of the structure. Total no. of models analyzed is 11. The parameters studied after analyses are-
1. Bending moment of column
2. Axial force on column

4.1 Column Moment

These column moments are studied after the analysis of the above 11 models. The column moment studied for the column C10 which is at the periphery of the building in X-direction. Column C10 is connected with shear wall SW1. The results are taken for the load combination 1.5DL+ 1.5LL +1.5SDL.

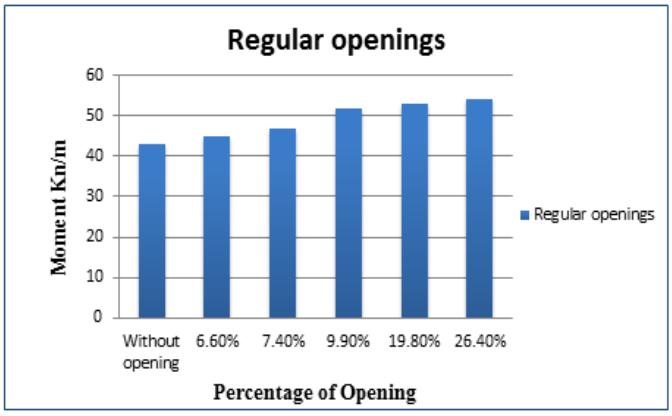


Chart -1: Moment comparison for regular openings

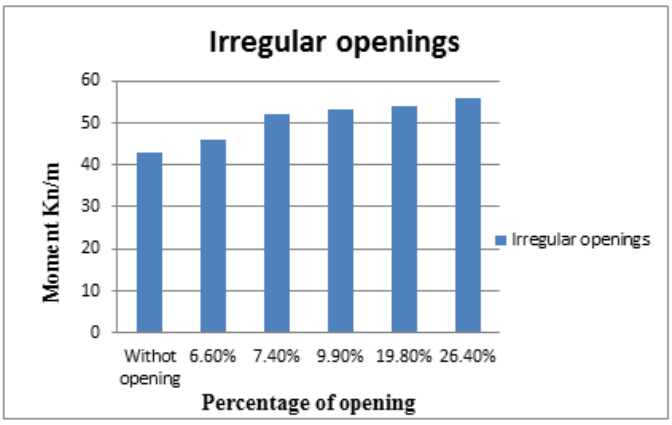


Chart -2: Moment comparison for irregular openings

4.2 Axial Force

These axial forces are studied after the analysis of the above 11 models. The axial forces studied for the column C10 which is at the periphery of the building in X- direction. Column C10 is connected with shear wall SW1. The results are taken for the load combination 1.5DL+ 1.5LL +1.5SDL.

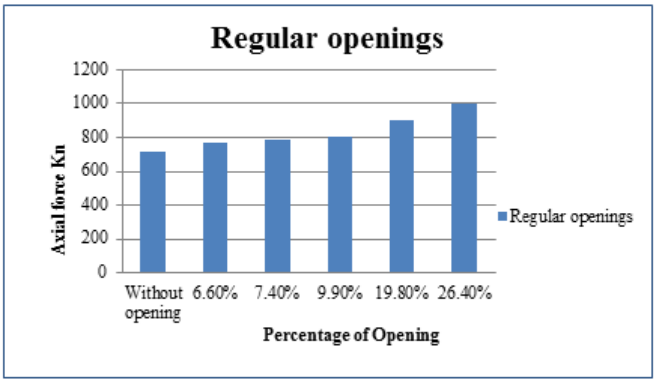


Chart -3: axial forces comparison for regular openings

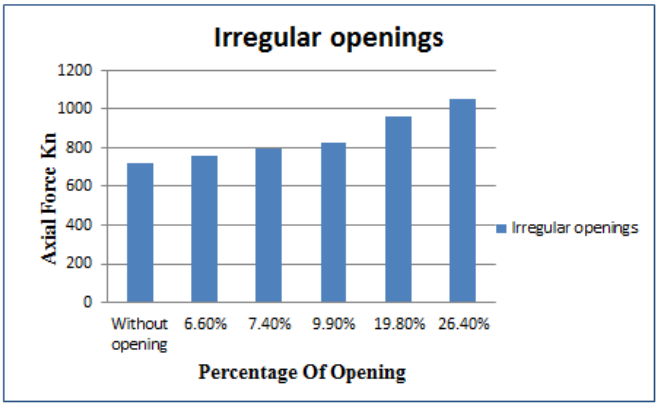


Chart -4: axial forces comparison for irregular openings

5. CONCLUSION

This paper studies the effect of different sizes and arrangements of openings in shear wall on the columns of the structure. The study is carried out on the G+10 mid-rise structure. Analysis is done by linear static response spectrum method. From the considerations of different sizes and combinations of the openings, total 11 no. of models are prepared and analyzed. In which the model 1 is having shear wall without opening and all the other 10 models have been compared with it considering it as a reference model. After comparing the results of these 11 models obtained from analysis, following are some predominant conclusions are drawn-

1. As the sizes of openings increases, the values of bending moment and axial forces increase. Because of the decreasing values of the story stiffness respectively.

2. For the regular opening arrangements, the value of bending moment increases by the 25% of the bending moment of column having shear wall without opening.

3. For the irregular opening arrangements, the value of bending moment increases by the 30% of the bending moment of column having shear wall without opening.

4. For the regular opening arrangements, the value of axial force increases by the 38% of the axial force of column having shear wall without opening.

5. For the irregular opening arrangements, the value of axial force increases by the 46% of the axial force of column having shear wall without opening.

6. For the given irregularity (which is shown maximum in the model 8), the values of bending moments and axial forces doesn't show any major variation between regular and irregular openings of the same sizes.

7. The maximum variation of bending moment values between regular and irregular openings of same size is shown for the opening size 450X900mm which is 10%.

8. The maximum variation of axial force values between regular and irregular openings of same size is shown for the opening size 900X1200mm which is 6%.

9. The building or model having shear wall with opening 600X600mm arranged in a regular manner shows the greater performance amongst the all. (except the model 1 which is reference model)

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