Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 05, May - 2017

Seismic Performance of RC Floating Column Considering Different Configurations

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Abstract—**Floating columns are columns which rest on beams and do not have foundation, are common multi storey buildings which are proposed to accommodate parking at ground floor or open halls at higher floors. These columns have discontinuities in the load transfer path and are designed for gravity loads but these buildings are not designed for earthquake loads. So these buildings are unsafe in seismic prone areas.**

In the study, the effect of varying the location of floating columns floor wise and within the floor of multi storied RC building on various structural response quantities of the building using response spectrum analysis is studied in the software ETABS 2015. The main objective here is to study the seismic response of building with floating columns and to find out the most suitable configuration for providing floating columns. Various parameters such as total base shear force, storey displacement, storey drift, story acceleration of a building are studied with respect to different configurations of floating columns. Also, the critical configuration is taken and made it resistant against lateral loads by providing shear wall

Index terms—Floating columns, ETABS 2015, Story drift, Base shear, Story displacement, Story acceleration

INTRODUCTION

India is a developing country, where urbanization is at the faster rate in the country such as adopting the methods and type of constructing buildings which is under vast development in the past few decades. As a part of urbanization multi-storey buildings with architectural complexities are forced to be constructed. These complexities are nothing but soft storey, floating column, heavy load, the reduction in stiffness, etc. Now a day's most of the urban multi-storey buildings have open first storey as an unavoidable feature. Accommodation of parking or reception lobbies is the primary use of this open first story in the multi-storey buildings constructed. But Conventional Civil Engineering structures are designed on the basis of strength and stiffness criteria. Usually the ground storey is kept free without any constructions, except the columns which transfer the building weight to the ground. This thesis adopts the multi-storey building with a architectural complexities. The complexity of a multi-storey building with "Floating column" and the behavior of the building in higher seismic zones is observed and considered some recommendations.

Research Significance

In urban areas, multi storey buildings are constructed by providing floating columns at the various floor for the various purposes like parking spaces, conference halls etc. These floating column buildings are designed for gravity loads and safe under gravity loads but these buildings are not designed for earthquake loads. So these buildings are unsafe in seismic prone areas. The paper aims to create awareness about these issues in earthquake resistant design of multi-storied buildings.

FLOATING COLUMNS

A column is supposed to be a vertical member starting from foundation level and transferring the load ultimately to the ground. "Floating Column" is also a vertical element which at its lower level rests on abeam which is a horizontal member.

At present, a building with floating column is a typical feature in the modern multistory construction. There are many projects in which floating columns are adopted, especially above the ground floor, where transfer girders are employed, so that more open space is available in the ground floor. As the load path in the floating columns is not continuous, they are more prone to the seismic activity.

OBJECTIVES OF PRESENT STUDY

- To illustrate the basic concept and behaviour of the buildings with floating column
- To study the effect of varying the location of floating columns floor wise and within the floor of multi storied RC building on various structural response quantities of the building using response spectrum analysis
- To study and compare total base shear force, storey drift, displacement and of floating column under different configurations
- To find best configuration which causes minimum damage or collapse after the removal of the columns
- Provision of shear wall to resist the lateral load

MODELLING OF THE BUILDING

The study is carried out on a (G+14) building having floating columns at ground floor, fifth floor, tenth floor and fifteenth floor under different configurations. The building is considered to be located in Zone III as per IS 1893:2002. The building is modeled using the software ETABS 2015. The dimensions of the beams, columns and slabs also the loads applied are summarized in the Table 1

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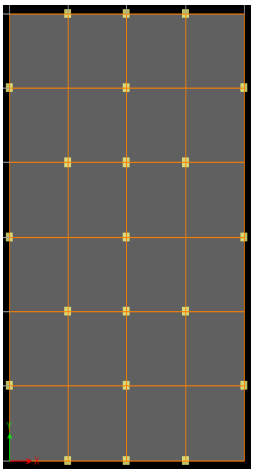
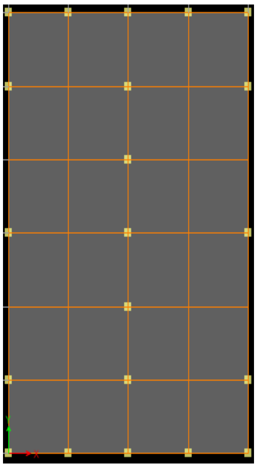
CONFIGURATIONS OF FLOATING COLUMN CHOSEN

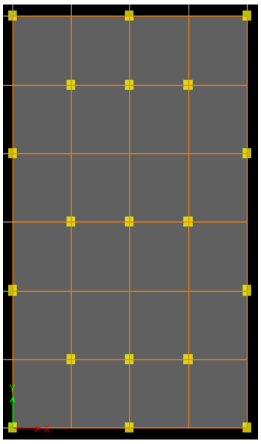
Model 1



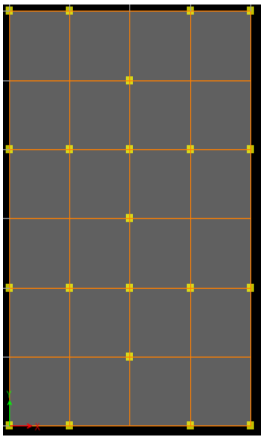
Model 2



Model 3



Model 4



Model 5

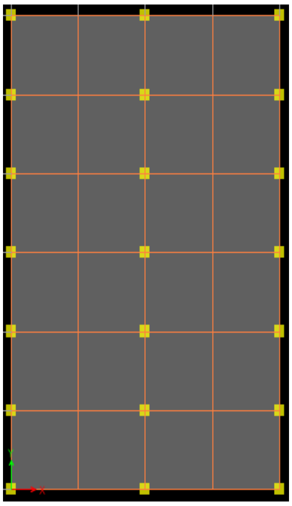


Table 1: Details of Building Models

1	Type of structure	Multi-storey rigid jointed plane frame (SMRF)
2	Seismic Zone	III
4	Floor Height	3m
5	Infill wall	230mm thick brick masonry wall along X direction and Y direction
6	Type of soil	Medium
7	Size of column	600mmX600mm 600mmX900mm 400mmX400mm
8	Size of beam	230mmX450mm 230mmX750mm
9	Depth of slab	150mm
10	Live Load	On floor = 3kN/m^2
11	Floor Finish Load	On floor = 1.5kN/m^2 On roof = 15kN/m^2
12	Material	M 30 Grade concrete & Fe 415 Reinforcement
13	Damping in structure	5%
14	Importance factor	1

ANALYSIS OF BUILDING

In India, Indian standard criterion for earthquake resistant design of structures IS 1893:2002 (Part 1) is the main code that provides outline for calculating seismic design forces. This force depends on the mass and seismic coefficient of the building and the latter in turn depends on properties such as seismic zone in which the structures lies, importance of the structure the soil strata, its stiffness and its ductility.

Response spectrum Method

Response spectrum method is a linear dynamic analysis. This method is applicable for structures where modes other than the fundamental one affect significantly the response of the structure .In this method, the response of Multi Degree of Freedom (MDOF) system is expressed as the superposition of modal response, each of the modal response being determined from the spectral analysis of Single Degree of Freedom (SDOF) system, which are then combined to compute the total response. Modal analysis leads to the response history of the structure to a specified ground motion; however, the method is usually used in conjunction with a response spectrum method.

Shear walls

Shear walls are specially designed structural walls included in the buildings to resist horizontal forces that are induced in the plane of the wall due to wind, earthquake and other forces. They are mainly flexural members and usually provided in high rise buildings to avoid the total collapse of the high rise buildings under seismic forces. Shear walls have very high in plane stiffness and strength, which can be used to simultaneously resist large horizontal loads and support gravity loads, making them quite advantageous in many structural engineering applications.

RESULT AND DISCUSSIONS

By the application of lateral loads in X and Y directions the structure can be analyzed for various load combinations given IS 1893:2002. For the given load combinations the

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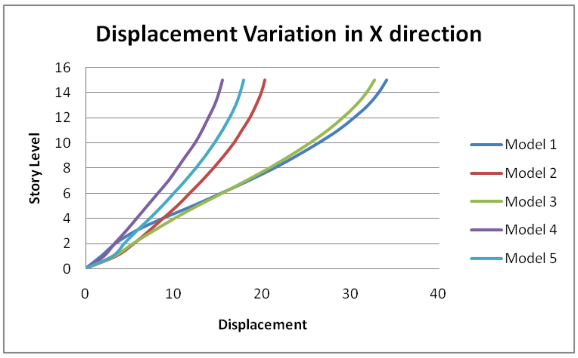
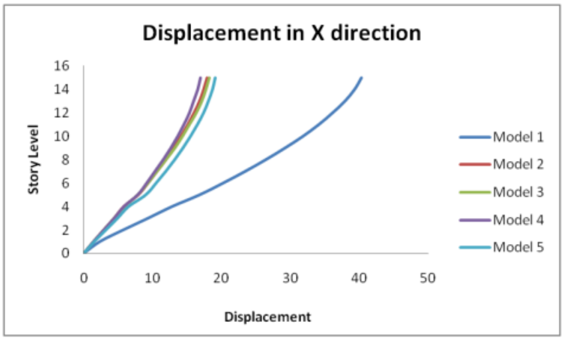
displacement, drift, total base shear and variation of story acceleration at each floor is noted in X and Y direction and are shown below in the form of a graph

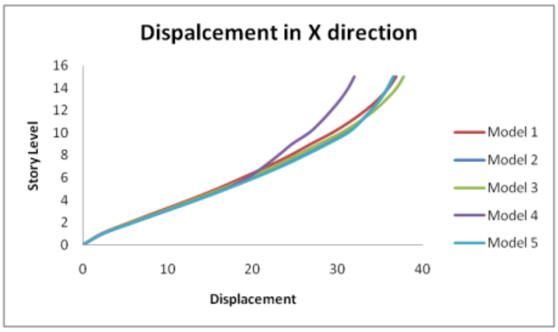
Displacement Variation for various models in X direction for different floor levels



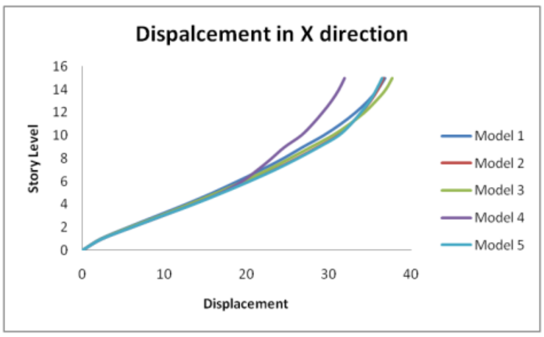
Ground floor



Fifth floor

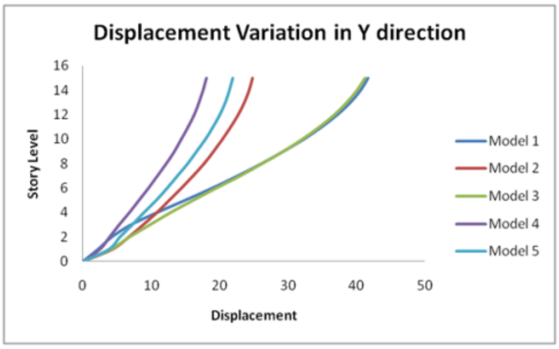


Tenth floor

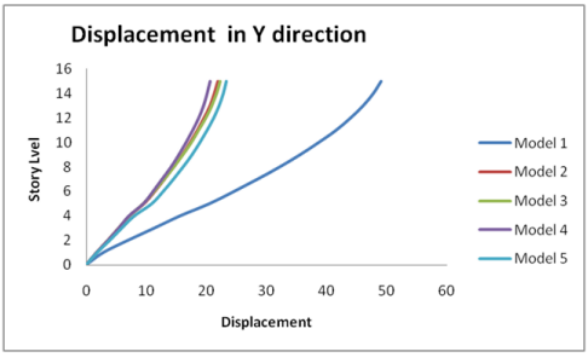


Fifteenth floor

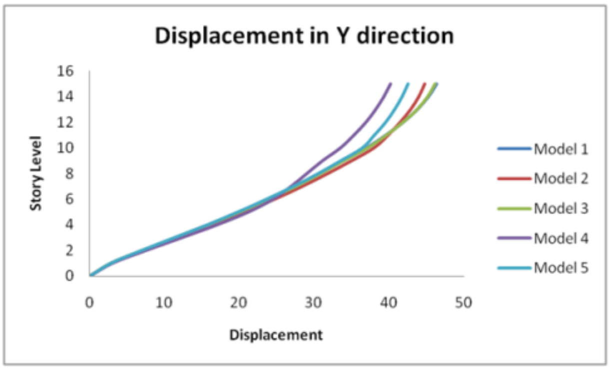
Displacement Variation for various models in Y direction for different floor levels



Ground floor



Fifth floor



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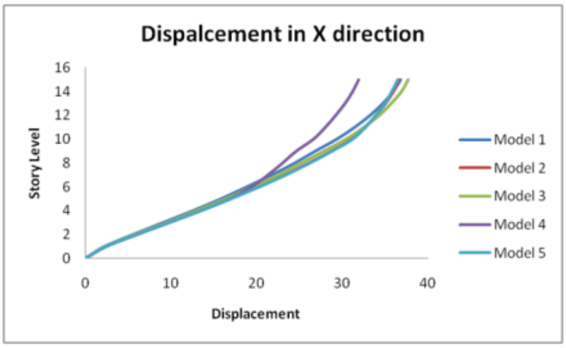
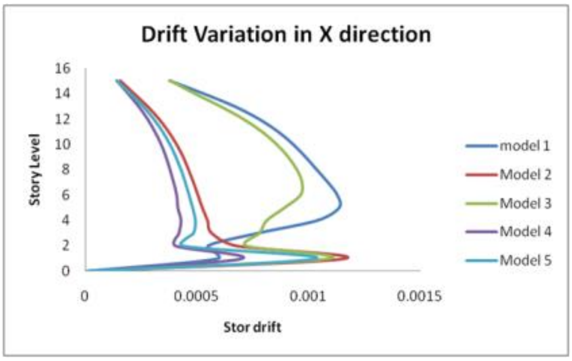
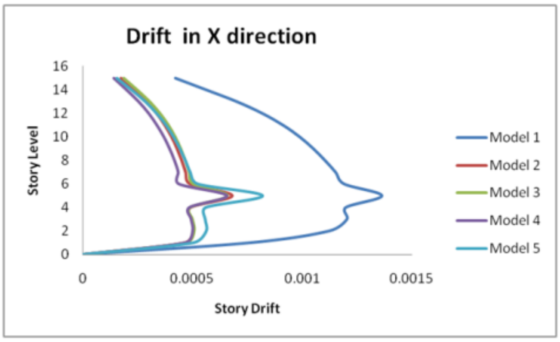


Fifteenth floor

Drift Variation for various models in X direction for different floor levels



Ground floor



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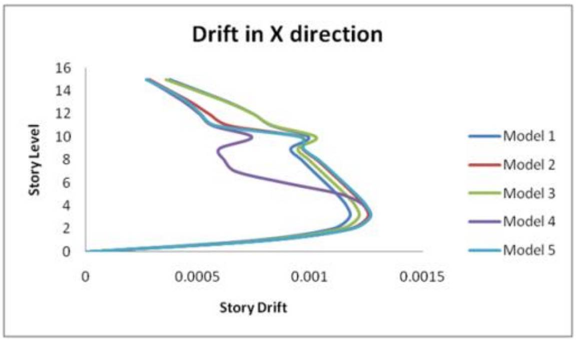
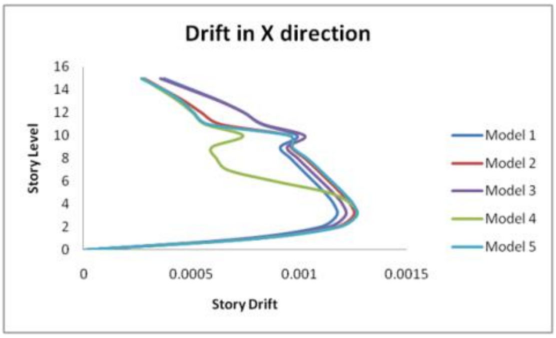
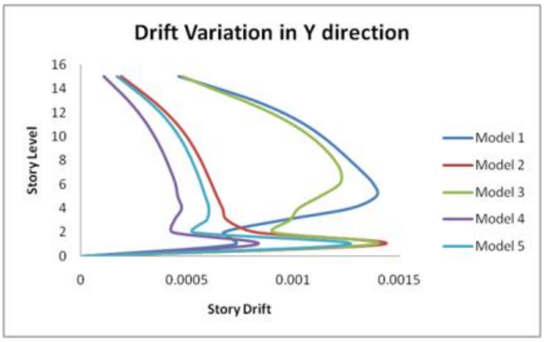


Tenth floor

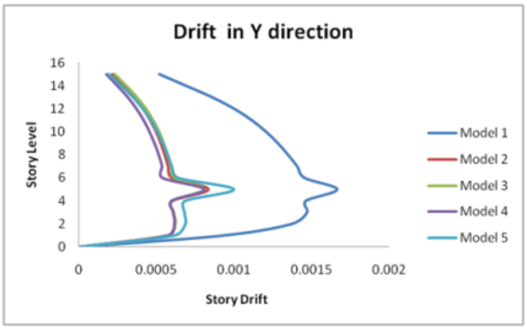


Fifteenth floor

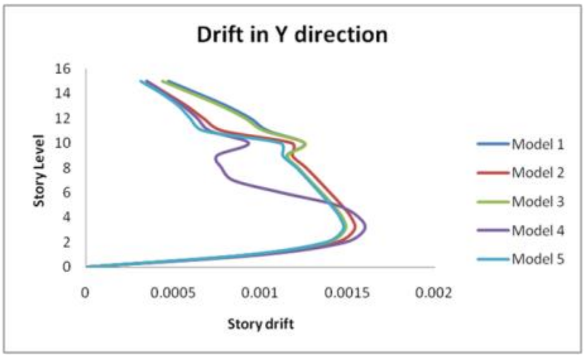
Drift Variation for various models in Y direction for different floor levels



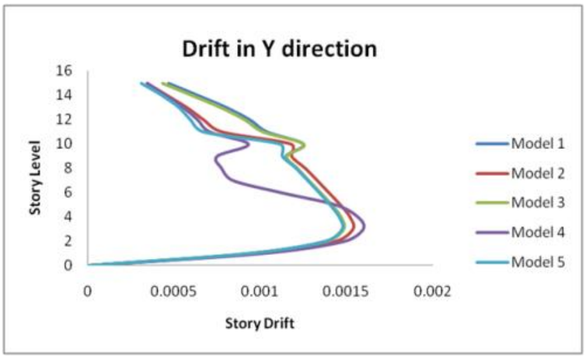
Ground floor



Fifth floor



Tenth floor



Fifteenth floor

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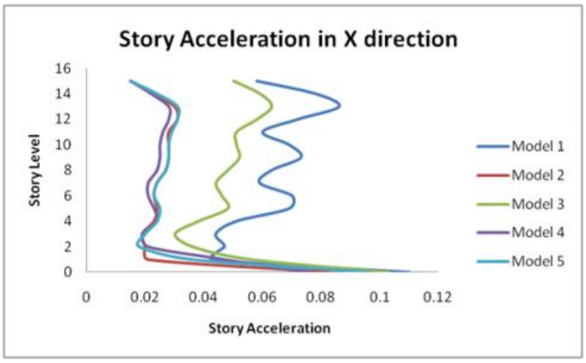
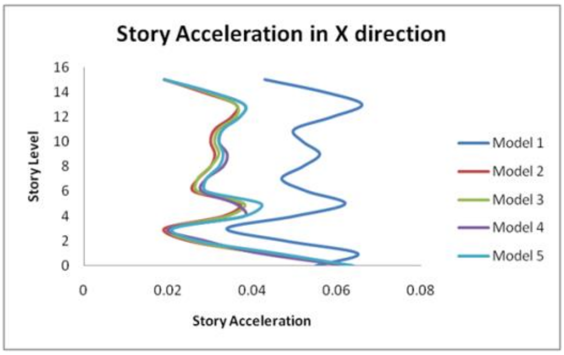
Variation of Story acceleration for various models in X direction for different floor levels



Ground floor



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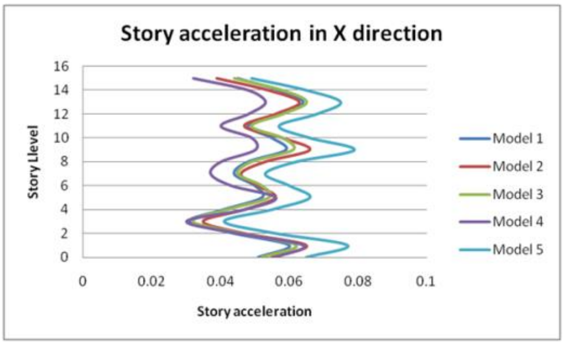

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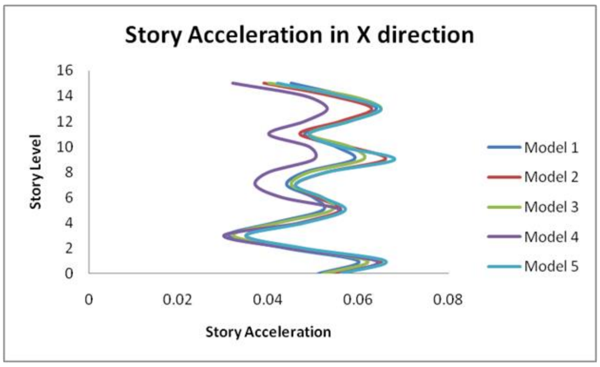
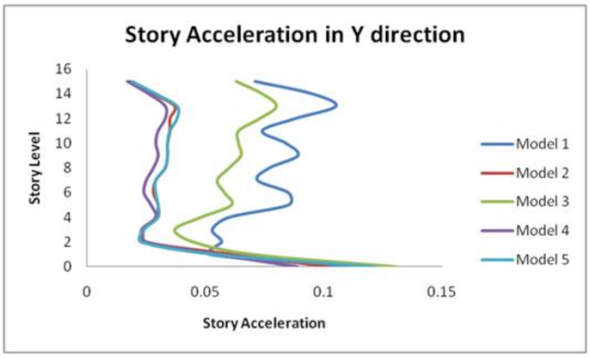
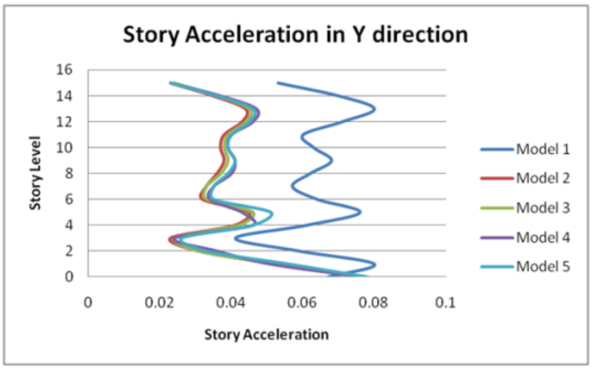


Fifteenth floor

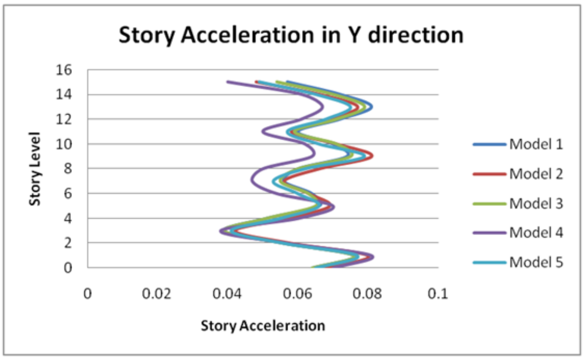
Variation of Story acceleration for various models in Y direction for different floor levels



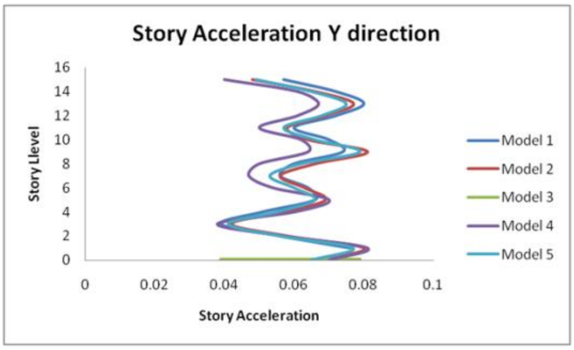
Ground floor



Fifth floor



Tenth floor



Fifteenth floor

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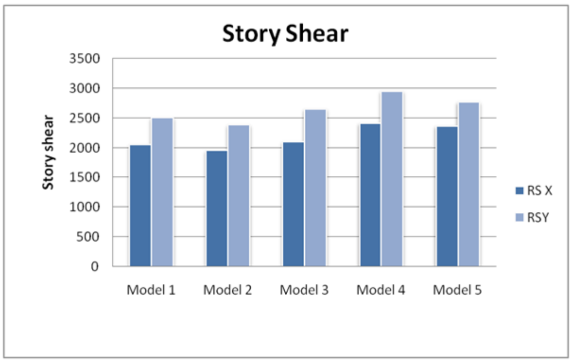
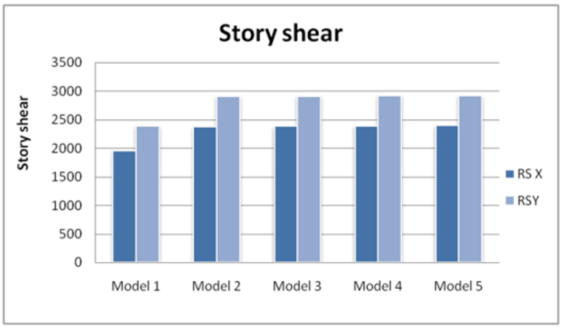
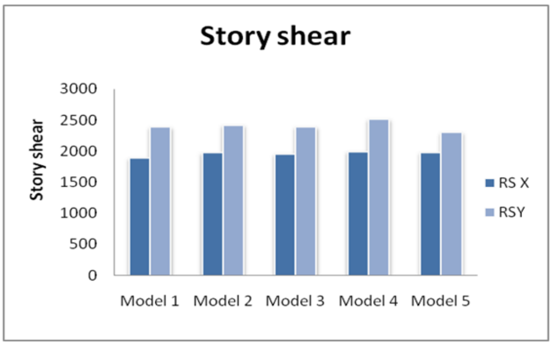
Variation of Story shear for various models under different floor levels



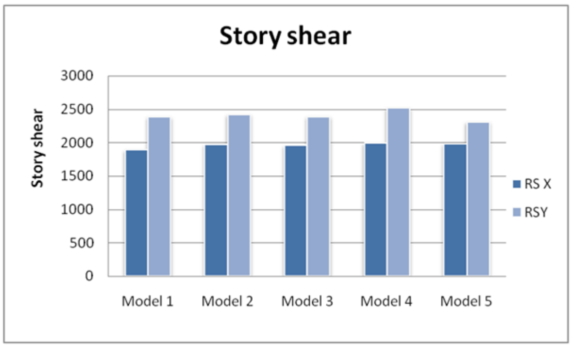
Ground floor



Fifth floor

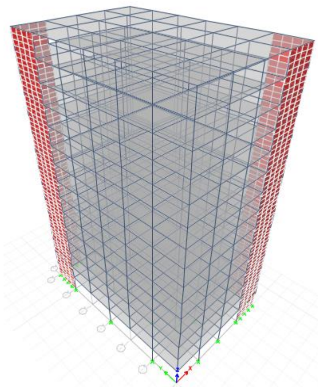


Tenth floor

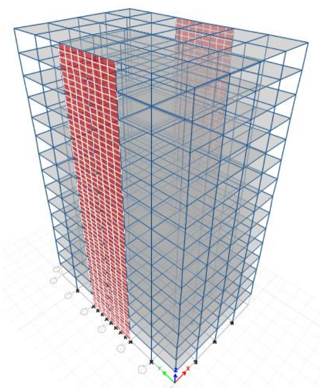


Fifteenth floor

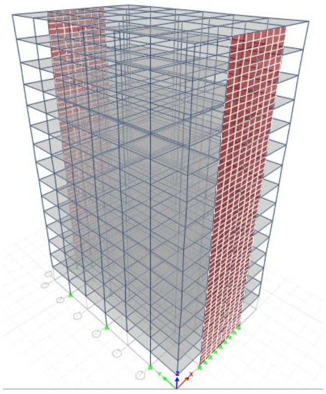
Shear wall provided for model 1



Model (a)



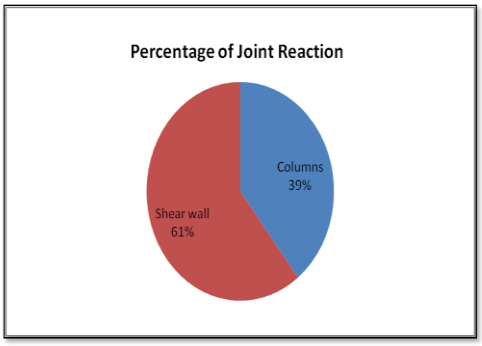
Model (b)



Model (c)

Best model with shear wall is chosen by taking the sum of the total joint reactions taken by the shear wall and the columns at the base level. Shear wall which takes maximum percentage of joint reaction than the columns was chosen as the best position.

The following pie chart shows the percentage of total load shared by shear and columns when model 1 is provided with shear wall at different locations.



Sum of joint reactions for model (a)

The above figure shows the percentage of load shared by columns and shear wall for model (a). We can see that around 61 % of the total load is taken by the shear wall and only 39 % is taken by the columns.

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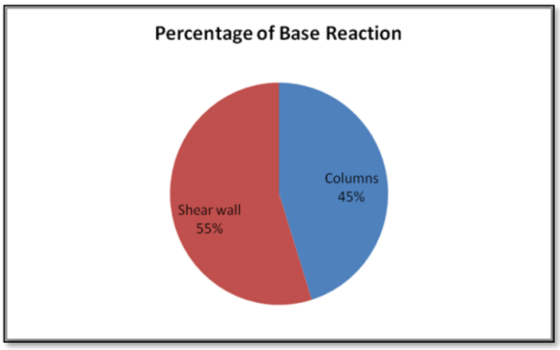
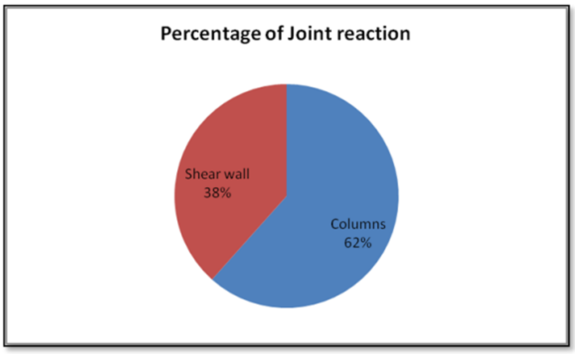


Sum of joint reactions for model (b)

The above figure shows the percentage of load shared by columns and shear wall for model (b). We can see that around 55 % of the total load is taken by the shear wall and only 45 % is taken by the columns.



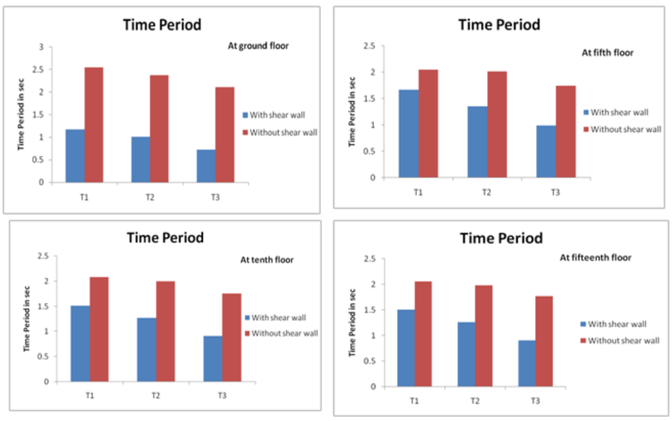
Sum of joint reactions for model (c)

The above figure shows the percentage of load shared by columns and shear wall for model (b). We can see that around 38 % of the total load is taken by the shear wall and 62 % is taken by the columns.

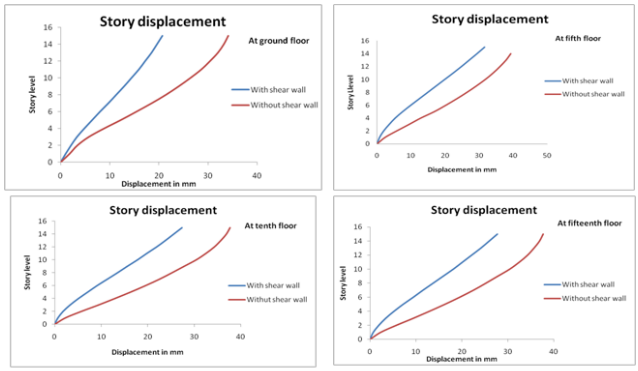
From the above results, it is evident that shear wall when provided at corners take maximum load than when provided at the center of longer and shorter side. Model (a) is found to be effective than three models chosen. Therefore model (a) is chosen for increasing the lateral resistance of model 1.

Results after providing shear wall

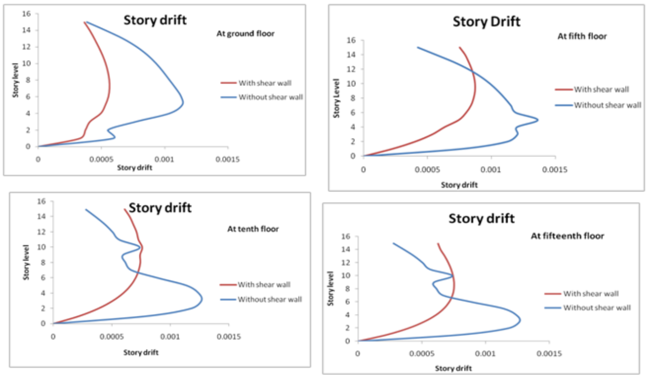
a) Variation of Fundamental Time Period



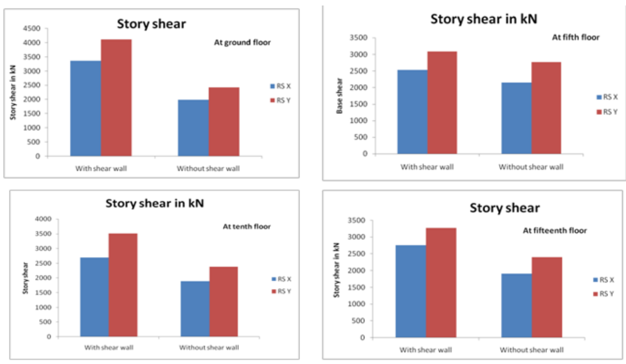
b) Variation of Story displacement



c) Variation of Story Drift



d) Variation of story shear



OBSERAVTIONS FROM STUDY

The behavior of multi storied building with floating column under different column configurations is studied by Response spectrum analysis.

From the present study, it is concluded that

1. By the application of lateral loads in X and Y direction at each floor, the time period for model 4 is less than the other four models and model 1 is having more time period.
2. When floating columns are provided in upper floors , the time period got reduced

3. There was a constant time period for all configurations towards upper floors
4. The story displacement is found to be more for model 1 and model 4 is having less displacement
5. Floating column when provided in fifth floor showed maximum displacement value
6. The story drift is more when floating columns are provided in the fifth floor.
7. Except ground floor, model 1 is having higher value of drift and model 4 is having less drift value
8. At ground floor, model 2 is having more drift value model 5 is having less drift value
9. From the response spectrum analysis, it was seen that the story acceleration is less for model 4 compared to all other models for ground floor and fifth floor and the graph was almost parallel to y axis which shows that the vibration was not vigorous.
10. It was observed that the base shear value is more when floating columns are provided in ground floor and Model 1 is having less base shear at lower floors.
11. Shear wall provided at diagonal corners was found to have effective lateral load bearing capacity
12. After providing shear wall at diagonal corners in model 1,
13. Story displacement was decreased by 39 %, 17.9%, 27.32% and 26.5% in ground floor, fifth floor, tenth floor and tenth floor respectively.
14. Story drift was decreased by 50.35%, 17.9%, 40.1% and 40.52 % in ground floor, fifth floor, tenth floor and tenth floor respectively.
15. Story shear was increased from 40.9%, 15.5%, 29.94% and 30.9% in ground floor, fifth floor, tenth floor and tenth floor respectively.

CONCLUSIONS

- Time Period is more when floating columns are provided at ground floors
- Story drift and story displacement is more when floating columns are provided in fifth floor
- Base shear is more when floating columns are provided in ground floor
- Model 1 and model 3 with corner columns as floating columns showed least resistant against lateral loads
- Model 4 with maximum number of external columns is found to be better configuration to resist lateral load.
- Shear wall provided at diagonal corners can be used as the best effective method to resist the lateral forces
- When shear wall was provided, displacement was decreased to 1/3rd of the initial displacement
- Also, story drift was decreased to ½ of the initial story drift
- Story shear was increased to ¼ of the initial story shear value

Now a days, buildings with complexities are getting popular, but they carry a risk of having damages during earthquakes Therefore, such buildings should be designed properly taking care of their dynamic character.

ACKNOWLEDGMENT

I am thankful to my guide, Asst. Professor, Ancy Mathew in Civil Engineering Department for her constant encouragement and able guidance. Also I thank my parents, friends and above all, the god almighty for making this work complete.

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