Seismic Analysis of Buildings with Shear Wall having Horizontal Irregularity

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Abstract – *In the today's time, In the seismic design of buildings, shear walls are the major members of the building to resist the lateral forces which acts on the structure during earthquakes. Shear Walls have very good in-plane strength and stiffness, that's why these are used to resist gravity loads and large horizontal loads. During an earthquake, failure of structure generally starting to occur at the points of weakness. These weak points in the building cane be due to discontinuity in mass, stiffness and geometry of structure. That's why in this study horizontally irregular buildings are taken.*
In this study, the seismic behavior and performance of horizontally irregular buildings with shear wall is shown. For this purpose, five types of buildings are taken, namely, E-shaped, I-shaped, L-shaped, +-shaped and Box shaped. All buildings are modelled and analyzed in SAP2000v20.2.0. The method of analysis used is Response Spectrum Analysis and analysis is done on the basis of IS 1893-2016 (Part I). Medium soil strata and Zone-IV is taken for all the cases. After the analysis various parameters like lateral displacement/storey displacement, base shear, storey drift and time period are compared.

Key Words: **Shear wall, Response spectrum analysis, Storey Drift, Lateral Displacement, Base Shear etc.**

1.INTRODUCTION

In the 21st century, there has been the tremendous growth in the infrastructure development in the developing countries, especially India, in terms of construction of buildings, bridges and industries etc. This infrastructure development is mainly due to the growing population and to fulfill their demands. Since the land is limited, there is a huge scarcity of land in urban cities. To overcome this problem tall and slender multi-storied buildings are constructed. There is a high possibility that such structures are subjected to huge lateral loads. These lateral loads are generated due to inertia forces induced by earthquake which tends to snap the building in shear and push it over in bending. Lateral loads can develop high stresses, produce sway movement or cause vibration. Therefore, it is very important for the structure to have sufficient strength against vertical loads together with adequate stiffness to resist lateral forces.

Shear wall are one of the excellent means of providing earthquake resistance to Multi-storied reinforced concrete building. For the regions of high seismicity, the use of shear walls in building structures to resist the lateral forces, is very common in engineering practice. The provision of shear wall in building to achieve rigidity has been found effective and economical. When buildings are tall, beam, column sizes are quite heavy and steel required is large. So, there is lot of congestion at these 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 the building, they can form an efficient lateral force resisting system. The structure is still damaged due to some or the other reason during earthquakes. Behavior of structure during earthquake motion depends on distribution of weight, stiffness and strength in both horizontal and planes of building. To reduce the effect of earthquake reinforced concrete shear walls are used in the building. These can be used for improving seismic response of buildings. Structural design of buildings for seismic loading is primarily concerned with structural safety during major Earthquakes, in tall buildings, it is very important to ensure adequate lateral stiffness to resist lateral load. The major criteria now-a-days in designing RCC structures in seismic zones is control of lateral displacement resulting from lateral forces.

1.1 Objectives

The reinforced concrete shear wall is one of the frequently used lateral load fighting system in RCC structures. Because of its high strength and in plane stiffness, it can overcome large horizontal forces and support gravity load simultaneously. During seismic excitation, they contribute in absorbing moments and shear forces and reduces torsional response. The scope of this thesis is to study the seismic behavior of horizontally irregular building with shear walls. So, the objective of the project is given as follows:

a) To study seismic behavior of 6-sorey RC frame buildings of horizontally irregular shapes like +-shaped, E-shaped, I-shaped, L-shaped and Box shaped with shear walls by response spectrum method using SAP2000v20.2.0.

b) To study the results obtained after the analysis of buildings using SAP2000v20.2.0.

c) The various parameters which are taken into consideration for comparison are lateral displacement/storey displacement, base shear, storey drift and time period will be compared.

1.2 Methodology

The process involved in this study to achieve the above stated objectives is:

a) First, model five different horizontally irregular shaped building models of same height with shear walls.

b) Then, perform Response spectrum analysis on each taken models.

c) Analyzing and comparison of the result of seismic analysis.

d) Detailed discussion on the results with the help of graphs and tables considering all the parameters.

2. LITERATURE REVIEW

Shubham Kasat and Prof. Vinesh S. Thorat (2018) carried out the analysis of a R.C.C building with different position of shear wall on floor plan by using ETABS. For this a G+6 storey building example is taken from NICEE website and the results of which are compared with the results of ETABS analysis of the same building. An earthquake analysis is applied to the building in Zone III as per code provision IS-1893 and as per that resulting lateral displacement, storey drift, storey shear is calculated. The analysis of building with core shear wall and edge shear wall is done. They performed the seismic analysis by three methods, namely, Equivalent Static Coefficient Method, Time History Method and Response Spectrum Method. From this work they concluded that, 1. The analysis of building with Core shear wall and edge shear wall shows that Shear wall at core shows stiffer behavior. 2.When shear walls are provided on edge maximum storey displacement of buildings is increased comparing to when shear walls are provided on center portion. 3.When dynamic analysis is done storey drift decreases.

Axay Thapa and Sajal Sarkar (2017) had compared the dynamic responses of frame structure with and without shear wall. Three models namely, G+5, G+10 and G+15 RCC frame models with and without shear walls are generated with varying structural member dimensions according to height. The models are analyzed by Static Method and Response Spectrum Method considering seismic zone V in STAAD. Pro V8i. Parameters like lateral displacement, story drift, base shear and mode shapes are determined for all the models and are compared and the effectiveness of shear walls is enumerated. Bare-frame model showed higher displacement, than shear walled-frame model. A significant amount of increase in the lateral stiffness has been also observed in all models of shear wall frame as compared to bare frame. The variation in displacement between the bare frame and shear walled frame model increase with the increase of height, the variation in displacement of the two frames for G+5 floors was comparatively less than that of G+15 floors.

Kavish Patwari and L. G. Kalurkar (2016) had studied the combined effect of with and without shear wall of flat slab building on the seismic behavior of high-rise building with various positions of shear wall. For that, a 11-storey building is analyzed with 5 different models. Model 1-Flat slab building with C-type shear wall. Model 2-Flat slab building without shear wall. Model 3-Flat slab building with L-type shear wall. Model 4-Flat slab building with shear wall along periphery. Model 5-Flat slab building with non-parallel shear wall along periphery. To study the effect of different location of shear wall on high rise structure, linear dynamic analysis (Response spectrum analysis) in software ETABS is carried out and seismic parameters like time period, base shear, storey displacement and storey drift are checked out. From the results they conclude that the seismic responses namely base shear in X and Y directions for structure with shear wall are found to be 3.08% more than structure without shear wall and the story displacement without shear wall along EQX is 48.52% more and along EQY is 53.36% more than displacement with shear wall.

Dileshwar Rana and Juned Raheem (2015) showed the performance & behavior of regular & vertical geometric irregular RCC framed structure under seismic motion. Five types of building geometry are taken in this project: one regular frame & four irregular frames. A comparative study is made between all these building configurations height wise and bay wise. All building frames are modeled & analyzed in Staad.Pro V8i. Various seismic responses like shear force, bending moment, storey drift, storey displacement, etc. are obtained. The seismic analysis is done according to IS 1893:2002(part-1). The change in the different seismic response is observed along different height. It is concluded that as the amount of setback increases the shear force also increases. The fluctuation of critical shear force from regular to vertical geometric irregular is very high. The critical bending moment of irregular frames is more than the regular frame for all building heights. This is due to decrease in stiffness of building frames due to setbacks.

P. V. Sumanth Chowdary and Senthil Pandian. M (2014) had done the study on solution for shear wall location and type of shear wall in seismic prone areas. The effectiveness of 8-storey RCC shear wall building is studied with help of four different models. Model 1-Floor plan of the bare framed structure. Model 2-Floor plan of the core type at lift wells and rectangle type shear wall frame structure. Model 3-Floor plan of the coupled type with openings and core type shear walls at lift wells of frame structure. Model 4-Floor plan of core type shear walls at the lift wells and four corners of framed type structure. Models are studied in four different zones. The performance of building is evaluated in terms of lateral displacements of each storey by using Response spectrum analysis method with the help of a structural finite element analysis software (SAP2000). From analysis it is observed that the corner type shear wall (model 2) has less deflection as compared to all other models. In high earthquake intensity areas provide shear walls on all four corners and centroid of the building to reduce deflection. Rectangle type shear wall (model 3) is suitable for zone III as the deflection of this model is allowable for the building in zone III.

P. S. Kumbhare and A. C. Saoji (2012) had worked on the effect of seismic loading on placement of shear wall in mid-rise building at different alternative location. The residential mid-rise building is analyzed for earthquake force by considering two type of structural system i.e. Frame system and Dual system. Effectiveness of shear wall has been studied with the help of four different models. Model 1 is bare frame structural system and other four models are dual type structural system. The Analysis is carried out by using ETABS. The comparison of these models for different parameters like Displacement, Storey Drift and Story Shear has been presented by replacing column with shear wall. Based on the analysis results they found that the displacement of Model II, Model V reduced up to 20-30 % as compared with bare frame model, whereas in model III and IV maximum displacement also reduced up to 30-50 % as compared with bare frame.

3. STRUCTURAL MODELLING

For this study, five buildings of different horizontal plan irregularity are taken. All the buildings are modelled using SAP2000v20.2.0. Each building is a 6-storey building and the height of each storey is 3.3m.

The plan of building models is given below: -

1. Model 1 – A plus - shaped model is taken as shown in fig -1.
2. Model 2 – A n E-shaped model is taken as shown in fig -2.
3. Model 3 – A L-shaped model is taken as shown in fig -3.
4. Model 4 – An I -shaped model is taken as shown in fig -4.
5. Model 5 – A square-shaped model is taken as shown in fig -5.

Table -1: Design details

S. No.	Particulars	Dimension/Value
1.	No. of Stories	G+5
2.	Floor to Floor height	3.3m
3.	Beam Size	230mmX350mm
4.	Column Size	500mmX500mm
5.	Thickness of Slab	125mm
6.	Thickness of Shear Wall	115mm
7.	Height of Building	19.8m
8.	Wall Thickness	230mm
9.	Grades of Concrete	M20, M25, M30
10.	Grade of Steel	Fe415
11.	Response Reduction Factor	5
12.	Importance Factor	1.2
13.	Soil Condition	Medium (II)
14.	Seismic Zone	IV (0.24)
15.	Damping	5%
16.	Live Load	$2KN/m^2$
17.	Floor Finish	$1.8KN/m^2$
18.	Earthquake Load	As per IS-1893-2016(Part-I)
19.	Analysis Method	Response Spectrum Analysis
20.	Software Used	SAP2000v20.2.0

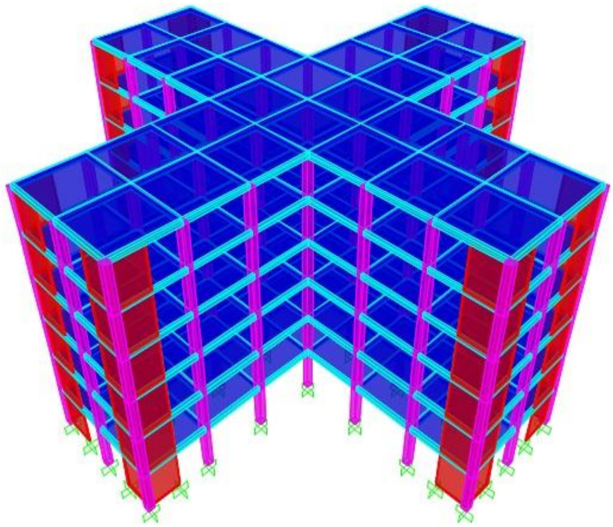


Fig-1: Plus-shaped model(3D)

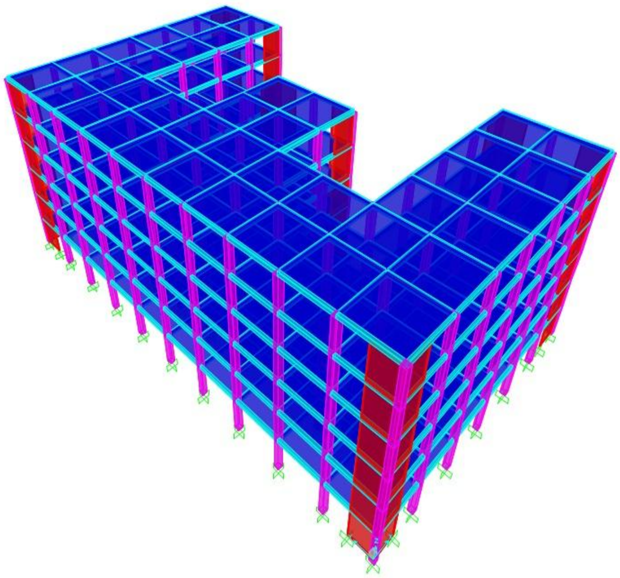


Fig-2: E-shaped model(3D)

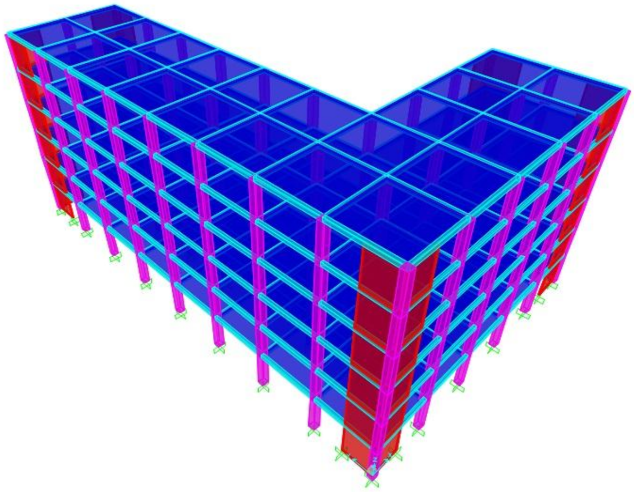


Fig-3: L-shaped model(3D)

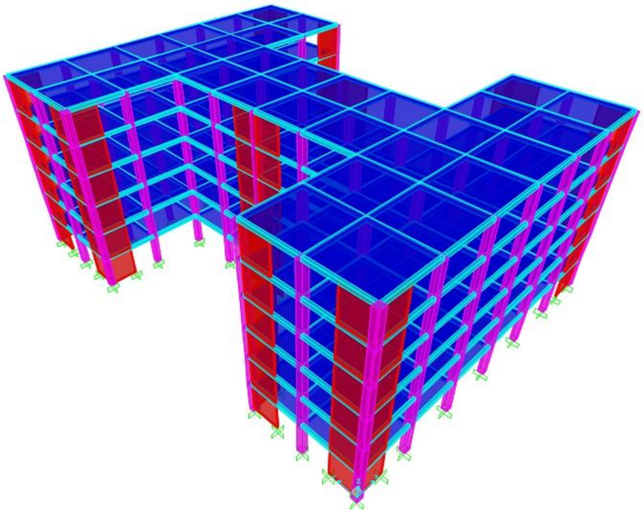


Fig-4: I-shaped model(3D)

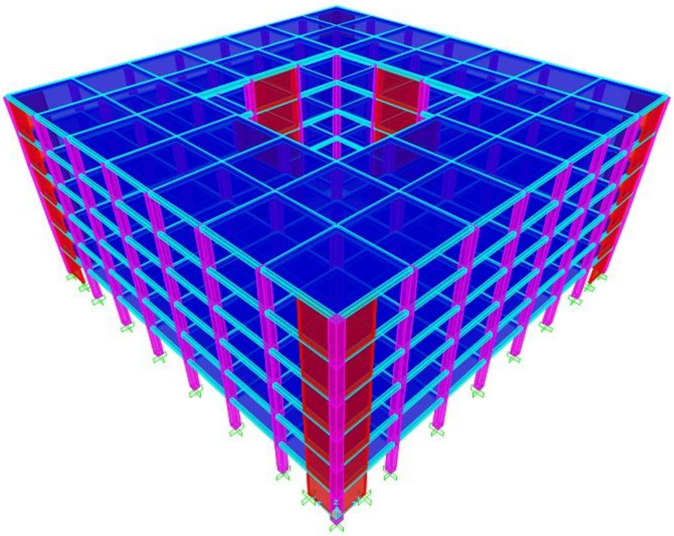
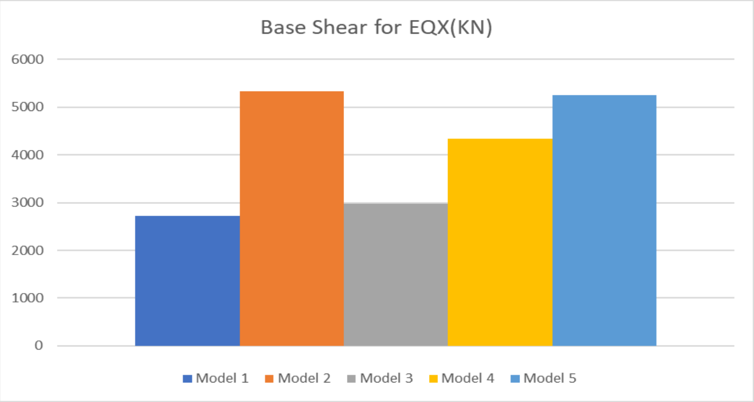
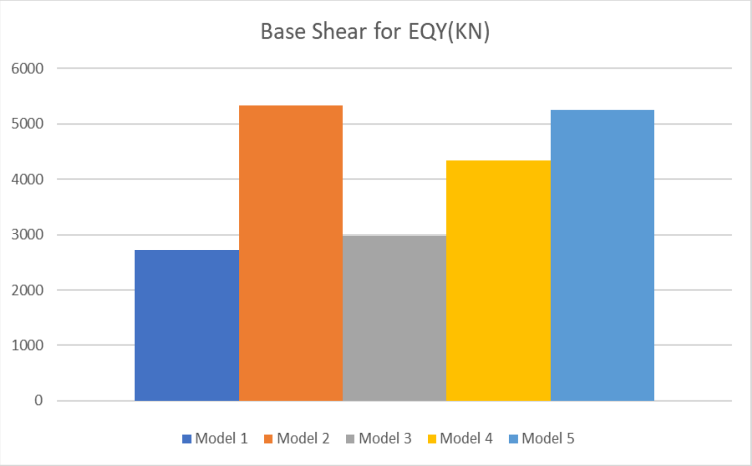
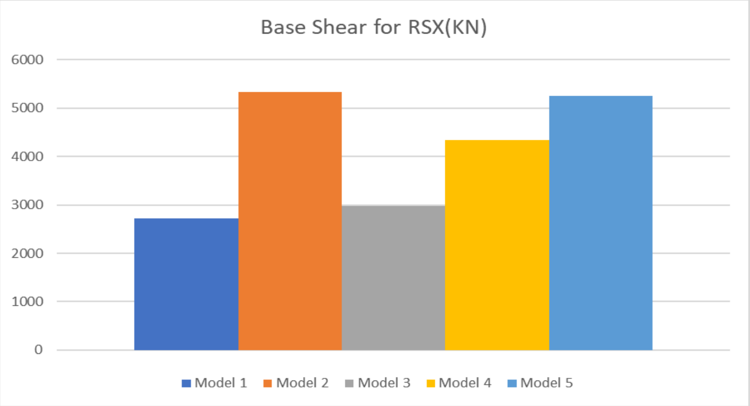


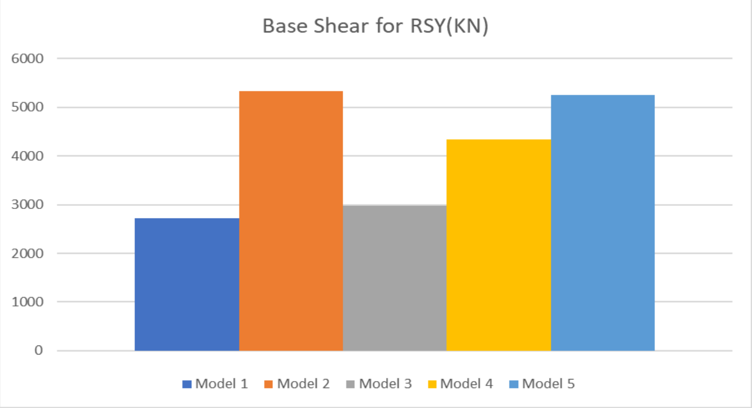
Fig-5: Square -shaped model(3D)

4. RESULTS









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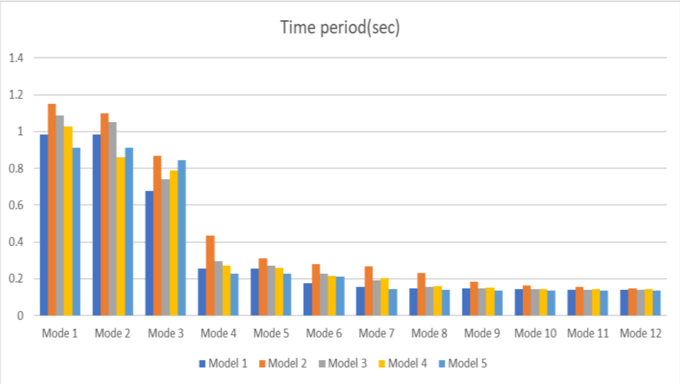

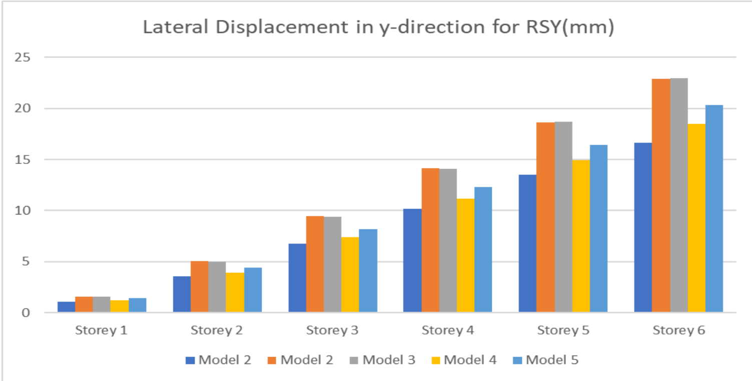

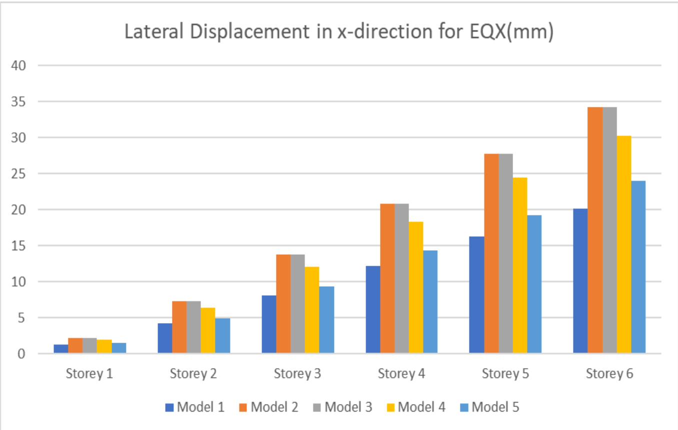

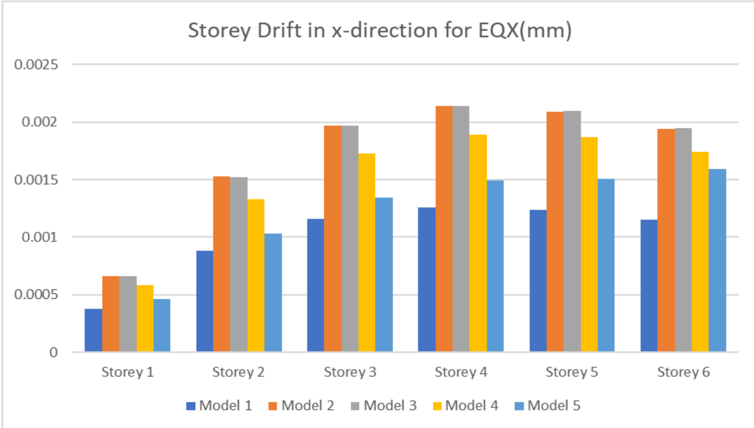

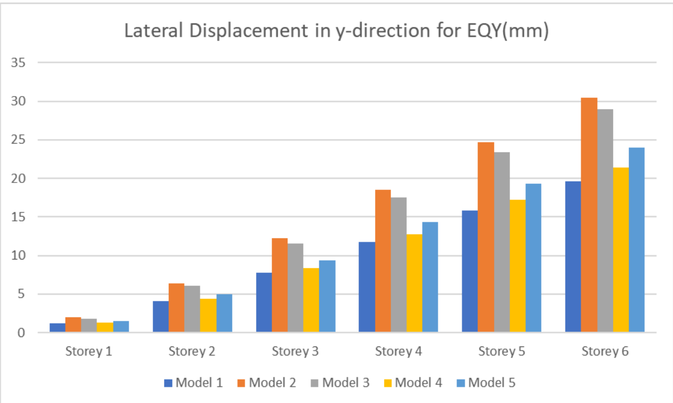

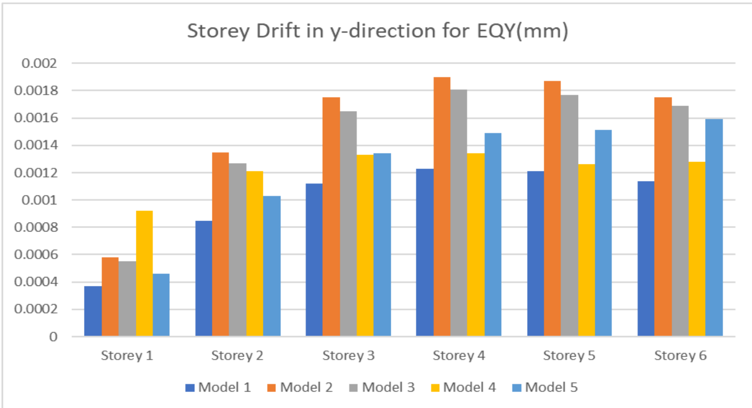

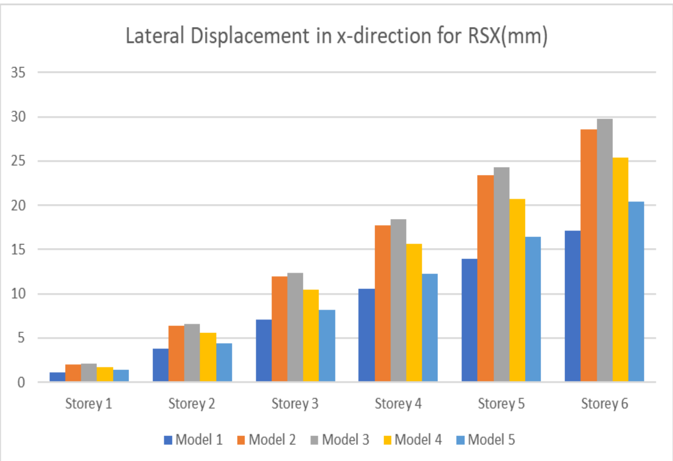

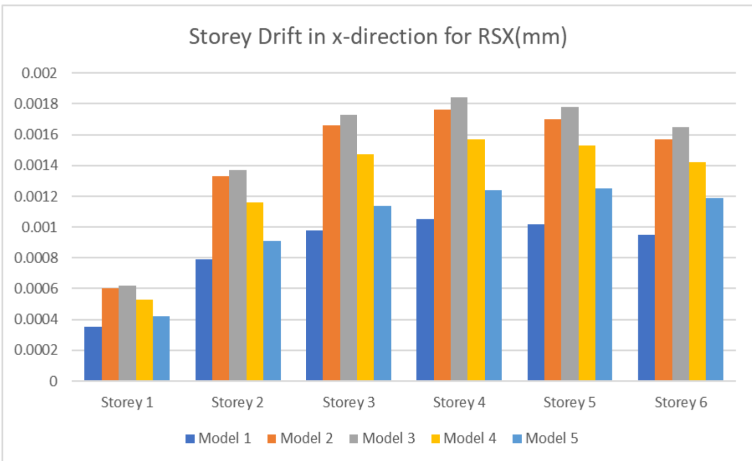

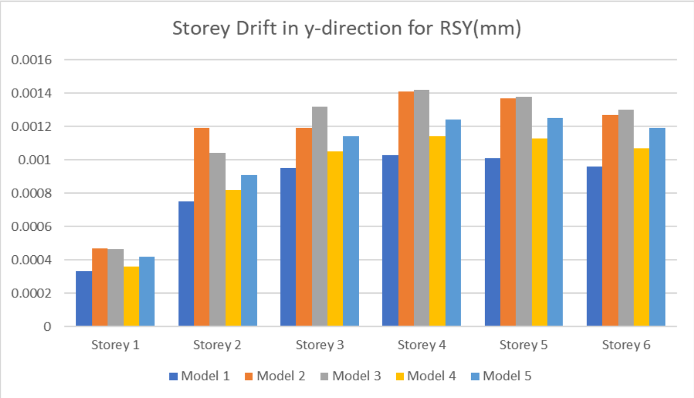

5. CONCLUSIONS

The following conclusions are drawn from the results: -

1. The value of Base shear is maximum for E-shaped model and minimum for + -shaped model in case of EQX, EQY. RSX and RSY.
2. The value of Lateral Displacement is maximum for E-shaped model and minimum for + -shaped model in case of EQX, EQY and RSY.
3. The value of Lateral Displacement is maximum for L-shaped model and minimum for + -shaped model in case of RSX.
4. The value of Storey Drift is maximum for E-shaped model and minimum for + -shaped model in case of EQX, EQY and RSY.
5. The value of Storey Drift is maximum for L-shaped model and minimum for + -shaped model in case of RSX.
6. The value of Time Period is maximum for E-shaped model and minimum for Square-shaped model.
7. The value of Time Period is increasing as the mode number increasing.

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7. BIOGRAPHIES

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