BEHAVIOR OF MULTISTORY RC BUILDING FOR DIFFERENT STRUCTURAL MODEL AND TERRAIN

A RESEARCH REPORT

Submitted by

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MASTERS OF TECHNOLOGY

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ABSTRACT

Response of a building is unpredictable during seismic and wind forces as the structure becomes more vulnerable to damage when subjected to lateral loads. In this study, an attempt is made to study the behavior of multistory RCC building with different structural frames and constructed on different terrain with varying zones. In this piece of research, a multistory high rise RCC building is analyzed using staad.pro and etabs software with the reference of IS 1893: 2002 and IS 456. Various parameters in the structural model like base shear, story drift, displacement, moment, shear force and time period are analyzed and their results are compared on flat and sloped ground with angle 0° to 20° made on three different zones which are zone 3, zone 4 and zone 5.

ACKNOWLEDGEMENT

I would like to thank **Dr. V Rajesh Kumar** who gave me the opportunity to work on dissertation II. I would also like to thank my dissertation mentor **Mr. Paramveer Singh** who gave me this opportunity to work on this project and helped me throughout my study. Without his guidance, I would not be able to work on this subject. I am able to understand the concepts of this study under his guidance.

Signature of mentor | **Signature of student**

Paramveer Singh | **Girvaan Mago**

Assistant Professor

DECLARATION

I, Girvaan Mago (11614531), hereby declare that this thesis report entitled **"Behavior of multistory RC building for different structural model and terrain"** submitted in the partial fulfillment of the requirements for the award of degree of Master of Civil Engineering, in the School of Civil Engineering, Lovely Professional University, Phagwara, is my own work. This matter embodied in this report has not been submitted in part or full to any other university or institute for the award of any degree.

Date: **Girvaan Mago**

Place:

ABBREVIATION USED

KN	Kilo Newton
N	Newton
m	Meter
cm	Centimeter
mm	Millimeter
KNm	Kilo Newton meter
fig.	Figure
&	And
No.	Number
3D	3-Dimensional
RCC	Reinforced Cement Concrete
%	Percentage

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CHAPTER 1: INTRODUCTION

1.1 General

In this study, behavior of multistory high rise building in analyzed for different structural models. Position of shear walls and infill walls are varied in a building with different storey. These structural models are analyzed for static and dynamic analysis on flat ground as well as sloping ground with slope varying from 0° to 30°. Different parameters like lateral displacement, story drift, base shear, time period, bending moment, shear force are analyzed and compared using Staad.Pro and ETABS software. Reference of IS 456 and IS 1893 : 2002 are also considered. Staad.pro helps in 3D structural analysis and designing steel as well as concrete structures. It can increase work productivity, reduces the project cost and save time. Etabs also helps in designing and analyzing multistory structures with a greater accuracy.

1.2 Types of seismic analysis

1.2.1 **Seismic Analysis:** Seismic analysis is computation of the response of a structure under earthquake loading. It is a component of earthquake engineering, structural design and retrofit process. It gives the quantitative estimation of maximum possible shaking of structure under earthquake loading. Inertia forces are induced by the earthquake that are relative to the mass of the building, that's why building's mass controls the seismic design in addition to the stiffness of the building.

1.2.2 **Lateral displacement** of a structure under lateral loads is a critical challenge nowadays for structural engineers. Earthquake response of reinforced concrete elements can be investigated by displacement based seismic analysis. Lateral displacements can be minimized if the structural components are revised for dimension and building stiffness.

1.2.3 **Story drift** and **interstory drift** is one of the responses of a high rise building under lateral loads. Story drift is the drift of one level in relative to the level below in a multistory building whereas interstory drift is difference between roof and floor displacement of any story as the building sways during earthquake. If the value of drift is high, larger is the possibility of damage.

1.2.4 **Base shear** is an estimate of utmost expected lateral force occurs at the base of structure during the seismic ground motion. Base shear depends upon the total weight of the structure as well as the soil conditions.

1.2.5 **Dynamic analysis:** It is an analysis of the structure under dynamic loading. Loads like earthquake, wind, waves, blasts, traffic comes under dynamic loading. Inertia forces are developed in a structure when dynamic loading is subjected to it. Response of a structure may be analyzed by dynamic analysis if load changes quickly with time.

1.2.6 **Response spectrum analysis** is a linear dynamic analysis in which peak response of a structure under earthquake loading is analyzed.

1.2.7 **Pushover analysis** is a static non linear analysis in which structure's response is analyzed under continuous gravity and lateral loads until an ultimate limit is attained.

1.2.8 **Time history analysis** is a non linear dynamic analysis which is used to analyze structure when the response is non linear. Time history analysis tells the dynamic response of structure for a particular loading that may vary with time.

1.2.9 **P-Delta analysis,** P means force and Delta means displacement. When a structural member is deflected due to loading, then secondary effects are induced in it like ground shear, overturning moment, axial force at the base of a tall structure. These secondary effects are approximated using P-Delta analysis.

1.3 Software Tools

In this study, staad.Pro and Etabs software are going to be used for various analyses. These are analysis and design software which are much reliable to make a structure with proper design considerations. They design the members as per the reference of codes of practice.

CHAPTER 2: LITERATURE REVIEW

2.1. General

In this paper, behavior of multistory high rise building is analyzed for different structural models and on different terrains. Different parameters like story drift, base shear, time period, moments, shear force, lateral displacement are computed using software and compared. Different papers are reviewed to know this study more accurately.

Kumar . M. V et al (2016), "Influence of shear walls and coupling beam dimensions on seismic behavior" [1]. In this study, four multistory buildings are analyzed using Etabs software and deflection and stress concentration are calculated. Mainly shear wall length to beam depth ratio and shear wall length to beam length ratio are calculated.

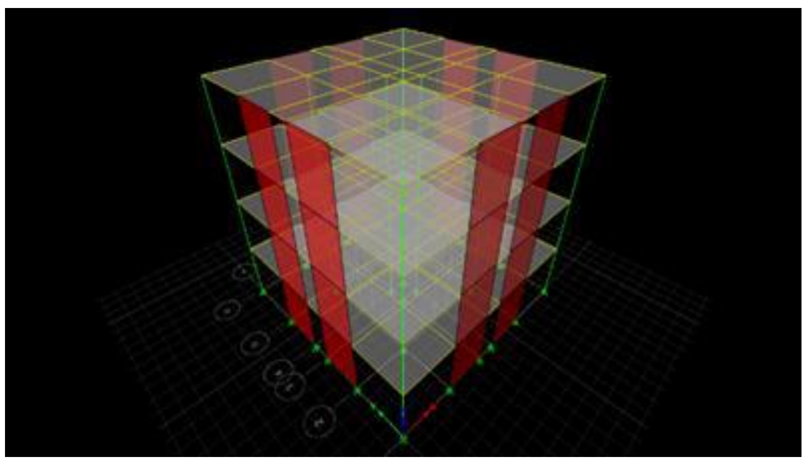

Figure 2.1: 3D view of structure modeled in Etabs (Kumar.M.V et al (2016))

It is observed from the study that stress decreases from top floor to first floor and stress at the fourth floor is less as compared to other floors. It is concluded that the deflection is least when shear wall length to beam depth ratio is 3 and stress is maximum when this ratio is 5. It is also concluded that deflection is minimum when shear wall length to beam length ratio is 2.2 and stress is maximum when this ratio is 2.3.

Gudur. A. S et al (2016), "Review on dynamic wind analysis of tall building provided with steel bracing as per proposed draft for IS code and effect of soft story" [2]. In this paper, author analyzed six different building as moment resisting frames using equivalent static and dynamic response spectrum method.

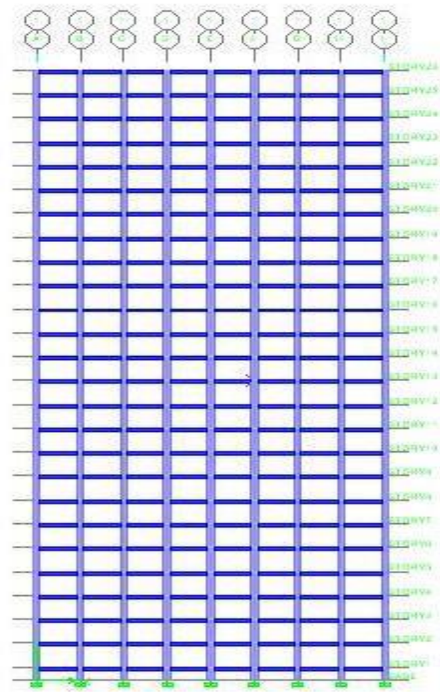

Figure 2.2 : Bare frame (Gudur.A.S. et al (2016))

Basic wind speed of 47 m/sec is considered in the study. It is observed from the study that with the increase in height of building, dynamic wind load also increases. With the position of soft storey, effect of soft story also increases. It is also concluded that wind forces remains constant up to 3 stories and then increases linearly with the height of building for wind speed zone 47 m/sec.

Santhosh. C et al (2016),"Analysis and design of multistory building with grid slab using Etabs" [3]. In this study, behavior of G+5 building is analyzed for both gravity and lateral loads. Earthquake and wind loads are considered and the grid slab is compared with flat slab using Etabs software. Author considered panel size as 12m X 12m.

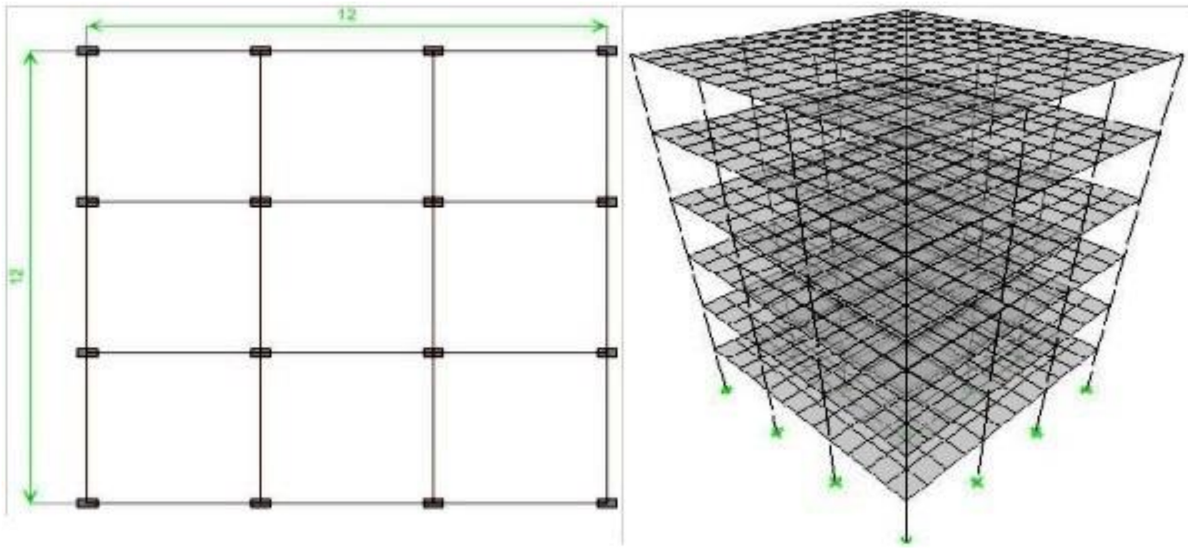

Figure 2. 3: Building plan and frame (Santhosh. C et al (2016))

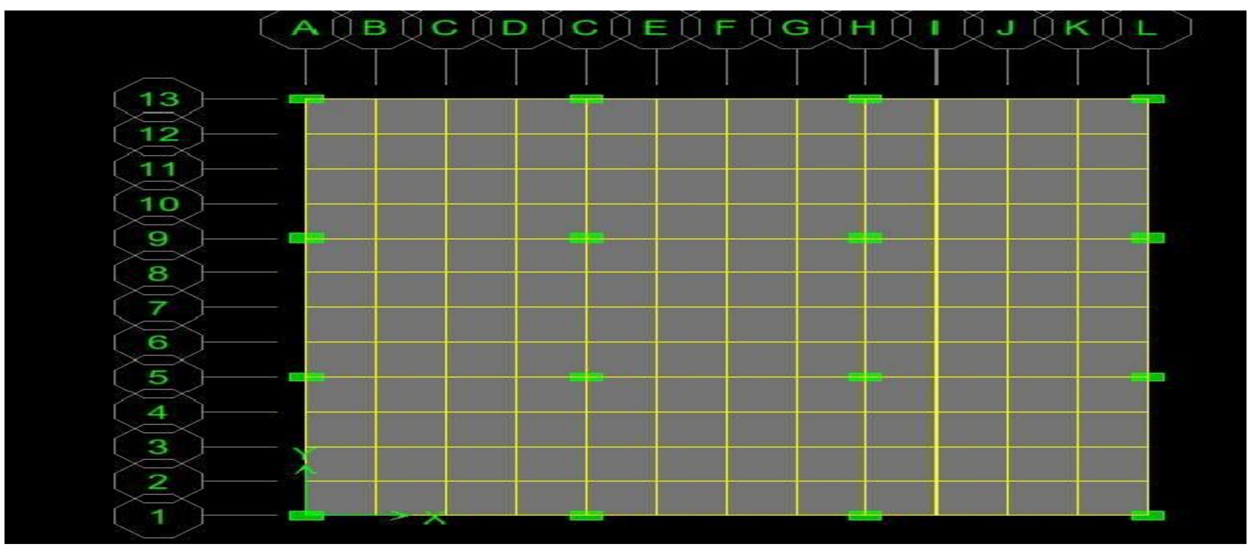

Figure 2.4: Grid slab with finite meshing (Santhosh. C et al (2016))

It is concluded from the results that maximum displacement is observed in flat slab with drop as compared to flat slab. It is also observed that maximum time period is less in grid slab as compared to flat slab with and without drop and grid slab possess maximum base shear than flat slab.

Belgaonker. S et al (2016), "Seismic comparison of building with or without deep beams" [4]. In this study, seismic analysis of a 10 stories building is done using Etabs software.

Author considered building under seismic zone 5. Behavior of building is observed with and without deep beams in it using dynamic method and equivalent static method to resist lateral loads on the structure. Three models are considered in the study, bare frame model, bare frame with 3 m deep beam at ground floor, bare frame with 3.2 m deep beam at ground floor level. It is observed from the study the base reaction increases with the addition of deep beams. Stiffness at ground level is increases up to 49.56% and natural time period is lowered with the addition of deep beams.

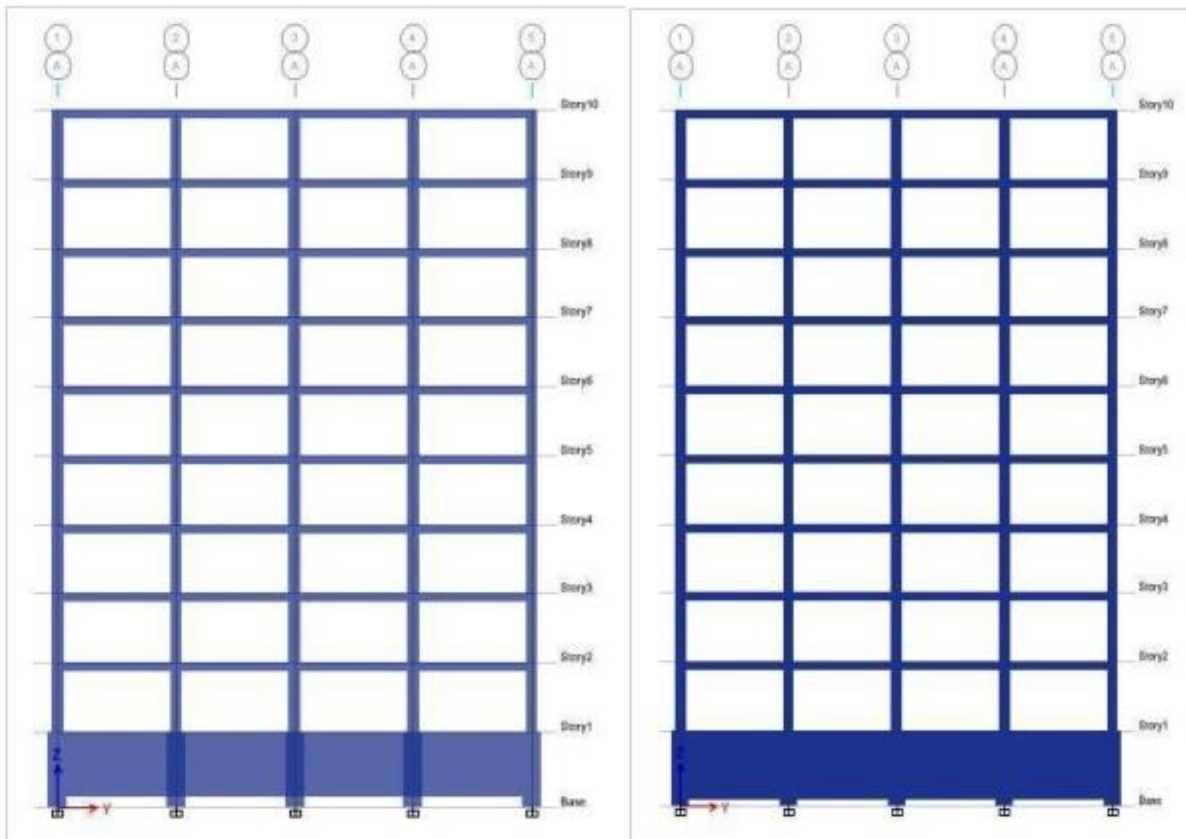

Figure 2. 5: Elevation of building with 3m and 3.2m deep beam (Belgaonkar. S et al (2016))

Patel. A et al (2016), "A study of positioning of different shapes of shear walls in L shaped building subjected to seismic forces" [5]. In this paper, a multistory RCC building of L shape is analyzed for different positions and shapes of shear wall using Etabs software. Various parameters like time period, base shear, story drift, story displacement, are computed and compared by the author using equivalent static analysis, response spectrum analysis and time history analysis. In this study, eight different models are considered of G+20 story building of

L shape. One model is of bare frame, one is of bare frame with brick infill masonry walls, and rests are with different shapes and positions of shear walls.

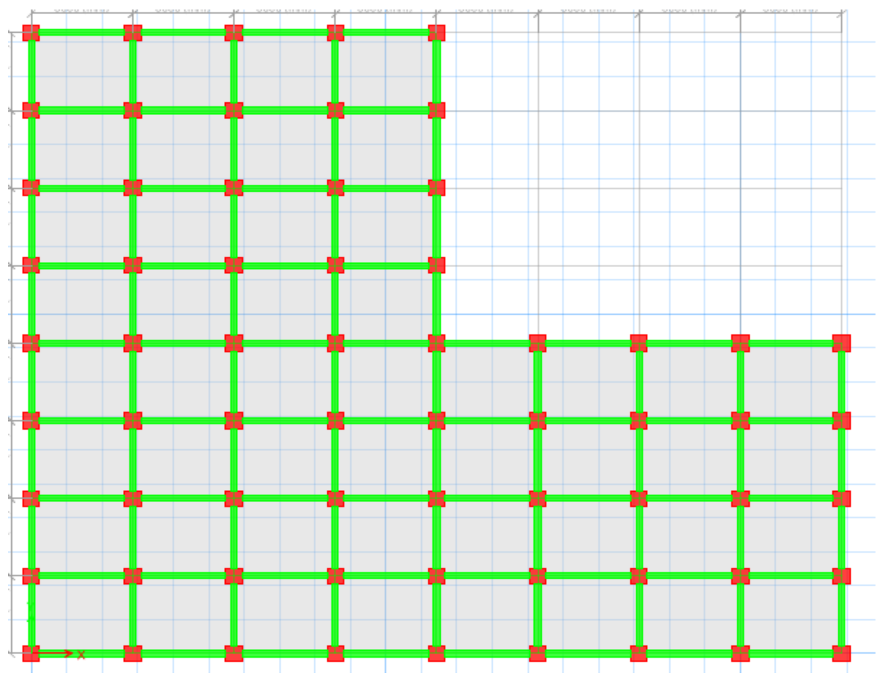

Figure 2. 6: Plan layout (Patel. A et al (2016))

It is concluded that as the seismic weight of building increases, base shear values are varied by the addition of shear walls moreover the base shear values are different calculated in software as compared to IS code method. Addition of shear walls in a structure helps in reducing story displacements as the stiffness of structure is increased by the shear walls.

Arjun. S et al (2016), "A study on dynamic characteristics of RC building on hill slopes" [6]. In this study, G+3 building with 3 bays in longitudinal as well as transverse direction is analyzed in zone III. The model is of step back setback configuration as shown in figure 3.7. Analysis is done with the help of Staad.Pro software. Slopes used for building are 16.7°, 21.8°, 26.57° and 30.96°. For the analysis, base shear and displacement are computed and compared. It is concluded from the results that 16.7° slope has maximum storey displacement due to low stiffness in columns. With the increase in slope angle of the building, top story displacement decreases. It is also observed that with the increase in slope, base shear increases.

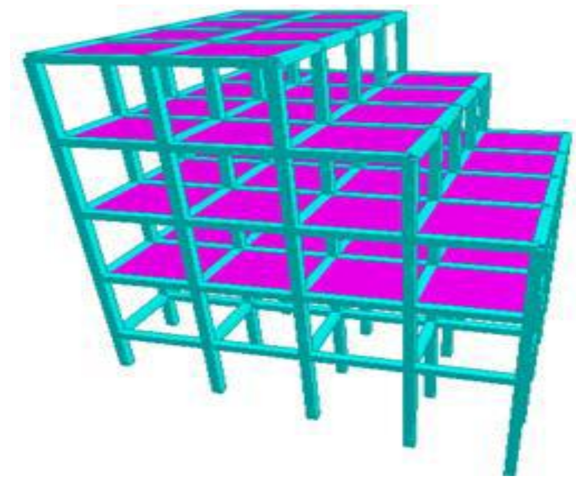

Figure 2.7: Three dimensional view of model (Arjun. S et al (2016))

Chourasiya. R et al (2015), “Seismic evaluation of multistory RC structure using different floor diaphragms” [7]. Author analyzed the response of building using different floor diaphragms. In this study, seismic analysis of G+7 building is carried out using staad.Pro software considering three different cases of floor diaphragms along with different zones as shown in figure 3.8. First case considered is bare frame without diaphragm, second case is frame with rigid diaphragm and third case considered is frame with semi rigid/flexible diaphragm. It is observed from the study that the displacement is least in the frame with rigid diaphragm in all zones. Bending moment is observed to be least in the rigid diaphragm frame in all zones; maximum shear force is also least for rigid diaphragm frame building. It is also concluded that the maximum story displacement increases with the increase in the height but maximum story displacement is still least in the frame with rigid diaphragm in all zones.

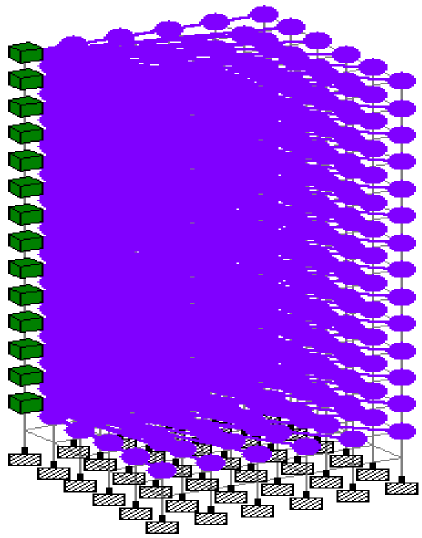

Figure2.8: A typical isomeric diagram for diaphragm (Chourasiya. R et al (2015))

Yarnal. S et al (2015), "Non linear analysis of Asymmetric shear wall with openings" [8]. In this study, author carried out seismic analysis of RC building with shear wall in zone III as shown in figure 3.9. Etabs 2013 software is used for this study. Model is analyzed with shear wall having different percentages of openings and results are compared. Different parameters like base shear, drift, moment, shear force, displacement are computed. In this study, different percentages for shear wall openings considered are 10%, 20%, 30% and 40%. It is observed from the results that base shear in a model with shear wall opening is less as compared to the shear wall without opening and frequency decreases with the increase in the opening in shear wall. It is also concluded that the time period increases with the increase in the opening in shear wall and also story drift is greater in the model with the shear wall opening as compared to shear wall without opening.

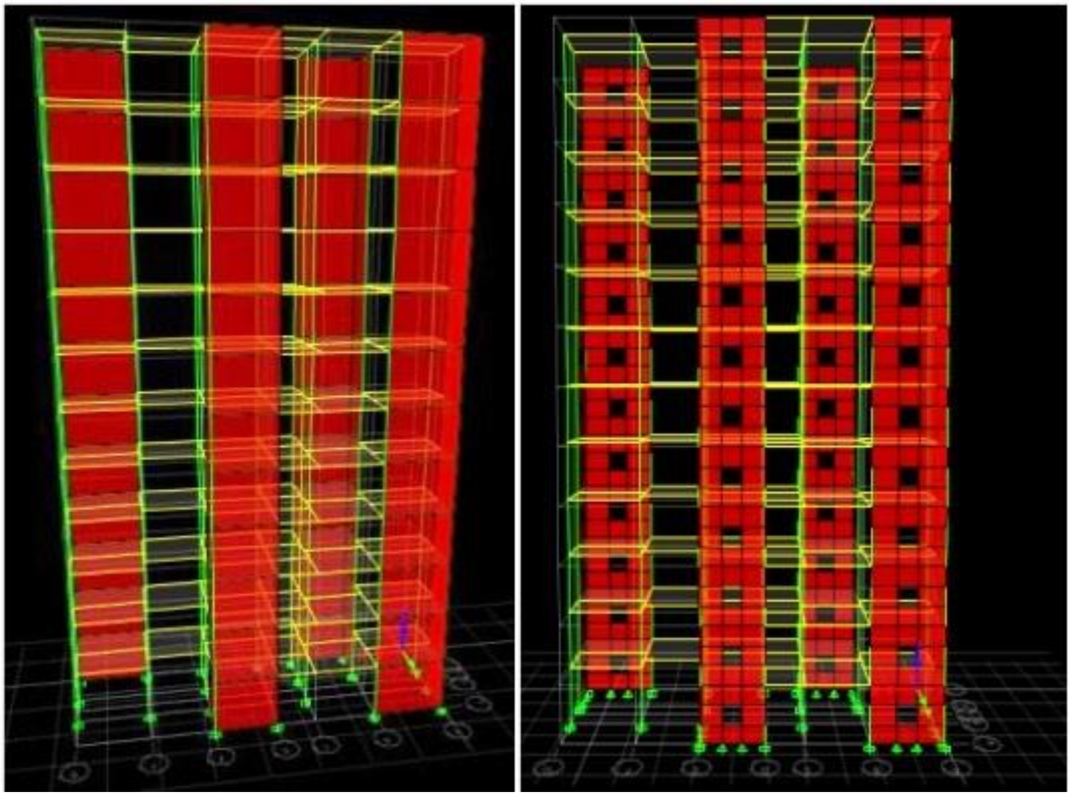

Figure 2.9: Elevation of shear wall building (Yarnal. S et al (2015))

Thejaswini. R et al (2015), "Analysis and comparison of different lateral load resisting structural forms" [9]. In this study, different forms of irregular structures are considered for analysis using Etabs software. Seven models of G+14 (figure 2.10) building are analyzed for using response spectrum method and wind load. First frame considered is rigid frame, second is core wall structure, and third is shear wall along width, fourth model considered is shear wall along length, fifth is shear wall at corners, sixth model is a tube structure and seventh model considered is an outrigger structure. It is concluded from the study that the sixth model with tube structure and with L shaped shear wall shown the best result as it has the lowest displacement and no torsional irregularity and is stable as compared to all general structures.

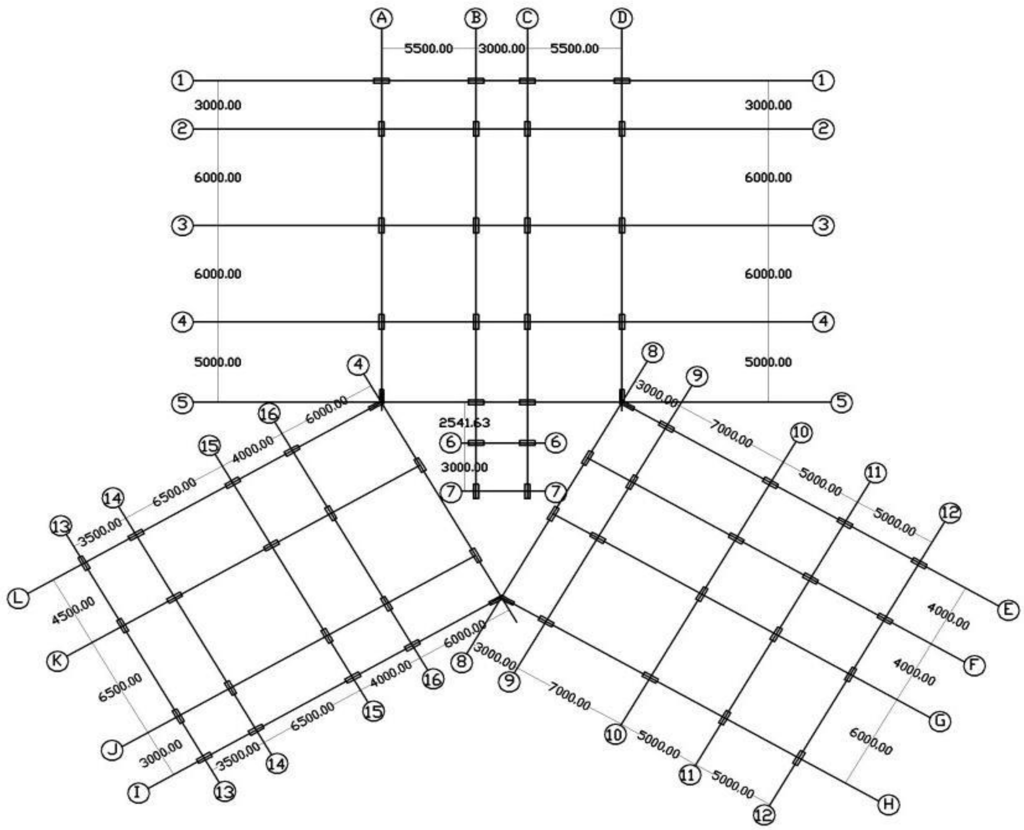

Figure 2.10: Plan of the considered model (Thejaswini. R et al (2015))

Ranjhita. K et al (2014), "Effect of wind pressure on RC tall buildings with gust factor method" [10]. In this study, different shapes of building are analyzed using Etabs software. Building is analyzed in zone I and zone IV and is considered with and without gust factor. 15 story RC building with square and I shapes are considered for study as shown in figure 3.11. Different parameters like base shear, story displacement, story drift, overturning moment and story shear are computed and compared. It is observed from the results that as the story increases, displacement also increases in both the zones and when the wind zone increases, story displacement also increases. It is concluded that the displacement in regular structure with and without gust factor is less as compared to the irregular structure. Story drift increases from first to second story and after that, it becomes zero at top story and as wind zone increases, story drift also increases.

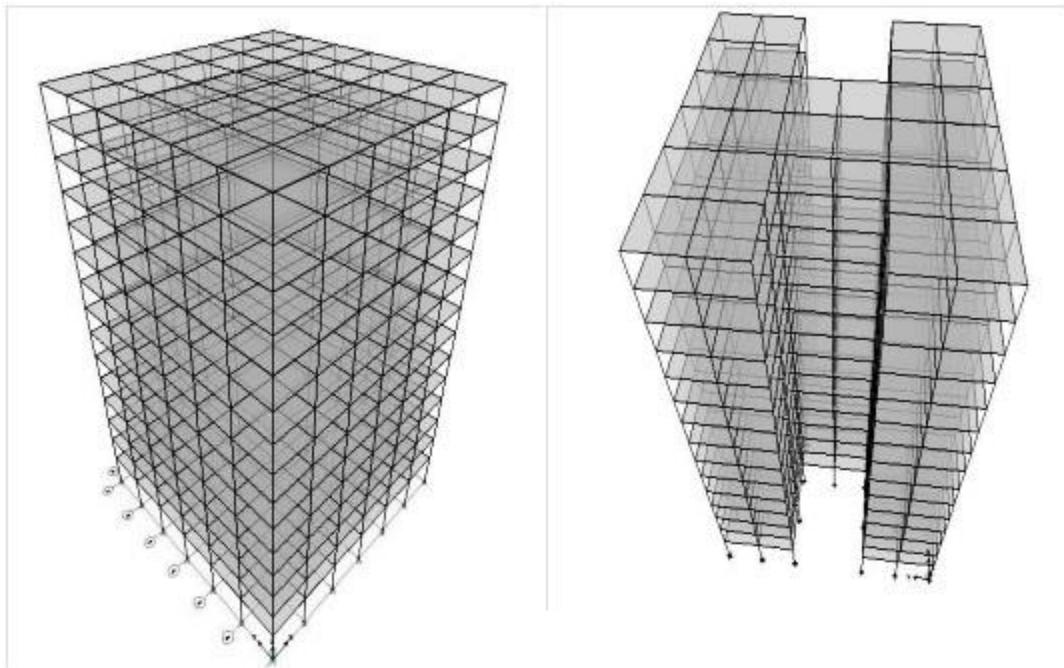

Figure 2.11: 3D model of square and I shape (Ranjhita. K et al (2014))

Govalkar. V et al (2014), "Analysis of bare frame and infilled frame with different position of shear wall" [11]. Author studied the response of RC building using staad.pro software by changing the position of shear wall. In this study, eight models are considered with different position of shear walls out of which, four models are bare frame and four are infilled frame. Story drift and axial forces are computed and compared. It is observed from the study that axial forces and drift are decreased with the addition of shear wall. It is also concluded that the best results are obtained when shear walls are located at the corners. Plan of the building is shown in figure 3.12.

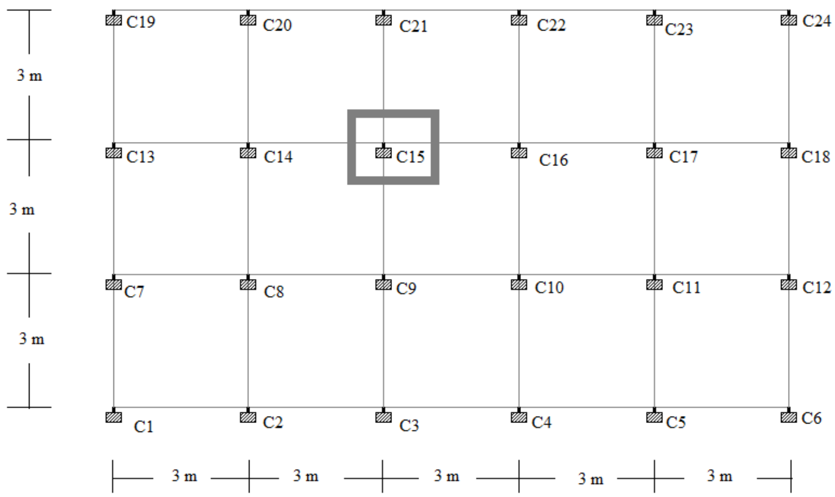

Figure 2.12: Plan of the public building (Govalkar. V et al (2014))

Kumawat. M et al (2014), "Analysis and design of multistory building using composite structure" [12]. In this study, steel concrete composite and RCC are analyzed as per IS 1893: 2002 (part I) and compared using SAP 2000 software. G+9, office building is considered in zone III. Author carried out the analysis using response spectrum method and equivalent static analysis. In this, beams and columns are modeled as two nodded beam elements with six DOFs' at each node and for slabs, four nodded element is used with six DOFs' at each node. It is observed from the study that the twisting moment, bending moment, drift and shear force is less in the composite structure as compared to RCC. It is also concluded that stiffness is more in composite structure than RCC. Displacement, story drift and axial force are less in composite structure than RCC structure. Also, frequency is increased in composite as compared to RCC structure.

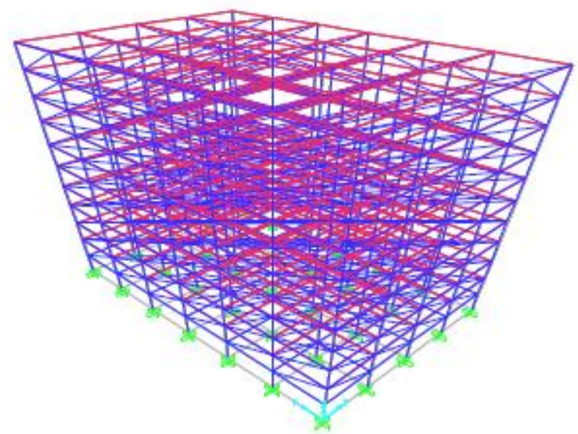

Figure 2.13: 3D model of commercial building (Kumawat. M et al (2014))

Umakant. A et al (2014), "Wind analysis of building frames on sloping ground" [13]. In this, response of structure is analyzed by the effect of wind velocity using Staad.Pro v8i software. Three different types of buildings are analyzed for four different angles. Results in terms of shear force, bending moment, displacements, support reactions, axial force are computed and compared. Author considered eight, twelve and sixteen story building with 3 bays with slope angles 0°, 5°, 10°and 15°. Wind zones considered are 33, 39, 44, 47, 55m/sec as per IS : 875 (part III :1987). It is observed that maximum axial force increases with increase in ground slope in case of beams whereas in case of columns, it increases with the height of building. Maximum shear force increases with increase in wind velocity in case of beams whereas in columns, it increases with velocity as well as height. Maximum bending moment increases with wind velocity in beams but is not effected by ground slope. It is also observed that maximum displacement increases with the wind velocity but is not affected by increase in ground slope from 0° to 15°. Maximum drift increase with the overall building height.

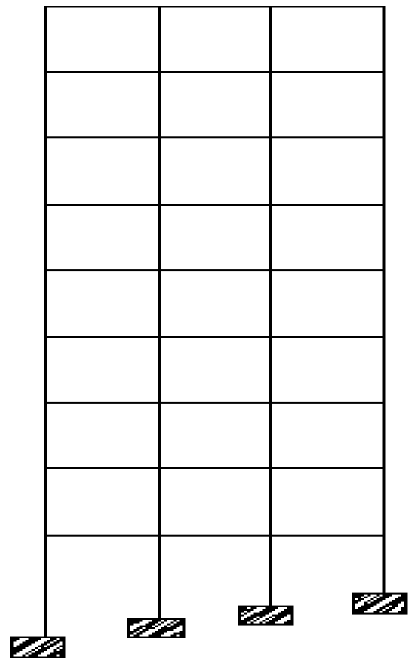

Figure.2.14: Critical face of building (Umakant. A et al (2014))

Halkude. S. A et al (2013), "Seismic analysis of building resting on sloping ground with varying number of bays and hill slopes" [14]. In this study, Author studied the behavior of two types of buildings, step back and step back set back. He has done response spectrum, analysis on these structures with different number of bays and hill slope ratio. It is observed that the base shear is more in step back frame than step back set back frame, time period is also more in step back frame as compared to step back set back frame. Top story displacement and torsion effect is more in step back frame than step back set back frame. It is also concluded that as the number of bays increases, time period and top story displacement decreases.

Ahmed. J et al (2013), "Wind analysis and design of multi bay multistory 3D RC frame" [15]. In this study, they have done the wind analysis of RC building with different number of stories with the help of Etabs software. They took 45 models, fifteen for 5 stories, fifteen for 15 stories and fifteen for 35 stories. They have studied the response of building by comparing bare frame, building with shear wall in X and Y direction and double diagonal bracing in X and Y direction. They have also considered the aspect ratio of 1, 1.5 and 2.0.

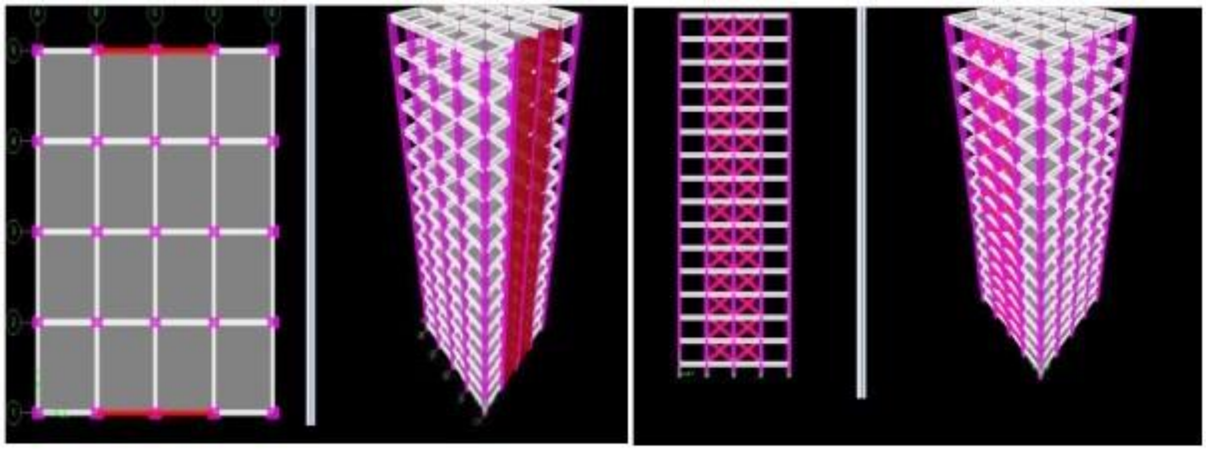

Figure 2.15: Model showing shear walls and double diagonal bracing in building (Ahmed. J et al (2013))

It is observed that providing shear wall in X and Y direction gives least displacement than providing bracing in X and Y direction. Also, story drift is less with shear walls as compared to bracing. It is concluded that shear wall gives better results in resisting lateral loads and compared to double diagonal bracings. Moreover, shear walls can be used effectively to strengthen the structure.

Patil. S .S et al (2013), "Static analysis of high rise building with different lateral load resisting system" [16]. In this study, a G+14 story building is analyzed under earthquake forces with equivalent static method by studying the effect of bracing and shear wall on the structure. They analyzed the structure with the help of Staad.Pro software by considering models of bare frame, braced frame and shear wall frame with different positions of bracings and shear walls in the building.

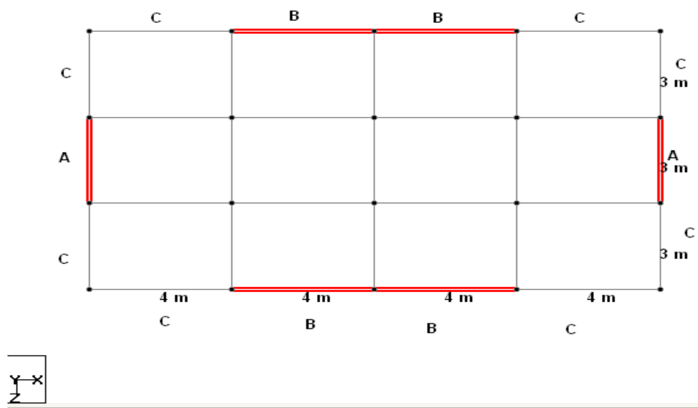

Figure 2.16: Plan of building showing location of braced frame and shear wall frame (Patil .S. S et al (2013))

They concluded that the story drift decreases with bracing at X and XZ direction, with shear wall at X and XZ direction the story deflection and story drift is less than bare and brace frame. Time period is decreased in braced and shear wall frame as compared to bare frame. Axial force is minimum for shear wall models and lateral stiffness is increased in both braced and shear wall frame as compared to bare frame.

Romy. M et al (2011), "Dynamic analysis of R.C.C building with shear wall" [17]. In this study, they analyzed two different multistory buildings of six and eleven stories with the help on SAP2000 software with the use of six different shapes of shear walls. They made a comparison of results of time history analysis with response spectrum analysis and equivalent static analysis. It is observed that equivalent static method can be used upto 25m height whereas for higher and unsymmetrical structures, response spectrum is to be used. Moreover, time history analysis gives accurate results as compared to above two methods. They observed that the square shaped shear wall is most effective and L shaped shear wall is the least effective under lateral forces.

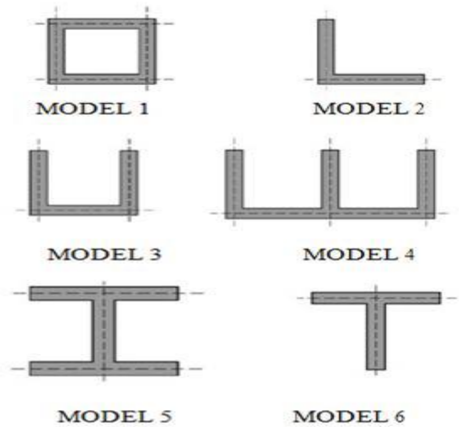

Figure.2.17: Types of shear wall (Romy. M et al (2011))

CHAPTER 3: SCOPE OF THE STUDY

1. Through this work, unexpected behavior of building can be evaluated under utmost conditions of seismic and wind forces.
2. A structure with zero deformability is not really possible, but with the help of this study, most precise structural models can be made that undergo to the lower degree of deformation and can hold up high lateral forces.
3. This study may help to enhance the performance of building in damage prone areas.
4. This will help to understand the design considerations to be followed to make the structure more efficient and economical.

CHAPTER 4: OBJECTIVE OF STUDY

In this piece of research, the main objective is to know the response of RCC structure under different types of loading conditions on different terrain with various structural frames using several analyses and their comparisons during seismic and wind forces.

It may be convenient to empathize the crucial members in a structure that requires special care. Building can be made safe and working during extreme conditions with eminent strength and endurable economy.

CHAPTER 5: RESEARCH METHODOLOGY

In this study, a multistory RCC building will be analyzed with different models of structures on different terrain with the help of staad.pro and E tabs software. Static and dynamic analysis of structure will be carried out as per the reference of code IS 1893: 2002. Different slopes are considered from 0° to 20° and results will compared with the flat ground. Different models are considered with different shape and dimensions of shear walls and bracings at different locations. Various parameters involved in analysis are computed and results are compared

Table 5.1: Structural Specification Details

S.NO.	PARTICULARS	SPECIFICATIONS
1	No. of storey	10
2	Base plan	40×30m
3	Storey height	3m
4	Depth of foundation	3m
5	Type of soil	Medium
6	Column size	0.35×0.4m, 0.4×0.4m, 0.5×0.5m, 0.8×0.8m
7	Beam size	0.3×0.35m
8	Shear wall thickness	0.150m
9	Zones considered	Zone 3, zone 4, zone 5

NOTE: Dead loads are considered as per IS 875-1 and live loads are considered as per IS 875-2.

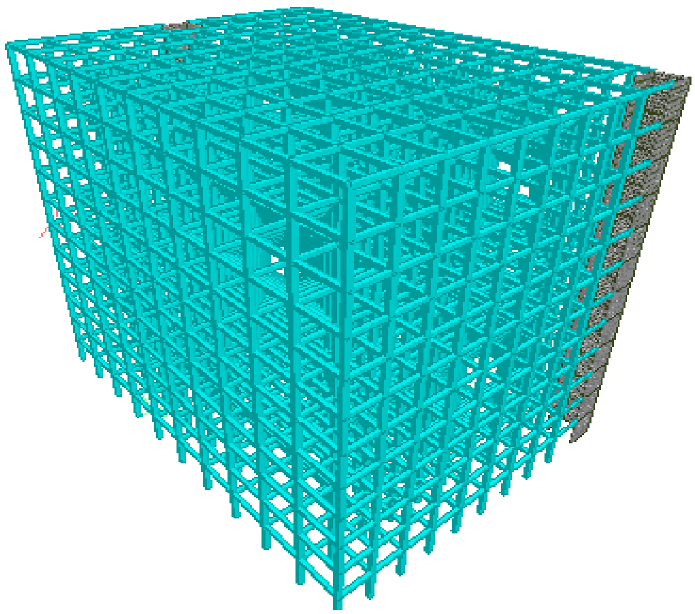

Figure 5.1: 3D rendered view of model

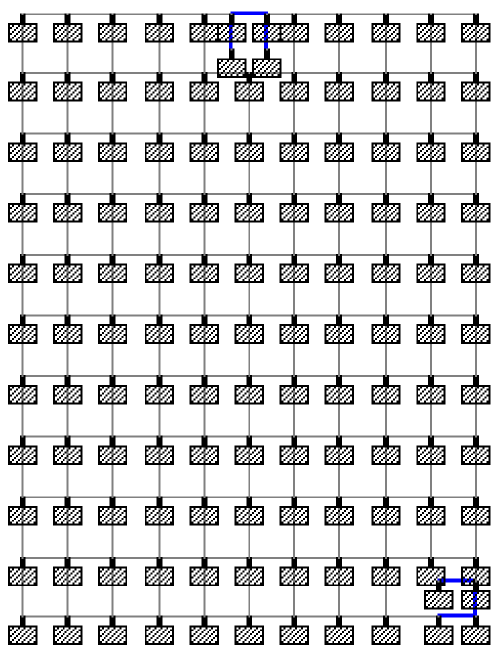

Figure 5.2: Plan view of model

Table 5.2: Analysis to be performed

LINEAR ANALYSIS	NON LINEAR ANALYSIS
Seismic analysis	Time history analysis
Response spectrum analysis	Pushover analysis

Table 5.3: Parameters to be determined

S.NO	PARAMETERS
1	Base shear
2	Storey drift
3	Storey displacement
4	Overturning moment
5	Shear force
6	Dead load
7	Live load

Table 5.4: Model Description

Model	Terrain slope	Zone
MOD 03	0°	3
MOD 04	0°	4
MOD 05	0°	5
MOD 103	10°	3
MOD 104	10°	4
MOD 105	10°	5
MOD 153	15°	3
MOD 154	15°	4
MOD 155	15°	5
MOD 203	20°	3
MOD 204	20°	4
MOD 205	20°	5

Table 5.5: Dead loads as per IS 875 (Part 1)

Floor slab	4.87 KN/m^2
Roof slab	7 KN/m^2
Exterior walls	13.1 KN/m
Interior walls	6.47 KN/m
Parapet wall	5.1 KN/m
Floor finish	0.15 KN/m^2

Table 5.6: Live loads as per IS 875 (Part 2)

Roof load	1.5 KN/m^2
Floor load	4 KN/m^2
Load on elevators	10 KN

Table 5.7 : Seismic Parameters

Response reduction	SMRF
Importance factor	1.5
Soil type	Medium
Structure type	RC frame building
Damping ratio	0.05
Foundation depth	3m
Period in X	0.59 seconds
Period in Z	0.51 seconds

CHAPTER 6: RESULTS AND DISCUSSIONS

6.1 General

In this chapter, through the analysis of three different models on flat ground with three different zones, several parameters are recorded and compare

6.2 BASE SHEAR

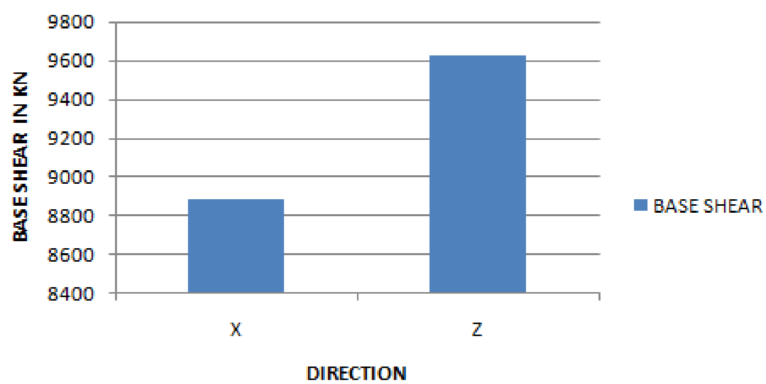

Figure 6.1: Base shear in MOD 03

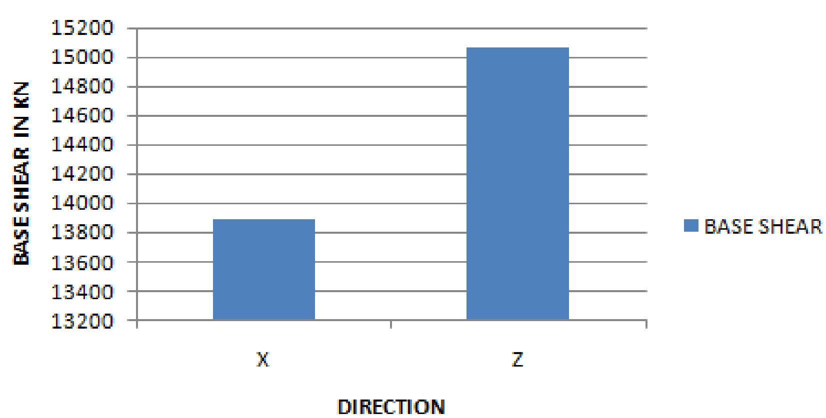

Figure 6.2: Base shear in MOD 04

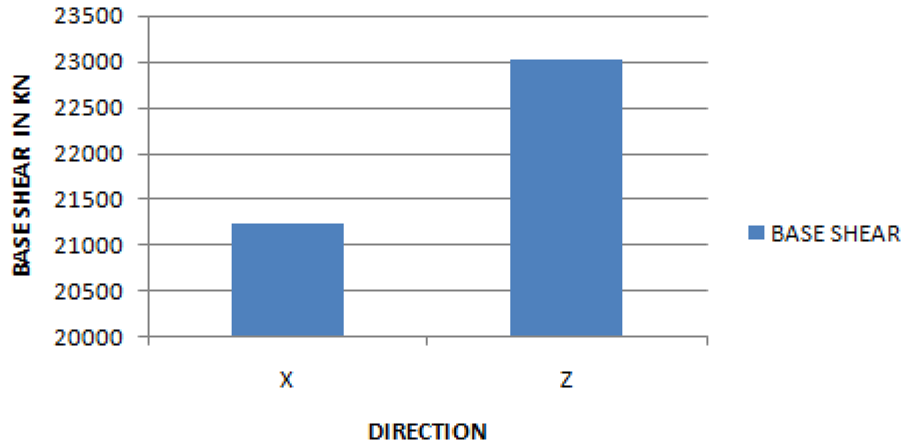

Figure 6.3: Base shear in MOD 05

The above graph shows the base shear in models with zone 1, 2 and 3. In all the three models, base shear is calculated as per IS 1893 2002 with medium soil condition and time period 0.59 seconds in X and 0.51 seconds in Z. Base shear is more in z direction as compared to x direction.

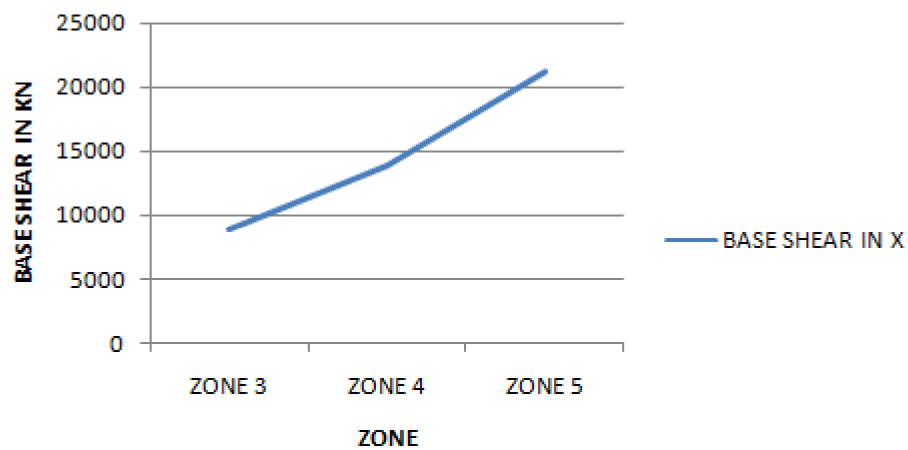

Figure 6.4: Comparison of base shear in MOD 03, MOD 04, MOD 05

Figure 6.5: Comparison of base shear in MOD 03, MOD 04, MOD 05

Base shear in MOD 05 has the highest base shear as compared to other two models in both X and Z directions

6.3 FORCES

Figure 6.6 Beam forces in MOD 03

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kip-in	My kip-in	Mz kip-in
Max Fx	228	14 GENERAT	129	**4637.991**	-300.195	-3.853	1.101	-50.344	3997.842
Min Fx	12	15 GENERAT	1	**-1484.118**	71.183	3.088	18.517	-9.099	510.194
Max Fy	228	12 GENERAT	1	2256.221	**300.823**	3.489	-1.086	-46.116	3986.715
Min Fy	228	18 GENERAT	1	3247.246	**-300.321**	-3.780	1.098	50.783	-3975.777
Max Fz	228	17 GENERAT	1	1173.127	-63.986	**340.826**	-14.221	-4520.210	-847.455
Min Fz	228	15 GENERAT	1	4330.339	64.488	**-341.116**	14.233	4524.877	858.392
Max Mx	1	19 GENERAT	1	307.196	1.062	-63.917	**174.485**	935.763	-143.428
Min Mx	1	13 GENERAT	1	-294.524	32.718	63.860	**-185.389**	-934.940	80.339
Max My	228	17 GENERAT	129	1182.054	-63.986	340.826	-14.221	**4529.506**	851.518
Min My	228	15 GENERAT	129	4345.218	64.488	-341.116	14.233	**-4532.559**	-853.910
Max Mz	228	18 GENERAT	129	3256.173	-300.321	-3.780	1.098	-49.581	**3998.440**
Min Mz	228	12 GENERAT	129	2271.099	300.823	3.489	-1.086	46.528	**-4000.833**

Figure 6.7 Beam forces in MOD 04

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kip-in	My kip-in	Mz kip-in
Max Fx	228	14 GENERAT	129	**16182.828**	-4887.153	-1148.266	391.823	-15171.895	65101.793
Min Fx	228	1 EQX	1	**-3892.574**	3247.798	725.306	-264.229	-9641.078	42976.164
Max Fy	228	16 GENERAT	1	326.711	**4862.424**	1051.775	-399.055	-13948.246	64344.703
Min Fy	228	14 GENERAT	1	16114.815	**-4887.153**	-1148.266	391.823	15317.236	-64663.480
Max Fz	228	17 GENERAT	1	1928.719	145.265	**6977.337**	7.364	-92473.758	1957.028
Min Fz	228	15 GENERAT	1	14512.806	-169.994	**-7073.827**	-14.595	93842.750	-2275.805
Max Mx	228	18 GENERAT	1	12004.433	-4880.970	-1124.143	**393.631**	14974.988	-64583.789
Min Mx	228	12 GENERAT	1	4437.092	4856.241	1027.652	**-400.863**	-13605.998	64265.012
Max My	228	15 GENERAT	1	14512.806	-169.994	-7073.827	-14.595	**93842.750**	-2275.805
Min My	228	15 GENERAT	129	14580.820	-169.994	-7073.827	-14.595	**-93983.828**	2237.936
Max Mz	228	14 GENERAT	129	16182.828	-4887.153	-1148.266	391.823	-15171.895	**65101.793**
Min Mz	228	16 GENERAT	129	367.519	4862.424	1051.775	-399.055	13978.821	**-64763.957**

Figure 6.8 Beam forces in MOD 05

For MOD 03, maximum force is coming along X direction with load combination 1.5DL+1.5LL. For MOD 04, maximum force is coming along X direction with load combination 1.5DL-1.5EQX. Whereas for MOD 05, maximum force is coming along same direction as above 2 models but with load combination of 1.5DL-1.5EQX.

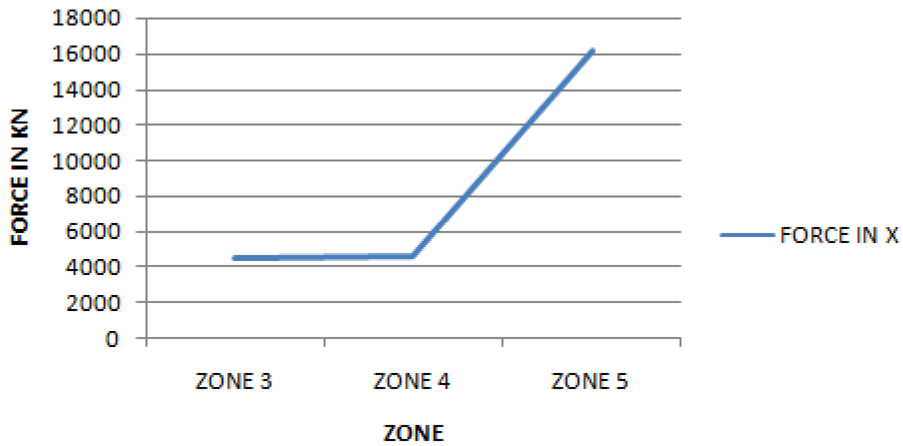

Figure 6.9: Comparison of maximum force in MOD 03, MOD 04, MOD 05

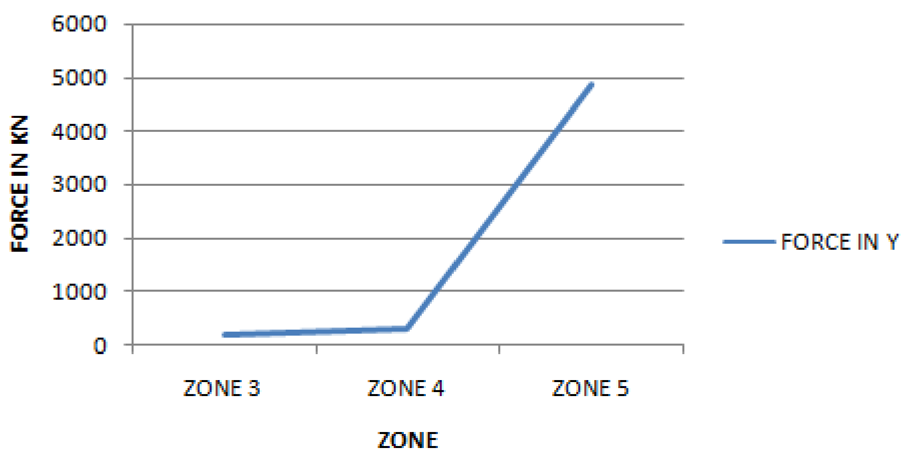

Figure 6.10: Comparison of maximum force in MOD 03, MOD 04, MOD 05

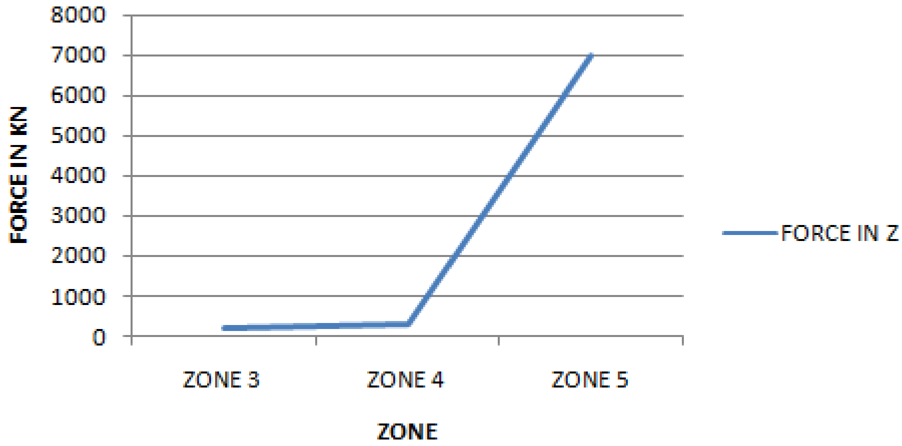

Figure 6.11: Comparison of maximum force in MOD 03, MOD 04, MOD 05

6.4 STRESSES

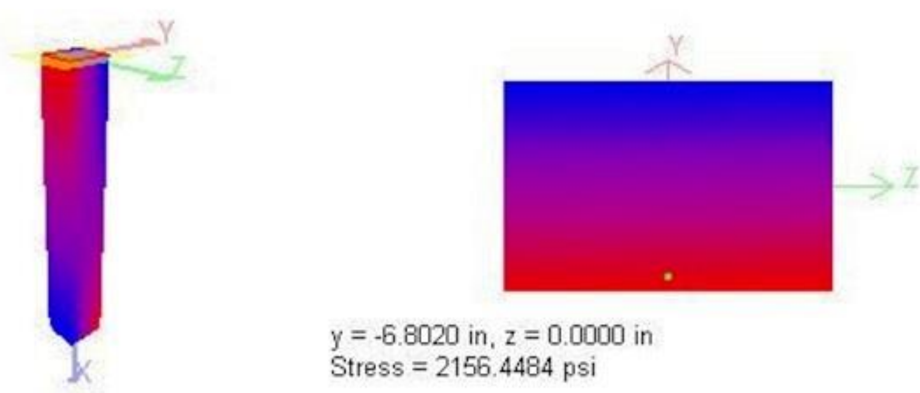

Figure 6.12: Beam stresses in MOD 03

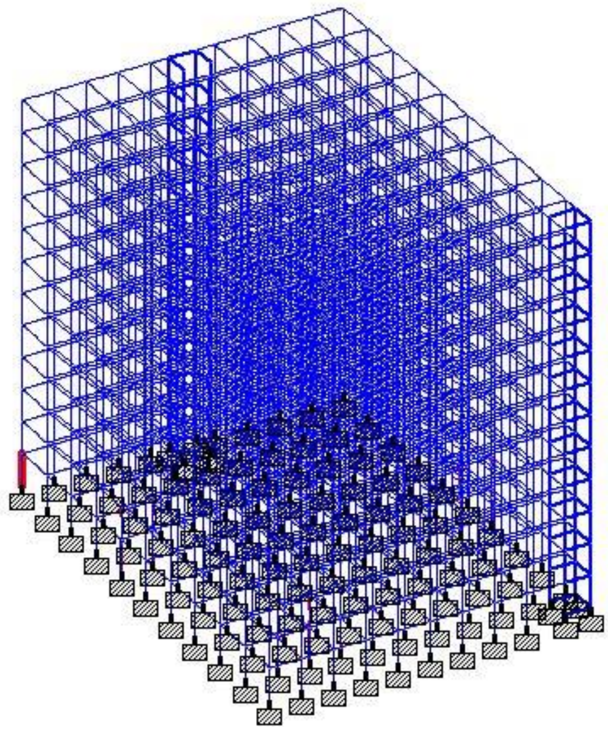

Figure 6.13: Beam stress in MOD 03

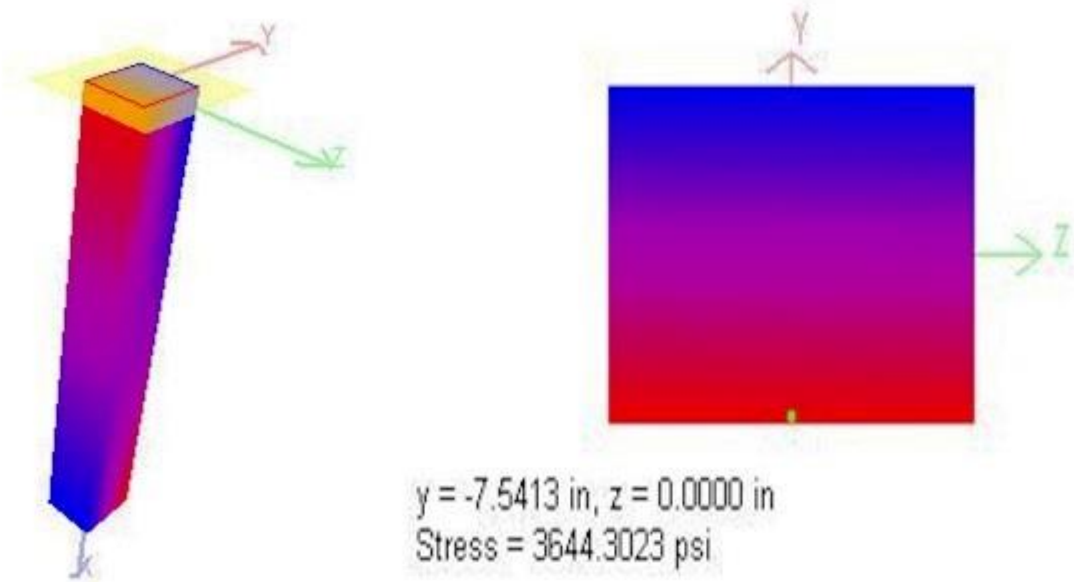

Figure 6.14: Beam stresses in MOD 04

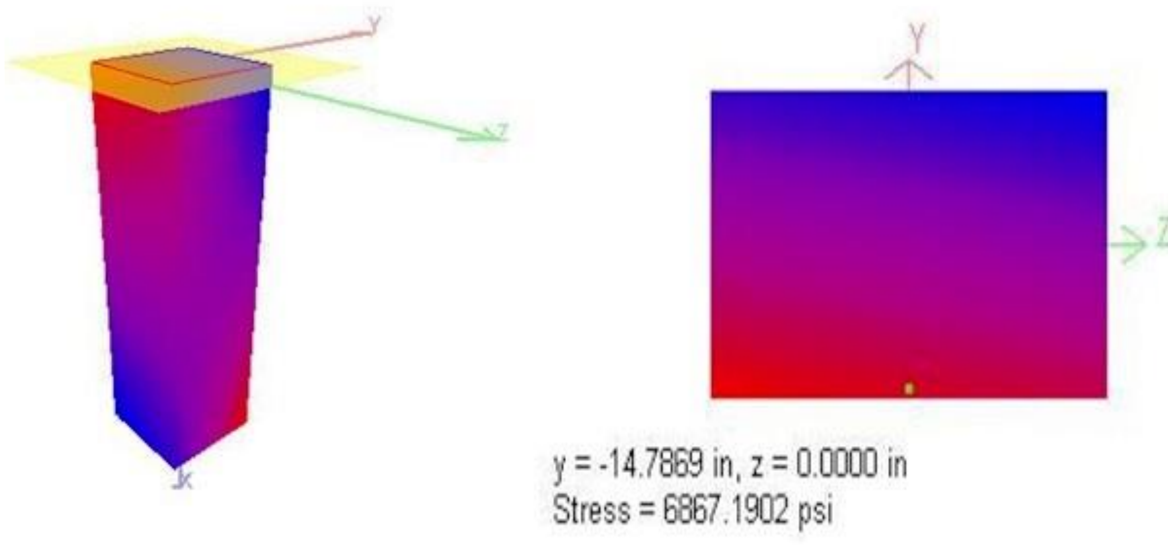

Figure 6.15: Beam stresses in MOD 05

6.5 DISPLACEMENT

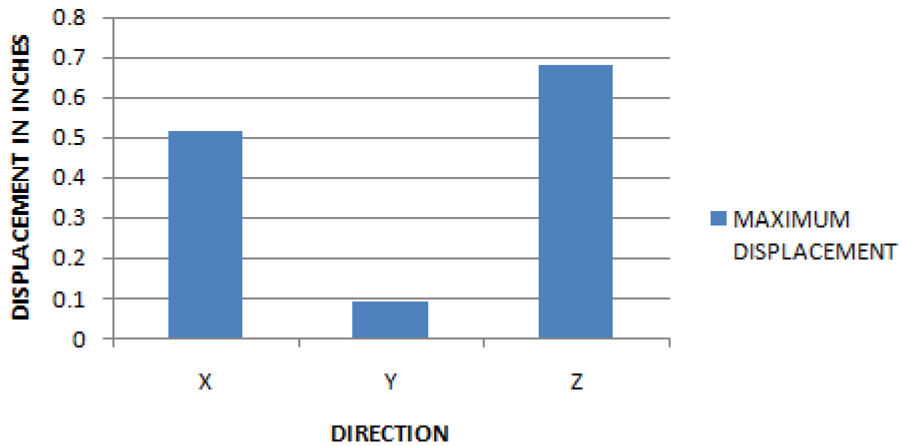

Figure 6.16: Node displacements in MOD 03

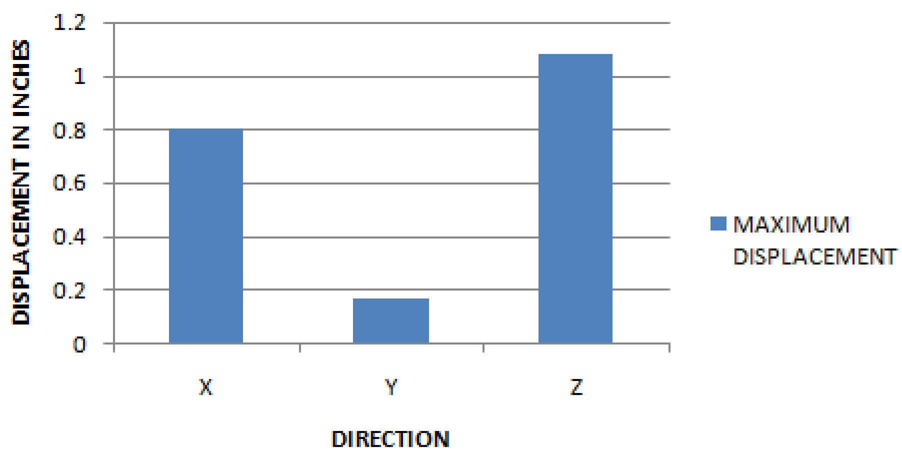

Figure 6.17: Node displacements in MOD 04

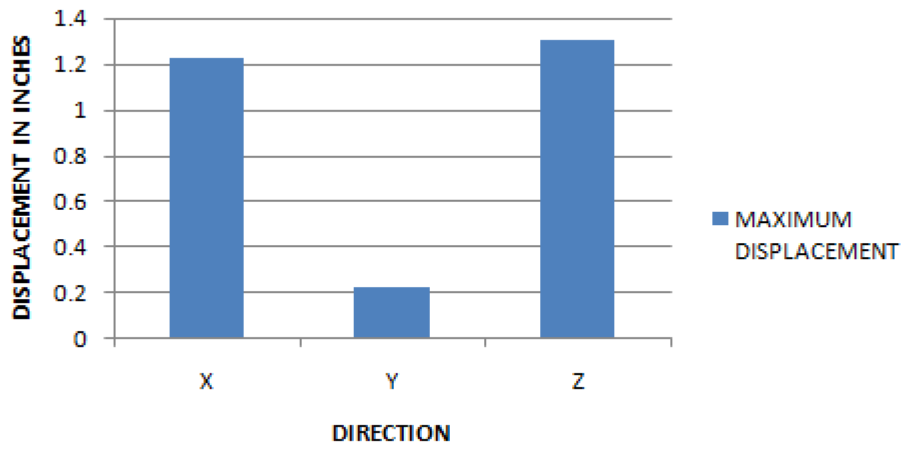

Figure 6.18: Node displacements in MOD 05

For MOD 03, maximum displacement is along Z direction due to load combination 0.9DL+1.5EQZ. For MOD 04, maximum displacement is due to load combination 1.5DL+1.5EQZ. on the other hand, MOD 05 has maximum node displacement in Z direction for load combination 1.5DL+1.5EQZ.

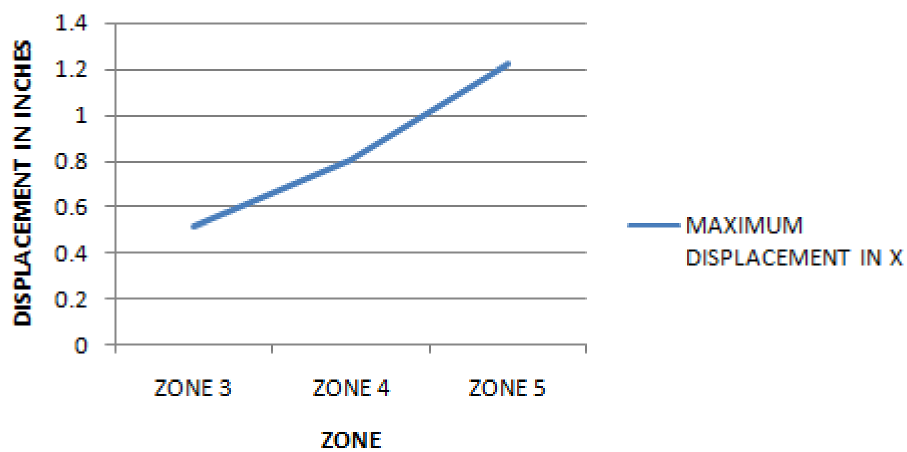

Figure 6.19: Comparison of displacement in MOD 03, MOD 04, MOD 05

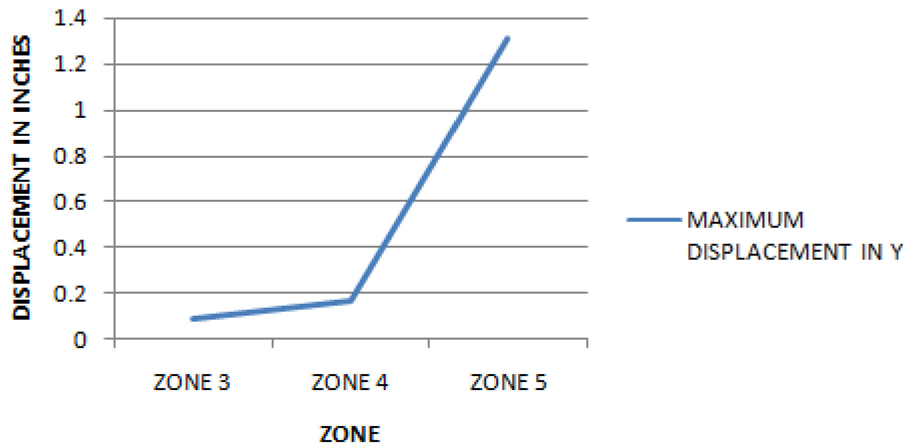

Figure 6.20: Comparison of displacement in MOD 03, MOD 04, MOD 05

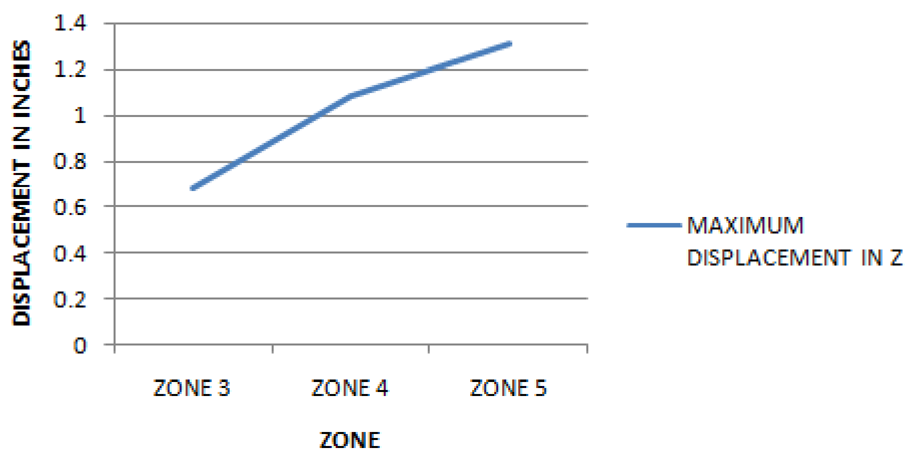

Figure 6.21: Comparison of displacement in MOD 03, MOD 04, MOD 05

It is evident from the above graphs that maximum displacement is occurred in MOD 05 which is built in zone 5.

6.6 REACTIONS

All | Summary | Envelope

	Node	L/C	Horizontal Fx kN	Vertical Fy kN	Horizontal Fz kN	Moment Mx kip-in	My kip-in	Mz kip-in
Max Fx	134	14 GENERAT	2003.944	4541.664	533.644	-565.878	122.865	-62.799
Min Fx	135	12 GENERAT	-2026.814	4584.618	539.331	-568.925	-123.349	62.401
Max Fy	135	15 GENERAT	-1449.027	5449.457	1428.833	-275.085	12.017	-393.914
Min Fy	135	2 EQZ	597.347	-2111.423	-561.991	61.194	-6.816	133.869
Max Fz	248	15 GENERAT	-232.088	3542.929	1743.801	139.552	127.886	-528.469
Min Fz	247	13 GENERAT	-681.896	5071.329	-2093.355	-2.157	-114.362	-584.810
Max Mx	129	15 GENERAT	-40.143	4090.452	216.981	2883.925	8.855	530.977
Min Mx	129	17 GENERAT	39.763	1539.064	-216.963	-2882.948	-8.842	-529.522
Max My	248	19 GENERAT	-28.599	2758.682	1555.691	206.344	128.739	-465.949
Min My	248	13 GENERAT	-785.354	378.307	-803.251	-473.513	-132.153	215.873
Max Mz	129	12 GENERAT	-200.456	2758.287	3.525	47.449	1.145	2665.291
Min Mz	129	18 GENERAT	200.076	2871.229	-3.507	-46.471	-1.132	-2663.836

Figure 6.22 Maximum Reactions in MOD 03

All | Summary | Envelope

	Node	L/C	Horizontal Fx kN	Vertical Fy kN	Horizontal Fz kN	Moment Mx kip-in	My kip-in	Mz kip-in
Max Fx	134	14 GENERAT	2711.960	5603.549	493.852	-748.939	184.680	-196.148
Min Fx	135	12 GENERAT	-2739.586	5644.674	494.277	-754.786	-185.804	197.357
Max Fy	135	15 GENERAT	-1948.622	7175.831	1885.233	-322.781	16.722	-497.770
Min Fy	135	17 GENERAT	1095.309	-3656.540	-979.204	41.023	-13.845	200.406
Max Fz	248	15 GENERAT	-114.333	4579.434	2495.760	299.410	200.982	-750.432
Min Fz	247	13 GENERAT	-827.215	7009.329	-3047.281	-79.344	-179.413	-840.406
Max Mx	129	15 GENERAT	-64.488	4345.218	341.116	4532.559	14.233	853.910
Min Mx	129	17 GENERAT	63.986	1182.054	-340.826	-4529.506	-14.221	-851.518
Max My	248	19 GENERAT	106.071	3729.695	2291.216	371.561	201.856	-682.728
Min My	248	13 GENERAT	-987.689	-330.741	-1473.039	-660.163	-205.352	411.914
Max Mz	129	12 GENERAT	-300.823	2271.099	-3.489	-46.528	-1.086	4000.833
Min Mz	129	18 GENERAT	300.321	3256.173	3.780	49.581	1.098	-3998.440

Figure 6.23 Maximum Reactions in MOD 04

All | Summary | Envelope

			Horizontal	Vertical	Horizontal	Moment		
	Node	L/C	Fx kN	Fy kN	Fz kN	Mx kip-in	My kip-in	Mz kip-in
Max Fx	129	14 GENERAT	**4887.153**	16182.828	1148.266	15171.895	391.823	-65101.793
Min Fx	129	16 GENERAT	**-4862.424**	367.519	-1051.775	-13978.821	-399.055	64763.957
Max Fy	129	14 GENERAT	4887.153	**16182.828**	1148.266	15171.895	391.823	-65101.793
Min Fy	247	19 GENERAT	-222.037	**-4125.076**	2462.330	379.075	221.129	776.808
Max Fz	129	15 GENERAT	169.994	14580.820	**7073.827**	93983.828	-14.595	-2237.936
Min Fz	129	17 GENERAT	-145.265	1969.527	**-6977.337**	-92790.758	7.364	1900.099
Max Mx	129	15 GENERAT	169.994	14580.820	7073.827	**93983.828**	-14.595	-2237.936
Min Mx	129	17 GENERAT	-145.265	1969.527	-6977.337	**-92790.758**	7.364	1900.099
Max My	129	18 GENERAT	4880.970	12045.241	1124.143	14873.626	**393.631**	-65017.332
Min My	129	12 GENERAT	-4856.241	4505.106	-1027.652	-13680.553	**-400.863**	64679.496
Max Mz	129	16 GENERAT	-4862.424	367.519	-1051.775	-13978.821	-399.055	**64763.957**
Min Mz	129	14 GENERAT	4887.153	16182.828	1148.266	15171.895	391.823	**-65101.793**

Figure 6.24 Maximum Reactions in MOD 05

6.7 STORY V/S DISPLACEMENT

As per the results, displacement in more in Z direction as compared to X direction for each storey level in all the three zones.

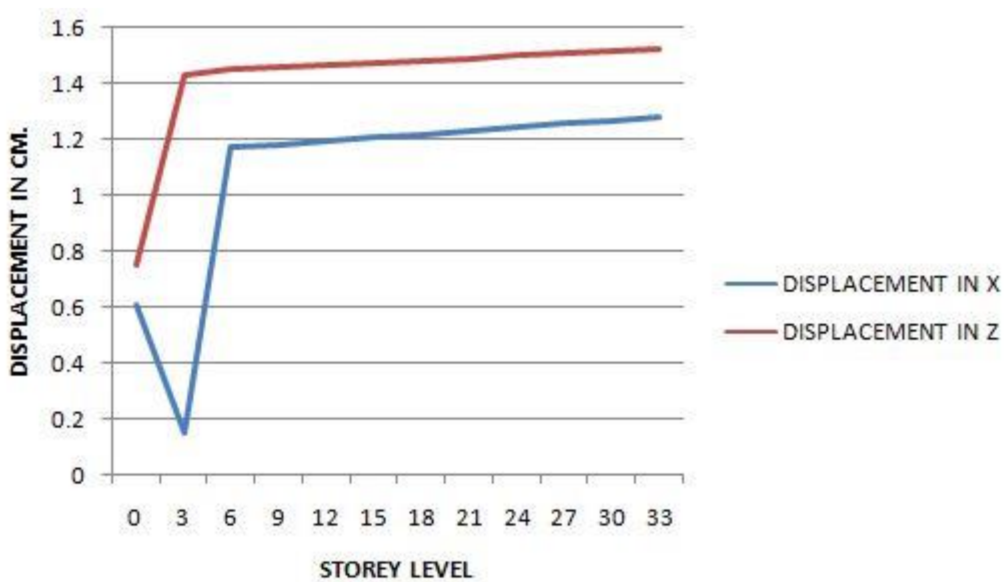

Figure 6.25: Story v/s displacement in MOD 03

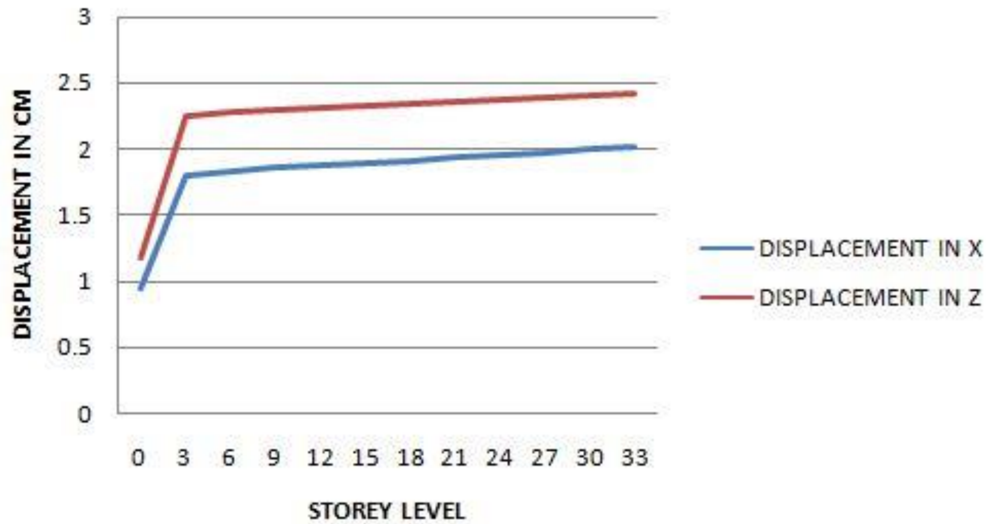

Figure 6.26: Story v/s displacement in MOD 04

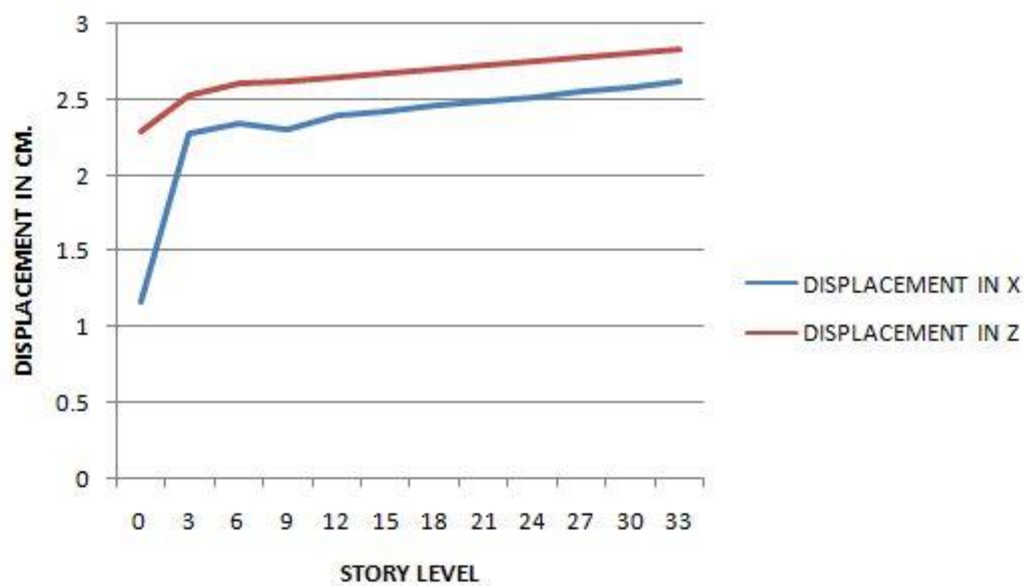

Figure 6.27: Story v/s displacements in MOD 05

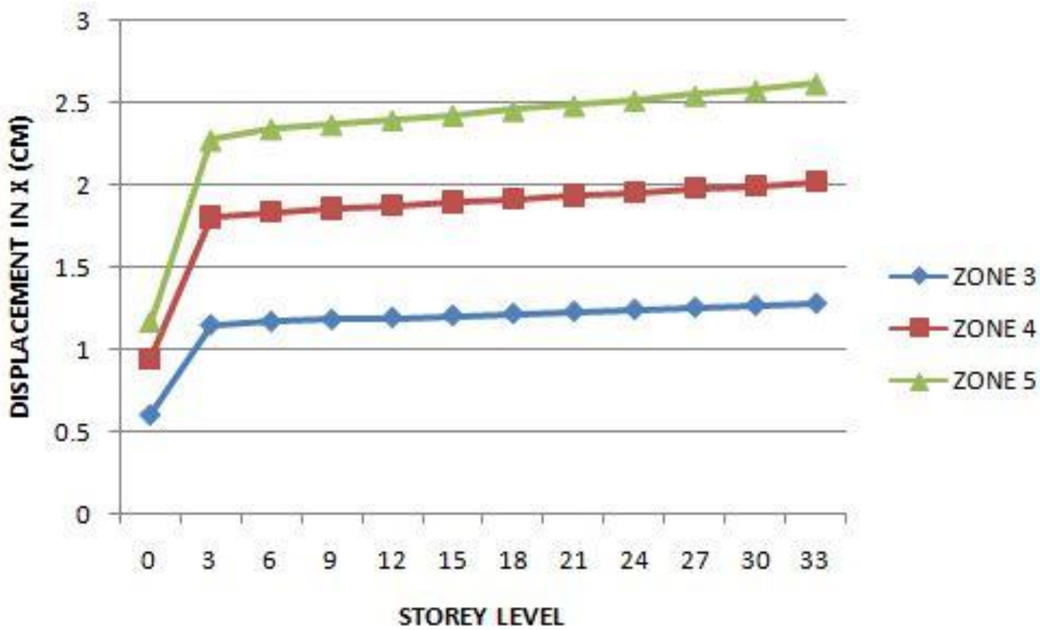

Figure 6.28: Comparison of story v/s displacement in X

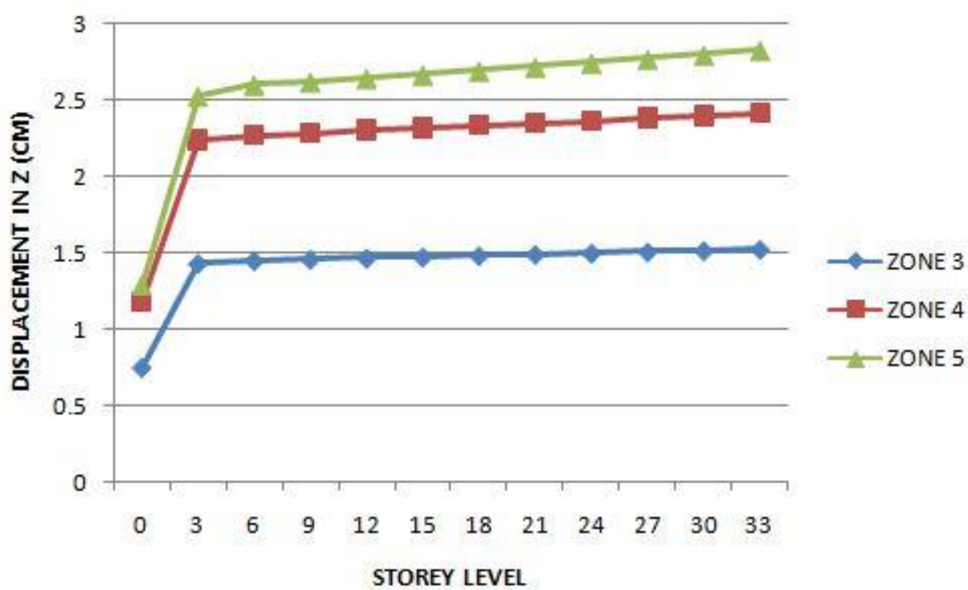

Figure 6.29: Comparison of story v/s displacement in Z

On comparing story v/s displacements for all three zones in X and Z direction, it is found that zone 5 has the highest displacement for each storey height in both the directions. Whereas zone 3 has the minimum values of displacement for both the directions.

6.8 STORY V/S DRIFT

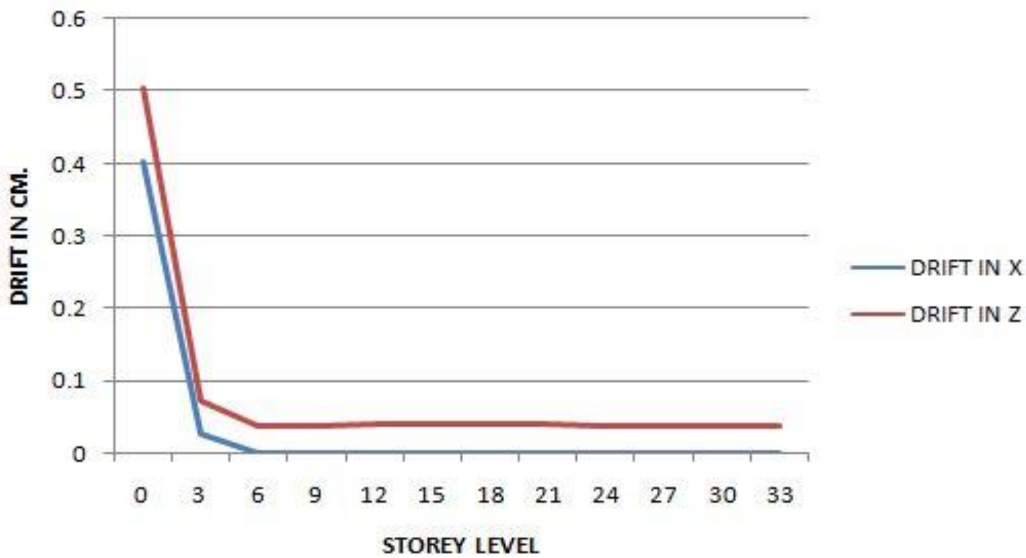

Figure 6.30: Storey v/s drift in MOD 03

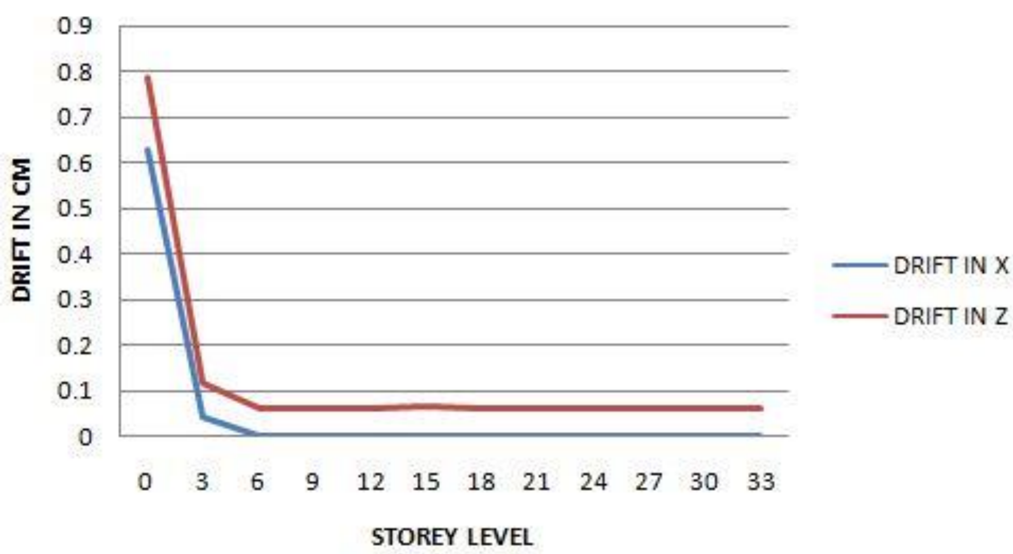

Figure 6.31: Storey v/s drift in MOD 04

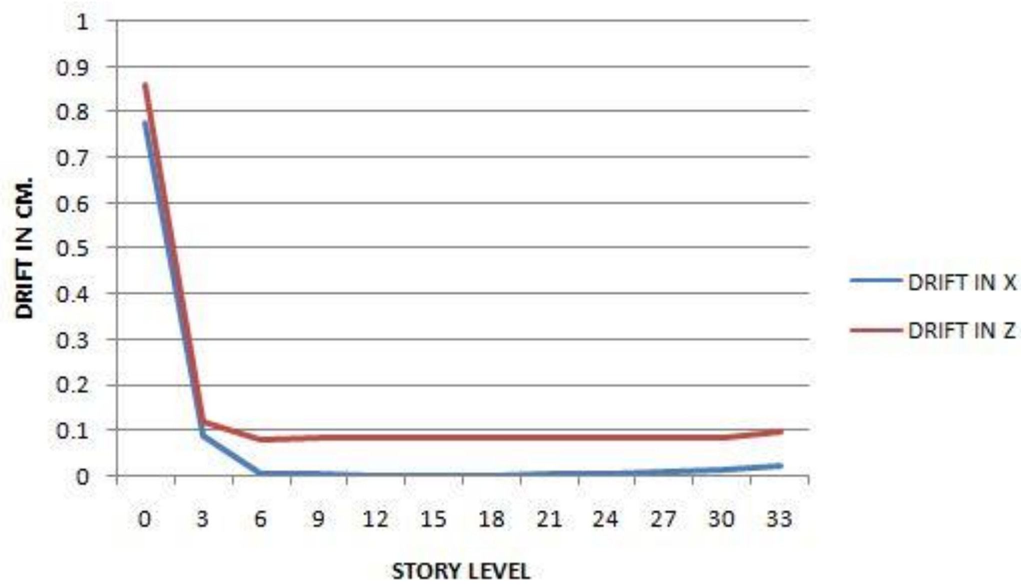

Figure 6.32: Storey v/s drift in MOD 05

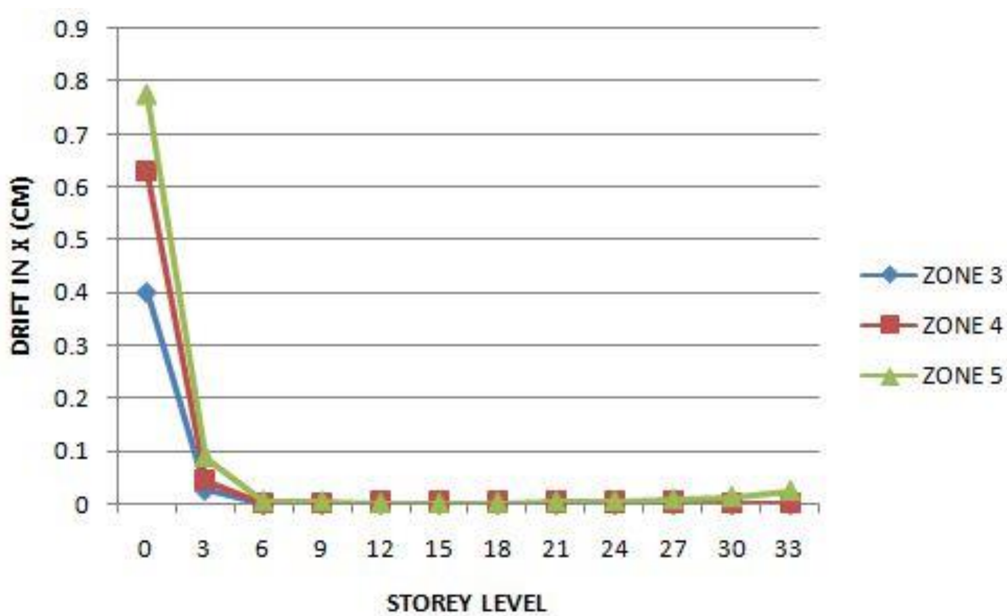

Figure 6.33: Comparison of storey v/s drift in X

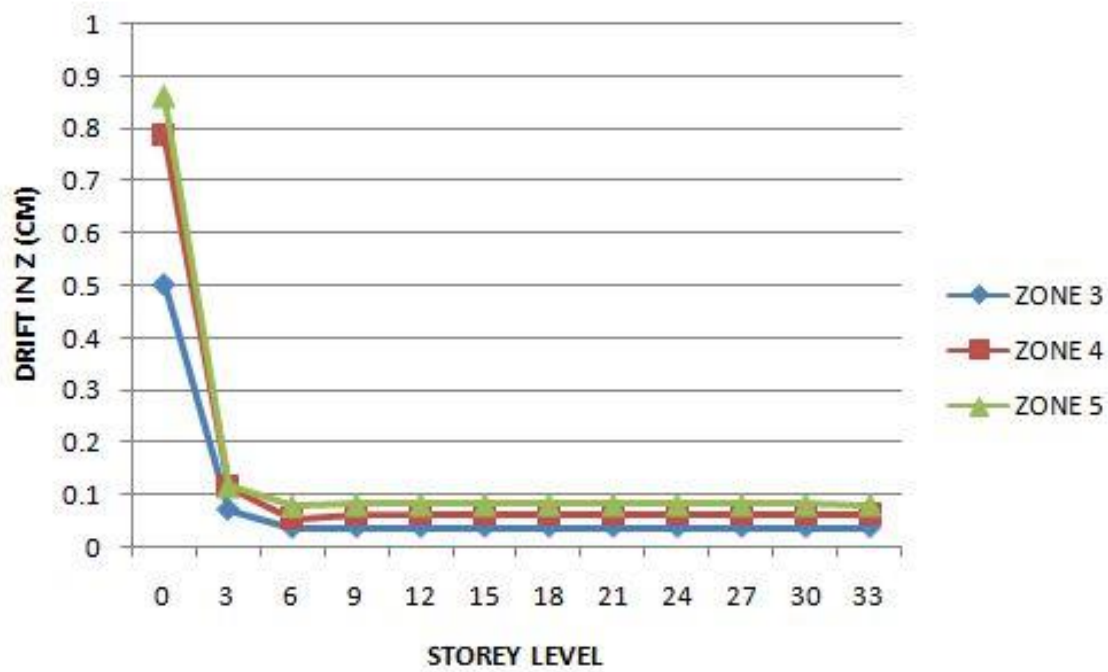

Figure 6.34: Comparison of storey v/s drift in Z

6.9 OVERTURNING MOMENT

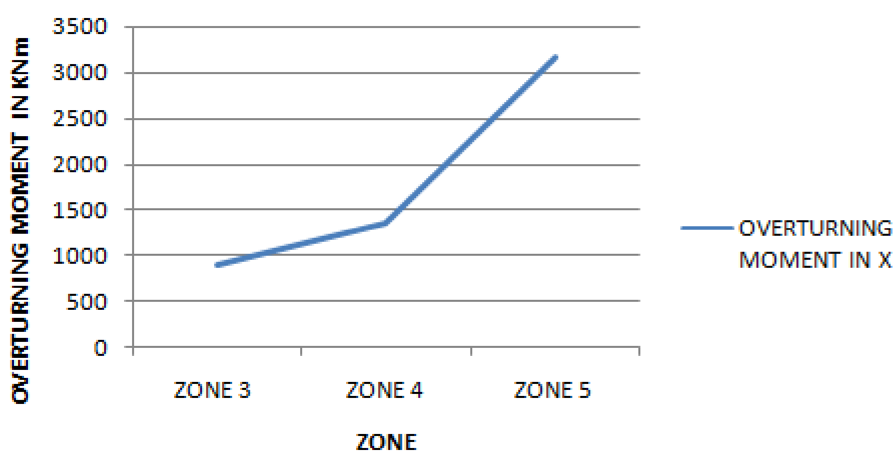

Figure 6.35: Overturning moment for MOD 03, MOD 04, MOD 05

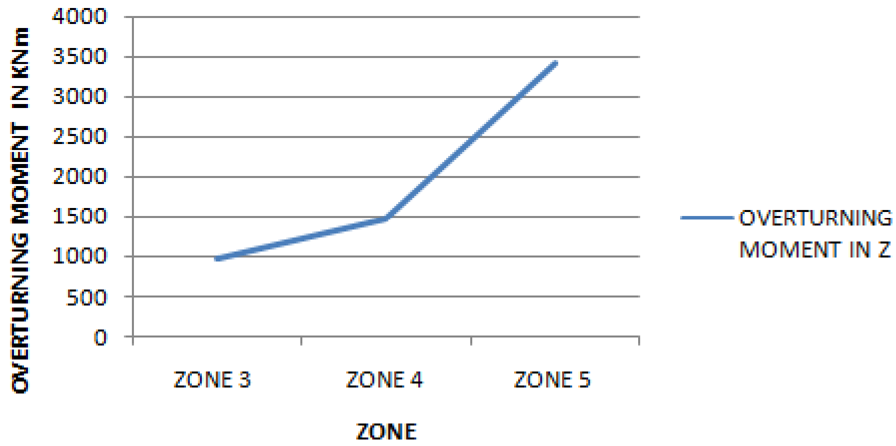

Figure 6.36: Overturning moment for MOD 03, MOD 04, MOD 05

According to the result, MOD 05 has the highest overturning moment in both X and Z directions. This value is followed by MOD 04 and MOD 03 which has the minimum moment in both the cases

6.10 DEAD LOAD AND LIVE LOAD

Table 6.1: Load specifications

MODEL	DEAD LOAD	LIVE LOAD
MOD 03	141594.97 KN	34640.23 KN
MOD 04	141594.97 KN	34640.23 KN
MOD 05	144698.09 KN	34640.23 KN

Live load remains same for all three zones whereas dead load for zone 3 and zone 4 are same. As size of columns are increased to 800×800mm, 500×500mm and 400×400mm. This resulted in the increase in self weight of the building.

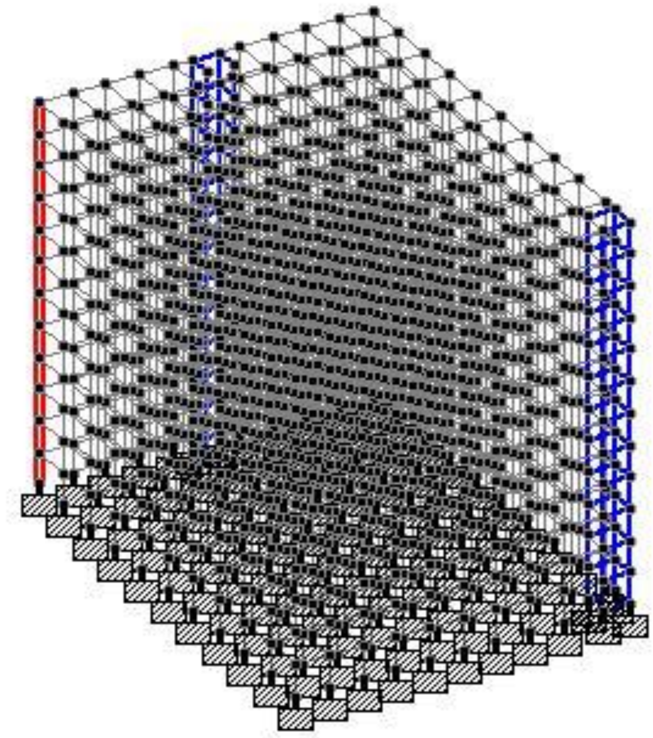

Figure 6.36: Column 800×800mm

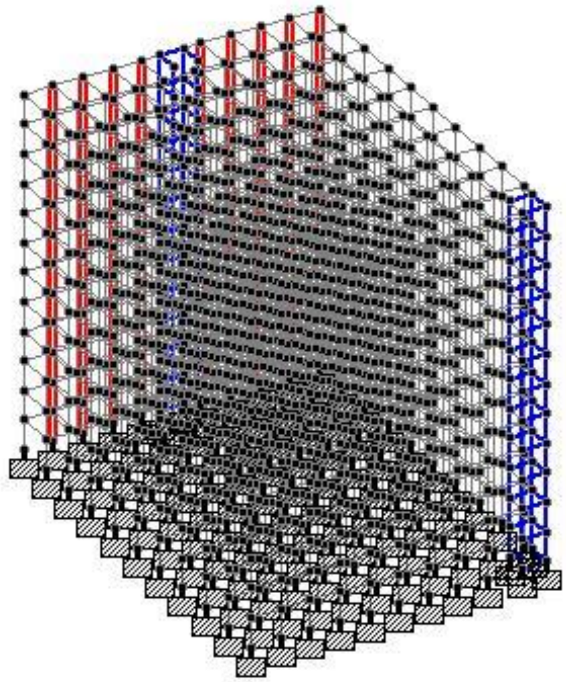

Figure 6.37: Column 500×500mm

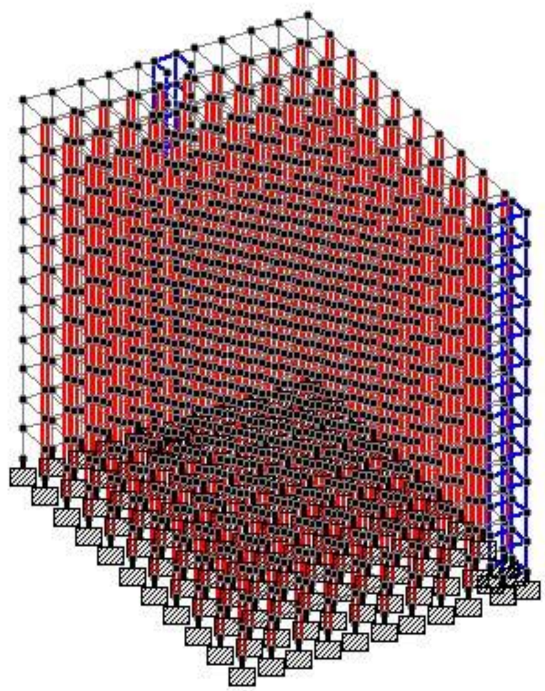

Figure 6.38: Column 400×400mm

CHAPTER 7: CONCLUSION AND FUTURE SCOPE

Conclusions given below are interpreted from the analysis of different models for different load combinations and zones:

- Base shear gets increased when zone is critical and maximum base shear in Z direction is greater than in X direction in all the three zones because with of building is less in X direction and thus time period is more.
- Maximum force in MOD 05 in highest among three zones. In each model, Forces in X direction is higher than Y and Z direction because zone is critical and base shear is more.
- In every model, node displacement in minimum along Y axis and MOD 05 has the highest value of maximum displacement.
- As the story height rises, displacement increases with the increase in height which causes drift.
- MOD 05 has the utmost drift value as compared to MOD 03 and MOD 04.
- Overturning moment of MOD 05 dominates the moment in MOD 04 and MOD 03.
- As the zone gets critical, some members need to get wider so as to avoid the failure of structure which ultimately contributes to the self weight of the structure.

CHAPTER 8: REFERENCES

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