DYNAMIC ANALYSIS OF HIGH RISE BUILDING ON DIFFERENT GROUND CONDITIONS: A COMPARATIVE STUDY

Submitted in partial fulfillment of the requirements

of the degree of

MASTER OF TECHNOLOGY

in

CIVIL ENGINEERING

by

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Transforming Education Transforming India

School of Civil Engineering

LOVELY PROFESSIONAL UNIVERSITY, PHAGWARA

2017

DECLARATION

I, **CH. AVINASH** (11503231), hereby declare that this submission is my own work and that to the best of my insight and conviction, it contains no material beforehand distributed or composed by other individual or office. No material which has been acknowledged for reward of some other degree or certificate of the college or other organization of higher learning with the exception of where due affirmations have been made in the content. It was arranged and displayed under the direction and supervision of **Mr. Parijat Hasija** (Assistant Professor).

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CERTIFICATE

This is to certify that **CH. AVINASH** under Registration No. **11503231** has prepared the Predissertation report titled "**Dynamic Analysis of High Rise Building on Different Ground Conditions: A Comparative Study**" under my direction. This is a bonafide work of the above competitor and has been submitted to me in fractional satisfaction of the prerequisite for the honor of Masters of Technology in Civil Engineering.

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ACKNOWLEDGEMENT

I wish to express our sincere gratitude to our esteemed guide assistant professor **Mr. PARIJAT HASIJA** for his guidance during the course of this Project. We also thank him for the timely advices and suggestions throughout the course work. I am highly obliged to, Head of Department of Civil Engineering for her continuous encouragement and providing all the facilities required for completion of this Project. I am also thankful to our teaching staff, non-teaching staff and all others involved in this Project.

Signature of Student

CH. AVINASH

ABSTRACT

In India construction is one of the most booming areas as there is a huge growth in country's economy. RCC structures are convenient in construction so RCC structures are majorly used. Several types of forces are subjected in its life span such as static forces due to dead and live loads, dynamic force due to wind and seismic loads. The static loads are constant with time and mostly acts vertically downward while the dynamic loads are varying with time and acts lateral (horizontal) direction. The dynamic analysis depends mainly ground conditions, Importance of its use and geometry of structure. So, this thesis describes the building is located in zone II and III, and constant wind profile analysis of structure varies with different ground conditions (topography, terrain category and exposure). The static and dynamic analysis has carried out by STAAD Pro software using the parameters as per IS 875.3.1987, IS 1893.1.2002 and post processing result obtained are summarized.

For the comparative analysis, we considered the building of two different heights G+15 and G+30 storied regular building, the plan area 20x20 m with a story height of 3m each, the ground conditions that we considered are 1) The structure is under open terrain and surrounding buildings are below 1.5m height. 2) The structure is under open terrain and surrounding buildings are 1.5 to 10m height. 3) The structure is under numerous closely terrain and surrounding buildings are up to 10m height. 4) Terrain with highly closely spaced obstructions. The results considered for comparative analysis are bending moment, shear force, support reactions, and deflection.

KEYWORDS: Geometry of Building, Building Height, Ground Conditions, STAAD Pro.

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LIST OF SYMBOLS

%	Percentage
mm	Millimeter
KN	Kilo Newton
m	Meter
Mton	Metric ton
Mton-m	Metric ton meter

CHAPTER 1
INTRODUCTION

1.1) BACKGROUND

In present scenario land scarcity and cost of land is highly rising. The population growth has led people to move from village to urban regions thus construction of multi-storied reinforced concrete structures has become necessary for both residential and as well as office purposes. As there is a huge growth in metro cities in India there is increasing demand in high rise building. RCC structures have long life and it carries a lot of lateral loads. There is very less requirement of carrying out maintenance in these structures. The analysis is mainly concerned with finding out the behavior of a structure when subjected to static and dynamic forces. The static force can be in the form of self-weight of members, load due to the weight of things such as people, furniture, while the dynamic force in the form of wind and earthquake (seismic). Earthquake and wind loads are considered as major devastating forces while analyzing any tall structure. As it is known the dynamic forces that can occur any place at any point of time without any warning. Hence if high raised structures are not properly designed for the resistance of lateral forces it may lead to the complete failure of the structure.

Considering all these stability conditions in the analysis of structure we will be using in thesis the present leading design software in India is STAAD Pro. Many design companies' use this software for their project design purposes. In the past, we have seen that the analysis which are done manually would take a great amount of time but as the technology have changed we now have lot of new emerging software's which really saves lot of our time and efforts. Consequently, the use of STAAD will make it easy. STAAD-PRO does both static and dynamic analysis as it inculcates IS-Code as its packaged features.

The analysis involves assigning the input data by manually and further analyzing the whole structure by STAAD Pro. The wind load values are generated by STAAD PRO considering the given wind intensities at different heights and strictly abiding by the specifications of IS 875.3.1987, Seismic load calculations were done following IS 1893.1.2002.

1.2) WIND

1.2.1) GENERAL

Wind is essentially a large-scale movement of free air on earth surface. Wind is occurred when there is difference in atmospheric pressure. The movement of wind from higher to lower pressure area, resulting the various wind speeds. In normal cyclones, the wind speed is up to 30-36 m/s while in sever cyclones it may reach up to 90 m/s. The wind flow in horizontal direction develop lateral pressure on the building so it has to consider in design. IS 875.3.1987 provides the basic wind speed.

The wind pressure or load acting on the building depends on the following.

1) Velocity of wind.
2) Height of the structure above ground level.
3) Geometry and Shape of the Structure.
4) Aspect ratio of the building.
5) Topography.
6) Angle of wind attack
7) Openings in structure.

In general, when the wind hits the body it diverted in two mutually perpendicular directions. Thus, the effect of wind on structure is shown in fig 1.1. The effect of wind on anybody is derived into two components.

1) Along Wind.
2) Cross Wind.

Along wind, refers the motion of wind is parallel to the direction of wind and Cross wind, refers the motion of wind is perpendicular to the direction of wind. The term along wind refers drag force and cross wind refers transvers wind. The cross wind is dominating the along wind, while the maximum wind pressure and deflection are generally in the direction of wind.

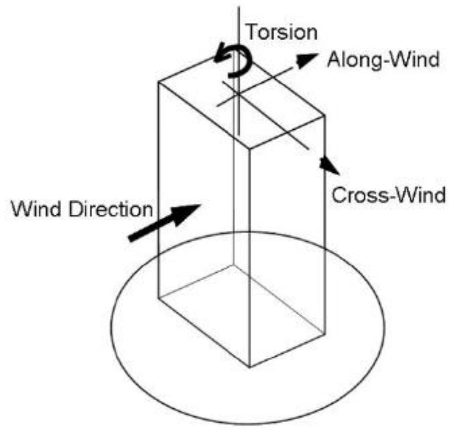


Fig 1.1 Wind Response direction

1.2.2) WIND EFFECTS ON TALL BUILDING

High rise buildings are those building having vertical cross sections are more than of base cross section. When the wind hit the structure some part of wind energy is absorbed by the structure and some part of energy dissipates. The wind energy absorbed by the structure is higher than energy dissipated by structural damping then the aptitude of the oscillation will increase continuously leads to destruction of the structure. The wind pressure near to the ground surface is less or minimum and vary with height of the structure is shown in fig 1.2.

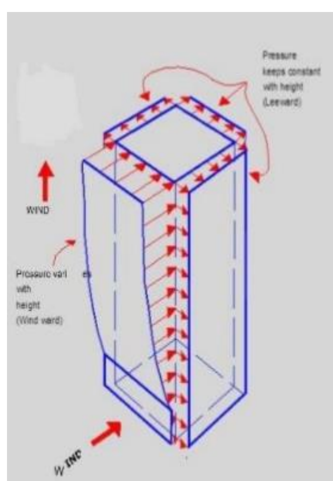


Fig 1.2 Variation of Wind Pressure with Height of Building

1.3) LOADS

1.3.1) PRIMARY LOADS AND LOAD COMBINATIONS

As per IS: 456:2000 the primary loads cases are

1) Dead Load
2) Live Load
3) Wind Load acting on positive x direction
4) Wind Load acting on negative x direction
5) Wind Load acting on positive z direction
6) Wind Load acting on negative z direction
7) Seismic Load acting on positive x direction
8) Seismic Load acting on negative x direction
9) Seismic Load acting on positive z direction
10) Seismic Load acting on negative z direction

As per IS: 456:2000 the load combinations are

11) 1.5 (DL+LL)
12) 1.5 (DL+WL+X) Wind load acting on the positive x- direction
13) 1.5 (DL+WL-X) Wind load acting on the negative x- direction
14) 1.5 (DL+WL+Z) Wind load acting on the positive z- direction
15) 1.5 (DL+WL-Z) Wind load acting on the negative z- direction
16) 1.5 (DL+EL+X) Seismic load acting on the positive x- direction
17) 1.5 (DL+EL-X) Seismic load acting on the negative x- direction
18) 1.5 (DL+EL+Z) Seismic load acting on the positive z- direction
19) 1.5 (DL+EL-Z) Seismic load acting on the negative z- direction
20) 0.9 DL+1.5 WL+X
21) 0.9 DL+1.5 WL-X
22) 0.9 DL+1.5 WL+Z
23) 0.9 DL+1.5 WL-Z
24) 0.9 DL+1.5 EL+X
25) 0.9 DL+1.5 EL-X
26) 0.9 DL+1.5 EL+Z

27) 0.9 DL+1.5 EL-Z
28) 1.2 (DL+LL+WL+X)
29) 1.2 (DL+LL+WL-X)
30) 1.2 (DL+LL+WL+Z)
31) 1.2 (DL+LL+WL-Z)
32) 1.2 (DL+LL+EL+X)
33) 1.2 (DL+LL+EL-X)
34) 1.2 (DL+LL+EL+Z)
35) 1.2 (DL+LL+EL-Z)

1.4) MATERIALS

The materials that we considered for the analysis are

1) M25: For all Members
2) Fe500: For Main Reinforcement
3) Fe415: For Secondary Reinforcement
4) The density for masonry wall 18 KN/m^3

COLUMN

1) The minimum reinforcement diameter that are used for main reinforcement is 12mm.
2) The maximum reinforcement diameter that are used for main reinforcement is 32mm.
3) The minimum reinforcement diameter that are used for secondary reinforcement is 8mm.
4) The maximum reinforcement diameter that are used for secondary reinforcement is 12mm.

BEAM

1) The minimum reinforcement diameter that are used for main reinforcement is 12mm.
2) The maximum reinforcement diameter that are used for main reinforcement is 32mm.
3) The minimum reinforcement diameter that are used for secondary reinforcement is 8mm.
4) The maximum reinforcement diameter that are used for secondary reinforcement is 10mm.

1.5) OBJECTIVE OF THE STUDY

The thesis describes the analysis of two different heights of high rise building (G+15, G+30) subjected to static forces and dynamic forces. For the whole analysis, we considered the loads due to dead, live, and seismic (zone II & III) and wind will varies based on its ground conditions. The main parameters that are considered for comparative study are shear force, bending moment, support reactions and deflection.

The main objectives for this study:

1) To study the effect of wind and seismic on high rise building.
2) To study the effect of wind on different heights of building at different ground conditions as per IS 875.3.1987.
3) To study the effect of K1, K2, K3 coefficients on high rise building at different ground conditions for constant wind velocity as per IS 875.3.1987.
4) To determine the effect of wind and seismic load on various parameters like shear force, bending moment, support reactions and deflection.

For the comparative study, we are considered different ground conditions are

1) The structure is under open terrain and surrounding buildings are below 1.5m height.
2) The structure is under open terrain and surrounding buildings are 1.5 to 10m height.
3) The structure is under numerous closely terrain and surrounding buildings are up to 10m height.
4) Terrain with highly closely spaced obstructions.

The analysis of all cases carried by STADD Pro software using parameters as per IS 875.3.1987, IS 1893.1.2002 and the post processing results obtained are summarized.

1.6) SCOPE OF THE STUDY

The investigation is done on seismic and wind analysis of high rise building at different ground conditions by using STADD Pro software and the main parameters for comparing the post processing results like shear force, bending moment, support reactions and deflection. Generally, all the buildings are affected to dynamic loads. It is not possible to avoid these type of loads, so this analysis is done by taking consideration of dynamic loads. Buildings through this analysis and design can be more durable than other buildings. There may be rise in initial cost but it gives good result in future.

CHAPTER 2
REVIEW OF LITERATURE

2.1) GENERAL

Lodhi Saad et al (2015): stated that for the comparative analysis they have considered various shapes and sizes of the building (9 models) and the wind load as per IS 875.3.1987 and ASCE 7-02. The analysis has carried out by STAAD Pro software and the post processing result obtained are summarized.

Model No	Building Height Ratio	Building Plan Ratio
1	h/w < ½	1 < l/w < 3/2
2		3/2 < l/w < 4
3	1/2 < h/w < 3/2	1 < l/w < 3/2
4		3/2 < l/w < 4
5	3/2 < h/w < 6	1 < l/w < 3/2
6		3/2 < l/w < 4
7	h/w > ∞	l/w = 3/2
8		l/w = 1
9		l/w = 2

Table 2.1 External Pressure Coefficients

1) For pair of models from 1 to 4 the displacement in both X and Z directions are more as per ASCE 7-02 than IS 875.3.1987.
2) For pair of models from 5 and 6 the displacement in X direction is more as per ASCE 7-02 and the displacement in Z direction is more as per IS 875.3.1987.
3) For pair of models from 7 to 9 the displacement in X and Z directions are more as per IS 875.3.1987 than ASCE 7-02.
4) It also observed that the Building Plan Ratio is about (3/2 < l/w < 4) the displacement in X direction is more as per IS 875.3.1987 and the displacement in Z direction is more as per ASCE 7-02.

5) It also observed that for small and medium height buildings the analysis as per IS 875.3.1987 is economical and for high rise building it is safer.

Kintali Sai NandaKishore et al (2015): stated that for the comparative analysis they have considered various shapes of plans like (rectangle, L and U shape) and 15 storey height building. The loads that considered are dead, live and wind load as per IS 875.1987 (part I, II, III). The analysis has carried out by STAAD Pro software and the post processing result obtained are summarized.

1) Bending moment is high in all shape of buildings for high rise structures. As height of the building decreases the bending moment also decreases.
2) Bending moment values in regular shape building are less comparatively L and U shape structures.

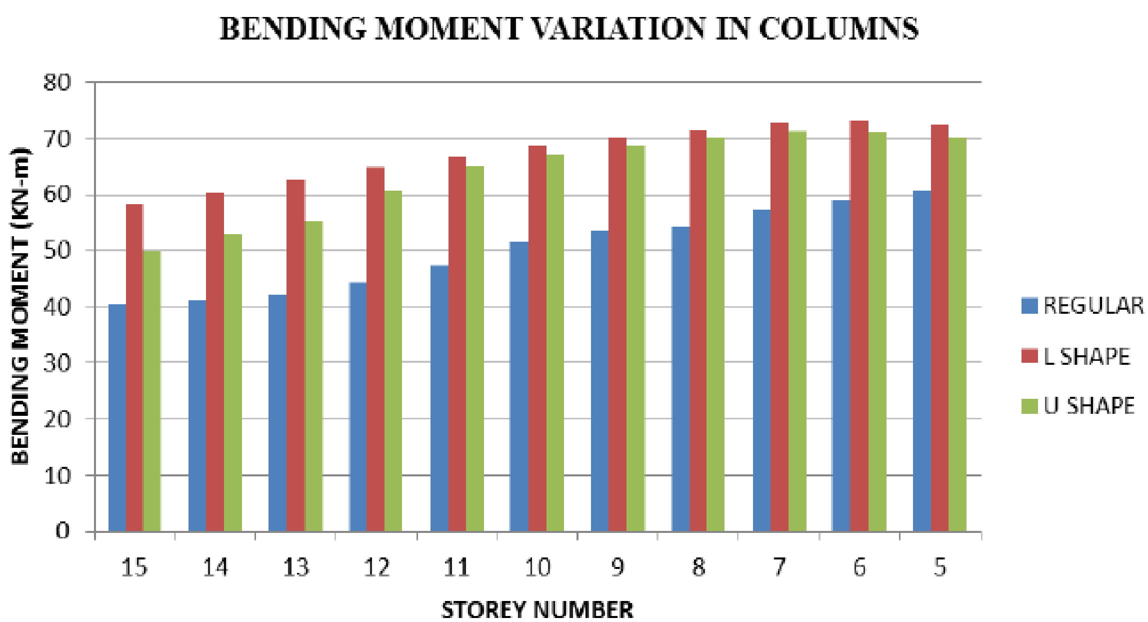


Fig 2.1 Bending Moment Variation in Columns

3) Nodal displacement decreases as height of the building decreased. Displacement in U shape building are two times more than regular building.
4) Effect on bending moment is more due to wind load rather than static loads.

V. Ajay Kumar et al (2015): stated that for the analysis they considered three different height of buildings (40m, 60m, 80m), different shapes (Rectangular Structure, Rectangular structure with rounded corners, Square Structure, Square Structure with rounded corners, Circular Structure and Elliptical Structure). The analysis has carried out by STAAD Pro software using parameters as per IS 875.3.1987 and the post processing result obtained are summarized.

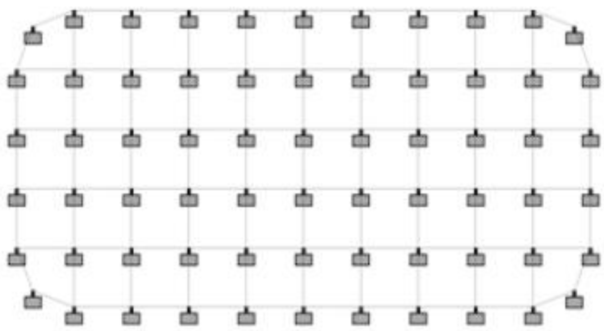


Fig 2.2 Rectangular Structure Rounded at Corners

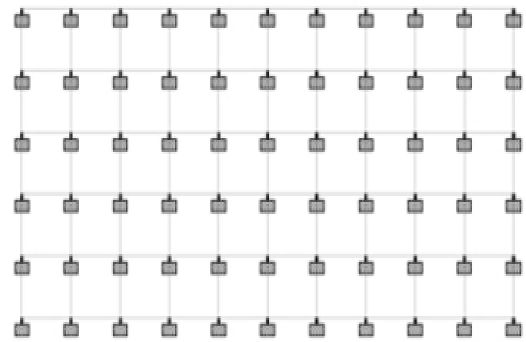


Fig 2.3 Rectangular Structure

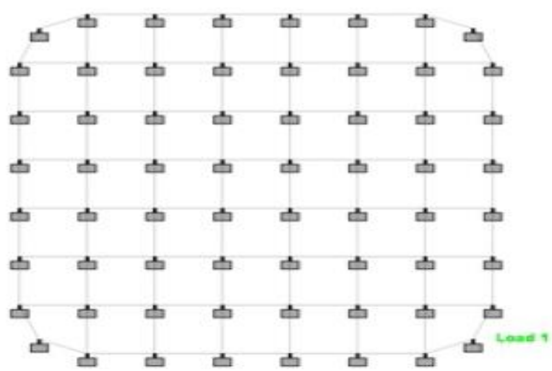


Fig 2.4 Square Structure Rounded at Corners

Fig 2.5 Square Structure

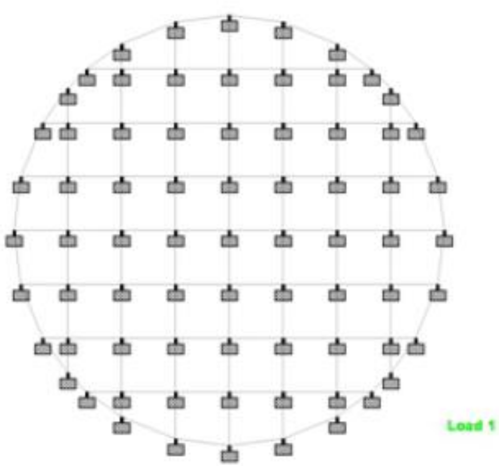


Fig 2.6 Circular Structure

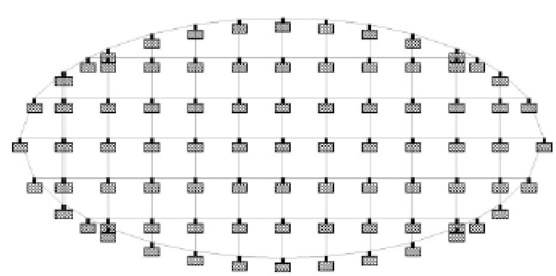


Fig 2.7 Elliptical Structure

1) The bending moment reduced by an average of 70percent by rounded corners than regular corners.
2) As the height of the building increases the gradually decrease in bending moment for rounded corners.
3) The axial force decreases in columns for rounded corners up to certain height beyond that the axial force increases in corner columns.
4) The roof displacement were decreased by 50 percent for square structures and 10 percent for rectangular structures with rounded corners.
5) Circular and elliptical structure are more effective for high rise structures.

Umakant Arya et al (2014): Stated that for the analysis they considered three different height of buildings, different wind zones and different ground slope. The analysis has carried out by STAAD Pro software using parameters as per IS 875.3.1987 and the post processing result obtained are summarized.

Axial Force:

1) The axial force in the columns increased with increases the height of the building.
2) The axial force in the columns for different heights of the building will not varies by changing the velocity of the wind.
3) The axial force in the columns are affected minutely by increases the ground slope.
4) The axil force in the beams are affected by wind velocity and ground slope.

Shear Force:

1) The shear force in the columns increased with increase the ground slope, wind velocity.
2) The shear force in the beams increased with increase in height of the building, wind velocity and affected minutely with increase in ground slope.

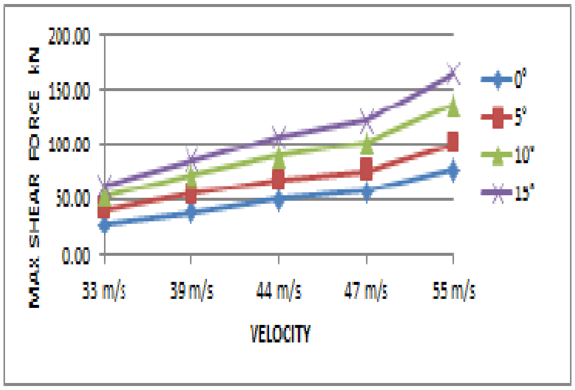


Figure 1.6: Graph between the Max Shear force and velocity, 24 meter

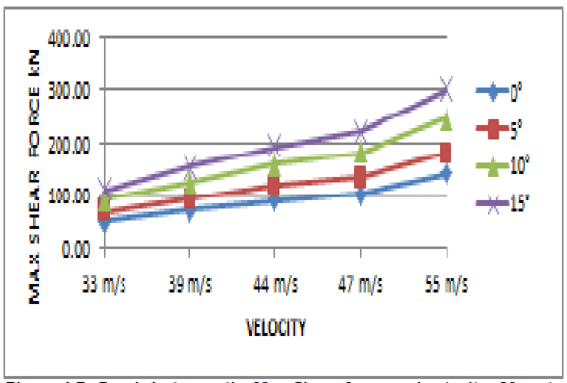


Figure 1.7: Graph between the Max Shear force and velocity, 36 meter

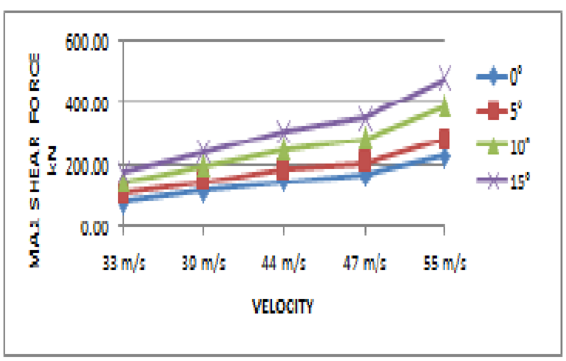


Figure 1.8: Graph between the Max Shear force and velocity, 48 meter

Fig 2.8 Shear Force in Columns

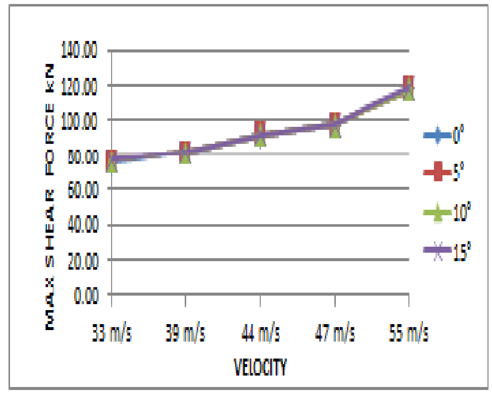


Figure 1.3: Graph between the Max Shear force and velocity,24 meter

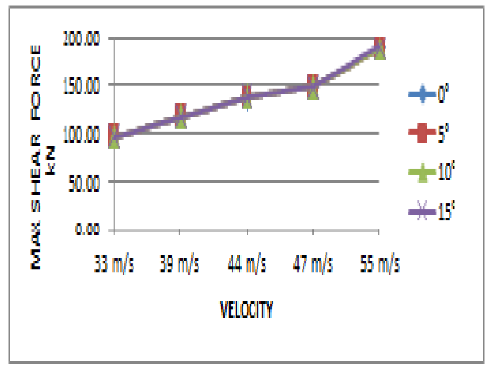


Figure 1.4: Graph between the Max Shear force and velocity, 36 meter

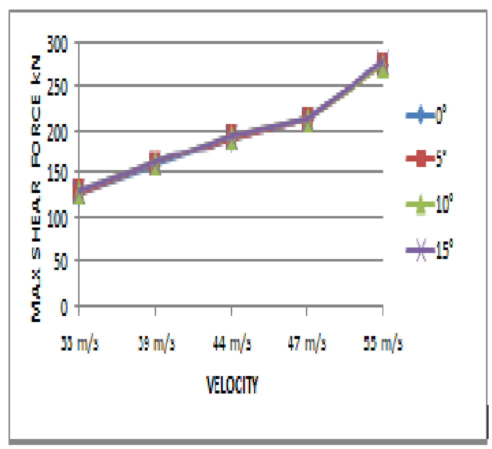


Figure 1.5: Graph between the Max Shear force and velocity, 48 meter

Fig 2.9 Shear Force in Beams

Bending Moment:

1) The bending moment in the columns increased with increase the height of the building, wind velocity and ground slope.
2) The bending moment in beams for different height of buildings will increased with increase in wind velocity and affected minutely with increase in ground slope.

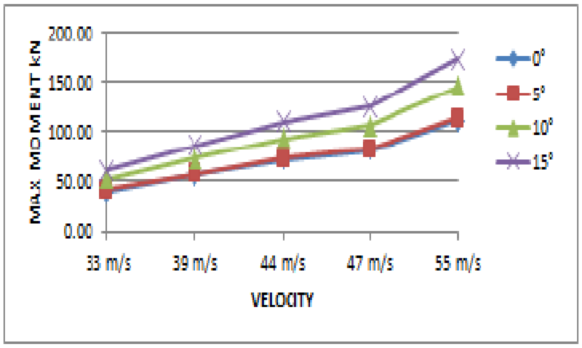


Figure 1.12: Graph between the Max moment and velocity, 24 meter

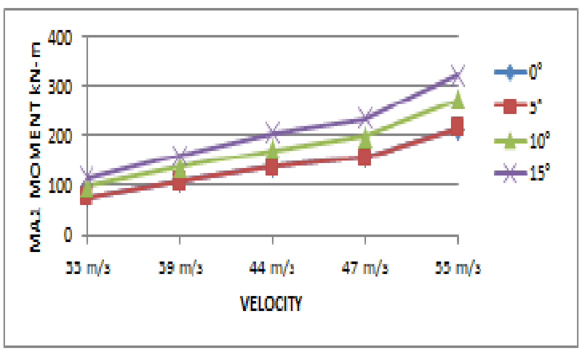


Figure1.13: Graph between the Max moment and velocity, 36 meter

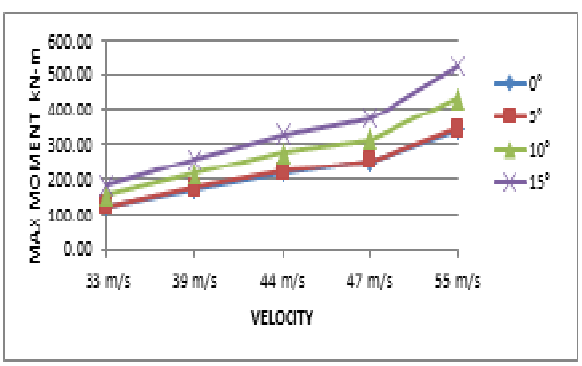


Figure 1.14: Graph between the Max moment and velocity, 48 meter

Fig 2.10 Bending Moment in Columns

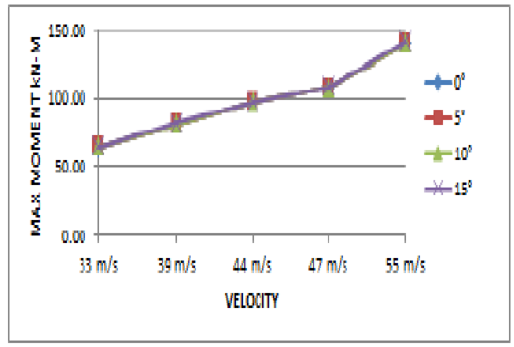


Figure 1.9: Graph between the Max moment and velocity, 24 meter

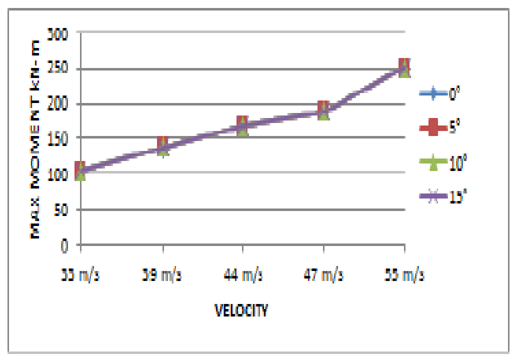


Figure 1.10: Graph between the Max moment and velocity, 36 meter

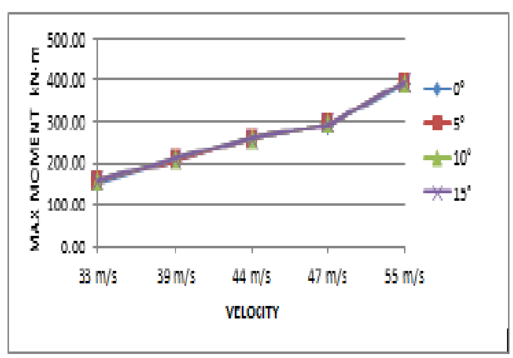


Figure 1.11: Graph between the Max moment and velocity, 48 meter

Fig 2.11 Bending Moment in Beams

Displacement:

1) The displacement for different height of the buildings increased with increase in wind velocity at critical load combination 1.5(DL+WL).
2) The displacement is not affected by increase the slope of ground 0 to 15 degree.

Table 1.13: Maximum displacement for 24 meter building height at L/C 1.5(D.L+W.L)

SLOPE	VELOCITY				
	33 m/s	39 m/s	44 m/s	47 m/s	55 m/s
0°	21.80	30.18	38.29	43.63	59.63
5°	21.88	30.47	38.77	44.25	60.65
10°	21.89	30.60	39.06	44.65	61.35
15°	21.89	30.60	39.20	44.85	61.84

Table 5.14: Maximum displacement for 36 meter building height at L/C 1.5(D.L+W.L)

SLOPE	VELOCITY				
	33 m/s	39 m/s	44 m/s	47 m/s	55 m/s
0°	66.22	92.20	117.18	133.65	182.88
5°	66.39	92.85	118.29	135.06	185.20
10°	66.40	93.19	119.01	136.03	186.93
15°	66.44	93.29	119.43	136.67	188.24

Table 1.15: Maximum displacement for 48 meter building height at L/C 1.5(D.L+W.L)

SLOPE	VELOCITY				
	33 m/s	39 m/s	44 m/s	47 m/s	55 m/s
0°	156.50	218.20	277.51	316.55	433.24
5°	157.04	219.70	279.93	319.58	438.07
10°	157.20	220.68	281.71	321.86	441.94
15°	157.65	221.27	283.00	323.69	445.11

Table 2.2 Displacement in Columns

Support reaction:

1) Support reactions on lee ward columns increased and support reactions on wind ward columns decreased with increase in wind velocity.
2) Support reactions affected minutely with increase the slope of ground.

K. Vishnu Haritha et al (2013): stated for the analysis they have considered equivalent static method with different aspect ratios (1, 2, and 3). The analysis has carried out by STAAD Pro software using parameters as per IS 875.3.1987 and the post processing result obtained are summarized.

1) The effect due to wind load is more predominant when compared to dead and live loads in high rise structures.
2) For different height of building and increase in aspect ratios when wind load is acting along the length of the building the variation in displacement is increasing but it is varies minutely.
3) For different height of building and increase in aspect ratios when wind load is acting across the length of the building (along shorter direction) the variation in displacement is decreasing.

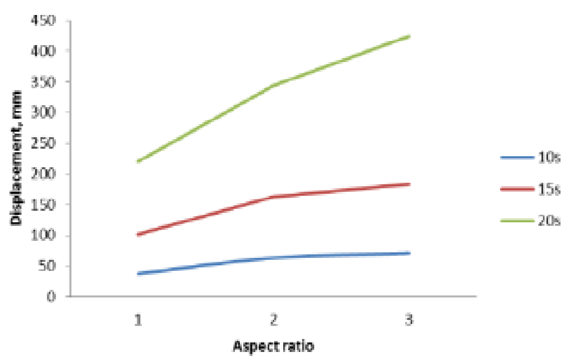


Fig 2.12 Wind Load along Length

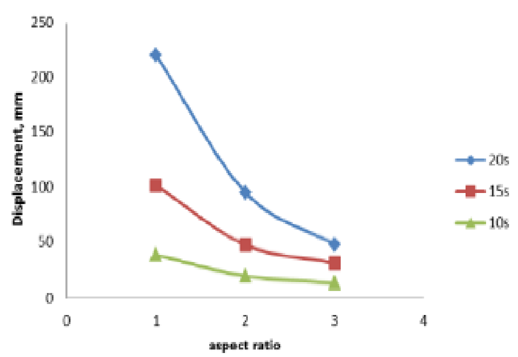


Fig 2.13 Wind Load across Length

4) For constant aspect ratio (1) with variation in geometry (5X5, 10X10 and 15X15) the variation in displacement increasing at different storey heights.
5) For constant aspect ratio (2) with variation in geometry (5X10 and 10X20) the variation in displacement increasing at different storey heights.

6) When wind load is acting along the length of the building the displacement for 20 storied building is high compare to that of 10 and 15 storied.
7) When wind load is acting along the shorter direction the displacement gradually decreases with increase in aspect ratio.

Swati D. Ambadkar et al (2012): stated for the analysis they have considered 11 storey building for various categories such as

1) Open placed terrain with surrounding structures are less than 1.5m height.
2) Open placed terrain with surrounding structures are 1.5m to 10m height.
3) Closely placed terrain with surrounding structures are up to 10m height and with or without few isolated tall structures.
4) Highly closely placed terrain.

The wind loads that considered as per IS 875. 3. 1987. The analysis has carried out by STAAD Pro software and the post processing result obtained are summarized.

1) Bending moment, Shear force and displacement values are increased as wind speed is increases.

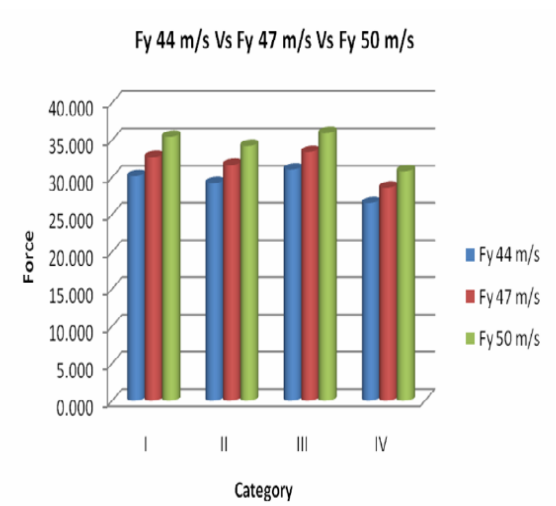


Fig 2.14 Shear Force in Fy Direction

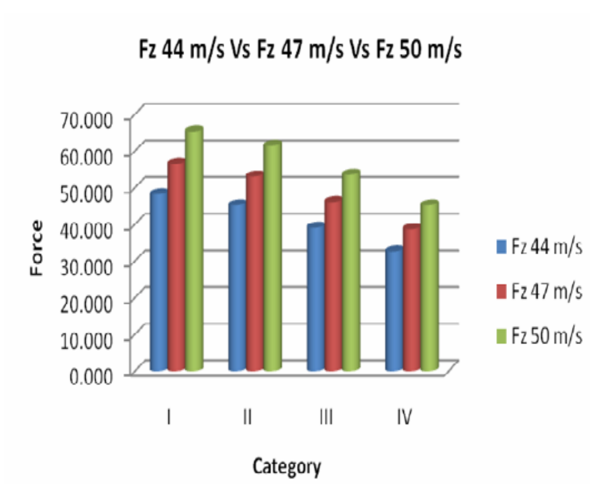
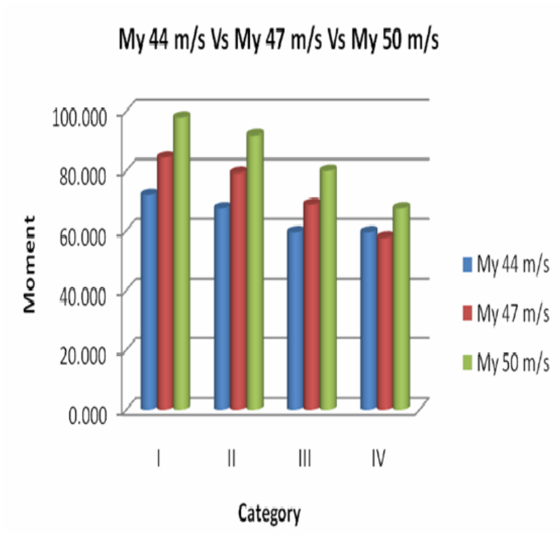


Fig 2.15 Shear Force in Fz Direction



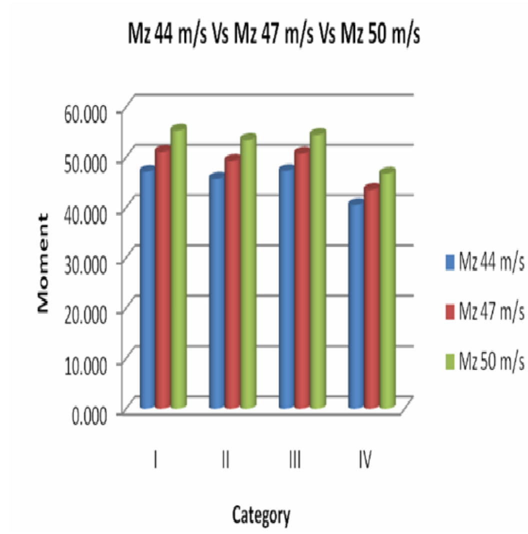


Fig 2.16 Bending Moment in My Direction

Fig 2.17 Bending Moment Mz Direction

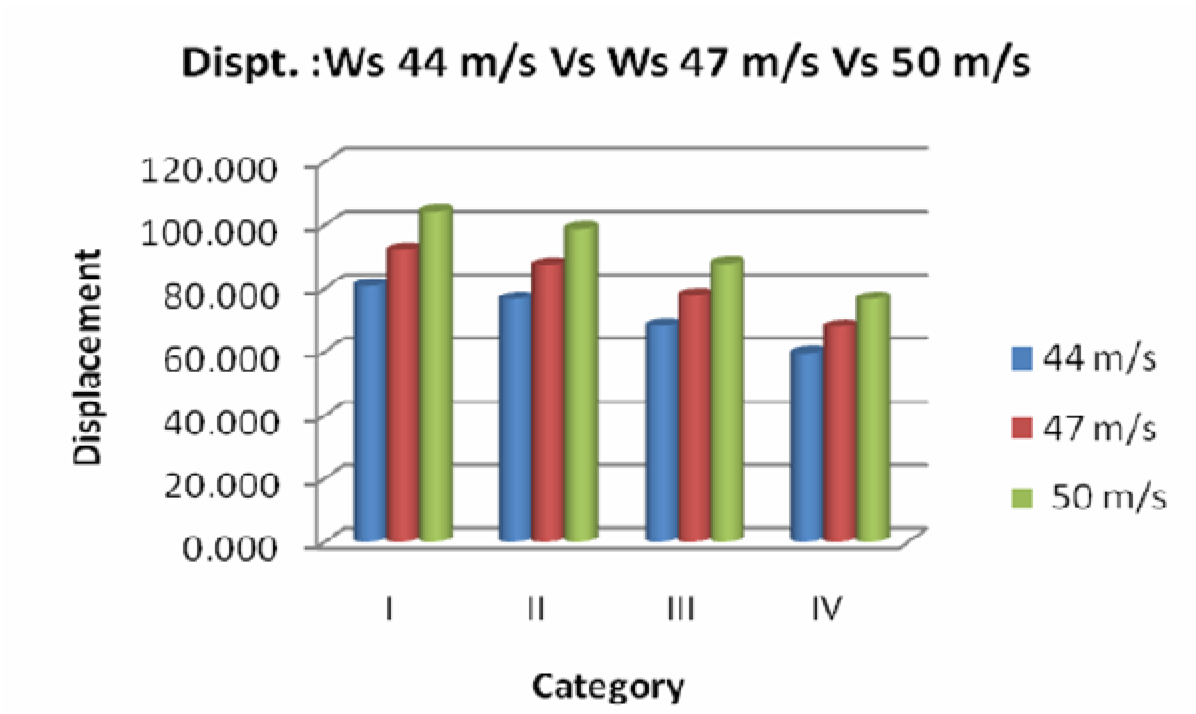


Fig 2.18 Displacement in Structure

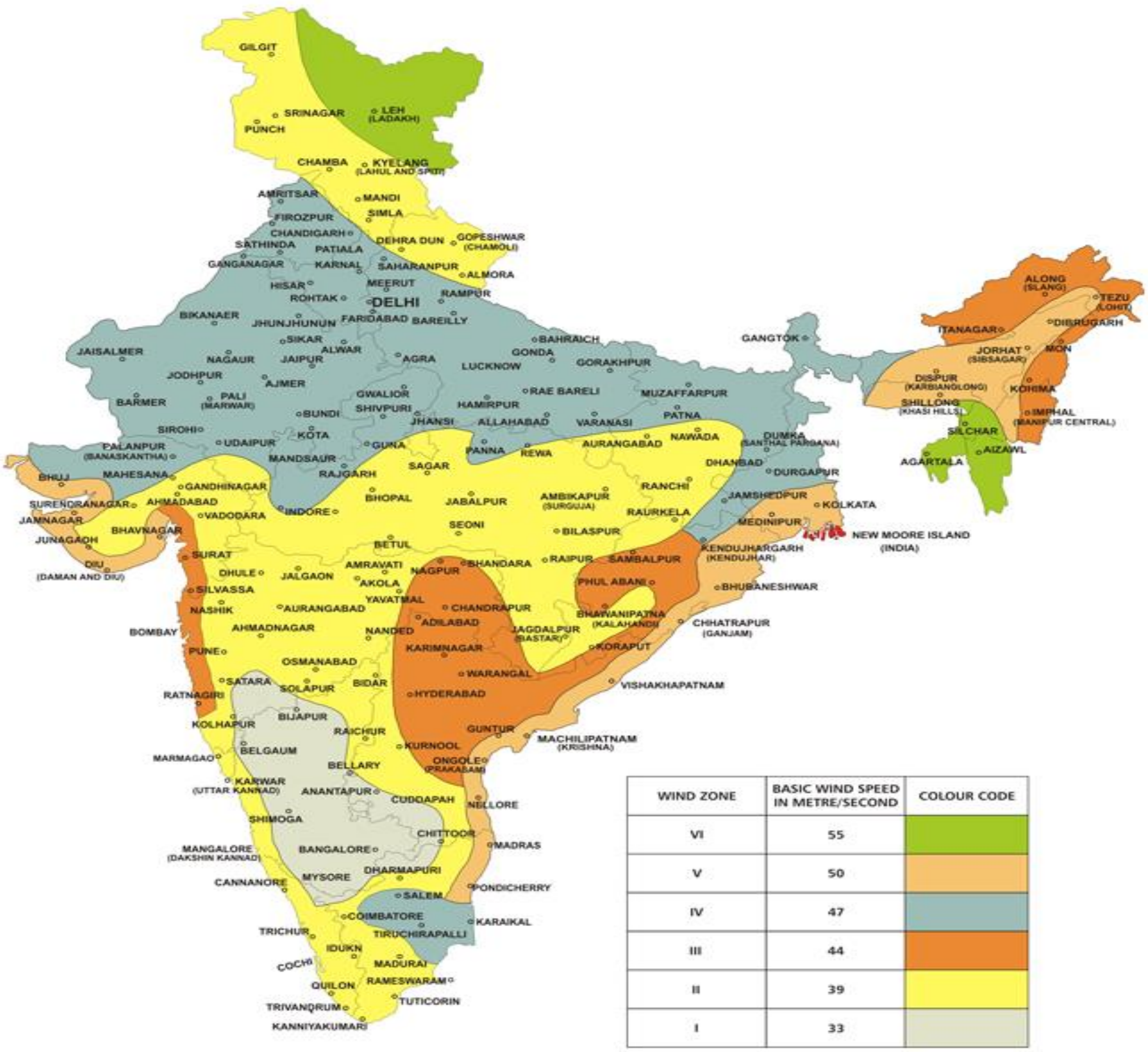
CHAPTER 3
RESEARCH METHODOLOGY

For assigning the wind load on the structure the methodology that used in this thesis is equivalent static method as per IS 875.3.1987.

3.1) EQUIVALENT STATIC METHOD:

Step 1: Basic Wind Speed

The Basic wind speed is taken as per figure-1 as per IS 875.3.1987



WIND ZONE	BASIC WIND SPEED IN METRE/SECOND	COLOUR CODE
VI	55	
V	50	
IV	47	
III	44	
II	39	
I	33	

Fig 3.1 Wind Zones

Step 2: Design Wind speed

The basic wind speed obtained from figure-1 is modified based on Risk level, geometry of the structure and topography.

It can be mathematically expressed as fallows

$V_z = V_b \times K_1 \times K_2 \times K_3$

Where V_z = Design Wind Pressure

V_b = Basic Wind Speed

K_1 = Probability Factor

K_2 = Terrain, height and Size factor

K_3 = Topography factors

K_1 factor depends on class of structure and basic wind speed.

K_2 factor depends on terrain category and class (geometry). The value of K2 varies with the height.

K_3 factor depends on topography.

S. No	Height	Basic Wind Speed (V_b)	K_1	K_2				K_3 Plain Terrain
				Category I Class B	Category II Class B	Category III Class B	Category IV Class B	
1	10	50	1.08	1.03	0.98	0.88	0.76	1
2	15	50	1.08	1.07	1.02	0.94	0.76	1
3	20	50	1.08	1.1	1.05	0.98	0.76	1
4	30	50	1.08	1.13	1.1	1.03	0.93	1
5	50	50	1.08	1.18	1.15	1.09	1.05	1

Table 3.1 Multiple Factors for G+15 Building

S. No	Height	Basic Wind Speed (V_b)	K_1	K_2				K_3
				Category I Class C	Category II Class C	Category III Class C	Category IV Class C	Plain Terrain
1	10	50	1.08	0.99	0.93	0.82	0.67	1
2	15	50	1.08	1.03	0.97	0.87	0.767	1
3	20	50	1.08	1.06	1.00	0.91	0.67	1
4	30	50	1.08	1.09	1.04	0.96	0.83	1
5	50	50	1.08	1.14	1.10	1.02	0.95	1
6	100	50	1.08	1.20	1.17	1.10	1.05	1

Table 3.2 Multiple Factors for G+30 Building

Step 3: Design Wind Pressure

The design wind pressure at any height above mean ground level can be obtained by

$P_z = 0.6V_z^2$

P_z = Design Velocity Pressure at z meter height.

V_z = Design Wind Velocity at z meter height.

Design Wind Speed (V_z m/s)				Design Wind Pressure (P_z KN/m^2)			
Model 1,2	Model 3,4	Model 5,6	Model 7,8	Model 1,2	Model 3,4	Model 5,6	Model 7,8
55.62	52.92	47.52	41.04	1.86	1.68	1.36	1.01
57.78	55.08	50.76	41.04	2.00	1.82	1.55	1.01
59.4	56.7	52.92	41.04	2.12	1.92	1.68	1.01
61.02	59.4	55.62	50.22	2.23	2.12	1.86	1.53
63.72	62.1	58.86	56.7	2.44	2.31	2.08	1.93

Table 3.3 Design Wind Pressure for G+15 Building

Design Wind Speed (V_z m/s)				Design Wind Pressure (P_z KN/m^2)			
Model 9,10	**Model 11,12**	**Model 13,14**	**Model 15,16**	**Model 9,10**	**Model 11,12**	**Model 13,14**	**Model 15,16**
53.46	50.22	44.28	36.18	1.71	1.51	1.18	0.79
55.62	52.38	46.98	36.18	1.86	1.65	1.32	0.79
57.24	54	49.14	36.18	1.97	1.75	1.45	0.79
58.86	56.16	51.84	44.82	2.08	1.89	1.61	1.21
61.56	59.4	55.08	51.3	2.27	2.12	1.82	1.58
64.8	63.18	59.4	56.7	2.52	2.40	2.12	1.93

Table 3.4 Design Wind Pressure for G+30 Building

Step 4: Wind Load Calculation

The wind load on structure can be calculated for the following

1) Building as a whole
2) Individual Structural elements such as roof and columns
3) Equal area Method.

In this thesis, I considered Equal area method for wind load calculation on structure and no permeability of the structure.

1) Wind load on corner columns is calculate by half of the span that wind exposed multiply with wind pressure.
2) Wind Load on Edge Columns is calculated by half of span on either side of columns multiply with wind Pressure.

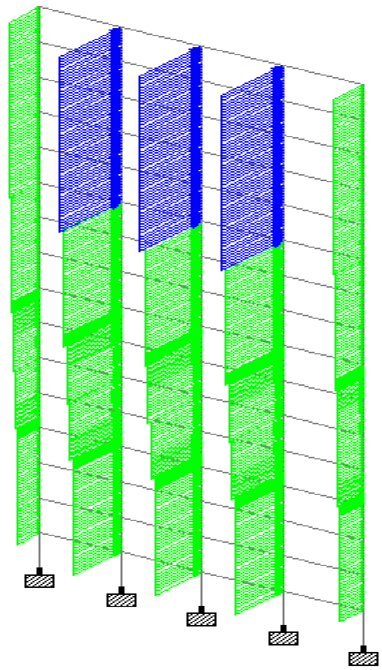


Fig 3.2 Typical Wind Load for G+15 Building

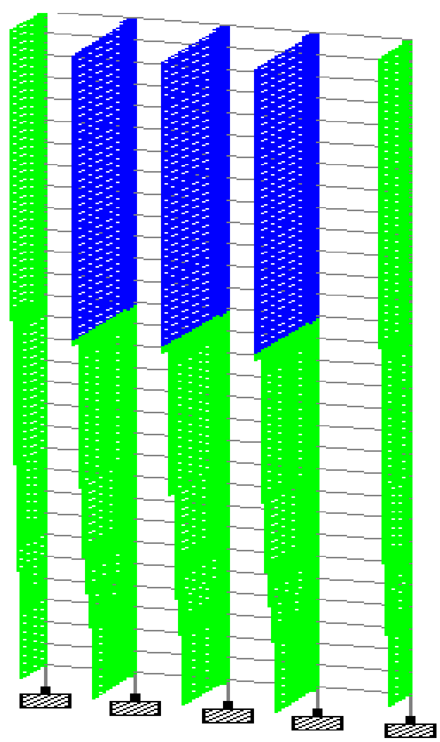


Fig 3.3 Typical Wind Load for G+30 Building

CHAPTER 4

EXPERIMENTAL SETUP

4.1) GEOMETRY OF THE STRUCTURE

4.1.1) GENERAL LAYOUT

The experimental investigation consists the building of two different heights G+15 and G+30 storied regular building, the plan area 20x20 m with a story height of 3m each, depth of foundation below ground level is 3m and bay distance is 5m.

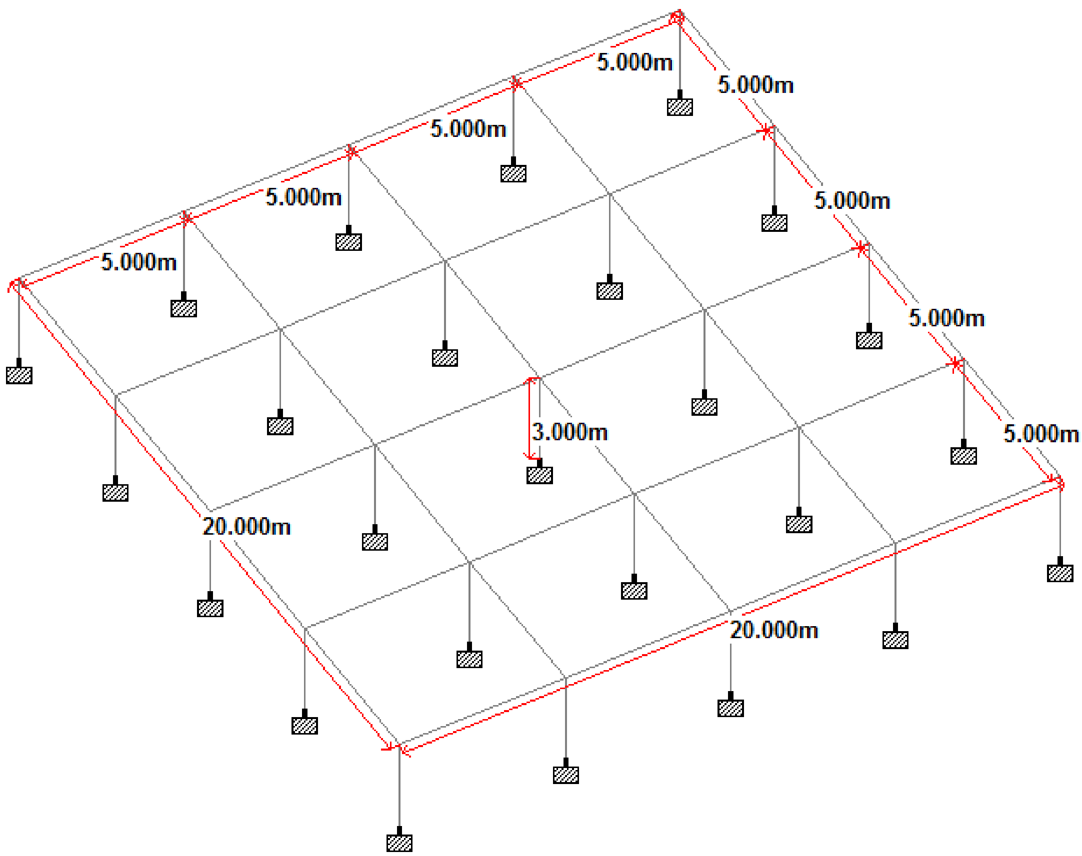


Fig 4.1 Plan of Structure

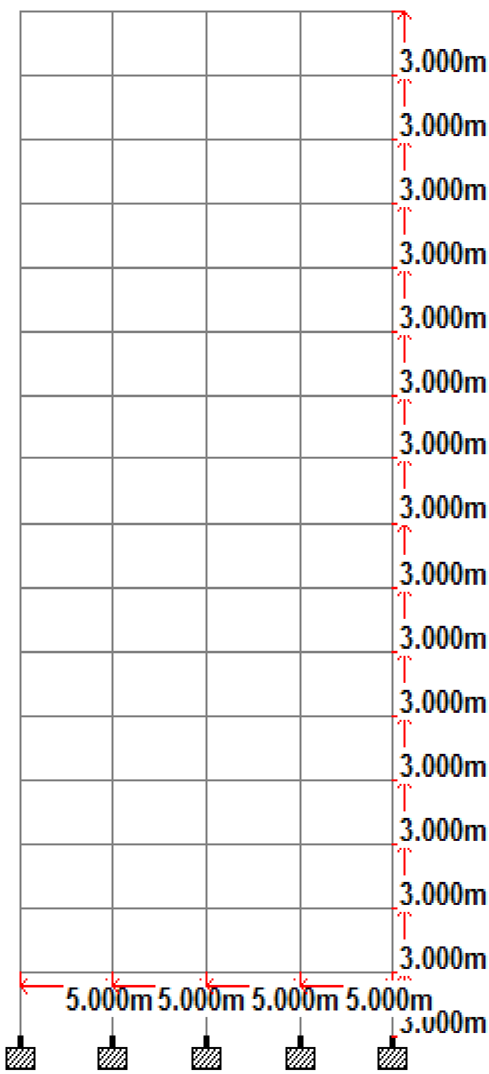


Fig 4.2 Elevation for G+15 Building

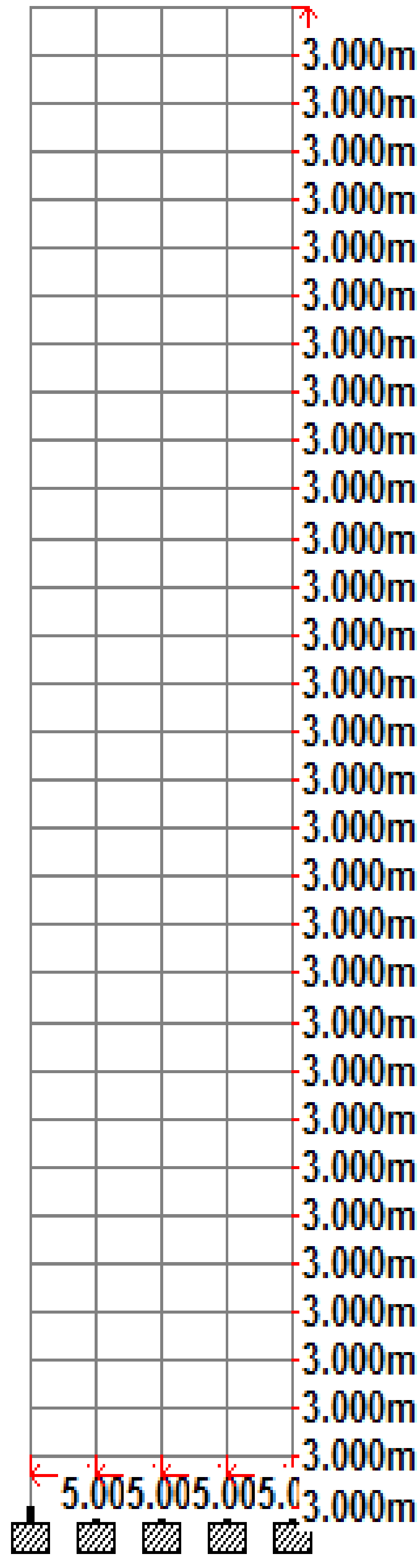


Fig 4.3 Elevation for G+30 Building

4.2) PRELIMINARY DATA

The various details required for the analysis of the structure are as follows.

S. No	Particulars	Dimension/Size/Value
1	Plan Area	20x20 m
2	Building Height	G +15, G +30
3	Floor Height	3 m
4	Depth of Foundation	3 m
5	Size of Columns	700x700, 1200x1200
6	Size of Beams	300x500
7	External Wall Internal Wall	230 mm 115 mm
8	Slab Thickness	125mm
9	Earthquake load	As per IS 1893.1.2002
10	Seismic Zone	II & III
11	Type of Soil	Medium
12	Response Reduction Factor	Special RC Moment Resisting Frame (SMRF)
13	Importance factor	Important Building
14	Structure Type	RC Frame Building
15	Wind Load	As Per IS 875.3.1987
16	Basic Wind Speed	50 m/s
17	Floor Finish	1 KN/m^2
18	Live Load	3 KN/m^2
19	Materials	M 25 – For all Members Fe 500 – For Main Reinforcement Fe 415 – For Secondary Reinforcement
20	Specific Weight of RCC	25 KN/m^3
21	Specific Weight of Infill	18 KN/m^3
22	Software used	STAAD Pro for both static and dynamic analysis.

Table 4.1 preliminary Data

4.3) MODELLING OF STRUCTURE IN STAAD PRO

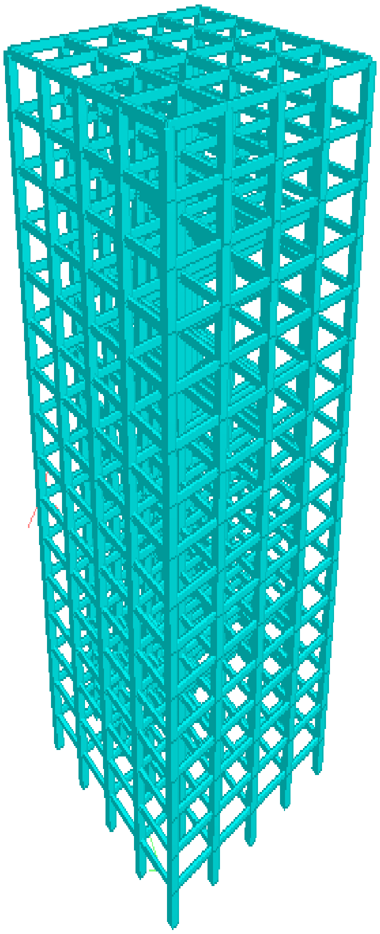


Fig 4.4 3D View for G+15 Building

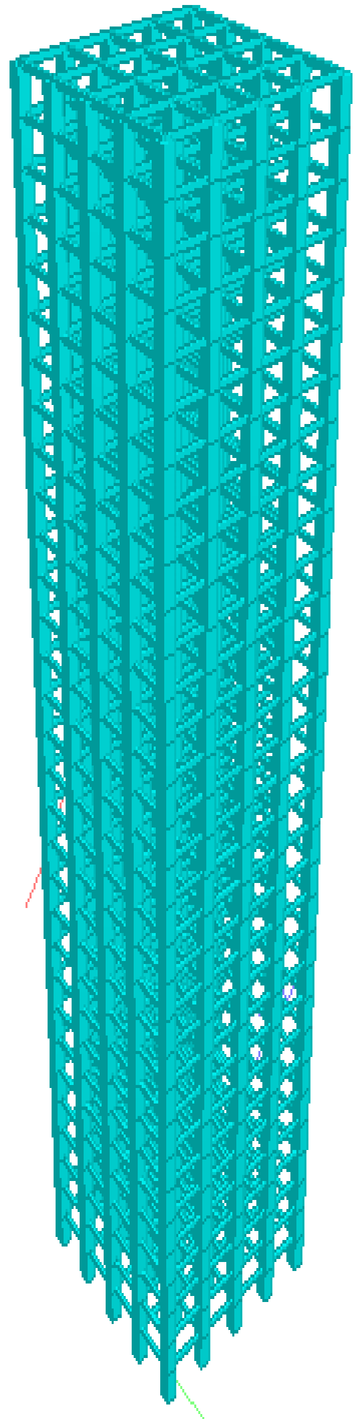


Fig 4.5 3D View for G+30 Building

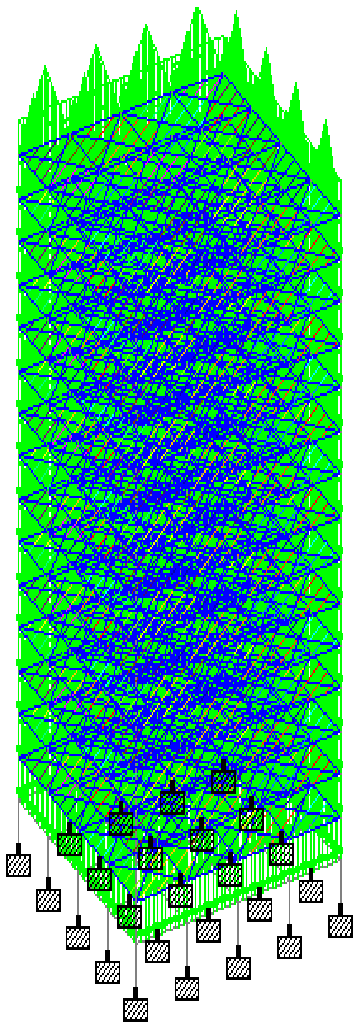


Fig 4.6 Dead Load for G+15 Building

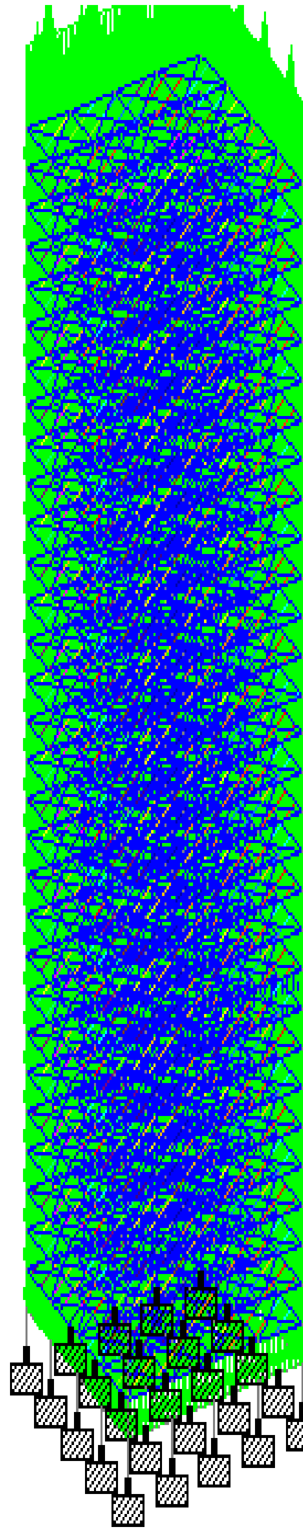


Fig 4.7 Dead Load for G+30 Building

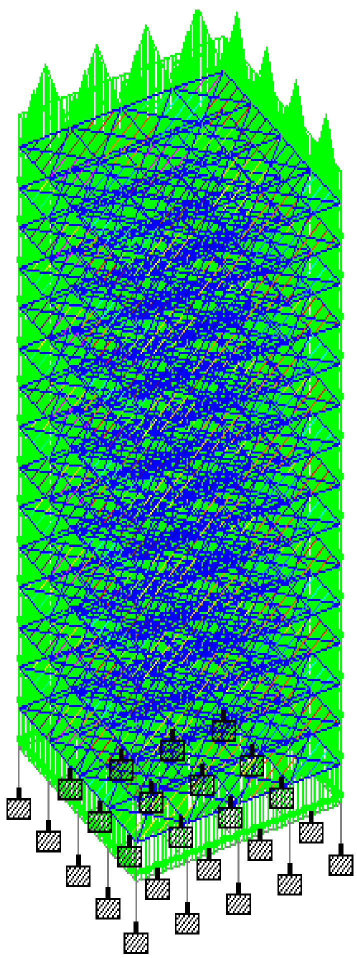


Fig 4.8 Live Load for G+15 Building

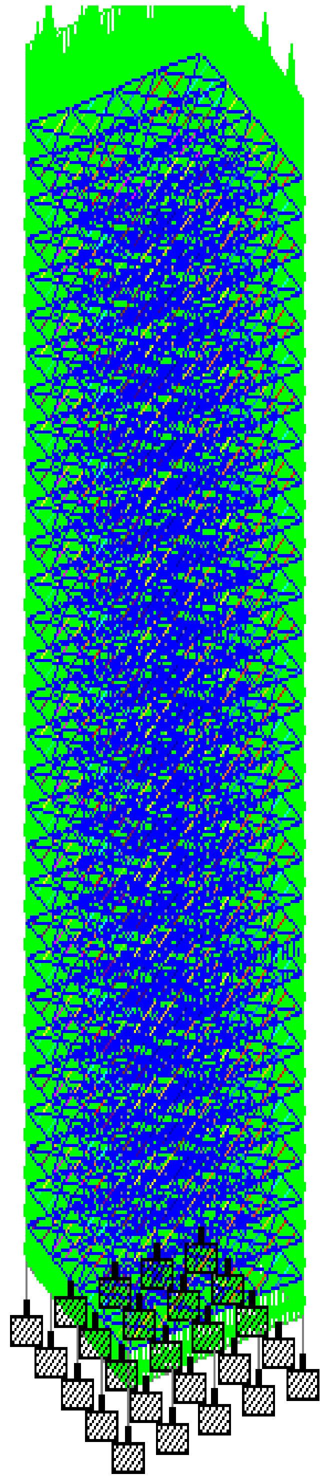


Fig 4.9 Live Load for G+30 Building

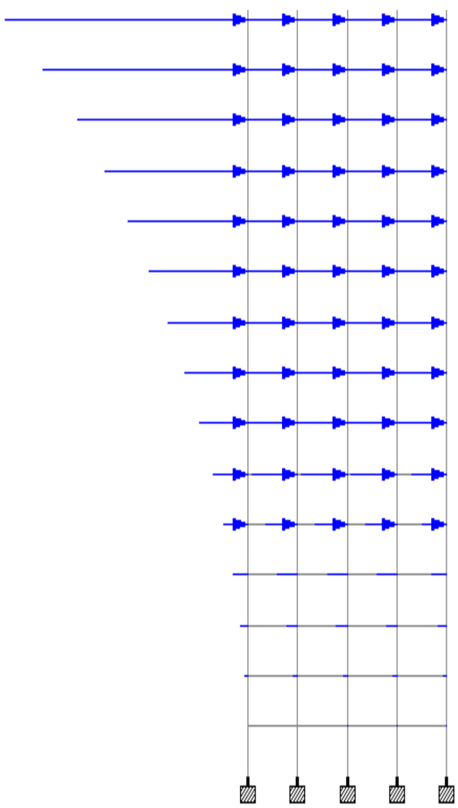


Fig 4.10 Seismic Load for G+15 Building

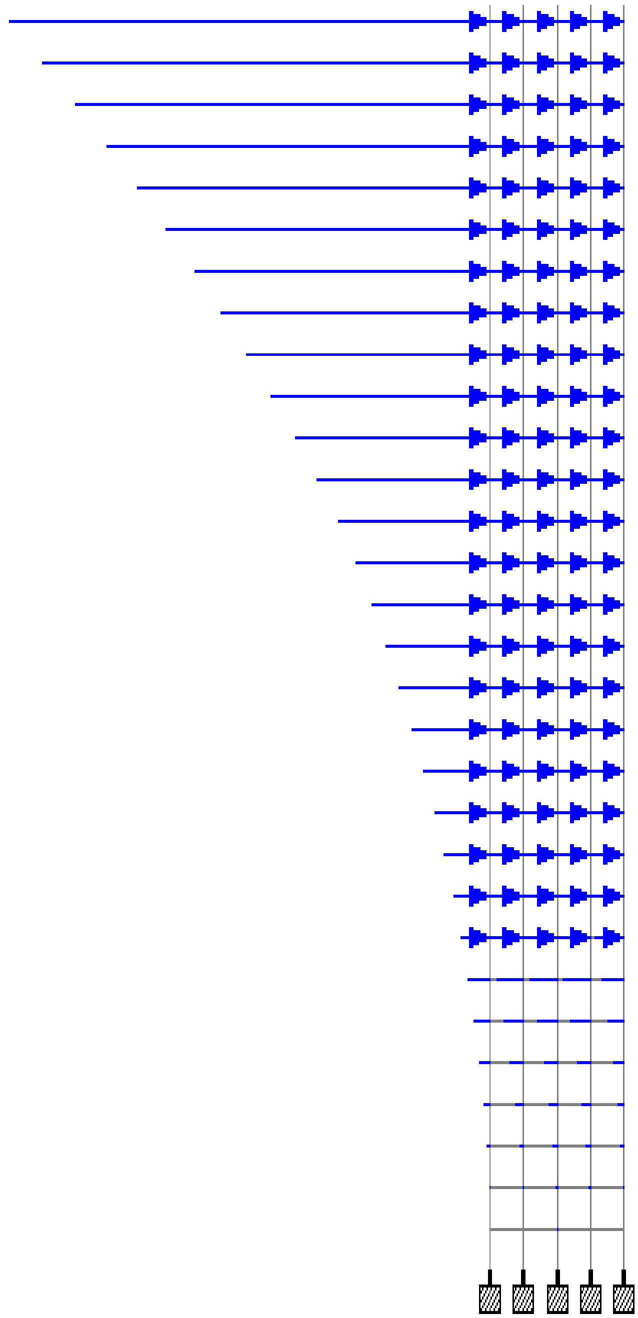


Fig 4.11 Seismic Load for G+30 Building

CHAPTER 5
RESULTS AND DISCUSSIONS

For the comparative analysis, we considered the building of two different heights G+15 and G+30 storied building, the plan area 20x20 m with a story height of 3m each, the analysis is done for 16 models in STADD Pro software the outcomes are discussed.

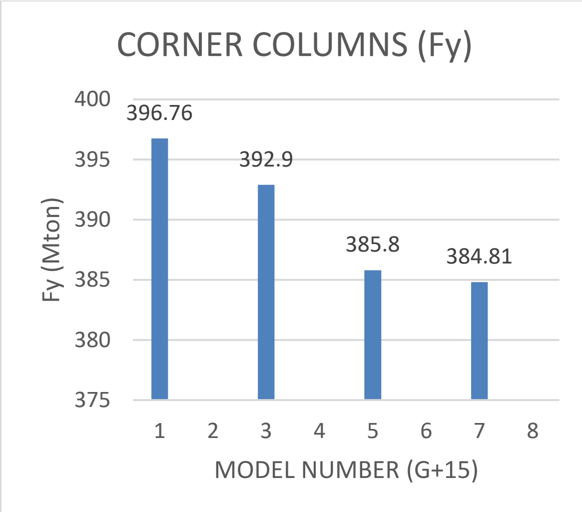
Model No	Building Height	Seismic Zone	Wind Zone
1	G+15	Zone II	Category I, Class B
2	G+15	Zone III	Category I, Class B
3	G+15	Zone II	Category II, Class B
4	G+15	Zone III	Category II, Class B
5	G+15	Zone II	Category III, Class B
6	G+15	Zone III	Category III, Class B
7	G+15	Zone II	Category IV, Class B
8	G+15	Zone III	Category IV, Class B
9	G+30	Zone II	Category I, Class C
10	G+30	Zone III	Category I, Class C
11	G+30	Zone II	Category II, Class C
12	G+30	Zone III	Category II, Class C
13	G+30	Zone II	Category III, Class C
14	G+30	Zone III	Category III, Class C
15	G+30	Zone II	Category IV, Class C
16	G+30	Zone III	Category IV, Class C

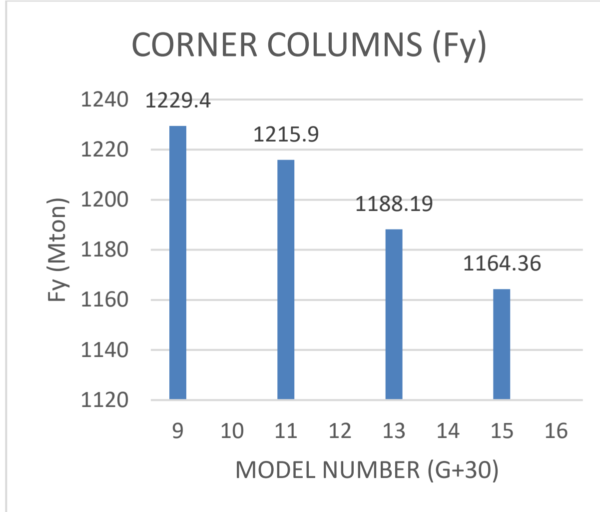
Table 5.1 Critical Models

5.1) SUPPORT REACTION

SUPPORT REACTIONS (Mton)						
MODEL NODE	**CORNER**	**EDGE**		**INTERNAL**		
	26	**27**	**28**	**32**	**33**	**38**
1	396.76	506.62	519.47	650.51	665.89	681.74
	1.5DL+1.5WL	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL
2	416.31	506.62	519.47	650.51	665.89	681.74
	1.5DL+1.5EQ	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL
3	392.9	506.62	519.47	650.51	665.89	681.74
	1.5DL+1.5WL	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL
4	416.31	506.62	519.47	650.51	665.89	681.74
	1.5DL+1.5EQ	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL
5	385.8	506.62	519.47	650.51	665.89	681.74
	1.5DL+1.5WL	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL
6	416.31	506.62	519.47	650.51	665.89	681.74
	1.5DL+1.5EQ	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL
7	384.81	506.62	519.47	650.51	665.89	681.74
	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL
8	416.31	506.62	519.47	650.51	665.89	681.74
	1.5DL+1.5EQ	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL
9	1229.4.	1391.7	1411	1602.3	1634.25	1667.15
	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL
10	1238.49	1399.75	1418.58	1602.3	1634.25	1667.15
	1.5DL+1.5EQ	1.5DL+1.5EQ	1.5DL+1.5EQ	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL
11	1215.9	1378.14	1397.36	1602.23	1634.25	1667.15
	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL
12	1238.49	1399.75	1418.58	1602.23	1634.25	1667.15
	1.5DL+1.5EQ	1.5DL+1.5EQ	1.5DL+1.5EQ	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL
13	1188.19	1350.12	1369.24	1602.28	1634.25	1667.14
	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL
14	1238.49	1399.75	1418.58	1602.28	1634.25	1667.14
	1.5DL+1.5EQ	1.5DL+1.5EQ	1.5DL+1.5EQ	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL
15	1164.36	1327.95	1355.22	1602.28	1634.25	1667.14
	1.5DL+1.5WL	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL
16	1238.49	1399.75	1418.58	1602.28	1634.25	1667.14
	1.5DL+1.5EQ	1.5DL+1.5EQ	1.5DL+1.5EQ	1.5DL+1.5LL	1.5DL+1.5LL	1.5DL+1.5LL

Table 5.2 Maximum Support Reactions for G+15 & G+30 Buildings


CORNER COLUMNS (Fy)
Fy (Mton)
MODEL NUMBER (G+15)
396.76
392.9
385.8
384.81


CORNER COLUMNS (Fy)
Fy (Mton)
MODEL NUMBER (G+30)
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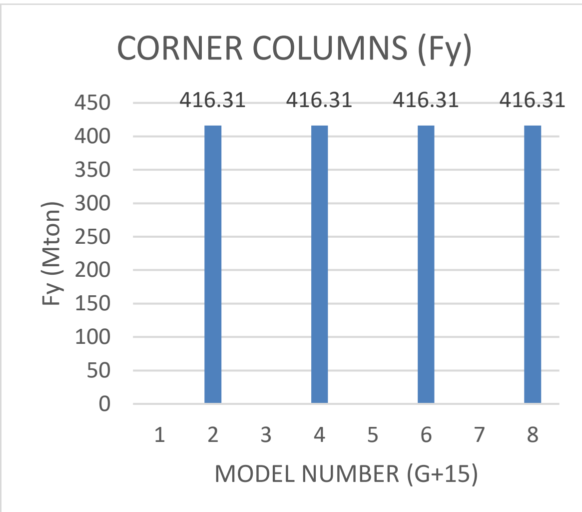
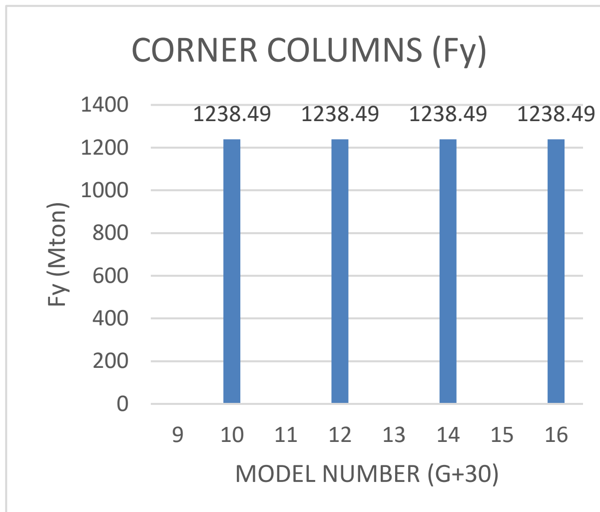
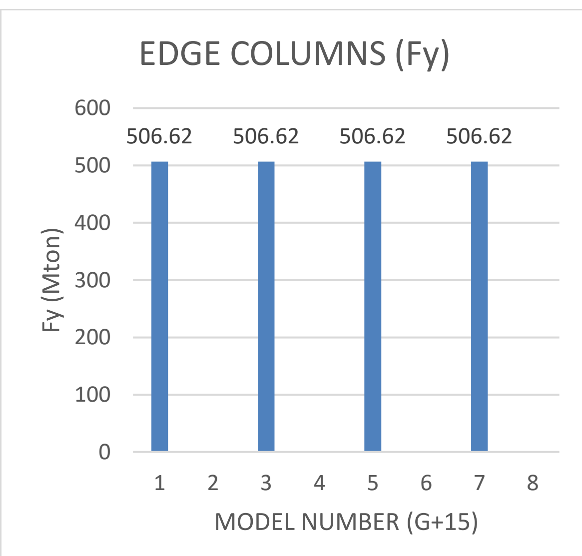
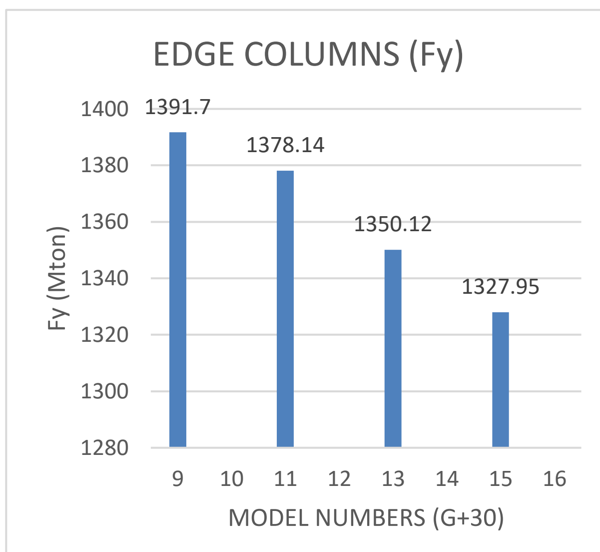
1188.19
1164.36


CORNER COLUMNS (Fy)
Fy (Mton)
MODEL NUMBER (G+15)
416.31
416.31
416.31
416.31


CORNER COLUMNS (Fy)
Fy (Mton)
MODEL NUMBER (G+30)
1238.49
1238.49
1238.49
1238.49


EDGE COLUMNS (Fy)
Fy (Mton)
MODEL NUMBER (G+15)
506.62
506.62
506.62
506.62


EDGE COLUMNS (Fy)
Fy (Mton)
MODEL NUMBERS (G+30)
1391.7
1378.14
1350.12
1327.95

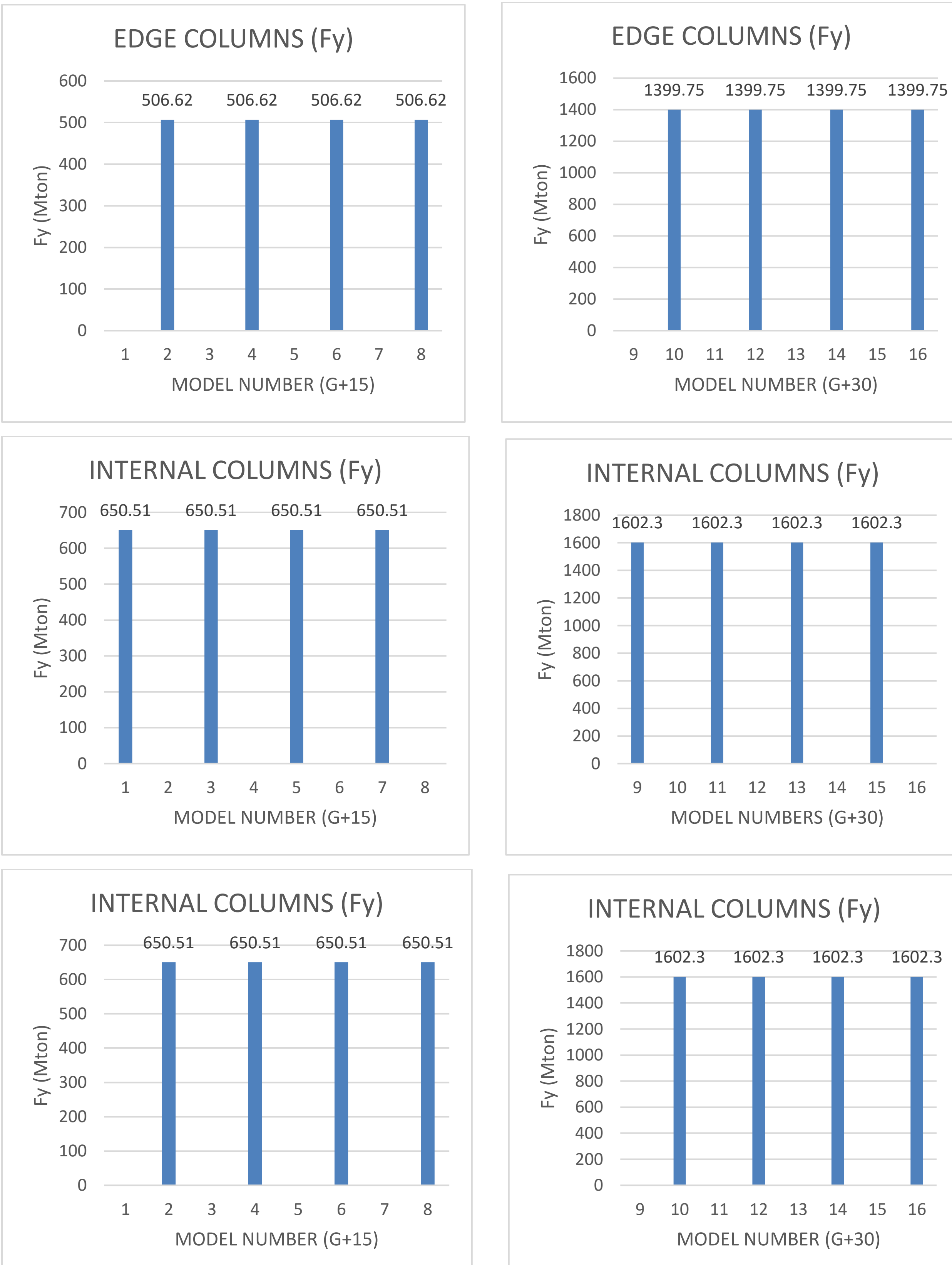


Fig 5.1 Maximum Support Reactions for G+15 & G+30 Buildings

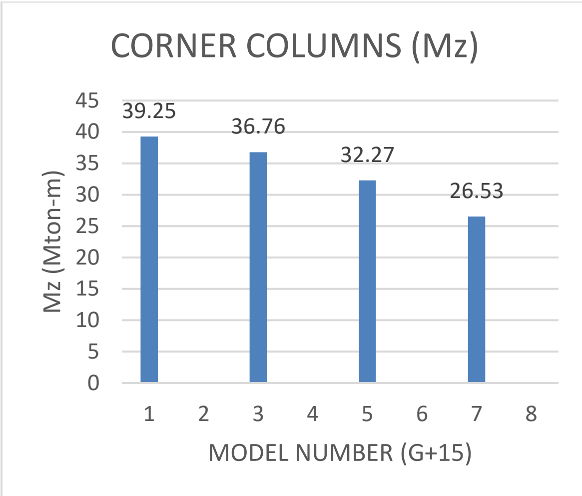
In the **Fig 5.1** the model numbers are taken on x axis and support reaction values are taken on y axis. The graphs are drawn for G+15 & G+30 storied. The static and dynamic loads are applied to the frame. The variation of support reactions is decreasing at low rate. The same trend is observed for G+15 and G+30 storey heights.

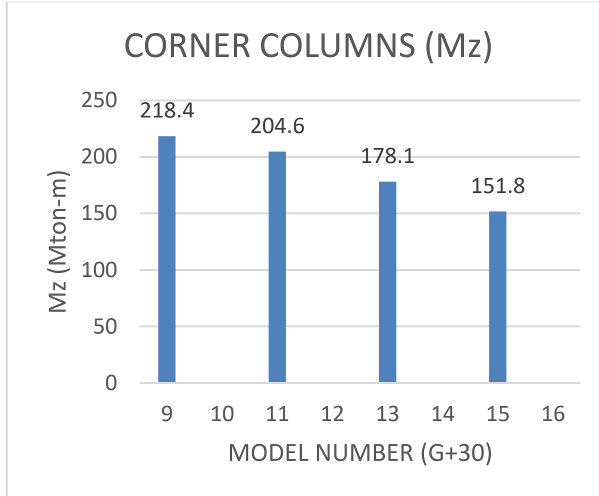
1) For G+15 storey building and seismic zone II, the maximum support reactions obtained in inner and edge columns are due to dead and live load combination (1.5DL +1.5LL), corner columns are due to dead and wind load combinations (1.5DL+1.5WL). While in seismic zone III the inner and edge columns are same as Zone II and corner columns are due to dead and seismic load combination (1.5DL+1.5EL).
2) For G+30 storey building and seismic zone II, the maximum support reactions obtained in inner columns are due to dead and live load combination (1.5DL +1.5LL), edge and corner columns are due to dead and wind load combinations(1.5DL+1.5WL). While in seismic zone III the inner columns are same as zone II, edge and corner columns are due to dead and seismic load combination (1.5DL+1.5EL).
3) The Support Reactions in internal columns are higher than edge and corner columns.
4) While increasing the building height from G+15to G+30 and same loading, the Support Reactions in columns increases up to 3times.
5) The support reaction values increase while increased the building height.
6) The Support reactions in Leeward columns are higher than Windward columns. Due to Symmetry in plan area and load application the Support Reaction value of central column are equal in both Leeward and Windward directions.

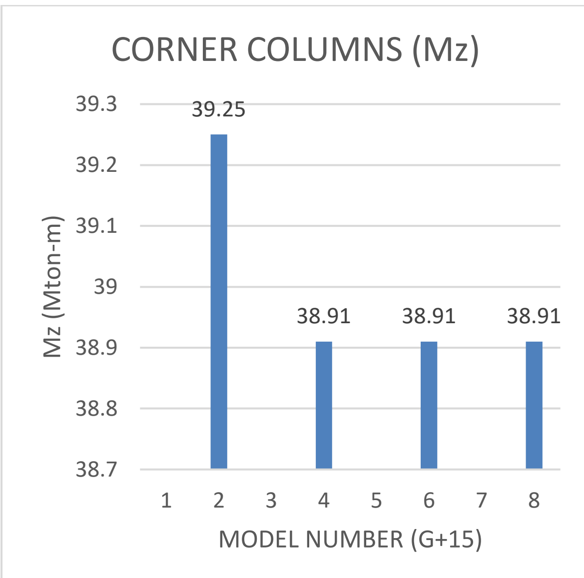
5.2) BENDING MOMENT

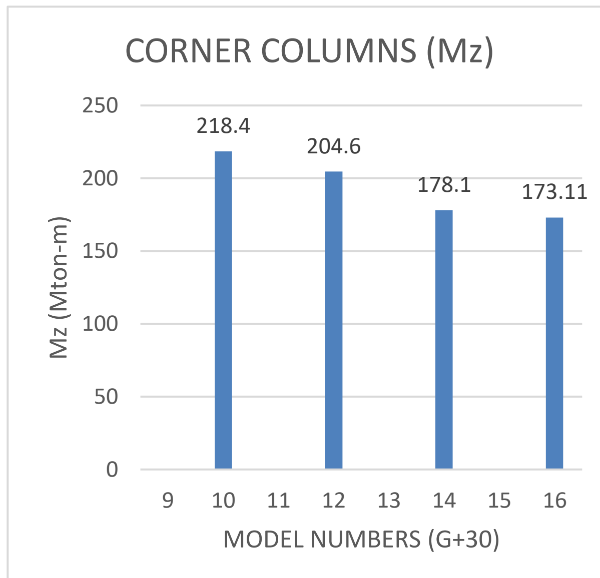
BENDING MOMENT(Mton-m)						
MODEL	CORNER	EDGE		INTERNAL		
NODE	26	27	28	32	33	38
1	39.25	41.53	42.44	44.04	45.01	44.98
	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL
2	39.25	41.53	42.44	44.04	45.01	44.98
	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL
3	36.76	38.78	39.61	41.1	41.99	41.93
	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL
4	38.91	40.46	40.34	41.1	41.99	41.93
	1.5DL+1.5EQ	1.5DL+1.5EQ	1.5DL+1.5EQ	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL
5	32.27	33.83	34.53	35.81	36.56	36.45
	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL
6	38.91	40.46	40.34	40.9	41.07	40.86
	1.5DL+1.5EQ	1.5DL+1.5EQ	1.5DL+1.5EQ	1.5DL+1.5EQ	1.5DL+1.5EQ	0.9DL+1.5EL
7	26.53	27.5	28.01	29.05	29.6	29.43
	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL
8	38.91	40.46	40.34	40.9	41.07	40.86
	1.5DL+1.5EQ	1.5DL+1.5EQ	1.5DL+1.5EQ	1.5DL+1.5EQ	1.5DL+1.5EQ	0.9DL+1.5EL
9	218.4	227.45	229.2	230.4	232.94	232.9
	1.5DL+1.5WL	0.9DL+1.5LL	1.5DL+1.5WL	0.9DL+1.5LL	1.5DL+1.5WL	1.5DL+1.5WL
10	218.4	227.45	229.2	230.4	232.94	232.9
	1.5DL+1.5WL	0.9DL+1.5LL	1.5DL+1.5WL	0.9DL+1.5LL	1.5DL+1.5WL	1.5DL+1.5WL
11	204.6	212.26	214.56	215.12	217.46	217.5
	1.5DL+1.5WL	0.9DL+1.5LL	0.9DL+1.5LL	0.9DL+1.5LL	0.9DL+1.5LL	0.9DL+1.5LL
12	204.6	212.26	214.56	215.12	217.46	217.5
	1.5DL+1.5WL	0.9DL+1.5LL	0.9DL+1.5LL	0.9DL+1.5LL	0.9DL+1.5LL	0.9DL+1.5LL
13	178.1	184	185.9	186.4	188.3	188.5
	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	0.9DL+1.5LL	1.5DL+1.5WL	1.5DL+1.5WL
14	178.1	184	185.9	186.4	188.3	188.5
	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	0.9DL+1.5LL	1.5DL+1.5WL	1.5DL+1.5WL
15	151.8	155.8	157.1	157.53	158.9	158.9
	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL
16	173.11	174.78	174.79	175.38	175.54	175.3
	1.5DL+1.5EQ	1.5DL+1.5EQ	0.9DL+1.5EL	1.5DL+1.5EQ	1.5DL+1.5EQ	1.5DL+1.5EQ

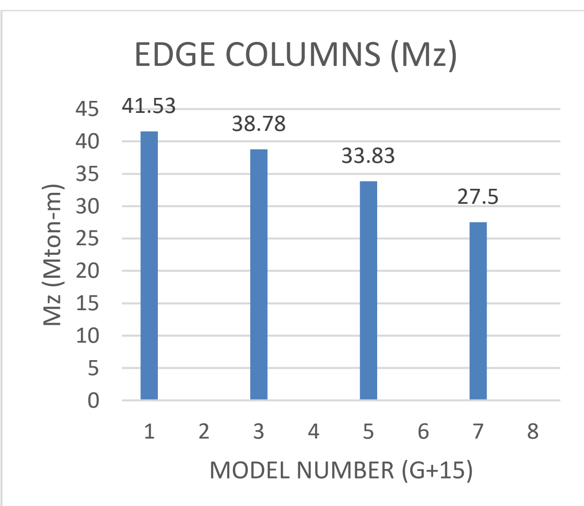
Table 5.3 Maximum Bending Moment for G+15 & G+30 Buildings

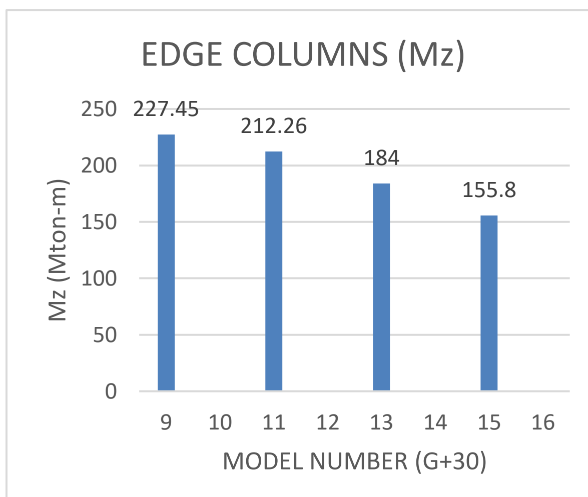

CORNER COLUMNS (Mz)
Mz (Mton-m)
39.25
36.76
32.27
26.53
MODEL NUMBER (G+15)


CORNER COLUMNS (Mz)
Mz (Mton-m)
218.4
204.6
178.1
151.8
MODEL NUMBER (G+30)


CORNER COLUMNS (Mz)
Mz (Mton-m)
39.25
38.91
38.91
38.91
MODEL NUMBER (G+15)


CORNER COLUMNS (Mz)
Mz (Mton-m)
218.4
204.6
178.1
173.11
MODEL NUMBERS (G+30)


EDGE COLUMNS (Mz)
Mz (Mton-m)
41.53
38.78
33.83
27.5
MODEL NUMBER (G+15)


EDGE COLUMNS (Mz)
Mz (Mton-m)
227.45
212.26
184
155.8
MODEL NUMBER (G+30)

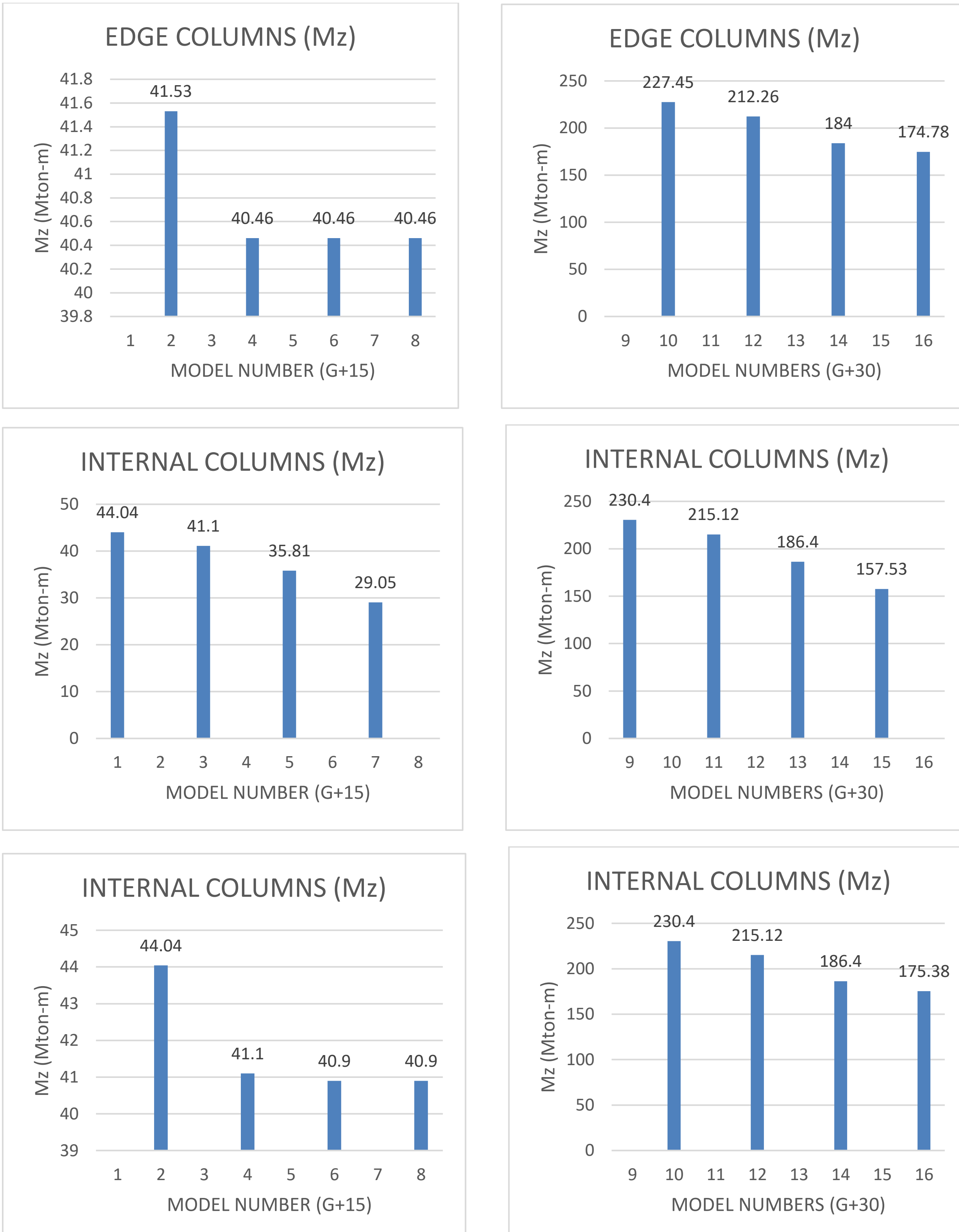


Fig 5.2 Maximum Bending Moment for G+15 & G+30 Buildings

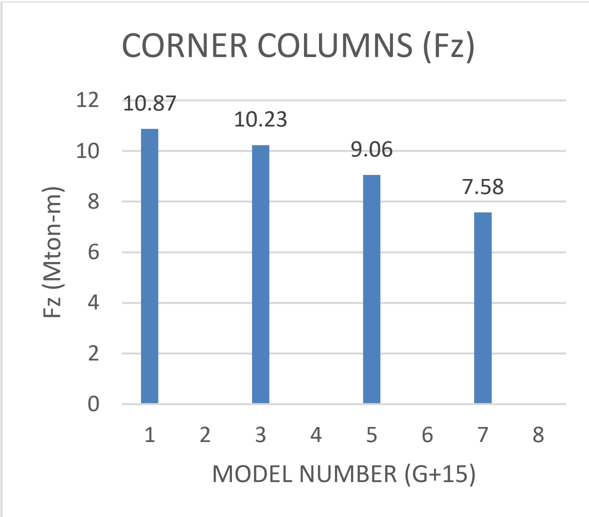
In the **Fig 5.2** the model numbers are taken on x axis and Bending Moment values are taken on y axis. The graphs are drawn for G+15 & G+30 storied. The static and dynamic loads are applied to the frame. The variation of Bending Moment is decreasing at low rate. The same trend is observed for G+15 and G+30 storey heights.

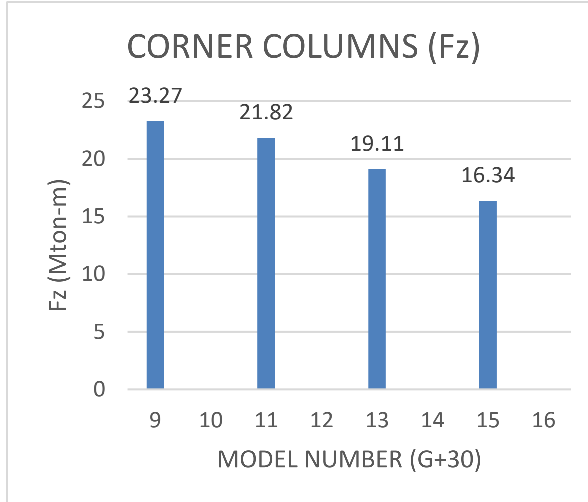
1) The Bending Moment in internal columns are higher than edge and corner columns.
2) The Bending Moment in Leeward columns are higher than Windward columns.
3) Due to Symmetry in plan area and load application the bending moment values of central column are equal in both Leeward and Windward directions.
4) For G+15 storey building and seismic zone II, the maximum bending moment obtained in columns are due to dead and wind load combination (1.5DL +1.5WL). while in zone III the corner and edge columns are due to dead and seismic load combination (1.5DL+1.5EL), inner columns due to dead and wind load combination (1.5DL +1.5WL), dead and seismic load combination (1.5DL+1.5EL).
5) For G+30 storey buildings and seismic zone II, the maximum bending moment obtained in corner columns are due to dead and wind load combination (1.5DL +1.5WL), edge and inner columns are due to dead and live load combination (1.5DL+1.5LL), dead and wind load combination (1.5DL+1.5WL). while in seismic zone III the values are same as zone II.
6) While increasing the building height from G+15to G+30 and same loading, the Bending Moment in columns increases up to 5.5times.
7) The Bending Moment values increase while increased the building height.

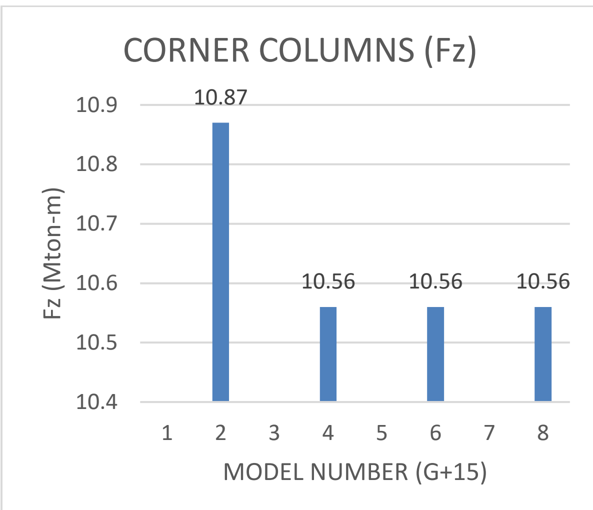
5.3) SHEAR FORCE

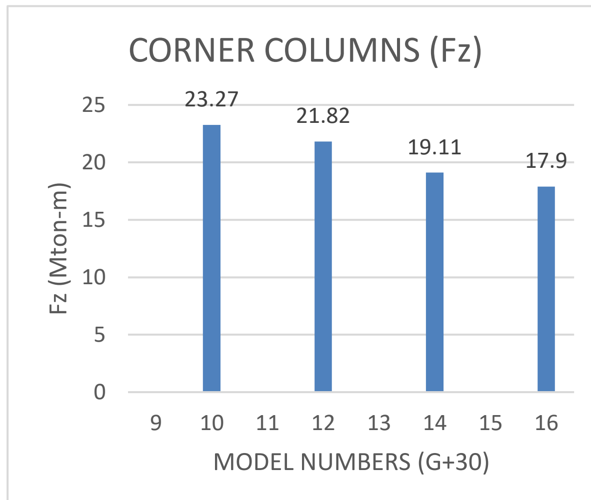
SHEAR FORCE(Mton)						
MODEL NODE	**CORNER**	**EDGE**		**INTERNAL**		
	26	**27**	**28**	**32**	**33**	**38**
1	10.87	12.47	12.41	13.58	13.89	13.82
	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL
2	10.87	12.47	12.41	13.58	13.89	13.82
	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL
3	10.23	11.66	11.59	12.67	12.95	12.87
	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	0.9DL+1.5WL
4	10.56	12.13	12.05	12.67	12.95	12.87
	1.5DL+1.5EQ	1.5DL+1.5EQ	0.9DL+1.5EL	1.5DL+1.5WL	1.5DL+1.5WL	0.9DL+1.5WL
5	9.06	10.19	10.1	11.03	11.27	11.17
	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL
6	10.56	12.13	12.05	12.28	12.33	12.2
	1.5DL+1.5EQ	1.5DL+1.5EQ	0.9DL+1.5EL	1.5DL+1.5EQ	0.9DL+1.5EL	0.9DL+1.5EL
7	7.58	8.33	8.22	8.95	9.12	8.99
	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL
8	10.56	12.13	12.05	12.28	12.33	12.2
	1.5DL+1.5EQ	1.5DL+1.5EQ	0.9DL+1.5EL	1.5DL+1.5EQ	0.9DL+1.5EL	0.9DL+1.5EL
9	23.27	25.22	25.37	26.67	27.02	27.18
	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL
10	23.27	25.22	25.37	26.67	27.02	27.18
	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL
11	21.82	23.58	23.7	24.87	25.19	25.31
	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL
12	21.82	23.58	23.7	24.87	25.19	25.31
	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL
13	19.11	20.47	20.53	21.53	21.79	21.83
	1.5DL+1.5WL	1.5DL+1.5WL	0.9DL+1.5EL	1.5DL+1.5WL	1.5DL+1.5WL	0.9DL+1.5EL
14	19.11	20.47	20.53	21.53	21.79	21.83
	1.5DL+1.5WL	1.5DL+1.5WL	0.9DL+1.5EL	1.5DL+1.5WL	1.5DL+1.5WL	0.9DL+1.5EL
15	16.34	17.31	17.31	18.04	18.22	18.17
	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	1.5DL+1.5WL	0.9DL+1.5EL
16	17.9	19.17	19.17	19.31	19.33	19.23
	1.5DL+1.5EQ	1.5DL+1.5EQ	0.9DL+1.5EL	1.5DL+1.5EQ	1.5DL+1.5EQ	0.9DL+1.5EL

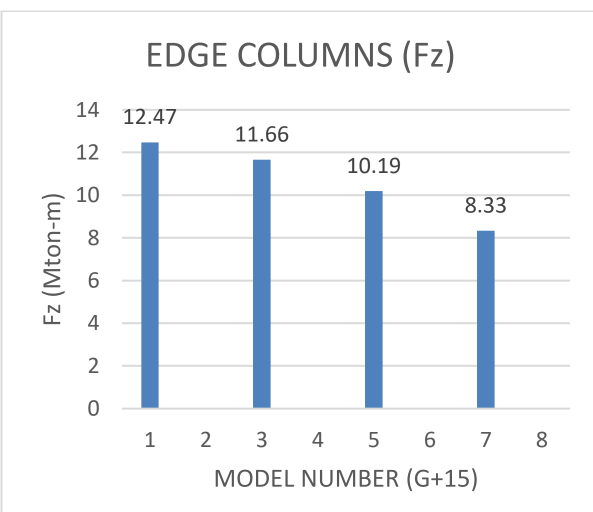
Table 5.4 Maximum Shear Force for G+15 & G+30 Buildings

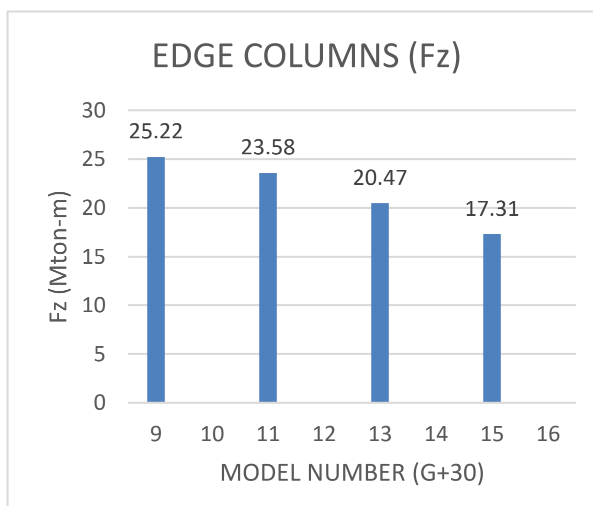

CORNER COLUMNS (Fz)
Fz (Mton-m)
0
2
4
6
8
10
12
10.87
10.23
9.06
7.58
1 2 3 4 5 6 7 8
MODEL NUMBER (G+15)


CORNER COLUMNS (Fz)
Fz (Mton-m)
0
5
10
15
20
25
23.27
21.82
19.11
16.34
9 10 11 12 13 14 15 16
MODEL NUMBER (G+30)


CORNER COLUMNS (Fz)
Fz (Mton-m)
10.4
10.5
10.6
10.7
10.8
10.9
10.87
10.56
10.56
10.56
1 2 3 4 5 6 7 8
MODEL NUMBER (G+15)


CORNER COLUMNS (Fz)
Fz (Mton-m)
0
5
10
15
20
25
23.27
21.82
19.11
17.9
9 10 11 12 13 14 15 16
MODEL NUMBERS (G+30)


EDGE COLUMNS (Fz)
Fz (Mton-m)
0
2
4
6
8
10
12
14
12.47
11.66
10.19
8.33
1 2 3 4 5 6 7 8
MODEL NUMBER (G+15)


EDGE COLUMNS (Fz)
Fz (Mton-m)
0
5
10
15
20
25
30
25.22
23.58
20.47
17.31
9 10 11 12 13 14 15 16
MODEL NUMBER (G+30)

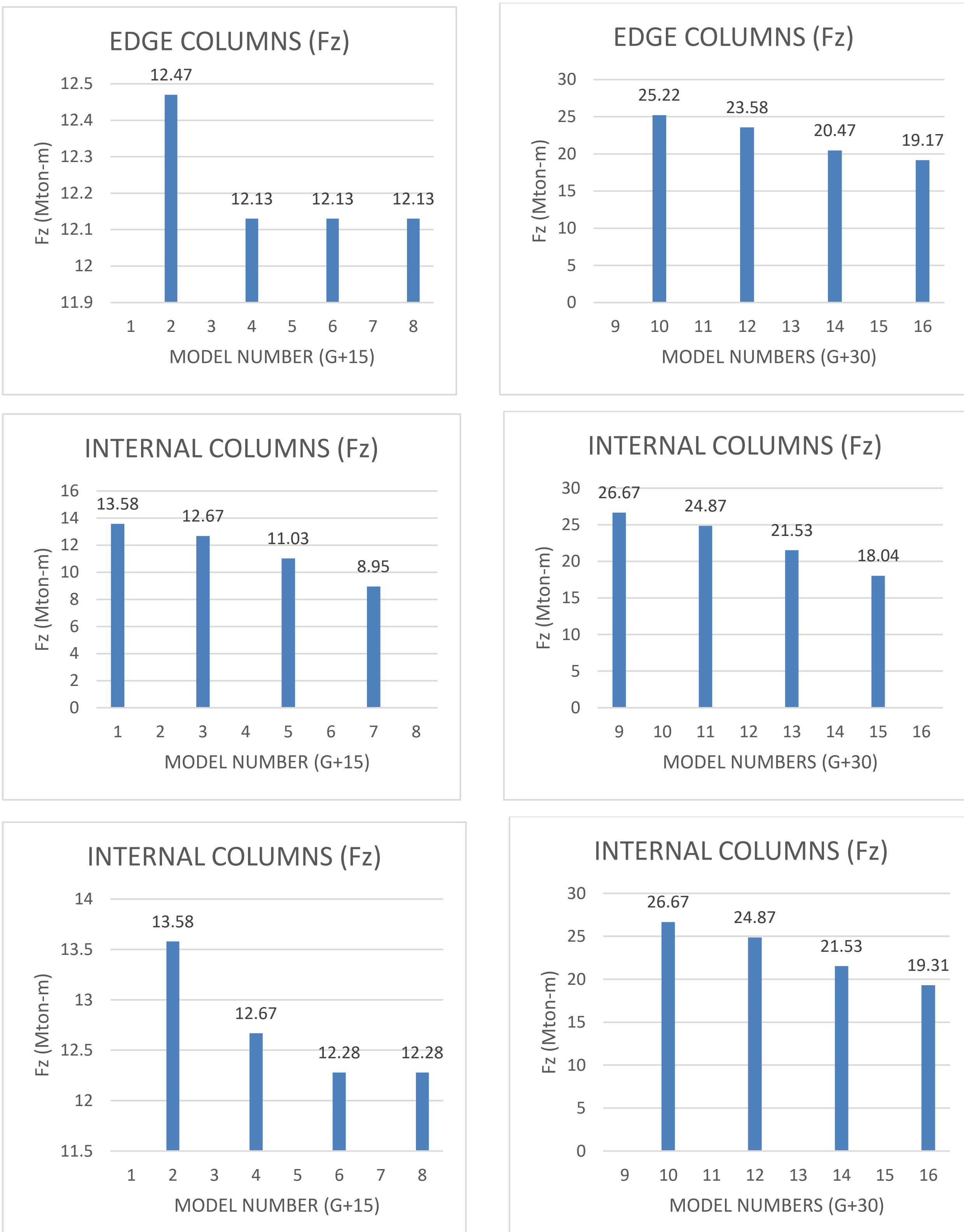
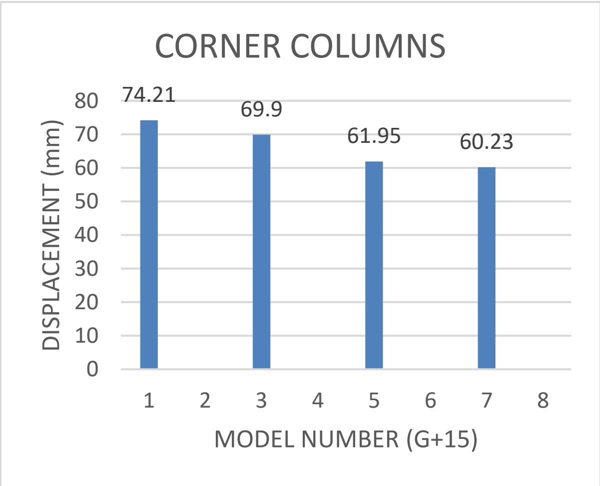


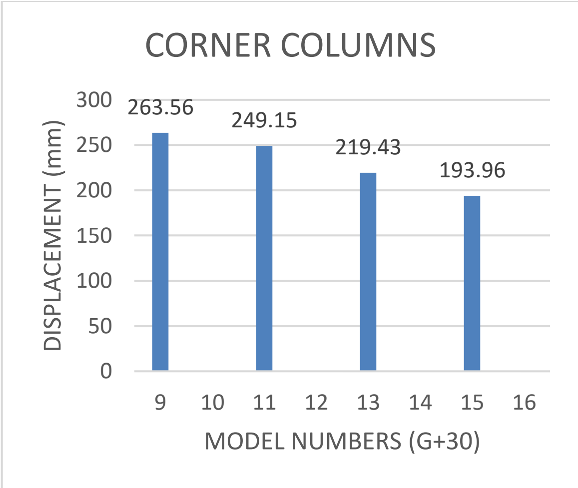
Fig 5.3 Maximum Shear Force for G+15 & G+30 Buildings

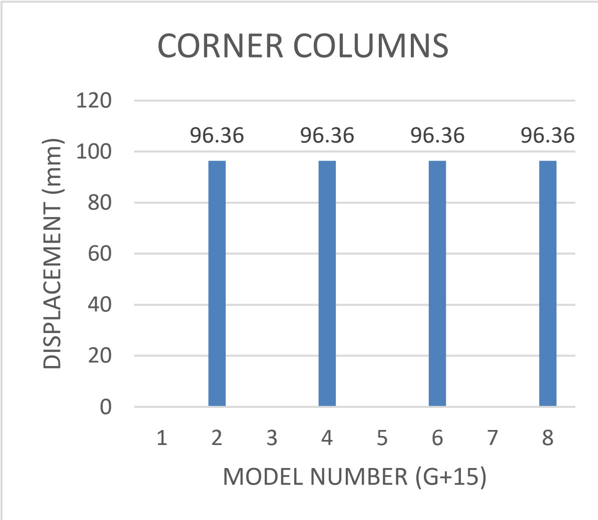
In the **Fig 5.3** the model numbers are taken on x axis and Shear Force values are taken on y axis. The graphs are drawn for G+15 & G+30 storied. The static and dynamic loads are applied to the frame. The variation of shear force is decreasing at low rate. The same trend is observed for G+15 and G+30 storey heights.

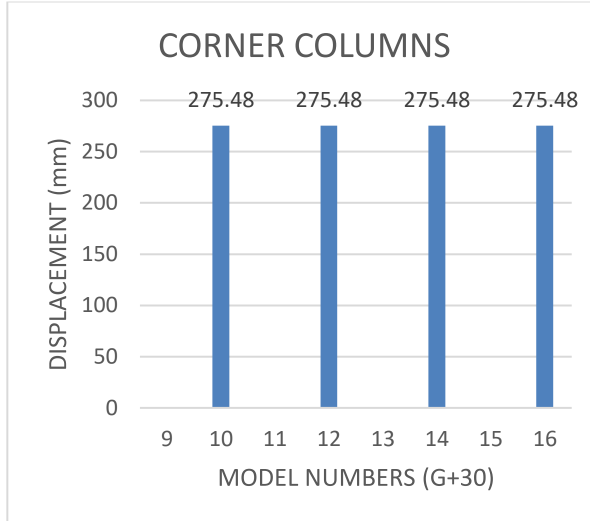
1) The Shear Force in internal columns are higher than edge and corner columns.
2) The Shear Force in Leeward columns are higher than Windward columns.
3) Due to Symmetry in plan area and load application the Shear Force values of central column are equal in both Leeward and Windward directions.
4) For G+15 storey buildings and seismic zone II, the maximum Shear Force obtained in columns are due to dead and wind load combination (1.5DL +1.5WL). while in zone III columns are due to dead and seismic load combination (1.5DL+1.5EL),
5) For G+30 storey buildings and seismic zone II and III, the maximum Shear Force obtained in columns are due to dead and wind load combination (1.5DL +1.5WL).
6) While increasing the building height from G+15to G+30 and same loading, the Shear Force in columns increases up to 2.1 times.
7) The Shear force values increases while increased the building height.

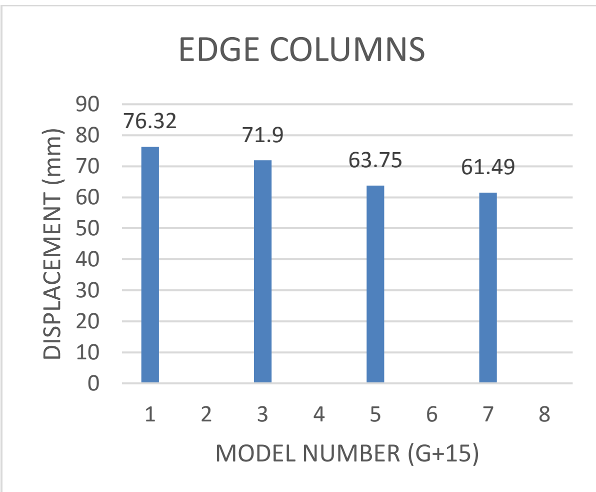
5.4) DISPLACEMENT

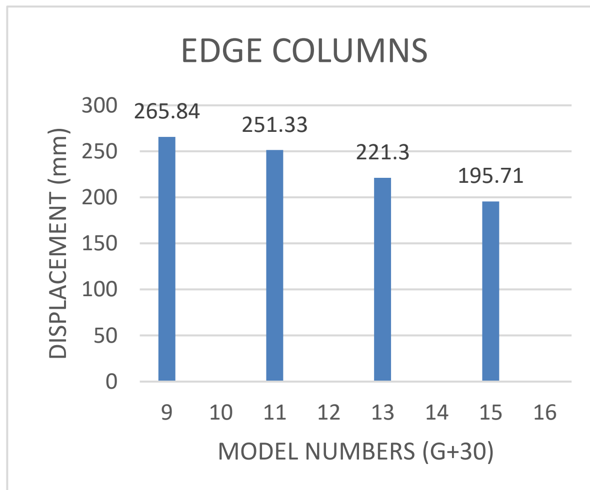


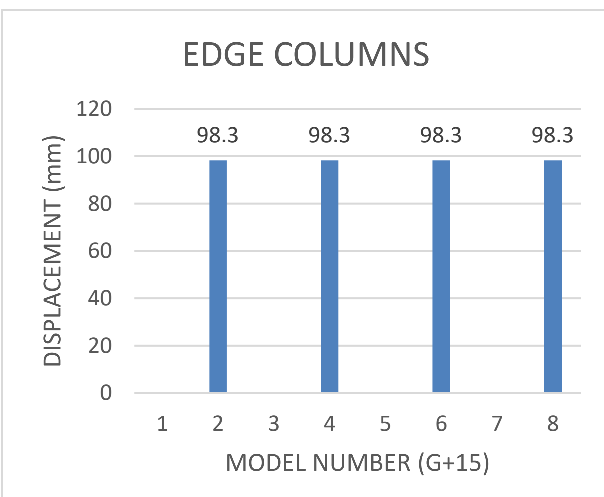


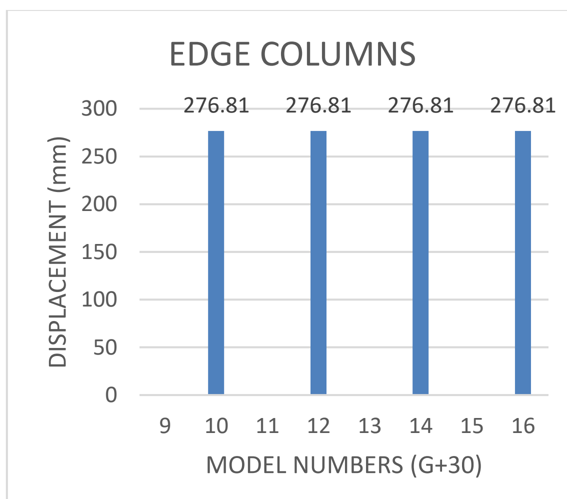

CORNER COLUMNS
DISPLACEMENT (mm)
120
100
80
60
40
20
0
96.36
96.36
96.36
96.36
1 2 3 4 5 6 7 8
MODEL NUMBER (G+15)


CORNER COLUMNS
DISPLACEMENT (mm)
300
250
200
150
100
50
0
275.48
275.48
275.48
275.48
9 10 11 12 13 14 15 16
MODEL NUMBERS (G+30)


EDGE COLUMNS
DISPLACEMENT (mm)
90
80
70
60
50
40
30
20
10
0
76.32
71.9
63.75
61.49
1 2 3 4 5 6 7 8
MODEL NUMBER (G+15)


EDGE COLUMNS
DISPLACEMENT (mm)
300
250
200
150
100
50
0
265.84
251.33
221.3
195.71
9 10 11 12 13 14 15 16
MODEL NUMBERS (G+30)


EDGE COLUMNS
DISPLACEMENT (mm)
120
100
80
60
40
20
0
98.3
98.3
98.3
98.3
1 2 3 4 5 6 7 8
MODEL NUMBER (G+15)


EDGE COLUMNS
DISPLACEMENT (mm)
300
250
200
150
100
50
0
276.81
276.81
276.81
276.81
9 10 11 12 13 14 15 16
MODEL NUMBERS (G+30)

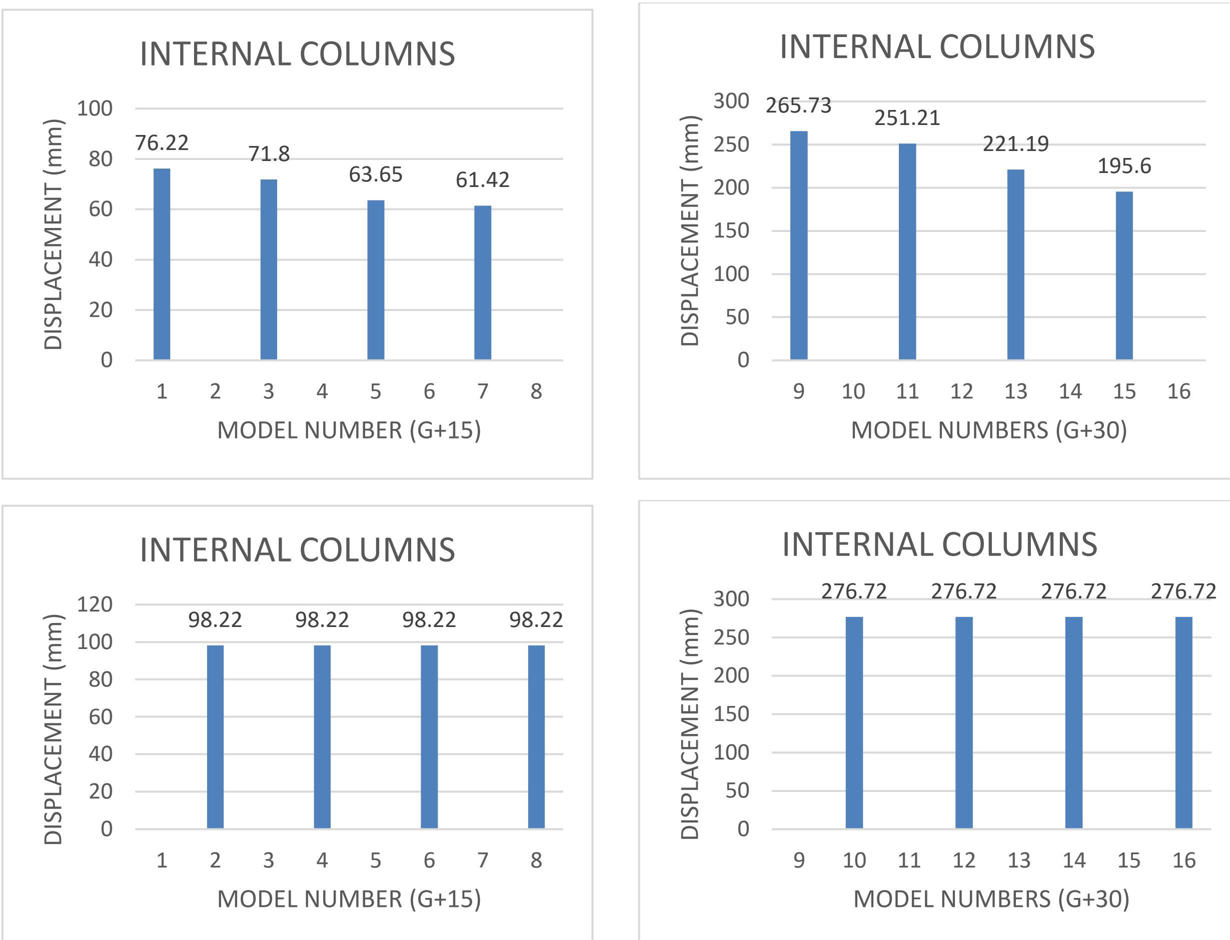


Fig 5.4 Maximum Displacement for G+15 & G+30 Buildings

In the **Fig 5.4** the model numbers are taken on x axis and Displacement values are taken on y axis. The graphs are drawn for G+15 & G+30 storied. The static and dynamic loads are applied to the frame. The variation of displacement is decreasing at low rate. The same trend is observed for G+15 and G+30 storey heights.

1) The Displacement in edge columns are higher than internal and corner columns.
2) The displacement in wind ward columns are higher than leeward columns.
3) Due to Symmetry in plan area and load application the Displacement values of central column are equal in both Leeward and Windward directions.
4) For G+15, G+30 storey buildings and seismic zone II, the maximum Displacement obtained in columns are due to dead and wind load combination (1.5DL +1.5WL), dead and seismic load combination (1.5DL+1.5EL).

5) For G+15, G+30 storey buildings and seismic zone III, the maximum Displacement obtained in columns are due to dead and seismic load combination (1.5DL+1.5EL).
6) While increasing the building height from G+15to G+30 and same loading, the Displacement in columns increases up to 3.56 times.
7) The Displacement values increases while increased the building height.

CHAPTER 6
CONCLUSIONS

1) The Support Reaction, Bending Moment, Shear Force and Displacement values increases while increased the building height.
2) The Support Reaction, Bending Moment, Shear Force and Displacement values in wind ward columns are higher than leeward columns.
3) Due to Symmetry in plan area, Geometry and load application the Support Reaction, Bending Moment, Shear Force and Displacement values of central column are equal in both Leeward and Windward directions.
4) The Support Reactions, Bending Moment and Shear Force values in internal columns are higher than edge and corner columns.
5) The Displacement in edge columns are higher than internal and corner columns.
6) The Support Reaction, Bending Moment, Shear Force and Displacement values are depending up on the ground conditions as building is located in open terrain the values are high than the building is located in closely terrain.
7) If the building is located in closely terrain and seismic zone III then the seismic load is dominating the wind load.

6.1) FUTURE SCOPE

1) This analysis is done for two heights (G+15 and G+30) this may have extended to further heights.
2) This study is done with seismic zone II & III and wind load for different ground conditions the same may extended to different seismic zones.
3) This study of wind load is considered as per IS 875.3.1987 this same may be considered as per ASCE.
4) This study is done for constant wind velocity the same may extended to different wind velocities.

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4) Umakant Arya, Aslam Hussain, Waseem Khan (2014) "*Wind Analysis of Building Frames on Sloping Ground*" International Journal of Scientific and Research Publications, Volume 4, Issue 5, May 2014.

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6) Swati D.Ambadkar, Vipul S. Bawner (2012) "*Behaviour of multistoried building under the effect of wind load*" Int. Journal of Applied Sciences and Engineering Research, Vol. 1, Issue 4, 2012.

7) IS: 875 (Part I) – 1987 "*Indian Standard Code of Practice for Design Loads (Other than Earthquake) for Buildings & Structures, Dead Loads".*

8) IS: 875 (Part I) – 1987 "*Indian Standard Code of Practice for Design Loads (Other than Earthquake) for Buildings & Structures, Imposed Loads".*

9) IS: 875 (Part I) – 1987 "*Indian Standard Code of Practice for Design Loads (Other than Earthquake) for Buildings & Structures, Wind Loads".*

10) IS: 1893 (Part I) – 2002 "*Indian Standard Criteria Earthquake resistant design of structure".*