# A COMPARATIVE STUDY ON SEISMIC ANALYSIS OF MULTI-STORED (G+7) RESIDENTIAL BUILDING FOR DIFFERENT ZONES IN BANGLADESH USING ETABS.

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A thesis submitted to the Department of Civil Engineering in partial fulfillment for the degree of Bachelor of Science in Civil Engineering





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Sonargaon University

147/I, Green Road, Dhaka-1215, Bangladesh Section: 25(B)


Semester-(FALL-2025)

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## DECLARATION

It is hereby declared that this thesis/project or any part of it has not been submitted elsewhere for any degree or diploma award.

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Dedication

To

“OUR PARENTS”

AND

“OUR HONORABLE & TEACHER”

# ACKNOWLEDGEMENTS

Regardless of our efforts, the success of this dissertation is largely dependent on the encouragement and direction of many others. We would like to take this opportunity to thank everyone who contributed to the successful completion of this thesis. First and foremost, we would like to praise and thank Allah, the Almighty, for bestowing countless blessings, knowledge, and opportunities on the writer, allowing us to finally complete the thesis, without which we would not have been able to complete this work on time.

We would like our heartfelt gratitude to our guide, the department of civil engineering at Sonargaon University, for their invaluable assistance. We would like to express our heartfelt gratitude to Tahmid Mustafa, Assistant Professor at Sonargaon University Department of Civil Engineering, for serving as the thesis supervisor. We can't thank him enough for his unwavering support and assistance. Every time we attend his meeting, we feel motivated and encouraged. This thesis would not have been possible without him encouragement and guidance. We are also grateful to all of the institution's teachers for their cooperation and dedicated teaching over the last four years.

## ABSTRACT

Modern residential buildings have efficient structural systems, and utilize high-strength materials, resulting in reduced building height, and thus, become slenderer and more flexible with low damping. These flexible buildings are very sensitive to wind excitation and earthquake load causing discomfort to the building occupants. Therefore, in order to mitigate such an excitation and to improve the performance of tall buildings against wind loads and earthquake loads, many researches and studies have been performed. Early integration of aerodynamic shaping, wind engineering considerations, and structural system selections play a major role in the architectural design of a residential building in order to mitigate the building response to the wind excitations. A residential building, whose shape is unsuitable, often requires a great deal of steel or a special damping mechanism to reduce its dynamic displacement within the limits of the criterion level for the design wind speed. Understandably, an appropriate choice of building shape and architectural modifications are also extremely important and effective design approaches to reduce wind and earthquake induced motion by altering the flow pattern around the building, hence for this research work four different shaped buildings are generally studied namely Rectangular.To achieve these purposes, firstly, a literature survey, which includes the definition, design parameters, and lateral load considerations of residential buildings, is presented. Then the results are interpreted for different shaped buildings and of different stories thereby concluding as to which shaped residential building is most stable for different conditions.



**Keywords:** Residential Building, Wind load Effect, Earthquake load.

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# CHAPTER 1

# INTRODUCTION

## 1.1 General

- Earthquakes are a real threat to people's lives and property. The recent earthquake in Dhaka city is the best proof that it is time to take seismic load seriously.
- Therefore, it is a must now to predict the strength of the earthquake and prepare for it to avoid or minimize damage.
- It should be noted here that strengthening the building against seismic load increases its cost, so this work was done.

The increase in population by which land deficit occurs and to control that, high-Rise buildings are opted. These types of high-rise buildings are affected by the natural calamities. Calamities like earthquakes are the most dangerous by means of the damage and chaos caused to the structural components and they cannot be controlled. These natural calamities caused property damage and interruptions in development of the normal lifecycle. Since it’s a global concern, most of the analysis should be carried out and provided with the results to prep the structure in order to attain time period. A seismic wave is the cause of ground motions that are much larger on the soil surface than on the rock base. Structures located on such sites sustain more damage than sites located closer to the rock surface. The seismic effect on any structure is determined by the seismic zone coefficient, response reduction factor, soil characteristics, structure importance, and so on. It is necessary to be aware of the most recent earthquake codes in order to design an earthquake-resistant structure. In most small and moderate-sized buildings, the dynamic effects of earthquake loads are typically analyzed as an equivalent static load Recent earthquakes in Bangladesh's urban areas have highlighted the importance of pushing to strengthen these seismically deficient structures and making progress in developing various strengthening and rehabilitation techniques to improve the seismic performance of structures.

## 1.2 Background of the Study

It is indicated that a significant number of structures are completely or partially harmed as a result of earthquakes, and it is now critical to decide seismic reactions over such structures. Structural analysis is a branch of engineering that focuses on the assurance of structures with the goal of anticipating the reactions of genuine structures such as structures, spans, trusses, and so on before developing any structure, basic outlining necessitates basic investigation and seismic examination. In order to meet the needs of this growing population in a constrained space, the building's height has been reduced to medium to tall. As a result, seismic examination study and planning quake protection structures are required to ensure safety against seismic powers of multistory working. Displacement of structure begins from the purposes of a shortcoming during an earthquake. Geometry, mass brokenness, and structure solidity are the most common causes of shortcoming. That is why' in general, structures fail during earthquakes due to vertical abnormality

The initial goal of this research is to investigate seismic reaction in various zones of structure for static and dynamic examination in standard minute opposing casing. We considered a residential building with (G+7) stories for the seismic Investigation. The method for establishing the base plan loads that must be acquired for dead loads, forced burdens, and other outside loadings attaches the basic necessities relating to the basic security of structures. The total structure was analyzed on a computer using the ETABS software. In this paper, an analysis done for (G+7=8) RCC building under seismic loads for Jessore District (Zone I), Dhaka District (Zone II), Cox’s Bazar District (Zone Ill) and Sylhet District (Zone IV). Numerous load combinations are observed in accordance with BNBC 2020.

## 1.3 Objective

- To study the effect of lateral loads in relation to different shapes of building according to BNBC manual.
- To interpret and make comment on which shaped buildings out of four taken in the consideration is most stable.
- To analyze a seven storied Residential building.
- Considering Seismic load at four different Seismic zone of Bangladesh.
- To check maximum drift and displacement for four different zone.

## 1.4 Organization of the thesis :

**Chapter 1: Introduction and Objective.** This chapter provides the background of study and motivations of the research. The overall objectives and expected outcomes are also described in this chapter.

**Chapter 2: Literature Review.** This part discusses the previous analysis history about earthquake or seismic wave, recent research on seismic zone, seismic design requirements as per BNBC-2020, lift pit details specifications, wind load and wind load code provisions as per BNBC-2020, seismic load and seismic load code provisions as per BNBC-2020.

**Chapter 3: Methodology.** This chapter discusses the analytical process in details step by step. The Zonal Parameters, Load principles and types of load acting on the structure are also discussed in this chapter.

**Chapter 4: Results and Discussion.** This chapter describes the results of the proposed buildings load and material properties, building load calculation. Different floor plan view and building analysis image are also shown in this chapter. Overall and zone to zone story drift, story displacement, Base shear analysis data and results are also discussed in this chapter.

**Chapter 5: Conclusions and Future Work.** This chapter summarizes the conclusions and major contributions of this study and provides recommendations for future studies.

# CHAPTER 2

# Literature Review

## 2.1 Introduction

The literature survey in the performance and behaviour of building structures when subjected to wind loads suggests that the requirement of establishing a methodology for studying the response of building structure to winded loads has become essential. Many researchers have performed work over various types of building. on the different types of buildings and find out the important parameter which is useful for understanding the behaviour of wind forces.Steel bracing system is an efficient and effective lateral load resisting system. Also used as the lateral load resistance system for reinforced concrete structure is an effective technique. Different types of bracing system reduce the storey drift and displacement of the structure. Out of various arrangements of bracing X bracing system is more effective in increasing lateral load capacity of the structure. Bracing system reduces bending moment and shear force in the column. Steel bracing transfer the lateral load through axial action. Steel bracing can be used to retrofit the existing structure.The concrete outrigger is superior in reducing the lateral storey displacement as compared to the steel outrigger in the tall RCC building.The moment resisting frame with shear walls are very good in lateral force such as earthquake and wind force. The shear walls provide lateral load distribution by transferring the wind and earthquake loads to the foundation. Also, impact on the lateral stiffness of the system and also carry gravity loads.When the high-rise building is subjected to different geometrical shapes such as regular and irregular. Then irregular shapes of buildings have feel more story drift, lateral displacement, deformation and less base shear as compare to regular shapes of buildings.

## 2.2 Earlier Research on Seismic Zone

Mir Abdul Kuddus, ParthaPritomDey:In this study, 3 separate ground plus 19 storied buildings of R.C.C., Steel and Steel-Concrete composite frame are designed by ETABS software and the design parameters are considered for relative comparison. The literature relating to R.C.C., Steel and Steel-Concrete composite structure for designing concept are reviewed. Evaluation of load

patterns and lateral forces according to UBC 94 codes were assigned and then the static and dynamic analysis was performed by using response spectrum analysis in ETABS to design the building. Then the comparative dynamic behavior is reviewed and estimation of the cost of superstructures frame is also calculated to find out the comparative differences. The building is considered to be constructed in Mongla Port, second largest international sea port in Bangladesh. Moreover, the building is designed to use as a multi-storied car parking for imported car from different countries of the world. The port is located 48 km south of Khulna city. The Port is surrounded as well as well protected by the Sundarban mangrove forest. The port is situated at the confluence of the Pashur River and the Mongla River. It lies about 62 miles (100km) north of the Bay of Bengal. According to Bangladesh National Building Code (BNBC2010), the basic wind speed is taken for Mongla Port Area is 279 km/hr. In Bangladesh most of the building structures fall under the category of low-rise buildings. So, for these structures reinforced concrete members are used widely because the construction becomes quite convenient and economical in nature. But since the population in cities is growing exponentially and the land is limited, there is a need of vertical growth of buildings in these cities. So, for the fulfillment of this purpose a large number of medium to high rise buildings are coming up these days.

## 2.3 Design Requirements for RCC Beam Design for Residential Buildings

- Material Strength
  - ✓ Minimum specified compressive strength $f'_c = 3{,}500$psi
  - ✓ Maximum specified yield strength of reinforcement, $F_y = 60{,}000$psi
- Clear Span of Beam for Buildings
  - ✓ Clear span > four times the effective depth i.e., In >4d
- Sectional dimensions of the beam for Buildings
  - ✓ Width-to-depth ratio 0.3 i.e., b/h 20.3
  - ✓ Minimum width 10 inch
  - ✓ Minimum width of the beam S [width of the supporting column + 1.5h]
- Main reinforcement
  - ✓ $\rho$ min $\geq 200/ f_y$
  - ✓ $\rho$ max $\leq 0.0250$

Both the top and bottom of the member should have two continuous bars. The top or bottom steel at any section should not be less than 14 of the steel for the maximum (- ve) moment at the supports. The min bottom (+ ve) steel at each support must be equal to 12 of the (- ve) moment steel [1]

✈ Spacing of main reinforcement

- ✓ Splices are not permitted to be used I within joints within 2 hours of the column face. Splices must be held together by hoops or spiral reinforcement with a maximum spacing or pitch of d/4 or 4 inches, whichever is less.

✈ Transverse reinforcement details

❖ Total required steel area, Av = $\frac{\frac{vn}{\emptyset}}{Fy*d} * S$

Hoops are used to provide confinement reinforcement.

Hoops are required over a 2h (h = depth of beam) distance from the faces of both supports.

The first hoop will be placed 2 inches from the face of the support

The smallest of the following values is the maximum hoop spacing: d/4

8 x diameter of smallest longitudinal bar

24 x the hoop bar's diameter (12 inches)

Stirrups with seismic hooks at both ends (detail A) shall be spaced not more than d/2 along the length of the member where hoops are not required (beyond the confinement zone and splicing).

## 2.4 Considerations for Column Design for Residential Buildings

✈ **Material Strength**

- Minimum compressive strength of all types of concrete, fc'= 4,000psi
- Maximum yield strength of reinforcement, $f_r$= 60,000psi
- Normal density concrete is preferable, $w_c$: 140-450 psf [2]

✈ Main reinforcement ratio

Columns are generally designed with reinforcement ratio between 1% to 8% of the gross section area. Oversized columns widely referred to as "Architectural

Columns", are often needed for functional purposes resulting in reinforcement ratios below 1% [3]

- ✓ p min = 0.01
- ✓ p max = 0.06
- ✓ Preferable p = 0

✈ Splicing of the Main reinforcement

- ✓ Lap splice shall be used only within the center of the column.
- ✓ Welded splices may be used at any section of column, provided that:

a) They are used only alternate longitudinal bars at a section.
b) The distance between splices along the longitudinal axis of reinforcement 24".
c) Splices are to be confined by hoops or spiral reinforcement with maximum spacing or pitch of d/4 or 4 inch whichever is smaller.

❖ **Splice length**

$$\text{Id} \geq 0.0004dbfy\left\{\frac{0.04Ab * fy}{\sqrt{f'y}}\right\}$$

Where,

Ab= Bar area

Splice length = 1.3 Id (class B splice)

Id = development length of the bars.

❖ **Transverse reinforcement**

Such reinforcement is provided as closed hoops for tied column or circular hoops for spiral column.

❖ **Circular hoops:** steel ratio of circular/spiral hoops

$$\rho s \geq \left\{0.12\ \frac{f'c}{fyh} * 0.45\left(\frac{Ag}{Ach} - 1\right)\frac{f'c}{fy}\right\}$$

Where,

$F_{yh}$ = yield strength of hoop reinforcement.

$A_{ch}$ = core area of column section measured to the outside of hoop reinforcement.

- **Closed hoops**: Total cross-sectional area of closed hoops

$$\text{As} \geq \left\{0.09\text{So}hc * 0.3\text{So}h\left(\frac{Ag}{Ac} - 1\right)\frac{f'c}{fy}\right\}$$

**Here,**

$h_c$ =cross-sectional dimension of column core measured center-to-center of hoop reinforcement.

$S_o$ = vertical spacing of hoop reinforcement.

- **Confinement length**: Confinement reinforcement is to be provided over a length 10 from each joint face of the column.

$$A_s \geq \left\{\frac{1}{6}(clear\ span\ of\ the\ column)\right\}\ depth\ of\ member\ 18''$$

The first hoop will be placed at 2 inches from the joint.

- Main reinforcement ratio
  - ✓ p min = 0.01
  - ✓ p max = 0.06
  - ✓ Preferable p = 0.04

- Splicing of the Main reinforcement
  - ✓ Lap splice shall be used only within the center of the column.
  - ✓ Welded splices may be used at any section of column, provided that.
  - ✓ They are used only alternate longitudinal bars at a section.
  - ✓ The distance between splices along the longitudinal axis of reinforcement 24".
  - ✓ Splices are to be confined by hoops or spiral reinforcement with maximum spacing or pitch of d/4 or 4 inch whichever is smaller.

- **<u>Splice length:</u>**

$$\text{Id} \geq 0.0004dbfy\left\{\frac{0.04Ab * fy}{\sqrt{f'y}}\right\}$$

Here,

Ab = Bar area

Splice length = 1.3 Id (class B splice)

Where, Id = development length of the bars

❖ Transverse reinforcement

Closed hoops are used for tied columns, while circular hoops are used for spiral columns.

✦ **Circular hoops:** steel ratio of circular/spiral hoops

$$\rho s \geq \left\{0.12\ \frac{f'c}{fyh} * 0.45\left(\frac{Ag}{Ach} - 1\right)\frac{f'c}{fy}\right\}$$

Here,

$f_{yh}$ = hoop reinforcement yield strength.

Ach = column section core area measured from the outside of the hoop reinforcement.

✦ **Closed hoops:** Closed hoop total cross-sectional area

$$As \geq \left\{0.09Sohc * 0.3Soh\left(\frac{Ag}{Ac} - 1\right)\frac{f'c}{fy}\right\}$$

In this case, hc is the cross-sectional dimension of the column core measured from center to center of the hoop reinforcement. So = hoop reinforcement vertical spacing.

❖ **Confinement length**: Concealment reinforcement should be applied along a length 10 from each joint face.

$A_{s\geq}\left\{\frac{1}{6}\ (clear\ span\ of\ the\ column)\right\}\ depth\ of\ member\ 18''$

The first hoop will be placed 2 inches away from the joint.

## 2.5 Wind Loads:

Wind Load refers to any pressures or forces apply by the wind on a building or structure. There are three types of wind forces that can be applied to a building Wind Loads: Uplift Wind Load, Shear Wind Load, and Lateral Wind Load.

Wind loads are dynamic loads that are applied at random. Wind velocity, air density, structure orientation, area of contact surface, and structure shape all influence the intensity of wind pressure on a structure's surface. Due to the complexities involved in defining both the dynamic wind load and the behavior of an indeterminate steel structure when subjected to wind loads, building codes and standards have adopted design criteria based on the application of an equivalent static wind pressure.

## 2.6 Basic Wind Speed:

The basic wind speed, V used in the determination of design wind loads on buildings and other structures. The wind shall be assumed to come from any horizontal direction.

Where records or experience show that wind speeds are higher than those depicted in Figure 2.1, the fundamental wind speed shall be raised. Unusual wind conditions will be investigated in mountainous terrain, canyons, and peculiar places. If necessary, the authority of BNBC with jurisdiction will update the values in Figure 2.1 to accommodate for increased local wind speeds. This modification must be based on accurate weather data and other relevant data.

**Table 2-1. Basic Wind Speeds, V, for selected Location in Bangladesh [10]**

| Location | Basic Wind Speed (m/s) | Location | Basic Wind Speed (m/s) |
|---|---|---|---|
| Angarpota | 47.8 | Lalmonirhat | 63.7 |
| Bagerhat | 77.5 | Madaripur | 68.1 |
| Bandarban | 62.5 | Magura | 65.0 |
| Barguna | 80.0 | Manikganj | 58.2 |
| Barishal | 77.7 | Meherpur | 58.2 |
| Bhola | 69.5 | Maheshkhali | 80.0 |
| Bagra | 61.9 | Moulvibazar | 53.0 |
| Brahmanbaria | 56.7 | Munshiganj | 57.1 |
| Chandpur | 50.6 | Mymensingh | 67.4 |
| Chapai Nawabganj | 41.4 | Naogaon | 55.2 |
| Chittagong | 80.0 | Narail | 68.6 |
| Chandanga | 61.9 | Narayanganj | 61.1 |
| Comilla | 61.4 | Narsinghdi | 59.7 |
| Cox's Bazar | 80.0 | Natore | 61.9 |
| Dahagram | 47.8 | Netrokona | 65.6 |
| Dhaka | 65.7 | Nilphamari | 44.7 |
| Dinajpur | 41.4 | Noakhali | 57.1 |
| Faridpur | 63.1 | Pabna | 63.1 |
| Feni | 64.1 | Panchagarh | 41.4 |
| Gaibandha | 65.6 | Patuakhali | 80.0 |

| | | | |
|---|---|---|---|
| Gazipur | 66.5 | Pirojpur | 80.0 |
| Gopanganj | 74.5 | Rajbari | 59.1 |
| Habiganj | 54.2 | Rajshahi | 49.2 |
| Hatiya | 80.0 | Rangamati | 56.7 |
| Ishurdi | 69.5 | Rangpur | 65.3 |
| Joypurhat | 56.7 | Satkhira | 57.6 |
| Jamalpur | 56.7 | Shariatpur | 61.9 |
| Jessore | 64.1 | Sherpur | 62.5 |
| Jhalakati | 80.0 | Sirajganj | 50.6 |
| Jhenaidah | 65.0 | Srimangal | 50.6 |
| Khagrachhari | 56.7 | St. Martin's Island | 80.0 |
| Khulna | 73.7 | Sunamganj | 61.1 |
| Kutubdia | 80.0 | Sylhet | 61.1 |
| Kishoreganj | 64.7 | Sandwip | 80.0 |
| Kurigram | 65.6 | Tangail | 50.6 |
| Kushtia | 66.9 | Teknaf | 80.0 |
| Lakshmipur | 51.2 | Thakurgaon | 41.4 |

### 2.7 Exposure Category according BNBC 2020

Exposure A: Urban and suburban areas, wooded areas, or other terrain with numerous closely spaced interference the size of single-family homes or larger.
Exposure B: Open terrain with scattered interference at heights of less than 9.1 meters. Flat open country, grasslands, and all water surfaces in cyclone-prone areas fall into this category.
Exposure C: Flat, unobstructed areas and water surfaces outside cyclone inclined regions. This category includes smooth mud flats and salt flats [4].

### 2.8 Variables Affecting Wind Pressure Distributions:

- **Building Shape:** Pressure on specific parts of a structure is very sensitive to changes in the building's shape. Inconsistent have little effect on suction on the windward side or suction on the leeward side. Shape details can have an unexpectedly large impact on wind pressure distribution. Parapet walls, large chimneys, silos, and spires can all have a significant impact, and testing a scale model in a wind tunnel is often the only way to assess such effects.

- **Openings:** The internal pressure that must be considered in the calculation of net forces of walls and roofs is determined by the size and location of openings such as windows and doors. Internal pressure tends to take on the values associated with the exterior of the wall where the opening dominates. If they are small and evenly distributed, a value of 2 is recommended, with the more critical of the two to be considered in each case.

- **Wind direction:** Orientation of the building toward the wind has a logistic effect on pressure distribution, particularly at maximum suction, which occurs over a small area near the leading edges of the roofs.

- **Increase of wind speed with height:** Because wind speed and thus velocity pressure increase with height above ground, a height factor is added to the base pressure in building design.

## 2.9 Seismic Zone Coefficients:

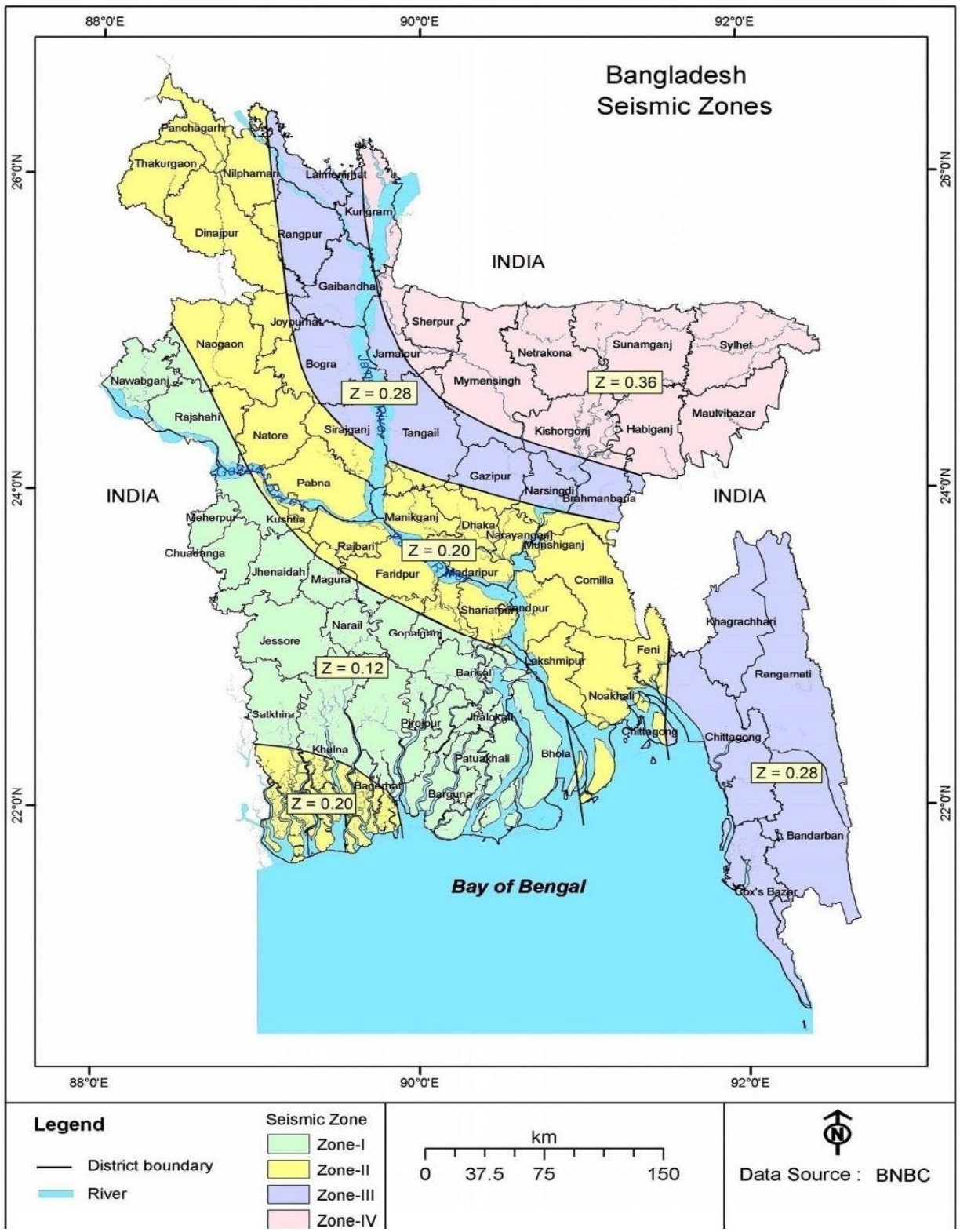



Figure 2-1. Seismic Zone Coefficients Bangladesh

❖ **Observation** – Above is the seismic zone coefficients figure for Bangladesh. In the legend, its color is mentioned as follows:

- Light green is Jessore District (zone I) Z = 0.12
- Turmeric Yellow is Dhaka District (zone II) Z = 0.20
- Light Purple is Cox Bazer District (zone III) Z = 0.28
- Deep Green is Sylhet District (zone IV) Z = 0.36

**Table 2-2. Seismic Zone Coefficients Z**

| Seismic Zone | Zone Coefficient |
|---|---|
| **Zone I** | 0.12 |
| **Zone II** | 0.20 |
| **Zone III** | 0.28 |
| **Zone IV** | 0. 36 |

**Table 2-3. Structure Importance Coefficients I~I'**

| Structure Importance Category | Structure Importance Coefficient | |
|---|---|---|
| | I | I' |
| Essential facilities | 1.25 | 1.50 |
| Hazardous facilities | 1.25 | 1.50 |
| Special occupancy structures | 1.00 | 1.00 |
| Standard occupancy structures | 1.00 | 1.00 |
| Low-risk Structures | 1.00 | 1.00 |

C must not be greater than 2.75, and this value can be used for any structure regardless of soil type or structure period. Except for requirements where the Code prescribed forces are scaled up by 0.375R, the minimum value of the C/R ratio is 0.12.

## 2.10 Earth Quake Magnitude :

According to the depth of field, the tectonic earthquake is classified as follows:
Shallow: the depth of field is "less than 60 km. Medium: depth of field between 60 and 70 1m. Depth: depth of field greater than 70 km. El The scale of seismic intensities was conveniently divided into 12 categories, until in 1935 CF Richter designed a scale with the number J5, with the magnitude of seismic strength 10 being the highest on this scale.
The strength of the earthquake in relation to the Richter scale is expressed as:

- ✓ Instrumental: detected by seismograph, magnitude 13;
- ✓ light: it is like the vibration of a passing truck, felt on the upper size 3.5 to 4.2;
- ✓ Moderate: felt when walking, intensity 4.3;
- ✓ Strong: trees sway, hanging objects sway, fall loose, objects, magnitude 4.9 to 5.4;
- ✓ Very strong: cracked walls, plaster falls, thickness 5.5-6;
- ✓ Destructive: chimneys fall; Damaged building, magnitude 6.8;
- ✓ Ruinous: collapse of houses, cracks in the floor, broken pipes, magnitude 6.9;
- ✓ Catastrophic: The cracks in the floor move a lot. Bent tracks, thickness 7 to 7.3;
- ✓ Very catastrophic: few buildings remain standing; Bridges destroyed, landslides and major floods, magnitude 7.4 to 8.1;
- ✓ Catastrophic: total destruction. Objects thrown into the air, the ground rises and falls in waves, magnitude 8.2 and higher.

There are three zones, mainly Zone I, which is the most active, Zone II, which is least active, and Zone III, which is the lowest possible earthquake magnitude. See figure

**2.4. The probable seismic magnitudes are:**

| Zone | Richter Scale |
|---|---|
| **I** | 7.0 |
| **II** | 6.50-7.0 |
| **III** | 6.0-6.5 |

Buildings should be designed for earthquake resistance in Zone I, of course. However, for low-rise buildings, an additional provision of 33 percent reinforcement may be provided. Qualified Civil Engineers should create proper technical designs for high-rise buildings.

## 2.11 Earthquake Effected Areas Recorded in Bangladesh

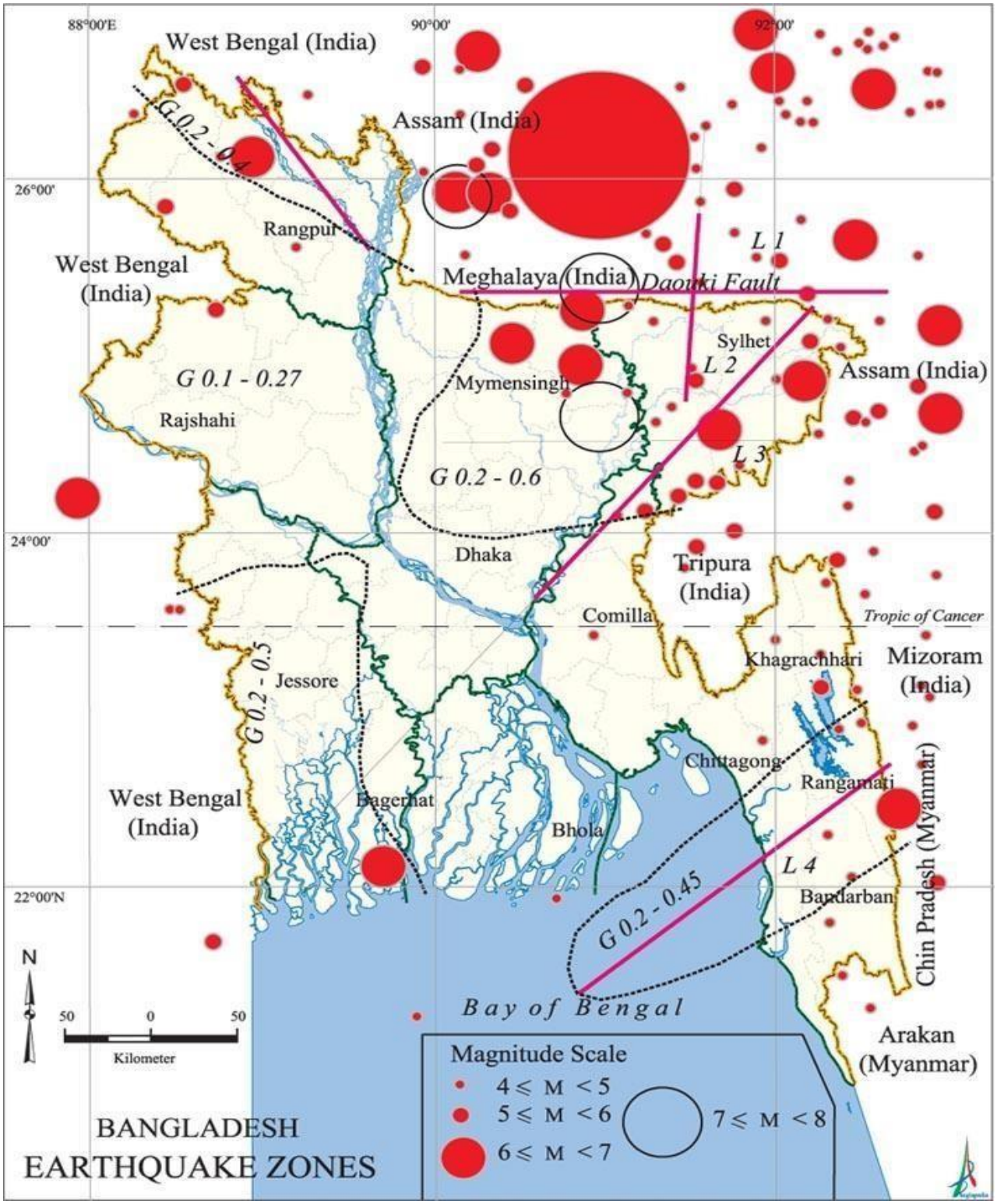



Figure 2-2. Bangladesh Earthquake Zones

# CHAPTER 3

# Methodology

## 3.1 Introduction

- Use Software & BNBC Code:
  1. For analysis, design, and details, Etabs-2016.
  2. AutoCAD-2017 Software.
  3. BNBC 2020.
  4. Analysis of Lateral Loads.
  5. Comparison of four different types of Zone in Bangladesh.

## 3.2 Notation

- ✓ $A_g$= gross sectional area
- ✓ Av= shear reinforcement area□
- ✓ d= distance between the extreme compression fiber and the tension reinforcement centroid
- ✓ fe'= concrete's specified compressive strength
- ✓ fy= reinforcement yield strength specified
- ✓ h= overall member thickness
- ✓ hw= total wall height from base to top
- ✓ k= effective length factor
- ✓ le= vertical distance between the support.
- ✓ Iw= horizontal length of the wall.
- ✓ Mu= sectional factored moment
- ✓ Nu= factored axial load normal to cross section that occurs concurrently with Vu
- ✓ Pnw= nominal axial load strength of the wall.
- ✓ S1= vertical reinforcement spacing in a wall.
- ✓ S2= horizontal reinforcement spacing in a wall
- ✓ Vs= shear reinforcement's shear strength.
- ✓ Vn= nominal shear strength.
- ✓ Vu= shear force factor.
- ✓ Ve= nominal shear strength provided by concrete.
- ✓ Ph= the ratio of horizontal shear reinforcement area to vertical section gross concrete area.

### 3.3 Bangladesh National Building Code (BNBC)

In this segment, provision for the one-of-a-kind seismic region in the BNBC (2020) has been explained. BNBC has been organized in the mild of internationally identified requirements of security and serviceability plausible by using software of cutting-edge science within the socioeconomic context of Bangladesh. Through adherence to the number necessities of the code, non-public and public builders and man or woman proprietors will be in a position to make certain a minimal and uniform well-known of constructions in the country.

### 3.4 Scope of the Code:

- The walls of the building must be designed to withstand eccentric loads as well as lateral or other loads that may be applied to them.

a) Axial load walls must be designed using several sections.

b) Unless detailed analysis proves otherwise, the horizontal length of the effective wall for each concentrated load should not exceed the center-to-center distance between the loads.

### 3.5 Minimum Reinforcement and Spacing in Slab

- The minimum vertical reinforcement area to gross concrete area ratio shall be:
    a) 0.0012 for deformed bars no larger than 16mm in diameter with a specified yield strength of at least 410 N/mm2, or
    b) 0.0015 For the remaining bars.

- The minimum horizontal reinforcement area to gross concrete area ratio shall be:
    a) 0.0020 for deformed bars no larger than 16mm in diameter with a specified yield strength of at least 410 N/mm2, or
    b) 0.0025 for the remaining deformed bars.

### 3.6 Design of Building:

The building model under this study has (G+7=8) ten stories with a constant floor height of 10 feet four areas are used for analysis, and the equal length and width along the two horizontal directions are kept constant in each area for ease of use. Use different ZONE FACTOR values and explain their corresponding effects in the results. Other details are as follows:

**Table 3-1. Zonal Parameter and Its Various Details**

| PARAMETERS | ZONE I Jessore | ZONE II Dhaka | ZONE III Cox's Bazar | ZONE IV Sylhet |
|---|---|---|---|---|
| Seismic Zone factor, Z= | 0.12 | 0.20 | 0.28 | 0.36 |
| Basic wind speed | 179mh | 147m h | 113m h | 140m h |
| Response reduction factor | 12 | 12 | 12 | 12 |
| importance factor, I= | 1 | 1 | 1 | 1 |
| importance coefficient R= | 7 | 6.5 | 7 | 7 |
| Site co-efficient, S= | 1.35 | 1.35 | 1.35 | 1.35 |
| $C_d$ classes of soil de end | 5.5 | 5.0 | 5.5 | 5.5 |
| n Nutrient availability Soil | 2.5 | 2.5 | 2.5 | 2.5 |
| Ss Spectral Acceleration | 0.3 | 0.5 | 0.3 | 0.3 |
| Seismic Desi n Cate o | | | | |
| Soil condition o inion | Good | Good | Good | Good |
| Slab thickness | 5 inches | 5 inches | 5 inches | 5 inches |
| Floor finish | 25 sf | 25 sf | 25 sf | 25 sf |
| All Steel $F_y$ | 60000psi | 60000psi | 60000psi | 60000psi |
| All Concrete Fc Column | 4000 psi | 4000 psi | 4000 psi | 4000 psi |
| All Concrete Fc Beam | 3500 psi | 3500 psi | 3500si | 3500si |
| All Concrete Fc Slab | 3000 psi | 3000 psi | 3000 psi | 3000 psi |
| Diaphragms | Rigid | Rigid | Rigid | Rigid |
| Poisson's ration of Concrete | 0.15 | 0.15 | 0.15 | 0.15 |
| Moment of inertia for Column | 1 | 1 | 1 | 1 |
| Torsional Constant Column | 1 | 1 | 1 | 1 |
| Moment of inertia for Beam | 0.5 | 0.5 | 0.5 | 0.5 |
| Torsional Constant Beam | 0.5 | 0.5 | 0.5 | 0.5 |

## 3.7 Loads Acting on a Structure :

A building of constructing two necessary elements regarded are protection and economy. If hundreds are adjudged and taken greater then economic system is affected, and if economic system is viewed and masses are taken lesser, then the protection is compromised.

Simply, if the hundreds are adjudged and spend greater financial system (cost) than plan, it would be higher for safety. But if financial system (expense) is regarded and stored in accordance to graph by means of offering much less load bearing materials, the protection will be compromised which is no longer safer for a structure.

So, the estimation of various loads acting is to calculate precisely. BNBC-2020 and American Standard Code ASCE 7: Minimum Design Loads for Buildings and Other Structures specifies various design loads for buildings and structures.

1. Dead loads.
2. Live Loads.
3. Wind loads.
4. Snow loads.
5. Earthquake loads.
6. Special loads.

## 3.8 Loads on Structures

The two most important detail to consider when building a structure are safety and cost. If the loads are adjudged and taken higher, the economy suffers; if the economy is considered and the loads are taken lower, the safety suffers. Loads acting on buildings and other structures are broadly Classified as vertical loads, horizontal loads, and longitudinal loads. Vertical loads are made up of dead load, live load, and impact load. Wind and earthquake loads are examples of horizontal loads. In the design of bridges, gantry girders, and other structures, longitudinal loads, such as tractive and braking forces, are taken into account.

**Table 3-2. Load Principles [14]**

| | | | |
|---|---|---|---|
| mbination Case 1 | 0.8 DL + LOEQX | ›mbination Case 25 | 1.2DL+1.6RLL+1.0LL |
| mbination Case 2 | 0.8 DL + LOEQX- | ›mbination Case 26 | 1.2DL+1.6RLL-0.8LL+0.5RLL |
| mbination Case 3 | 0.8 DL + LOEQY | ›mbination Case 27 | 1.3DL+1.0LL-1.0EQX |
| mbination Case 4 | 0.8 DL + LOEQY- | ›mbination Case 28 | 1.3DL+1.0LL-1.0EQX- |
| mbination Case 5 | 0.8 DL - LOEQX | ›mbination Case 29 | 1.3DL+1.0LL-1.0EQY |
| mbination Case 6 | 0.8 DL - LOEQX- | ›mbination Case 30 | 1.3DL+1.0LL-1.0EQY- |
| mbination Case 7 | 0.8 DL - LOEQY | ›mbination Case 31 | 1.3DL+1.0LL+1.0EQX |
| mbination Case 8 | 0.8 DL - LOEQ- | ›mbination Case 32 | 1.3DL+1.0LL+1.0EQX- |
| ›mbination Case 10 | 0.9DL | ›mbination Case 33 | 1.3DL+1.0LL+1.0EQY- |
| ›mbination Case 11 | 0.9DL+1.3WLX | ›mbination Case 34 | 1.4DL |
| mbination Case12 | 0.9DL+1.3WLY | ›mbination Case 35 | 1.4DL+1.4LL-1.4EQX |
| mbination Case13 | 0.9DL-1.3WLX | ›mbination Case 36 | 1.4DL+1.4LL-1.4EQY |
| ›mbination Case 14 | 0.9DL-1.3WLY | ›mbination Case 37 | 1.4DL+1.7LL |
| ›mbination Case 15 | 0.9DL+1.43EQX | ›mbination Case 38 | |
| ›mbination Case 16 | 0.9DL-1.43EQX | ›mbination Case 39 | DL+LL |
| ›mbination Case 17 | 1.2DL+1.0LL | ›mbination Case 40 | |
| ›mbination Case 18 | 1.2DL+1.0LL+1.0EQX | ›mbination Case 41 | 0.75(1.4DL+1.7EQX) |
| ›mbination Case 19 | 1.2DL+1.0LL+0.5RLL | ›mbination Case 42 | 0.75(1.4DL+1.7EQY) |
| ›mbination Case 20 | 1.2DL+1.6LL | ›mbination Case 43 | 0.75(1.4DL+1.7WLX) |
| ›mbination Case 21 | 1.2DL+1.6LL+0.5RLL | ›mbination Case 44 | 0.75(1.4DL+1.7WLX-) |
| ›mbination Case 22 | 1.2DL+1.6RLL | ›mbination Case 45 | 0.75(1.4DL+1.7WLY) |
| ›mbination Case 23 | 1.2DL-1.6RLL+0.8WLX | ›mbination Case 46 | 0.75(1.4DL+1.7WLY-) |

### 3.9 Dead Loads (DL)

The dead load is the first vertical load to be considered. Dead loads are permanent or immobilized loads that are transferred to a structure over the course of its life. The self- weight of structural members, permanent partition walls, fixed permanent equipment, and the weight of various materials are the primary causes of dead load. It primarily consists of the weight of roofs, beams, walls, and columns, among other things, which are otherwise permanent parts of the structure. [15]

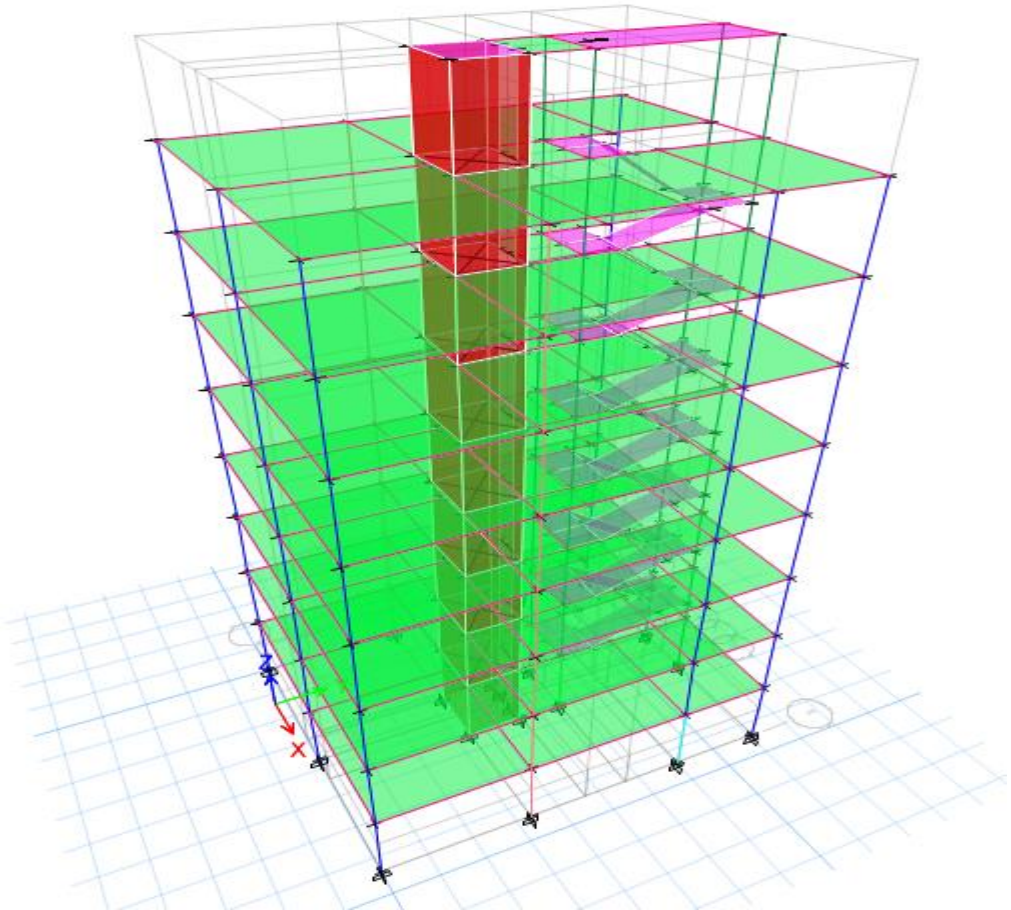


Figure 3-1. Dead Load

**Table 3-3. Weight of Dead Load Materials in Model Building**

| SI No. | Material | Weight |
|---|---|---|
| 1. | Brick Masonry | 18.8 kN/$m^3$ |
| 2. | Stone Masonry | 20.4-26.5 kN/$m^3$ |
| 3. | Plain Cement Concrete | 24 kN/$m^3$ |
| 4. | Reinforced Cement Concrete | 24 kN/$m^3$ |
| 5. | Timber | 5-8 kN/$m^3$ |

### 3.10 Live Load (LL)

Imposed loads or live loads are the second vertical load that must be considered in the design of a structure. Live loads are portable or moving loads that do not experience any acceleration or impact these loads are assumed to be produced by the building's intended use or occupancy, and include the weights of movable partitions or furniture, among other things Some of the important values are presented in the table below, which are the minimum values, and where more than these values are required, they are to be assumed.

**Table 3-4. Live Load Distribution according to BNBC 2020**

| Occupancy | Use of floor | KN/m | lb./ft |
|---|---|---|---|
| **Two unit** | All other areas except stairs and balconies | 2.0 | 42 |
| | Internal Stairs and Exit ways | 4.8 | 100 |
| **As above** | Balconies Exterior | 4.8 | 100 |

The wind load is not critical for low-rise buildings of four to five stories because the moment of resistance provided by the continuity of the floor system to column

connection and the walls provided between columns are sufficient to accommodate the effect of these forces. Furthermore, when wind is considered in the limit state method, the factor for design load is reduced to 1.2 (DL+LL+WL) as opposed to 1.5 (DL+LL) calculate the design wind velocity, $Vz = k1 * k2 * k3 * Vb$ Where, kl is the risk coefficient, k2 is the terrain, height and structure size coefficient, and k3 is the topography factor. As a result, pz = 0.6V2z gives the design wind pressure. Where $p_z$ is the pressure in N/m2 at height Z and $V_z$ is the speed in m/sec. Wind pressure is assumed to be uniform up to a height of 30 m. Wind pressure rises above a height of 30 meters.

### 3.11 Wind Load

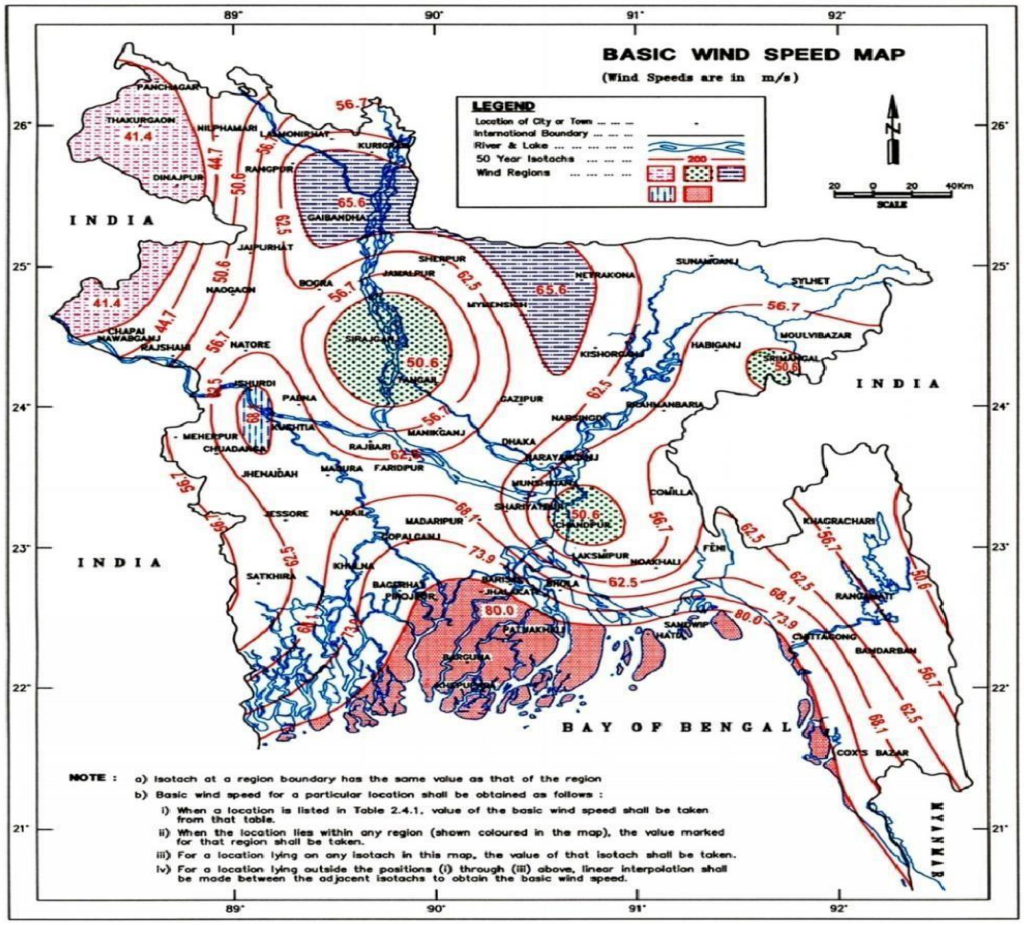



**Figure 3-2. Basic wind speed map of Bangladesh**

# CHAPTER 4

Results and Discussion

## 4.1 Introduction:

The following is the structural organization of this Chapter:

- ❑ Article
  - ✓ Discusses the planned building's loads and material properties.
  - ✓ Building Load Calculation.

## 4.2 Details of Loads and Material Properties:

The entire inquiry is based on a few criteria and specifications, as shown in Table.

**Table 4-1. Summary of the design considerations and specification of the study:**

| Items | Description |
|---|---|
| **Design code** | Bangladesh National Building Code (BNBC) 2020. |
| **Building Components** | Column type = Tied<br>Foundation type = Shallow Foundation (pilling)<br>Thickness of all partition walls = 6 inch.<br>Thickness of Slab (All slabs) = 6 inch. |
| **Material Properties** | Yield strength of reinforcing bar,<br>fr = 60,000 psi<br>Concrete compressive strength, fc' = 4,000 psi (Column)<br>Concrete compressive strength, fc'= 3,000 psi (Beam)<br>Concrete compressive strength, fc' = 3,000 psi (Slab)<br>Normal density concrete, unit weight = 150 psf.<br>Unit weight of brick = 120 psf.<br>Unit weight of water = 62.5 psi |

❑ **Live loads:**

- ✓ For floor = 70psf (with partition wall)
- ✓ For floor = 42psf (no partition wall)
- ✓ For stair = 100.22psf (20.88 X 4.80)
- ✓ For car parking slab = 50psf
- ✓ For stair room = 15psf

❑ **Live loads:**

- ✓ For floor = 78.33psf (with partition wall)
- ✓ For floor = 42psf (no partition wall)
- ✓ For stair = 100.22psf (20.88 X 4.80)
- ✓ For car parking slab = 50psf
- ✓ For stair room = 15psf

❑ **Seismic and Wind Loads:**

❖ Seismic Zone 1 (Jessore District)

- ✓ Coefficient Z= 0.12
- ✓ Importance Coefficient (Essential facilities), I = 1
- ✓ Exposure Condition = B
- ✓ Wind Pressure in Jessore City, Vb = 64.1 m/s or 143.3876 mph or 230.76 kmph
- ✓ Windward coefficient = 0.80
- ✓ Leeward coefficient = 0.50

❖ Seismic Zone 2 (Dhaka District)

- ✓ Coefficient Z = 0.20
- ✓ Importance Coefficient (Essential facilities), I = 1
- ✓ Exposure Condition = A
- ✓ Wind Pressure in Dhaka City; Vb = 65.7 m/s or 146.97mph or 236.52 kmph
- ✓ Windward coefficient = 0.80
- ✓ Leeward coefficient = 0.50

❖ Seismic Zone 3 (Cox's Bazar District)

- ✓ Coefficient, Z = 0.28
- ✓ Importance Coefficient (Essential facilities), I = 1
- ✓ Exposure Condition = B
- ✓ Wind Pressure in Cox's Bazar City; Vb = 80.0 m/s or 178.955 mph or 288kmph
- ✓ Windward coefficient = 0.80
- ✓ Leeward coefficient = 0.50

❖ Seismic Zone 4 (Sylhet District)

- ✓ Coefficient, Z = 0.36
- ✓ Importance Coefficient (Essential facilities), 1= 1
- ✓ Exposure Condition = B
- ✓ Wind Pressure in Sylhet, Vb = 61.1 m/s or 136.6768 mph or 219.96 kmph
- ✓ Windward coefficient = 0.80
- ✓ Leeward coefficient = 0.50

Note-ETABS-2016 auto-calculated wind and earthquake loads using ASCE 7-05, which is the most often used BNBC-2020 code.

## 4.3 Floor Plan details

- ✓ Height of building: 102 ft.
- ✓ Length of building: 45.5 ft.
- ✓ Width of building: 37 ft.
- ✓ Total floors: 7 nos. (Typical Floors, 1st to 7th, Lift Machine Room, Stair Top and OHWR)

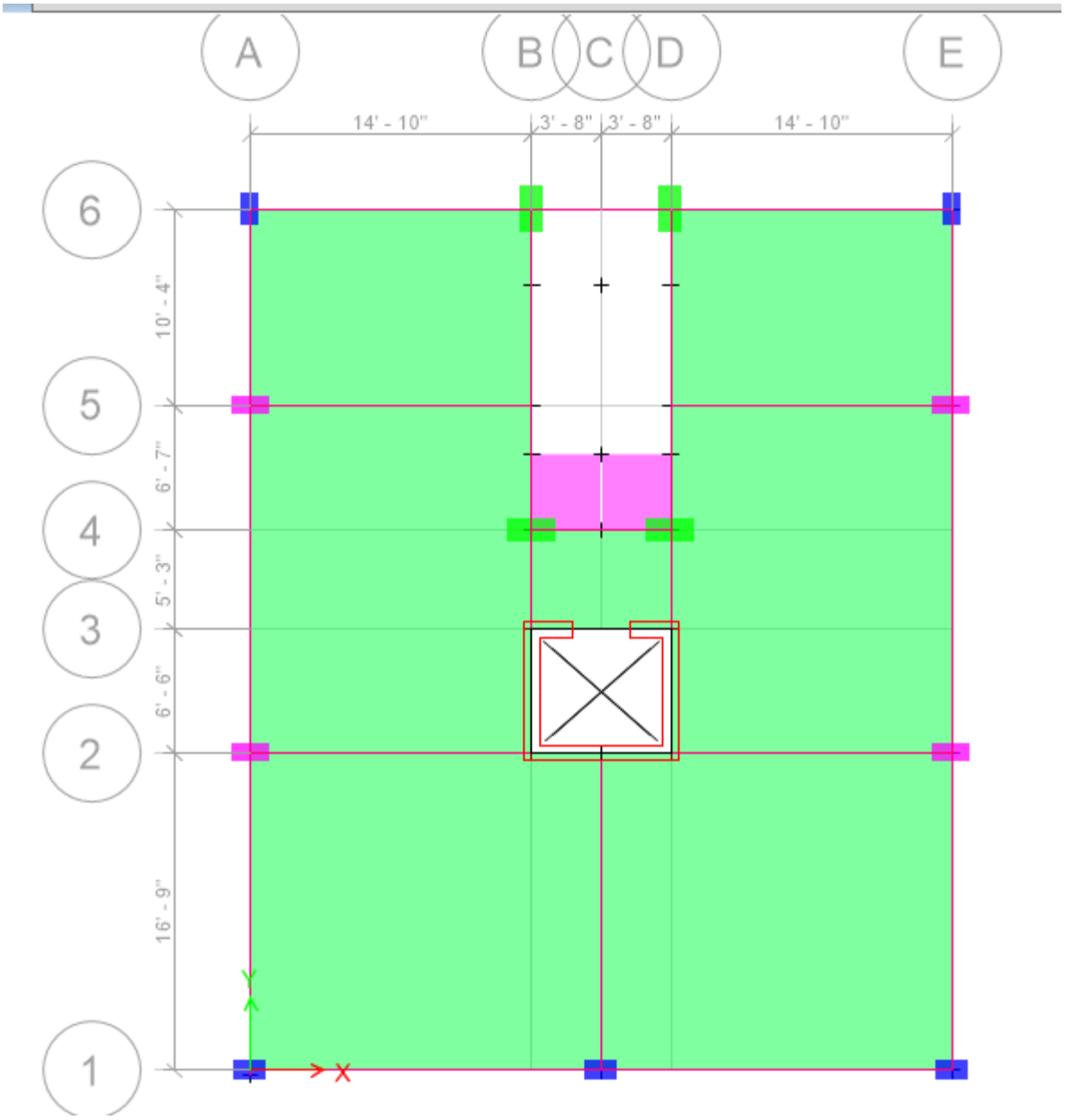



Figure 4-3. ETABS Structural Modeling Plan

**Table 4 -2. Legend of Building Columns and Beams:**

| COLUMN NAME | COLUMN SIZE | BEAM NAME | BEAM SIZE |
|---|---|---|---|
| C1 | 12 X 18 | Grade Beam (GB) | 12X18 |
| C2 | 12 X 20 | Floor Beam (FB) | 12X18 |
| C3 | 12 X 24 | Stair Beam (SB) | 12X18 |
| C4 | 12 X 30 | | |
| C5 | 12 X 25 | | |

❖ **Column Layout :**

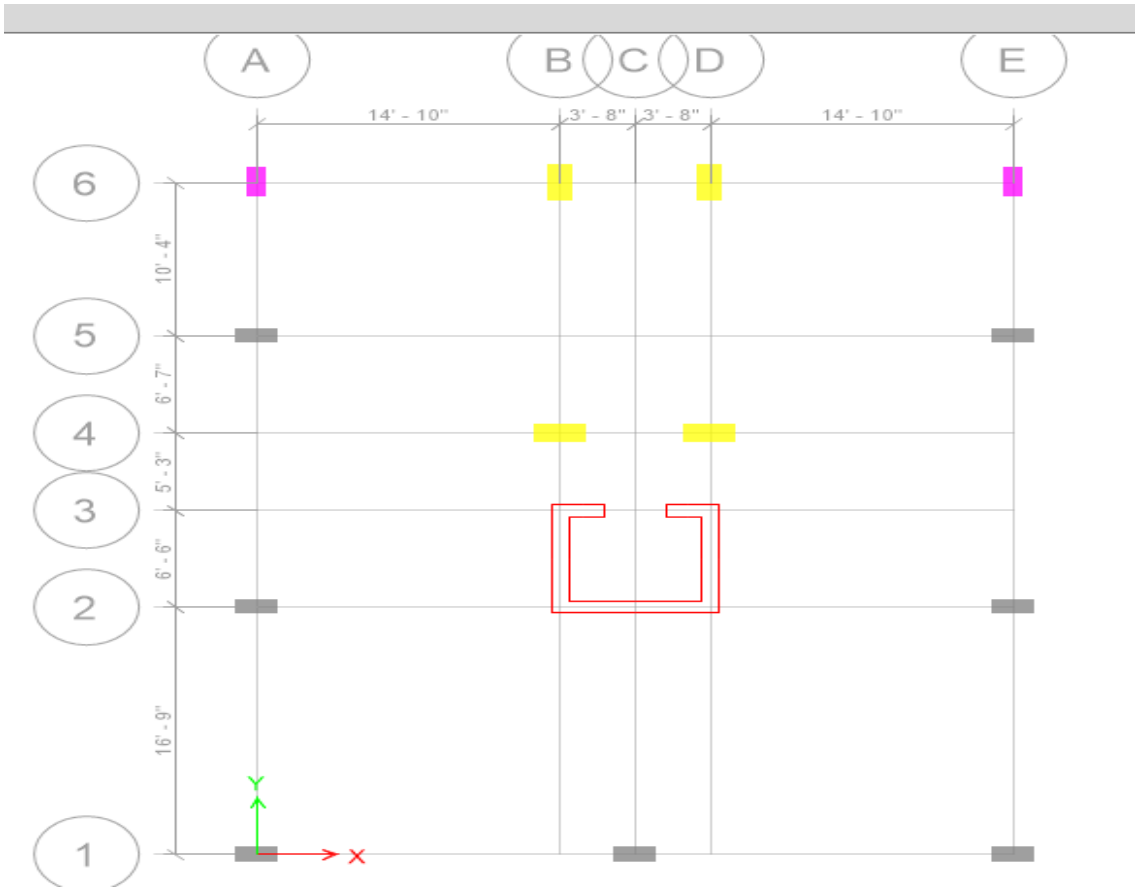



Figure 4-3. Column Layout

**Building Analysis Figures by (ETABS 2016)**

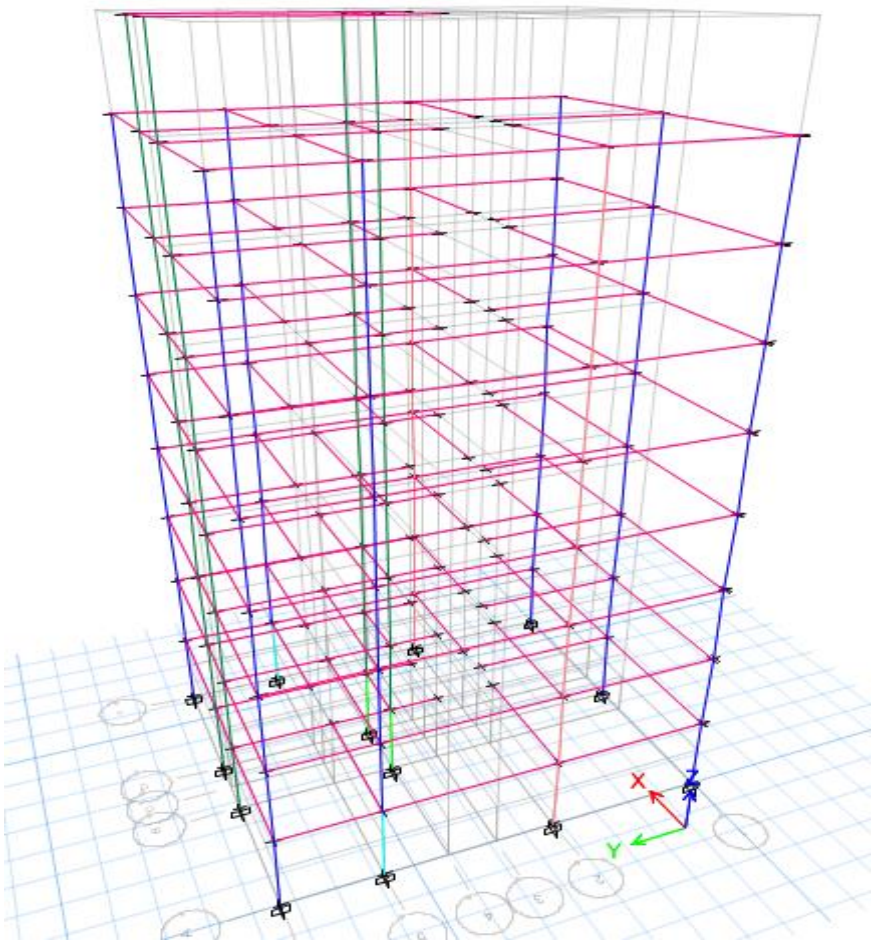



Figure 4-4. Perspective Analysis Image (Front)

- **Observation**: While analyzing the G+7 building by ETABS 2016, it was observed that the building is still stable and bears all the loads mentioned above.

## 4.7 Building Analysis Figures by (ETABS 2016)

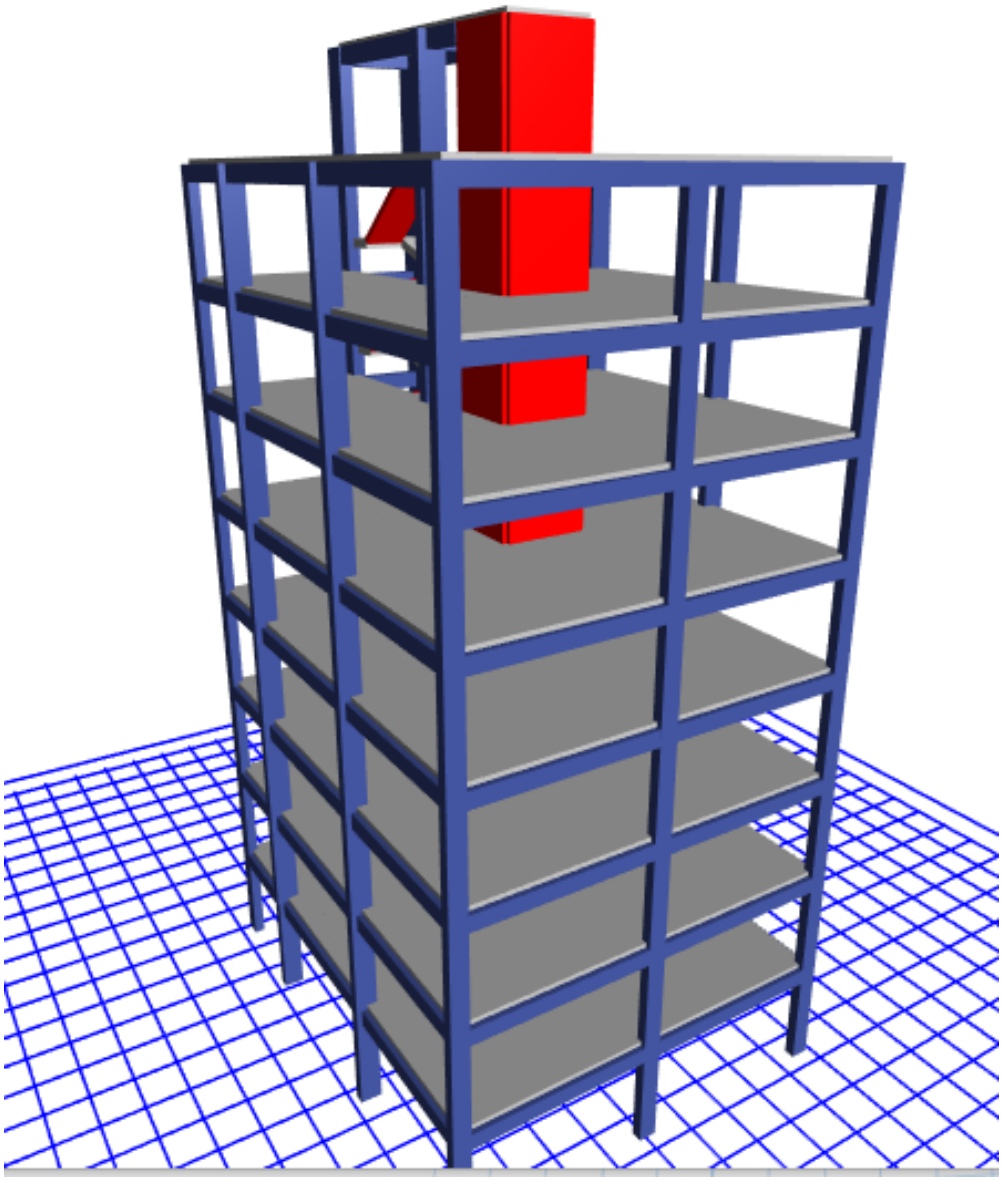
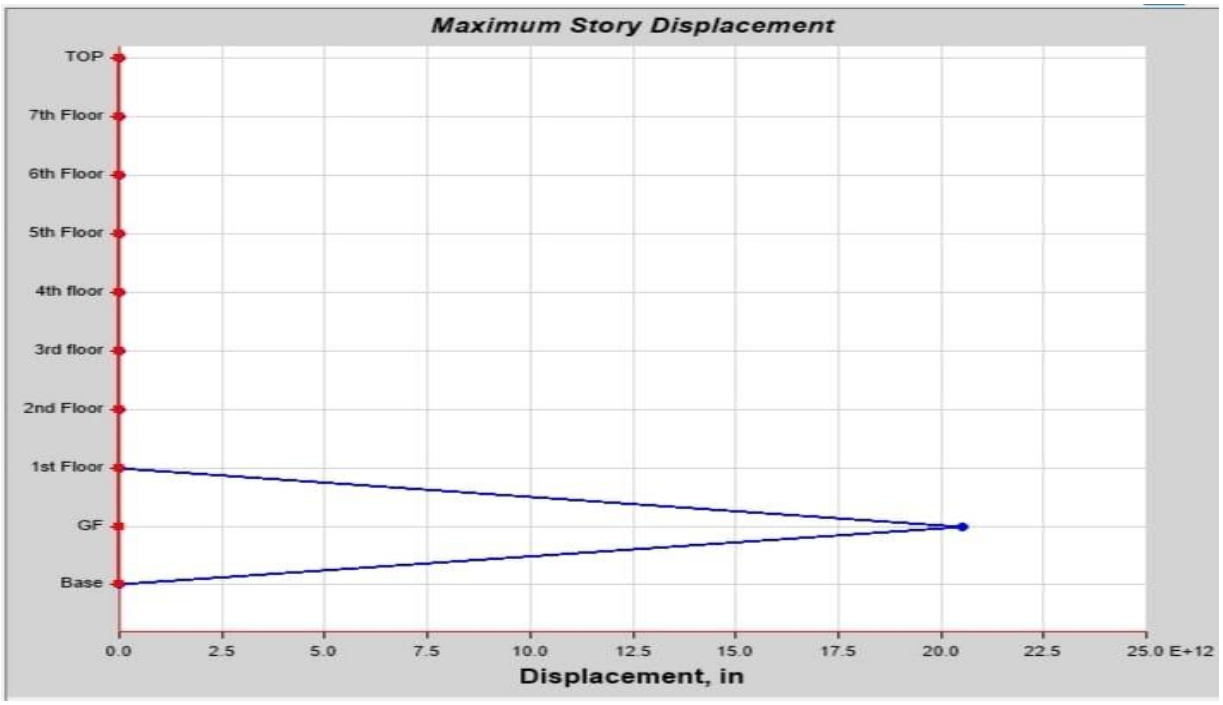


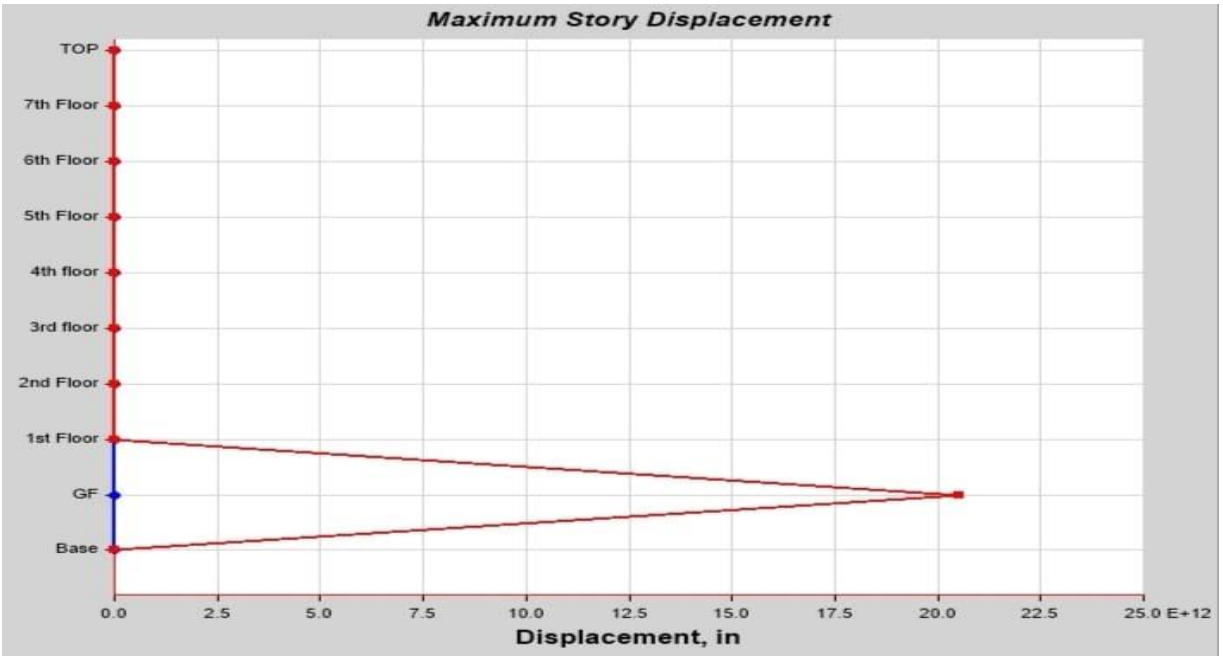
**Figure 4-5. 3D view of a residential buildings slab, beam, column, lift.**

❖ **Observation**: While analyzing the G+7 building by ETABS 2016, it was observed that the building is still stable and bears all the loads mentioned above.

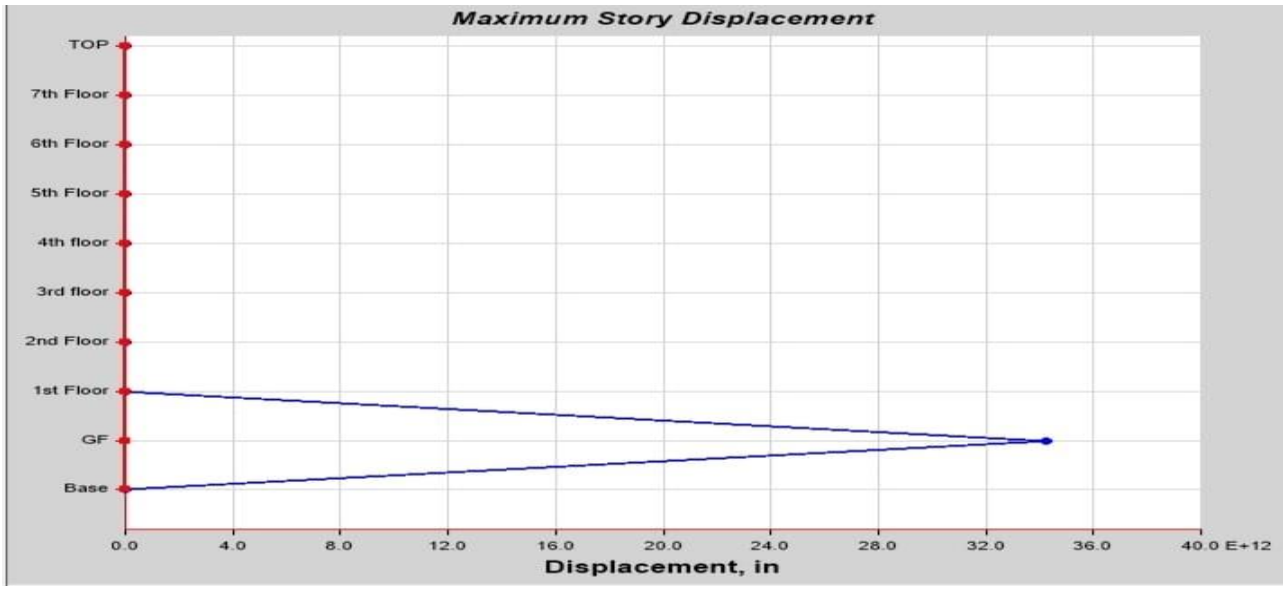
## 4.3 Maximum Story Displacement Graph



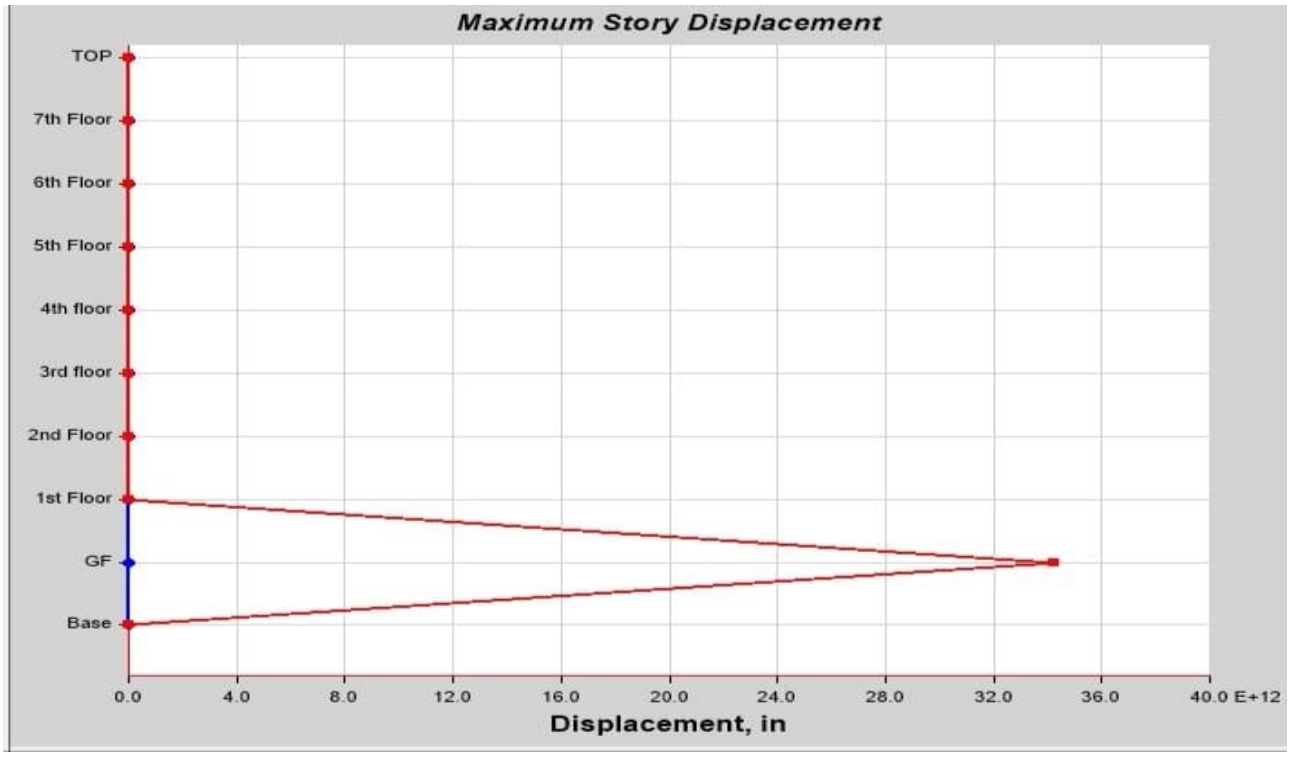

ZONE-1 (X-X)



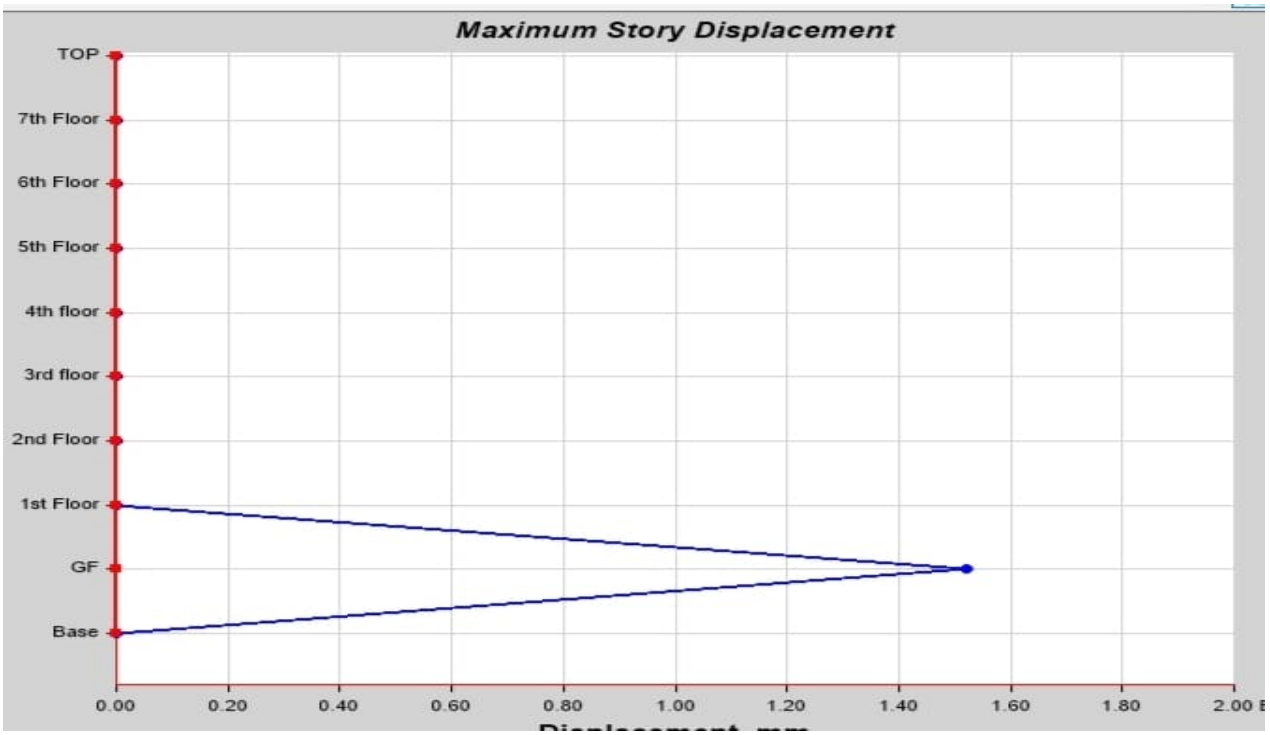

ZONE-1 (Y-Y)



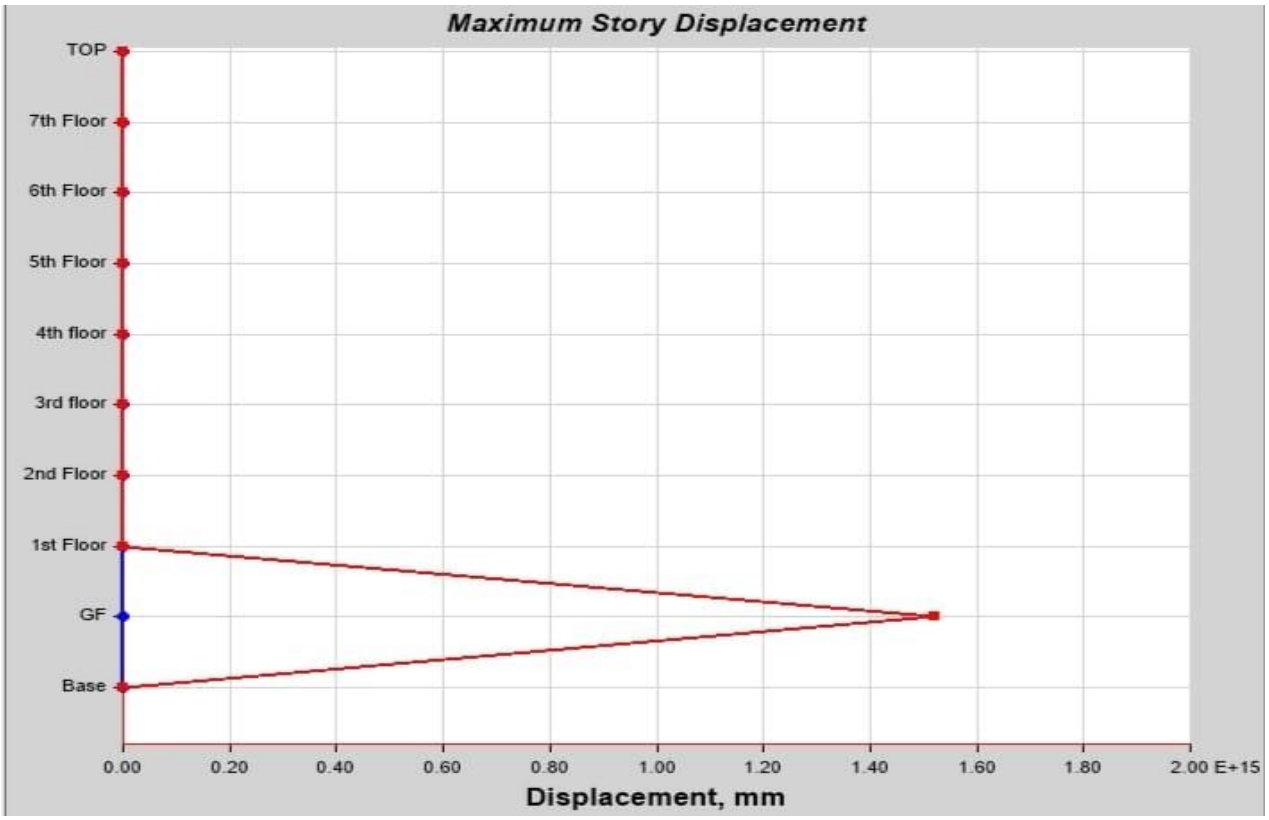

ZONE -2 (X-X)



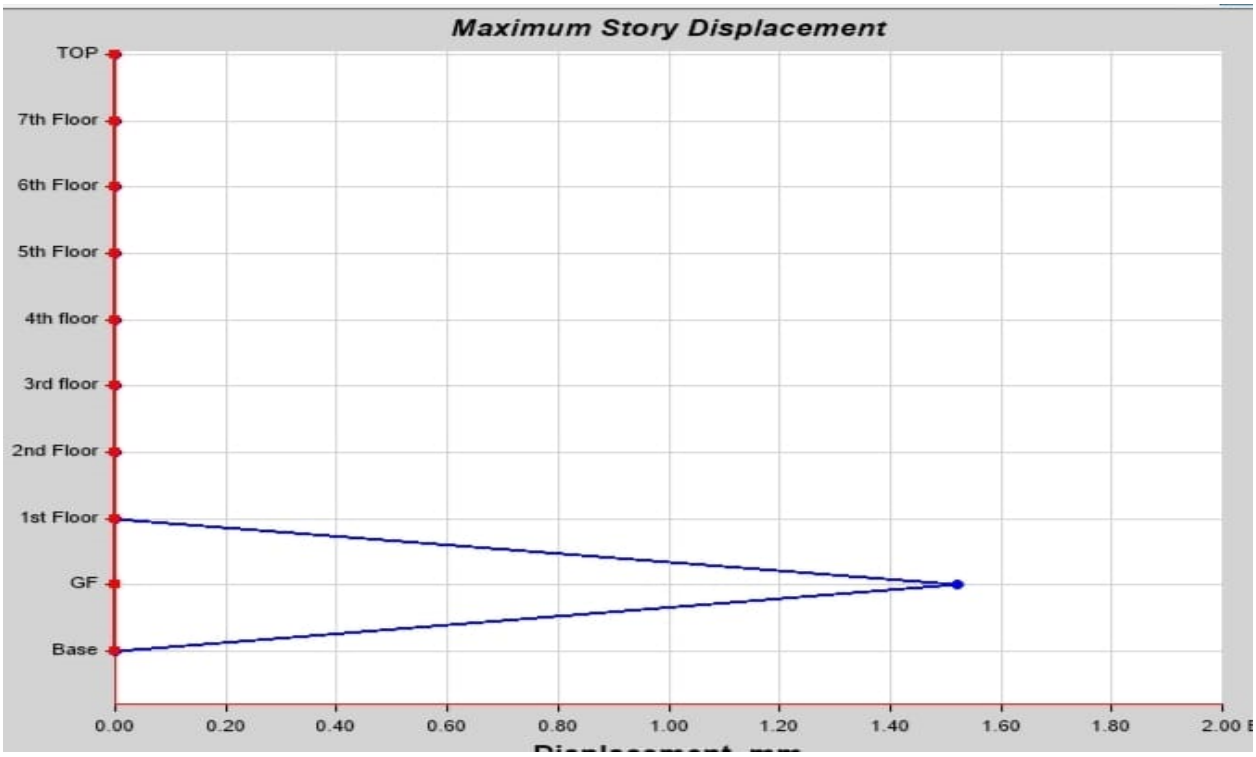

ZONE-2 (Y-Y)



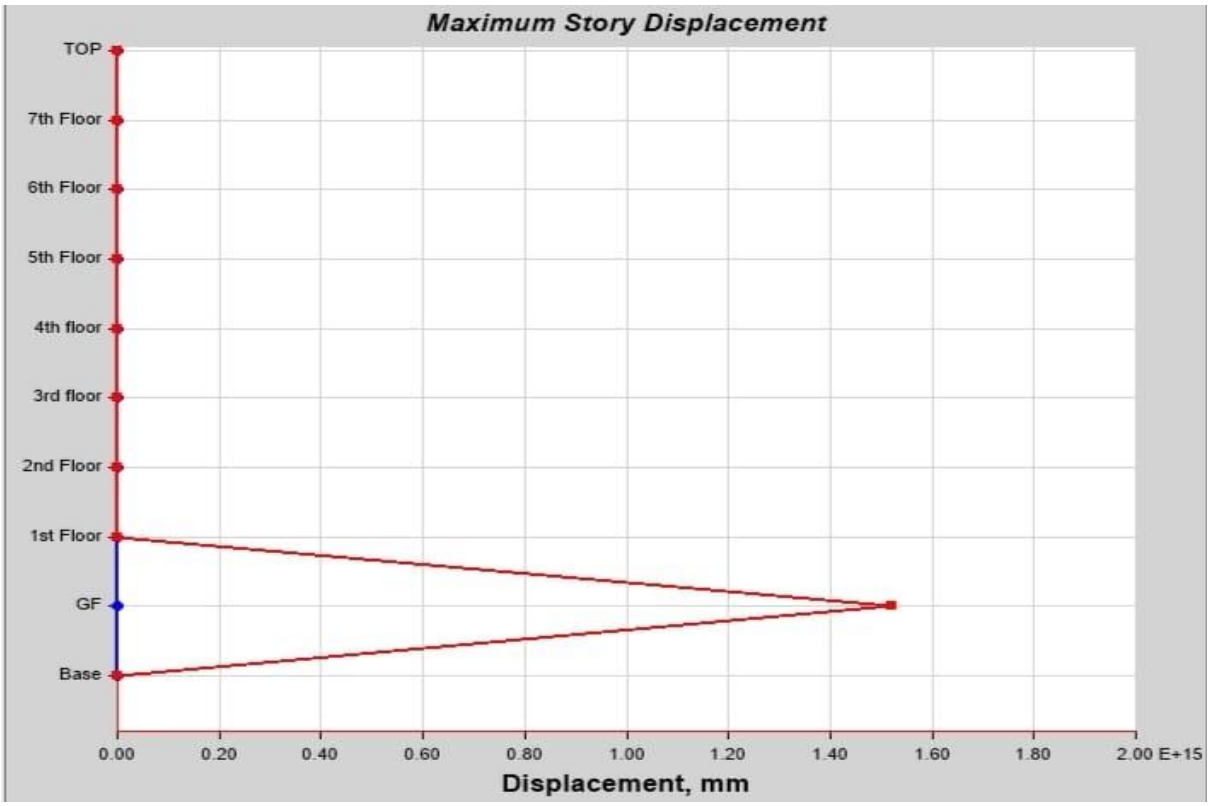

ZONE-3 (X-X)




ZONE-3 (Y-Y)




ZONE-4 (X-X)




ZONE-4 (Y-Y)

## 4.3 Maximum story displacement

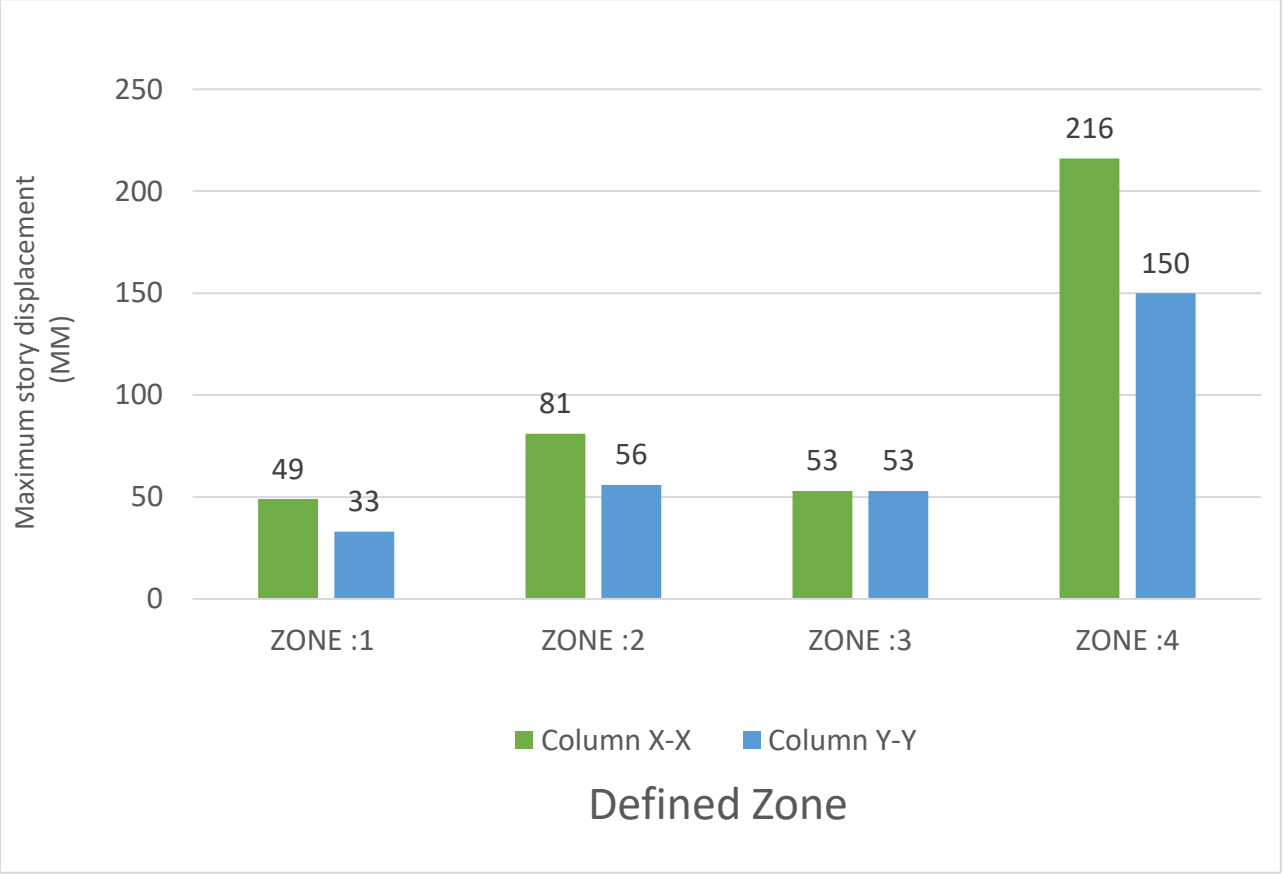
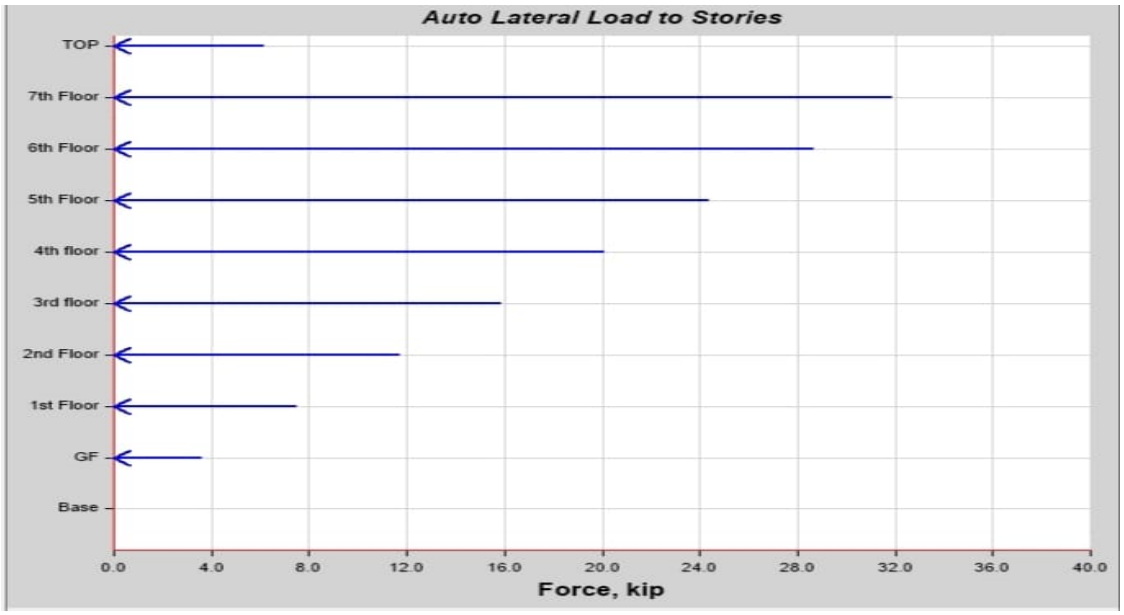
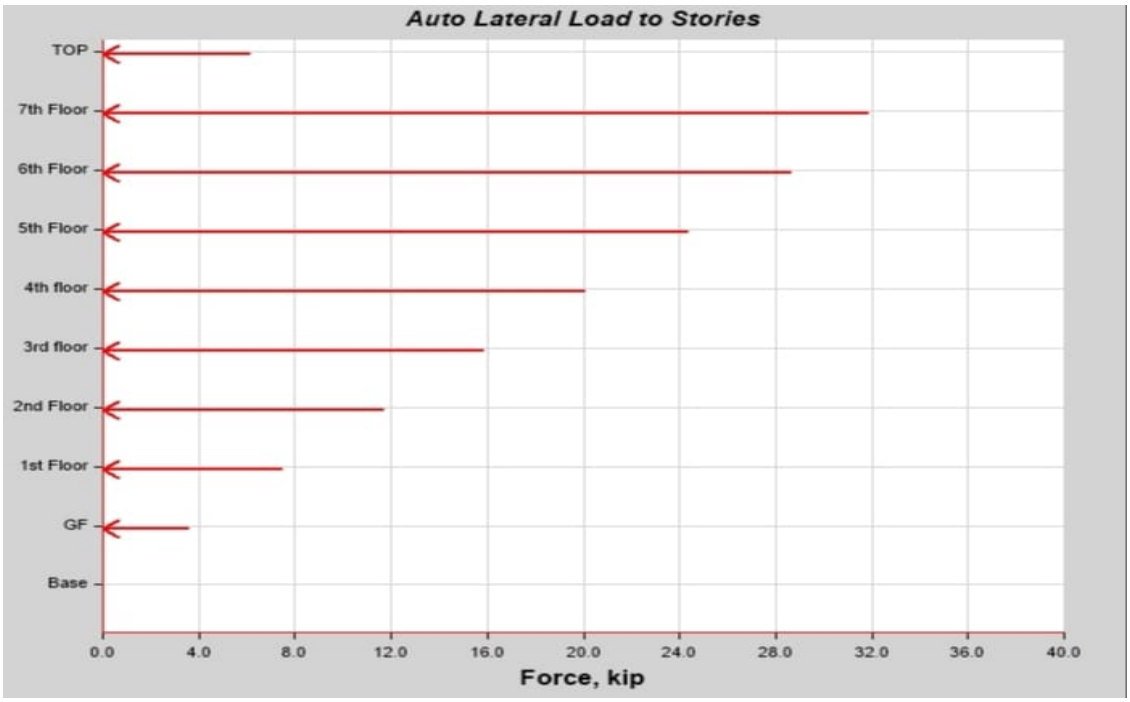



Figure 4.11 Maximum Story Displacement

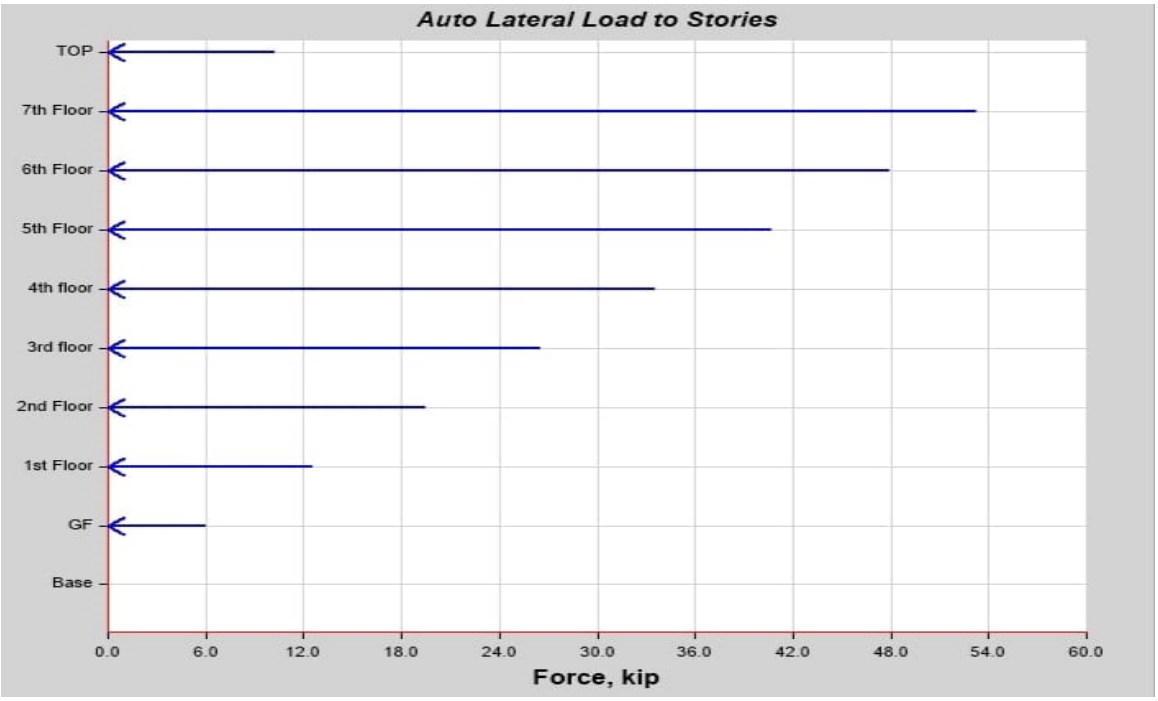
## 4.4 Auto Lateral Load to Stories Graph



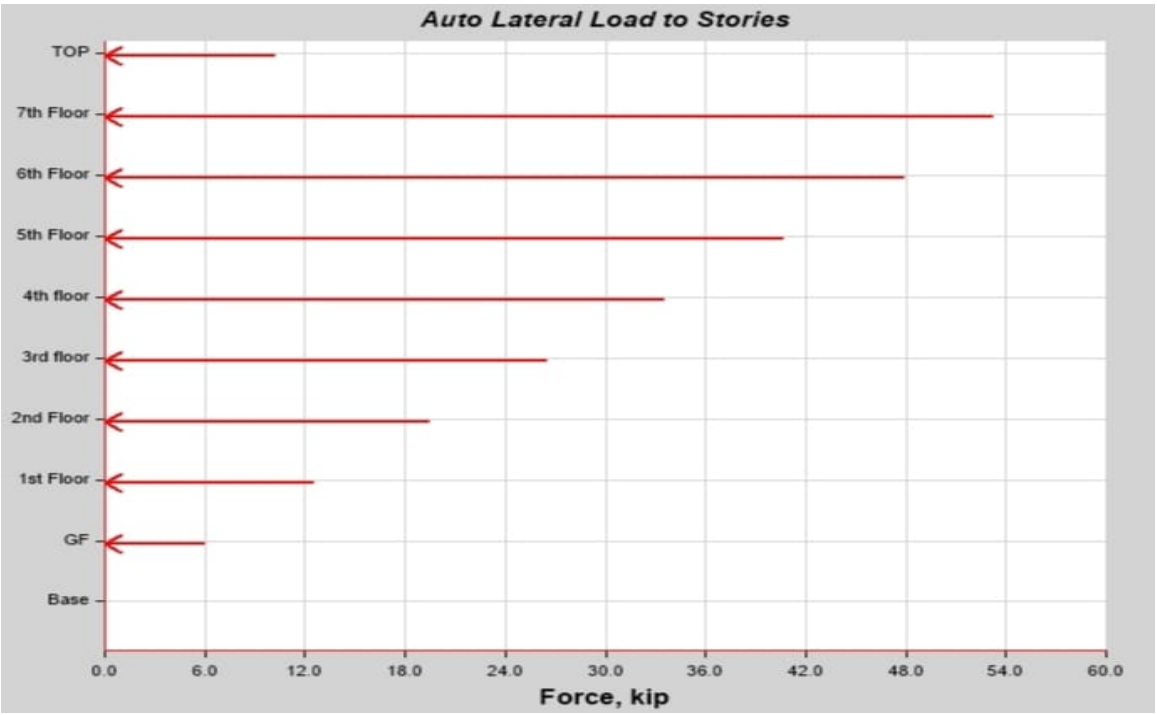

ZONE-1 (X-X)



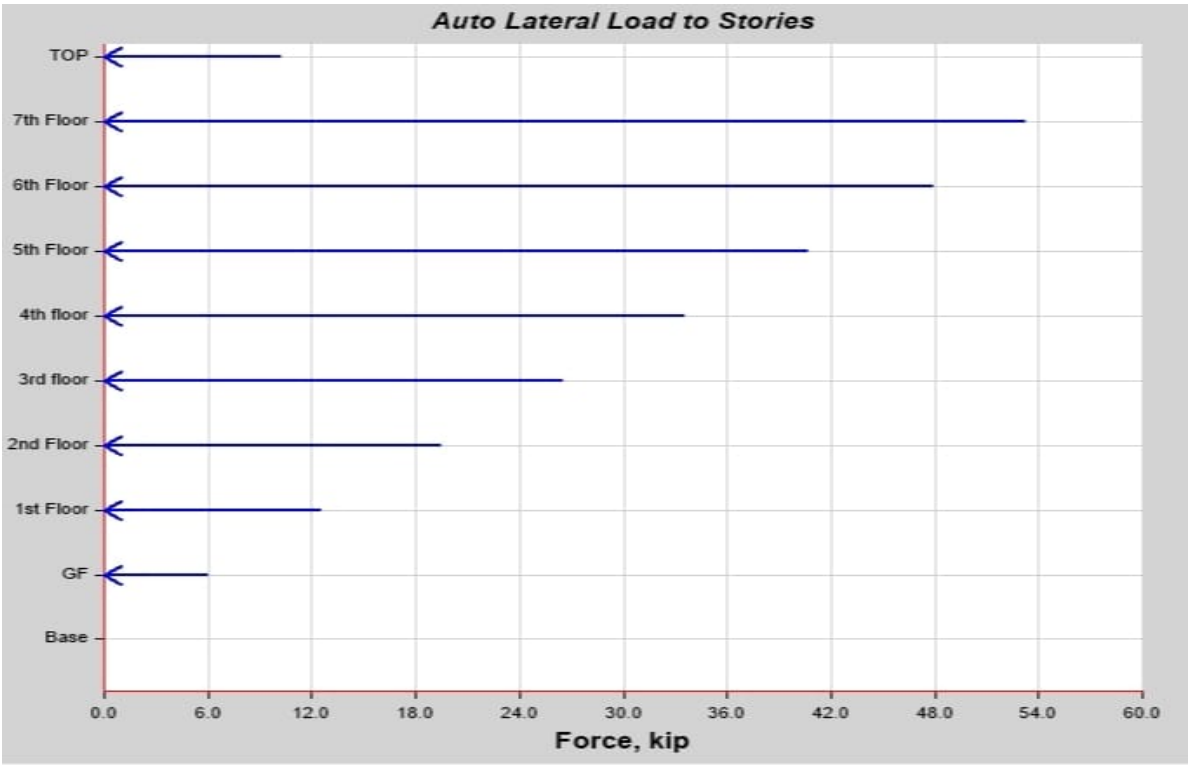

ZONE-1 (Y-Y)



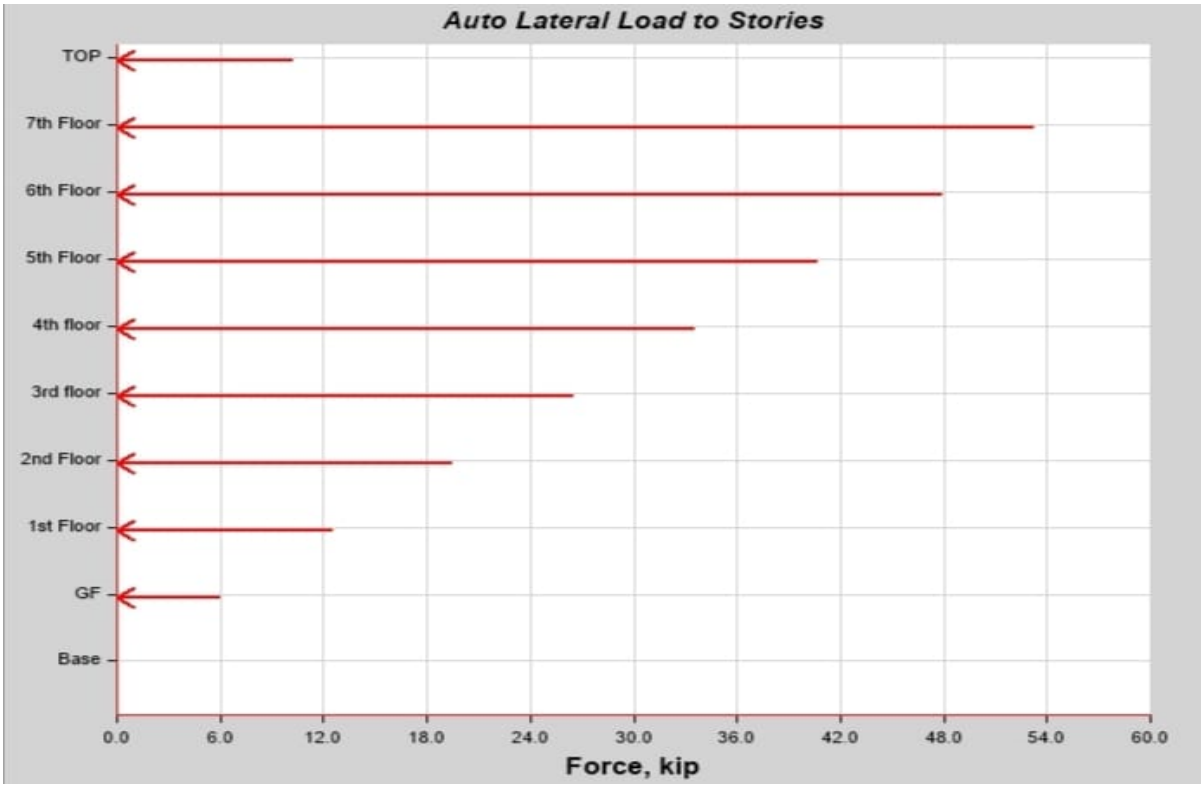

ZONE-2 (X-X)



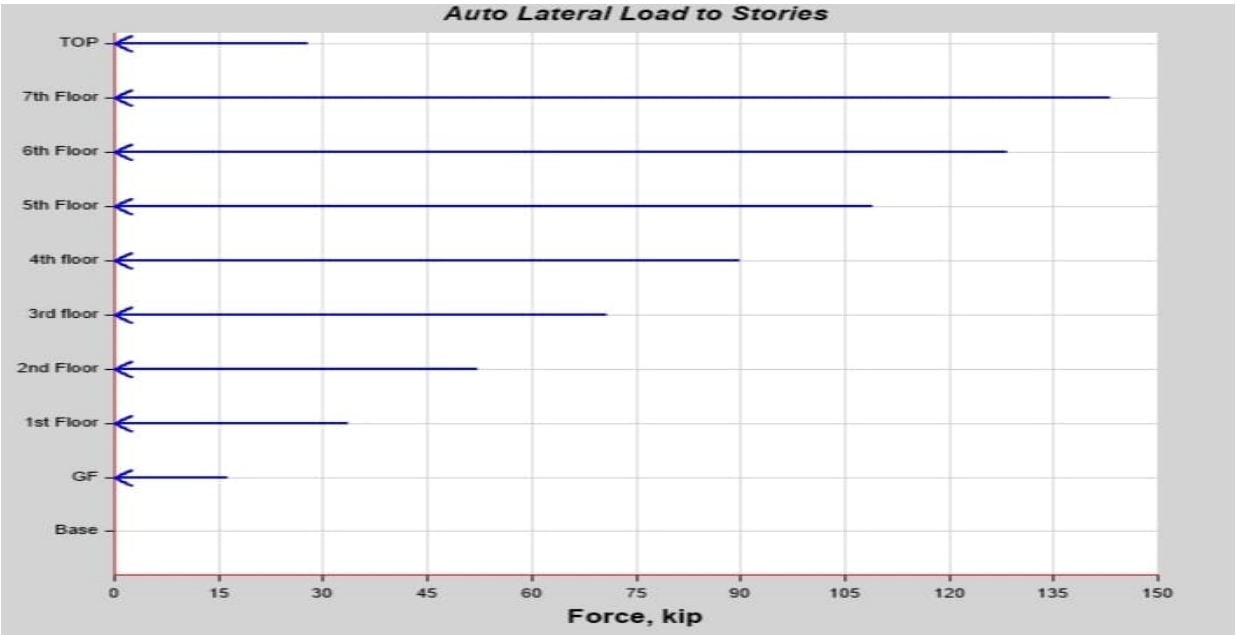

ZONE-2 (Y-Y)



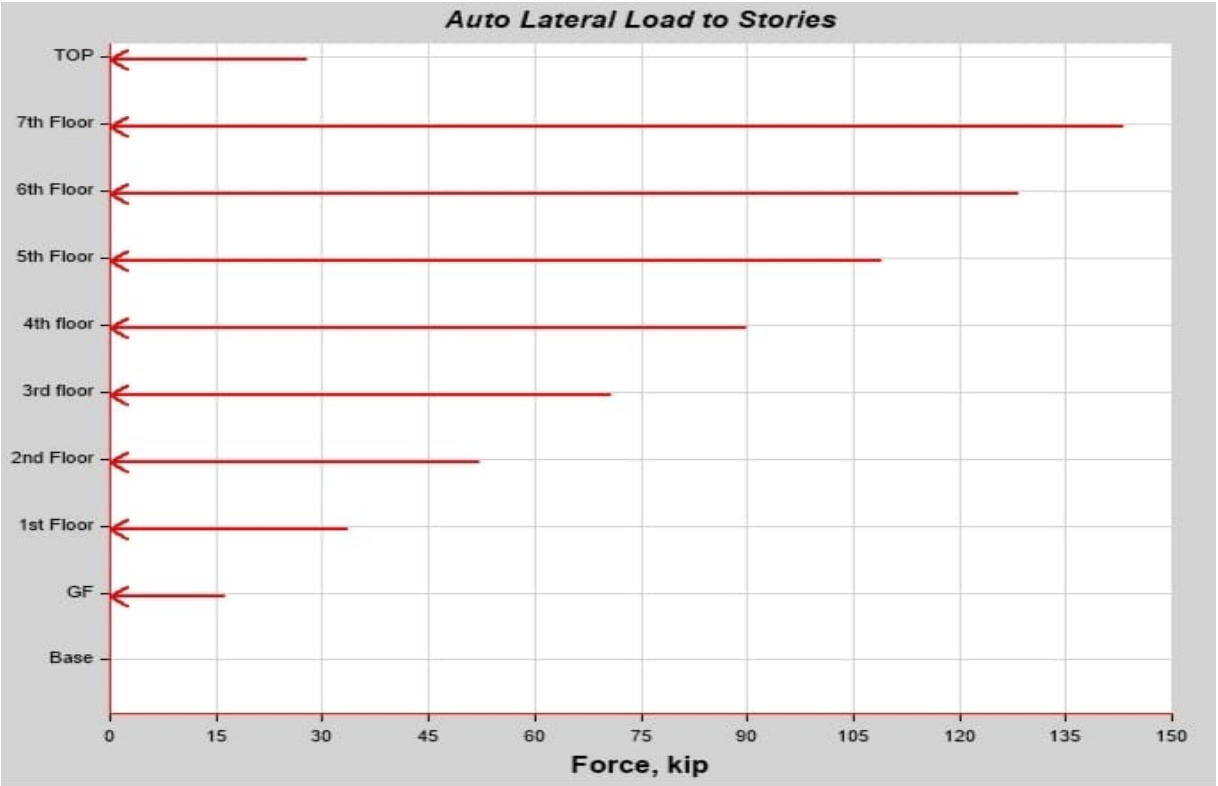

ZONE-3 (X-X)




ZONE-3 (Y-Y)




ZONE-4 (X-X)




ZONE-4 (Y-Y)

## 4.4 Auto Lateral Load to Stories

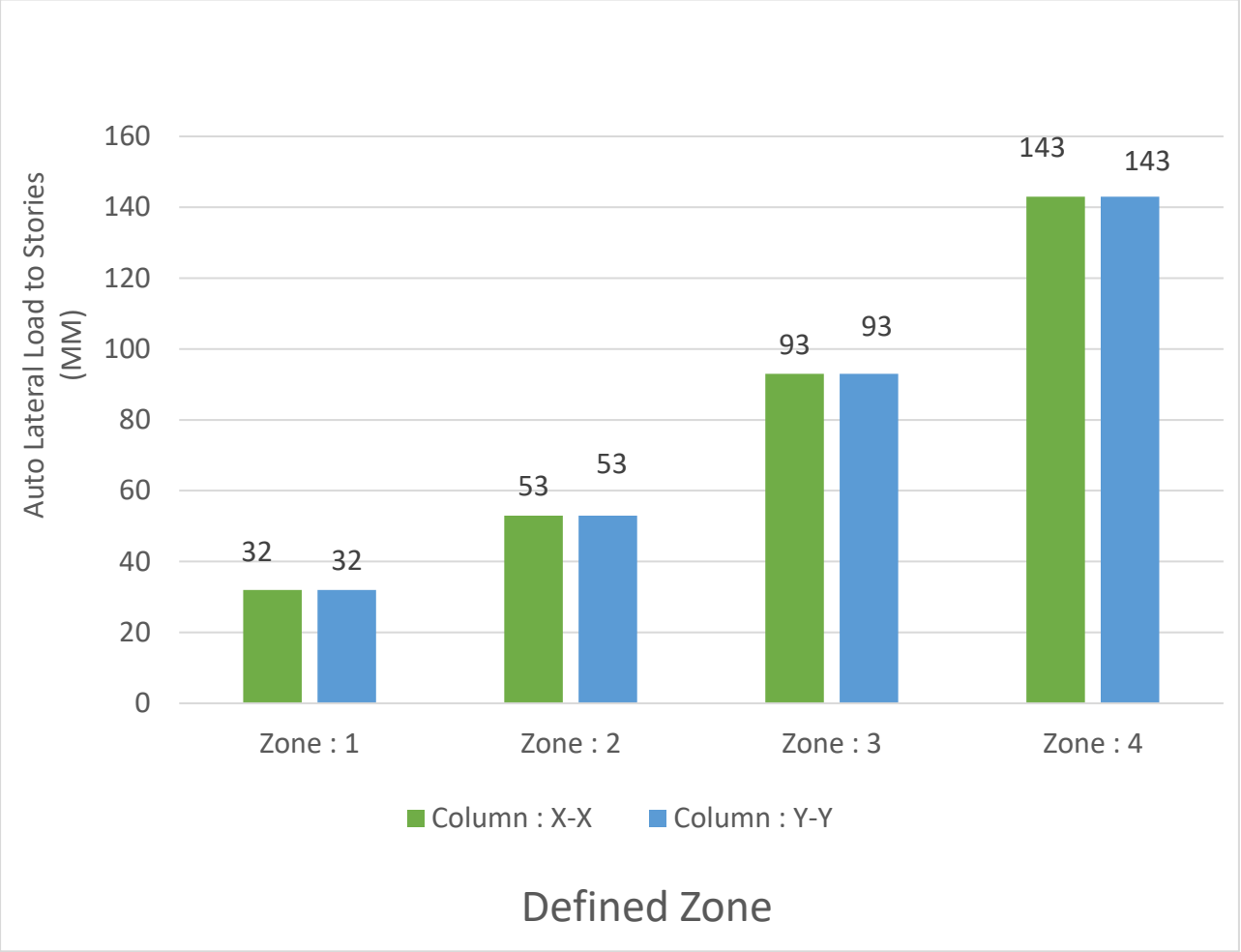
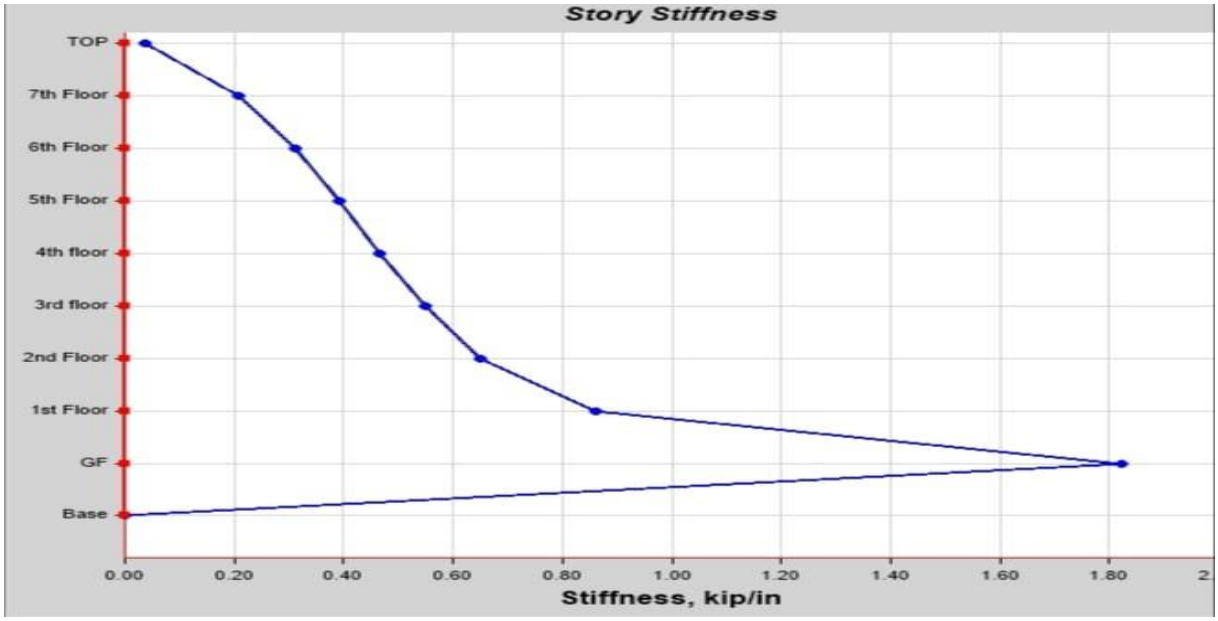
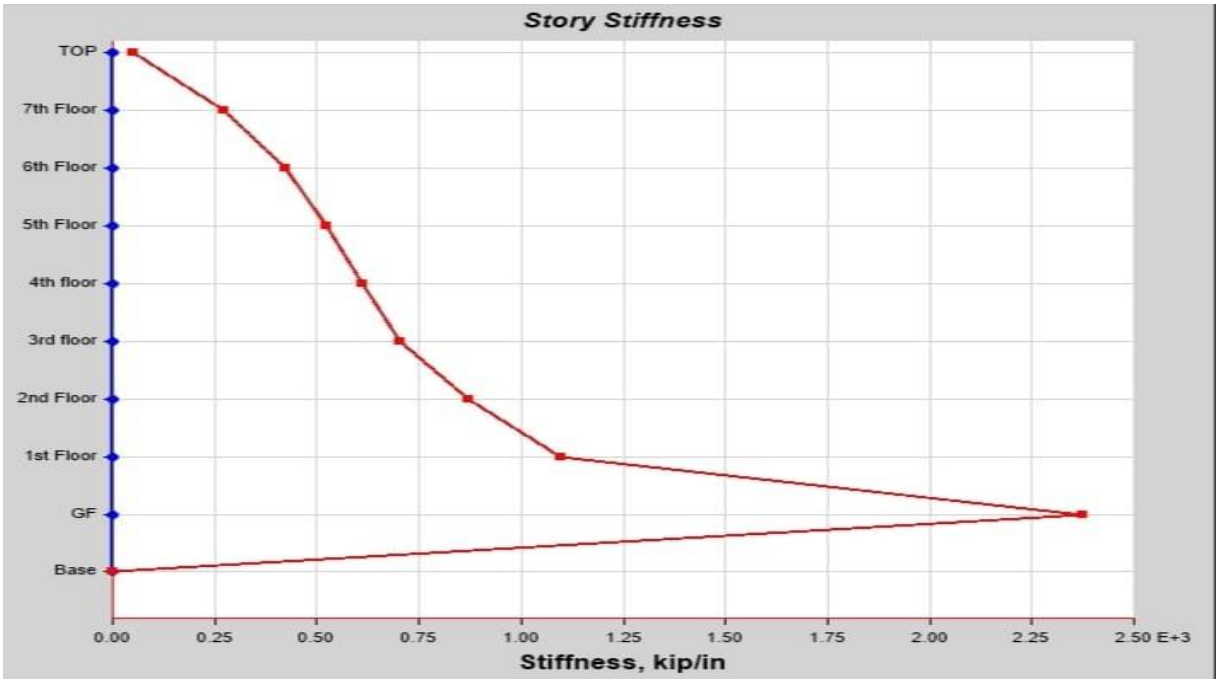



Figure 4.12 Auto Lateral Load to Stories

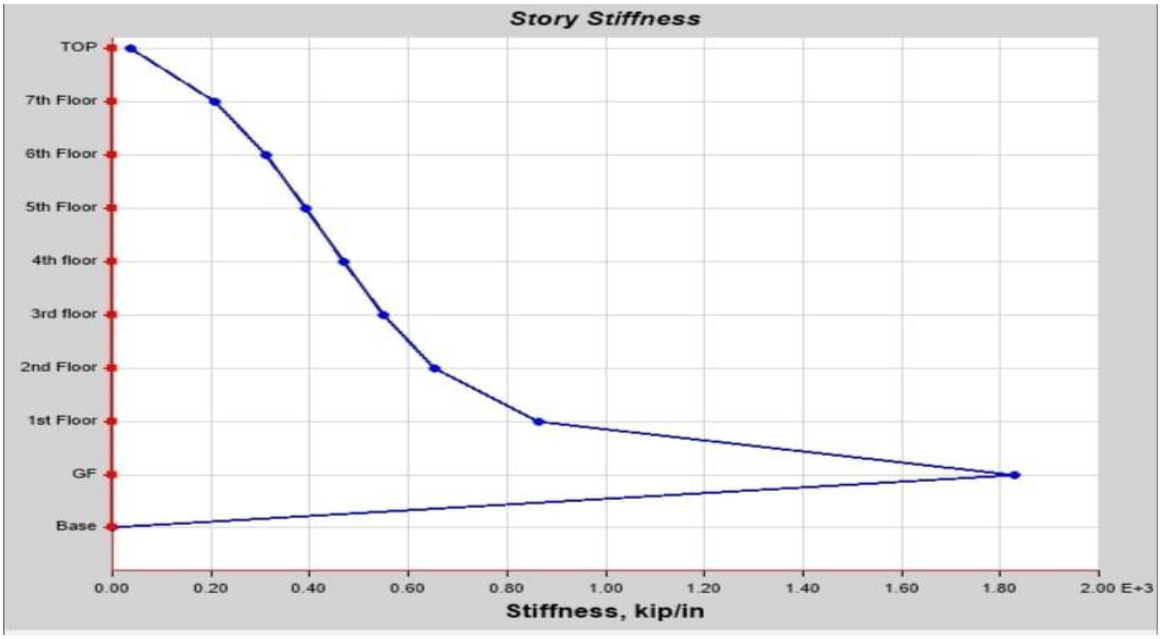
# 4.5 Story Stiffness Graph



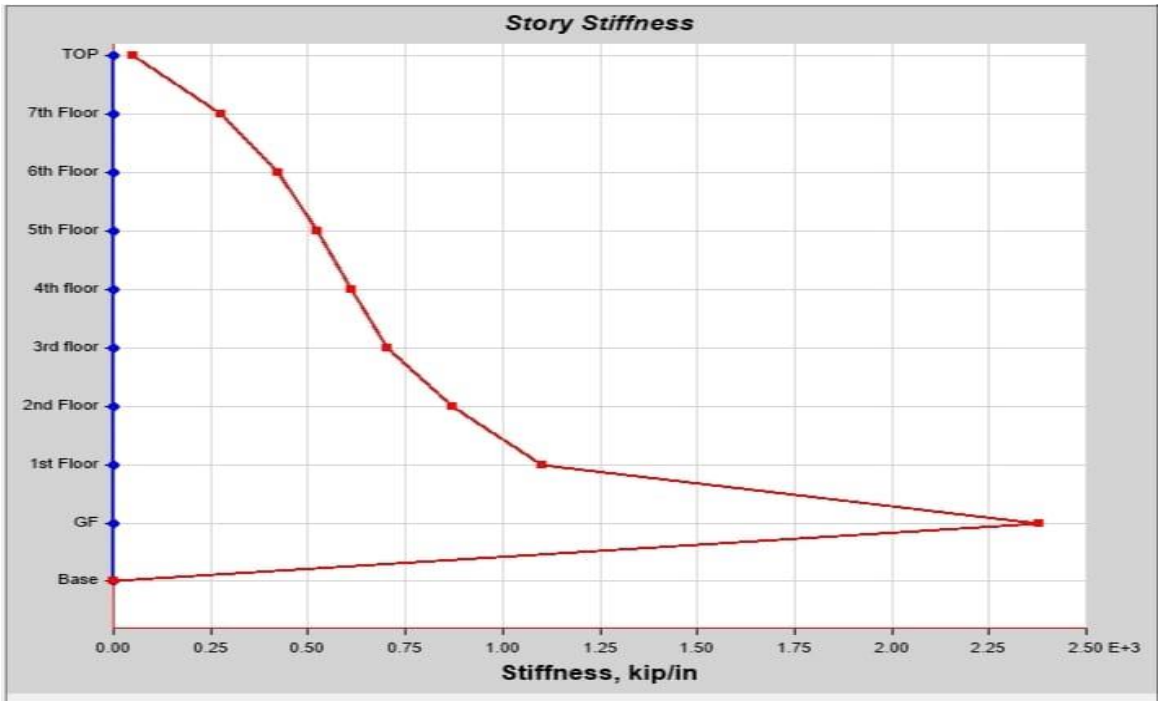

ZONE-1 X-X



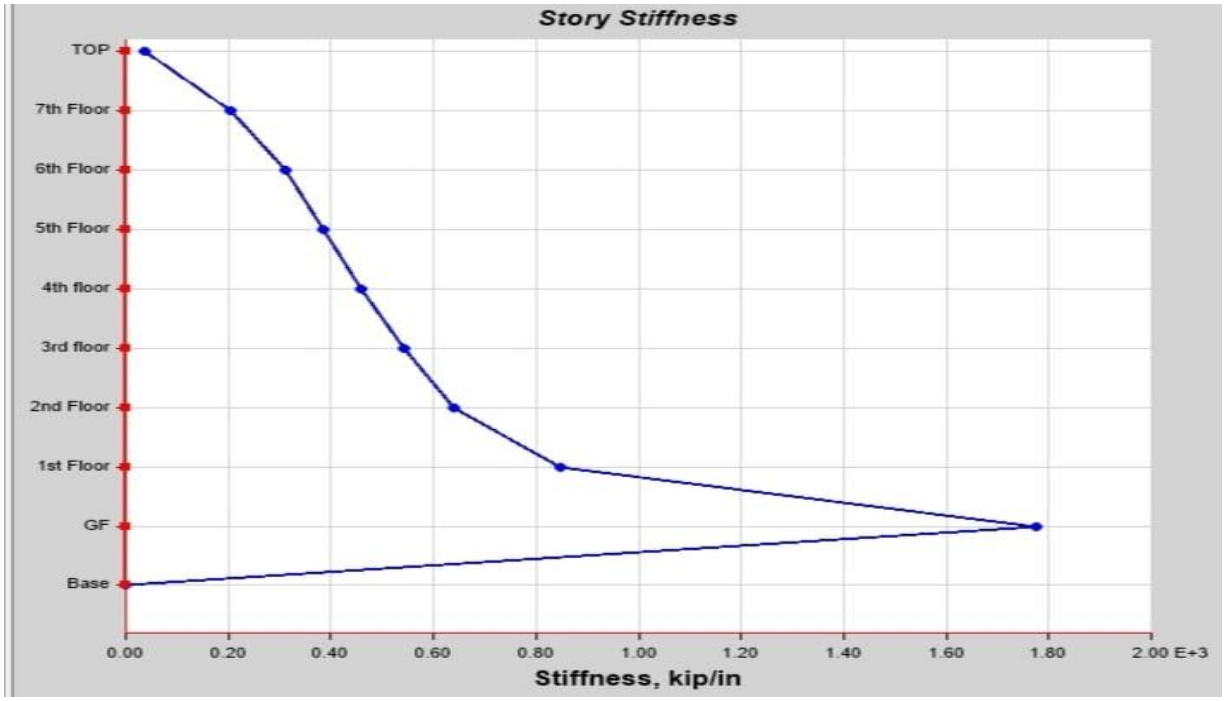

ZONE -1 Y-Y



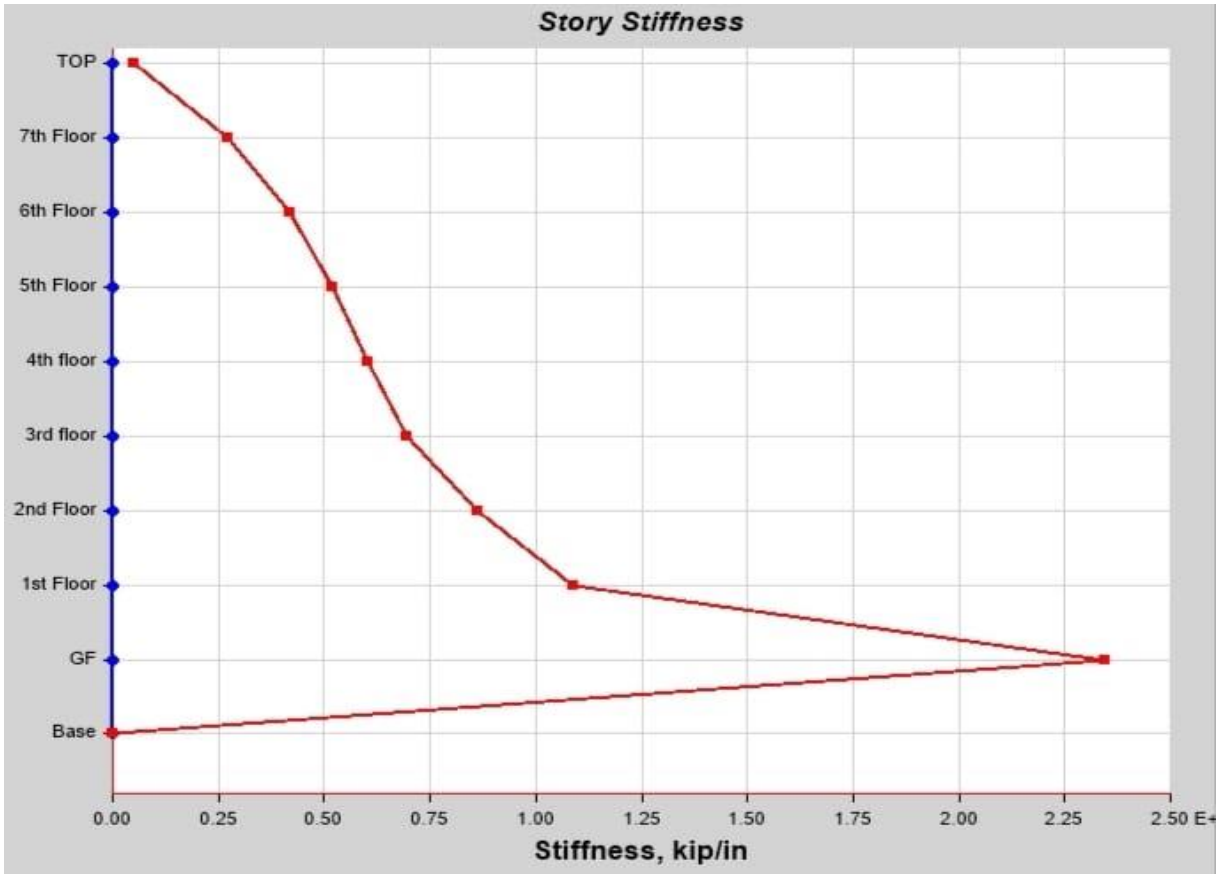

ZONE-2 X-X



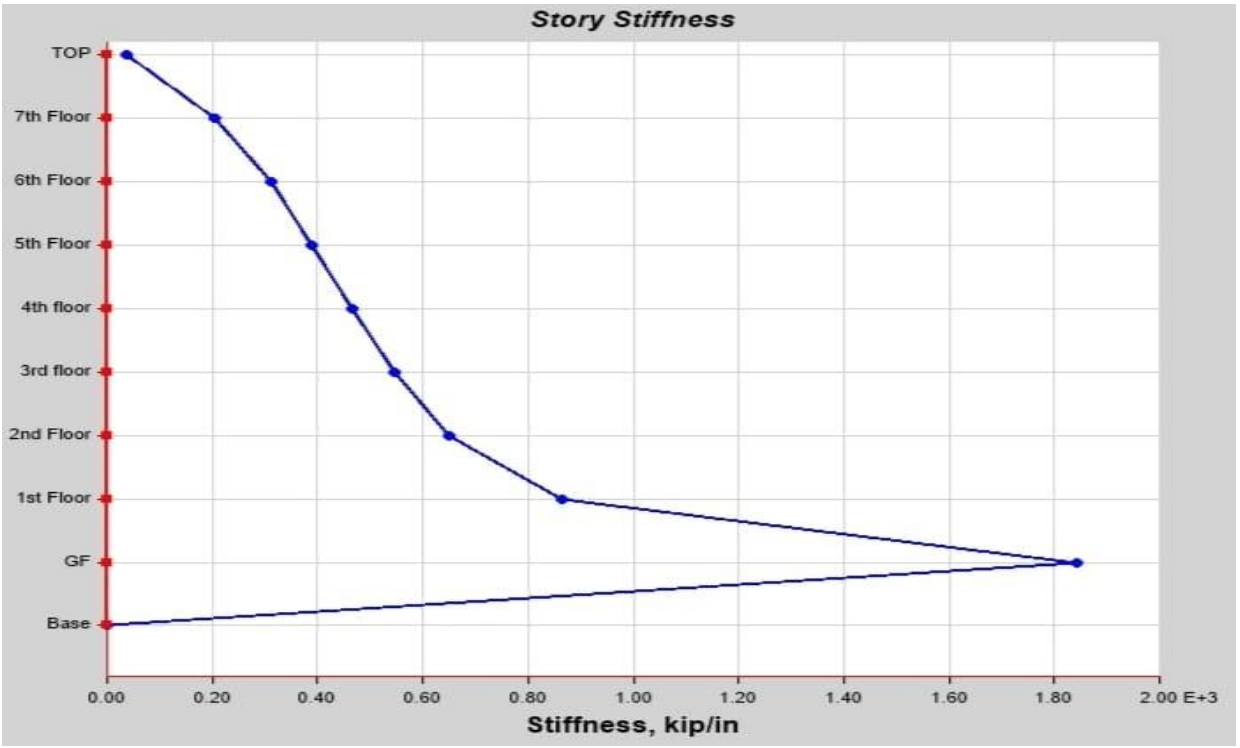

ZONE-2 Y-Y



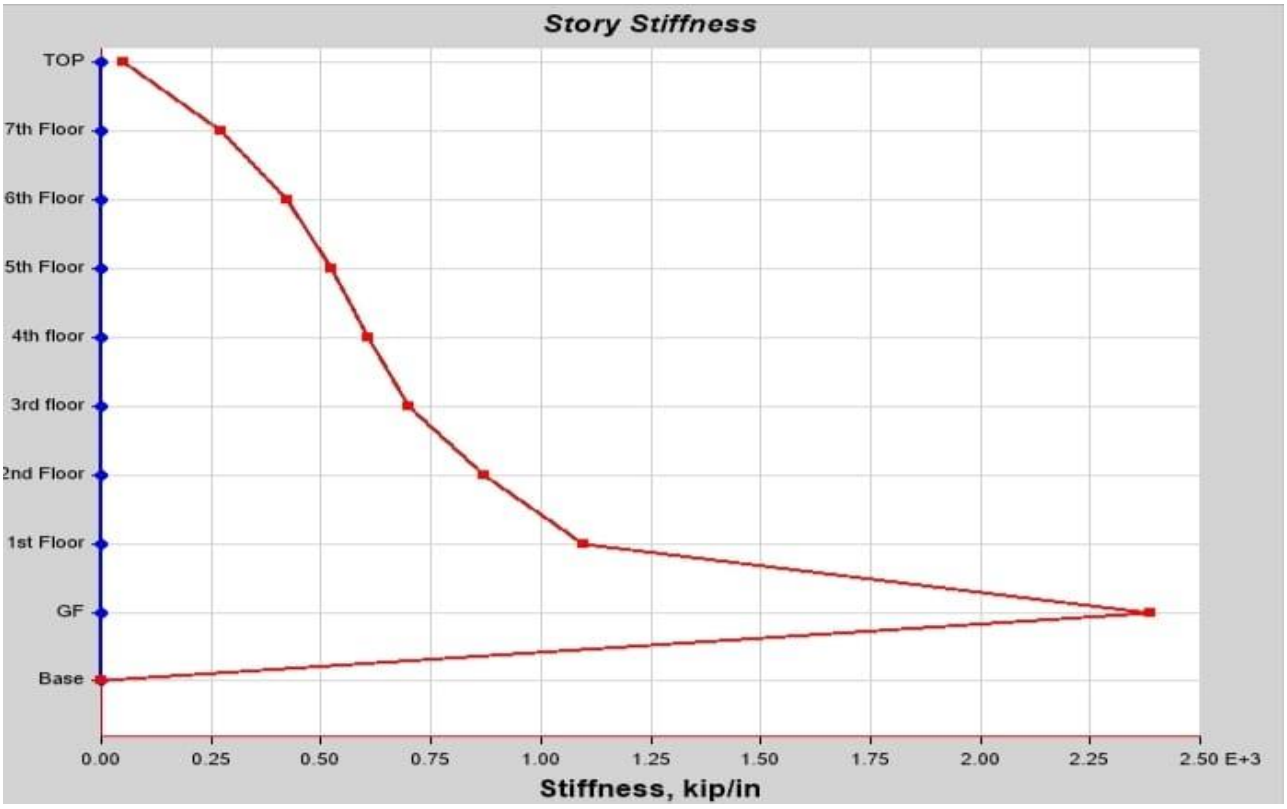

ZONE-3 X-X




ZONE-3 Y-Y




ZONE-4 X-X




ZONE-4 Y-Y

## 4.5 Maximum Story Stiffness

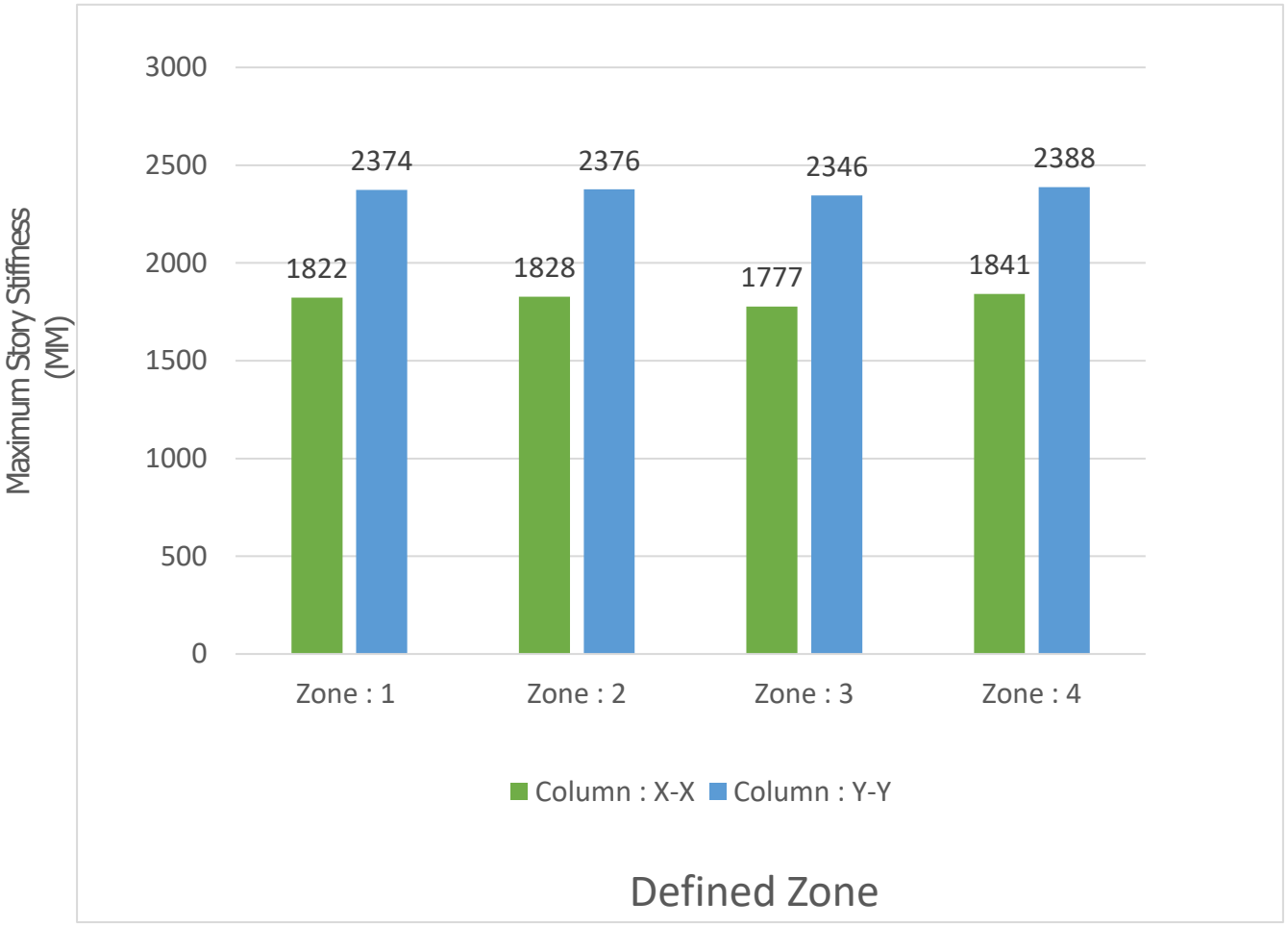
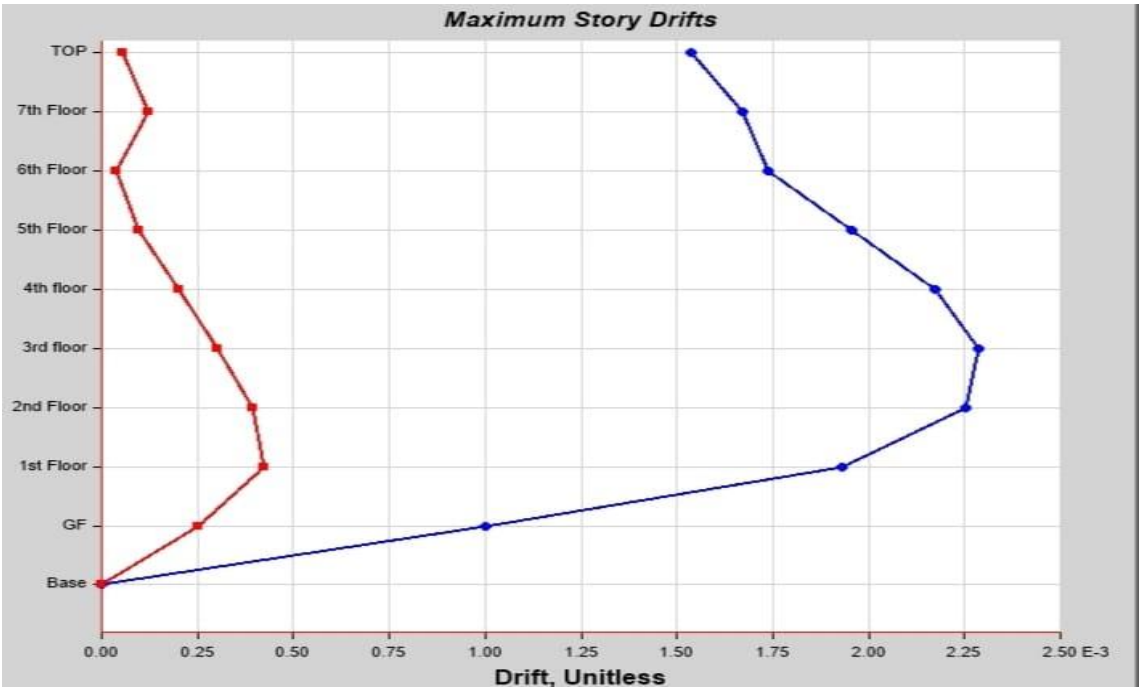
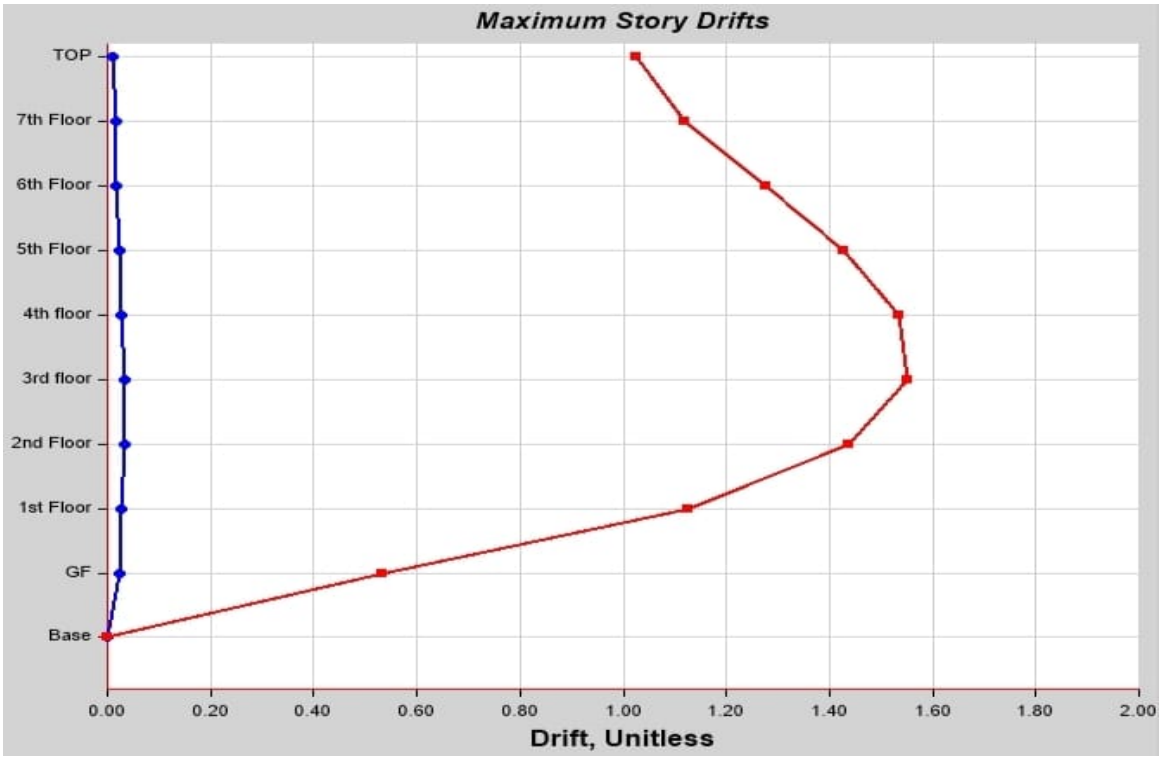



Figure 4.13 Maximum Story Stiffness

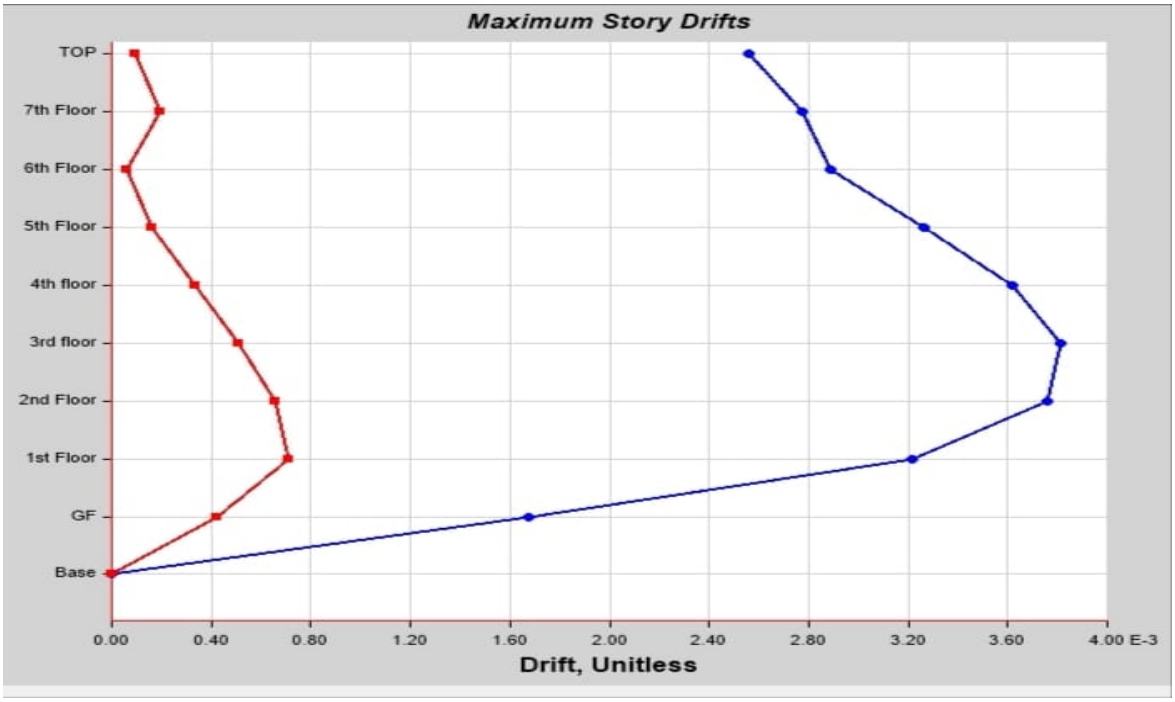
## 4.6 Graphically Story Drifts



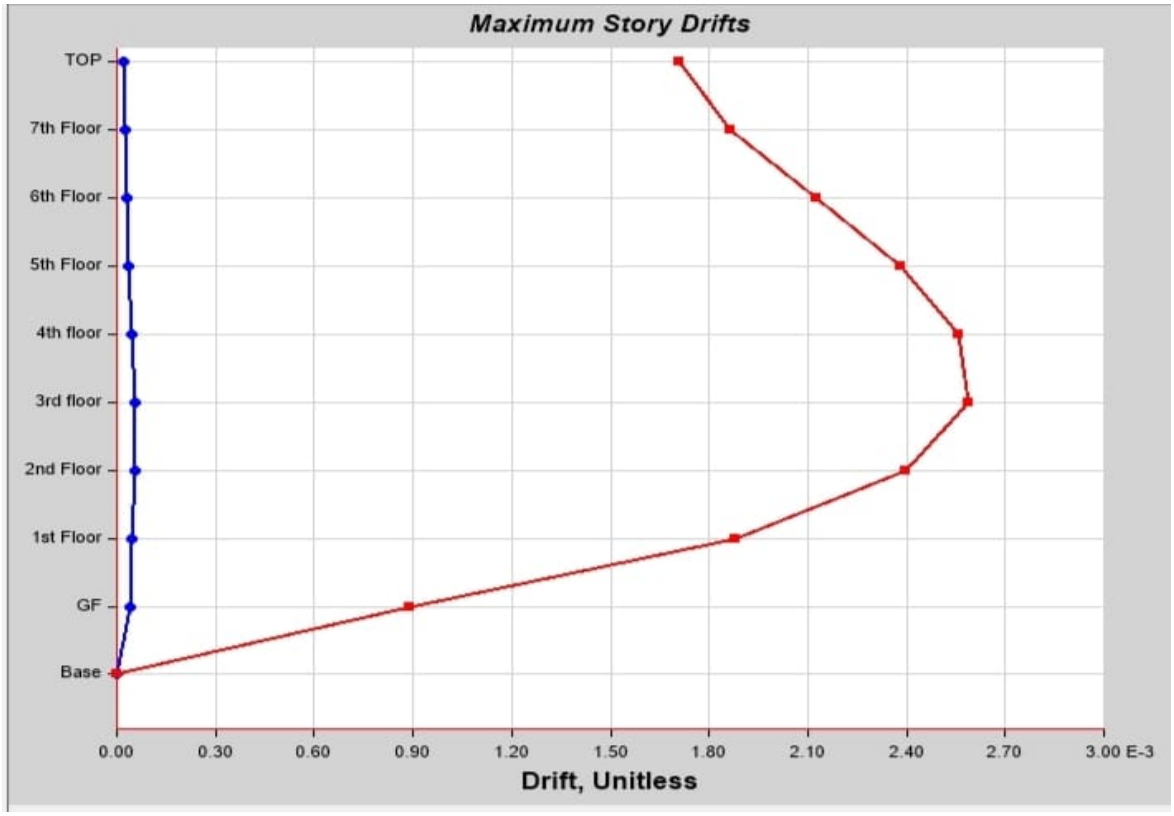

ZONE -1 X-X



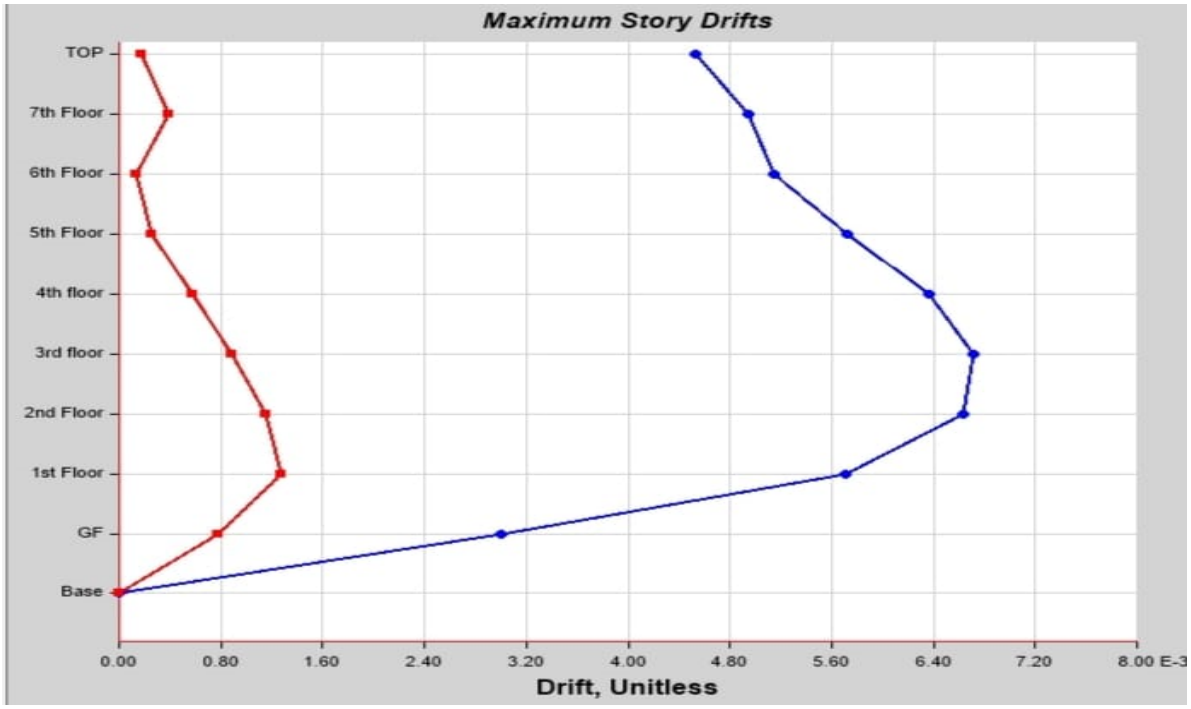

ZONE -1-Y-Y



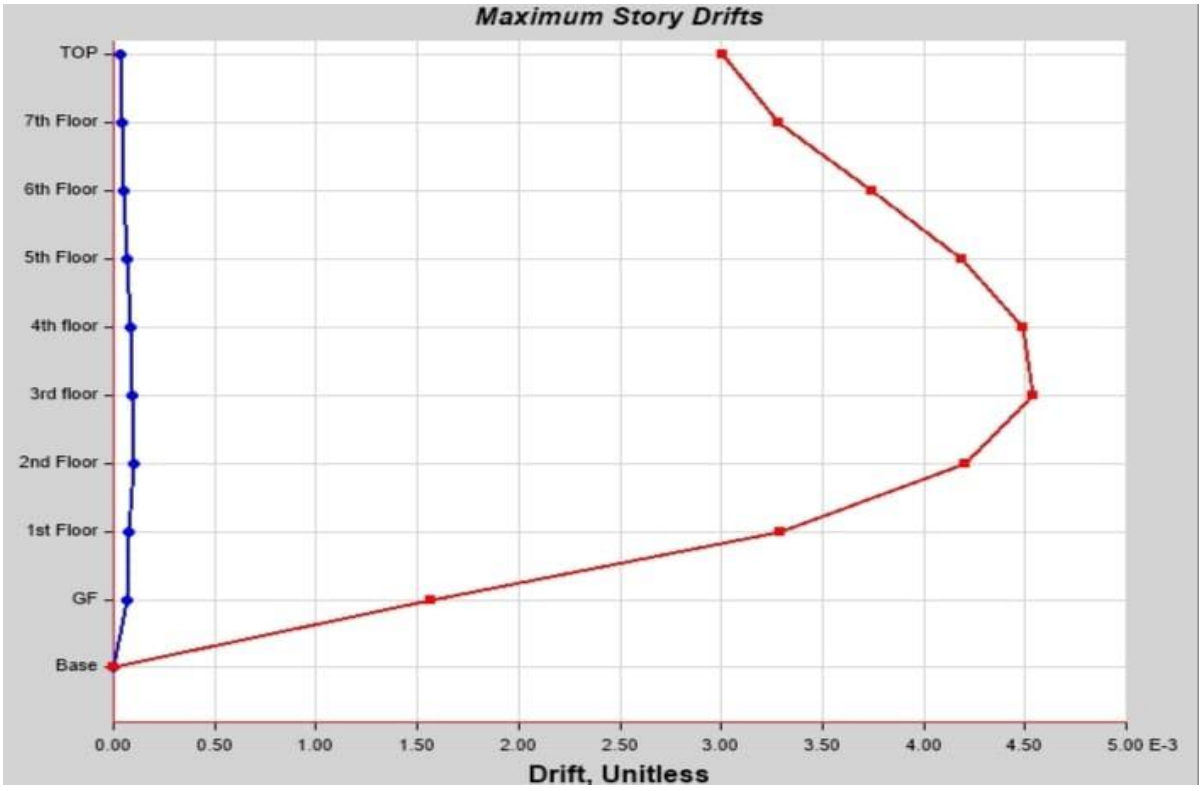

ZONE -2 X-X



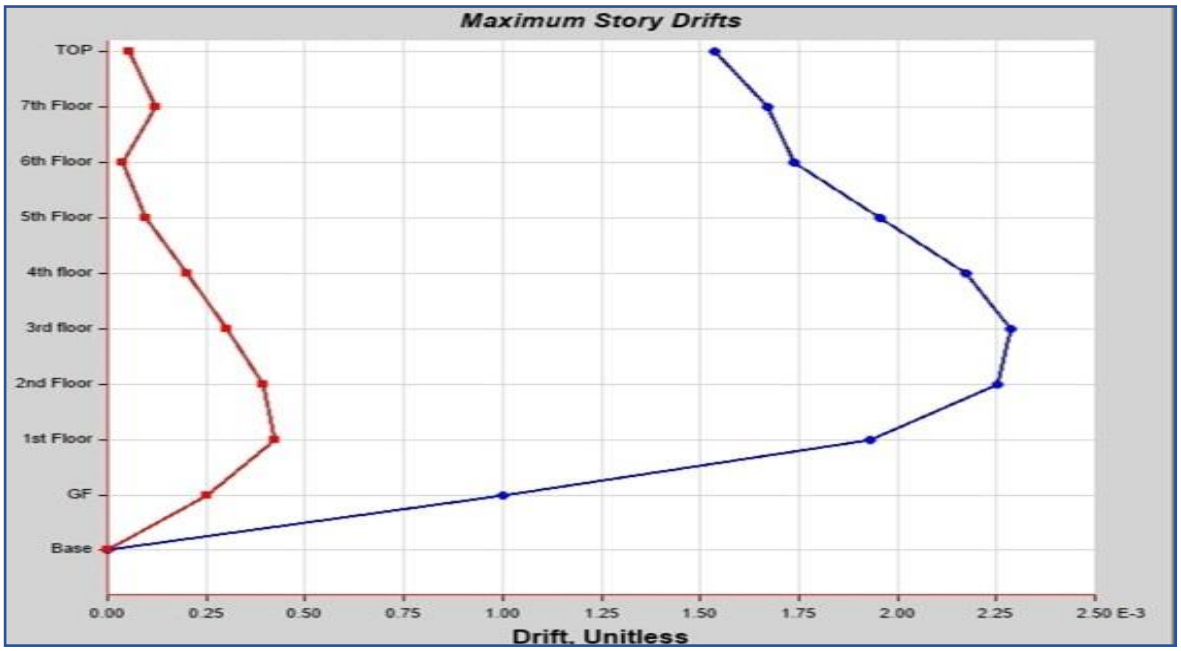

ZONE -2 Y-Y



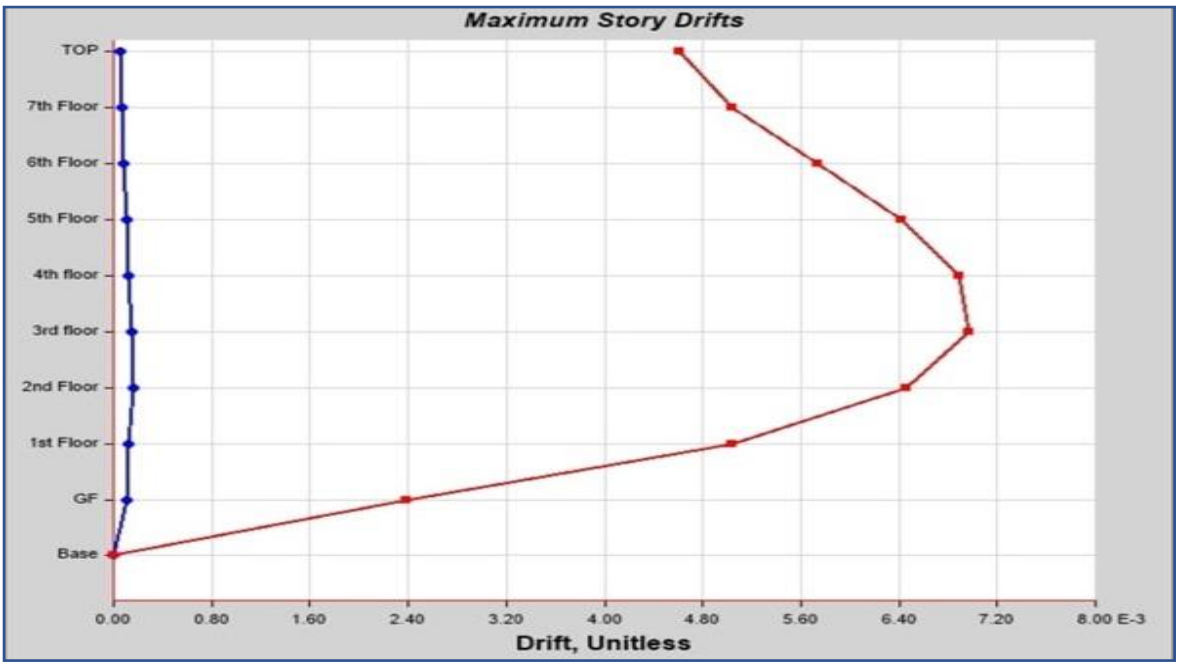

ZONE -3 X-X




ZONE -3, Y-Y




ZONE - 4 X-X




ZONE - 4 Y-Y

## 4.6 Maximum Story Drifts

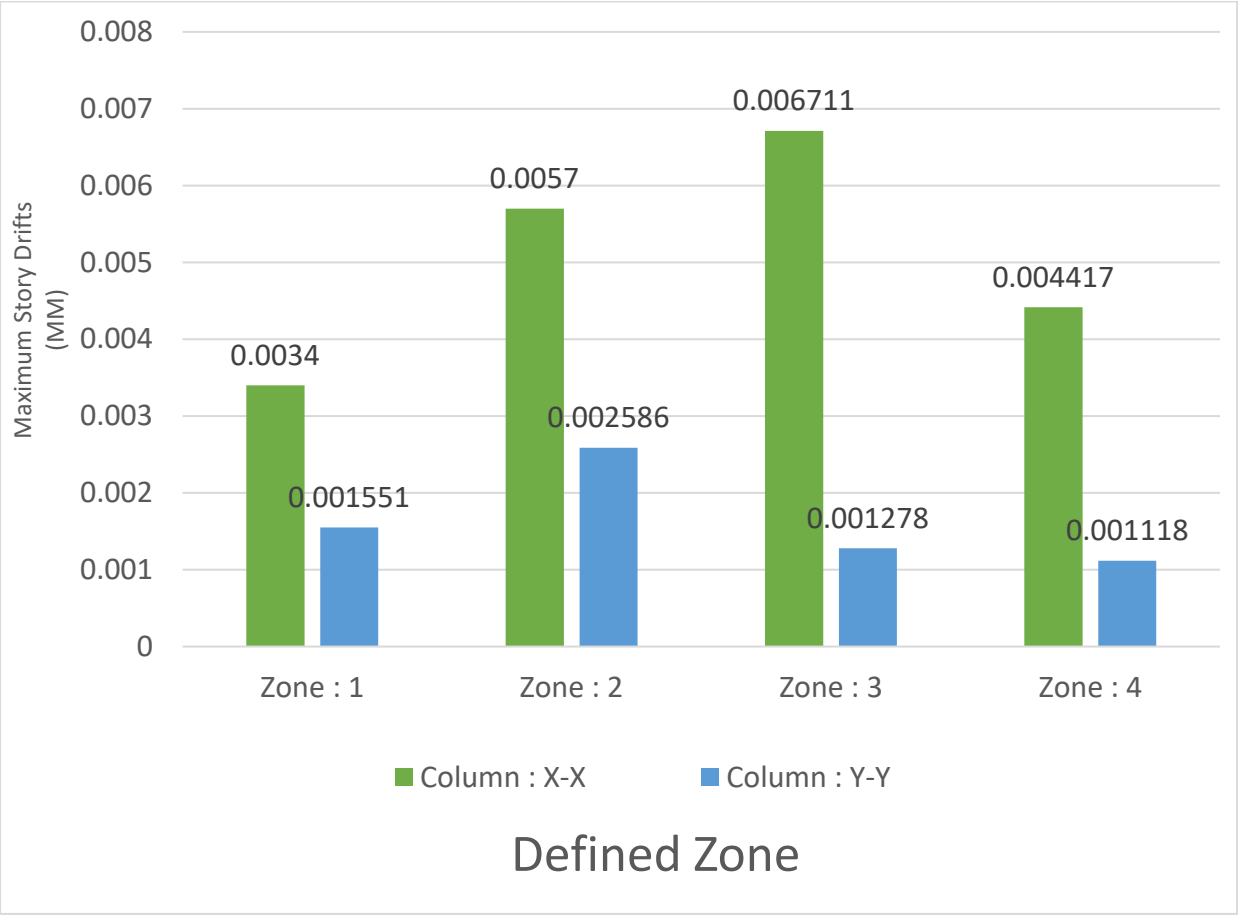



Figure 4.14 Maximum Story Drifts

### 4.7 Base Share Reaction

| Story | Elevation m | Location | X-Dir mm | Y-Dir mm |
|---|---|---|---|---|
| TOP | 29.8704 | Top | 48.365 | 1.011 |
| 7th Floor | 26.8224 | Top | 44.733 | 4.735 |
| 6th Floor | 23.7744 | Top | 40.45 | 5.024 |
| 5th Floor | 20.7264 | Top | 35.343 | 5.065 |
| 4th floor | 17.6784 | Top | 29.381 | 4.778 |
| 3rd floor | 14.6304 | Top | 22.763 | 4.169 |
| 2nd Floor | 11.5824 | Top | 15.789 | 3.248 |
| 1st Floor | 8.5344 | Top | 8.92 | 2.052 |
| GF | 5.4864 | Top | 52140000000... | 0.772 |
| Base | 2.4384 | Top | 0 | 0 |

ZONE-1 X-X

| Story | Elevation m | Location | X-Dir mm | Y-Dir mm |
|---|---|---|---|---|
| TOP | 29.8704 | Top | 0.59 | 33.34 |
| 7th Floor | 26.8224 | Top | 0.556 | 30.485 |
| 6th Floor | 23.7744 | Top | 0.509 | 27.076 |
| 5th Floor | 20.7264 | Top | 0.456 | 23.186 |
| 4th floor | 17.6784 | Top | 0.389 | 18.832 |
| 3rd floor | 14.6304 | Top | 0.306 | 14.159 |
| 2nd Floor | 11.5824 | Top | 0.208 | 9.432 |
| 1st Floor | 8.5344 | Top | 0.103 | 5.051 |
| GF | 5.4864 | Top | 0.07 | 5214000000... |
| Base | 2.4384 | Top | 0 | 0 |

ZONE-1 Y-Y

| Story | Elevation m | Location | X-Dir mm | Y-Dir mm |
|---|---|---|---|---|
| TOP | 29.8704 | Top | 80.622 | 1.702 |
| 7th Floor | 26.8224 | Top | 74.57 | 7.966 |
| 6th Floor | 23.7744 | Top | 67.431 | 8.439 |
| 5th Floor | 20.7264 | Top | 58.916 | 8.494 |
| 4th floor | 17.6784 | Top | 48.979 | 8.004 |
| 3rd floor | 14.6304 | Top | 37.947 | 6.979 |
| 2nd Floor | 11.5824 | Top | 26.322 | 5.434 |
| 1st Floor | 8.5344 | Top | 14.872 | 3.433 |
| GF | 5.4864 | Top | 86910000000... | 1.293 |
| Base | 2.4384 | Top | 0 | 0 |

ZONE-2 X-X

| Story | Elevation m | Location | X-Dir mm | Y-Dir mm |
|---|---|---|---|---|
| TOP | 29.8704 | Top | 0.981 | 55.584 |
| 7th Floor | 26.8224 | Top | 0.924 | 50.824 |
| 6th Floor | 23.7744 | Top | 0.847 | 45.143 |
| 5th Floor | 20.7264 | Top | 0.758 | 38.66 |
| 4th floor | 17.6784 | Top | 0.647 | 31.402 |
| 3rd floor | 14.6304 | Top | 0.508 | 23.611 |
| 2nd Floor | 11.5824 | Top | 0.345 | 15.73 |
| 1st Floor | 8.5344 | Top | 0.172 | 8.423 |
| GF | 5.4864 | Top | 0.117 | 8691000000... |
| Base | 2.4384 | Top | 0 | 0 |

ZONE-2 Y-Y

| Story | Elevation m | Location | X-Dir mm | Y-Dir mm |
|---|---|---|---|---|
| TOP | 29.8704 | Top | 142.092 | 2.953 |
| 7th Floor | 26.8224 | Top | 131.444 | 13.852 |
| 6th Floor | 23.7744 | Top | 118.958 | 14.794 |
| 5th Floor | 20.7264 | Top | 104.03 | 14.982 |
| 4th floor | 17.6784 | Top | 86.577 | 14.188 |
| 3rd floor | 14.6304 | Top | 67.189 | 12.44 |
| 2nd Floor | 11.5824 | Top | 46.735 | 9.755 |
| 1st Floor | 8.5344 | Top | 26.528 | 6.223 |
| GF | 5.4864 | Top | 1.52E+15 | 2.381 |
| Base | 2.4384 | Top | 0 | 0 |

Z0NE -3 X-X

| Story | Elevation m | Location | X-Dir mm | Y-Dir mm |
|---|---|---|---|---|
| TOP | 29.8704 | Top | 1.767 | 97.655 |
| 7th Floor | 26.8224 | Top | 1.665 | 89.299 |
| 6th Floor | 23.7744 | Top | 1.525 | 79.291 |
| 5th Floor | 20.7264 | Top | 1.367 | 67.887 |
| 4th floor | 17.6784 | Top | 1.167 | 55.13 |
| 3rd floor | 14.6304 | Top | 0.919 | 41.446 |
| 2nd Floor | 11.5824 | Top | 0.625 | 27.61 |
| 1st Floor | 8.5344 | Top | 0.311 | 14.785 |
| GF | 5.4864 | Top | 0.206 | 1.52E+15 |
| Base | 2.4384 | Top | 0 | 0 |

ZONE-3 Y-Y

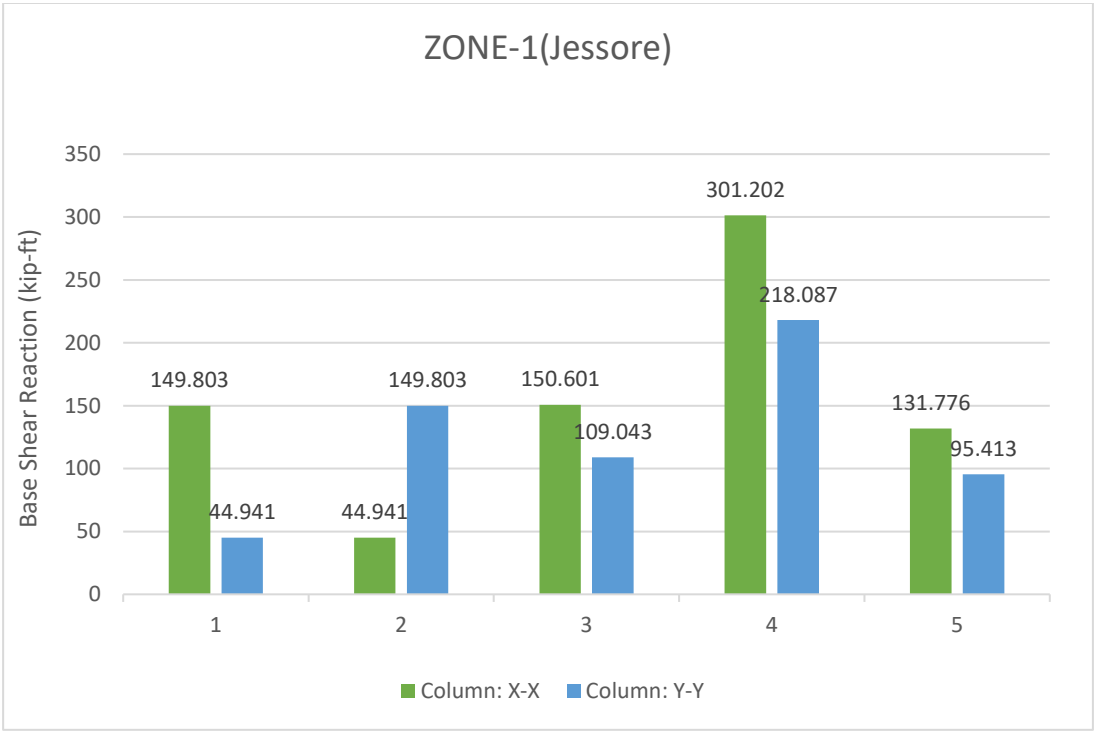
| Story | Elevation m | Location | X-Dir mm | Y-Dir mm |
|---|---|---|---|---|
| TOP | 29.8704 | Top | 216.452 | 4.453 |
| 7th Floor | 26.8224 | Top | 200.129 | 20.728 |
| 6th Floor | 23.7744 | Top | 180.955 | 22.124 |
| 5th Floor | 20.7264 | Top | 158.062 | 22.384 |
| 4th floor | 17.6784 | Top | 131.309 | 21.149 |
| 3rd floor | 14.6304 | Top | 101.604 | 18.461 |
| 2nd Floor | 11.5824 | Top | 70.313 | 14.358 |
| 1st Floor | 8.5344 | Top | 39.521 | 9.018 |
| GF | 5.4864 | Top | 2.346E+15 | 3.408 |
| Base | 2.4384 | Top | 0 | 0 |

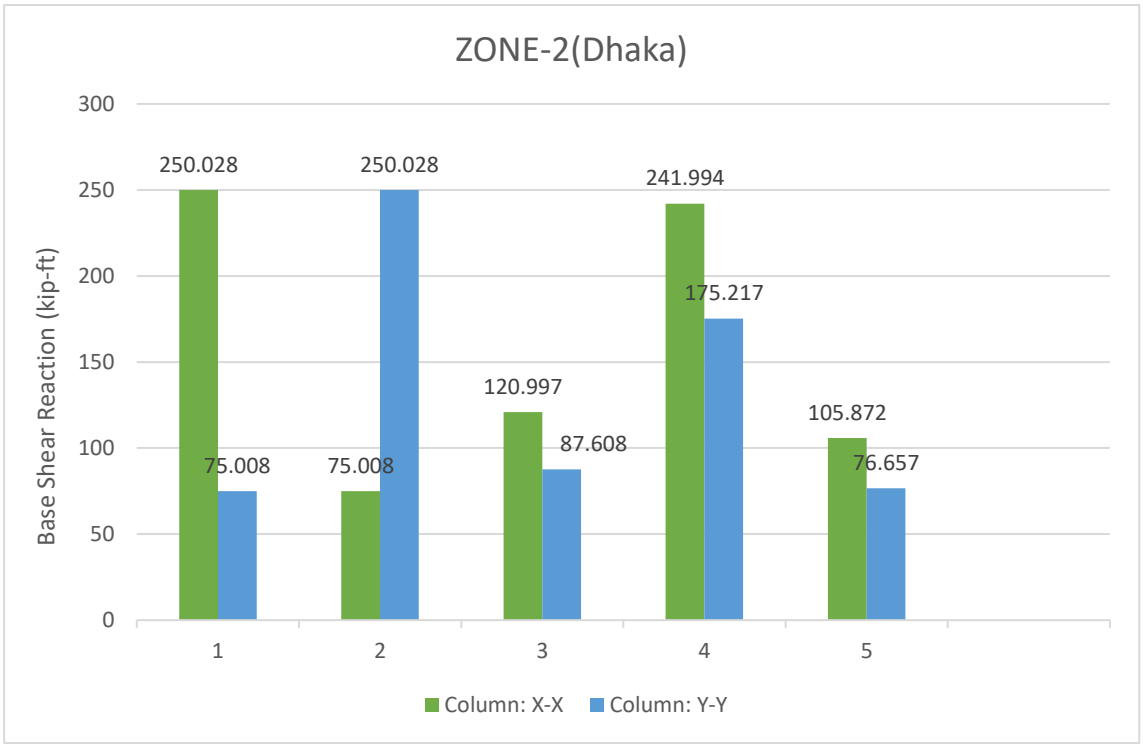
ZONE-4 X-X

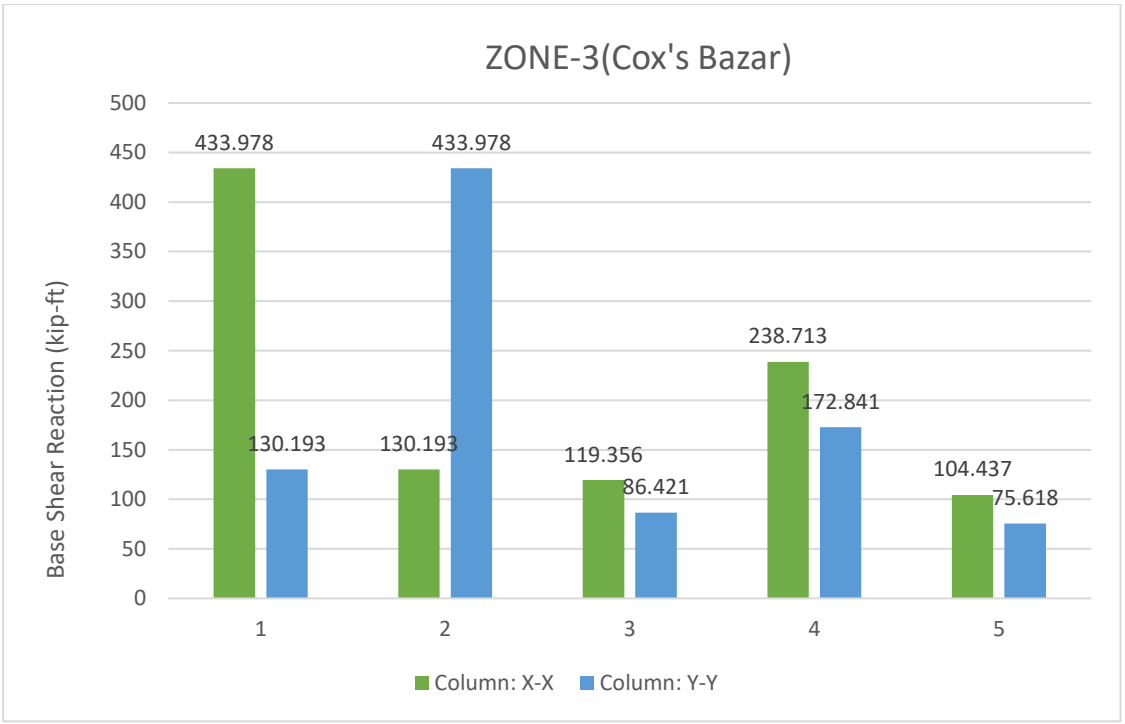
| Story | Elevation m | Location | X-Dir mm | Y-Dir mm |
|---|---|---|---|---|
| TOP | 29.8704 | Top | 2.706 | 149.761 |
| 7th Floor | 26.8224 | Top | 2.548 | 136.952 |
| 6th Floor | 23.7744 | Top | 2.332 | 121.614 |
| 5th Floor | 20.7264 | Top | 2.087 | 104.117 |
| 4th floor | 17.6784 | Top | 1.779 | 84.532 |
| 3rd floor | 14.6304 | Top | 1.396 | 63.52 |
| 2nd Floor | 11.5824 | Top | 0.946 | 42.273 |
| 1st Floor | 8.5344 | Top | 0.466 | 22.589 |
| GF | 5.4864 | Top | 0.317 | 2.346E+15 |
| Base | 2.4384 | Top | 0 | 0 |

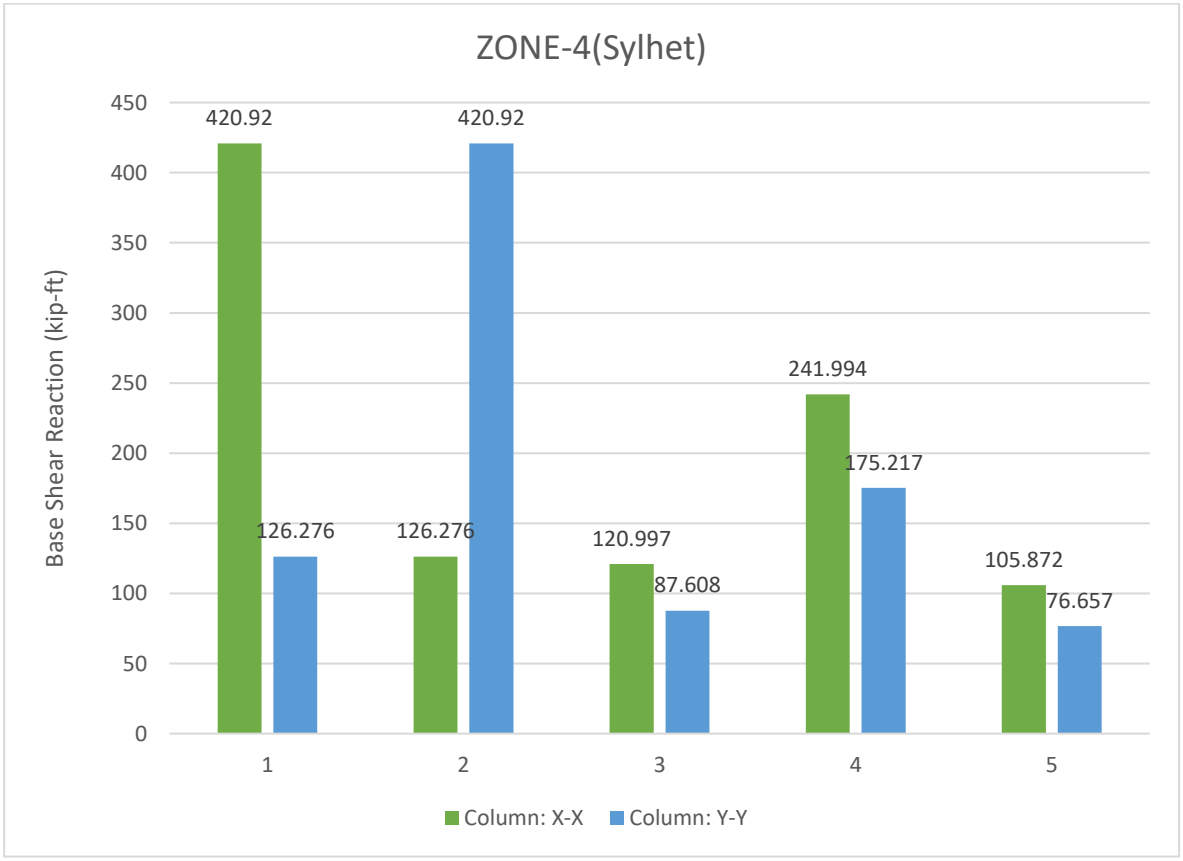
ZONE-4 Y-Y

❖ **Base Share Reaction :**




ZONE-3(Cox's Bazar)
Base Shear Reaction (kip-ft)
500
450
400
350
300
250
200
150
100
50
0
433.978
130.193
433.978
130.193
119.356
86.421
238.713
172.841
104.437
75.618
1
2
3
4
5
Column: X-X
Column: Y-Y


ZONE-4(Sylhet)
Base Shear Reaction (kip-ft)
450
400
350
300
250
200
150
100
50
0
420.92
126.276
420.92
126.276
120.997
87.608
241.994
175.217
105.872
76.657
1
2
3
4
5
Column: X-X
Column: Y-Y

# CHAPTER 5

## Conclusions and Future Works

### 5.1 CONCLUSIONS:

- ❖ Graphically data analysis Zone 4 exhibits the highest displacement in both X-X and Y-Y directions, indicating it is the most structurally vulnerable area and requires immediate reinforcement.
- ❖ Graphically Auto Lateral Load to Stories the values of Column-X-X and Column-Y-Y are almost the same in every zone.
- ❖ Graphically Story Stiffness Story stiffness remains almost constant across all seismic zones, but it is always higher in the Y-direction than in the X-direction.
- ❖ Graphically maximum story drifts the most important point Zone 3 has the highest story drift in the X-X direction indicating it is the weakest zone.

### 5.2 Limitations:

- ❖ This research was conducted using a medium-rise structural design concept.
- ✓ This study was conducted on a medium-rise (G+7) residential building.
- ✓ Architectural plan followed BNBC 2020 code.
- ✓ ETABS-2016 and AutoCAD-2017 were used for analysis and modeling.

### 5.3 Recommendation for Future Works

- ❖ The following recommendations can be made for future research work-
- ✓ The case study conducted in this research is for three districts of Bangladesh. However, the different Seismic zone coefficient and Wind varies for different parts of Bangladesh. Similar study can be performed for other parts of Bangladesh especially for different area and different seismic zones.
- ✓ Similar study can be performed for other types of buildings such as steel frames, ordinary moment resisting frames and masonry structures etc. located in different in places with different site conditions.
- ✓ To find the impact on design only the reinforcement requirement in point displacement, story drifts and longitudinal reinforcement are considered. This study can be extended of analysis Steel building.
- ✓ The current research was conducted on only one types of structural systems. Other structural systems listed in BNBC-2020, can be investigated further.
- ✓ Continuity of study on higher vertical structures in different seismic zones of Bangladesh.
- ✓ Future studies should consider taller or irregular buildings for more comprehensive analysis.
- ✓ Soil-structure interaction and different soil types should be incorporated for accuracy

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