COMPARATIVE ANALYSIS OF EARTHQUAKE RESISTANT DESIGN OF A (G+12) STORIED COMMERCIAL BUILDINGS IN DHAKA CITY THROUGH DIFFERENT PLAN CONFIGURATIONS USING ETABS SOFTWARE.

By

Md. Saiful Islam

Md. Sazib Hossain

Md. Saymoon Islam

Md. Mehedi Hasan

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

Department of Civil Engineering

Sonargaon University

147/I, Green Road, Dhaka-1215, Bangladesh

Section: 20B

Fall-2023

COMPARATIVE ANALYSIS OF EARTHQUAKE RESISTANT DESIGN OF A (G+12) STORIED COMMERCIAL BUILDINGS IN DHAKA CITY THROUGH DIFFERENT PLAN CONFIGURATIONS USING ETABS SOFTWARE.

By

MD. SAIFUL ISLAM	BCE 2002020034
MD. SAZIB HOSSAIN	BCE 2002020087
MD. SAYMOON ISLAM	BCE 2002020088
MD. MEHEDI HASAN	BCE 1901016024

Supervisor

Hamamah Sadiqa
Lecturer
Department of Civil Engineering
Sonargaon University, (SU)

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

Department of Civil Engineering

Sonargaon University

147/I, Green Road, Dhaka-1215, Bangladesh

Section: 20B

Fall-202

BOARD OF EXAMINERS

The thesis titled "Comparative analysis of earthquake resistant design of a (G+12) storied commercial buildings in dhaka city through different plan configurations using ETABS software" submitted by Md. Saiful Islam ID:BCE2002020034, Md. Sazib Hossain ID:BCE2002020087, Md. Saymoon Islam ID:BCE2002020088, Md. Mehedi Hasan ID: BCE1901016024, has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Bachelor of Science in Civil Engineering on Date-of-Defense.

1.	Hamamah Sadiqa Lecturer Department of Civil Engineering Sonargaon University, (SU)	Chairman
2.	Internal / External Member	Member
3.	Internal / External Member	Member

DECLARATION

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

STUDENT NAME	STUDENT ID.	SIGNATURE
Md. Saiful Islam	BCE 2002020034	
Md. Sazib Hossain	BCE 2002020087	
Md. Saymoon Islam	BCE 2002020088	
Md. Mehedi Hasan	BCE 1901016024	

Dedicated

to

“Our Honourable Teachers

&

Parents”

ACKNOWLEDGEMENTS

All praises and profound gratitude to the almighty Allah who is the most beneficent and the most merciful for allowing great opportunity and ability to bring this effort to fruition safety and peacefully.

The authors expresses sincere appreciation to Supervisor, Hamamah Sadiqa, Lecturer, Department of Civil Engineering, Sonargaon University, Dhaka, Bangladesh, for her cordial guidance and support during our research efforts and course work her keen interest and valuable suggestions, constructive criticisms and proper advice at every stage made this research valuable.

Secondly, we would also like to thank the Civil Engineering Department of Sonargaon University including Head of the department Lutfor Rahman sir for helping us a lot in finalizing this project within the limited time frame. Also sincerely grateful for the cooperation of all the faculties, officers and employees of Sonargaon University.

Finally, the authors express their gratitude and appreciation to their beloved parents and family members, without who’s blessing the research work would not be possible successfully.

ABSTRACT

The objective of this study was to the Comparative Analysis of Earth Quake Resistant Design of (G+12) Storied Commercial Buildings in Dhaka City through Different Plan Configurations Using ETABS Software. Structural designing of a building is the responsibility of a Civil Engineer. Engineer must keep in mind the economic, aesthetics, safety and other aspects of any project. As per requirement, structural design and analysis of a (G+12) storied residential building has been done by considering all types of gravitational and lateral load.3d nonlinear computer-aided analysis is done by using ETABS software (Extended Three Dimensional Analysis of Building System). The rapid urban growth is causing further deterioration and increasing the vulnerability of human lives, economy and infrastructures. When natural hazard like earthquake will hit this large metropolitan city, it may create catastrophe and the whole country may suffer. One of the major challenges is to reduce the vulnerability caused by earthquake by taking necessary steps. At the same time, it is very much essential to develop an effective earthquake risk management plan, which requires long-term plan of action and involves multidisciplinary contribution. Considering this situation this paper is about the comparative analysis of earthquake resistant design of a (G+12) storied commercial buildings in dhaka city through different plan configurations using ETABS software. The properties of beams and columns are used from BNBC-2020 in ETABS model. Building story flow results are compared for earthquake-resistant buildings.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1
INTRODUCTION

1.1 Background and Motivations

The dynamic urban landscape of Dhaka City, where rapid urbanization and population growth are prevalent, the construction of high-rise buildings is indispensable to meet the escalating demands for commercial spaces. However, the seismic vulnerability of the region necessitates a meticulous approach to structural design, especially in the context of earthquake-resistant considerations. This study delves into the Comparative Analysis of Earthquake-Resistant Design of a (G+12) Storied Commercial Building in Dhaka City, employing various plan configurations and utilizing the sophisticated ETABS software.

The seismic hazard in Dhaka City, situated in a seismically active region, underscores the imperative for robust structural engineering practices to ensure the safety and resilience of high-rise structures. The selection of an appropriate plan configuration is crucial, as it significantly influences the distribution of seismic forces and moments throughout the building. This research aims to evaluate and compare the earthquake-resistant performance of (G+12) storied commercial buildings with different plan configurations, exploring the capabilities of the ETABS software for structural analysis and design.

ETABS a widely used finite element analysis and design software, offers a comprehensive platform for simulating and assessing structural behavior under seismic loads. Through a parametric study, this research will investigate how variations in plan configurations, such as rectangular, L-shaped, and T-shaped layouts, impact the seismic performance of the building. By employing advanced analysis techniques and considering various factors like material properties, soil conditions, and building geometry, the study seeks to provide valuable insights into optimizing earthquake-resistant design strategies for high-rise commercial buildings in Dhaka City.

The outcomes of this research are expected to contribute to the advancement of seismic design practices in urban environments, particularly in regions prone to seismic activity. As the findings unfold, they may guide architects, structural engineers, and policymakers in making informed decisions regarding the design and construction of resilient commercial structures, ultimately enhancing the seismic safety of Dhaka City's built environment.

1.2 Research Objectives and Overview

The objectives of the research work are as follows:

a) To study the seismic behavior of building by using IS 1893:2002.

b) To study the multi storied (G+12) building by using Push over analysis.

c) To compare the results of story drift of buildings for earthquake resistant buildings.

1.3 Organization of The Thesis

A title and brief descriptions of the content of each chapter. An example guide is provided below.

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

Chapter 2: Literature Review. This chapter review explores the earthquake-resistant design of multi-story commercial buildings in Dhaka city (G+12) with a focus on different plan configurations using ETABS 16.2.1 version.

Chapter 3: Methodology. This chapter describes the methodology adopted to carry out the research.

Chapter 4: Results and Discussion. This chapter describes the results of Comparative analysis of earthquake resistant design of a (G+12) storied commercial buildings in dhaka city through different plan configurations using ETABS software.

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

Most buildings in our country are still specifically designed for loads of gravity. Among Bangladesh's structural designers, the understanding and application of seismic details are very limited. This is quite unexpected, especially since a chapter on detailing reinforced concrete structures is included in the Bangladesh National Building Code BNBC (PART 6, Chapter 8). The Earthquake Resistant Structure Design Criteria are used as a code of practice to analyze and design earthquake-resistant buildings.

2.2 Scope of The Study

The objective of this limited study was to the Comparative Analysis of Earth Quake Resistant Design of (G+12) Storied Commercial Buildings in Dhaka City through Different Plan Configurations Using ETABS Software. The study highlights the effect of earthquake in Different Plan Configurations that is in which is considered in the earthquake performance evaluation of buildings. The study emphasis and discusses the effect of Different Plan Configurations on the earthquake performance of (G+12) storied commercial building structure. The entire process of modeling, analysis and design of all the primary elements for all the models are carried by using ETABS 16 version software [1].

2.3 Review of Some Existing Literature

Mr Abhay Guleria studied the structural behavior of multi-storey building for different plan configurations like rectangular, C, L and I-shape. In his study he discussed about Post analysis of the structure, maximum shear forces, bending moments, and maximum storey displacement and then compared for all the analyzed cases [2].

Mr A. Dhumal and Dr. A. Deshmukh investigate the effect of different plan configurations on performers of building. in this stady they observed the maximum shear force, maximum bending moment, maximum story displacement and story drift for different plan configuration for skyscrapers. They design G +30 storey structure as per code (IS 1893:2016 and IS 875:2016 part III) by ETABS software and studied the comparative change in lateral drift, the effect of overturning moment cause due to earthquake and wind forces for different plan configurations [3].

J.M. Raisul Islam Sohag and Kaushik Majumdar in their study, evaluated the performance of G +12 storey residential buildings in different seismic zones of Bangladesh for different plan configurations (H shape, L shape and rectangular shape) following BNBC 2020 guidelines and using ETABS software. Maximum story drifts, Story Displacement, and overturning moments are analyzed in four seismic zones of Bangladesh by imposing different types of lateral loads to obtain the desired results.[4]

CHAPTER 3
METHODOLOGY

3.1 Introduction

The vulnerability of urban areas to earthquake risk has emphasized the seismic performance of buildings, especially in earthquake-prone areas. Dhaka city, located in an earthquake active region, demands a comprehensive understanding of earthquake-resistant design practices. The aim of this study is to conduct a comparative analysis of earthquake-resistant designs for commercial buildings of (G+12) storeys in Dhaka city. The focus will be on evaluating seismic performance through various plan configurations using advanced structural analysis software ETABS version 16.2.1. this research endeavors to provide valuable insights into optimizing the seismic performance of commercial buildings in Dhaka City, facilitating the development of safer and more resilient urban structures.

3.2 Methodology Overview

3.2.1 Site selection

Site analysis is very important before starting any construction. A detailed study of the site and surrounding areas helps to design the project efficiently. For site selection, the site at New Eskaton was finalized by visiting various places in Dhaka (eg. Savar, New Eskaton, Mohakhali and Azimpur).

3.2.2 Plan Configuration

An RCC framed structure is basically an assembly of slabs Beams, columns and foundations act as a unit interconnected with each other. The load transfer mechanism in this structure is slab to beam, beam to column and column to foundation, which in turn carry the soil load. In this structural analysis study we adopted five cases assuming different shapes of the same structure, as explained below.

1. Plan-1: Rectangular Shape (No Punch)
2. Plan-2: Rectangular Shape (Center Punch)
3. Plan-3: H-Shape
4. Plan-4: L-Shape
5. Plan-5: C-Shape

3.2.3 Grid Preparation

Grid lines are imaginary lines that are used in a plan to help you see where you are looking quickly. They are visible on all levels and in all views. They are numbered horizontally and lettered vertically. The building of 60ft x 68ft plan considers 5 grids in X direction and 7 grids in Y direction.

3.2.4 ETABS Plan and 3D View

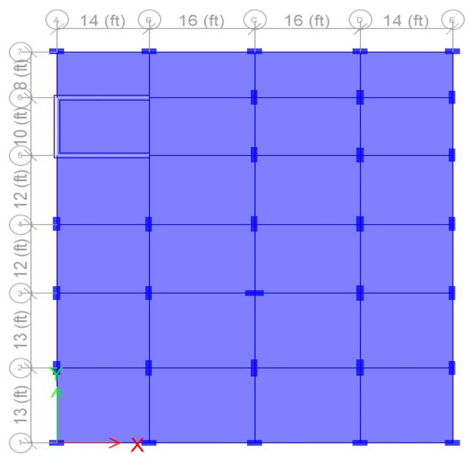

Figure 3-1 Plan view of (G+12) storied commercial building for Plan 01

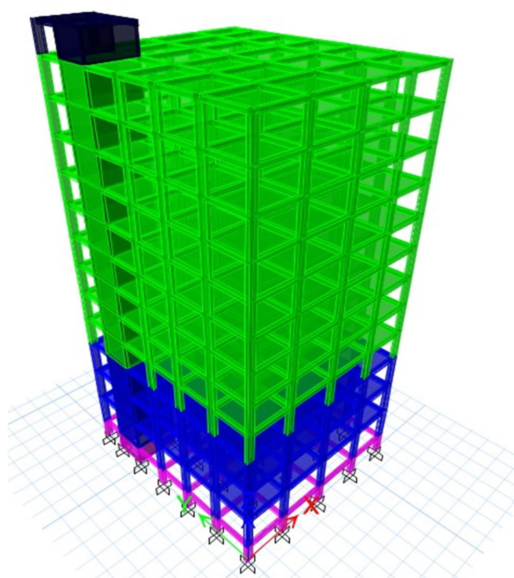

Figure 3-2 3D view of (G+12) storied commercial building for Plan 01

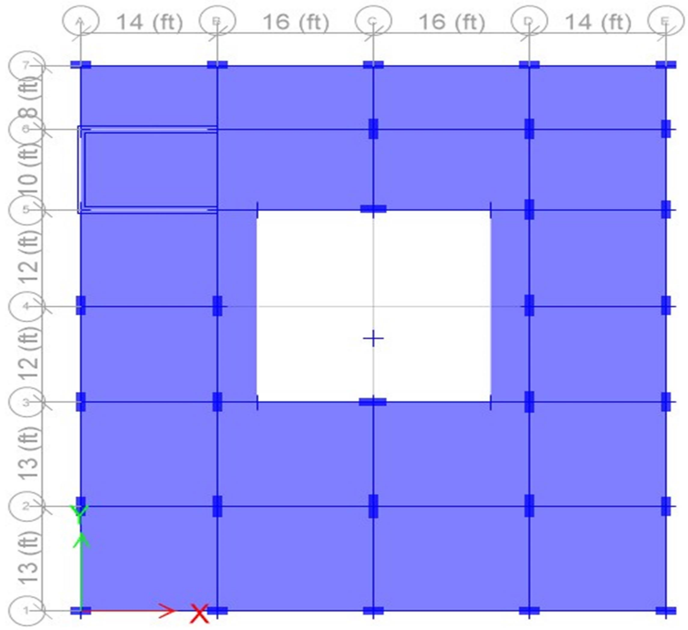

Figure 3-3 Plan view of (G+12) storied commercial building for Plan 02

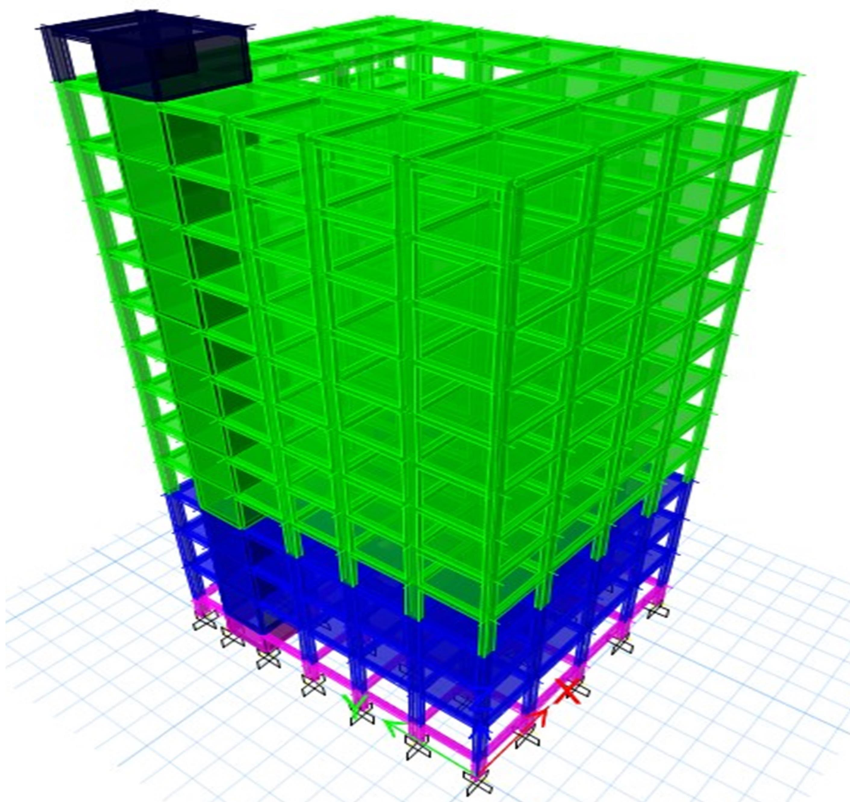

Figure 3-4 3D view of (G+12) storied commercial building for Plan 02

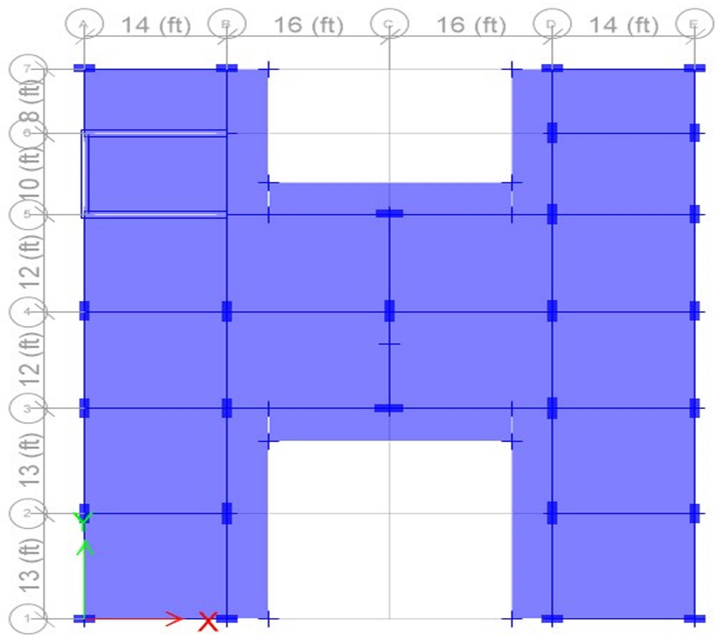

Figure 3-5 Plan view of (G+12) storied commercial building for Plan 03

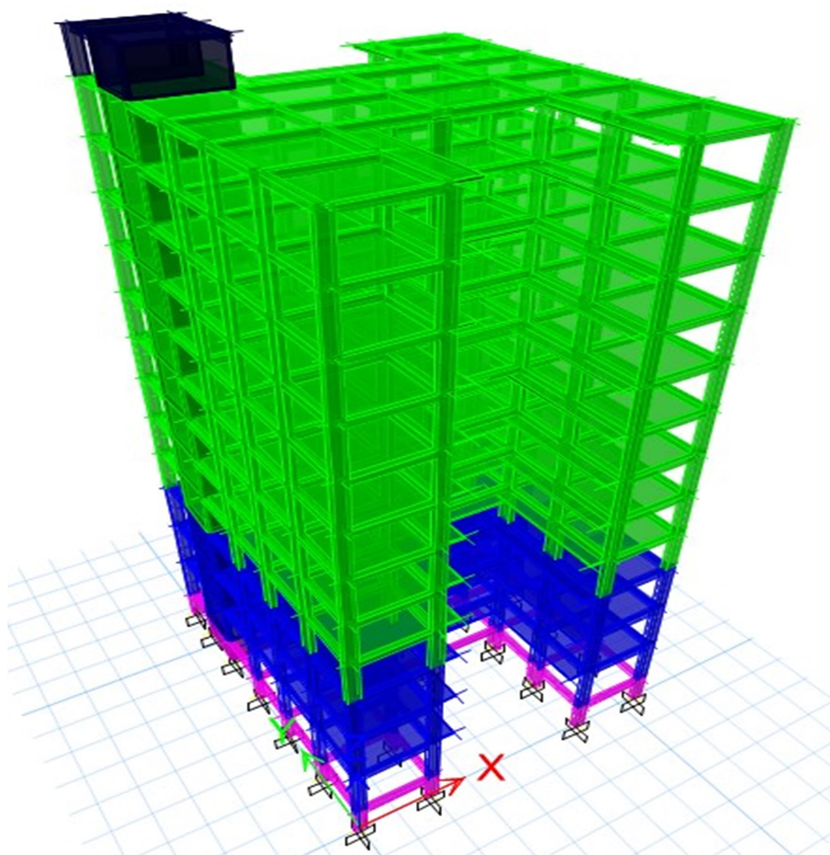

Figure 3-6 3D view of (G+12) storied commercial building for Plan 03

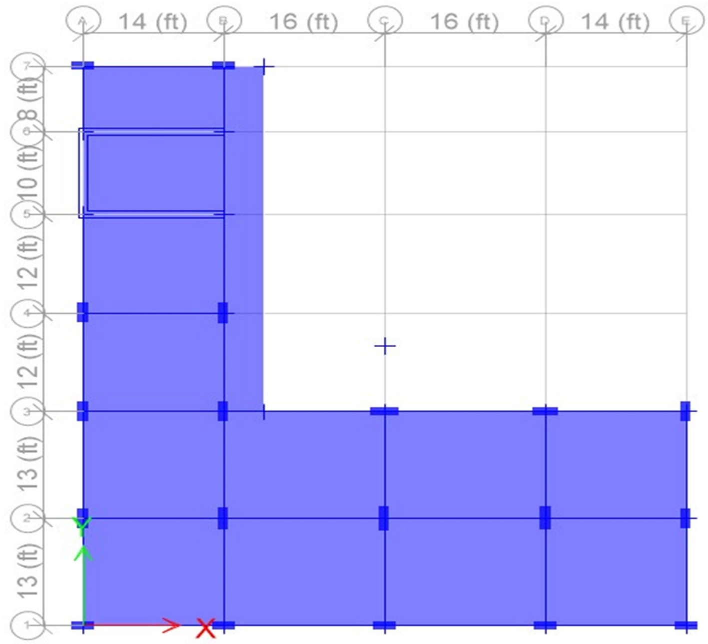

Figure 3-7 Plan view of (G+12) storied commercial building Plan 04

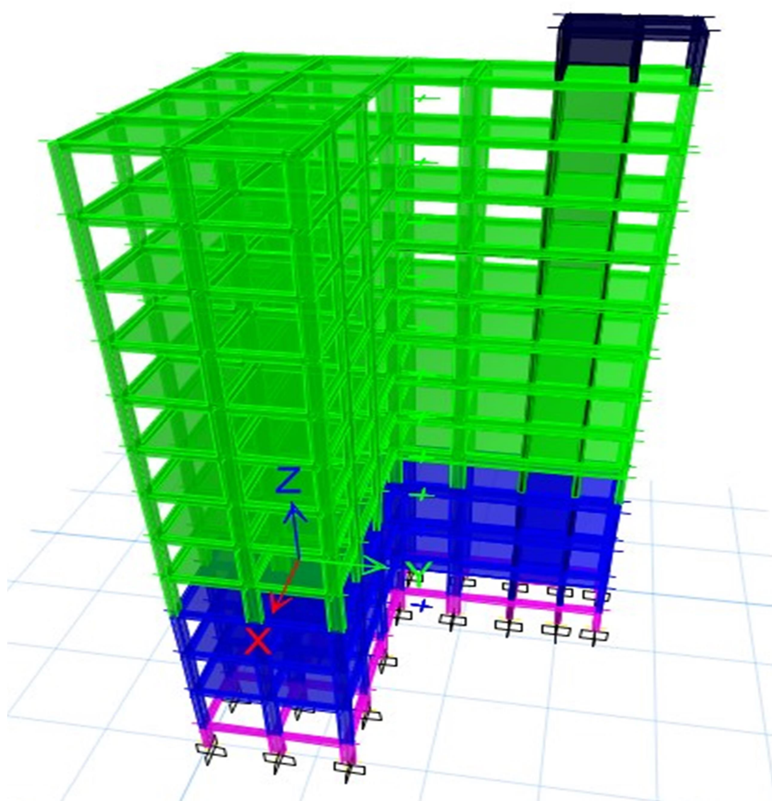

Figure 3-8 3D view of (G+12) storied commercial building for Plan 04

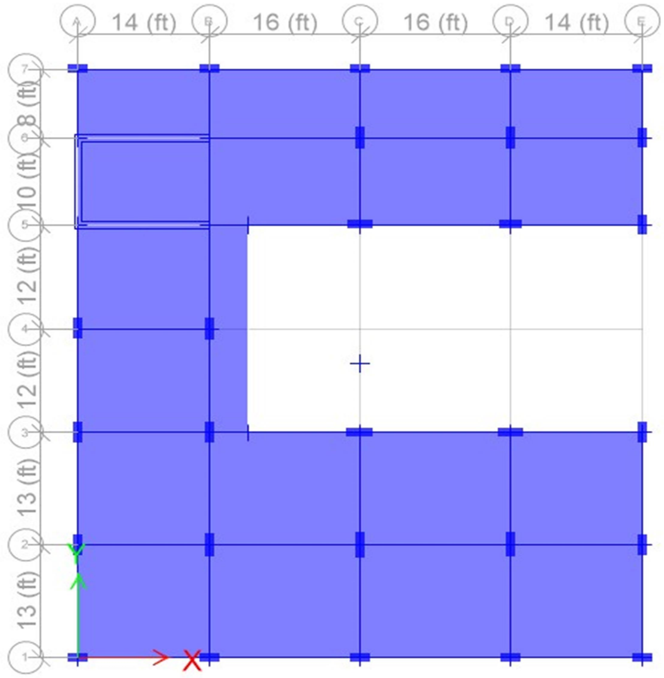

Figure 3-9 Plan view of (G+12) storied commercial building for Plan 05

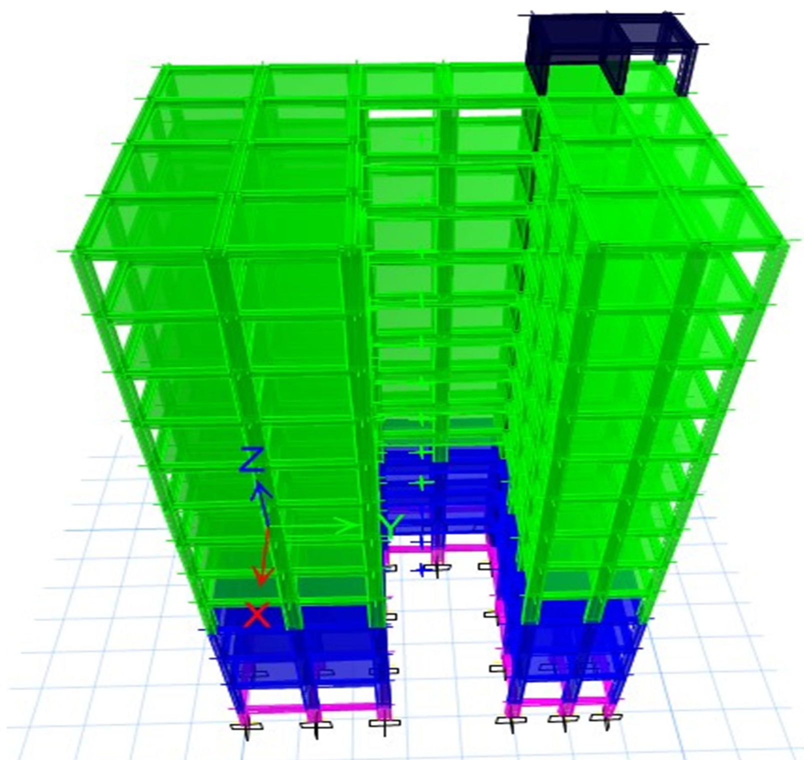

Figure 3-10 3D view of (G+12) storied commercial building for Plan 05

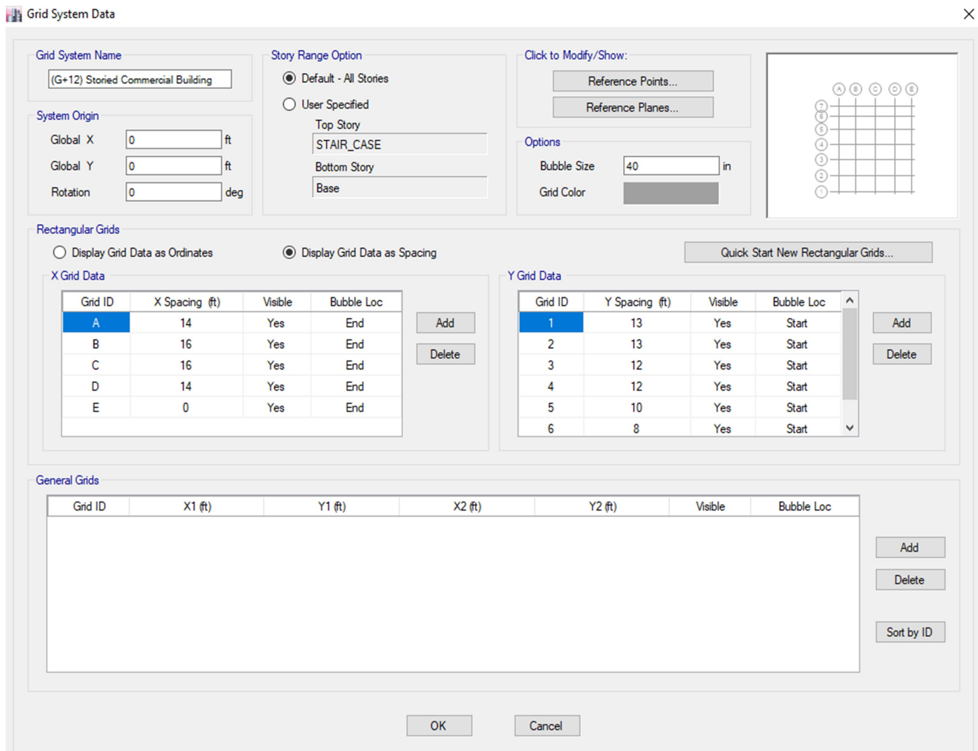

Figure 3-11 Grid system data of (G+12) storied commercial building

3.2.5 Providing Material Property

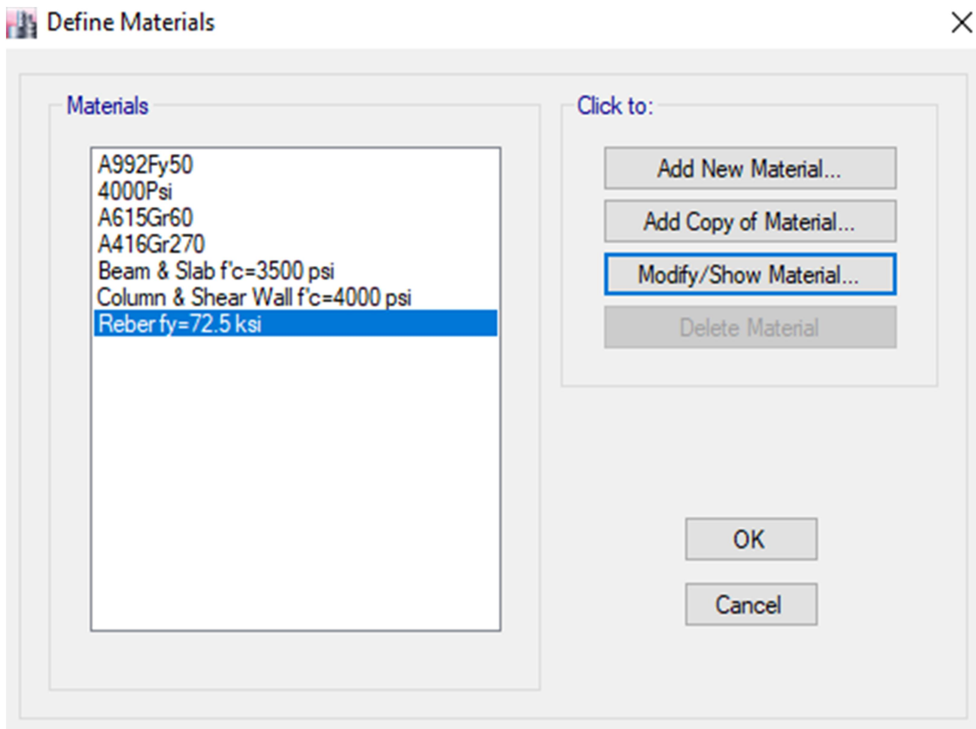

Figure 3-12 Material property data of (G+12) storied commercial building

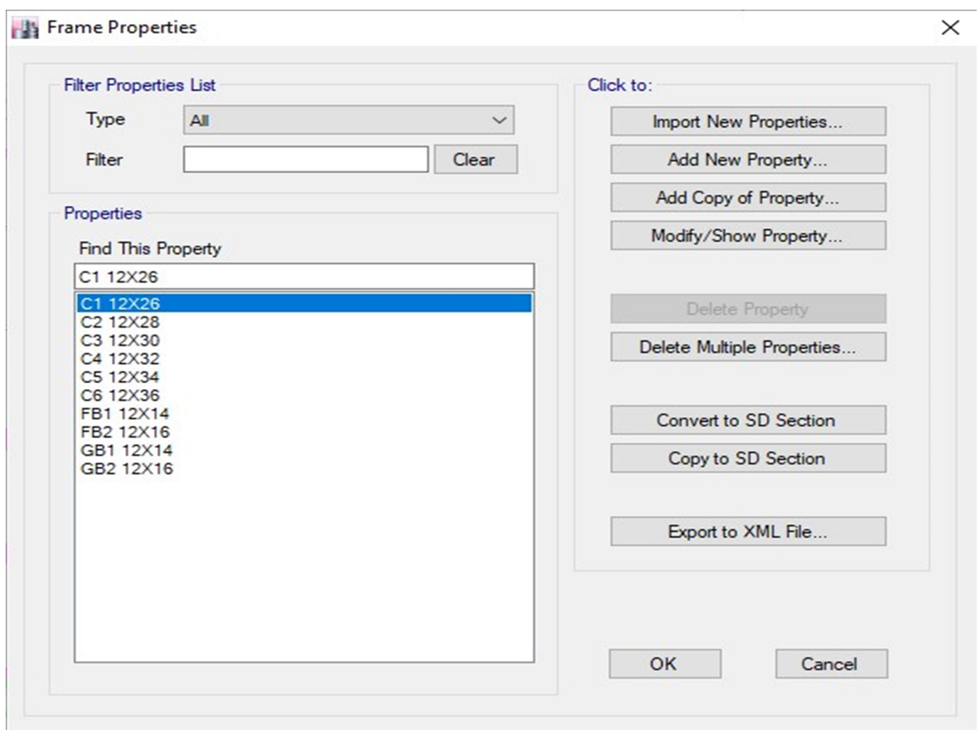

Figure 3-13 Frame properties of (G+12) storied commercial building

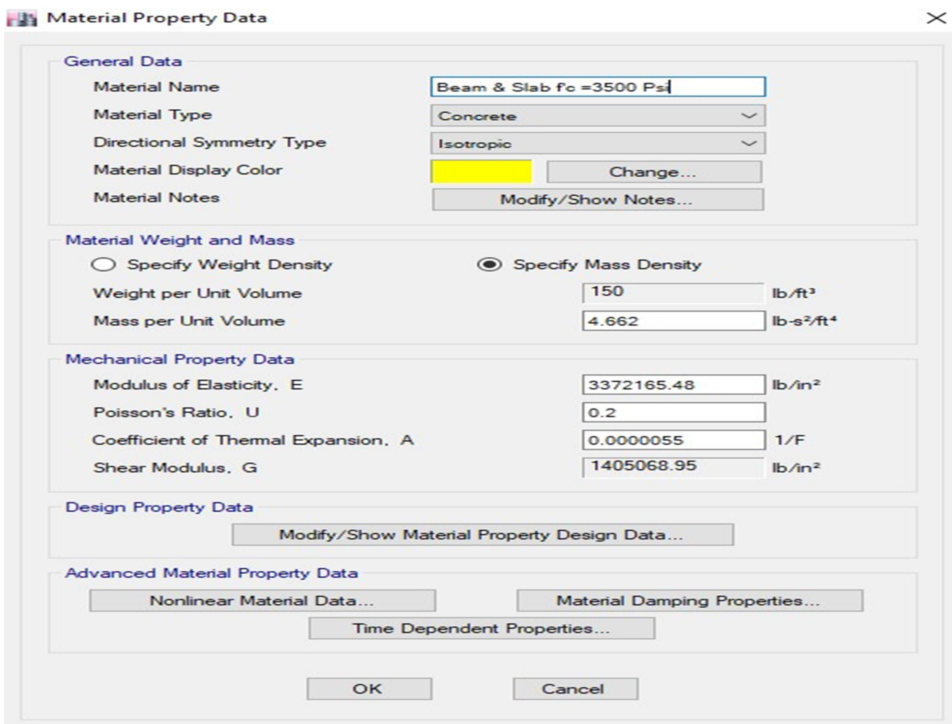

Figure 3-14 Beam & slab material property data of (G+12) storied commercial building

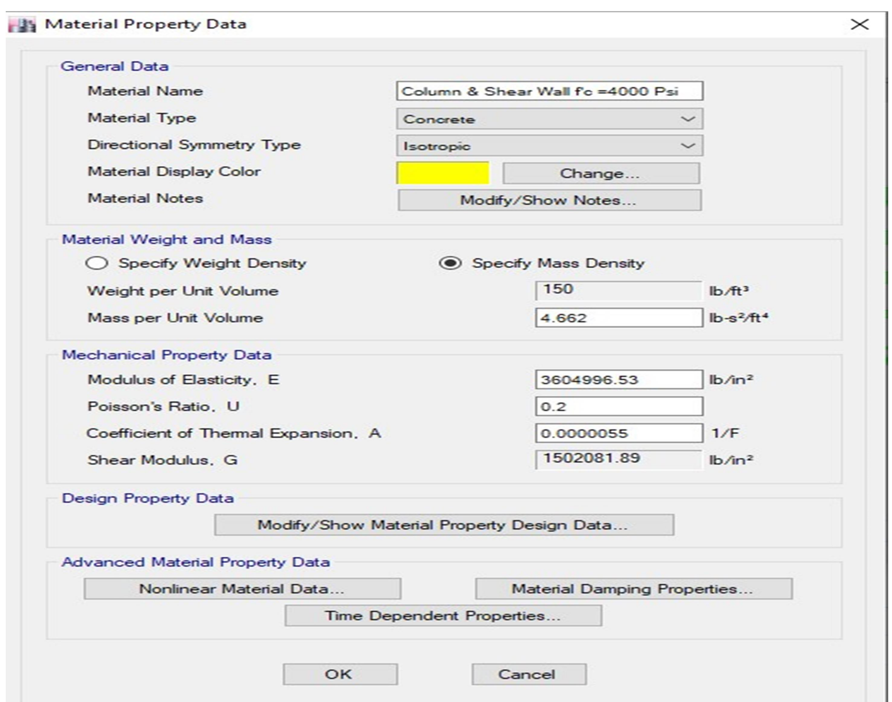

Figure 3-15 Column & shear wall material property data of (G+12) storied commercial building.

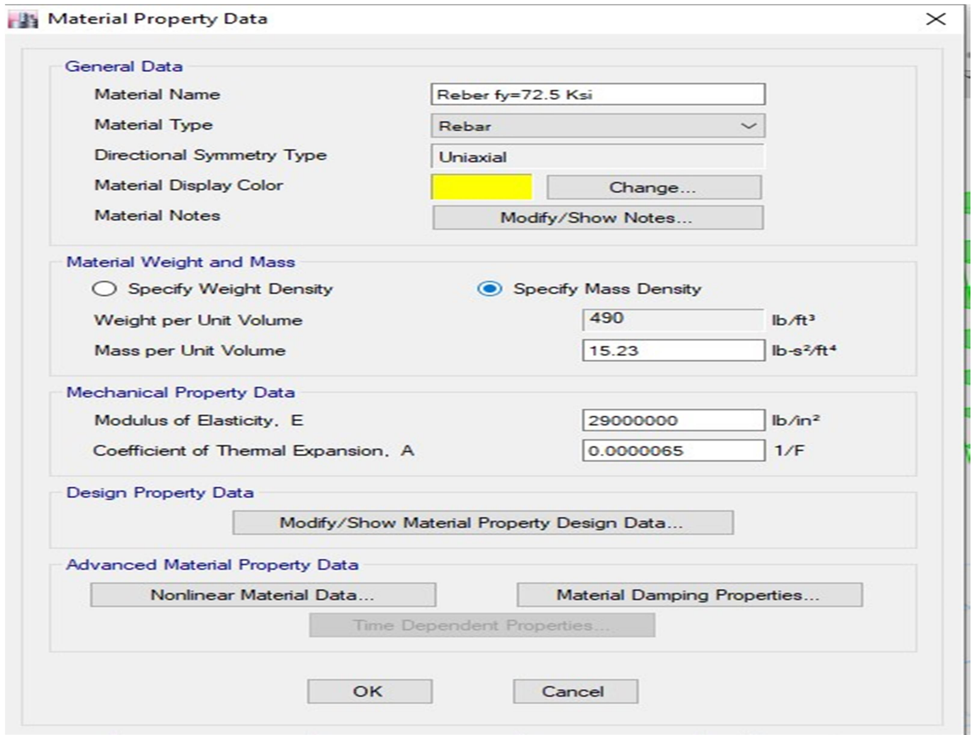

Figure 3-16 Reber material property data of (G+12) storied sommercial suilding.

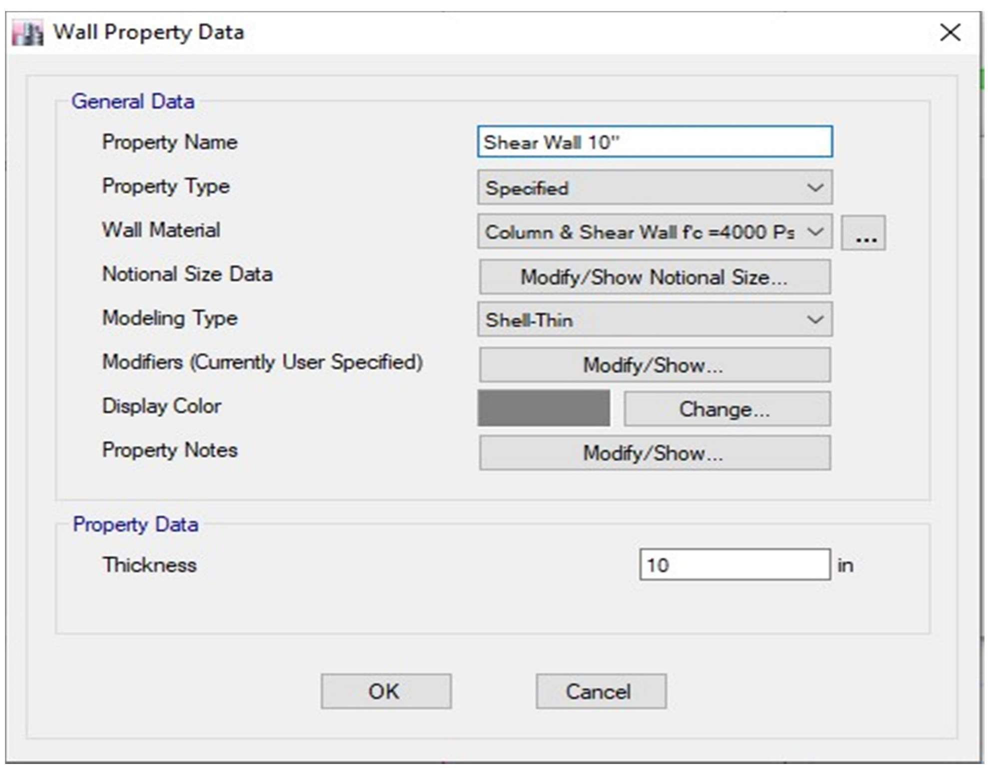

Figure 3-17 Shear wall property data of (G+12) storied commercial building.

3.2.6 Providing Load Pattern and Load Combination

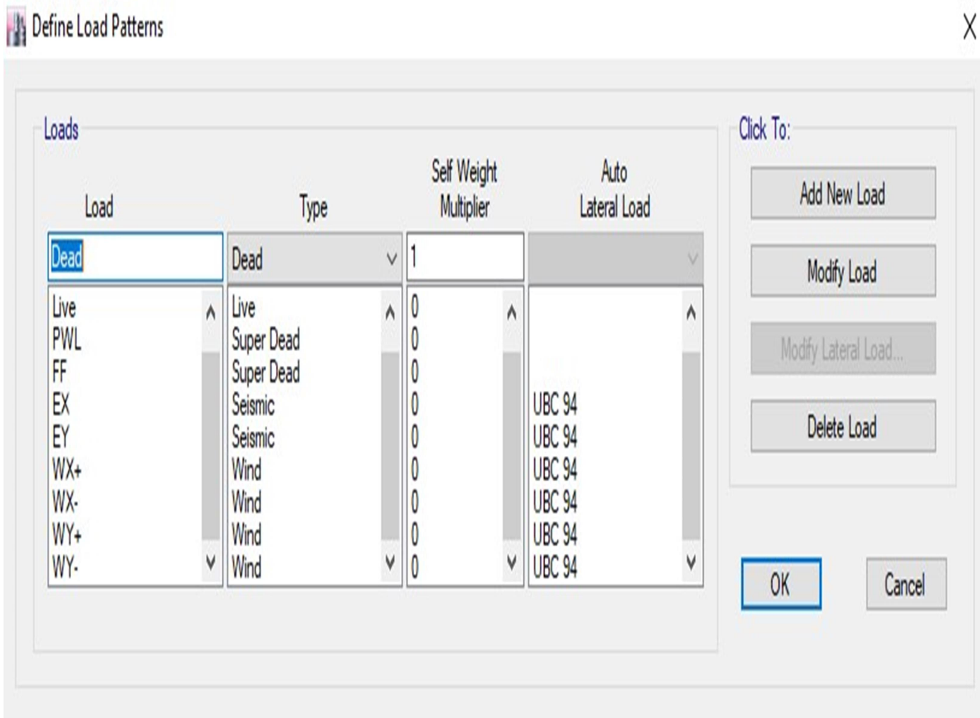

Figure 3-18 Load pattern of (G+12) storied commercial building.

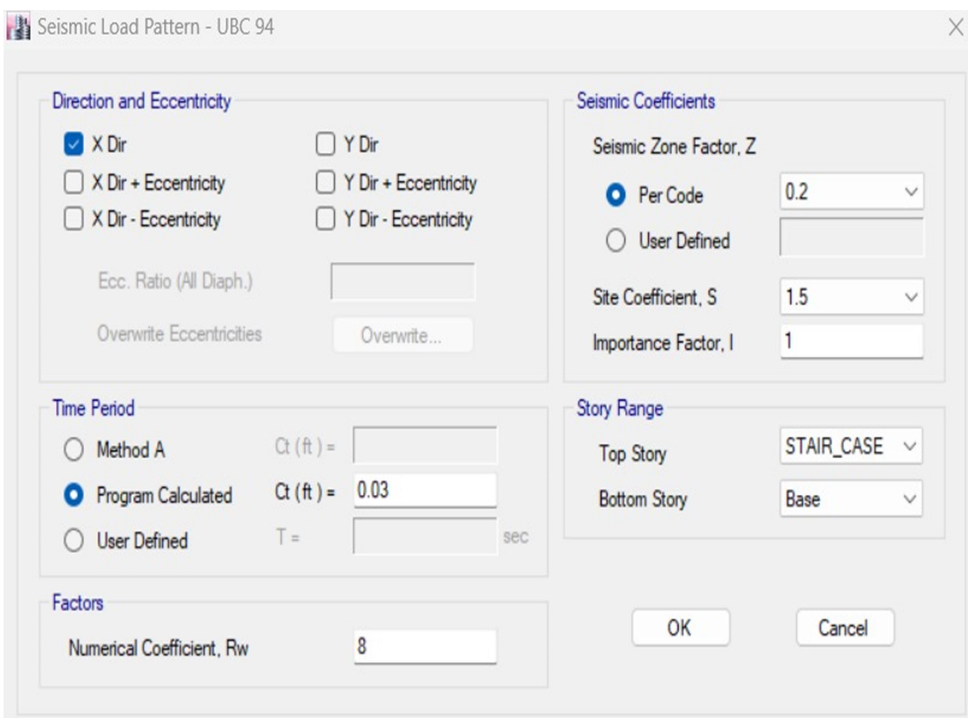

Figure 3-19 Seismic load pattern Ex of (G+12) storied commercial building

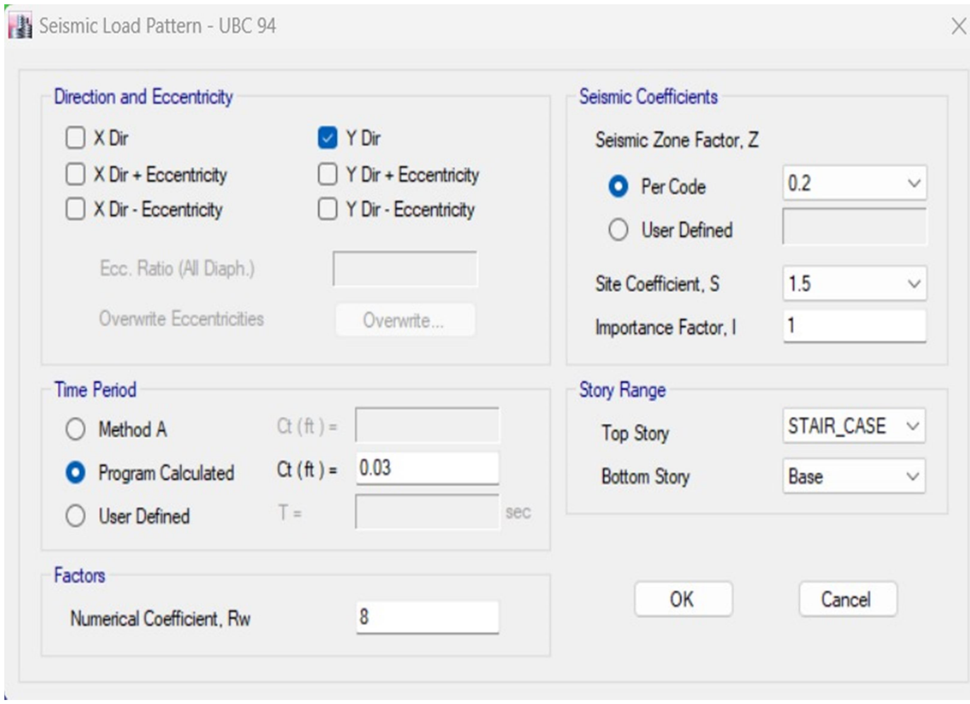

Figure 3-20 Seismic load pattern Ey of (G+12) storied commercial building.

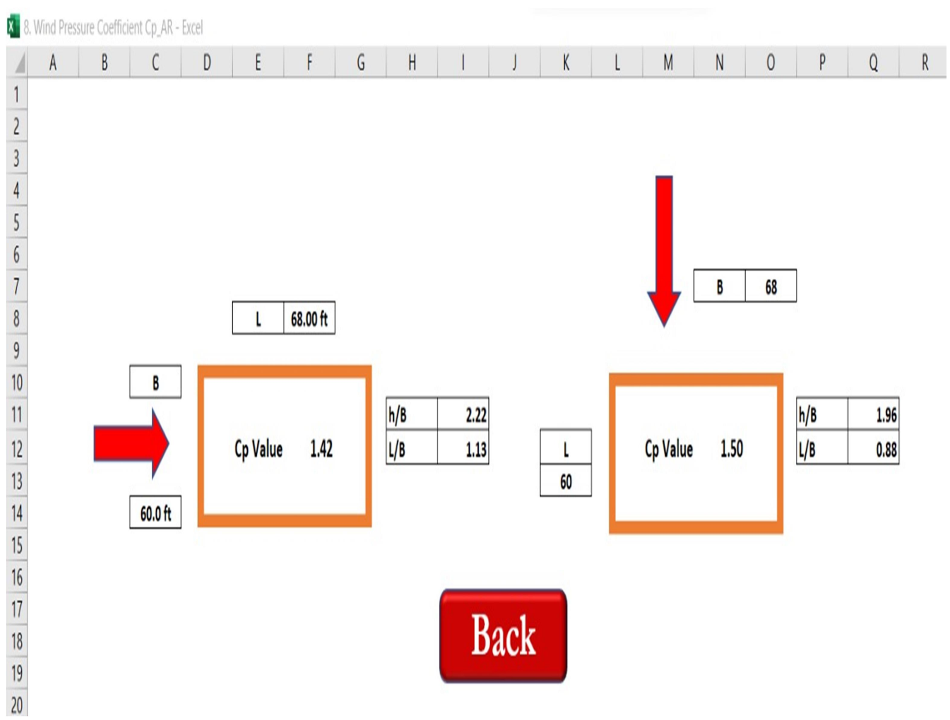

Figure 3-21 Wind pressure coefficient Cp of (G+12) storied commercial building

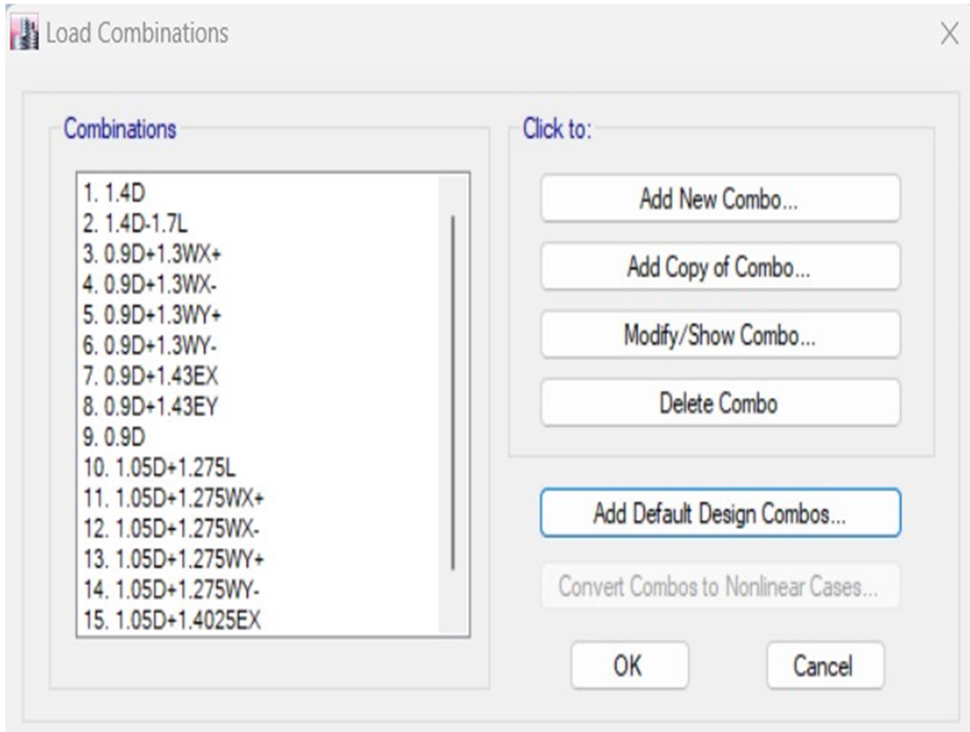

Figure 3-22 Load combination of (G+12) storied commercial building.

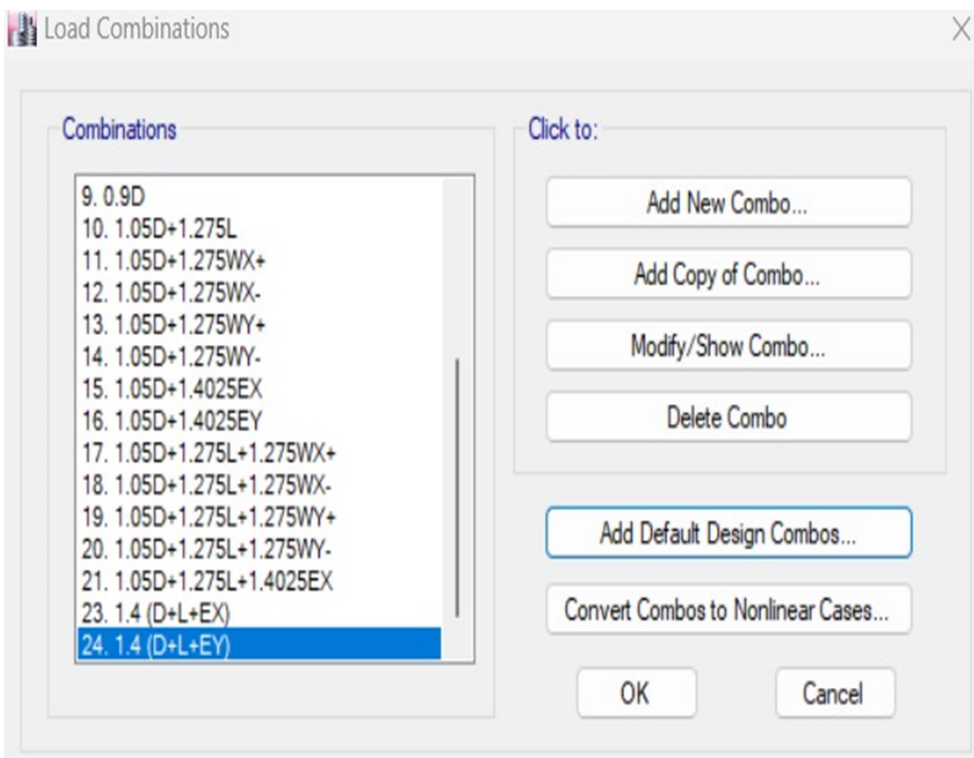

Figure 3-23 Load combination of (G+12) sStoried commercial building.

3.2.7 Detailed Design Data

Table 3. 1 Design data

Sl No	Building parameters	Description	
1.	Type of frame	MRF	
2.	Seismic Zone	Zone II : 0.20 (as per BNBC 2020)	
3.	Importance Factor (I)	1	
4.	Site Coefficient coefficient, R	1.50	
5.	**Loadings**		
	i) Dead Load	Self-weight of structural elements	
	ii) Floor Finishes	20 psf	
	iii) Partition Wall	50 psf	
	iv) Live Loads	84 psf	
6.	**Floor to floor height**		
	Foundation to Pinth Level	07 ft	
	1st to 3rd Floor	12 ft	
	5th to 12th Floor	10 ft	
	Satir case	08 ft	
7.	Specific Weight of RCC	150 pcf	
8.	Load Combinations	i.	1.4D
		ii.	1.4D - l.7L
		iii.	0.9D+l.3WX+
		iv.	0.9D+l.3WX-
		v.	0.9D+l.3WY+
		vi.	0.9D+l.3WY-
		vii.	0.9D+l.43EX
		viii.	0.9D+l.43EY
		ix.	0.9D
		x.	1.05D+1.275L
		xi.	1.05D+1.275WX+
		xii.	1.05D+1.275WX-
		xiii.	1.05D+1.275WY+
		xiv.	1.05D+1.275WY-
		xv.	1.05D+1.4025EX
		xvi.	1.05D+1.4025EY
		xvii.	1.05D+1.275L+1.275WX+
		xviii.	1.05D+1.275L+1.275WX-
		xix.	1.05D+1.275L+1.275WY+
		xx.	1.05D+1.275L+1.275WY-
		xxi.	1.05D+1.275L+1.4025EX
		xxii.	1.4 (D+L+EX)
		xxiii.	1.4 (D+L+EY)
9.	Size of Beam (Inch)	FB1 (12×14), FB2 (12×16), GB1 (12×14), GB2 (12×16)	
10.	Size of Column (Inch)	C1 (12×26), C2 (12×28), C3 (12×30), C4 (12×32), C5 (12×34), C6 (12×36)	

11.	Thickness of Slab	Floor Slab (5"), Waist Slab (7")
12.	Thickness of Shear Wall	10 Inch
13.	Material Properties	Slab & Beam (3,500 psi) and Column & Shear Wall (4,000 psi)
14.	**Modulus of Elasticity**	
	(i) Concrete	3372.165 Ksi & 3604.997 Ksi
	(ii) Reber/Reinforcement	29×106 Psi

3.3 Wind Load

3.3.1 General

Scope: Buildings and other structures, including the Main Wind-Force Resisting System (MWFRS) and all components and cladding thereof, shall be designed and constructed to resist wind loads as specified herein [5].

3.3.2 Direction of Wind

Structural design for wind forces shall be based on assumption that wind may blow from any horizontal direction [5].

3.3.3 Design Considerations

Design wind load on the primary framing systems and components of a building or structure shall be determined on the basis of the procedures provided in Sec 2.4 Chapter 2 Part 6 considering the basic wind speed, shape and size of the building, and the terrain exposure condition of the site. For slender buildings and structures, dynamic response characteristics, such as fundamental natural frequency, shall be determined to estimate gust response coefficient. Load effects, such as forces, moments, and deflections etc. on various components of building due to wind shall be determined from static analysis of the structure as specified in Sec 1.2.7.1 of this Chapter [5].

3.3.4 Topographic Factor

The wind speed-up effect shall be included in the calculation of design wind loads by using the factor K_{zt}:

$$K_{zt} = (1 + K_1 + K_2 + K_3)^2$$

Where, K_1, K_2 and K_3 are given in Figure 6.2.4. If site conditions and locations of structures do not meet all the conditions specified in Sec 2.4.7.1 then $K_{zt} = 1.0$[5].

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Introduction

The introduction aims to provide a context for the research, emphasizing the critical need for earthquake-resistant designs in urban areas like Dhaka. The choice of a (G+12) commercial building as the subject of investigation reflects the relevance of the study to contemporary construction practices and potential seismic threats.

4.2 Story Drift

The horizontal deflection at the top of the story relative to bottom of the storey. Maximum story drift corresponding to the design lateral force including displacement due to vertical deformation of the isolation system shall not exceed the following limits:

- The maximum story drift of the structure above the isolation system calculated by response spectrum analysis shall not exceed $0.015h_{sx}$
- The maximum story drift of the structure above the isolation system calculated by nonlinear time history analysis shall not exceed $0.020\ h_{sx}$

The storey drift shall be calculated as in Sec 2.5.7.7 except that C_d for the isolated structure shall be taken equal to R_I and importance factor equal to 1.0[5].

4.2.1 Deflection And Storey Drift

The deflections (δx) of level at the center of the mass shall be determined in accordance with the following equation:

$$\delta x = \frac{C_d\ \delta_{xe}}{I}$$

Where, C_d = Deflection amplification factor given in Table 6.2.19

δ_{xe} = Deflection determined by an elastic analysis

I = Importance factor defined in Table 6.2.17

The design storey drift at storey shall be computed as the difference of the deflections at the centers of mass at the top and bottom of the story under consideration:[5].

$$\Delta x = \delta x - \delta x{-}1$$

4.2.2 Storey Drift Limitation

Storey drift is the horizontal displacement of one level of a building or structure relative to the level above or below due to the design gravity (dead and live loads) or lateral forces (e.g. wind and earthquake loads). Calculated storey drift shall include both translational and torsional deflections and conform to the following requirements:

(a) Storey drift, Δ, for loads other than earthquake loads, shall be limited as follows:

$\Delta \leq 0.005h$ for T < 0.7 second

$\Delta \leq 0.004h$ for T ≥ 0.7 second

$\Delta \leq 0.0025h$ for unreinforced masonry structure

Where, h = height of floor. The period used in this calculation shall be the same as that used for determining the base shear in Sec 2.5.7.2

(b) The drift limits set out in (a) above may be exceeded where it can be demonstrated that greater drift can be tolerated by both structural and nonstructural elements without affecting life safety.

(c) For earthquake loads, the story drift, Δ shall be limited in accordance with the limits set forth in Sec 2.5.14.1[5].

Table 4. 1 Allowable storey drift limit (Δa) (Table 6.2.21 BNBC 2020) [5]

Structure	Occupancy Category		
	I and II	III	IV
Structures, other than masonry shear wall structures, 4 stories or less with interior walls, partitions, ceilings and exterior wall systems that have been designed to accommodate the story drifts.	$0.025h_{sx}$	$0.020h_{sx}$	$0.015h_{sx}$
Masonry cantilever shear wall structures	$0.010h_{sx}$	$0.010h_{sx}$	$0.010h_{sx}$
Other masonry shear wall structures	$0.007h_{sx}$	$0.007h_{sx}$	$0.007h_{sx}$
All other structures	$0.020h_{sx}$	$0.015h_{sx}$	$0.010h_{sx}$

4.2.3 Storey Drift Analysis

The drifts obtained from the analysis of five different plan configurations are given below respectively.

4.2.3.1 Story Drift Analysis for Ex

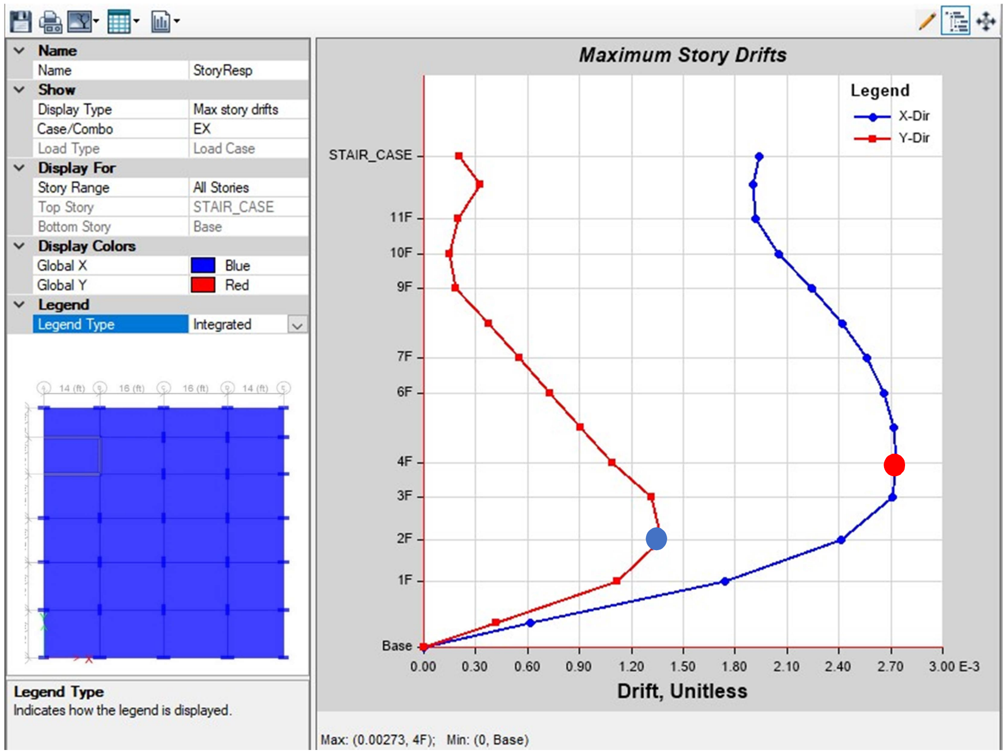

Figure 4- 1 Maximum story drift Ex of (G+12) storied commercial building at 4th floor of x-direction and 2nd floor of y-direction for plan 01

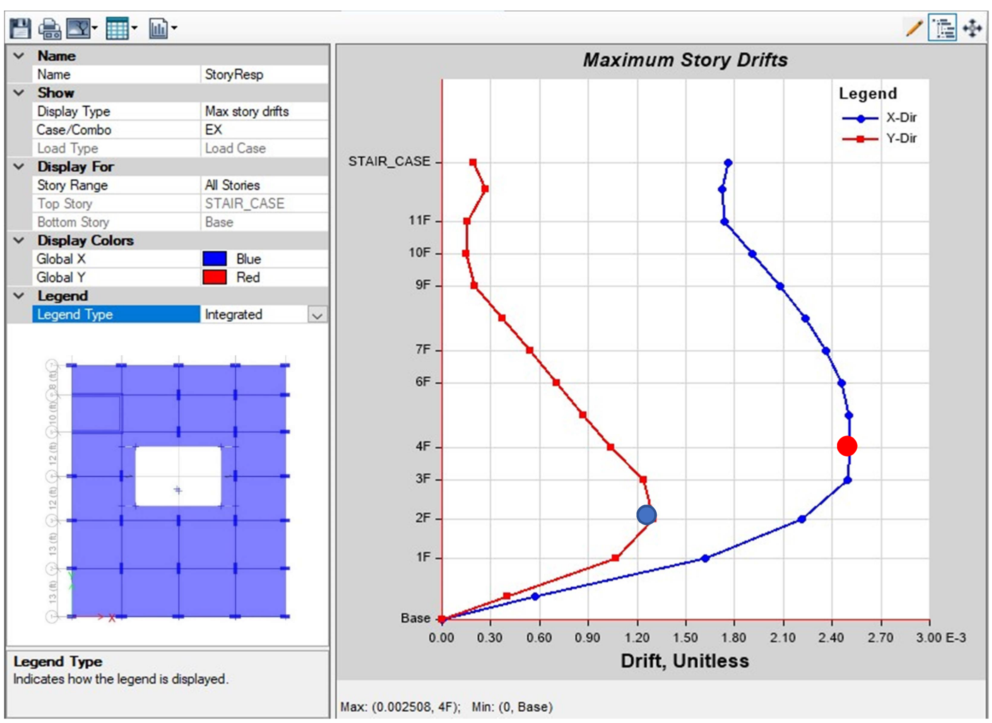

Figure 4- 2 Maximum story drift Ex of (G+12) storied commercial building at 4th floor of x-direction and 2nd floor of y-direction for plan 02

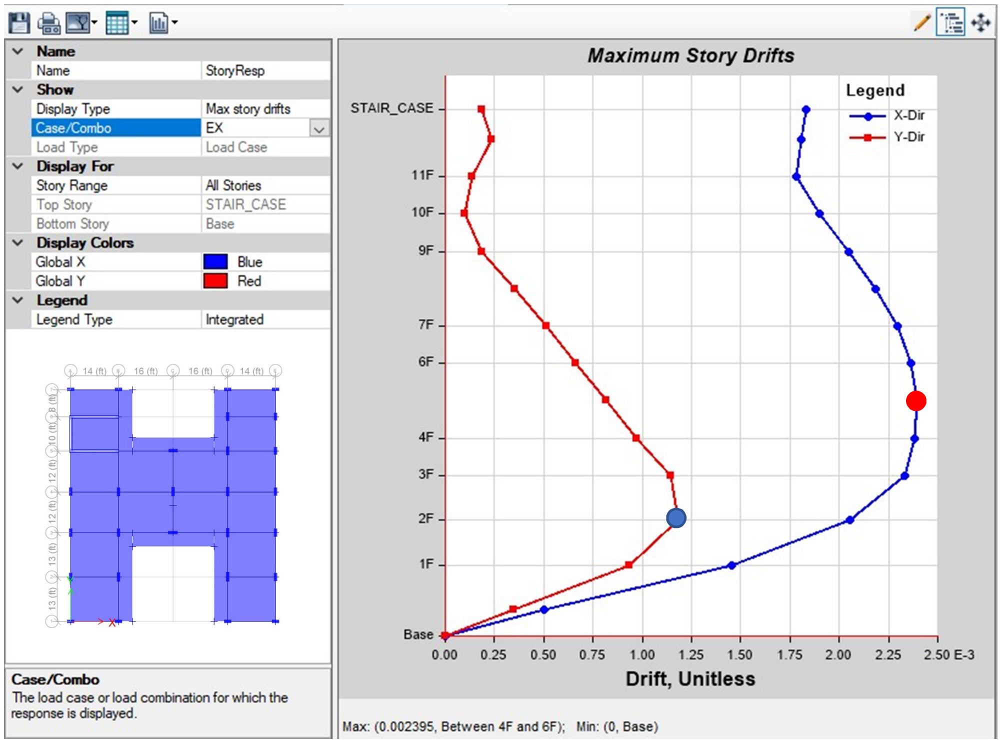

Figure 4- 3 Maximum story drift Ex of (G+12) storied commercial building at 5th floor of x-direction and 2nd floor of y-direction for plan 03

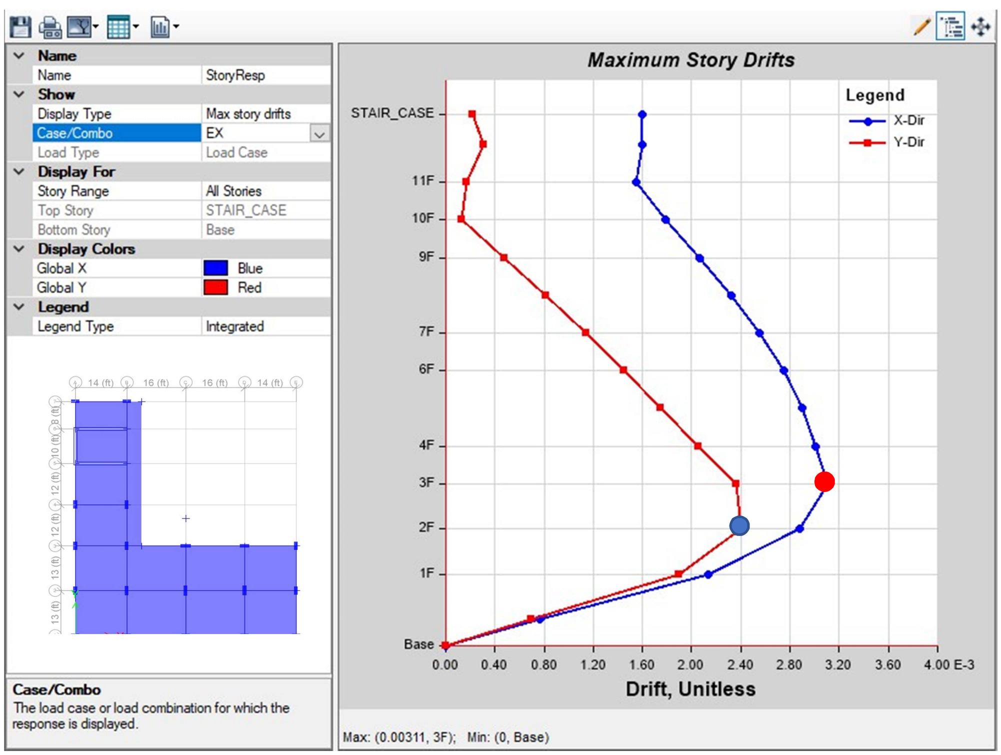

Figure 4- 4 Maximum story drift Ex of (G+12) storied commercial building at 3rd floor of x-direction and 2nd floor of y-direction for plan 04

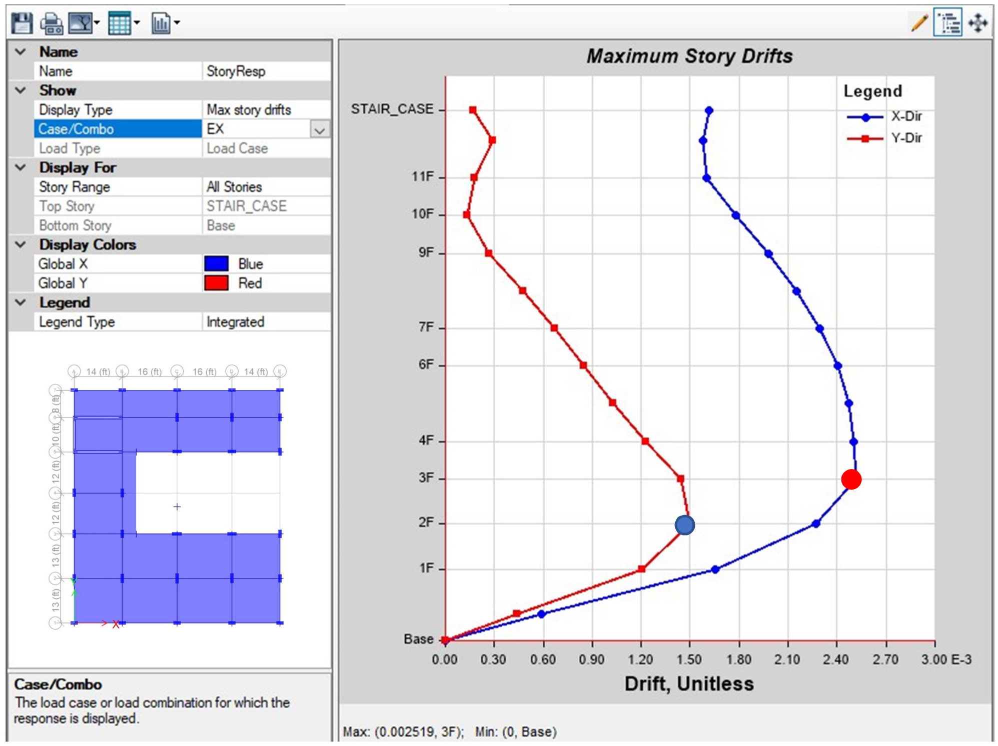

Figure 4- 5 Maximum story drift Ex of (G+12) storied commercial building at 3rd floor of x-direction and 2nd floor of y-direction for plan 05

4.2.3.2 Story Drift Analysis for Ey

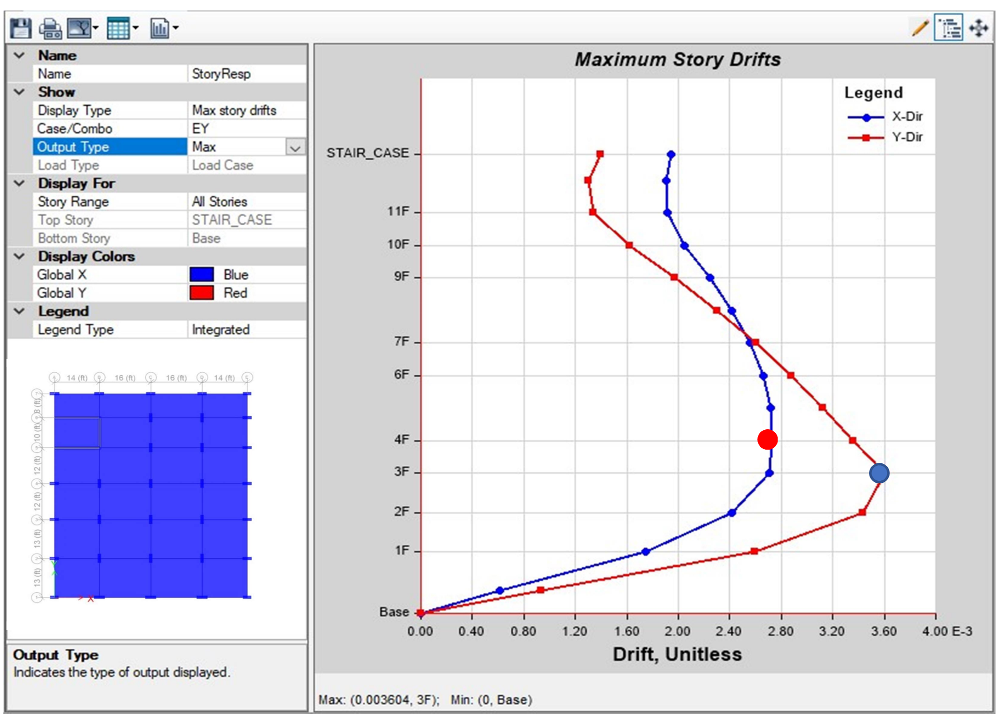

Figure 4- 6 Maximum story drift Ey of (G+12) storied commercial building at 4th floor of x-direction and 3rd floor of y-direction for plan 01

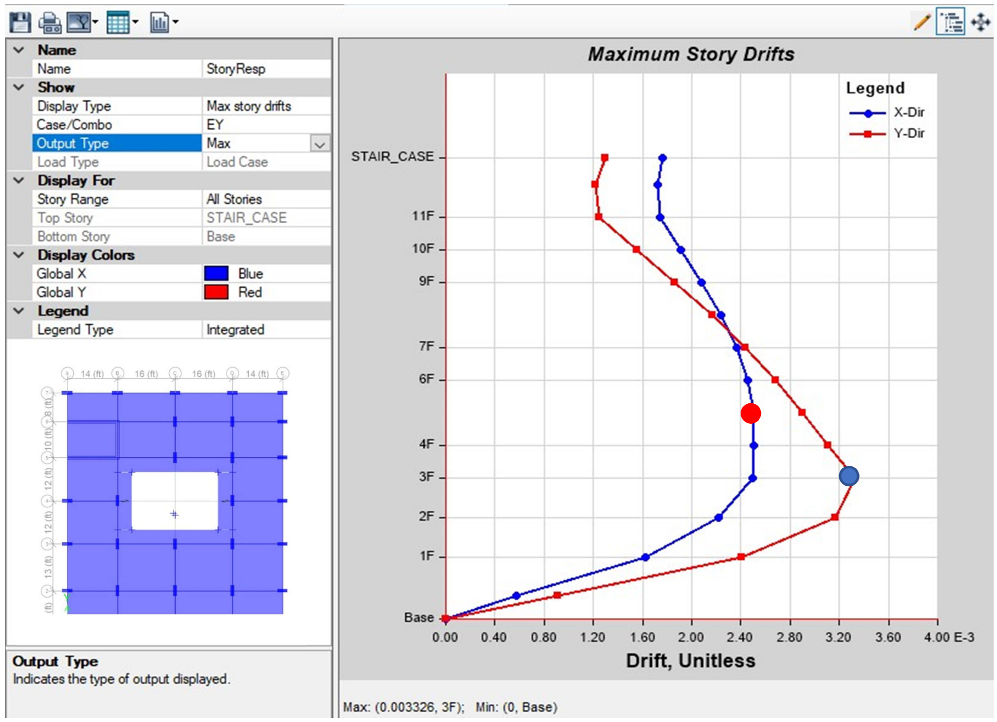

Figure 4- 7 Maximum story drift Ey of (G+12) storied commercial building at 5th floor of x-direction and 3rd floor of y-direction for plan 02

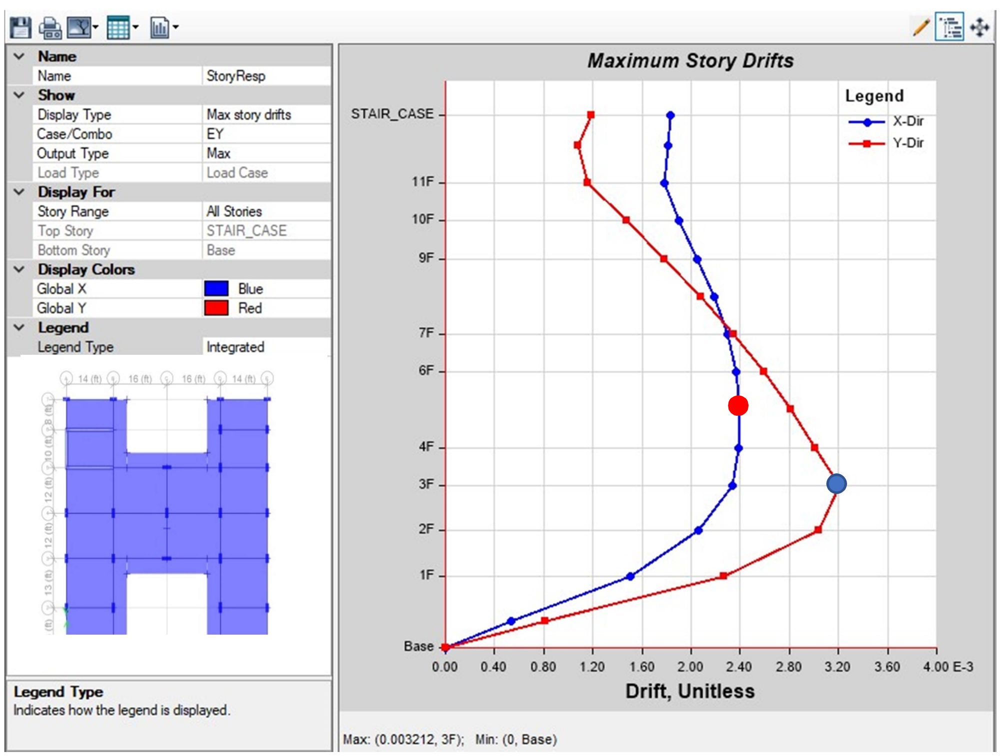

Figure 4- 8 Maximum story drift Ey of (G+12) storied commercial building at 5th floor of x-direction and 3rd floor of y-direction for plan 03

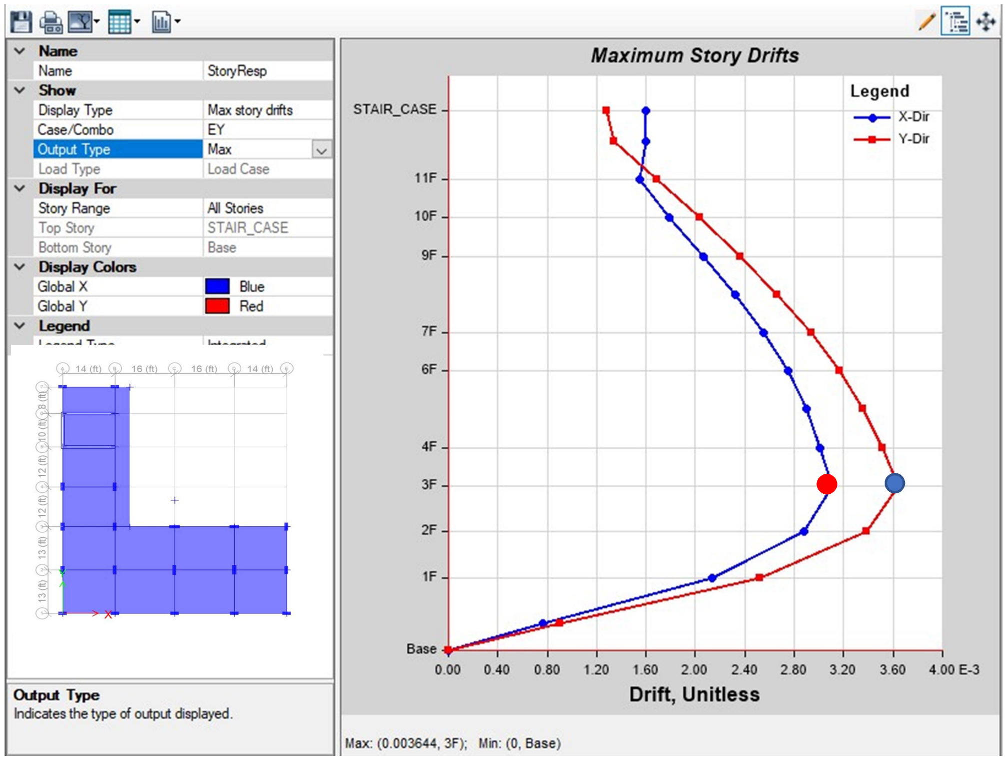

Figure 4- 9 Maximum story drift Ey of (G+12) storied commercial building at 3rd floor of x-direction and 3rd floor of y-direction for plan 04

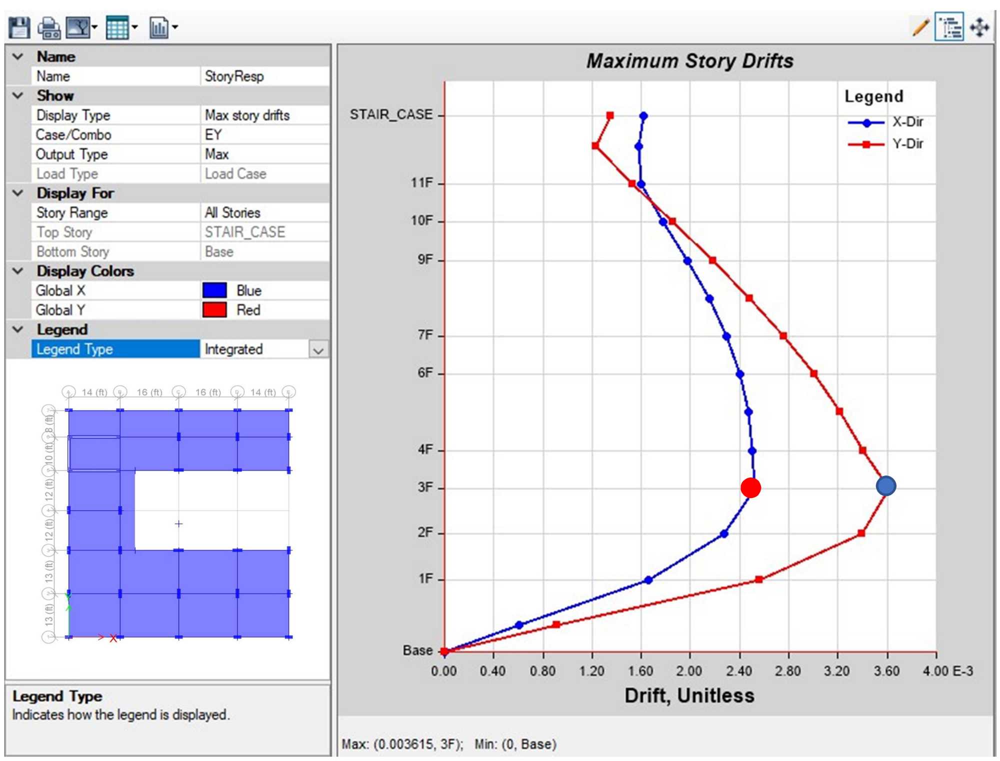

Figure 4- 10 Maximum story drift Ey of (G+12) storied commercial building at 3rd floor of x-direction and 3rd floor of y-direction for plan 05

4.2.3.3 Maximum and Average Drift Value for Ex Direction

Table 4. 2 Maximum and average drift value for Ex direction for Plan 01

Story	Load Case/Combo	Direction	Max Drift mm	Avg Drift mm	Ratio
STAIR_CASE	EX	X	4.731	4.648	1.018
RF	EX	X	5.8	5.325	1.089
RF	EX	Y	1.003	0.638	1.57
11F	EX	X	5.85	5.743	1.019
10F	EX	X	6.249	6.005	1.041
9F	EX	X	6.833	6.251	1.093
8F	EX	X	7.365	6.451	1.142
7F	EX	X	7.803	6.569	1.188
6F	EX	X	8.118	6.582	1.233
6F	EX	Y	2.224	0.868	2.562
5F	EX	X	8.29	6.468	1.282
5F	EX	Y	2.758	1.146	2.406
4F	EX	X	8.32	6.206	1.341
4F	EX	Y	3.329	1.455	2.288
3F	EX	X	9.91	6.948	1.426
3F	EX	Y	4.805	2.194	2.19
2F	EX	X	8.817	5.789	1.523
2F	EX	Y	5.032	2.355	2.136
1F	EX	X	6.37	3.903	1.632
1F	EX	Y	4.091	1.917	2.134
GF	EX	X	1.308	0.773	1.693
GF	EX	Y	0.89	0.359	2.478

Table 4. 3 Maximum and average drift value for Ex direction for Plan 02

Story	Load Case/Combo	Direction	Max Drift mm	Avg Drift mm	Ratio
STAIR_CASE	EX	X	4.299	4.238	1.014
RF	EX	X	5.262	4.827	1.09
RF	EX	Y	0.818	0.555	1.474
11F	EX	X	5.304	5.264	1.008
10F	EX	X	5.821	5.518	1.055
9F	EX	X	6.343	5.732	1.107
8F	EX	X	6.818	5.902	1.155
7F	EX	X	7.208	6	1.201
6F	EX	X	7.485	6.002	1.247
6F	EX	Y	2.155	0.848	2.542
5F	EX	X	7.627	5.887	1.296
5F	EX	Y	2.649	1.109	2.388
4F	EX	X	7.645	5.642	1.355
4F	EX	Y	3.18	1.399	2.272
3F	EX	X	9.115	6.32	1.442
3F	EX	Y	4.548	2.09	2.176
2F	EX	X	8.105	5.261	1.541
2F	EX	Y	4.758	2.238	2.126
1F	EX	X	5.934	3.585	1.655
1F	EX	Y	3.902	1.841	2.12
GF	EX	X	1.228	0.714	1.719
GF	EX	Y	0.852	0.352	2.424

Table 4. 4 Maximum and average drift value for Ex direction for Plan 03

Story	Load Case/Combo	Direction	Max Drift mm	Avg Drift mm	Ratio
STAIR_CASE	EX	X	4.473	4.366	1.025
RF	EX	X	5.509	5.041	1.093
11F	EX	X	5.44	5.356	1.016
10F	EX	X	5.795	5.576	1.039
9F	EX	X	6.25	5.746	1.088
8F	EX	X	6.661	5.871	1.135
7F	EX	X	6.99	5.924	1.18
7F	EX	Y	1.562	0.621	2.515
6F	EX	X	7.209	5.884	1.225
6F	EX	Y	2.027	0.856	2.367
5F	EX	X	7.299	5.728	1.274
5F	EX	Y	2.485	1.095	2.269
4F	EX	X	7.269	5.445	1.335
4F	EX	Y	2.961	1.352	2.19
3F	EX	X	8.54	6.024	1.418
3F	EX	Y	4.197	1.978	2.122
2F	EX	X	7.518	4.963	1.515
2F	EX	Y	4.329	2.074	2.087
1F	EX	X	5.326	3.277	1.625
1F	EX	Y	3.423	1.643	2.084
GF	EX	X	1.07	0.63	1.699
GF	EX	Y	0.735	0.304	2.418

Table 4. 5 Maximum and average drift value for Ex direction for Plan 04

Story	Load Case/Combo	Direction	Max Drift mm	Avg Drift mm	Ratio
STAIR_CASE	EX	X	3.894	3.81	1.022
STAIR_CASE	EX	Y	0.523	0.448	1.167
RF	EX	X	4.881	4.249	1.149
RF	EX	Y	0.949	0.656	1.447
11F	EX	X	4.732	4.644	1.019
10F	EX	X	5.442	4.974	1.094
9F	EX	X	6.284	5.261	1.194
9F	EX	Y	1.444	0.546	2.643
8F	EX	X	7.076	5.501	1.286
8F	EX	Y	2.478	1.089	2.275
7F	EX	X	7.782	5.674	1.372
7F	EX	Y	3.47	1.613	2.151
6F	EX	X	8.371	5.758	1.454
6F	EX	Y	4.414	2.118	2.084
5F	EX	X	8.827	5.741	1.537
5F	EX	Y	5.326	2.614	2.038
4F	EX	X	9.178	5.632	1.63
4F	EX	Y	6.25	3.122	2.002
3F	EX	X	11.376	6.512	1.747
3F	EX	Y	8.648	4.381	1.974
2F	EX	X	10.517	5.651	1.861
2F	EX	Y	8.781	4.473	1.963
1F	EX	X	7.818	3.938	1.985
1F	EX	Y	6.938	3.532	1.964
GF	EX	X	1.625	0.788	2.062
GF	EX	Y	1.478	0.713	2.074

Table 4. 6 Maximum and average drift value for Ex direction for Plan 05

Story	Load Case/Combo	Direction	Max Drift mm	Avg Drift mm	Ratio
STAIR_CASE	EX	X	3.94	3.885	1.014
RF	EX	X	4.816	4.318	1.115
RF	EX	Y	0.894	0.577	1.548
11F	EX	X	4.879	4.791	1.018
10F	EX	X	5.422	5.074	1.068
9F	EX	X	6.028	5.324	1.132
8F	EX	X	6.558	5.514	1.189
7F	EX	X	6.997	5.629	1.243
7F	EX	Y	2.032	0.822	2.473
6F	EX	X	7.324	5.653	1.295
6F	EX	Y	2.582	1.109	2.328
5F	EX	X	7.526	5.571	1.351
5F	EX	Y	3.137	1.406	2.231
4F	EX	X	7.629	5.38	1.418
4F	EX	Y	3.733	1.733	2.155
3F	EX	X	9.213	6.088	1.513
3F	EX	Y	5.284	2.526	2.091
2F	EX	X	8.313	5.144	1.616
2F	EX	Y	5.484	2.662	2.06
1F	EX	X	6.058	3.499	1.731
1F	EX	Y	4.399	2.14	2.056
GF	EX	X	1.248	0.695	1.794
GF	EX	Y	0.943	0.414	2.281

4.2.3.4 Maximum and Average Drift Value for Ey Direction

Table 4. 7 Maximum and average drift value for Ey direction for Plan 01

Story	Load Case/Combo	Direction	Max Drift mm	Avg Drift mm	Ratio
STAIR_CASE	EY 2	X	0.398	0.336	1.185
STAIR_CASE	EY 2	Y	3.393	3.304	1.027
RF	EY 2	X	1.074	0.611	1.758
RF	EY 2	Y	3.956	3.453	1.146
11F	EY 2	X	0.543	0.439	1.235
11F	EY 2	Y	4.071	3.981	1.023
10F	EY 2	Y	4.938	4.559	1.083
9F	EY 2	Y	6	5.151	1.165
8F	EY 2	Y	7.013	5.7	1.23
7F	EY 2	X	2.736	0.739	3.703
7F	EY 2	Y	7.944	6.181	1.285
6F	EY 2	X	3.517	1.027	3.425
6F	EY 2	Y	8.78	6.581	1.334
5F	EY 2	X	4.304	1.326	3.246
5F	EY 2	Y	9.53	6.903	1.381
4F	EY 2	X	5.163	1.665	3.101
4F	EY 2	Y	10.243	7.157	1.431
3F	EY 2	X	7.397	2.485	2.977
3F	EY 2	Y	13.183	8.842	1.491
2F	EY 2	X	7.659	2.652	2.888
2F	EY 2	Y	12.562	8.148	1.542
1F	EY 2	X	6.087	2.158	2.821
1F	EY 2	Y	9.484	5.972	1.588
GF	EY 2	X	1.301	0.464	2.801
GF	EY 2	Y	1.998	1.263	1.582

Table 4. 8 Maximum and average drift value for Ey direction for Plan 02

Story	Load Case/Combo	Direction	Max Drift mm	Avg Drift mm	Ratio
STAIR_CASE	EY 2	X	0.409	0.337	1.211
STAIR_CASE	EY 2	Y	3.165	3.08	1.028
RF	EY 2	X	0.849	0.515	1.647
RF	EY 2	Y	3.704	3.289	1.126
11F	EY 2	X	0.395	0.38	1.039
11F	EY 2	Y	3.801	3.784	1.005
10F	EY 2	Y	4.724	4.311	1.096
9F	EY 2	Y	5.683	4.844	1.173
8F	EY 2	Y	6.598	5.338	1.236
7F	EY 2	X	2.589	0.7	3.699
7F	EY 2	Y	7.436	5.768	1.289
6F	EY 2	X	3.3	0.965	3.42
6F	EY 2	Y	8.185	6.123	1.337
5F	EY 2	X	4.015	1.239	3.241
5F	EY 2	Y	8.853	6.404	1.382
4F	EY 2	X	4.793	1.548	3.095
4F	EY 2	Y	9.483	6.622	1.432
3F	EY 2	X	6.829	2.296	2.975
3F	EY 2	Y	12.164	8.156	1.491
2F	EY 2	X	7.06	2.447	2.885
2F	EY 2	Y	11.582	7.505	1.543
1F	EY 2	X	5.688	2.024	2.809
1F	EY 2	Y	8.8	5.532	1.591
GF	EY 2	X	1.224	0.44	2.783
GF	EY 2	Y	1.934	1.211	1.598

Table 4. 9 Maximum and average drift value for Ey direction for Plan 03

Story	Load Case/Combo	Direction	Max Drift mm	Avg Drift mm	Ratio
STAIR_CASE	EY 2	X	0.377	0.289	1.305
STAIR_CASE	EY 2	Y	2.892	2.785	1.039
RF	EY 2	X	0.646	0.389	1.659
RF	EY 2	Y	3.304	2.986	1.106
11F	EY 2	Y	3.54	3.457	1.024
10F	EY 2	Y	4.485	3.982	1.126
9F	EY 2	Y	5.43	4.503	1.206
8F	EY 2	X	2.089	0.567	3.686
8F	EY 2	Y	6.331	4.987	1.269
7F	EY 2	X	2.813	0.832	3.381
7F	EY 2	Y	7.162	5.414	1.323
6F	EY 2	X	3.516	1.093	3.216
6F	EY 2	Y	7.907	5.772	1.37
5F	EY 2	X	4.215	1.359	3.102
5F	EY 2	Y	8.568	6.057	1.414
4F	EY 2	X	4.962	1.653	3.002
4F	EY 2	Y	9.181	6.281	1.462
3F	EY 2	X	6.934	2.38	2.913
3F	EY 2	Y	11.749	7.74	1.518
2F	EY 2	X	7.052	2.482	2.841
2F	EY 2	Y	11.133	7.109	1.566
1F	EY 2	X	5.489	1.949	2.816
1F	EY 2	Y	8.31	5.163	1.61
GF	EY 2	X	1.15	0.406	2.834
GF	EY 2	Y	1.741	1.083	1.607

Table 4. 10 Maximum and average drift value for Ey direction for Plan 04

Story	Load Case/Combo	Direction	Max Drift mm	Avg Drift mm	Ratio
STAIR_CASE	EY 2	X	1.074	0.854	1.258
STAIR_CASE	EY 2	Y	3.113	2.914	1.068
RF	EY 2	X	1.241	0.548	2.262
RF	EY 2	Y	4.089	3.705	1.104
11F	EY 2	Y	5.147	4.308	1.195
10F	EY 2	Y	6.207	4.896	1.268
9F	EY 2	Y	7.197	5.444	1.322
8F	EY 2	Y	8.115	5.944	1.365
7F	EY 2	X	3.73	0.827	4.509
7F	EY 2	Y	8.941	6.377	1.402
6F	EY 2	X	4.437	1.11	3.998
6F	EY 2	Y	9.652	6.722	1.436
5F	EY 2	X	5.113	1.391	3.674
5F	EY 2	Y	10.234	6.971	1.468
4F	EY 2	X	5.793	1.693	3.422
4F	EY 2	Y	10.716	7.131	1.503
3F	EY 2	X	7.819	2.445	3.198
3F	EY 2	Y	13.327	8.614	1.547
2F	EY 2	X	7.744	2.555	3.03
2F	EY 2	Y	12.368	7.789	1.588
1F	EY 2	X	5.998	2.083	2.88
1F	EY 2	Y	9.22	5.659	1.629
GF	EY 2	X	1.27	0.451	2.814
GF	EY 2	Y	1.918	1.178	1.629

Table 4. 11 Maximum and average drift value for Ey direction for Plan 05

Story	Load Case/Combo	Direction	Max Drift mm	Avg Drift mm	Ratio
STAIR_CASE	EY 2	X	0.629	0.486	1.296
STAIR_CASE	EY 2	Y	3.288	3.15	1.044
RF	EY 2	X	0.553	0.391	1.413
RF	EY 2	Y	3.756	3.69	1.018
11F	EY 2	Y	4.672	4.248	1.1
10F	EY 2	Y	5.663	4.805	1.179
9F	EY 2	Y	6.646	5.352	1.242
8F	EY 2	X	2.561	0.616	4.154
8F	EY 2	Y	7.575	5.855	1.294
7F	EY 2	X	3.3	0.891	3.703
7F	EY 2	Y	8.417	6.288	1.339
6F	EY 2	X	4.014	1.163	3.452
6F	EY 2	Y	9.162	6.643	1.379
5F	EY 2	X	4.721	1.441	3.276
5F	EY 2	Y	9.803	6.911	1.418
4F	EY 2	X	5.471	1.748	3.13
4F	EY 2	Y	10.392	7.109	1.462
3F	EY 2	X	7.575	2.517	3.009
3F	EY 2	Y	13.221	8.721	1.516
2F	EY 2	X	7.686	2.644	2.907
2F	EY 2	Y	12.428	7.96	1.561
1F	EY 2	X	6.067	2.151	2.821
1F	EY 2	Y	9.351	5.825	1.605
GF	EY 2	X	1.294	0.463	2.793
GF	EY 2	Y	1.957	1.224	1.599

Table 4. 12 Comparison of story drift data

Maximum story drift for Ex (mm)								Maximum story drift for Ey (mm)						
Story Data	**Direction**	**Plan 1**	**Plan 2**	**Plan 3**	**Plan 4**	**Plan 5**		**Story Data**	**Direction**	**Plan 1**	**Plan 2**	**Plan 3**	**Plan 4**	**Plan 5**
STAIR_CASE	X	**4.73**	4.30	4.47	3.89	3.94		STAIR_CASE	X	0.40	0.41	0.38	**1.07**	0.63
STAIR_CASE	Y	-	-	-	0.52	-		STAIR_CASE	Y	3.39	3.17	2.89	3.11	3.29
RF	X	**5.80**	5.26	5.51	4.88	4.82		RF	X	1.07	0.85	0.65	**1.24**	0.55
RF	Y	**1.00**	0.82		0.95	0.89		RF	Y	3.96	3.70	3.30	**4.09**	3.76
11F	X	**5.85**	5.30	5.44	4.73	4.88		11F	X	0.54	0.40	**3.54**	-	-
10F	X	**6.25**	5.82	5.80	5.44	5.42		11F	Y	4.07	3.80	4.49	**5.15**	4.67
9F	X	**6.83**	6.34	6.25	6.28	6.03		10F	Y	4.94	4.72	5.43	**6.21**	5.66
9F	Y	-	-	-	**1.44**	-		9F	Y	6.00	5.68	2.09	**7.20**	6.65
8F	X	**7.37**	6.82	6.66	7.08	6.56		8F	X	-	-	-	-	2.56
8F	Y	-	-	-	**2.48**	-		8F	Y	7.01	6.60	6.33	**8.12**	7.58
7F	X	**7.80**	7.21	6.99	7.78	7.00		7F	X	2.74	2.59	2.81	**3.73**	3.30
7F	Y	-	-	1.56	**3.47**	2.03		7F	Y	7.94	7.44	7.16	**8.94**	8.42
6F	X	8.12	7.49	7.21	**8.37**	7.32		6F	X	3.52	3.30	3.52	**4.44**	4.01
6F	Y	2.22	2.16	2.03	**4.41**	2.58		6F	Y	8.78	8.19	7.91	**9.65**	9.16
5F	X	8.29	7.63	7.30	**8.83**	7.53		5F	X	4.30	4.02	4.22	**5.11**	4.72
5F	Y	2.76	2.65	2.49	**5.33**	3.14		5F	Y	9.53	8.85	8.57	**10.23**	9.80
4F	X	8.32	7.65	7.27	**9.18**	7.63		4F	X	5.16	4.79	4.96	**5.79**	5.47
4F	Y	3.33	3.18	2.96	**6.25**	3.73		4F	Y	10.24	9.48	9.18	**10.72**	10.39
3F	X	9.91	9.12	8.54	**11.38**	9.21		3F	X	7.40	6.83	6.93	**7.82**	7.58
3F	Y	4.81	4.55	4.20	**8.65**	5.28		3F	Y	13.18	12.16	11.75	**13.33**	13.22
2F	X	8.82	8.11	7.52	**10.52**	8.31		2F	X	7.66	7.06	7.05	**7.74**	7.69
2F	Y	5.03	4.76	4.33	**8.78**	5.48		2F	Y	**12.56**	11.58	11.13	12.37	12.43
1F	X	6.37	5.93	5.33	**7.82**	6.06		1F	X	**6.09**	5.69	5.49	6.00	6.07
1F	Y	4.09	3.90	3.42	**6.94**	4.40		1F	Y	**9.48**	8.80	8.31	9.22	9.35
GF	X	1.31	1.23	1.07	**1.63**	1.25		GF	X	**1.30**	1.22	1.15	1.27	1.29
GF	Y	0.89	0.85	0.74	**1.48**	0.94		GF	Y	**2.00**	1.93	1.74	1.92	1.96

CHAPTER 5
CONCLUSIONS AND FUTURE WORKS

5.1 Conclusions

The whole study is done on the comparative analysis of earth quake resistant design of a (G+12) storied commercial building in Dhaka city with different plan configurations. The reinforcement provided in the building is compared with the story flow. After all the research the following conclusions are observed:

- In this study it is clearly understandable that storey drifts are higher in plan 4 (C Shape) comparing to other plans.
- After performing a seismic analysis, ETABS provides detailed results, including the drift at different locations in the structure. Use these results to assess whether the structure complies with the specified drift limits.
- Drift limits are typically specified by building codes and standards to ensure that the building's lateral displacement remains within acceptable limits.
- For seismic design, ETABS allows to define maximum allowable drift ratios for different building components, such as stories or structural elements.

5.2 Limitations

- The case study conducted in this research is for Dhaka only. However, the seismic zone coefficient and wind speed varies for different parts of our country. Similar study can be other parts of Bangladesh especially for seismic active zones.
- To find the impact on design only story drifts were considered.
- This study can be extended on a large scale of analysis including without shear wall building.
- This study has not considered any adjacent buildings. But pounding effect between adjacent buildings should be checked if there are adjacent buildings.
- Only five different (G+12) storied models are made by ETABS software for with shear wall have been studied.

5.3 Recommendations

- Comparison of lateral load in BNBC 2020 can be made with other codes such as Euro code, Indian code, UBC, ACI, Italian code etc.

- This study can be extended on a large scale of analysis including without shear wall building.
- Dynamic analysis such as time history analysis and response spectrum analysis can be adopted for further and better analysis process.
- The applied dead loads and live loads were same accepting the earthquake loading as it is different in four different zones of Bangladesh.

REFERENCES

[1] P. Siva sai, B. Reshma, M. Sai krishna, P. Siva nagaraju, K. Venkata sai, Mr. V. Nagaraju,"SEISMIC ANALYSIS AND DESIGN OF MULTISTOREY BUILDING IN DIFFERENT SEISMIC ZONES BY USING ETABS," *International Research Journal of Engineering and Technology (IRJET),* 6(3), pp. 6854-6859, Mar 2019.

[2] Guleria, A. (2014). Structural analysis of a multi-storeyed building using ETABS for different plan configurations. *Int. J. Eng. Res. Technol*, *3*(5), 1481-1485.

[3] Dhumal, A., & Deshmukh, A. Structural Analysis of Building using ETABS for Different Plan Configuration. *IJARIIE, 7(5),* pp.232 – 240.

[4] Shohag, J. R. I., & Mozumder, K. Performance Assessment of Residential Building for Different Plan Configurations in Different Seismic Zones of Bangladesh Using ETABS. *Journal of Civil, Construction and Environmental Engineering, 7(5)*, pp. 93-101

[5] BNBC 2020, *Bangladesh National Building Code*, HBRI-BSTI.