COMPARATIVE ANALYSIS OF THE STRUCTURAL RESPONSE OF A G+8 STORIED BUILDING WITH VARYING SHEAR WALL PLACEMENTS 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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Section: 27A

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DECLARATION

We the undersigned hereby declare that the work and all resources presented in this thesis titled "**COMPARATIVE ANALYSIS OF THE STRUCTURAL RESPONSE OF A G+8 STORIED BUILDING WITH VARYING SHEAR WALL PLACEMENTS USING ETABS** " are the result of our original efforts and have not been submitted either in whole or in part for academic credit at any university, college or institution.

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Dedicated

to

“This study is dedicated to our parents, who have always loved and supported us without conditions, as well as to the teachers who have imparted information and motivated us to reach our objectives.’’

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ABSTRACT

This study presents a comparative analysis of three structural building models subjected to seismic and wind load conditions. The objective is to evaluate their performance with respect to interstorey drift limits, total sway limitations, and overall structural efficiency in accordance with applicable code requirements. Each model was analyzed using ETABS to obtain lateral displacement and drift responses under EQ_x, EQ_y, W_x, and W_y load cases. The results show that Option -2 provides superior performance, satisfying both drift and sway criteria for all load combinations. In contrast, Option -1 fails to meet the drift and sway requirements in the EQ_x direction, indicating comparatively low lateral stiffness. Option -3 performs better than Option -1 but fails the sway limit in the EQ_x case, demonstrating the need for additional stiffness enhancement. Among the three, Option -2 not only ensures structural safety and full code compliance but also proves to be the most economical solution, offering optimized material usage while maintaining adequate lateral resistance. This study concludes that Option -2 represents the most effective and efficient structural configuration for the building under the evaluated loading conditions.

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CHAPTER 1
INTRODUCTION

1.1 General Overview

In recent years, the demand for multi-story buildings has significantly increased due to rapid urbanization and limited land availability. As the height of buildings increases, their structural design becomes more complex because of lateral loads such as wind and earthquake forces. These lateral forces can induce large moments and deflections, which may lead to discomfort to occupants or even structural failure if not properly resisted. Therefore, the structural stability of high-rise buildings primarily depends on their ability to resist both vertical and horizontal loads efficiently. The introduction of shear walls in reinforced concrete structures has proven to be one of the most effective lateral load-resisting systems. Shear walls provide high in-plane stiffness and strength, making them essential in multi-story buildings, particularly in seismic and wind-prone areas. However, the inclusion of shear walls affects the overall structural behavior, cost, and architectural flexibility. Hence, it becomes necessary to perform a comparative study between buildings with and without shear walls to understand their impact on performance parameters such as story displacement, story drift, and base shear. This study focuses on the structural analysis of a G+8 (Ground plus eight story) reinforced concrete building using ETABS, a widely used structural analysis and design software. The analysis is carried out according to the provisions of BNBC 2020 (Bangladesh National Building Code), ensuring that the design follows modern standards for safety and performance.

1.2 Background of the Study

With the advancement of computational tools, engineers can now simulate the real behavior of structures more accurately. Software like ETABS allows for precise modeling of structural members and analysis of their response under different loading conditions. Traditionally, frame systems alone were used to resist both gravity and lateral loads in medium-rise buildings. However, as the building height increases, frame systems alone become insufficient to control lateral displacements.

1.3 Problem Statement

High-rise buildings without adequate lateral load-resisting systems are vulnerable to structural damage during seismic or wind events. Excessive lateral displacement not only causes structural cracking and instability but also reduces the comfort and safety of occupants. In many developing regions, including Bangladesh. Therefore, a detailed comparative study is essential to demonstrate how the inclusion of shear walls affects the building's performance and to provide design guidance for future projects.

1.4 Objectives of the Study

The main objectives of this research are as follows:

- To analyze a G+8 reinforced concrete building using ETABS software.
- To compare the structural behavior of the building with varying shear wall placements.
- To evaluate and compare parameters such as story displacement and story drift, under lateral loading conditions.

1.5 Scope and Limitations

This study focuses on the analysis of a G+8 building using ETABS. The investigation is limited to linear static and dynamic analysis methods. The design is performed according to BNBC 2020 load combinations and material properties. The study is purely analytical and does not cover experimental or construction aspects.

1.6 Significance of the Study

This study project is devotedly dedicated to our parents, whose steadfast support, unconditional love, and unceasing encouragement have served as the cornerstone of both our academic and personal journeys. Their selflessness, tolerance, and faith in our potential have consistently inspired us to overcome obstacles and pursue greatness. We are also incredibly appreciative of our instructors, whose leadership, insight, and dedication to teaching have influenced our intellectual development. Their motivation, guidance, and commitment to developing our potential have been crucial in assisting us in reaching our objectives and successfully finishing our study.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

Siddik, S. M., Disha, N., Ahamed, M. (2024) analyzed threat of earthquakes. As the number of high-rise buildings is increasing daily, there is an urgent need to design structures considering seismic loading. During earthquakes, structures are subjected to lateral displacement. Most reinforced concrete structures are designed to resist gravity loads, but they neglect the effect of lateral forces arising due to earthquakes. Shear walls are added to the building's interior as well as exterior to provide more strength and stiffness to the building. The studies have been carried out using CSI ETABS (v 16.2.1) software, and the model was developed using Finite Element Method (FEM), the model analysis was done by using Equivalent Static Analysis (ESA). The building under analysis consists of 15 floors. The building is located in Bangladesh's seismic zone – III (Bogura). After the study, various parameters like maximum lateral displacement, storey drift, storey shear, and storey stiffness were compared to find the suitable position of the shear wall.

Chauhan, S., Ghidode, P. (2025) analyzed the shear wall systems are the most suitable technique for lateral load resistance. Steel plate shear walls and traditional reinforced concrete shear walls are utilized all over the world to withstand seismic and wind loads. Composite columns, beams, and slabs have just recently begun to be used in the industry, which has adopted composite construction techniques. Given its benefits over steel and reinforced concrete shear walls, research on composite shear walls has recently attracted more attention. Combined shear walls are a good technique for earthquake-resistant structures because they provide improved stiffness and ductility, reduce dead load and wall thickness, improve structural response, and save construction time and expense, among other benefits. The researchers conducted on the seismic behavior of shear walls in multistory buildings utilizing a variety of methodologies are reviewed in this study. The performance of various composite shear wall types about reinforced and composite shear walls was the primary focus of the research.

Ganesh, B., and Dnyaneshwar B. Mohite. (2024) investigated the impact of shear wall positioning on the seismic performance of a G+22 commercial building and to identify the most efficient configuration for achieving stability, safety, and economy. Three shear wall arrangements were considered for comparison: (i) corner positions, (ii) middle outer positions, and (iii) inner/core positions. The building’s response was assessed in terms of story drift, lateral displacement, base shear, and story stiffness. The analysis reveals that shear walls located at the inner/core region of the building deliver superior performance compared to corner and middle-outer placements. The core configuration effectively minimizes lateral displacements and inter-story drifts, while also enhancing stiffness and overall stability under seismic loading. Although other arrangements contribute to resistance, they are less efficient in controlling deformations and ensuring uniform load distribution.

Sylviya, B. P. E. (2018) analyzed RCC building has been carried out by changing the locations of shear walls in the building. Also, the effect of variations in seismic zones as per IS codes has been presented. The seismic analysis performed is linear dynamic response spectrum analysis using the well-known analysis and design software ETABS16.2.0. Seismic performance of the building has been investigated based on parameters such as storey drift, base shear and storey displacements.

Rishab, J. et al. (2022) analyzed the G+15 storey with using shear walls RCC building. The adopted building plan configuration as 36 m x 36 m along to length and width respectively. 3.2 m each floors height with 230 mm thick brick wall while 200 mm thick shear wall and also for this analysis work, provided various properties like size of column 450 mm x 350 mm, beams 400 mm x 300 mm, thickness of slab 180 mm thick, M25 grade of concrete for slabs and M30 grade concrete for beams and columns and Fe415 grade of steel and also used various seismic parameters such as seismic zone III, zone factor 0.16 with medium soil condition, Importance factor 1.5, damping ration 5 percent for factor 1, response reduction factor 5 for Special RC moment resisting frame structure.

Yadav, D. H., and Rai, A. (2020) Investigated the resistance of a Tall RC frame building without a shear wall and the optimal shear wall configuration to lateral loads is investigated. It is very important to design structures that perform well in various lateral load actions. The G + 31 high RC frame building is considered for the design and analysis of various parameters. This RC frame building structure is subjected to a lateral load at an average basic wind speed of 50 m / sec. The analysis of this frame structure is performed according to Indian Standard Code IS 875: 2015 Part III. A different arrangement of shear walls is used to protect the structure from critical wind loads. The results are as natural time period, drift of story, and story displacement. After the analysis of the results, the optimal location of the shear wall is obtained.

2.2 Shear Wall Types and Functions

Shear walls are categorized based on location, connectivity, and function. The main types include:

- **Coupled Shear Walls**

Coupled shear walls consist of two or more walls connected by beams, known as coupling beams. These beams allow stress transfer and improve ductility by permitting controlled deformation. Coupled walls are commonly used in buildings where architectural openings or layout requirements prevent continuous walls along the building perimeter.

- **Core Walls**

Core walls are placed around vertical shafts, such as elevators or staircases. They provide central stiffness, resist torsion, and reduce lateral displacement. Core walls are especially effective in taller buildings where symmetry and stiffness are critical for seismic performance.

- **Peripheral Walls**

Peripheral walls run along the outer edges of buildings. They increase lateral stiffness and can be integrated into the architectural design. These walls often work together with frame elements to resist wind and earthquake loads efficiently.

- **Functions of Shear Walls**

a) Provide lateral stiffness and reduce story drift.
b) Increase base shear capacity.
c) Prevent soft-story mechanisms.
d) Reduce torsion and improve stability.
e) Support non-structural components by limiting deformation.

2.3 Seismic Performance of Buildings with Shear Walls

Earthquake-induced lateral forces are one of the primary concerns in building design Studies have shown that:

a) Buildings with shear walls have a lower fundamental period due to increased stiffness, resulting in reduced roof and story displacements.
b) Inter-story drift is significantly lower in buildings with shear walls, improving serviceability and reducing non-structural damage.
c) Shear walls can prevent soft-story failures, which are common in bare frame buildings, especially on ground floors with large openings for shops or lobbies.

d) Symmetric placement of shear walls reduces torsional irregularities, whereas asymmetrically placed walls can amplify torsion and cause stress concentration.

2.4 Wind Load Performance

Wind forces act as lateral loads on tall structures, causing sway and dynamic vibrations. Literature shows:

a) Shear walls help distribute wind-induced lateral forces uniformly across the structure.
b) ETABS modeling of multi-storey buildings demonstrates that roof displacement under wind can be reduced by 30–50% with shear walls.
c) Peripheral walls enhance torsional resistance by stiffening the building edges.
d) Proper wall thickness and continuity along height are critical for wind performance.

2.5 Material and Design Codes

- **Bangladesh National Building Code (BNBC 2020)**

  a) BNBC provides load combinations, seismic zoning, drift limitations, and detailing requirements for RC buildings.

  b) Specifies design coefficients for lateral loads and importance factors based on occupancy.

- **IS Codes**
  a) IS 456: Design and detailing of RC structures, including minimum reinforcement requirements.
  b) IS 1893: Seismic design criteria, response spectrum analysis, and fundamental period estimation.

- **ACI 318**
  a) Emphasizes ductile detailing for shear walls.
  b) Provides guidelines for vertical and horizontal reinforcement distribution.

2.6 Summary

Chapter 2 provides a comprehensive review of shear wall types, their function in lateral load resistance, performance under seismic and wind loads, and local/global research gaps. The literature highlights the necessity of shear walls in medium-rise buildings, their placement, and detailed design following code provisions. This establishes the foundation for the methodology and analysis in subsequent chapters.

CHAPTER 3
METHODOLOGY

3.1 Introduction

This chapter addresses the methodology of the study. Necessary data for analysis and model development with AutoCAD and ETABS are elaborated on in detail here. An analysis has been conducted for Zone-2 (Dhaka). Data for design are selected from BNBC-2020.

3.2 Different types of loads in structure:

Structural components need to be engineered to bear certain loads. Loads refer to the forces that a specific suture must be designed to handle. Typically, loads can be categorized as:

1. Dead Loads
2. Imposed loads or live load
3. Wind Loads
4. Earthquake loads

3.2.1 Dead Load:

Include the permanent structural material weights compressing the roof, flooring, walls, and foundation systems, along with finishes and installed equipment. Dead load refers to the overall weight of all building elements that typically remain constant over time, including concrete columns, concrete floors, bricks, roofing materials, etc. In ETABS, dead load assignment is performed automatically by specifying the member's properties. In the load case, there is an option named self-weight that automatically computes weights based on the material properties, such as density. In this research, the dead loads on the slab include the slab's self-weight, floor finishes, and partition walls. The overall vertical load on the slab is 25 psf for the floor finish and 30 psf for the random wall, plus the self-weight of the slab

3.2.2 Live Load:

Live loads arise from the use and occupancy of a structure. Loads comprise those from human occupants, furniture, movable equipment, storage, and activities related to construction and maintenance. To properly characterize the loading condition, loads are expressed as uniform area loads, concentrated loads, and uniform line loads. In ETABS.

3.2.3 Wind Load:

Buildings and other structures, encompassing the main Wind-Force Resisting System (MWFRS) along with all its components and cladding, must be designed and constructed to withstand wind loads as stipulated herein

i) Total wind force is calculated by projected area method using the formula:

$F_z = \{P_z A_z\}$ ……………………………………………………………………………(i)

ii) Basic Wind Equation:

$p = qGC_p$ ………………………………………………………………………..…(ii)

Wind Loads (BNBC-2020)

Sign Convention: Positive pressure acts toward the surface and negative pressure acts away from the surface.

i) Main wind-force resisting systems

Rigid Buildings of All Heights: Design wind pressures for the MWFRS of buildings of all heights shall be determined by the following equation:

$p = q[GC_p - q_i (GC_{pi})]$ (kN/m^2) ……………………………………………..……(iii)

ii) Low-Rise Building: Alternatively, design wind pressures for the MWFRS of low-rise buildings shall be determined by the following equation:

$p = qh[(GCpd-(GCpi)]$ (kN/m) ………………………………………..….……….(iv)

iii) Flexible Buildings: Design wind pressures for the MWFRS of flexible buildings shall be determined from the following equation:

$p = qGpCp$ (kN/m^2) …………………………………………………….……..…(v)

iv) Parapets: The design wind pressure for the effect of parapets on MWFRSs of rigid, low-rise, or flexible buildings with flat, gable, or hip roofs shall be determined by the following equation:

$Pp = qpGCpn$ (kN/m^2) ……………………………………..…………………(vi)

Table 3.1: Basic Wind Speeds (As per BNBC Table - 6.2.8)

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
Barisal	78.7	Meherpur	58.2
Bhola	69.5	Maheshkhali	80.0
Bogra	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
Chuadanga	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
Gopalganj	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	73.3	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

3.2.4 Earthquake Load

The program has computed earthquake loading according to BNBC-2020, which has been applied to the building's mass center. This 'Equivalent Static Analysis' for seismic vibrations relies on the principle of substituting the inertia forces at different 'lumped masses' (i.e., story levels) with equivalent horizontal forces that correlate to the weight of the body (thus its mass) and its displacement (and hence its acceleration). The total of these concentrated forces is countered by a 'base shear' at the bottom of the structure. The subsequent regulations are extracted from the Uniform Building Code of the USA (UBC, 1994) and are largely applicable to the Bangladesh National Building Code (BNBC, 1993).

- **Design Base Shear**

The total design base shear in a given direction is determined from the following relation:

$V = S_a W$ ……………………………………………………………………(vii)

Where,

S_a = Lateral seismic force coefficient calculated

W = Total seismic weight of building defined.

Alternatively, for building with natural period less than or equal to 2.0 sec, the seismic design base share can be calculated using ASCE 7 -02 with seismic design parameters as given in Appendix C. However, the minimum value of S_a should not be less than 0.044 $S_{DS}I$. The values of S_{DS} are provided in Appendix C

- **Structure Period**

The value of the fundamental period, T of the structure can be determined from one of the following methods:

Method A:

For all buildings the value of T may be approximated by the following formula:

$C = C_t (hn)_m$ ……………………………………………………………………(viii)

Where,

C_t = 0.0724 for steel moment resisting frames

= 0.0731 for reinforced concrete moment resisting frames

= 0.0466 for reinforced concrete moment

= 0.0488 for all other structural systems

H_n = Height in meters above the base to level n.

Alternatively, the value of C_t for buildings with concrete or masonry shear walls maybe taken as0.031/VA_c. The value of A_c shall be obtained from the relation:

$$A_c = A_e\,[0.2 + (D_e/h_n)] \quad \text{……………………………………………………(ix)}$$

Where,

A_c = the combined effective area, in square meters, of the shear walls in the first story of the structure.

A_e = the effective horizontal cross-sectional area, in square meters of a shear walls in the first story of the structure.

D_e = the length, in meters of a shear wall element in the first story in the direction parallel to the applied forces.

The value of D_e/h_n should not exceed 0.9.

Method B:

The fundamental period I may be calculated using the structural properties and deformational characteristics of the resisting elements in a properly substantiated analysis.

This requirement may be satisfied by using the following formula: The values of fi represent any lateral force distributed approximately in accordance with the principles

Table 3.2: Description of Seismic Zones (As per BNBC Table - 6.2.14)

Seismic Zone	Location	Seismic Intensity	Seismic Zone Coefficient, *Z*
1	Southwestern part including Barisal, Khulna, Jessore, Rajshahi	Low	0.12
2	Lower Central and Northwestern part including Noakhali, Dhaka, Pabna, Dinajpur, as well as Southwestern corner including Sundarbans	Moderate	0.20
3	Upper Central and Northwestern part including Brahmanbaria, Sirajganj, Rangpur	Severe	0.28
4	Northeastern part including Sylhet, Mymensingh, Kurigram	Very Severe	0.36

Table 3.3: Seismic Zone Coefficient Z for Some Important Towns of Bangladesh (As per BNBC Table - 6.2.15)

Town	Z	Town	Z	Town	Z	Town	Z
Bagerhat	0.12	Gaibandha	0.28	Magura	0.12	Patuakhali	0.12
Bandarban	0.28	Gazipur	0.20	Manikganj	0.20	Pirojpur	0.12
Barguna	0.12	Gopalganj	0.12	Maulvibazar	0.36	Rajbari	0.20
Barisal	0.12	Habiganj	0.36	Meherpur	0.12	Rajshahi	0.12
Bhola	0.12	Jaipurhat	0.20	Mongla	0.12	Rangamati	0.28
Bogra	0.28	Jamalpur	0.36	Munshiganj	0.20	Rangpur	0.28
Brahmanbaria	0.28	Jessore	0.12	Mymensingh	0.36	Satkhira	0.12
Chandpur	0.20	Jhalokati	0.12	Narail	0.12	Shariatpur	0.20
Chapainababganj	0.12	Jhenaidah	0.12	Narayanganj	0.20	Sherpur	0.36
Chittagong	0.28	Khagrachari	0.28	Narsingdi	0.28	Sirajganj	0.28
Chuadanga	0.12	Khulna	0.12	Natore	0.20	Srimangal	0.36
Comilla	0.20	Kishoreganj	0.36	Naogaon	0.20	Sunamganj	0.36
Cox's Bazar	0.28	Kurigram	0.36	Netrakona	0.36	Sylhet	0.36
Dhaka	0.20	Kushtia	0.20	Nilphamari	0.12	Tangail	0.28
Dinajpur	0.20	Lakshmipur	0.20	Noakhali	0.20	Thakurgaon	0.20
Faridpur	0.20	Lalmanirhat	0.28	Pabna	0.20		
Feni	0.20	Madaripur	0.20	Panchagarh	0.20		

Table 3.4: Soil Factor (As per BNBC Table - 6.2.16)

Soil type	S	T_B(s)	T_C(s)	T_D(s)
SA	1.0	0.15	0.40	2.0
SB	1.2	0.15	0.50	2.0
SC	1.15	0.20	0.60	2.0
SD	1.35	0.20	0.80	2.0
SE	1.4	0.15	0.50	2.0

Table 3.5: Importance Factors for Buildings (As per BNBC Table-6.2.17)

Occupancy Category	Importance factor I
I, II	1.00
III	1.25
IV	1.50

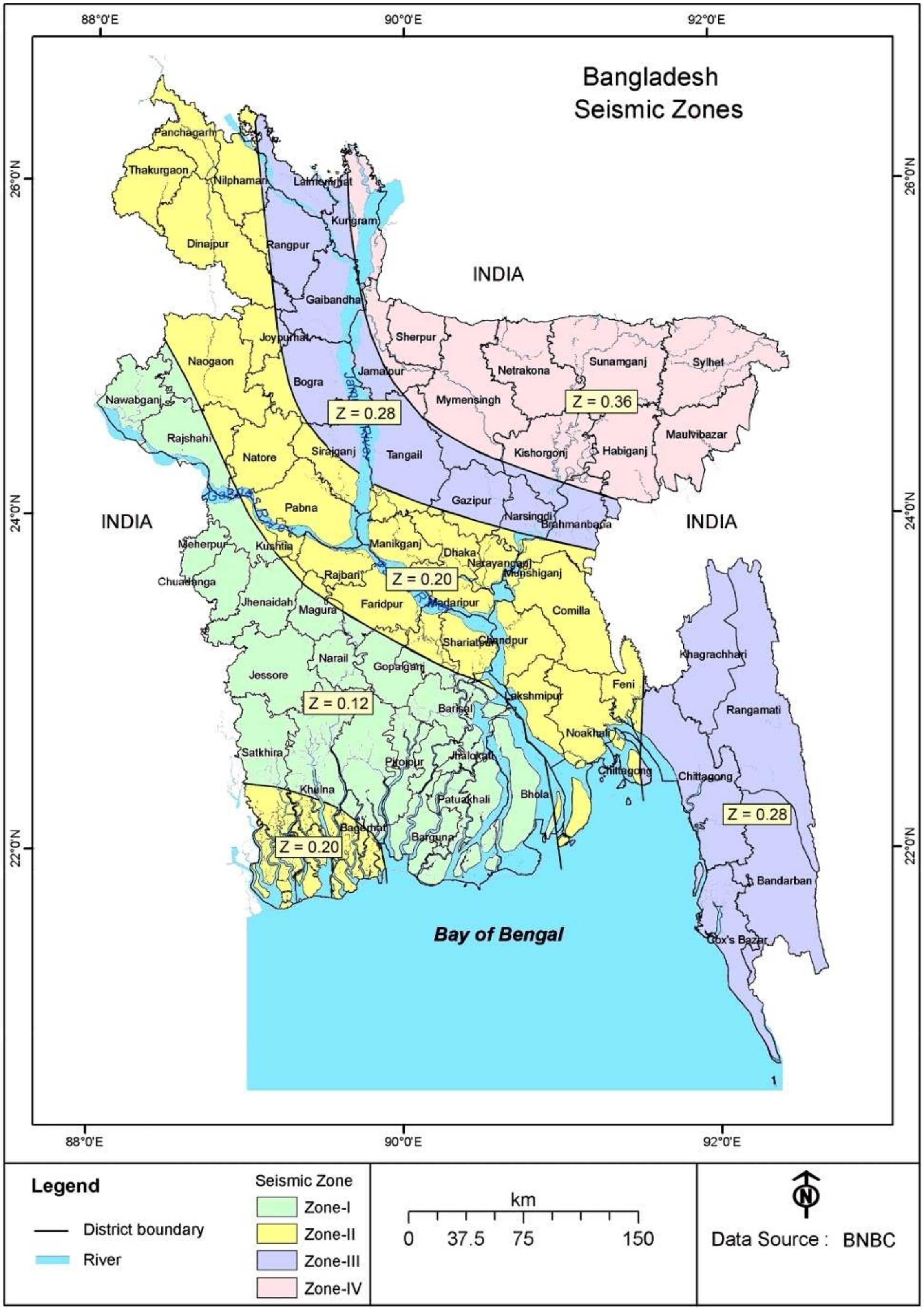

Figure 3.1: Seismic zoning map of Bangladesh

Table 3.6: Seismic Design Category (As per BNBC- 6.2.18)

Site Class	Occupancy Category I, II and III				Occupancy Category IV			
	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
SA	B	C	C	D	C	D	D	D
SB	B	C	D	D	C	D	D	D
SC	B	C	D	D	C	D	D	D
SD	C	D	D	D	D	D	D	D
SE, S_1, S_2	D	D	D	D	D	D	D	D

Table 3.7: Values for coefficients to estimate period (As per BNBC- 6.2.20)

Structure type	C_t	m	
Concrete moment-resisting frames	0.0466	0.9	Note: Consider moment resisting frames as frames which resist 100% of seismic force and are not enclosed or adjoined by components that are more rigid and will prevent the frames from deflecting under seismic forces.
Steel moment-resisting frames	0.0724	0.8	
Eccentrically braced steel frame	0.0731	0.75	
All other structural systems	0.0488	0.75	

Table 3.8: Reduction, Overstrength & Deflection Factor (As per BNBC Table - 6.2.19)

Seismic Force–Resisting System	Response Reduction Factor, R	System Overstrength Factor, Ω_o	Deflection Amplification Factor, C_d	Seismic Design Category B	Seismic Design Category C	Seismic Design Category D
				Height limit (m)		
A. BEARING WALL SYSTEMS (no frame)						
1. Special reinforced concrete shear walls	5	2.5	5	NL	NL	50
2. Ordinary reinforced concrete shear walls	4	2.5	4	NL	NL	NP
3. Ordinary reinforced masonry shear walls	2	2.5	1.75	NL	50	NP
4. Ordinary plain masonry shear walls	1.5	2.5	1.25	18	NP	NP
B. BUILDING FRAME SYSTEMS (with bracing or shear wall)						
1. Steel eccentrically braced frames, moment resisting connections at columns away from links	8	2	4	NL	NL	50
2. Steel eccentrically braced frames, non-moment-resisting, connections at columns away from links	7	2	4	NL	NL	50
3. Special steel concentrically braced frames	6	2	5	NL	NL	50
4. Ordinary steel concentrically braced frames	3.25	2	3.25	NL	NL	11

Seismic Force–Resisting System	Response Reduction Factor, R	System Overstrength Factor, Ω_o	Deflection Amplification Factor, C_d	Seismic Design Category B	Seismic Design Category C	Seismic Design Category D
				Height limit (m)		
5. Special reinforced concrete shear walls	6	2.5	5	NL	NL	50
6. Ordinary reinforced concrete shear walls	5	2.5	4.25	NL	NL	NP
7. Ordinary reinforced masonry shear walls	2	2.5	2	NL	50	NP
8. Ordinary plain masonry shear walls	1.5	2.5	1.25	18	NP	NP
C. MOMENT RESISTING FRAME SYSTEMS (no shear wall)						
1. Special steel moment frames	8	3	5.5	NL	NL	NL
2. Intermediate steel moment frames	4.5	3	4	NL	NL	35
3. Ordinary steel moment frames	3.5	3	3	NL	NL	NP
4. Special reinforced concrete moment frames	8	3	5.5	NL	NL	NL
5. Intermediate reinforced concrete moment frames	5	3	4.5	NL	NL	NP
5. Ordinary reinforced concrete moment frames	3	3	2.5	NL	NP	NP

Seismic Force–Resisting System	Response Reduction Factor, R	System Overstrength Factor, Ω_o	Deflection Amplification Factor, C_d	Seismic Design Category B	Seismic Design Category C	Seismic Design Category D
				Height limit (m)		
D. DUAL SYSTEMS: SPECIAL MOMENT FRAMES CAPABLE OF RESISTING AT LEAST 25% OF PRESCRIBED SEISMIC FORCES (with bracing or shear wall)						
1. Steel eccentrically braced frames	8	2.5	4	NL	NL	NL
2. Special steel concentrically braced frames	7	2.5	5.5	NL	NL	NL
3. Special reinforced concrete shear walls	7	2.5	5.5	NL	NL	NL
4. Ordinary reinforced concrete shear walls	6	2.5	5	NL	NL	NP
E. DUAL SYSTEMS: INTERMEDIATE MOMENT FRAMES CAPABLE OF RESISTING AT LEAST 25% OF PRESCRIBED SEISMIC FORCES (with bracing or shear wall)						
1. Special steel concentrically braced frames	6	2.5	5	NL	NL	11
2. Special reinforced concrete shear walls	6.5	2.5	5	NL	NL	50
3. Ordinary reinforced masonry shear walls	3	3	3	NL	50	NP

Seismic Force–Resisting System	Response Reduction Factor, R	System Overstrength Factor, Ω_o	Deflection Amplification Factor, C_d	Seismic Design Category B	Seismic Design Category C	Seismic Design Category D
				Height limit (m)		
4. Ordinary reinforced concrete shear walls	5.5	2.5	4.5	NL	NL	NP
F. DUAL SHEAR WALL-FRAME SYSTEM: ORDINARY REINFORCED CONCRETE MOMENT FRAMES AND ORDINARY REINFORCED CONCRETE SHEAR WALLS	4.5	2.5	4	NL	NP	NP
G. STEEL SYSTEMS NOT SPECIFICALLY DETAILED FOR SEISMIC RESISTANCE	3	3	3	NL	NL	NP

3.2.5 Load Groups: All possible live loads applied on floors and roof of a building due to various occupancies and uses, shall be divided into three load groups as described below for determining the appropriate live load reduction factors.

Load Group 1: Uniformly distributed live loads arising from the Occupancies and Two uses

(i) Assembly occupancies or areas with Uniformly distributed live load of 5.0 kN/m or less.

(ii) Machinery and equipment for which specific live load allowances have been made.

(iii) Special roof live load and printing plants, vaults, strong room and armories, shall be classified under Load Group 1. Reduction of live load shall not be allowed for members or portions thereof under This load group and a reduction factor, R-1.0 shall be applied for

Load Group 2: Uniformity distributed live loads resulting from Occupancies or uses of

(i) Assembly areas with uniformly distributed Live load greater than 5.0 kN/m, and

(ii) Storage, mercantile, Industrial and retail stores, shall be classified under Load Group 2, Live load reduction factor, $1.0 < R < 0.7$ shall be applied to this load group depending on the tributary area of the floors or roof supported by the member as specified.

Load Group 3: Uniformly distributed live loads arising due to all other occupancies and uses except those of Load Group I and Load Group 2, shall be grouped into Load Group 3. Live load reduction factor, $1.0 < R < 0.5$ as specified, shall be applied to tributary areas under this load group.

Tributary Area: The tributary area of a structural member supporting floors or roof shall be determined as follows:

a) Tributary Area for Wall, Column, Pier, Footing and the like: Tributary areas of these members shall consist of portions of the areas of all floors, roof or combination thereof that contribute live loads to the member concerned.

b) Tributary Area for Beam, Girder, Flat plate and Flat slab: Tributary area for such a member shall consist of the portion of the roof or a floor at any single level that contributes loads to the member concerned.

Exposure Category: The terrain exposure in which a building or structure is to be sited shall be assessed as being one of the following categories:

1. **Exposure A:** Urban and sub-urban areas, industrial areas, wooded

   areas, hilly or other terrain covering at least 20 per cent of the area with obstructions of 6 meters or more in height and extending from the site at least 500 meters or 10 times the height of the structure, whichever is greater.

2. **Exposure B:** Open terrain with scattered obstructions having heights generally less than10m extending 800 m or more from the site in any full quadrant. This category includes airfields, open park lands, sparsely built-up outskirts of towns, flat open country and grasslands.

3. **Exposure C:** Flat and unobstructed open terrain, coastal areas and riversides facing large bodies of water, over 1.5 km or more in width.

   Exposure C extends inland from the shoreline 400 m or 10 times the eight of structure, whichever is greater.

3.2.6 Load Combinations:

As per BNBC 2006, Chapter 2- Part 6 (Clause 11027.5), following load cases must be considered for analysis:

- U = 1.4 D.L……………………………………………..…………………………….…… (x)
- U = 1.2 D.L + 1.6 L.L + 0.5 Lr…………………………………………………..……… (xi)
- U = 1.2 D.L + 1.6 Lr + L.L….. (xii)
- U = 1.2 D.L + 1.6 Lr + 0.8 W……………………….……………………………….…… (xiii)
- U = 1.2 D.L + 1.6 W + L+0.5 Lr ……………………………………….......……….... (xiv)
- U = 1.2 D.L + 1.0 E + 1.0 L ……………………………………...………………....…(xv)
- U = 0.9 D.L + 1.6 W …………………………..…………………….……………..… (xvi)
- U = 0.9 D.L + 1.6 E………………………………………………….....…………… (xvii)

Earthquake load and Wind Load must be considered for +X, -X, +Y and -Y directions. Thus, +EL and + WL above implies 20 cases, and in all, 23 cases as per Table 3.6 must be considered. All 23 load combinations are analyzed using software.

3.2.7 Design Data:

- Design code ACI 318-08 (BNBC-2020).
- Gride line spacing A-H and 1-6.
- Column-12”x20”.
- Beam 10”x20”.
- Slab- 6” (for Two way).
- Waist Slab- 8” (for One way).
- Lift core Wall- 10”
- Assum, on 8” Waist slab thickness
- LL = 100 psi for Stair
- FF = 25 psi
- LL = 40 psi
- PW = 60 psi

➢ **Wind Load Data:**

- Site location : Dhaka
- Basic Wind Speed, V : 147 mph
- Exposure Type : B
- Structural Importance Co-efficient : 1.0
- Topographical Factor K_{zt} : 1.0
- Gust Factor : 0.85
- Directionality Factor K_d : 0.85

➢ **Earthquake Load Data:**

- Seismic Zone : II
- Seismic Zone Factor, Z : 0.02
- Response Modification Co-efficient, R : 7
- Site Class : SD
- System Over strength, Ω : 2.5
- Occupancy Category : II
- Deflection Amplification, C_d : 5.5
- Importance Factor : 1
- Spectral Response Acceleration, S_s : 0.5
- Spectral Response Acceleration, S_s : 0.2

- Time Period, T : 0.6140 sec

a) Dead Load:

Floor Finish (FF) : 25 psf

MEPC : 15 psf

Partitional Wall (PW) : 400 lb/fi (9.5ft)

Parapet Wall : 150 psf

b) Live Load:

Floor : 40 psf

Roof : 100 psf

3.3 Architectural plan:

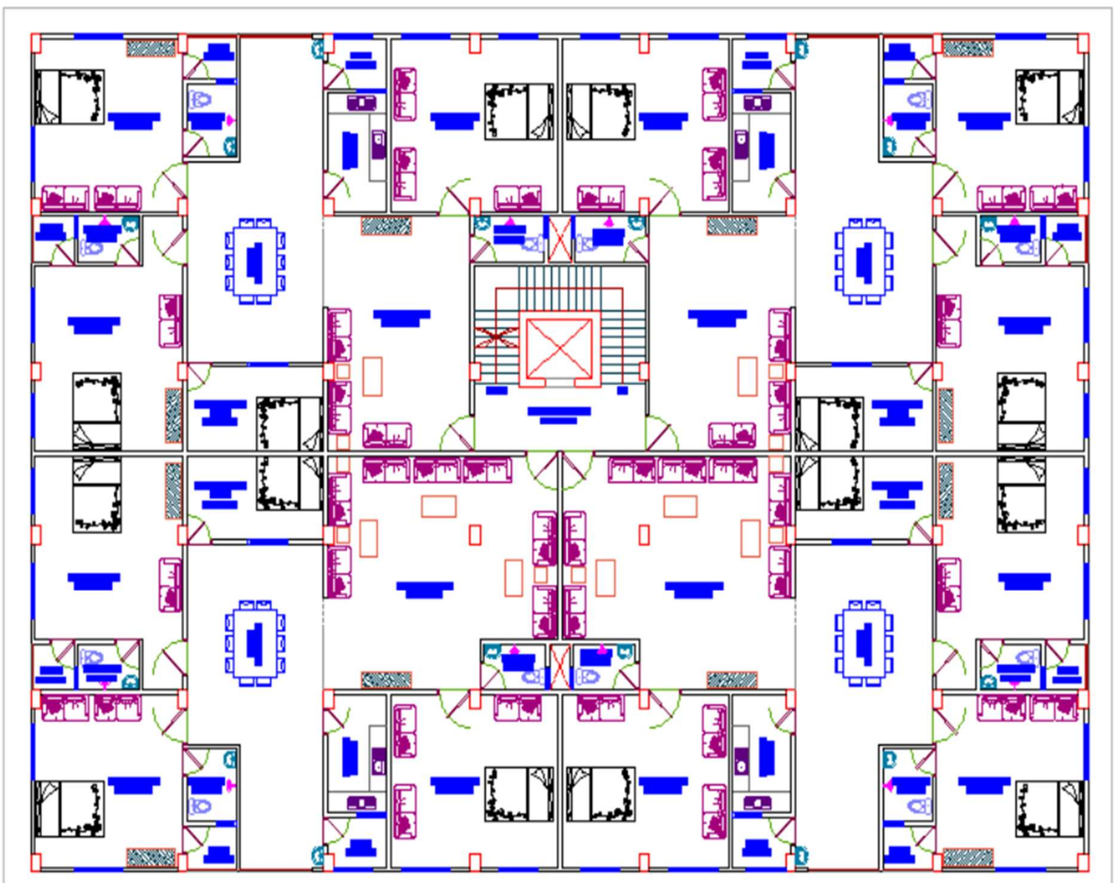

Figure 3.2: Typical Floor Plan

- **Column and Shear Wall Layout (Option-1):**

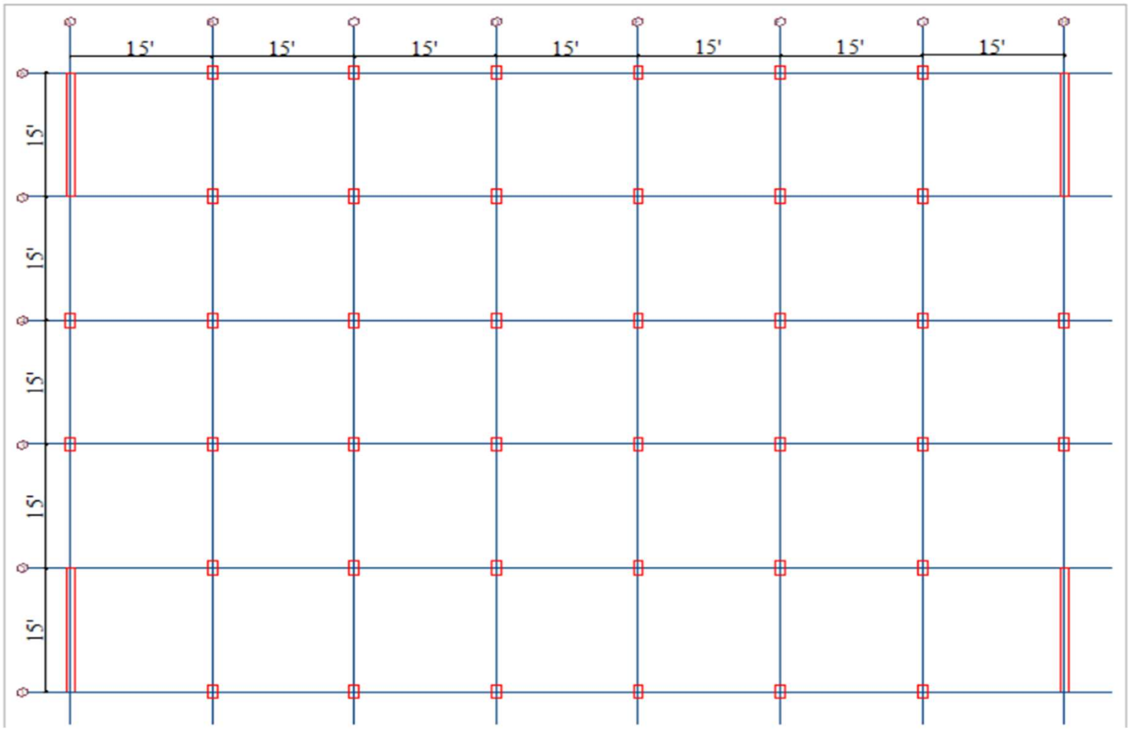

Figure 3.3: Option-1 Column Layout Plan

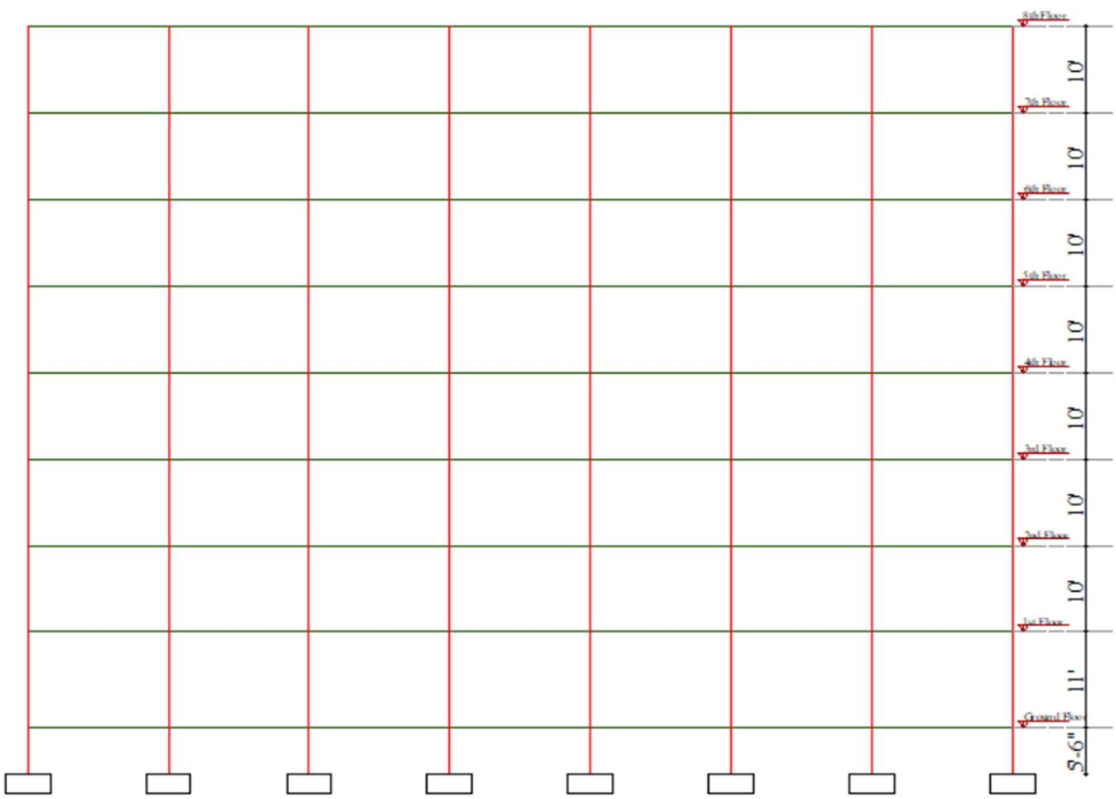

Figure 3.4: Option -1 Elevation

➢ **Column and Shear Wall Layout (Option-2):**

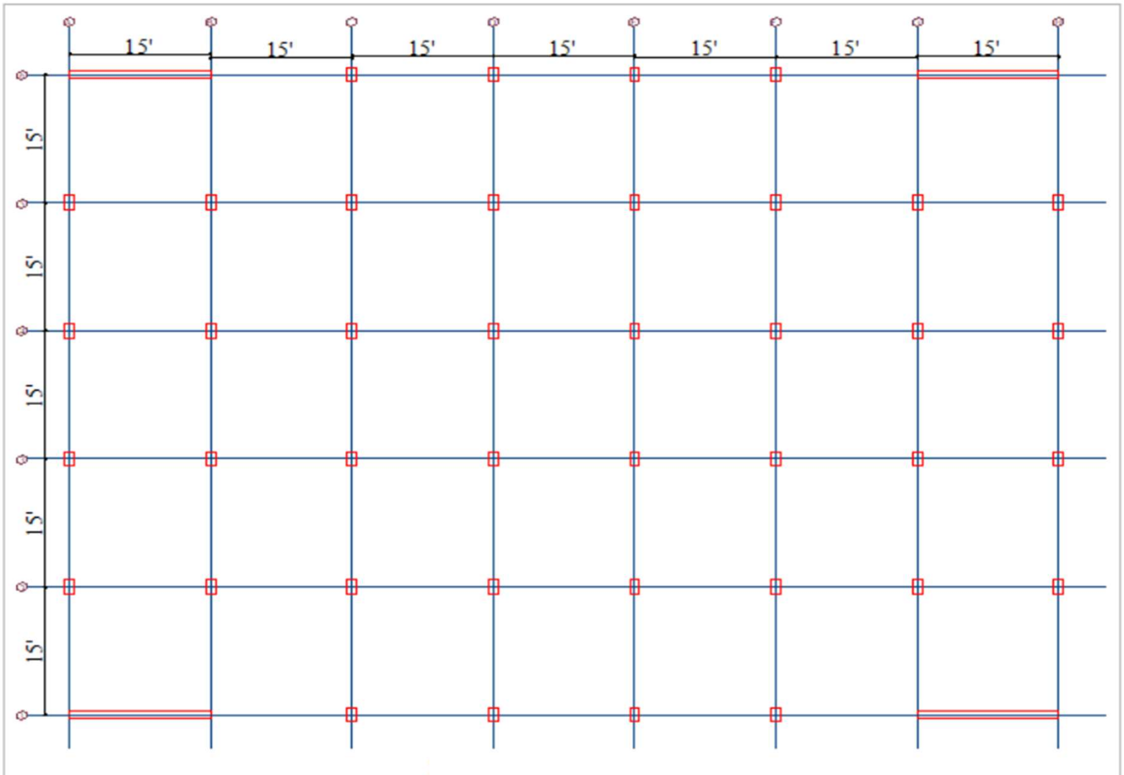

Figure 3.5: Option -2 Column Layout Plan

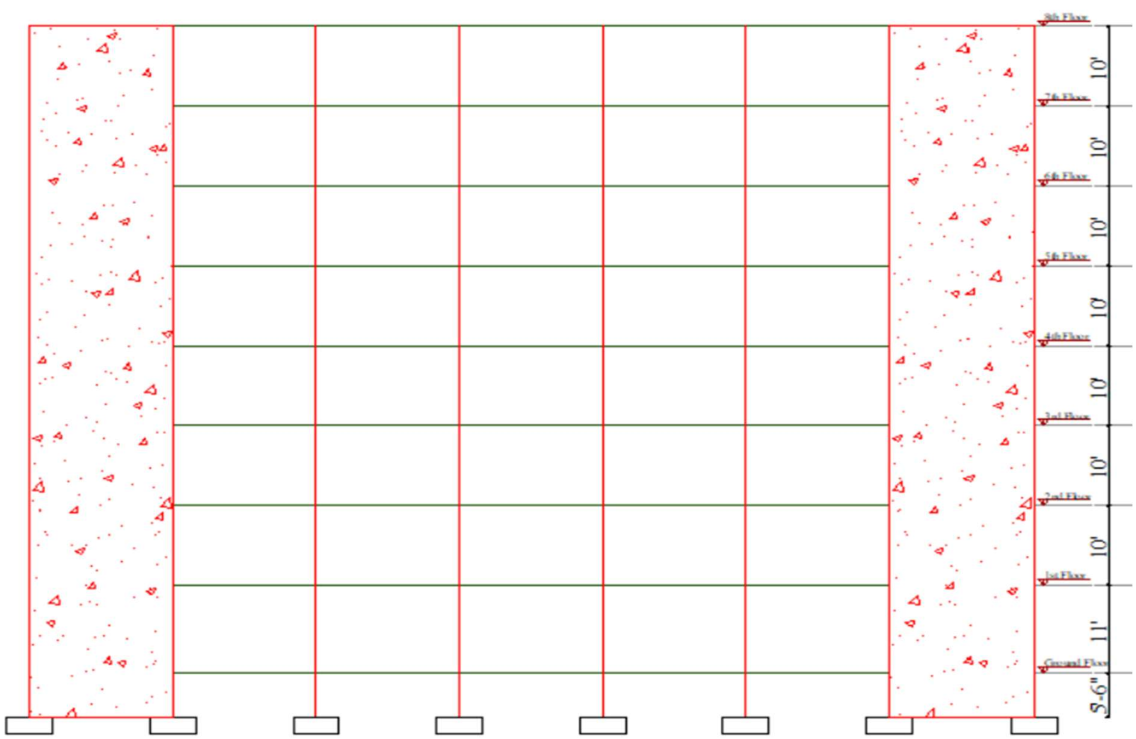

Figure 3.6: Option -2, Elevation

- **Column and Shear Wall Layout (Option-3):**

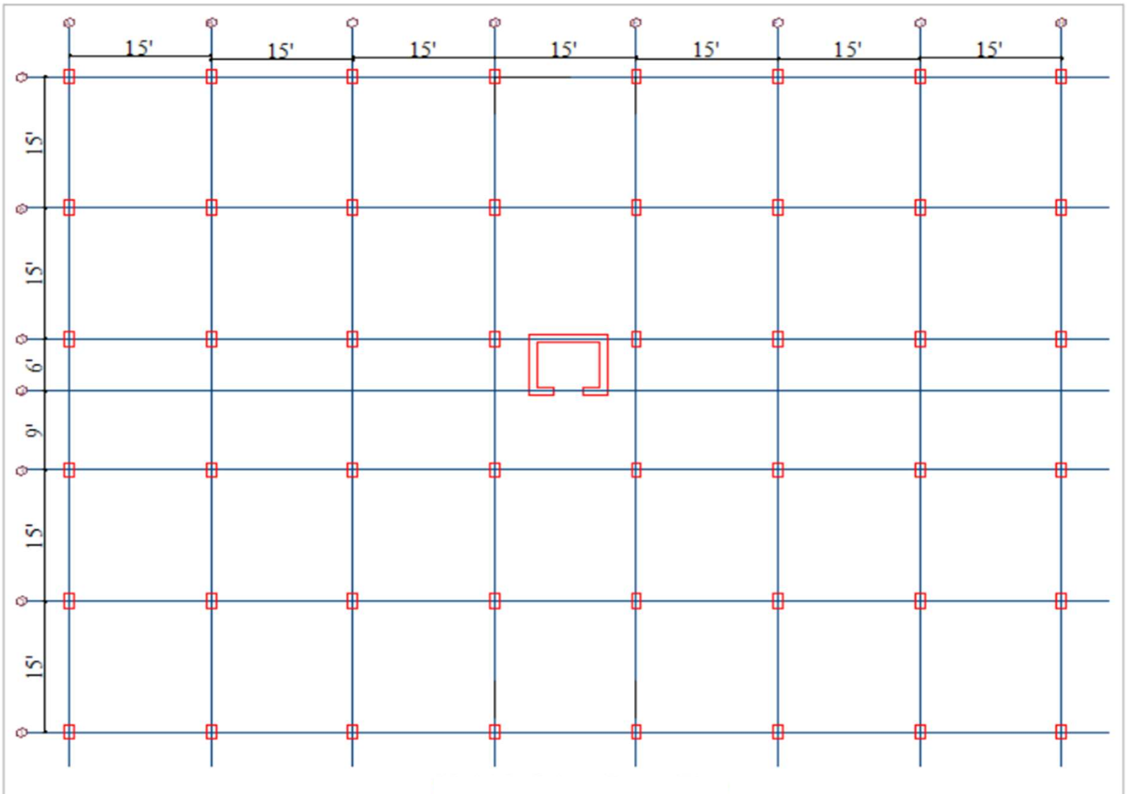

Figure 3.7: Option -3 Column Layout Plan

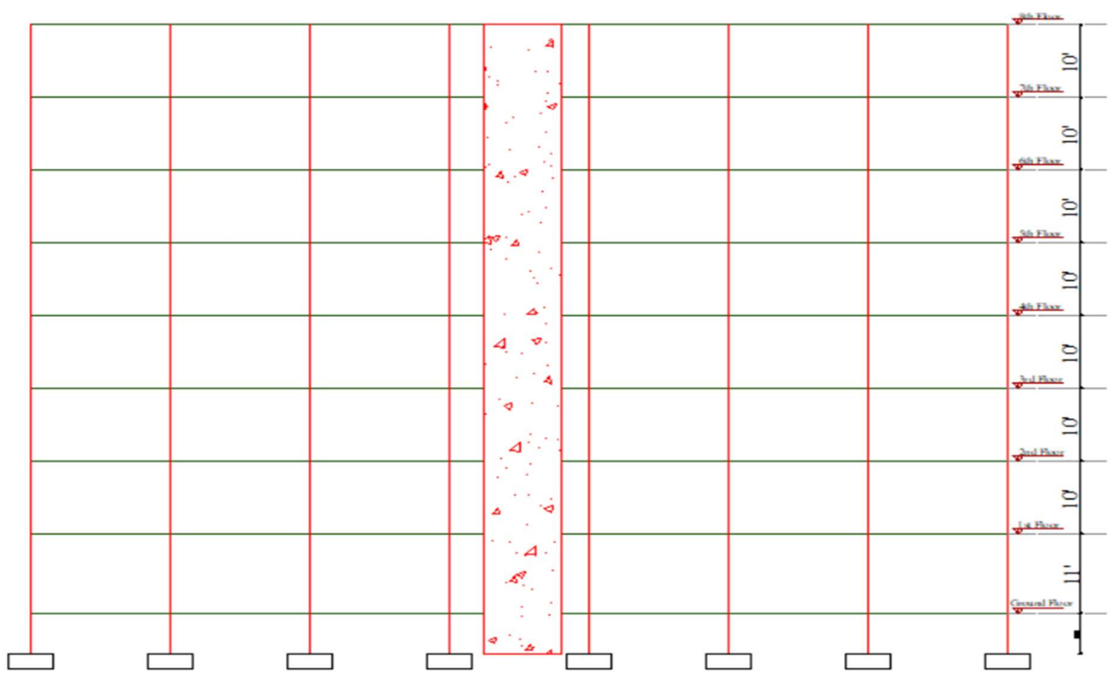

Figure 3.8: Option -3, Elevation

3.4 Define Section:

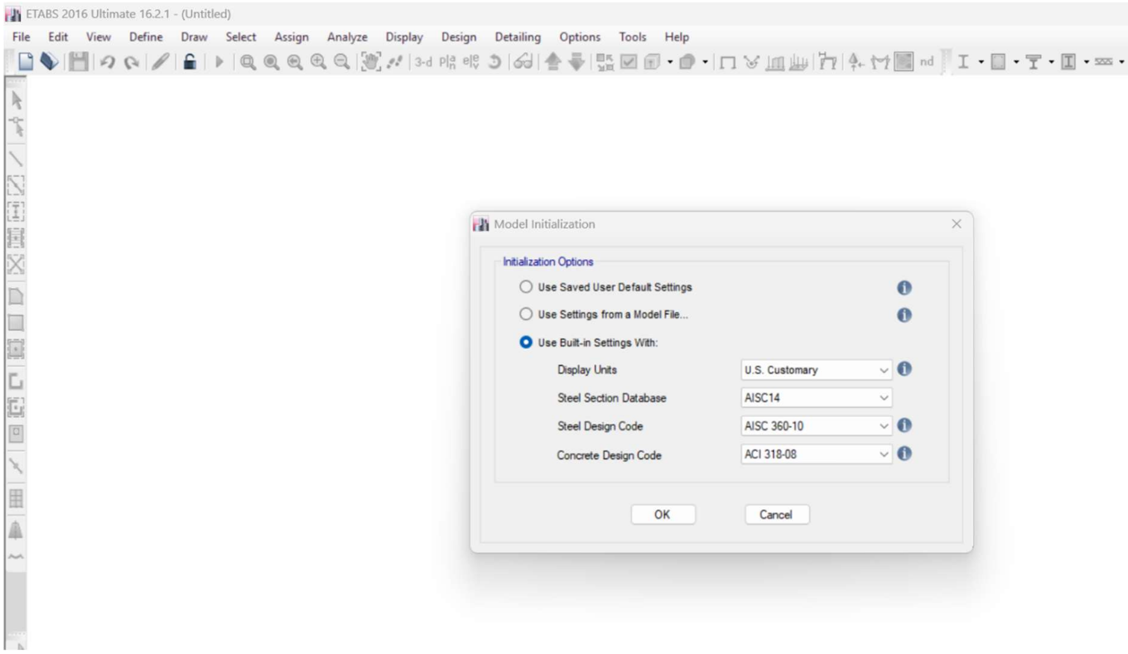

Figure 3.9: Option Initialization

➢ Grid System Data

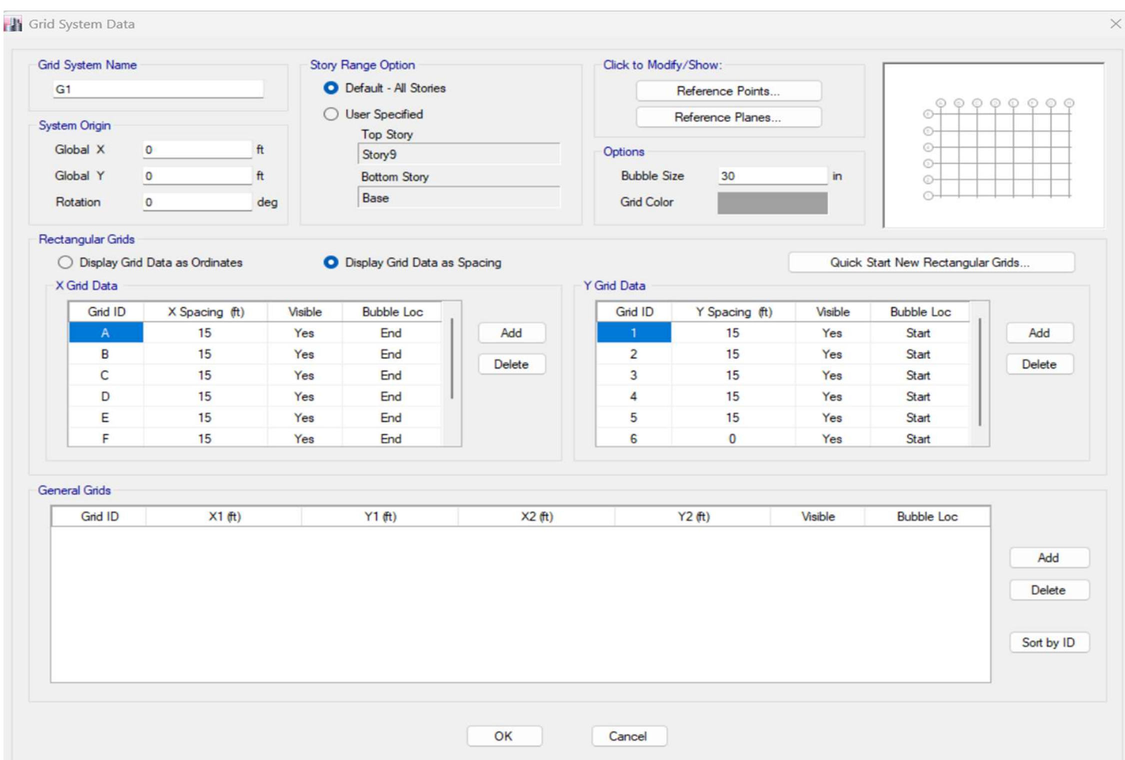

Figure 3.10: Grid System

- Define Materials

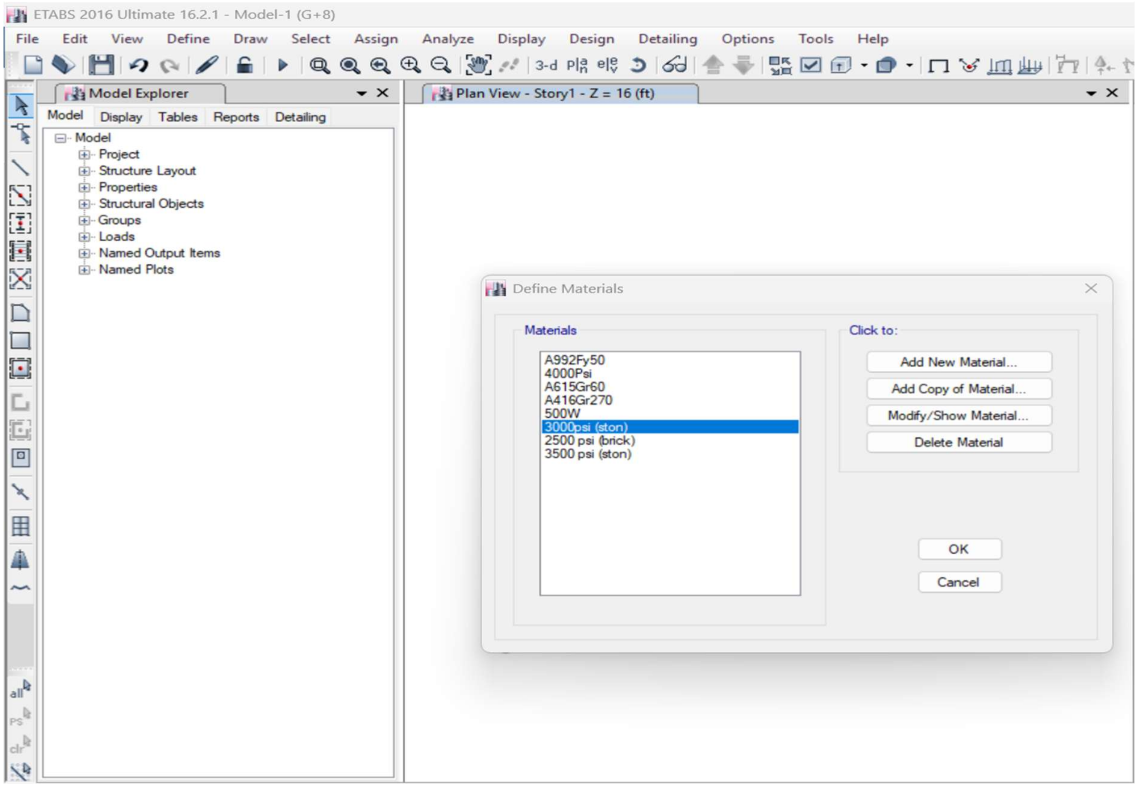

Figure 3.11: Material Define

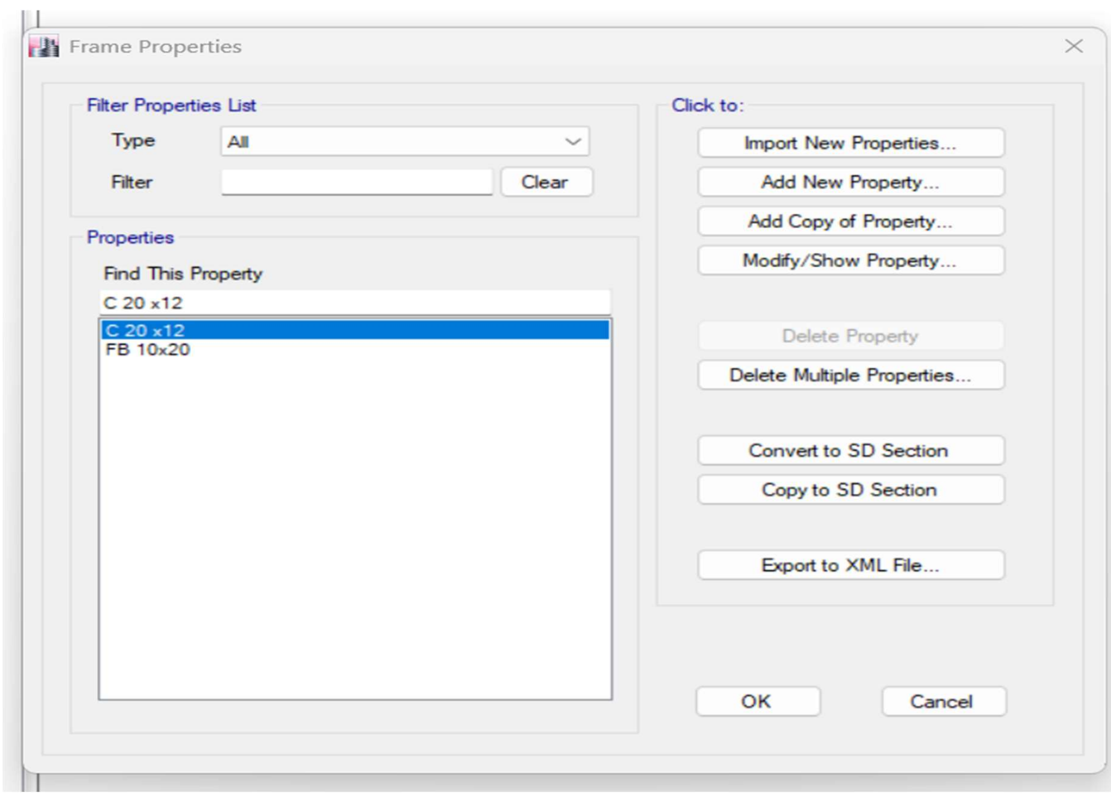

Figure 3.12: Frame Properties

- Define Properties

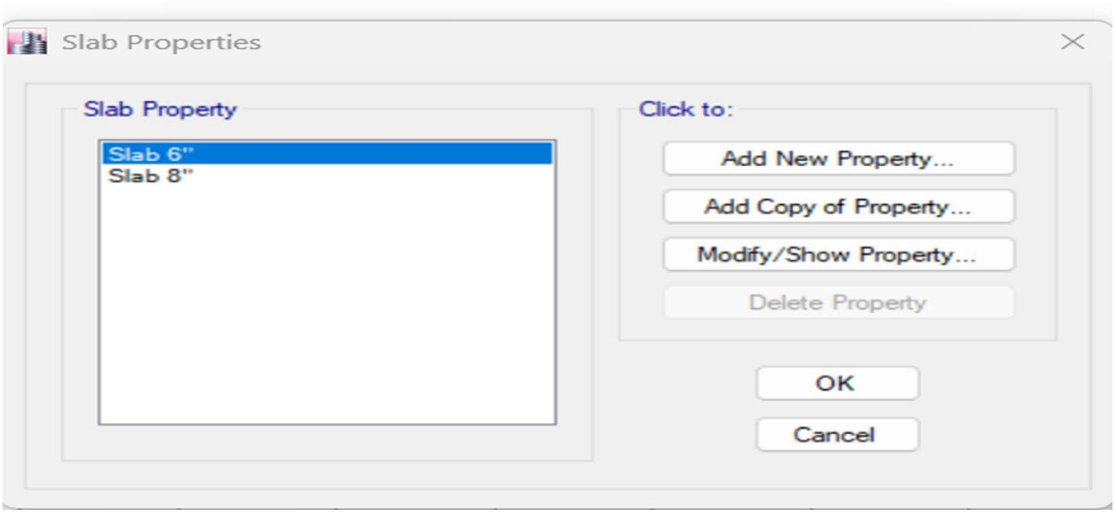

Figure 3.13: Slab Properties

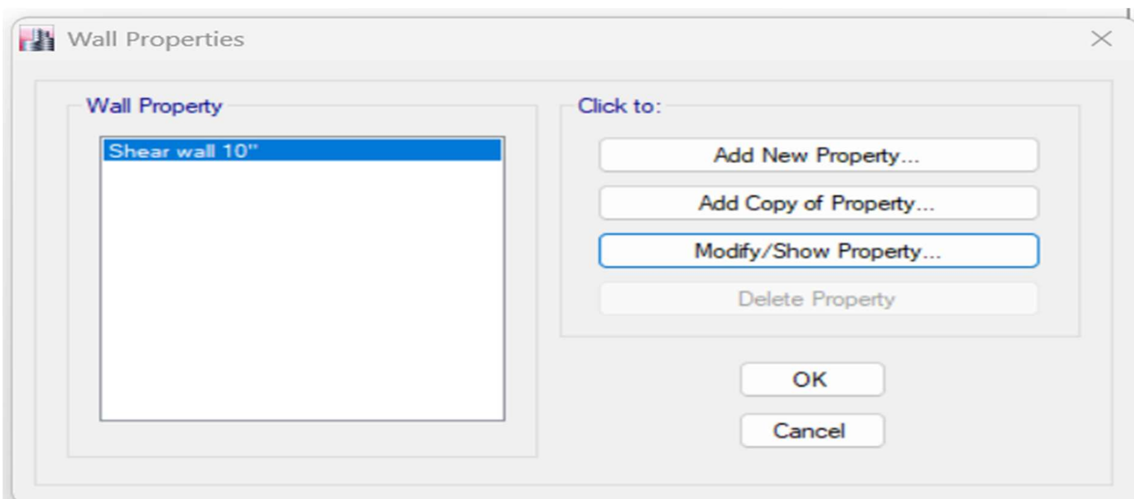

Figure 3.14: Shear Wall Properties

3.5 Define Load Pattern

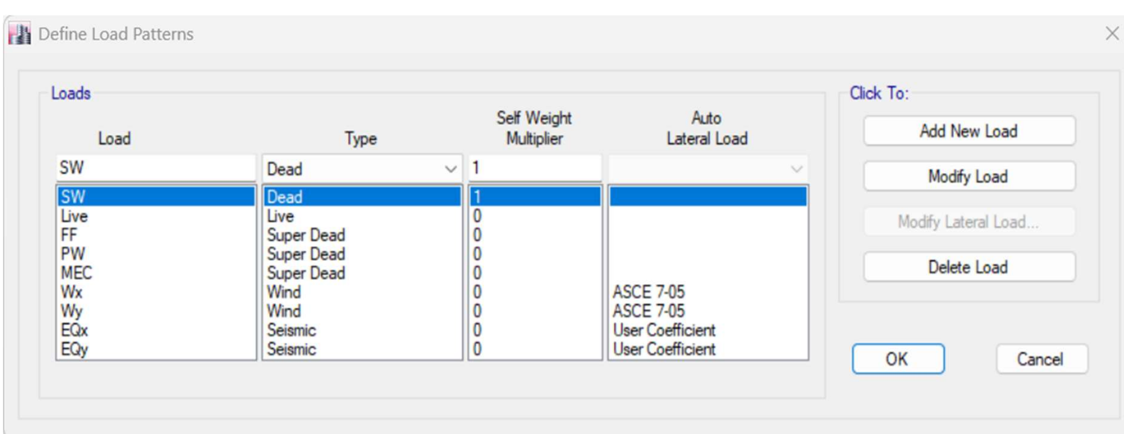

Figure 3.15: Frame Properties

➢ Load Pattern Define

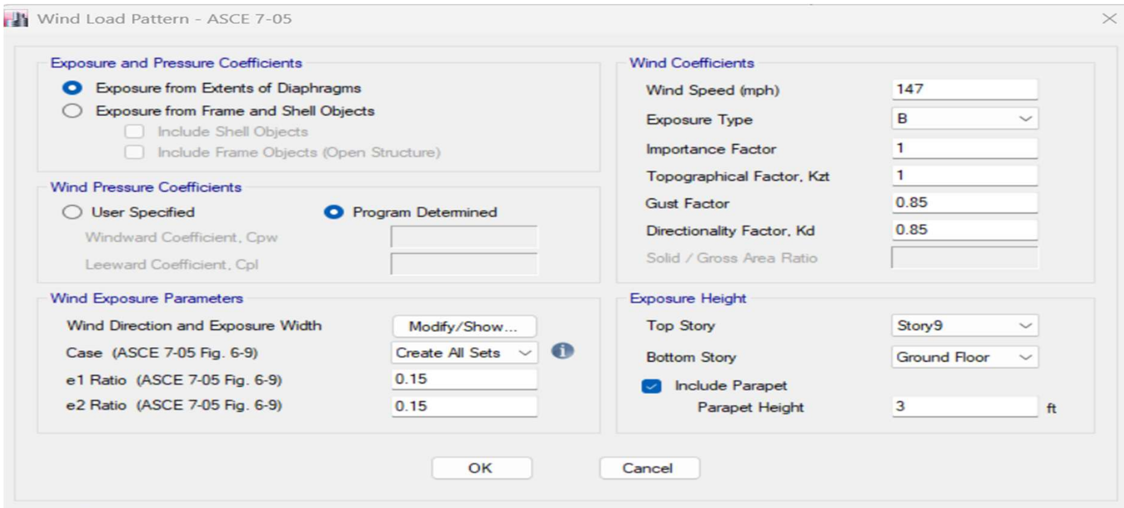

Figure 3.16: Wind Load Pattern

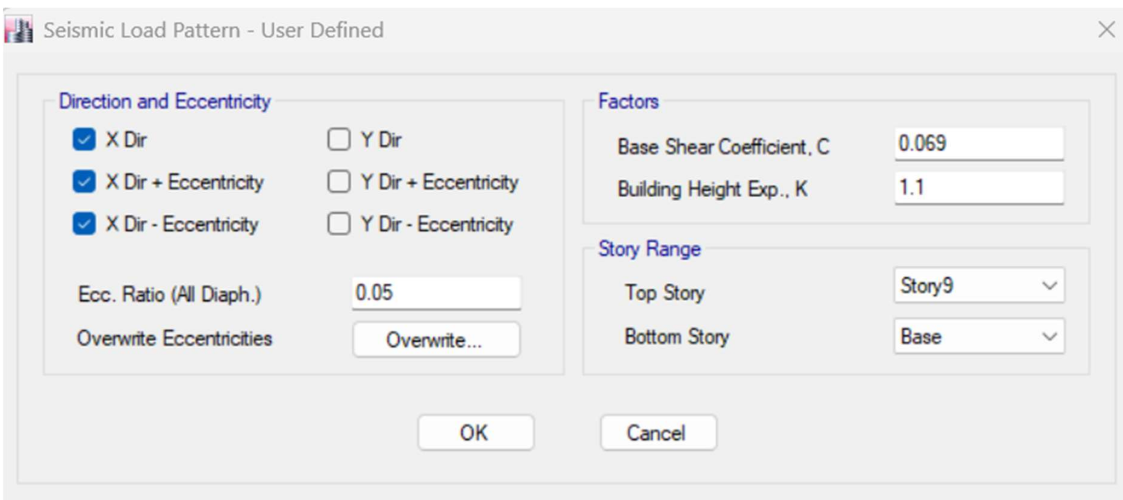

Figure 3.17: Seismic Load Pattern

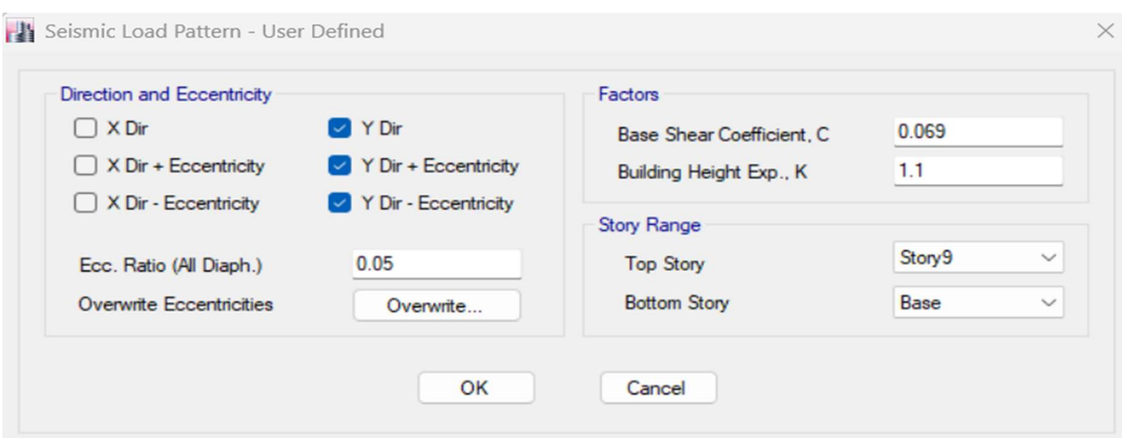

Figure 3.18: Seismic Load Pattern

3.6 ETABS Modeling:

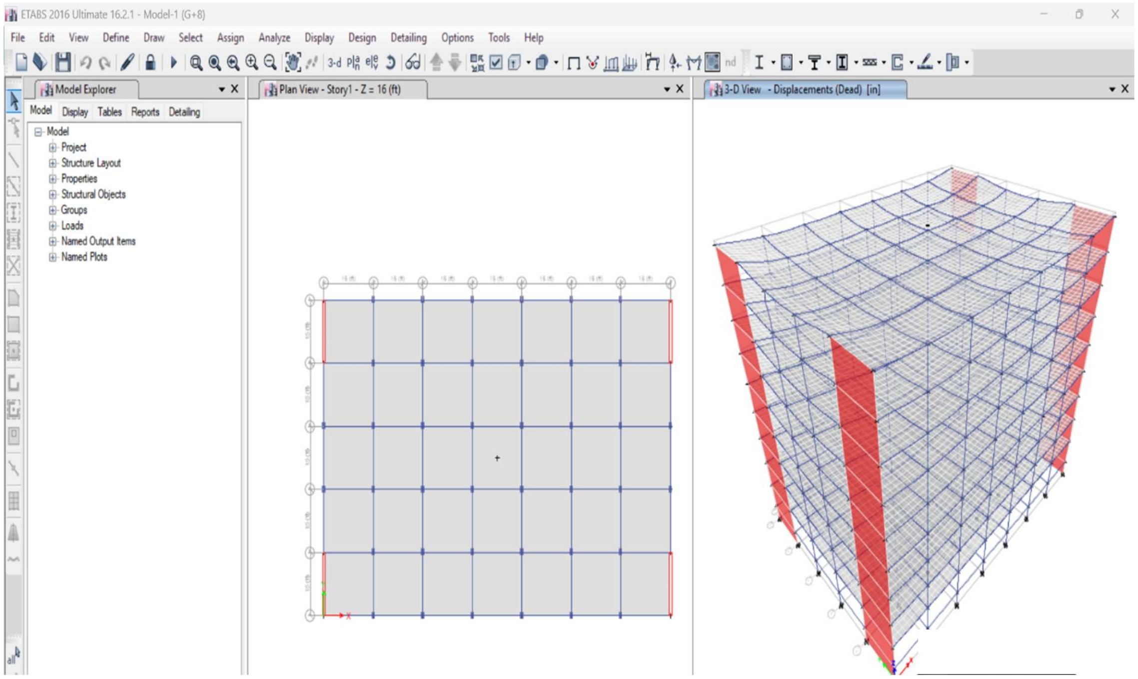

Figure 3.19: Option -1, plan and 3d view

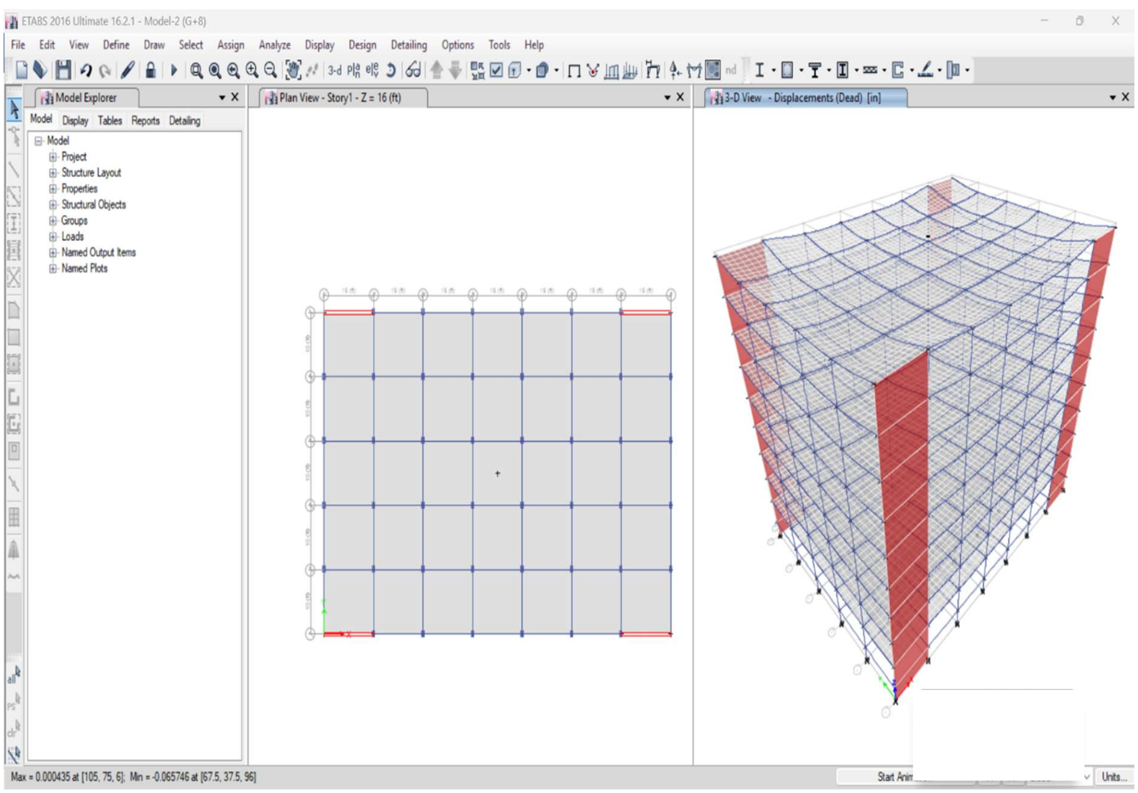

Figure 3.20: Option -2, plan and 3d view

➢ ETABS Modeling (Option-3)

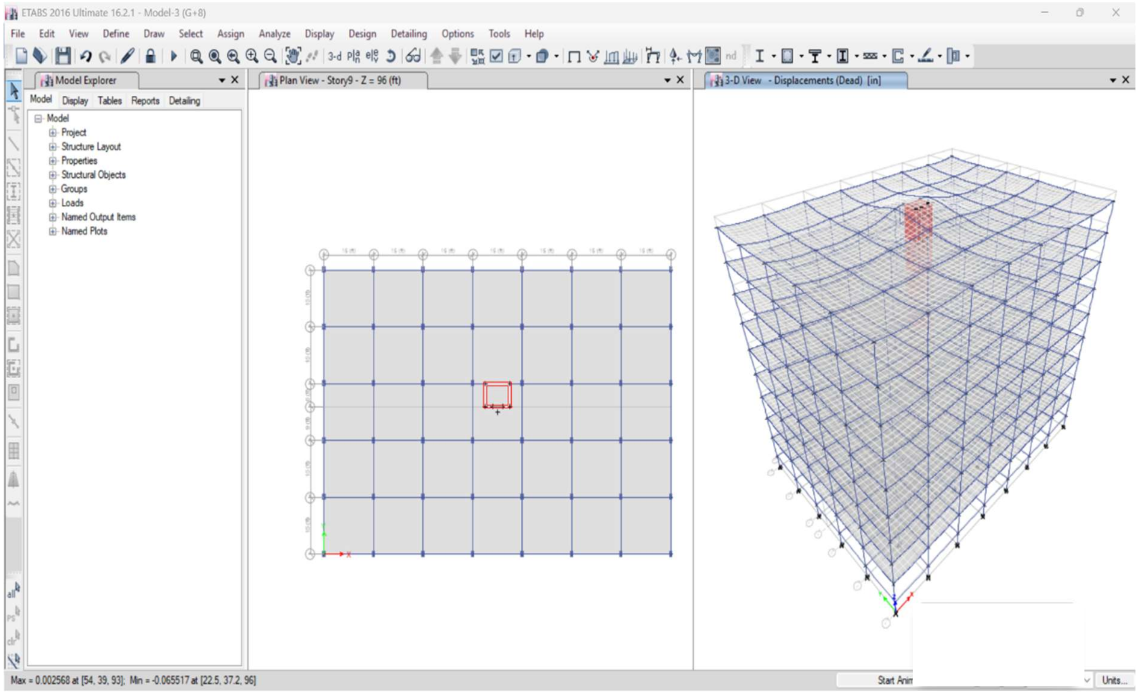

Figure 3.21: Option -3, plan and 3d view

3.7 Load Assign

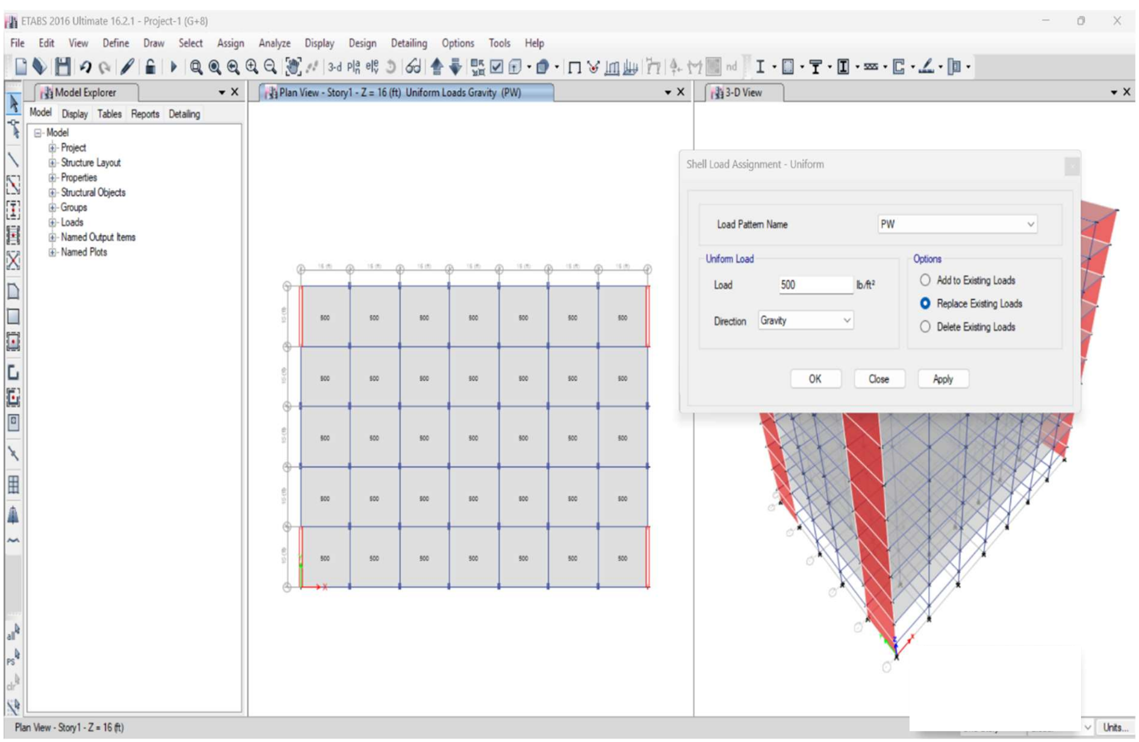

Figure 3.22: Load Assignment

➢ Load Assign

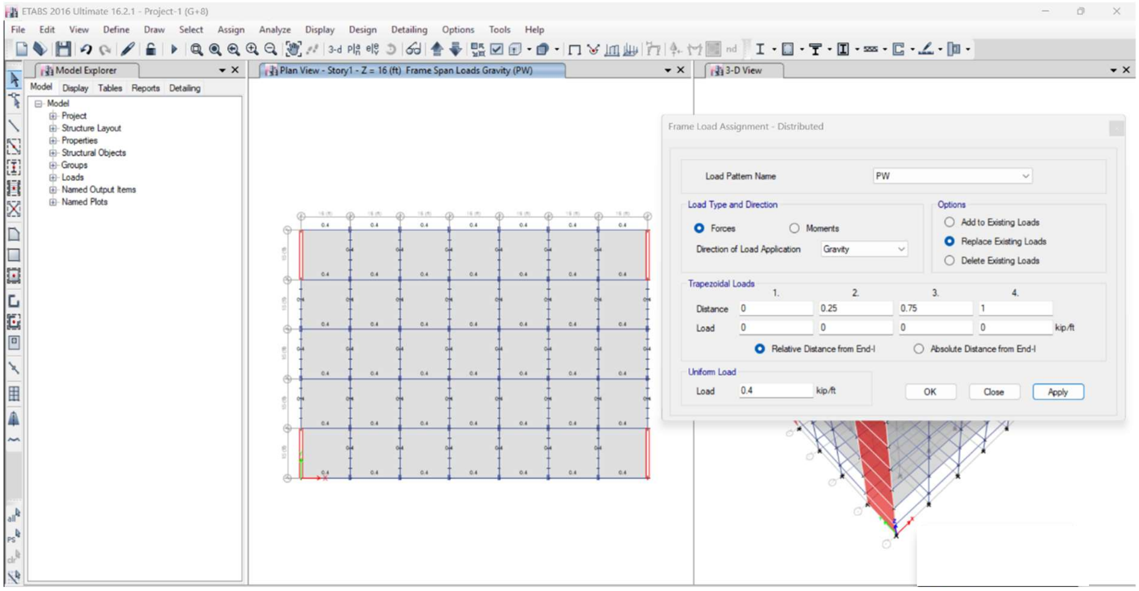

Figure 3.23: Load Assignment

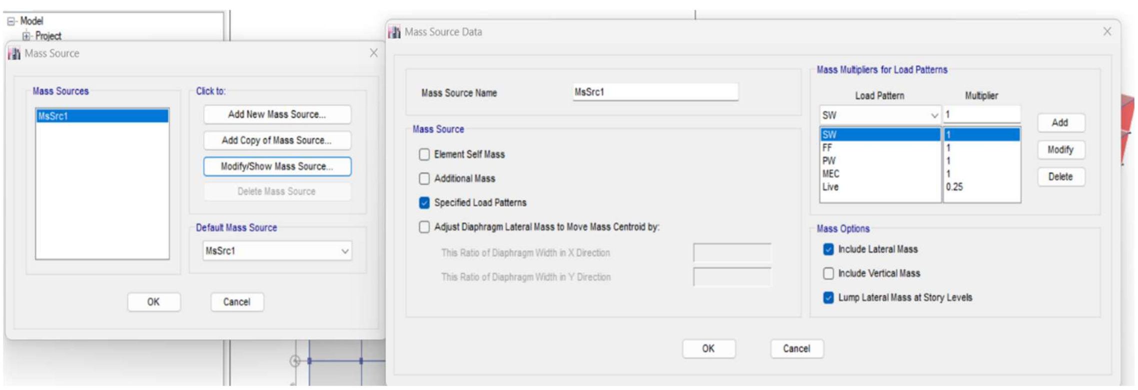

Figure 3.24: Mass Source

3.8 Model Check:

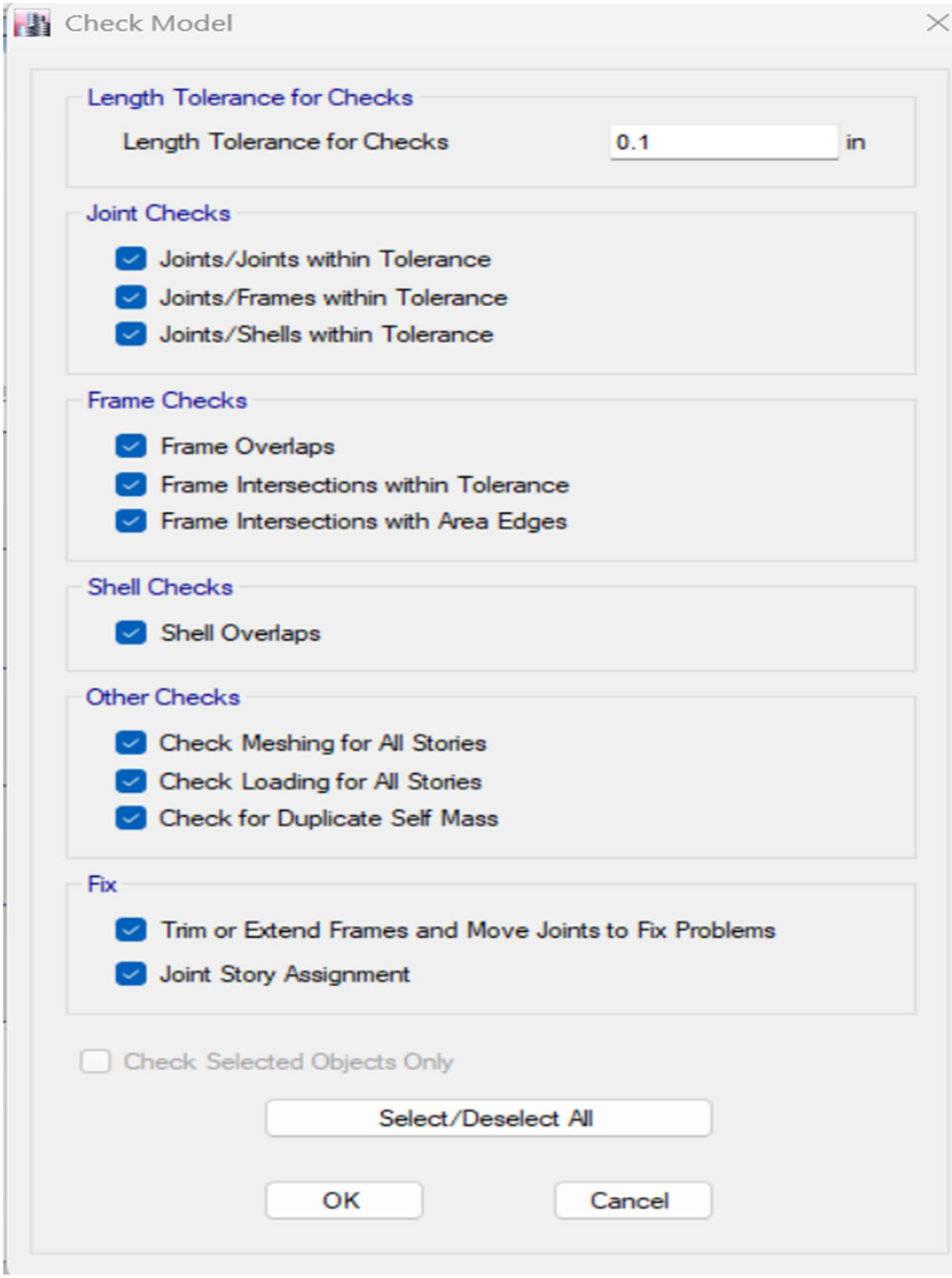

Figure 3.25: Model Check

3.9 Maximum Story Drift Check (Option-1):

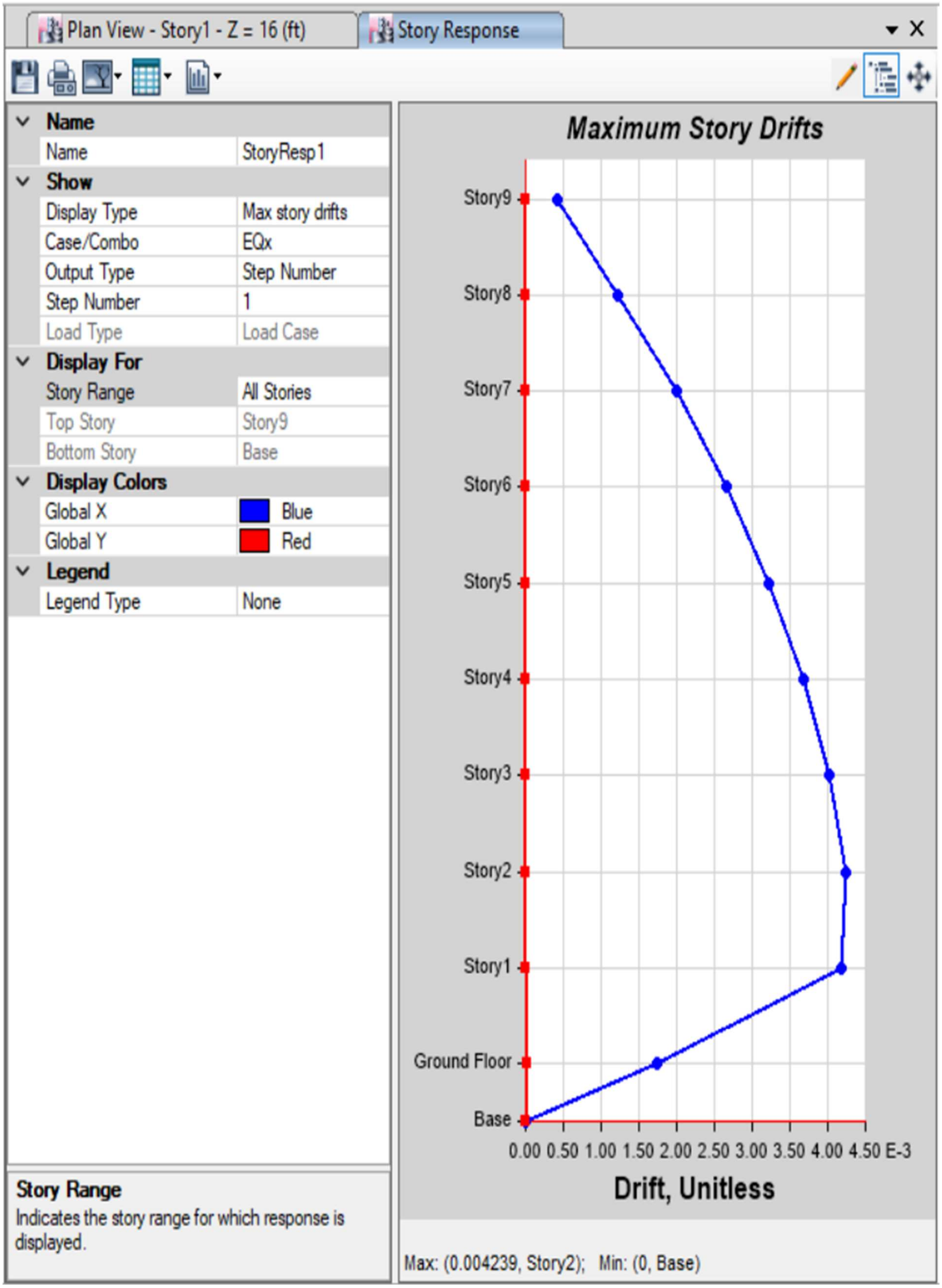

Figure 3.26: Maximum Story Drift Check (Option -1)

➢ Maximum Story Drift Check (Option-2):

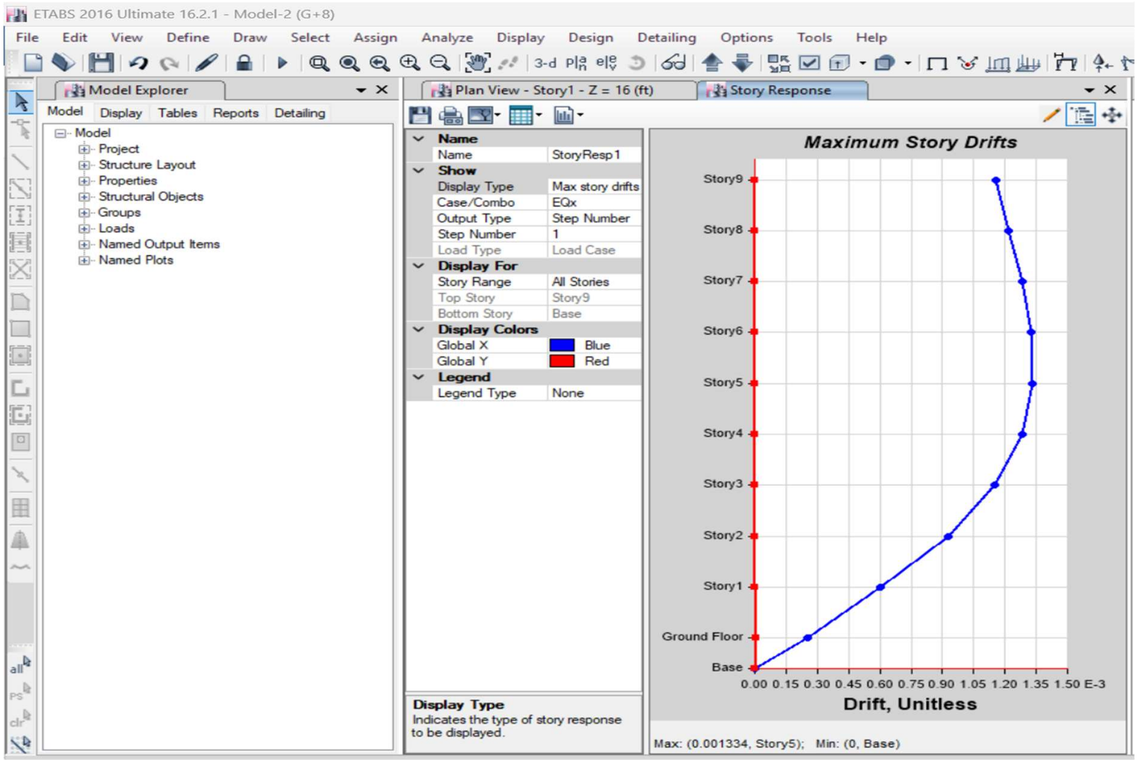

Figure 3.27: Maximum Story Drift Check (Option -2)

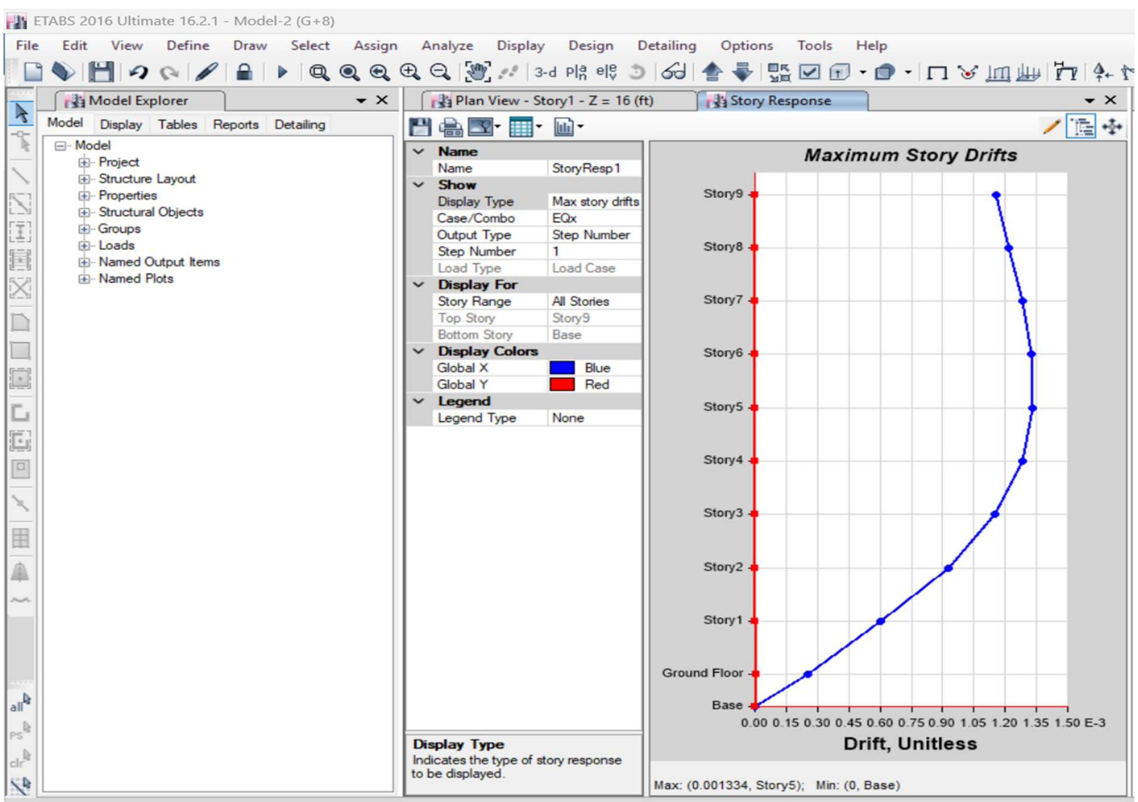

Figure 3.28: Maximum Story Drift Check (Option -3)

3.10 Maximum Story Displacement Check:

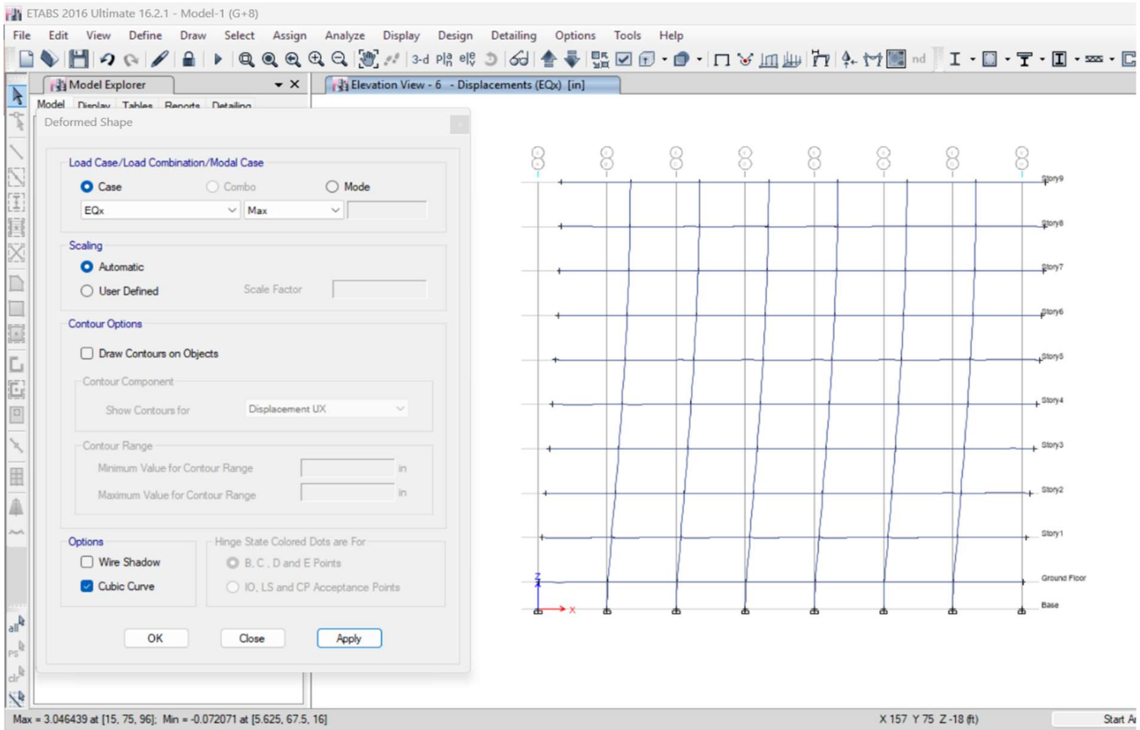

Figure 3.29: Maximum Story Displacement Check X direction (Option -1)

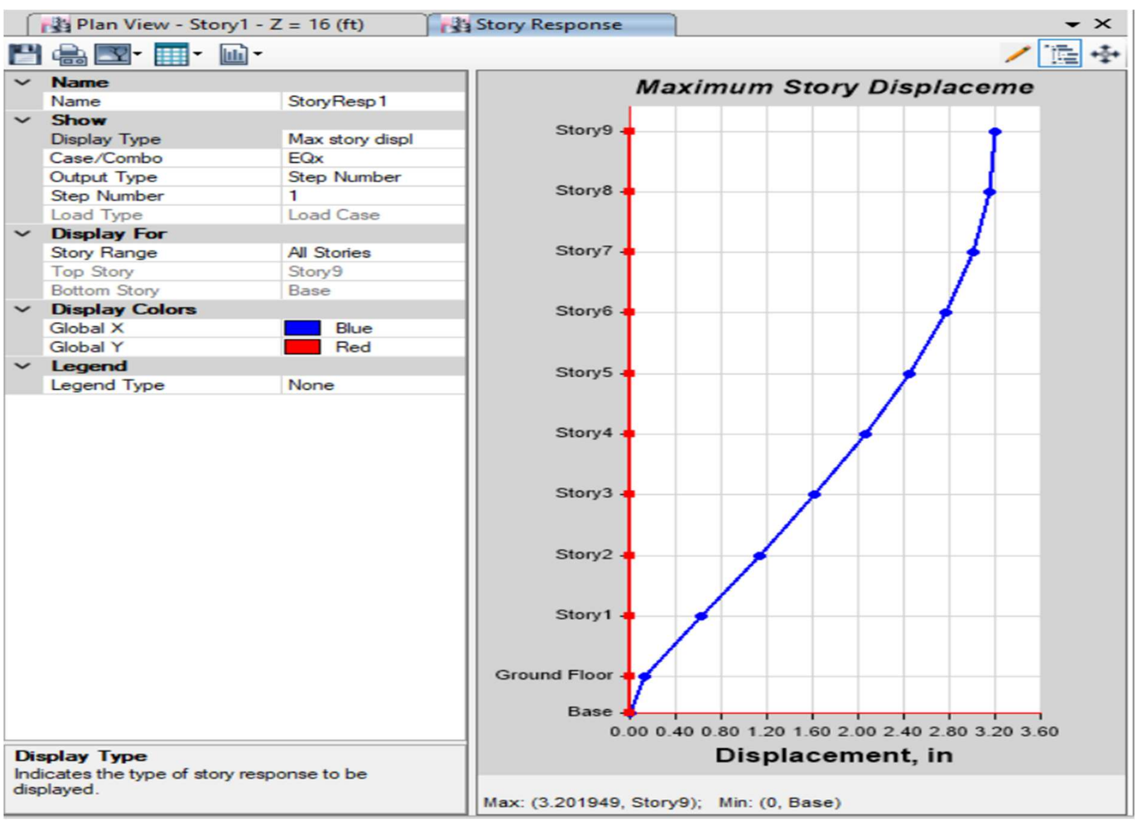

Figure 3.30: Maximum Story Displacement Check (Option -1)

➢ X direction Displacement Check (Option -2)

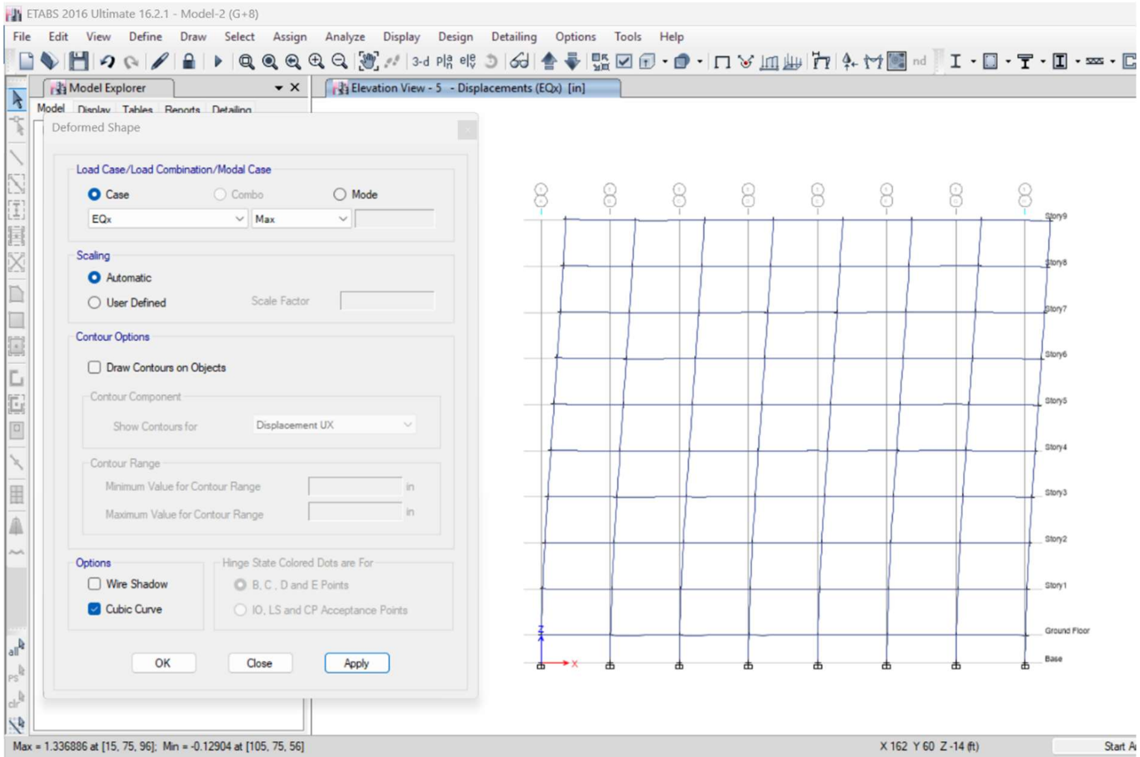

Figure 3.31: Maximum Story Displacement Check X direction (Option -2)

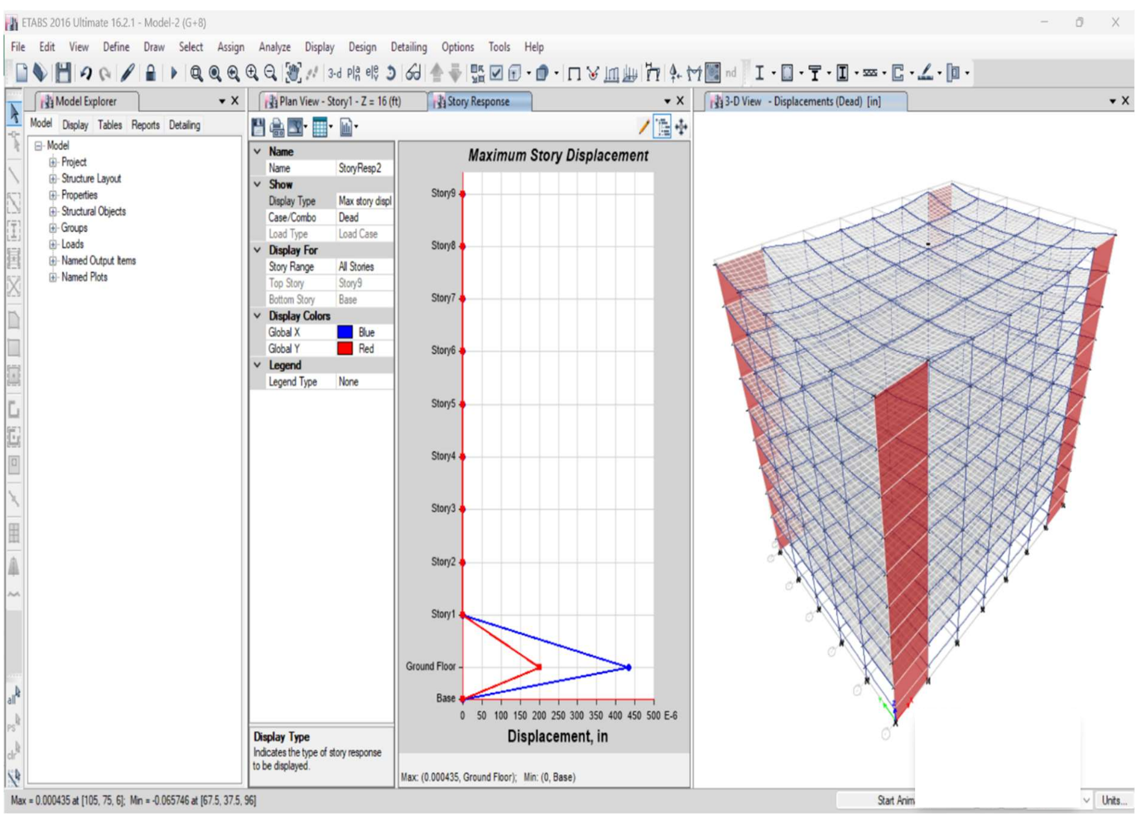

Figure 3.32: Maximum Story Displacement Check (Option -2)

➢ X direction Displacement Check (Option -3)

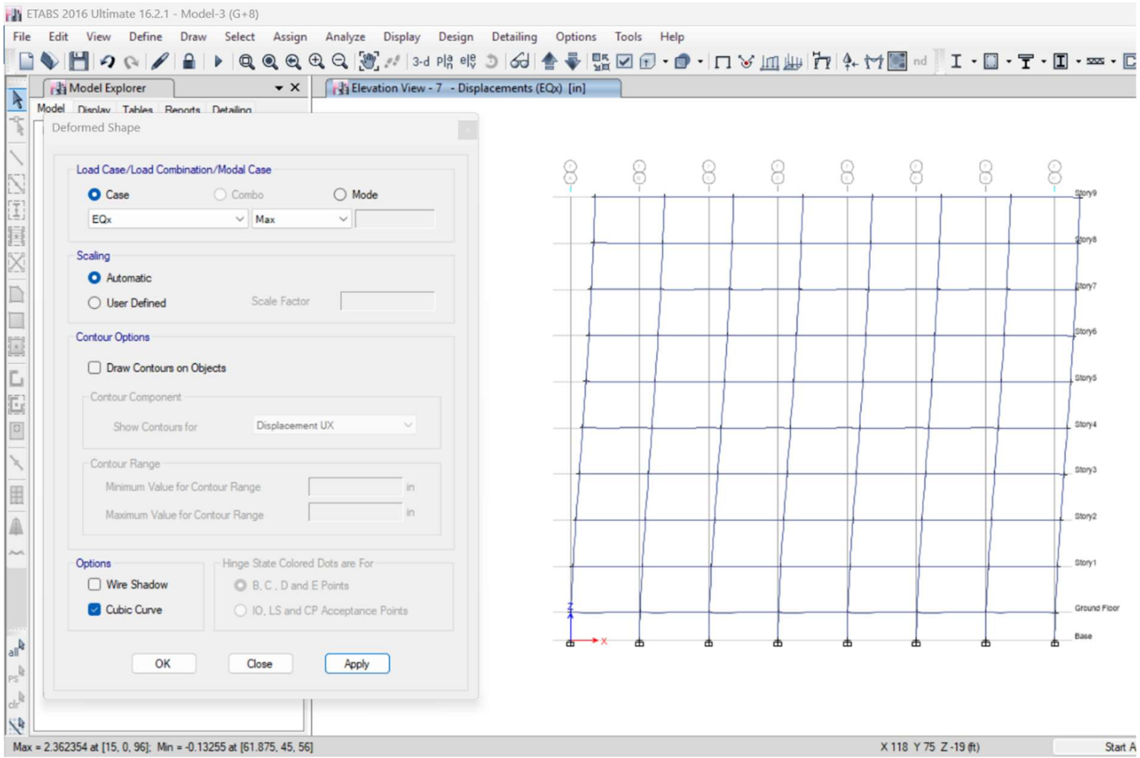

Figure 3.33: Maximum Story Displacement Check X direction (Option -3)

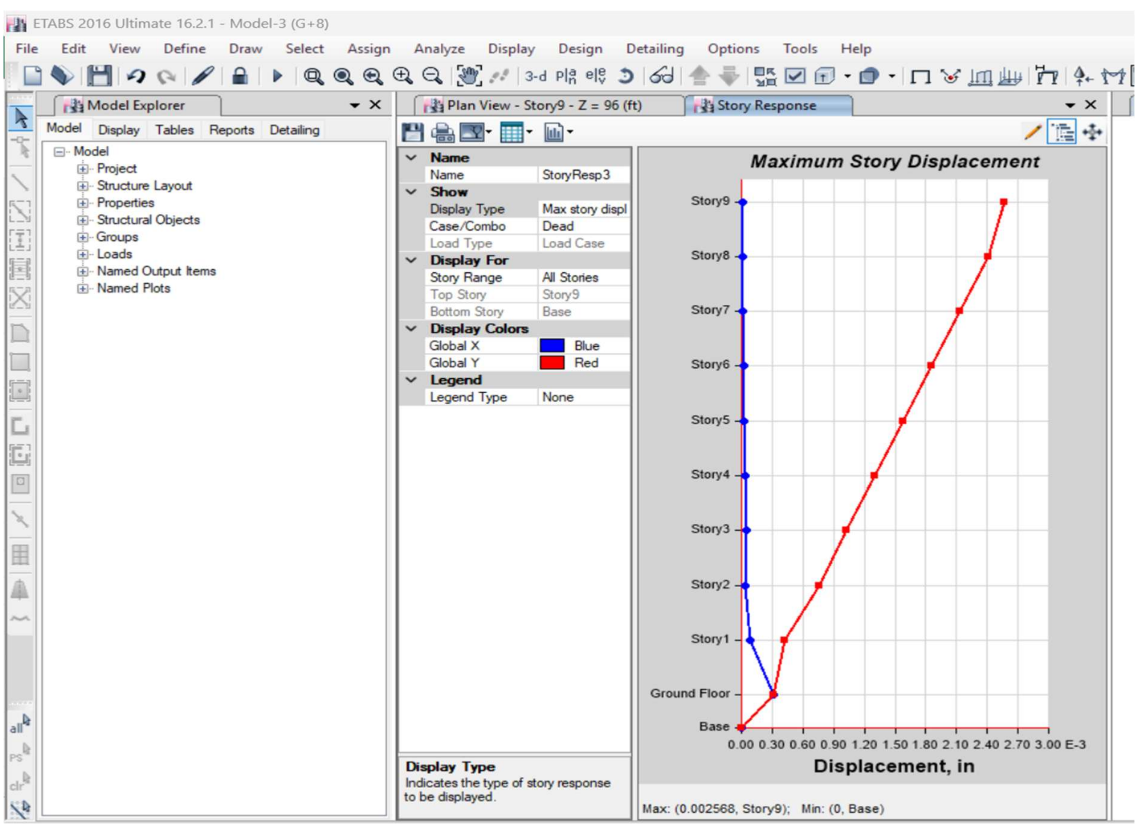

Figure 3.34: Maximum Story Displacement Check (Option -3)

CHAPTER 4
RESULT AND DISCUSSION

4.1 Introduction

In this chapter result output of the model has been shown and discussed. From the result comparison it is seen that BNBC 2020 have huge difference in designing methods and formulas.

4.2 Drift and Building Separation

4.2.1 Story drift limitation

Story 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 story drift shall include both translational and torsional deflections and conform to the following requirements:

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

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

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

$\Delta \leq 0.0025h$ for unreinforced masonry structures.

Where, h = height of floor.

(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

4.2.2 Sway limitation

The overall sway (horizontal deflection) at the top level of the building or structure due to wind loading shall not exceed (1/500) times the total height of the building above ground,

4.2.3 Building Separation

All components of a structure shall be designed and constructed to act as an integral unit unless they are separated structurally by a distance sufficient to avoid contact under the most unfavorable condition of deflections due to lateral loads. For seismic loads,

Table 4.1: Allowable Storey Drift Limit (as per BNBC-6.2.21)

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	$0.020h_{sx}$	$0.015h_{sx}$	$0.010h_{sx}$

Notes:

1. *h* is the story height below Level.
2. There shall be no drift limit for single-story structures with interior walls, partitions, ceilings, and exterior wall systems that have been designed to accommodate the storey drifts.
3. Structures in which the basic structural system consists of masonry shear walls designed as vertical elements cantilevered from their base or foundation support which are so constructed that moment transfer between shear walls (coupling) is negligible.
4. Occupancy categories are defined in Table 6.1.1

Table 4.2: Maximum Story Drift

Load Type	Option -1	Option -2	Option -3
EQ_x	0.003936	0.001334	0.002502
EQ_y	0.001175	0.00255	0.00202
W_x	0.000356	0.000111	0.000206
W_y	0.000144	0.00033	0.000248

Table 4.3: Maximum Story Displacement

Load Type	Option -1	Option -2	Option -3
EQ_x (inch)	2.973007	1.249642	2.186622
EQ_y (inch)	1.083979	1.946461	1.654043
W_x (inch)	0.253262	0.105594	0.183373
W_y (inch)	0.135851	0.245419	0.205579

Table 4.4: Allowable Story Drift Limit

Load Type	Option- 1				Option- 2			Option- 3		
	C_d	δ_{xe}	$\delta x = (C_d*\delta_{xe})/I$	$\delta_x <= 0.020$	δ_{xe}	$\delta_x = (C_d*\delta_{xe})/I$	$\delta_x <= 0.020$	δ_{xe}	$\delta_x = (C_d*\delta_{xe})/I$	$\delta_x <= 0.020$
EQ_x	5.5	0.00394	0.021648	Not OK	0.00133	0.007337	OK	0.0025	0.01376	OK
EQ_y		0.00118	0.006463	OK	0.00255	0.014025	OK	0.00202	0.01111	OK
W_x		0.00036	0.001958	OK	0.00011	0.000611	OK	0.00021	0.00113	OK
W_y		0.00014	0.000792	OK	0.00033	0.001815	OK	0.00025	0.00136	OK

Table 4.5: Displacement or Sway limitation

Load Type			Option- 1		Option- 2		Option- 3	
	Building Height (in)	Sway Limition (in)	Etabs Value (in)	Result	Etabs Value (in)	Result	Etabs Value (in)	Result
EQ_x	1080	2.16	2.97301	Not OK	1.24964	OK	2.18662	Not OK
EQ_y			1.08398	OK	1.94646	OK	1.65404	OK
W_x			0.25326	OK	0.10559	OK	0.18337	OK
W_y			0.13585	OK	0.24542	OK	0.20558	OK

4.3 Maximum Story Displacement:

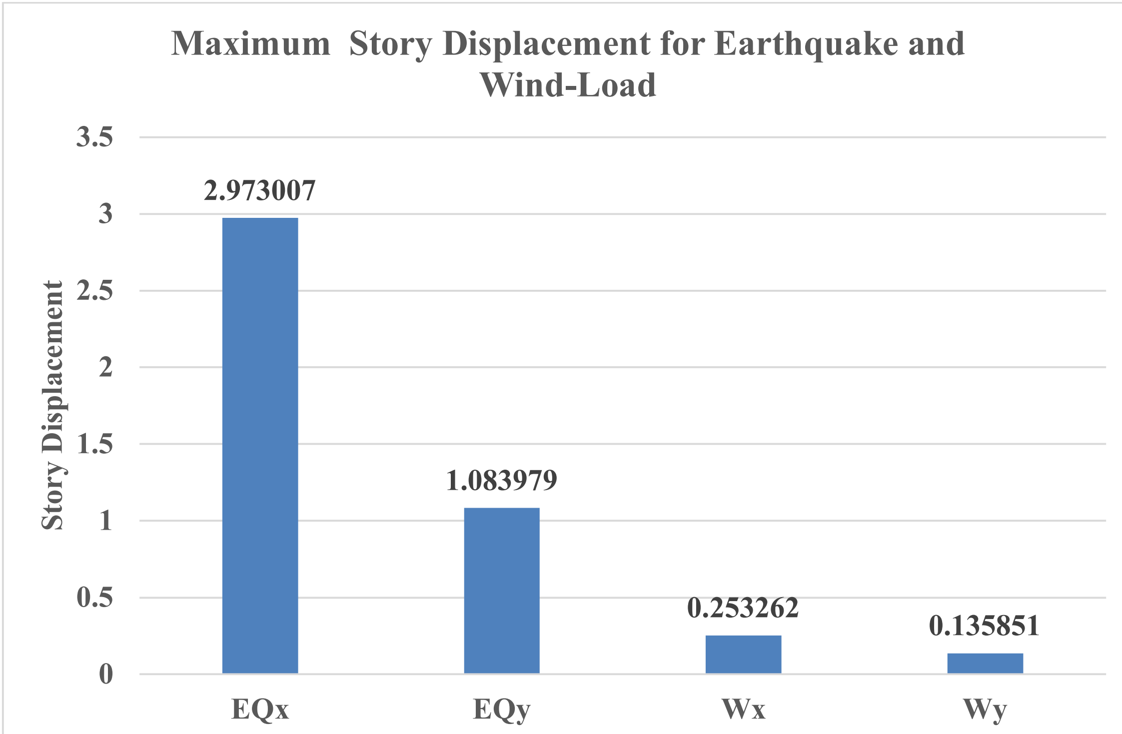

Figure 4.1: Maximum Story Displacement for Option-1

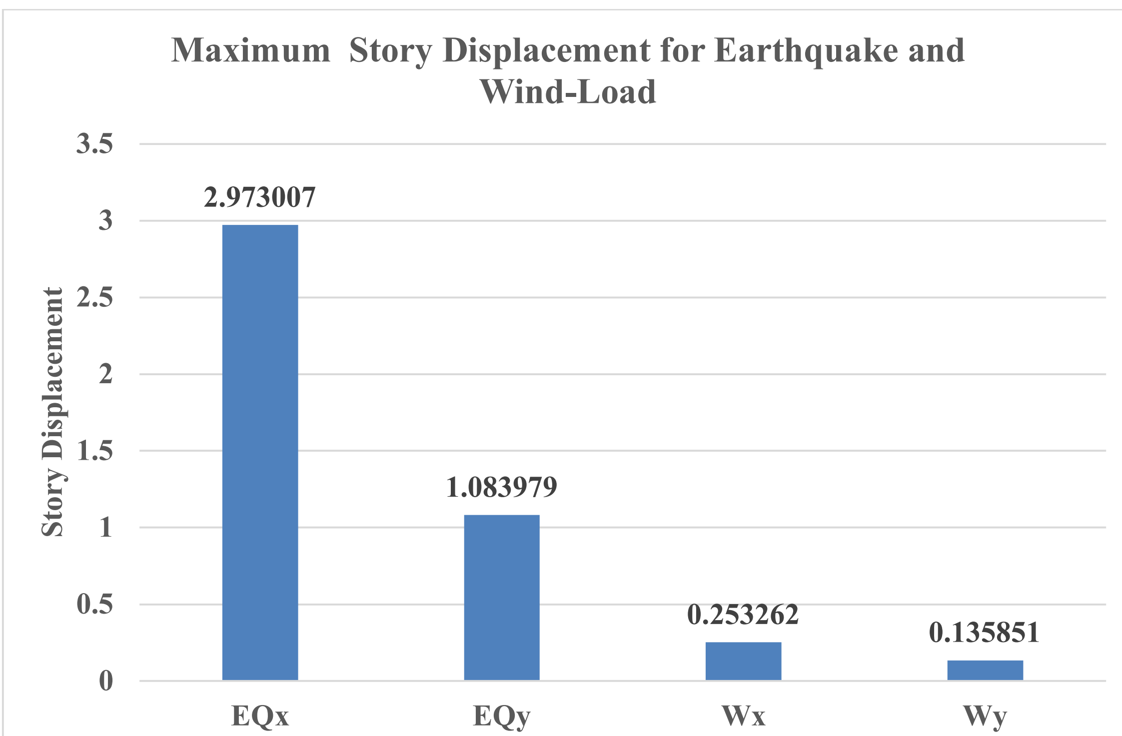

Figure 4.2: Maximum Story Displacement for Option-2

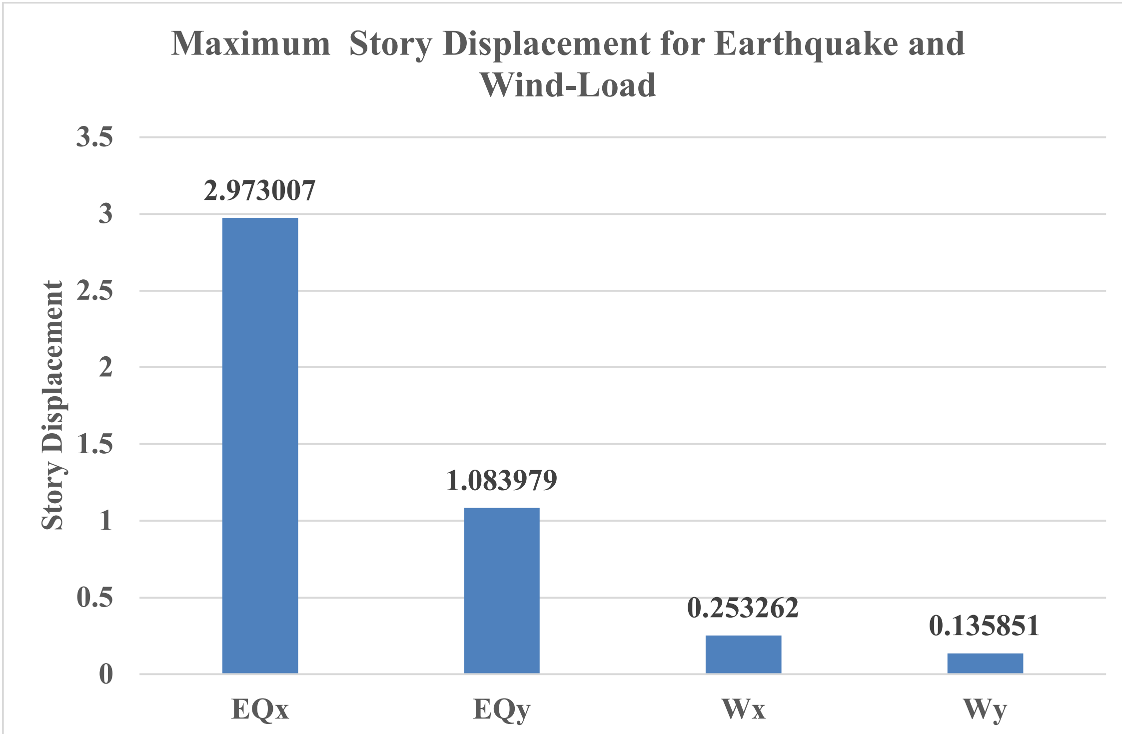

Figure 4.3: Maximum Story Displacement for Option-3

4.4 Result Comparison and Discussion:

4.4.1 Interstudy Drift Check (C_d δ_{xe} / ℓ ≤ 0.020)

- Option -1 shows the largest drift values among the three models.
- Option -2 consistently produces the smallest drift values, passing all drift criteria.
- Option -3 falls between Model-1 and Model-2, passing most checks but failing one critical case.

Critical Observations

- For EQ_x,
  - Option -1 fails (0.021648 > 0.020)
  - Option -2 passes
  - Option -3 passes
- For EQ_y, W_x, and W_y, all three models satisfy the drift limit.

Interpretation

- Option -1 appears more flexible or less stiff in the X-direction, causing excessive drift under EQ_x.

- Option -2 demonstrates the highest lateral stiffness, resulting in significantly lower drift values.
- Option -3 meets code requirements except for one direction in the next section (absolute sway).

4.4.2 Total Sway Check (Δ ≤ H/500 = 2.16 in)

Overall Trend

- Similar to the drift check, Option -1 again records the largest displacements.
- Option -2 performs the best with the smallest sway values.
- Option -3 performs moderately but fails in one direction.

Critical Observations

- For EQ_x:
    - Option -1 = 2.97301 in → Not OK
    - Option -2 = 1.24964 in → OK
    - Option -3 = 2.18662 in → Not OK (slightly above 2.16)
- All models are acceptable for EQ_y, W_x, and W_y in terms of sway.

Interpretation

- Both Option -1 and Option -3 show excessive lateral displacement under **EQ_x**, indicating insufficient stiffness or drift control in the X-direction.
- Option -2 again demonstrates optimal stiffness and lateral performance.

4.4.3 Combined Discussion

Option -1

- Fails drift for EQ_x in the first table.
- Fails sway for EQ_x in the second table.
- Shows the largest lateral movements, indicating the need for stiffness enhancement (bracing, shear walls, stronger moment frames, etc.).

Option -2

- Passes all checks in both drift and sway limits.
- Shows the lowest displacement values, suggesting well-balanced stiffness.
- Option -2 is clearly the most code-compliant and structurally efficient model.

Option -3

- Passes most drift and sway checks except:
    - Fails sway for EQ_x (2.18662 in > 2.16 in)
- Option -3 is safer than Option -1 but less robust than Option -2, particularly under X-direction seismic loading.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study investigated the structural behavior of a high-rise building under lateral and vertical loads for two different configurations: Option –1, Option –2 and Option –3 Using ETABS, the comparison highlights the essential effects of shear walls on overall stability, stiffness, and performance of tall buildings.

- The building incorporating shear walls exhibits a significant reduction in lateral displacement compared to the reference model, highlighting the effectiveness of shear walls in resisting lateral loads. Consequently, Option-2 is identified as the best-performing and code-compliant model in terms of both drift and total sway limitations.

- The story drift values are considerably reduced when shear walls are incorporated, resulting in a stiffer and more stable structure that meets drift limits. Although Option-3 is acceptable under most load cases, it requires improvement in EQ_x stiffness.

- The incorporation of shear walls significantly enhances the building's global stiffness by forming a rigid vertical lateral-resisting system, which reduces lateral displacement and story drift. As a result, the structure behaves stiffer and more stable, effectively meeting drift and sway limits. Among the analyzed options, Option-2 demonstrates the best overall performance and is fully code-compliant.

- The incorporation of shear walls enhances the building's lateral load-carrying capacity and mitigates stresses on beams and columns, with Option-2 exhibiting the most favorable performance.

5.2 Recommendations

1. Place shear walls symmetrically or around the building core to minimize torsion.
2. Perform dynamic analysis (Response Spectrum/Time History) for tall buildings.
3. Use proper wall thickness, reinforcement, and high-quality materials.
4. Avoid random or asymmetrical placement to prevent torsional irregularity.
5. Ensure full compliance with BNBC 2020 or relevant codes.
6. Future studies may include nonlinear analysis, cost optimization, and comparison with dual systems.

5.3 Final Remarks

The study confirms that incorporating shear walls into high-rise structural design significantly improves performance under lateral and gravity loads. Shear walls ensure stability, reduce damage, and increase long-term durability, making them essential for safe and economical high-rise structure.

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