Seismic Analysis of Multi-storied Building With & Without Shear Wall Using ETABS

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Section: 27 C

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It is hereby declared that this thesis/project or any part of this has not been submitted elsewhere for the award of any degree or diploma. The declaration is made by a group of five students, including:

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Dedicated

To

"Our Family and Teachers"

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ABSTRACT

This study presents a comparative structural analysis of a 12-story reinforced concrete building using the ETABS software. Three different analytical models were developed to evaluate the impact of shear walls on the overall structural performance. Model 1 represents a conventional moment-resisting frame without shear walls, while Model 2 and Model 3 incorporate shear walls in different configurations. The analysis focuses on key structural response parameters, including story displacement, story drift, and base shear under lateral loading conditions. The results demonstrate that the inclusion of shear walls significantly enhances the stiffness and stability of the structure, leading to reduced lateral displacements and inter-story drifts. Additionally, variations in shear wall positioning between Model 2 and Model 3 show notable differences in performance, highlighting the importance of optimal shear wall placement in high-rise building design. From the results, it can be observed that the maximum story displacement for Model-1 is 3", while for Model-2 it is 0.727", and for Model-3 it is 0.714". This study provides insights into the effectiveness of shear walls in improving seismic performance and offers practical guidance for structural engineers in selecting appropriate lateral load-resisting systems.

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CHAPTER – 1

INTRODUCTION

1.1 General

The structural analysis of multi-storied buildings requires careful evaluation of their behavior under gravity and lateral loads such as wind and earthquake forces. In modern engineering practice, advanced computational tools [1], [3], [12] are widely used to ensure accurate and efficient analysis of complex structures.

In this study, a 12-storey reinforced concrete building has been modeled and analyzed using ETABS. The main objective is to investigate the effect of shear walls on the structural performance of the building.

To achieve this, three different models have been developed. The first model represents a bare frame structure without shear walls, while the second and third models include shear walls placed at different locations within the building. This comparative approach allows for a clear understanding of how shear walls influence the overall structural behavior.

Key response parameters such as storey displacement, storey drift, and base shear have been evaluated for all three models. Storey displacement indicates the lateral movement of each floor, whereas storey drift measures the relative displacement between adjacent storeys, which is critical for structural safety and serviceability. Base shear represents the total lateral force acting at the base of the structure [10], [11].

By comparing the results of the three models, this study aims to assess the effectiveness of shear walls in reducing lateral displacements and improving the stability of the building. The findings will help in understanding the importance of shear wall placement in high-rise structures and ensuring compliance with relevant design standards.

1.2 Research Objective

- To analyze the structural behavior of a 12-story building using three different models.
- To compare models with and without shear walls for different seismic zone.
- To evaluate key parameters: story displacement, story drift, and base shear.
- To study the effect of shear walls on structural stability and stiffness.
- To assess the improvement in overall seismic performance due to shear walls.

1.3 Shear wall

Shear walls are vertical elements of a horizontal force-resisting system. They are constructed to counter the effects of lateral loads acting on a structure. In residential construction, shear walls are straight external walls that typically form a box providing lateral support to the building. Lateral forces caused by wind, earthquakes, and uneven settlement loads, along with the weight of the structure and occupants, create powerful twisting (torsion) forces. These forces can literally tear (shear) a building apart. Reinforcing a frame by attaching or placing a rigid wall inside it helps maintain the shape of the frame and prevents rotation at the joints. Shear walls are especially important in high-rise buildings subjected to lateral wind and seismic forces [6], [14].

1.4 Key Aspects of Shear Walls:

a) **Purpose**: Primarily to provide stability against lateral forces, reducing swaying and preventing structural damage from high winds or seismic activity.
b) **Location**: They can be exterior or interior walls, frequently designed to act as a braced core in high-rise buildings or placed along perimeter walls.
c) **Construction**: Commonly engineered with specific nailing patterns, plywood sheathing, or reinforced concrete, often including "hold-downs" to anchor them securely to the foundation.
d) **Structural Role**: Unlike standard load-bearing walls that carry vertical gravity loads, shear walls specifically handle horizontal, in-plane shear forces

1.5 Significance of the Study

The significance of this study lies in understanding the impact of shear walls on the structural performance of multi-storey buildings subjected to lateral loads. As building height increases, lateral forces such as wind and earthquake effects become more critical, often governing design.

This study provides a comparative evaluation of three different structural models analyzed using ETABS—one without shear walls and two with shear walls placed in different configurations. Such a comparison helps to clearly identify how the inclusion and positioning of shear walls influence key response parameters.

The findings of this study are important for assessing parameters such as storey displacement, storey drift, and base shear, which directly affect the safety, stability, and serviceability of structures. By analyzing these factors, the study demonstrates how shear walls can effectively reduce lateral displacement and improve overall structural stiffness.

Furthermore, this study serves as a practical reference for structural engineers and students in making informed decisions regarding the use and placement of shear walls in high-rise buildings. It also contributes to ensuring that structures meet the requirements of relevant design codes and standards, particularly in seismic and wind-prone regions.

Overall, the study highlights the importance of proper structural configuration in achieving economical and safe design solutions for tall buildings.

1.6 Organization of the Thesis

This thesis is organized into the following chapters:

Chapter 1: Introduction and Objectives.

This chapter provides the background of the study, outlines the problem statement, and defines the research objectives. It also highlights the significance and scope of the work, particularly focusing on the structural analysis of a 12-storey building using ETABS software.

Chapter 2: Literature Review.

This chapter presents a comprehensive review of previous studies related to structural analysis and design of multi-storey buildings. It includes discussions on analysis methods, modeling techniques in ETABS, relevant design codes, and past research findings.

Chapter 3: Methodology.

This chapter describes the overall methodology adopted for the study. It includes details of building configuration, material properties, load considerations (dead load, live load, wind load, and seismic load), modeling procedures in ETABS, and analysis techniques.

Chapter 4: Results and Discussion.

This chapter presents the analysis results obtained from ETABS, including displacements, story drift, base shear, and other structural responses. The results are discussed and interpreted with the help of tables, graphs, and comparisons to evaluate the building performance.

Chapter 5: Conclusions and Recommendations.

This chapter summarizes the key findings of the study, draws conclusions based on the analysis results, and provides recommendations for future work and practical applications in structural design.

CHAPTER – 2

LITERATURE REVIEW

2.1. Introduction

Earthquakes produce significant lateral forces on multi-storey buildings, which may cause excessive displacement, structural instability, and even collapse if the structure is not properly designed. In modern structural engineering, shear walls are widely used to improve the seismic performance of reinforced concrete buildings by increasing lateral stiffness and reducing deformation [5], [12], [14].
Many researchers have conducted studies on the behavior of high-rise buildings with and without shear walls under different seismic conditions. Parameters such as story displacement, story drift, and base shear are commonly used to evaluate structural performance during seismic analysis.

This chapter presents a review of previous studies related to seismic analysis of multi-storey buildings and the effectiveness of shear walls in improving structural stability.
In this study, three analytical models of a 12-storey reinforced concrete building were developed. Among these, Model-2 and Model-3 incorporated shear walls. Structural analysis was performed for four different seismic zones. The parameters evaluated include story displacement, story drift, and base shear. To prepare the literature review and compare the findings with previous studies, the following structure can be followed.

Seismic performance of buildings is a critical consideration in structural engineering, particularly in earthquake-prone regions. Buildings are subjected to dynamic lateral forces during seismic events, which can lead to excessive displacement, structural damage, or even collapse if not properly designed. Among various lateral load-resisting systems, shear walls are widely recognized for their effectiveness in enhancing structural stability and stiffness. This literature review examines previous studies on the seismic behavior of buildings with and without shear walls, highlighting key findings, methodologies, and research gaps.

2.2 Review of Previous Studies

Several researchers investigated the seismic behavior of reinforced concrete multi-storey buildings considering different structural configurations and seismic zones.
Previous studies showed that buildings without shear walls experience larger lateral displacement and story drift during earthquakes [5], [7], [12]. To minimize these effects, researchers introduced shear walls at different positions such as the building core, corners, and intermediate locations.

According to earlier research, the inclusion of shear walls significantly increases the stiffness of the structure and improves resistance against lateral seismic forces. Many studies concluded that properly positioned shear walls effectively reduce story displacement and inter-storey drift.
Researchers also compared buildings of different heights under various seismic zones. Their analyses revealed that seismic response increases with building height and earthquake intensity [6], [9], [12]. Base shear values were also found to vary depending on structural configuration, seismic zone, and stiffness of the building [5], [6], [9].
Some researchers used software-based structural analysis methods such as ETABS and STAAD Pro to evaluate the seismic performance of buildings. Their findings indicated that buildings with shear walls perform better than conventional frame structures under earthquake loading conditions.
Most previous studies focused on one or two seismic zones. However, limited research has been conducted on comparative analysis of multiple structural models under four different seismic zones [5], [9], [12].
The literature review should discuss previous research related to the seismic performance of multistorey buildings, especially the influence of shear walls on structural behavior.

The review should focus on:

- Effect of shear walls on lateral displacement reduction
- Influence of shear walls on story drift control
- Variation of base shear due to stiffness changes
- Performance of buildings in different seismic zones
- Comparison between buildings with and without shear walls

2.3 Seismic Behavior of Buildings without Shear Walls

Structures designed without shear walls typically rely on moment-resisting frames to withstand lateral loads. Several studies have shown that such systems exhibit relatively low lateral stiffness, resulting in larger inter-story drift and displacement under seismic loading [2], [5], [7], [10]. Early work by George W. Housner emphasized that flexible structures tend to experience higher deformation during earthquakes, which can compromise structural integrity and non-structural components [2], [10].

Further research indicates that bare frame systems are more susceptible to torsional effects, especially in irregular buildings. The absence of shear walls often leads to uneven distribution of seismic forces, increasing the vulnerability of columns and beams. Consequently, buildings without shear walls may require additional reinforcement or alternative systems to meet seismic design requirements.

2.4 Role of Shear Walls in Seismic Resistance

Shear walls are vertical structural elements designed to resist lateral loads through in-plane stiffness and strength [5], [10], [14]. Studies demonstrated that the inclusion of shear walls significantly improves a building's seismic performance by reducing lateral displacement and inter-story drift.

Shear walls also contribute to increased energy dissipation and improved load distribution [10], [12]. Their effectiveness depends on several factors, including geometry, material properties, and placement within the building [14]. Centrally located shear walls tend to minimize torsion, while asymmetrical placement may introduce additional complexities in structural response [6], [9].

2.5 Comparative Studies: Buildings with vs. without Shear Walls

Numerous comparative studies have evaluated the performance of buildings with and without shear walls using analytical and numerical methods. Simulation tools such as ETABS have been extensively used to model and analyze structural responses under seismic loads.

Findings consistently show that buildings with shear walls exhibit:

- Reduced lateral displacement
- Lower inter-story drift
- Increased stiffness
- Shorter natural time periods

In contrast, buildings without shear walls demonstrate greater flexibility and higher deformation, making them more vulnerable to seismic damage. Additionally, the effectiveness of shear walls becomes more pronounced in high-rise and irregular structures, where lateral loads are more significant.

2.6 Influence of Shear Wall Placement and Configuration

The location and configuration of shear walls play a crucial role in determining overall structural performance [12], [14]. Studies suggest that placing shear walls at the core or symmetrically along the perimeter enhances stability and reduces torsional effects [6], [9]. However, there is no universal agreement on the optimal configuration, as it varies depending on building geometry, height, and loading conditions [5], [12].

Research also highlights the importance of considering openings in shear walls, which may reduce stiffness and affect performance. Advanced modeling techniques are often required to accurately capture these effects.

2.7 Research Gap

From the literature review, it is observed that many researchers studied the seismic performance of buildings with shear walls. However, comparative analysis of multiple building models under four different seismic zones is relatively limited.

In addition, previous studies mainly focused on a single shear wall configuration, whereas the effect of different model arrangements with and without shear walls requires further investigation.

Therefore, this study aims to analyze a 12-storey reinforced concrete building using three different structural models, where the second and third models include shear walls. The seismic behavior of these models is evaluated for four different seismic zones based on parameters such as story displacement, story drift, and base shear.

Despite extensive research on shear walls, several gaps remain in the existing literature:

- Limited studies on the combined effects of soil-structure interaction and shear wall performance
- Inconsistent findings regarding optimal shear wall placement
- Lack of comprehensive comparisons across different building heights and configurations
- Insufficient focus on cost-effectiveness and practical implementation

Addressing these gaps is essential for developing more efficient and reliable seismic design strategies.

2.8 Summary

The reviewed literature indicates that shear walls play a vital role in improving the seismic performance of buildings. They significantly reduce displacement, enhance stiffness, and provide better resistance to lateral forces compared to structures without shear walls. However, further research is needed to optimize their design and placement under varying conditions. This study aims to contribute to this area by providing a comparative seismic analysis of buildings with and without shear walls.

CHAPTER- 3

METHODOLOGY

3.1 General

This study involves the structural analysis of a 12-story reinforced concrete building using ETABS. Three different analytical models were developed to evaluate the effect of shear walls on structural performance.

All models are idealized following standard structural engineering principles, ensuring uniformity in geometric configuration, material properties, boundary conditions, and gravity load assignments [3], [13].This consistency allows for a reliable comparison of results, where the observed differences in structural response can be attributed solely to the intended modeling variations.

3.2 Model Description

Model 1: Building without shear walls

Model 2: Building with shear walls (Configuration 1)

Model 3: Building with shear walls (Configuration 2)

Each model was divided into four different zones based on plan configuration to capture localized structural behavior.

3.3 Methodology Flow chart:

Define Material Property→ Define Section Property → Draw Column → Draw Beam → Draw Slab → Draw Stair →Property Modifier→ Define DL → Define LL→Mesh Slab → Define Earthquake load → Define Wind Load→ Load Combination →Assign Load → Run Analysis

3.4 Description of the building

Number of Stories	: 12
Plan Dimension	: 50'*36'
Structure height	: 138'(42 m)
Bottom story height	: 8'

Typical story height	: 10'
Total height of the building	: 138’
Column Size :	: Corner(18"*24") ; Stair portion (24"*30")
Beam Size	: GB(12"*15"), FB(12"*18")
Slab thickness	: 6"

3.5 Material property which's used in this structure

Beam f'c	= 3000psi
Slab. f'c	= 3000 psi
Column f'c	=3500 psi
Shear Wall f'c	= 3500 psi
Main Rebar fy	= 60 ksi
Stirrup fy	= 40 ksi

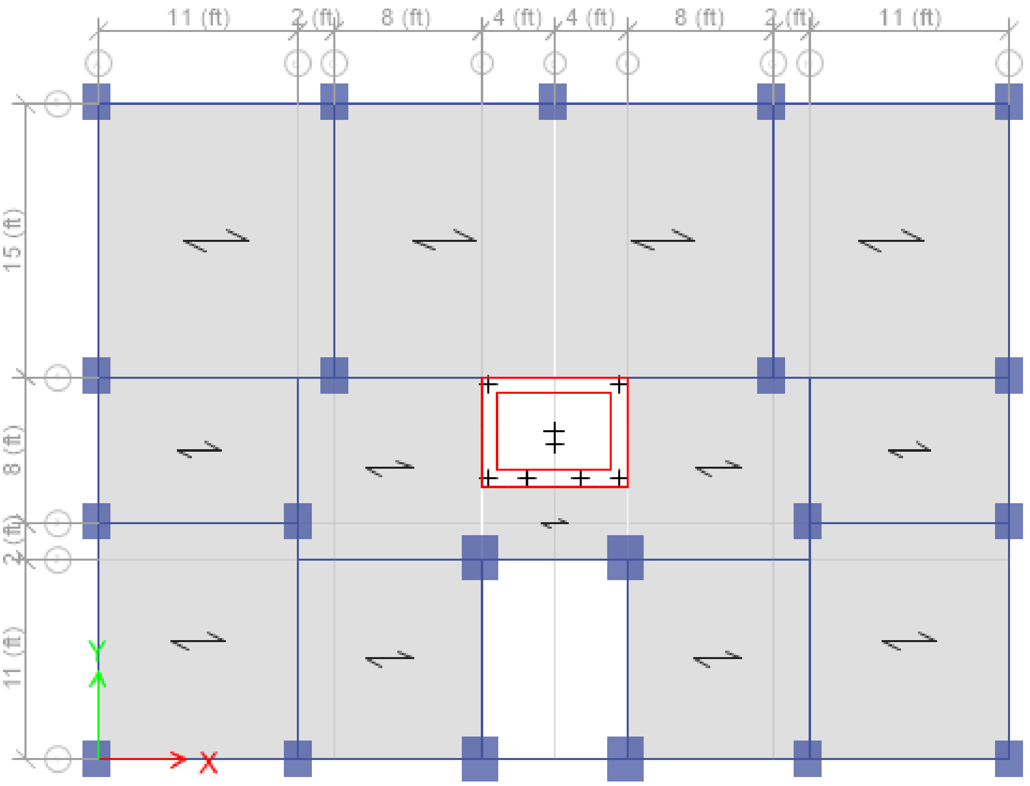


Figure 3.1: Model-1 (No Shear Wall)

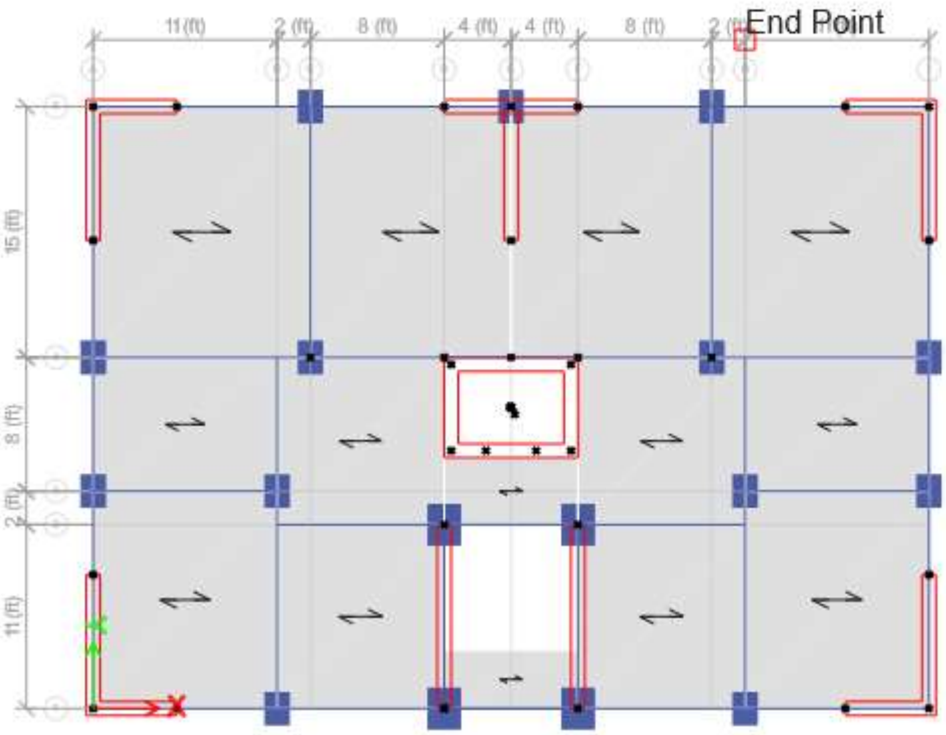


Figure 3.2 : Model-2 (With Shear Wall)

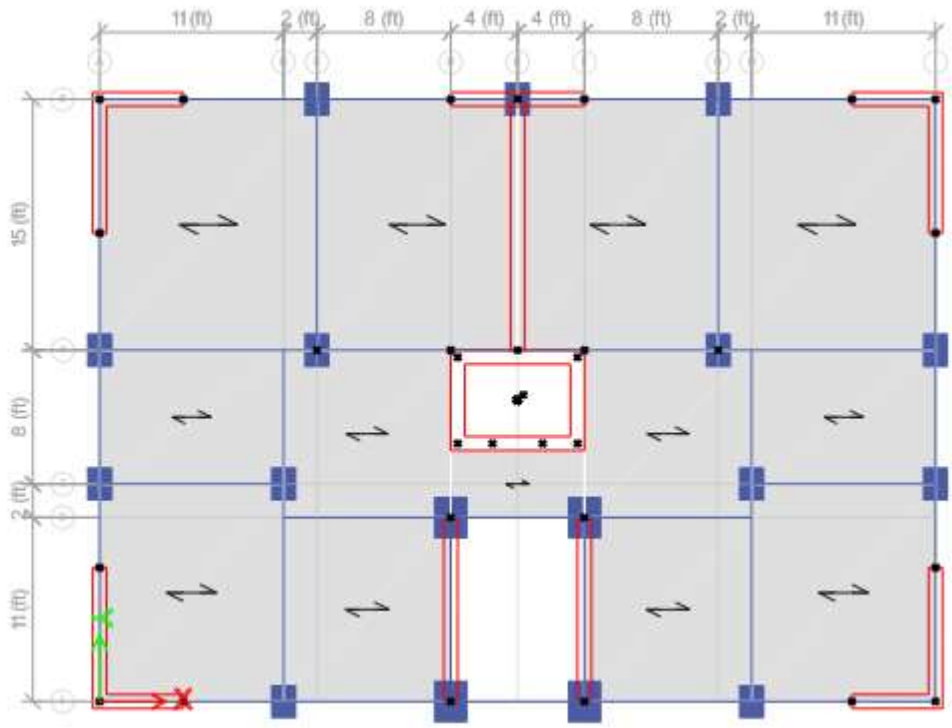


Figure 3.3 : Model-3 (With Shear Wall)

3.6 . Modeling Procedure in ETABS

The structural model of the building was developed using ETABS software [3], [8], [13]. Load combinations and seismic analysis procedures were performed according to standard engineering practice [5], [12]. The following modeling procedures were followed during the structural analysis and design process.

3.6.1 . Grid and Story Definition

- Grid lines were created according to the architectural plan.
- Story data including story height and number of floors were defined in ETABS.
- The base level and roof level were specified properly.

3.6.2 Material Properties

Material properties were assigned according to design standards.

a) Concrete Properties

Grade of concrete : 20 MPa(3000 psi)
Unit weight : 150 lb/ft^3
Modulus of elasticity : $57000\sqrt{f'c}$

b) Reinforcement Steel Properties

Yield strength : 40 Ksi
Modulus of elasticity : 29000,000 psi

3.6.3 Section Properties

Structural elements were defined as follows:

- Beam sections
- Column sections

  Frame Sections
- Slab sections
- Shear wall sections

The dimensions were assigned based on preliminary design assumption

- First, go to the Define menu and select Section Properties.
- Then click on Frame Sections.

- After that, click on Add New Property to create a new structural section.
- Next, select the desired column shape/beam shape type from the available options.
- Finally, input the required design data and section dimensions according to the structural requirements.

Similarly, the Slab Section and Wall Section must also be defined.

Define → Section Property → Frame section/ Slab Section/ Wall Section

3.6.4 (a) Draw Column:

From the Draw menu bar, select the Quick Draw Column option. An option named Object Properties will appear. Here, we need to choose the column size. After selecting the C 24×30 column(for Stair portion), the Draw option will be activated. Now, according to the column positions shown in the 2D plan, we need to draw the columns.

We need to make sure that the All Stories option remains enabled.

3.6.4 (b) Draw Beam

Similarly, select the Quick Draw Beam option from the draw Menubar & selecting Beam size (FB & GB) . Then click column joints to other column , after that the beam will be drawn.

3.6.4 (c) Draw Slab: Similar process will be done.

3.6.4 (d) Draw Stair:

First, we need to select only the stair objects. To do this, select the objects, right-click the mouse, and then click on the Show Selected Objects option. From here, the stairs can be drawn very easily.
Now, activate the Draw option and click on the four corners of the landing slab and floor slab to draw the stair.

3.6.5. Define Load Pattern:

The types of loads to be used in the building analysis must be defined in the ETABS software beforehand.

Primarily, the following loads need to be defined:

- Dead Load (DL)
- Live Load (LL)
- Earthquake Load (EQ)
- Wind Load (WL)

These load cases are assigned according to the Bangladesh National building codes and structural design requirements.

3.6.5.1(a) Define Dead Load:

Different types of dead loads act on the structure, such as: Floor Finish Load, Ceiling Plaster Load, External Wall Load, Partition Wall Load, Parapet Wall Load, Water Tank Load etc.

Each of these loads must be defined separately in the ETABS software to ensure accurate structural analysis and load distribution.

Define → Load Patterns → Named different Types of Dead load

3.6.5.1(b) Dead Load Calculation

Load Pattern	Load Type	Value
Floor Finish [Cement Plaster (10mm thickness) + Clay Tiling (13mm thickness)]	Super Imposed	(0.23+0.268) kn/m^2 = 0.498 kn/m^2 =(0.498*20.89) psf = 10.405 psf [1 kn/m^2 =20.89 psf]
Ceiling Plaster (13mm thickness)	Super Imposed	= 0.287 kn/m^2 = (0.287*20.89) psf = 6 psf

External wall:

Weight of the 5'' wall = Wall thickness *Height of wall*Unit weight of brick

= 5/12 * (10 – 15/12)*120.96

= 441 lb/ft

= 0.441 kip/ft

Partition Wall

Weight of the 5’’ wall = 0.441 kip/ft

Parapet Wall

Weight of the 5’’ wall = Wall thickness *Height of wall*Unit weight of brick

= 5/12 * 3.28*120.96

= 166.63 lb/ft

= 0.17 kip/ft

3.6.5.2 Define Live Load:

Three differtent types of live loads are used in three different areas of the building.

i. Floor portion

ii. Stair Portion

iii. Roof Portion

The uniform live loads for these cases are provided in Table 6.2.3 from BNBC-2020 .

Table 3.1: Live Load

Live Load	Kn/m^2	lb/ft^2
All other areas except stairs & balconies	2	41.78
Roofs used for promenade purpose	2.9	60.581
Stairs & exit ways	4.8	100.272

3.6.5.3 Define Earthquake and Wind Load

In every structure, lateral loads (earthquake and wind load **)** act in both the X and Y directions. These earthquake loads are denoted as Ex and Ey.

Similarly Wind Loads are denoted as Wx and Wy .

According to the ASCE 7-05 code, these loads need to be modified. So, select the existing load case and click on “Modify Lateral Load.”

Define → Load Pattern → Ex/Ey → Modify

For Model-1(No Shear Wall)

Zone - 1

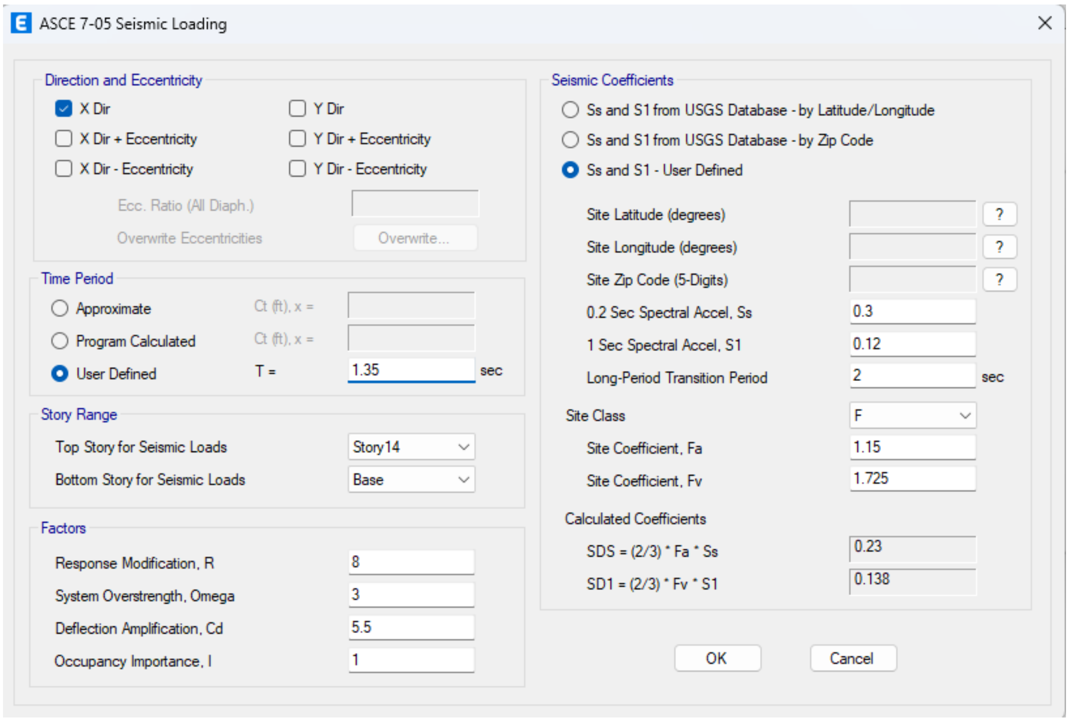


Figure 3.4 : Seismic Loading (Ex)

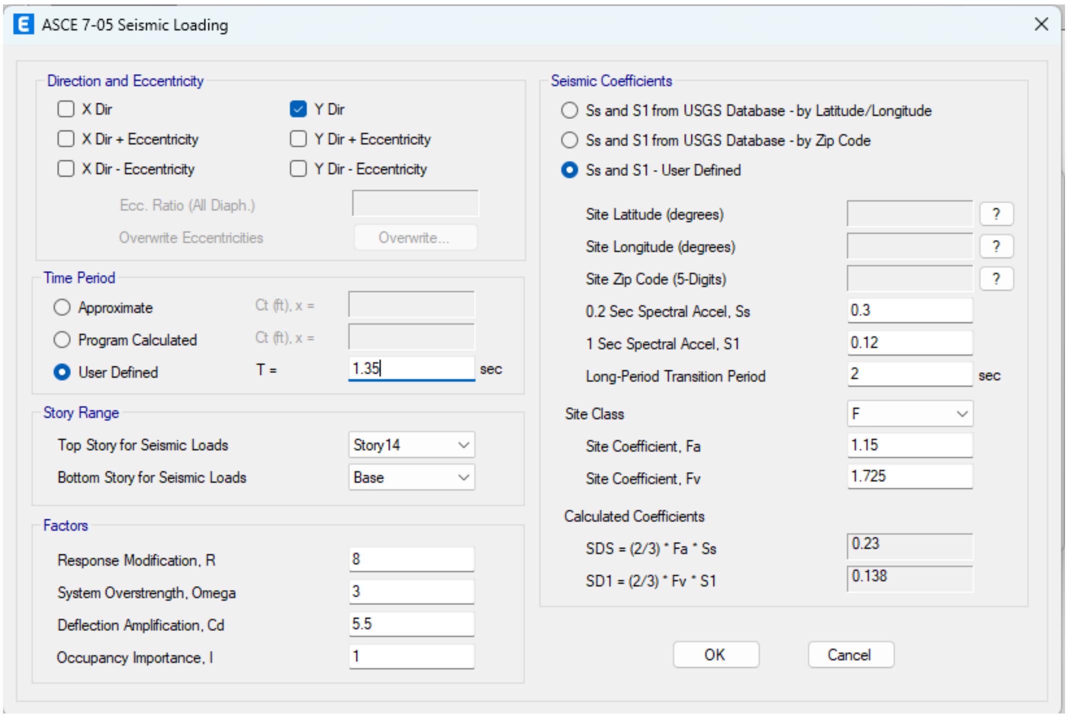


Figure 3.5 : Seismic Loading (Ey)

3.6.6 Site classification :

Site classification is the assessment and categorization of soil based on its geological properties, specifically its reactivity and expected movement (expansion/shrinkage) due to moisture changes. It is crucial for determining the appropriate foundation design (slabs/footings), ensuring structural stability, and preventing damage like cracks [10], [11].

Site will be classified as type SA, SB, SC, SD, SE, S1 & S2 based on the provisions of this section [11]. Classification will be done in accordance with Table 6.2.13 based on the soil properties of the upper 30 meters of the site profile [11].

Since we don't have any soil test report for this project based on actual site conditions, we are assuming the site classification as Category Sc.

I. Occupancy Category

Occupancy category" of a building means the classification of how a building is used and occupied. Building codes use occupancy categories to decide safety requirements such as fire protection, exits, structural design, ventilation, and accessibility**.**

We selected occupancy **category II** from the Table 6.1.1 ***[BNBC – 3061]***

II. Importance Factor

Buildings are classified into four occupancy categories in Chapter 1 (Table 6.1.1), depending on the consequences of collapse for human life, on their importance for public safety and civil protection in the immediate post-earthquake period, and on the social and economic consequences of collapse. Depending on occupancy category, buildings may be designed for higher seismic forces using an importance factor greater than one. Table 6.2.17 defines different occupancy categories and corresponding importance factor.

Table 3.2 : Importance factor

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

By selecting occupancy category II .

So, Importance factor , I = 1

3.6.7 Building period Calculation

The building period T may be approximated by the following formula :

$$T = C_t (h_n)^m$$

h_n is the height of the building in meters from the base

C_t & m are numerical coefficients based on structural system

Total height , h_n = 138 ft = 138/3.28 m = 42.073 m

To get the value of C_t & m , we need to go to page no 3209of the BNBC-2020 .

Table 6.2.20: Values for Coefficients to Estimate Approximate Period.

Structure type (Concrete moment resisting frame) > C_t = 0.0466 & m = 0.9

So, Time Period ,T = $0.0466 * (42.073)^{0.9}$

=1.35 s

Table 6.2.9: Response Reduction Factor, Deflection Amplification Factor , and Height Limitations for Different Structural Systems ***[BNBC – 3204]***

Table 3.3 : Response Reduction Factor

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. 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

We use option C, MOMENT RESISTING FRAME SYSTEMS (no shear wall)

(4) special reinforced concrete moment frame

Response Reduction Factor , R= 8

System Overstrength Factor = 3

Deflection Amplification Factor , C_d = 5.5

Table 3.4 : Spectral Response Acceleration Parameter

	Zone-1	Zone-2	Zone-3	Zone-4
Ss	0.3	0.5	0.7	0.9
S1	0.12	0.2	0.28	0.36

Table 3.5: Site Coefficients (F_a)

	Zone-1	Zone-2	Zone-3	Zone-4
SA	1	1	1	1
SB	1.2	1.2	1.2	1.2
SC	1.15	1.15	1.15	1.15
SD	1.35	1.35	1.35	1.35

Table 3.6: Site Coefficients (F_b)

	Zone-1	Zone-2	Zone-3	Zone-4
SA	1	1	1	1
SB	1.5	1.5	1.5	1.5
SC	1.725	1.725	1.725	1.725
SD	2.7	2.7	2.7	2.7

3.6.5.4 Define Wind Load

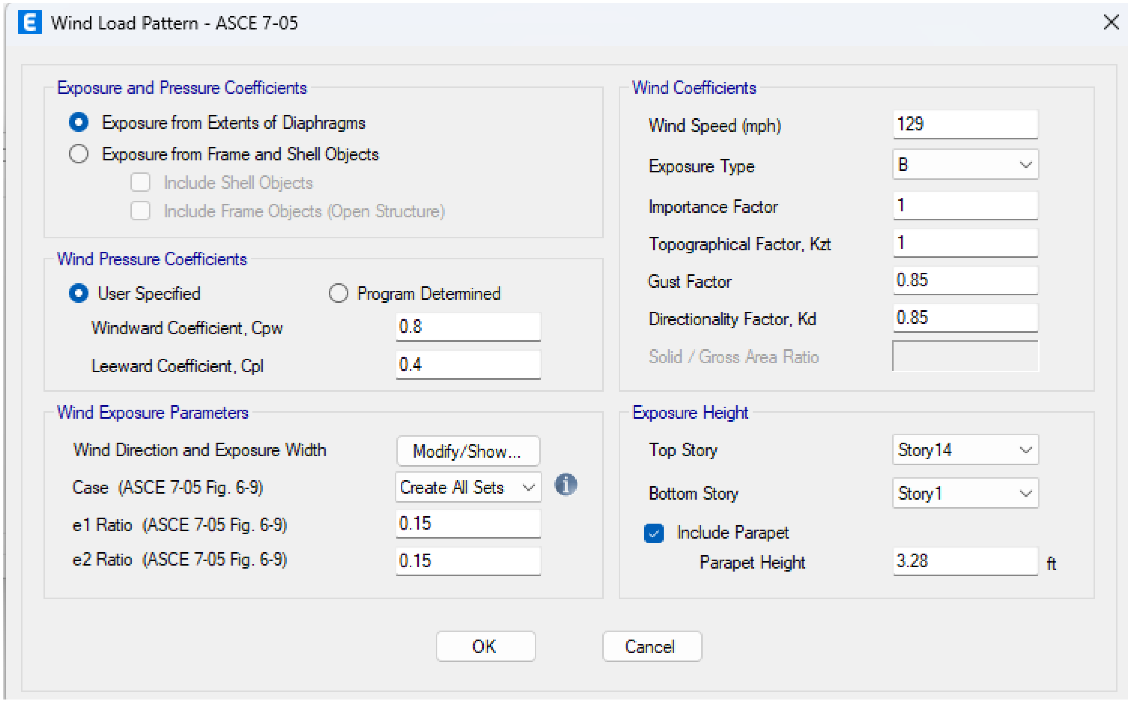


Figure 3.6: Modify Lateral Load (Wx)

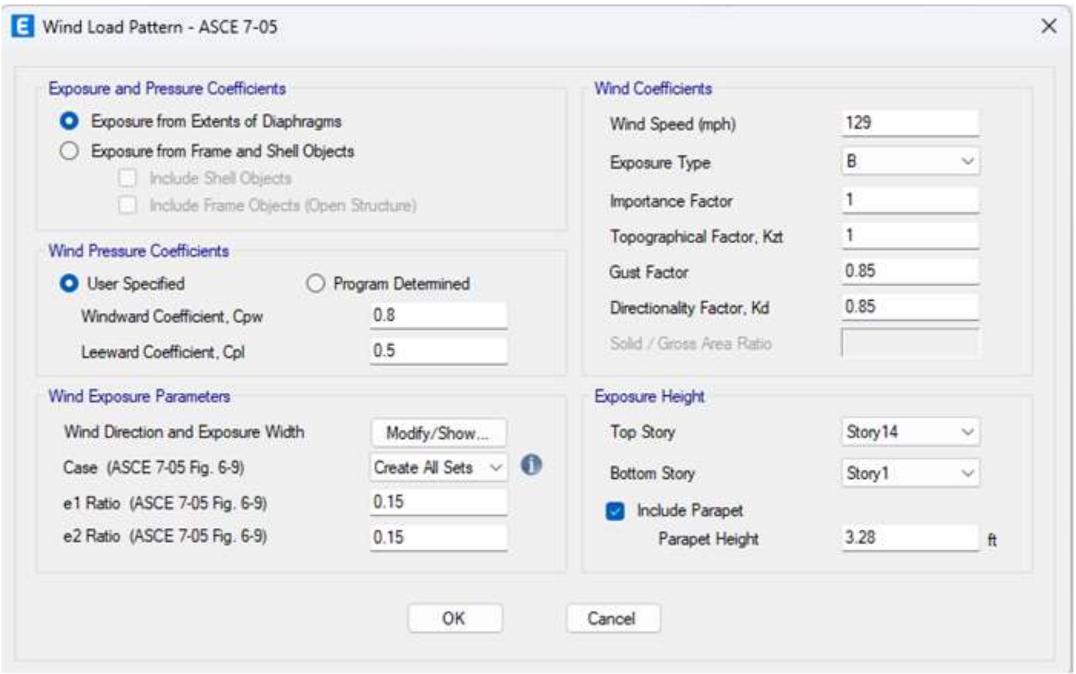


Figure 3.7 : Modify Lateral Load (Wy)

Wind Coefficients

(i) Wind Speed

We selected 4 districts from the 4 seismic zones of Bangladesh, and the wind speed values for those 4 districts were taken from page 3181 of the BNBC book.

Table 3.7 : Wind Speed

	Location	**Zone Factor**	**Wind Speed (m/s)**	**Wind Speed (mile/hr)**
Zone- 1	Shatkhira	0.12	57.6	129
Zone- 2	Dhaka	0.20	65.7	147.168
Zone- 3	Tangail	0.28	50.6	113.344
Zone- 4	Sylhet	0.36	61.1	136.86

So, The wind speed for Zone-1 , V = 57.6 m/s

= 57.6 * 2.24 mile/hr [1m/s = 2.24 mile/hr]

= 129 mile/hr

(ii) Importance Factor ,I (Wind Loads)

Here , V = 57.6 m/s > 44 m/s

So Importance factor is 1 for occupancy category II

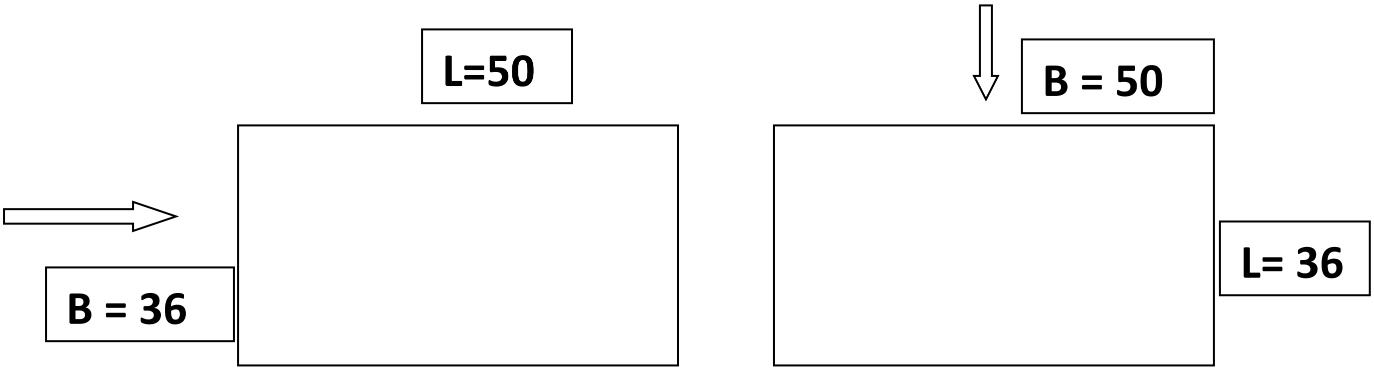
Wind pressure Coefficients

Windward Coefficients , C_{pw} = 0.8 (fixed)

Leeward Coefficients , C_{lw} = 0.4

Table 3.8 : External Pressure Coefficients

Surface	L/B ratio	C_p
Windward Wall	All Values	0.8
Leeward Wall	0-1	-0.5
	2	-0.3
	>4	-0.2
Side Wall	All Values	-0.7



Wind in X direction	Wind in Y direction
$L/B = 50/36 = 1.39$	$L/B = 36/50 = 0.72$
$C_p = 0.4$	$C_p = 0.5$

3.6.7 Assign Vertical & Lateral Load

3.6.7(a) Assign Dead Load

All dead loads (floor finish, partition wall, ceiling plaster) must be applied to all slab portions of the structure.

Select all slab → Assign → Shell Loads → Uniform → Select dead load → Input Value → Apply →Ok

Flow chart for slab portion

Select all beam → Assign → Frame Loads → Distributed → Select dead load → Input Value → Apply →Ok

Flow chart for frame portion

3.6.7(b) Assign Live Load

Select all Floor Slab → Assign → Shell Loads → Uniform→ Select dead load → Input Value → Apply →Ok

Flow chart for slab portion

Select all Waist Slab & Exit Way → Assign → Shell Loads → Uniform→ Select dead load → Input Value → Apply →Ok

Flow chart for stair portion

Select all Roof Slab → Assign → Shell Loads → Uniform→ Select dead load → Input Value → Apply →Ok

Flow chart for Roof portion

3.6.8 Meshing

ETABS Meshing is a process in which large structural elements (such as slabs, walls, shells, diaphragms, etc.) are divided into smaller finite elements so that the software can perform more accurate analysis.

Why is Meshing Required?

- To determine load distribution accurately
- To obtain more accurate bending moment, shear force, and deflection results
- To analyze complex geometry or irregular shapes effectively
- To better understand slab–beam interaction
- To perform Finite Element Analysis (FEA) efficiently

After completing the Dead load & Live load apply , we have to perform meshing .

3.6.9 Load Combination

Load combination is a structural engineering process that sums various primary loads—such as dead, live, wind, and seismic loads—multiplied by safety factors to determine the worst-case, maximum force a structure must withstand.

Why use load combination

- To ensure structural safety
- Different loads rarely act at full value together
- To account for uncertainty
- To check different failure condition

Different types of load combinations can be used in a structure. However, we have used only a few load combinations. Such as :

1) 1.2 D + Ex + L
2) 1.2 D - Ex + L

3) 1.2 D + Ey + L

4) 1.2 D - Ey + L

5) D + 0.5 L + 0.7 Wx

6) D + 0.5 L - 0.7 Wx

7) D + 0.5 L + 0.7 Wy

8) D + 0.5 L - 0.7 Wy

3.6.10 Support Assign

After defining the load combinations and before running the analysis, we need to assign supports. For this, go to the bottom level of the structure and select the joints. Then, click on Assign > Joint > Restraints.

There are Three types of support in all structures.

- Fixed Support
- Pin Support
- Roller Support

Here, select the Fixed Support option.

A fixed support is a rigid structural connection that prevents all movement—vertical translation, horizontal translation, and rotation—of a structural member at the connection point. It is the most constrained support type, ensuring stability by resisting forces and bending moments in all directions (3 degrees of freedom)

3.6.11 Run Analysis

We have already assigned all the required loads to our structure. Now it's time to run analysis. So, by selecting Run Analysis from the Analyze option, the model will start analyzing.

Now, by clicking on the Story Response Plot option from the Display menu bar, we can view the Story Displacement from the graph for different loads or load combinations.

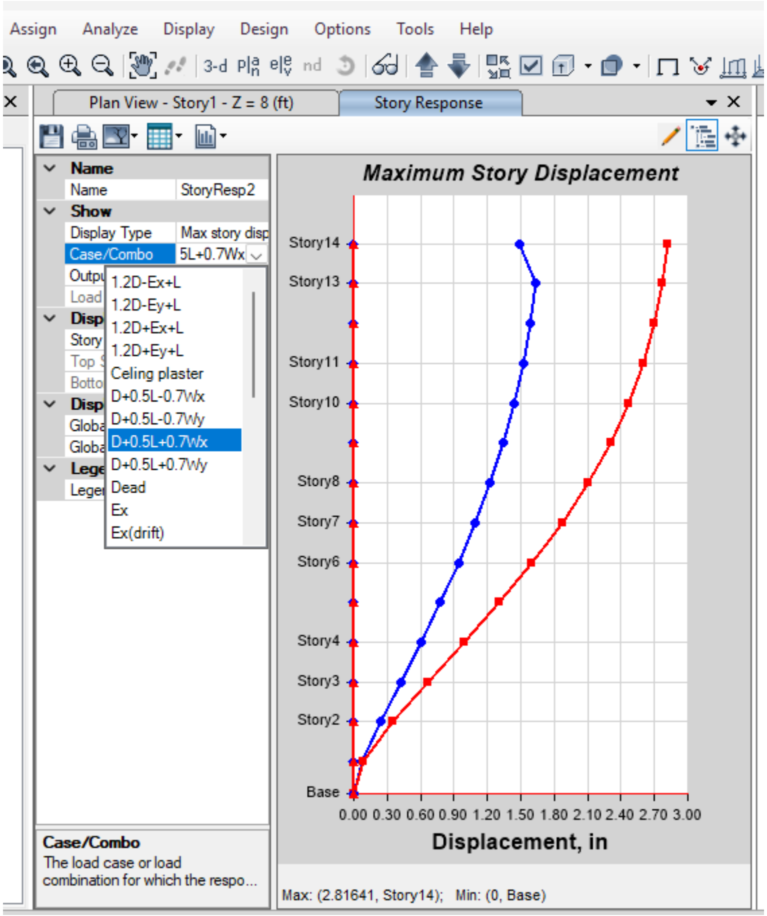


Figure 3.8 : Story Response Plot

3.7 Story Displacement Calculation & Check :

Sway limitation

The over all 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.

We checked the story displacement for the load combinations D + 0.5L ± 0.7Wx and D + 0.5L ± 0.7Wy.(Both X & Y Direction) .

Total height of the building from Ground , h = 130' = 130*12 = 1560 "

So Allowable Story Displacement = 1560 / 500 = 3.12 "

Maximum Story Displacement for Model-1 = 2.81 " < 3.12 "

So our structure is stable under sway limitation.

3.8 Story Drift calculation & Check :

Basically, story drift checks are performed for lateral loads such as wind loads and seismic loads.

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

$$\delta x = C_d * \delta_{xe} / I$$

C_d= Deflection amplification factor

δ_{xe} = Deflection determined by an elastic analysis

I = Importance factor

The design story drift at story x shall be computed as the difference of the deflections at the centers of mass at the top and bottom of the story under consideration:

$$\Delta x = \delta_x - \delta_{x-1}$$

Allowable Story Drift Limit = 0.020 h_x

= 0.020 * 120 "

= 2.4 " > Δx

Sample Calculation for Model-1

Story	hsx (ft)	Elastic Displaxement	Amplified Displacement	Story Drift	Allowable Story Drift	Result
Story-14	120	2.81641	15.490255	0.241384	2.4	0k
Story-13	120	2.772522	15.248871	0.3846975	2.4	0k
Story-12	120	2.702577	14.8641735	0.539748	2.4	0k
Story-11	120	2.604441	14.3244255	0.724207	2.4	0k
Story-10	120	2.472767	13.6002185	0.918797	2.4	0k
Story-9	120	2.305713	12.6814215	1.1065395	2.4	0k
Story-8	120	2.104524	11.574882	1.2926705	2.4	0k
Story-7	120	1.869493	10.2822115	1.469226	2.4	0k
Story-6	120	1.602361	8.8129855	1.625272	2.4	0k
Story-5	120	1.306857	7.1877135	1.745898	2.4	0k
Story-4	120	0.989421	5.4418155	1.8019485	2.4	0k
Story-3	120	0.661794	3.639867	1.7346175	2.4	0k
Story-2	120	0.346409	1.9052495	1.4190935	2.4	0k
Story-1	120	0.088392	0.486156	0.486156	2.4	0k
Base	0	0	0	0	2.4	0k

3.9 Base shear calculation

Total Seismic Weight [DL + LL(25%)] , W = 6563 kip **[from Etabs]**

Base Shear ,V = 83.313 kip

% Base Shear , (V / W) = 83.313 kip / 6563 kip = = 1.27 %

CHAPTER – 4

RESULT AND DISCUSSION

4.1 Introduction

This chapter presents the analytical results obtained from the three different ETABS models developed for the 12-story reinforced concrete building [1], [8], [12]. The primary objective of this study is to evaluate the structural behavior of the building under different seismic zone conditions and to investigate the effectiveness of corner shear walls in improving the lateral stability of the structure [5], [9], [14].

Three analytical models were considered:

- **Model 1:** Frame structure without shear walls
- **Model 2:** Structure with corner shear walls
- **Model 3:** Modified corner shear wall configuration

The performance of these models was evaluated based on the following parameters:

- Story Displacement
- Story Drift
- Base Shear

The comparison was carried out for different seismic zones to assess the influence of shear walls on structural response.

4.2 Story Displacement

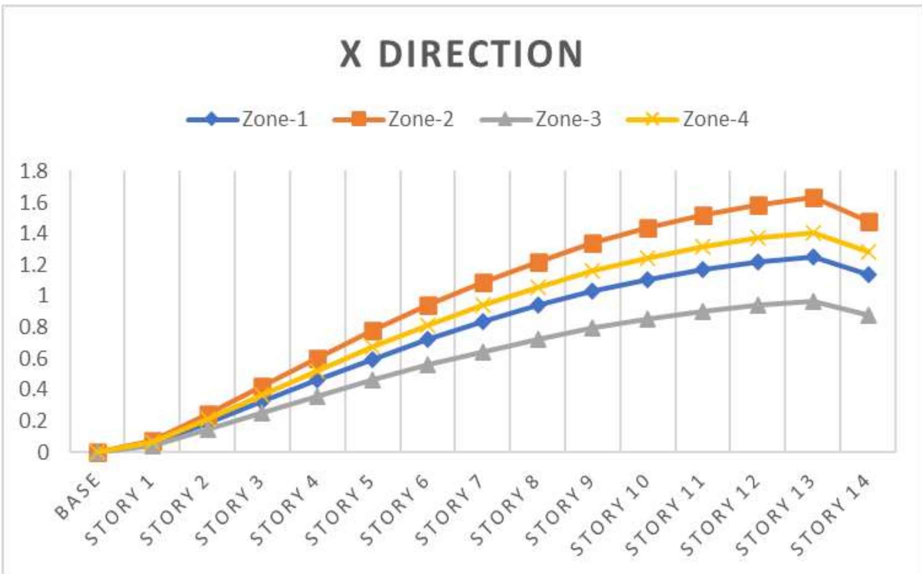
Story displacement is the absolute lateral movement of a floor or building level from its original, undeformed position. Story displacement refers to the lateral movement of each floor level due to seismic loading. Excessive displacement may affect structural stability and serviceability.

The displacement values obtained from ETABS analysis for all three models under different seismic zones are presented in the following tables and figures.

4.3 Comparison of Story Displacement

Model-1

Story Vs Displacement Graph



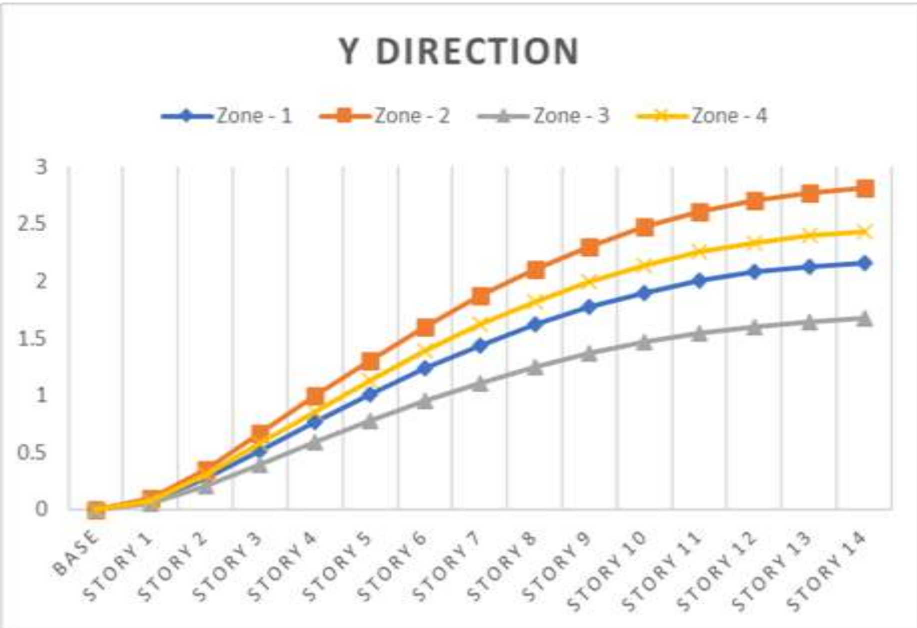


Figure 4.1: D+ 0.5L+0.7Wx

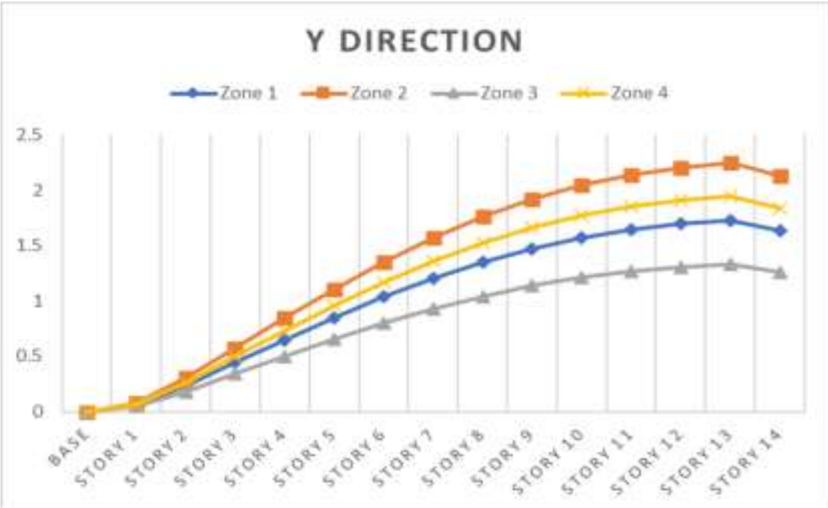


Figure 4.2: D+ 0.5L-0.7Wx

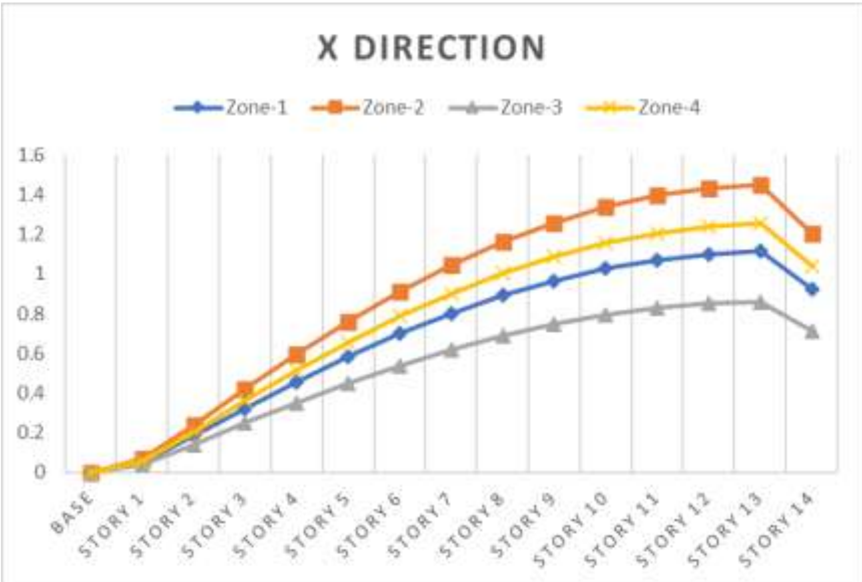


Figure 4.3: D+ 0.5L+ 0.7Wy

Figure 4.4 : D+ 0.5L - 0.7Wy

Model – 2

Story Vs Displacement Graph

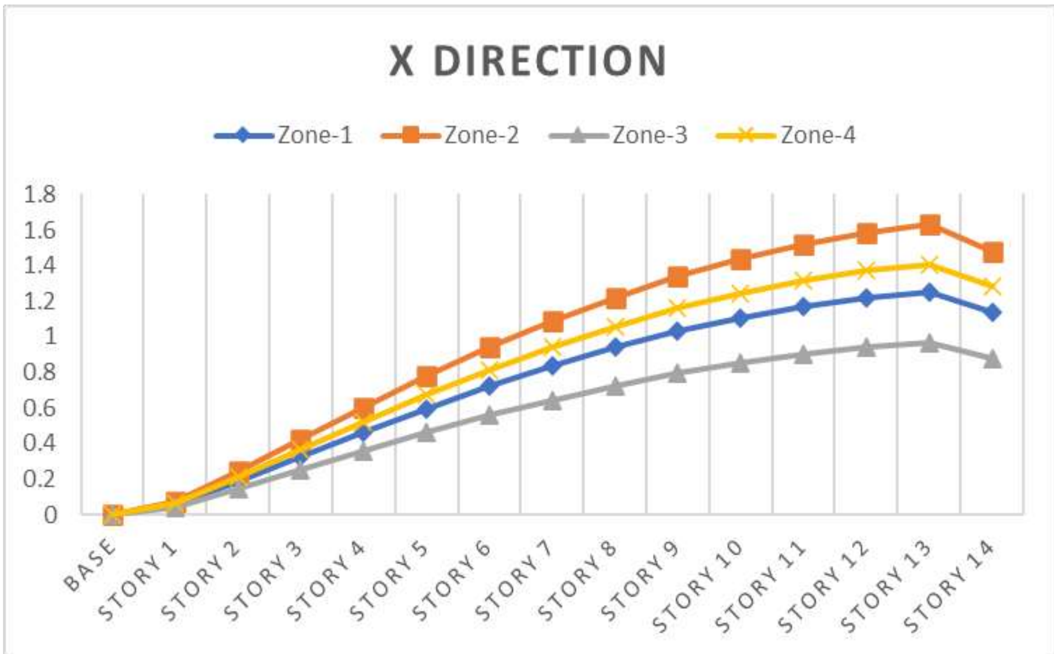
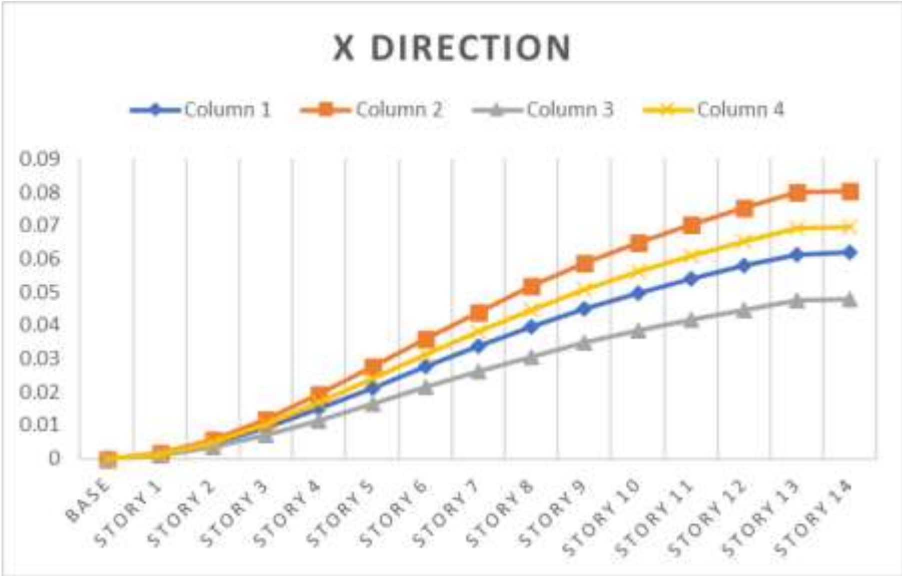


Figure 4.5: D+ 0.5L +0.7Wx



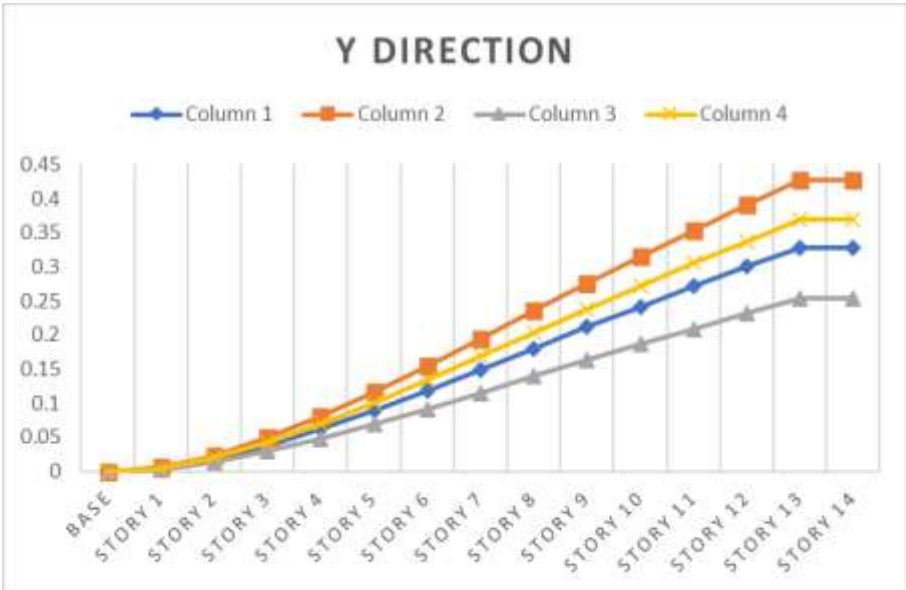


Figure 4.6: D+ 0.5L -0.7Wx

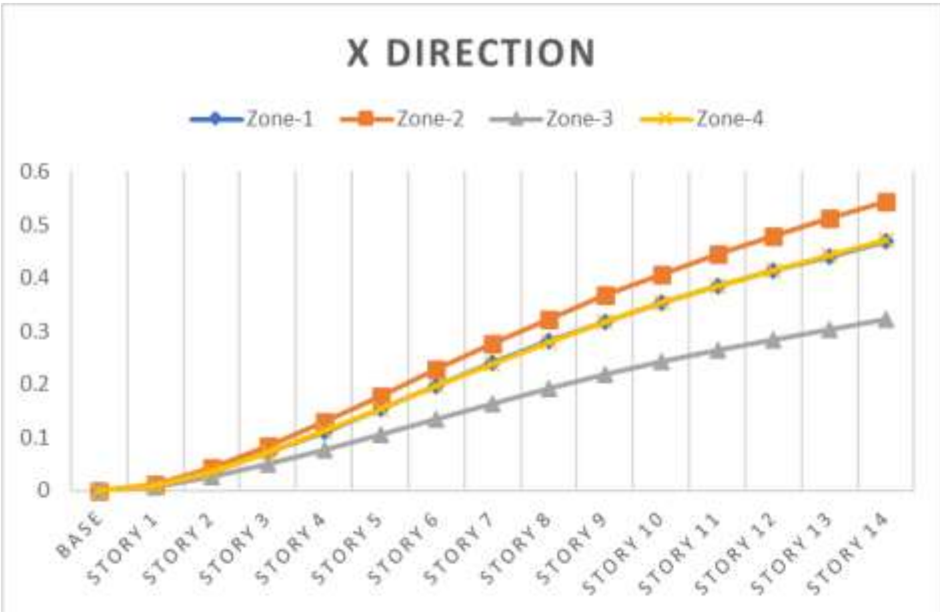


Figure 4.7: D+ 0.5L +0.7Wy

Figure 4.8: D+ 0.5L - 0.7Wy

Model – 3

Story Vs Displacement Graph

Figure 4.9 : D+ 0.5L + 0.7Wx

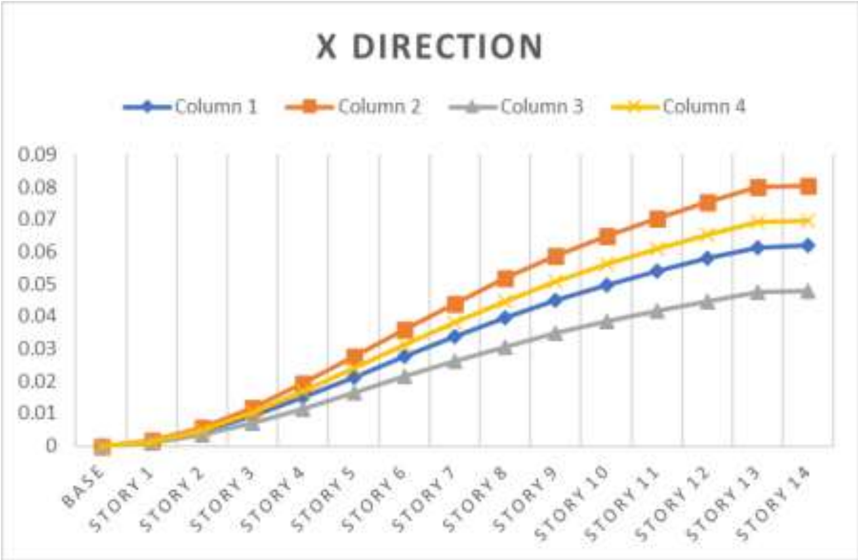


Figure 4.10: D+ 0.5L - 0.7Wx

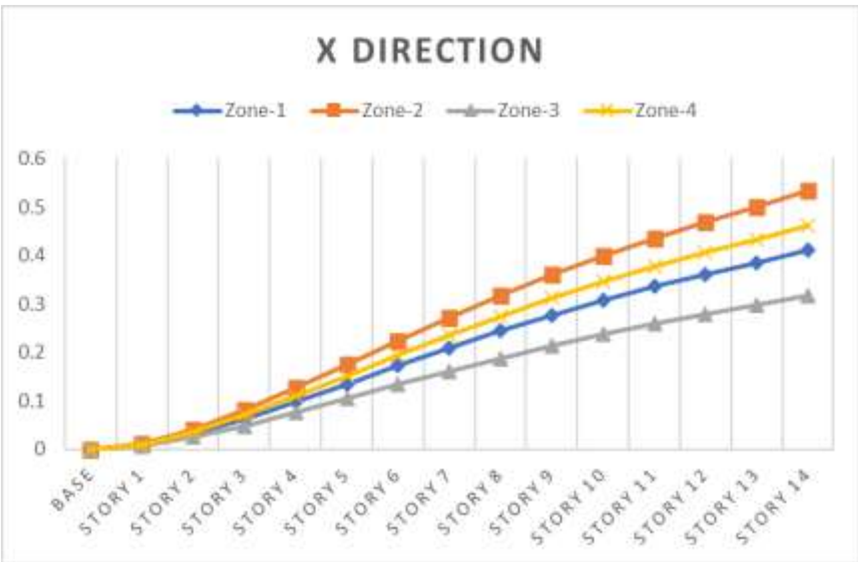


Figure 4.11 : D+ 0.5L + 0.7Wy

Figure 4.12 : D+ 0.5L - 0.7Wy

Discussion

From the analysis results, it is observed that the story displacement increases gradually from the base to the top story for all models. However, the maximum displacement occurs at the roof level.

Among the three models, Model 1 shows the highest displacement because it does not contain shear walls to resist lateral forces. In contrast, Models 2 and 3 exhibit significantly lower displacement values due to the presence of corner shear walls, which enhance the overall stiffness of the structure [5], [6], [12], [14].

Furthermore, Model 3 demonstrates better performance compared to Model 2, indicating that the modified shear wall configuration provides improved lateral resistance.

The displacement values are also found to increase with higher seismic zone intensity, which is expected because stronger seismic excitation generates greater lateral forces.

From the results, it can be observed that the maximum story displacement for Model-1 is **3"**, while for Model-2 it is **0.727"**, and for Model-3 it is **0.714".**

By comparing these three models, we can see that Model-3 shows the minimum displacement. This indicates that the use of a shear wall significantly reduces the story displacement [6], [12].

4.4 Story Drift

Story drift is the relative horizontal displacement (or deflection) of one level of a multi-story building compared to the level immediately below it. Caused by lateral forces like earthquakes or wind, it measures how much one floor moves sideways relative to the next, often used to prevent structural collapse and non-structural damage

The drift values obtained from ETABS analysis for all three models under different seismic zones are presented in the following tables and figures.

4.4 Comparison of Story Drift

Model – 1

Story Drift vs Story Graph

Figure 4.13:D+ 0.5L + 0.7Wx

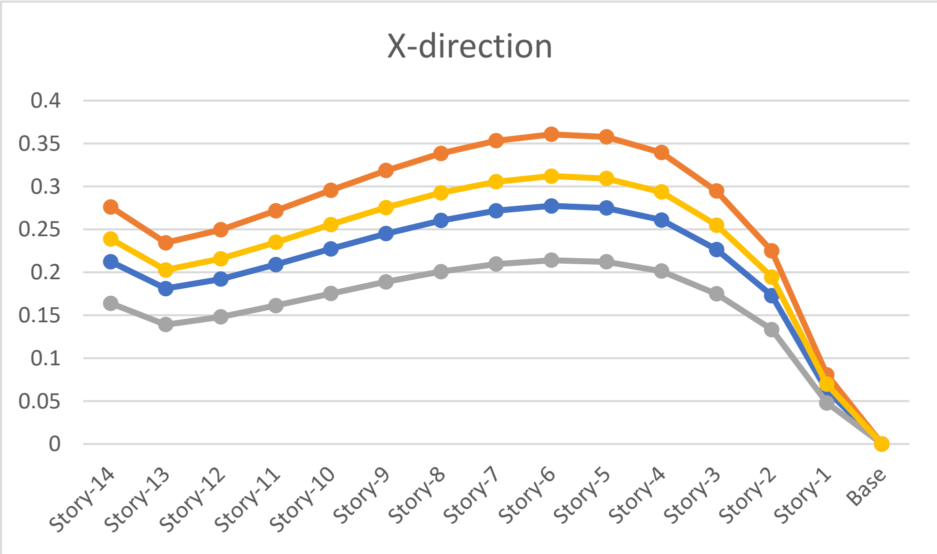
Figure 4.14: D+ 0.5L - 0.7Wx

Figure 4.15: D+ 0.5L + 0.7Wy

Figure 4.16: D+ 0.5L - 0.7Wy

Model-2

Story Drift vs Story Graph



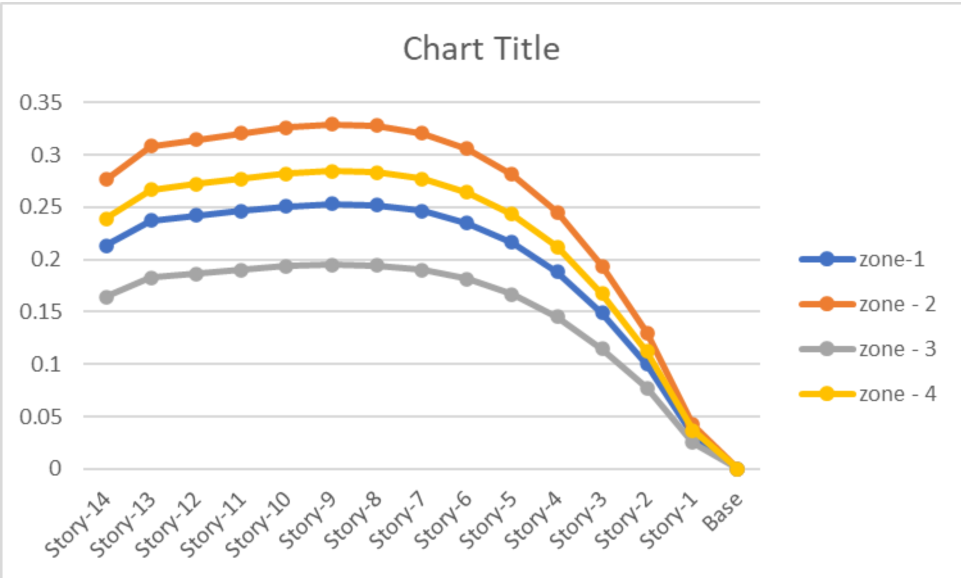
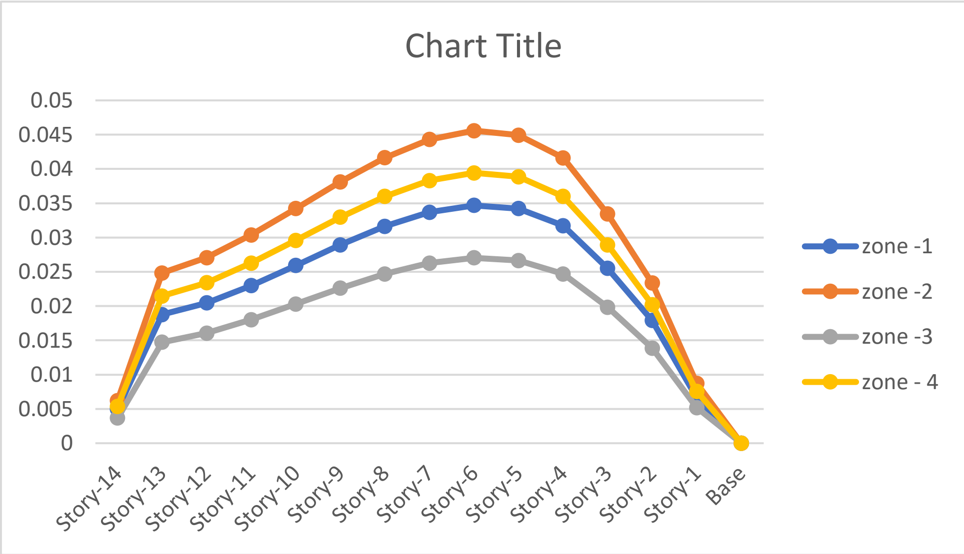


Figure 4.17: D+ 0.5L + 0.7Wx



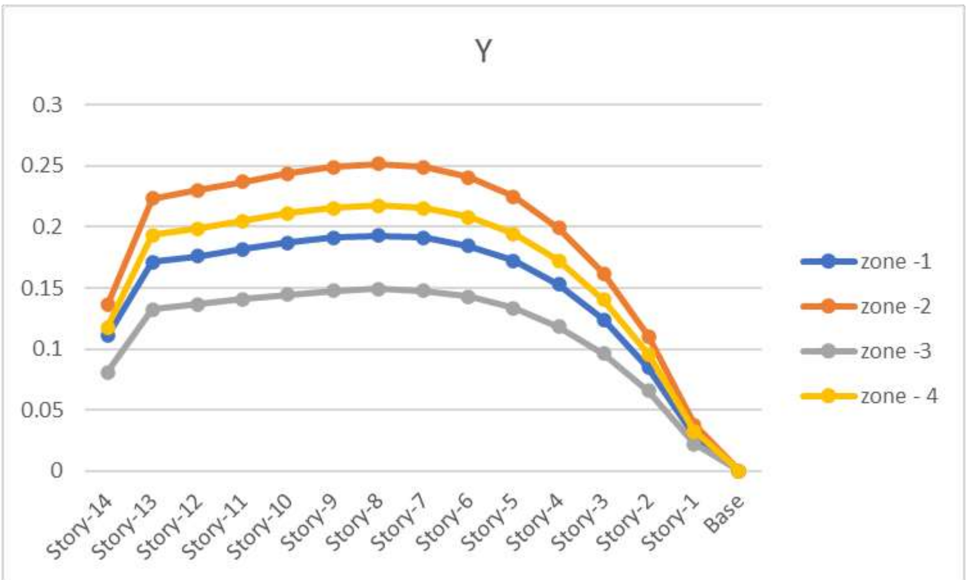
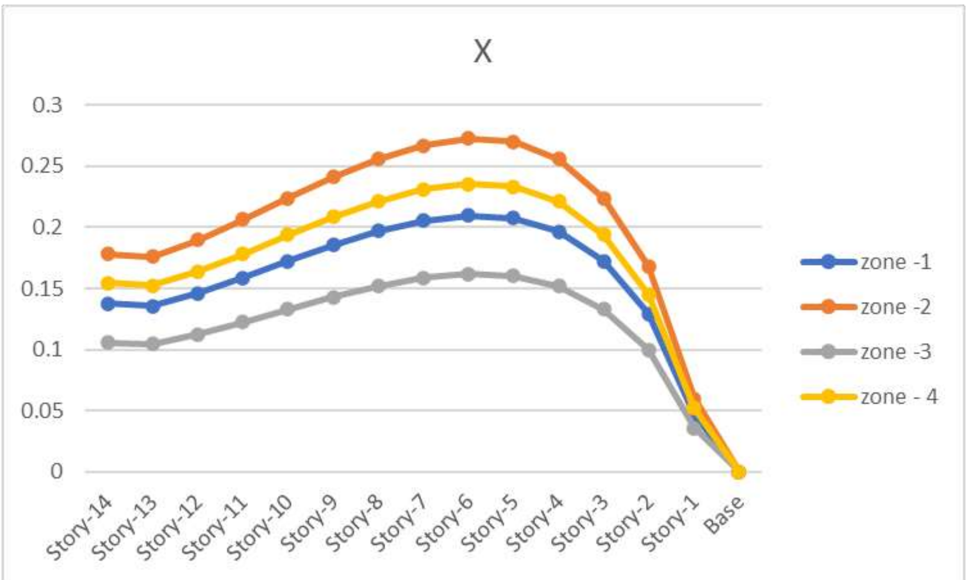


Figure 4.18 : D+ 0.5L - 0.7Wx



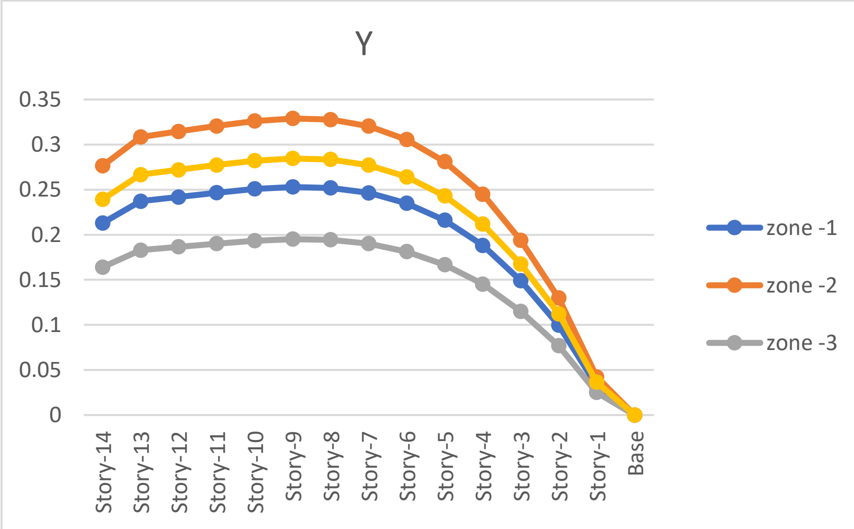
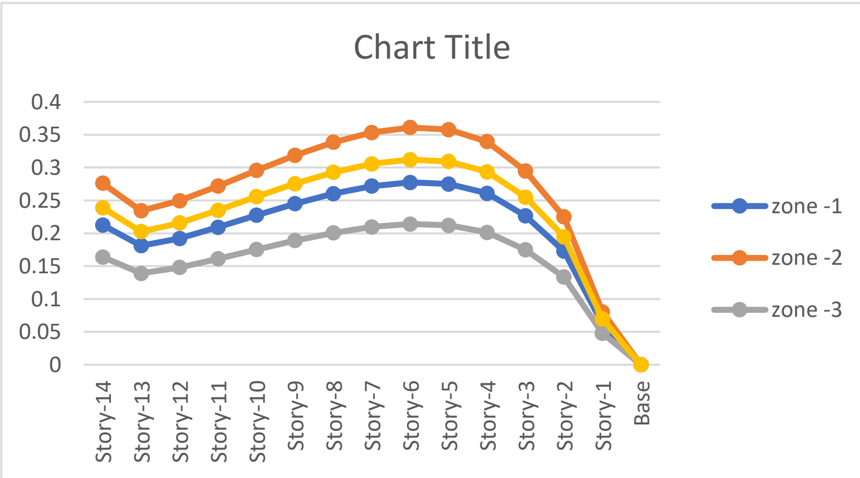


Figure 4.19: D+ 0.5L + 0.7Wy



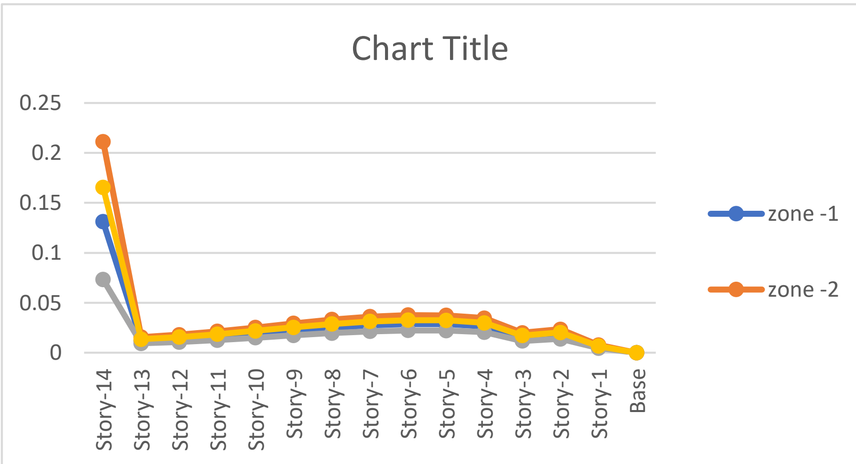
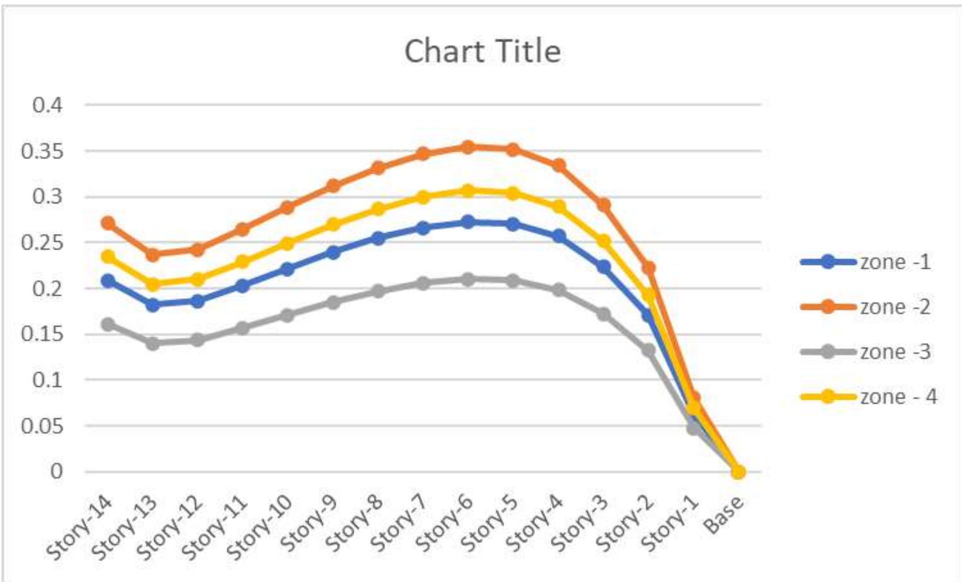


Figure 4.20: D+ 0.5L - 0.7Wy

Model -3

Story Drift vs Story Graph



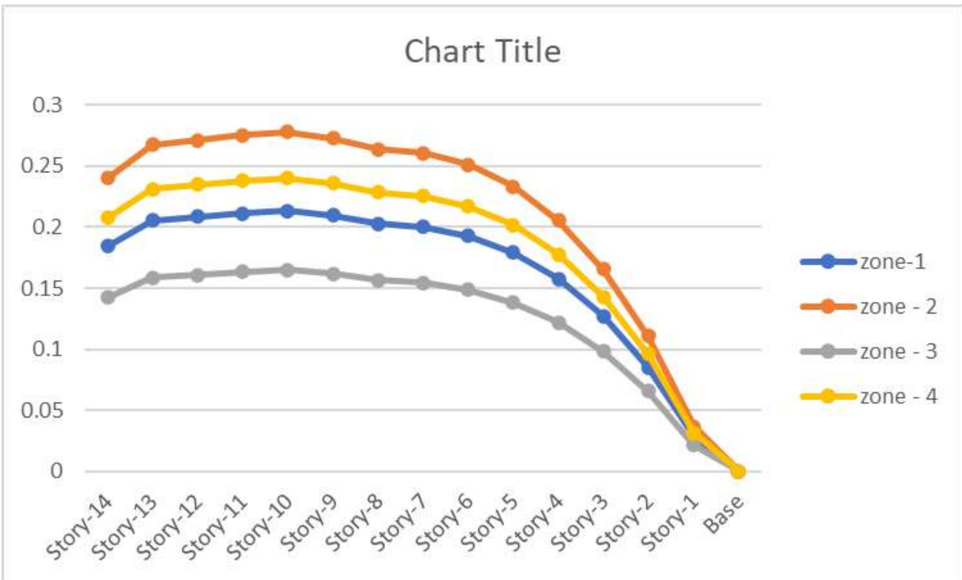
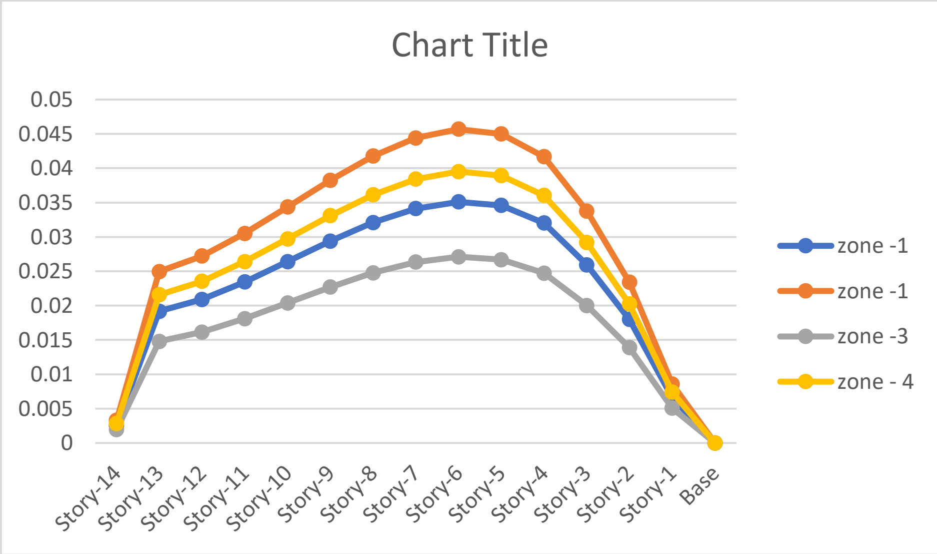


Figure 4.21: D+ 0.5L + 0.7Wx



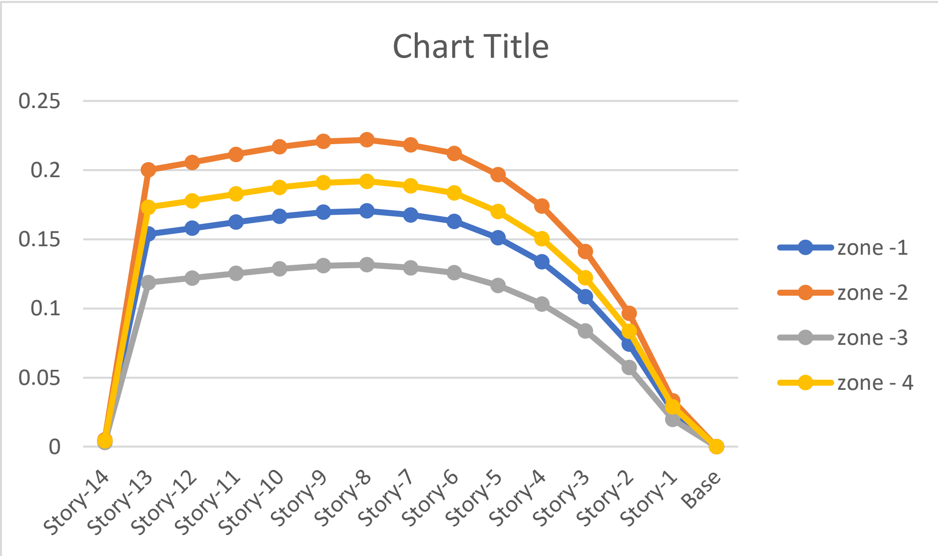
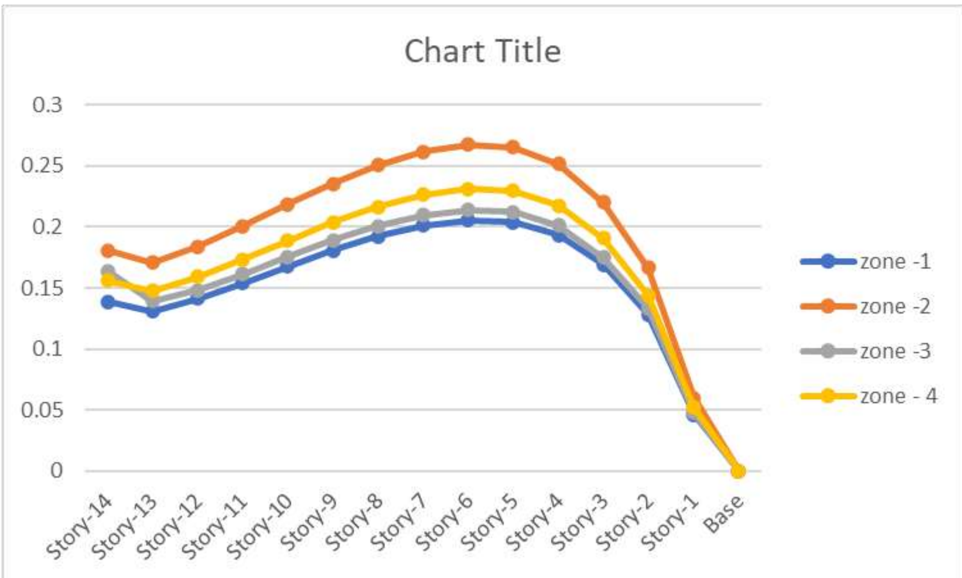


Figure 4.22: D+ 0.5L - 0.7Wx



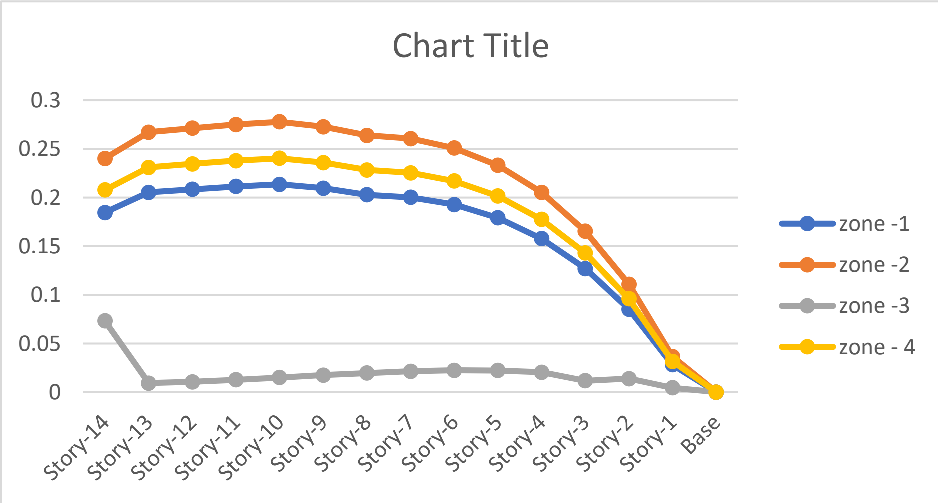
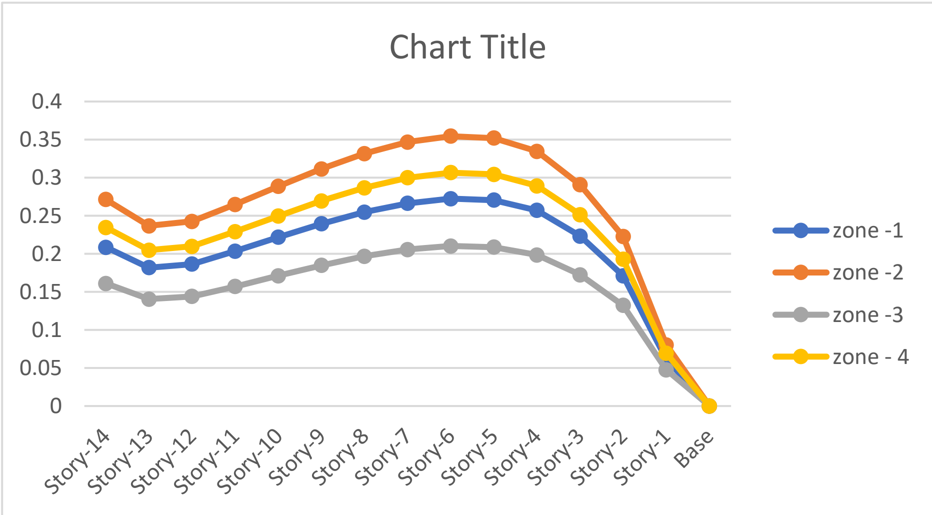


Figure 4.23 : D+ 0.5L + 0.7Wy



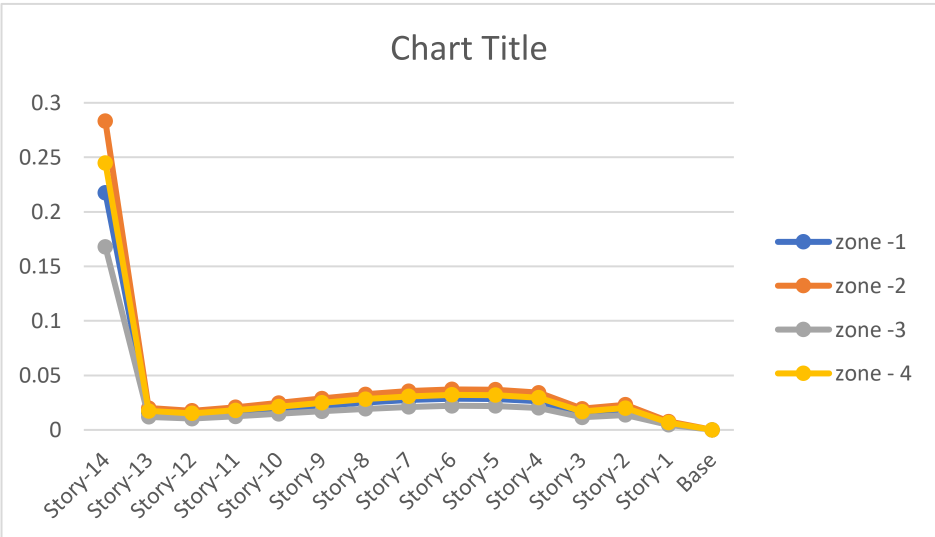


Figure 4.24: D+ 0.5L - 0.7Wy

Discussion

From the analysis results, it is observed that the story displacement increases gradually from the base to the top story for all models. However, the maximum displacement occurs at the roof level.

Among the three models, Model 1 shows the highest displacement because it does not contain shear walls to resist lateral forces. In contrast, Models 2 and 3 exhibit significantly lower displacement values due to the presence of corner shear walls, which enhance the overall stiffness of the structure.

Furthermore, Model 3 demonstrates better performance compared to Model 2, indicating that the modified shear wall configuration provides improved lateral resistance.

The displacement values are also found to increase with higher seismic zone intensity, which is expected because stronger seismic excitation generates greater lateral forces.

Comparison of Base Shear

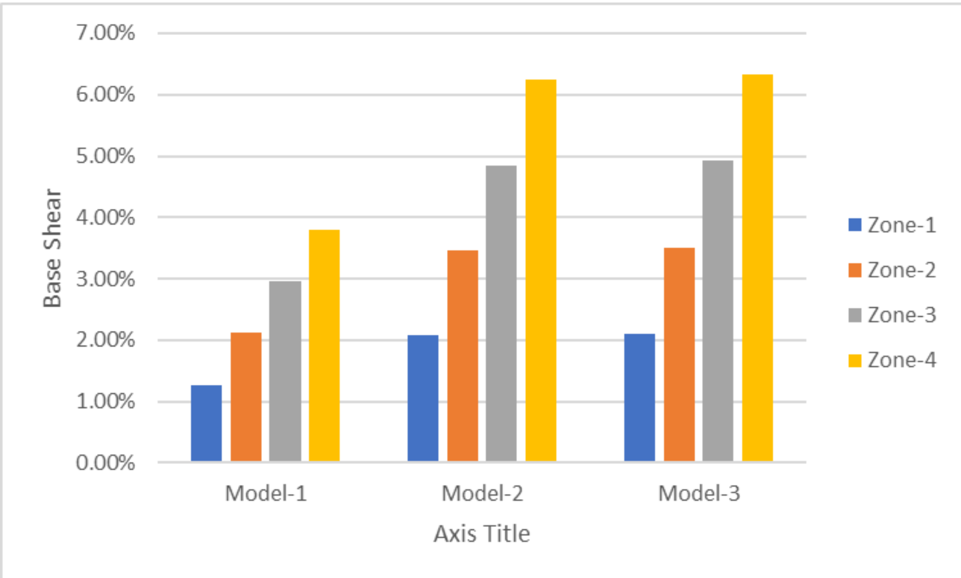


Figure 4.25: Base Shear

The base shear values increased in the models containing shear walls. This behavior agrees with earlier studies which explained that increased structural stiffness attracts higher seismic forces, resulting in larger base shear.

Additionally, higher seismic zones produced greater base shear values for all models due to increased earthquake intensity.

CHAPTER – 5

CONCLUSION AND FUTURE WORK

5.1 Conclusion

This thesis investigated the seismic behavior of the selected structural model using ETABS under four different seismic zones. The analysis mainly focused on key structural response parameters such as story displacement, story drift, and base shear. From the analytical results, the following conclusions can be drawn:

1. The seismic response of the structure significantly varies with the intensity of the seismic zone [5], [10], [11]. As the seismic zone factor increases, the overall lateral response of the structure also increases.
2. Story displacement was observed to increase progressively from lower seismic zones to higher seismic zones. The maximum displacement occurred at the top stories of the structure due to the cumulative lateral deformation effect.
3. Story drift values also increased with increasing seismic intensity [5], [12], [14]. Higher seismic zones produced comparatively larger inter-story drift, indicating greater deformation demand on the structure.
4. The maximum story drift remained within/close to the permissible limit specified by the relevant building code (modify according to your result). However, structures located in higher seismic zones require additional stiffness and proper lateral load-resisting systems to ensure safety and serviceability.
5. Base shear values increased considerably in higher seismic zones because seismic force is directly proportional to the seismic zone coefficient and structural mass.
6. The comparative analysis demonstrated that seismic zoning has a major influence on structural performance and must be carefully considered during structural design and analysis.
7. The use of ETABS proved effective for evaluating seismic behavior and understanding the dynamic response of multistory buildings [1], [3], [8].

Overall, the study highlights the importance of seismic analysis in designing earthquake-resistant structures, especially in regions with higher seismic vulnerability.

5.2.1 Effect of Shear Wall on Story Displacement

The analysis results revealed that the building without shear walls (Model 1) experienced the highest story displacement among all models. Due to lower lateral stiffness, the bare frame structure was more vulnerable to horizontal movement under seismic and lateral loading conditions.

The incorporation of shear walls in Model 2 and Model 3 significantly reduced the story displacement. The shear walls increased the overall rigidity of the structure and effectively resisted lateral forces.

Among all the configurations, Model 3 exhibited the minimum story displacement, indicating that its shear wall arrangement was more efficient in controlling lateral movement and enhancing structural stability.

Therefore, it can be concluded that shear walls play a vital role in minimizing lateral displacement in high-rise buildings.

5.2.2 Effect of Shear Wall on Story Drift

Story drift is an important factor in seismic design because excessive inter-storey drift can cause both structural and non-structural damage.

From the analysis, it was observed that:

- Model 1 showed the maximum story drift values.
- Model 2 demonstrated noticeable improvement after introducing shear walls.
- Model 3 achieved the lowest drift values among all models.

The reduction in story drift occurred because shear walls enhanced the stiffness and stability of the building and distributed lateral loads more efficiently throughout the structure.

The obtained drift values were found to be within the allowable limits specified by design codes. However, the shear wall models performed much better compared to the bare frame structure.

This confirms that properly positioned shear walls are highly effective in controlling inter-storey deformation and improving seismic behavior.

5.2.3 Effect of Shear Wall on Base Shear

Base shear represents the total seismic force transferred to the foundation level.

The results showed that the base shear values of Model 2 and Model 3 were comparatively higher than those of Model 1. This increase occurred due to the higher stiffness of the shear wall structures, which attracted greater seismic forces [5], [6], [12].

Although the base shear demand increased, the overall structural performance became more stable and safer because the structure gained improved resistance against lateral loading.

Model 3 provided the most balanced response in terms of stiffness, displacement control, and load distribution.

Therefore, it can be concluded that the inclusion of shear walls improves the seismic resistance capacity of high-rise buildings despite increasing base shear values.

Based on the overall analytical performance, Model 3 can be considered the most effective structural configuration due to its superior control over displacement and drift as well as enhanced lateral stiffness.

5.3 Engineering Significance of the Study

This research provides valuable insights into the behavior of shear wall structures and their importance in modern structural engineering design.

The outcomes of the study may help:

- Structural engineers in selecting efficient lateral load resisting systems
- Designers in optimizing shear wall positioning
- Researchers in conducting advanced seismic studies
- Students in understanding the behavior of high-rise structures

The findings also demonstrate the practical importance of using ETABS for structural modeling and seismic analysis of reinforced concrete buildings.

5.4 Limitations of the Study

Although the study achieved its objectives successfully, several limitations remain:

1. Only a 12-storey regular building was considered.
2. Linear analysis methods were used for structural evaluation.
3. Soil-structure interaction was not included.
4. Wind load effects were not extensively investigated.
5. Different shear wall thicknesses and materials were not considered.
6. Construction cost analysis was not performed.

These limitations may affect the generalized applicability of the study.

5.5 Future Work

Although the present study provides a detailed analysis of the seismic behavior of a 12-storey building with shear walls, several aspects may be investigated further in future research.

Future studies may include:

- Analysis of taller buildings with different heights and structural configurations
- Investigation of different shear wall locations, shapes, and thicknesses

- Comparative study using different analysis methods such as time history analysis and pushover analysis
- Consideration of different soil conditions and foundation effects
- Evaluation of torsional effects and irregular building configurations
- Study of different construction materials such as steel or composite structures
- Performance-based seismic design approaches for improved earthquake resistance
- Economic comparison between conventional frames and shear wall systems
- Optimization of shear wall placement for maximum structural efficiency
- Investigation of wind load and combined wind-earthquake effects on high-rise buildings

Further research on these aspects may provide a more comprehensive understanding of the seismic performance of multistorey buildings and help develop safer and more efficient structural design strategies.

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