EFFECT OF LATERAL LOADS ON RCC RESIDENTIAL BUILDING BY ETABS ACCORDING TO BNBC 2017

A Project and Thesis Submitted in partial fulfillment of the requirements

for the award of Degree of

Bachelor of Science in Civil Engineering

by

Md. Ashraful Hasan Swan
(ID #: 173-47-074)

Imroz Mahmud
(ID #: 181-47-707)

Md. Sahidul Islam
(ID #: 181-47-687)

Tanzir Hossain
(ID #: 171-47-035)

Supervised by
J.M.Raisul Islam Shohag
Lecturer
Department of Civil Engineering
Daffodil International University

DEPARTMENT OF CIVIL ENGINEERING

FACULTY OF ENGINEERING

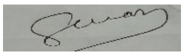
DAFFODIL INTERNATIONAL UNIVERSITY

DECEMBER-2021

Certification

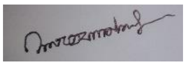
The thesis titled **“EFFECT OF LATERAL LOADS ON RCC RESIDENTIAL BUILDING BY ETABS ACCORDING TO BNBC 2017”**
Submitted by Md. Ashraful Hasan Swan, Md. Sahidul Islam, Imroz Mahmud, Tanzir Hossain, have been accepted as satisfactory in partial fulfillment of the requirements for the degree of Bachelor of Science in Civil Engineering on December 2021.

The thesis titled **“EFFECT OF LATERAL LOADS ON RCC RESIDENTIAL BUILDING BY ETABS ACCORDING TO BNBC 2017”**



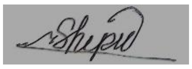
Md. Ashraful Hasan Swan ....

ID #: 173-47-074



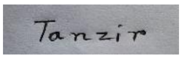
Imroz Mahmud ....

ID #: 181-47-707



Md. Sahidul Islam ....

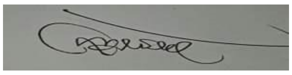
ID #: 181-47-687



Tanzir Hossain ....

ID #: 171-47-035

Countersigned



J.M.Raisul Islam Shohag
Lecturer
Department of Civil Engineering
Faculty of Engineering
Daffodil International University.

The project and thesis entitled **"EFFECT OF LATERAL LOADS ON RCC RESIDENTIAL BUILDING BY ETABS ACCORDING TO BNBC 2017"** submitted by **Md. Ashraful Hasan Swan**, ID No: 173-47-074, **Imroz Mahmud**, ID No: 181-47-707, **Md Sahidul Islam**, ID No: 181-47-687, **Tanzir Hossain** , ID No: 171-47-035 Session: Fall 2017 has been accepted as satisfactory in partial fulfillment of the requirements for the degree of **Bachelor of Science in Civil Engineering** on December 2021.

BOARD OF EXAMINERS

____

Dr. Mohammad Hannan Mahmud Khan Chairman

Assistant Professor& Head

Department of Civil Engineering, DIU

____

Md. Masud Alam Internal Member

Assistant Professor

Department of CE, DIU

____

Mr. Ryhan Md. Faysal Internal Member

Assistant Professor

Department of CE, DIU

____

Kazi Sirajul Islam External Member

Dedicated to

Our Parents

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLE

CHAPTER 5------------------

CHAPTER 6------------------

LIST OF ABBREVIATIONS

BNBC	Bangladesh National Building Code
ACI	American Concrete Institute
RC	Reinforced Concrete
ASCE	American Society of Civil Engineers
OMRF	Ordinary Moment Resisting Frame
SMRF	Special Moment Resisting Frame
IMRF	Intermediate Moment Resisting Frame
psi	Pound Per Square Inch
USD	Ultimate Strength Design
TMD	Tuned Mass Damper
FEM	Finite Element Method
BIM	Building Information Modeling

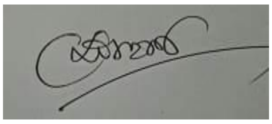
LIST OF SYMBOLS

DL	Dead Load
LL	Live Load
EQ-X	Earthquake Load in X direction
EQ-Y	Earthquake Load in Y direction
R	Response Reduction Factor
Cd	Deflection Amplification Factor
Ω_0	System Overstrength Factor
f'_c	Compressive Strength of Concrete
f_y	Yield Strength of Steel
E_c	Modulus of Elasticity of Concrete
E_s	Modulus of Elasticity of Steel
T	Fundamental Period of Vibration
Ct	Numerical Co-efficient
Z	Seismic Zone Co-efficient
S_S, S_1,	Spectral Response Acceleration Parameter for Different Seismic Zone
F_a, F_v	Site Coefficient for Different Seismic Zone and Soil Type
S_{DS}, S_{D1}	Spectral Response Acceleration Parameter for Different Seismic Zone and Soil Type
I	Structural Importance Factor
Ig	Moment of Inertia

DECLARATION

The dissertation entitled “**EFFECT OF LATERAL LOADS ON RCC RESIDENTIAL BUILDING BY ETABS ACCORDING TO BNBC 2017**” has been performed under the supervision of J.M.Raisul Islam Shohag (Lecturer), Department of Civil Engineering, Daffodil International University, Dhaka, Bangladesh and got approved in partial fulfillment of the requirement for the Bachelor of Science in Civil Engineering. To the best of our knowledge and belief, the capstone contains no materials previously published or written by another person except where due reference is made in the capstone itself.

Name of the supervisor



....

J.M.Raisul Islam Shohag
Lecturer
Department of Civil Engineering
Daffodil International University

ACKNOWLEDGEMENT

First of all, thanks to Almighty who helped us to complete the practicum work and the practicum report, leading to the Bachelor of Science in Civil Engineering degree. We would like to thank every families and friends that to get me in this intensity and individuals who support and share idea and also helping us to be like this. We would like to pay our gratitude to our respected Head, Department of Civil Engineering, and Prof. Dr. Md. Hannan Mahmud Khan who gave us the opportunity to do the report on "**EFFECT OF LATERAL LOADS ON RCC RESIDENTIAL BUILDING BY ETABS ACCORDING TO BNBC 2017"** by Using Manual Calculation & Software (ETABS) Approach"

.

Then we would like to pay our gratitude to J.M Raisul Islam Shohag (Lecturer of DIU).

We would also like to thanks J.M Raisul Islam Shohag (lecturer of DIU) for his endless support.

All teachers of Civil Engineering department who brought us tour present performance and shape us like this during the last four successive years, Special thanks to all faculty, Civil Engineering Department, DIU for providing us a lots of support to prepare this successful report.

ABSTRACT

The lateral load effect on R.C.C. buildings has gotten a lot of attention for establishing specialized characteristics according to the BNBC 2017. ETABS is used to assess steel constructions, R.C.C Low and High Rise Residential Buildings, and other structures. The effects of lateral loads on R.C.C. residential buildings, particularly for L shapes, are explored. The influence of lateral loads on maximum storey displacement, maximum storey drift, and storey overturning moment is investigated. Following the structural analysis, these characteristics are compared with and without the effect of lateral loads. In this study, the maximum storey displacement increases as the number of storeys increases, with the exception of the stair roof, which increases due to lateral loads. However, without lateral load effects, maximum storey displacement does not rise linearly as storey increases. Maximum storey drift grows none linearly as storey increases in both scenarios, and maximum storey drift is found for the floor for the impacts of lateral stresses. Overturning moments rise non-linearly as the number of storeys increases, and the maximum moment is obtained for storey 2 in both cases.

Keywords: Lateral, loads, ETABS, BNBC2017, Irregularity, Parameters.

CHAPTER 1

Introduction

1.1 General

Structural analysis entails determining a structure's overall shape as well as all of its precise dimensions. Lateral loads, such as earthquakes and wind, can have a substantial impact on buildings and other structures. ETABS is a 3D structural analysis program that can perform both static and dynamic analyses. In Civil Engineering, the term "building" refers to a structure that includes foundations, walls, columns, floors, roofs, doors, windows, ventilators, stair lifts, and other types of surface finishes, among other things. The target of structural exploration and design is to originate a structure that can withstand all applied onus for the duration of its desired entity. Geotechnical investigation is required prior to the study and design of any structure in order to gather vital information about the supporting soil. Structural engineers are faced with the task of achieving the most efficient and cost-effective design while guaranteeing that the final design of a structure and the building must be functional for its intended use for the duration of its design life. Various software packages, such as RISA, STAAD PRO, ETABS, STRUDL, MIDAS, SAP, and RAM, are now available in the market for analyzing and designing almost all sorts of structures.

This project is mainly concerned with the study "**EFFECT OF LATERAL LOADS ON RCC RESIDENTIAL BUILDING BY ETABS ACCORDING TO BNBC 2017**". The structural analysis of (G+8) story building is done with the help of ETABS software. The Linear static analysis and design is done for all three zones and response like axial force, bending moment, displacement, drift is compared

1.2 Background of Thesis

We have worked in L shape multi storied building and have analyzed "**EFFECT OF LATERAL LOADS ON RCC RESIDENTIAL BUILDING BY ETABS ACCORDING TO BNBC 2017**".

1.3 Scope of the study

The main focus is to find out maximum storey displacement, maximum storey drift, maximum storey overturning moment with lateral load and without lateral load.

1.4 Objective

The objectives of this project and thesis :

a) To analyze the multistoried building by using ETABS.

b) To calculate maximum storey displacement, maximum storey drift and overturning moment.

c) To assimilate maximum storey displacement, maximum storey drift and overturning moment among storey

d) To liken maximum storey displacement, maximum storey drift and overturning moment between X and Y direction.

e) To balance maximum storey displacement, maximum storey drift and overturning moment between X and Y direction between with lateral load & without lateral load.

CHAPTER 2

2.1 INTRODUCTION

Previously, buildings were designed only for gravity loads, and seismic analysis is a comparatively new phenomenon. It is an element of structural analysis and structural design in areas where earthquakes are common.

2.2 Previous Stories Regarding R.C.C Building Analysis

Md. Arman Chowdhury: This study investigated regular, irregular, and irregular structures with and without isolation system. Installation of an isolator in a structure extends the structure's life span, reducing the likelihood of resonance. The benefit of constructing an isolator in a building goes up, but the reinforcing and material costs go down.

P. P. Chandurkar: Shear walls are an important earthquake resisting element in this study. Structural walls provide an effective bracing system and have strong lateral load resistance potential. As a result, determining the seismic reaction of the wall or shear wall is critical. The major goal of this research is to figure out where the shear wall should go in a multi-story building.

Professor S.S. Patil: This study provides a seismic analysis of a high-rise building using the ETABS program, taking into account various lateral stiffness system circumstances. The response spectrum approach is used to do the analysis. This study accurately depicts the consequence of higher ways of quiver and the real force distribution in the elastic extent. Base shear, tale drift, and story deflection are among the outcomes provided.

Ragy JOSE:- In this work "Analysis and Design of Residential Building Using ETABS is performed.

Mayuri D. Bhagwat: In this paper, time history analysis and reaction spectrum analysis are used to do dynamic analysis of a G+8 multistory practical RCC building for the Koyna and

Himanshu Bansal (Himanshu Bansal): The storey shear force was found to be highest in the maiden storey and lowest in the top storey in all situations in this investigation. The base shear of mass irregular building frames is found to be greater than that of identical regular building frames. The base shear in the rigidity irregular building was lower, while the inter-storey drifts were bigger.

2.3 Residential Building and its Classification.

A infrastructure is a man-made structure having a roof and walls that remain in one place for the most part. Buildings come in a range of fervidity, sizes, and performances, and have been accommodated throughout history for a variety of causes, including the availability of construction materials, climate situations, land values, ground circumstances specific uses, and aesthetic considerations. Compares the list of non-building structures to better comprehend the term "building".

- Types of building:-
  1. Residential building
  2. Commercial and public building
- Banking building
- Shopping mall
- Mosque building
- Factory building
- Academic building
- Library building
- Theater building
- Castle building etc.

Finally, the phrase "engineering building planning" refers to the organization of all the units of a residence on all floors and levels, taking into account not only the aclinic array but also the elevation and level required to accommodate the site surrounded by walls, floors, and roofs. It is critical to keep the ordinary purpose of the infrastructure in mind when designing the construction. Each form of structure has its own set of requirements in order to effectively serve its intended purpose. The functional or utilitarian component of a structure should be carefully considered.

Principal regard of planning are-

- Human dwelling place and their essentials

- Climatic proviso and consequences
- Bye-laws for forethought and construction
- Gainable finance
- Ease, safety and economy
- Ordinary ethics of planning:-
- Flexibility
- Economy
- Elegance
- Sanitation
- Circulation
- Furniture requirement
- Roominess
- Orientation
- Privacy
- Prospect
- Aspect

2.4 Principal of Planning

Principles of planning details:-

Flexibility:-

- The building plan should be created with future requirements in mind.

Economy:-

- Building planning should be done within the client's budgetary constraints.

Elegance:-

- Elegance refers to the planning of the building's elevation and arrangement in order to give it a striking appearance.
- Elegance is created by the right width, height, location of doors and windows, materials used in exterior wall construction, and so on. The aesthetics of a structure are the outcome of elegance.

- Building planning should be done within the client's budgetary constraints.
- In sanitary units, cleanliness, illumination, and ventilation are provided to prevent the growth of bacteria and the spread of disease while also providing a hygienic environment. To keep the bath and wick glazed tiles clean, a dado should be installed on the walls.
- Rooms should be equipped with skirting. Bath tubs, unitary, w.c. pans, wash basins, and kitchen sinks should all be made of ceramic to make cleaning easier.

Sanitation:-

- In sanitation units, cleanliness, illumination, and ventilation are provided to prevent the growth of germs and the transmission of illness, as well as to provide a sanitary environment. Glazed tiles dado should be supplied on the wall in the bath and w.c. to keep the area clean.
- In rooms, skirting should be provided.
- Bath tubs, unitary, w.c., pans, wash basins, and kitchen sinks should all be made of ceramic to make cleaning easier.

Circulation:-

- The term "circulation" refers to the provision of a continuous path between rooms inside a structure..
- Horizontal circulation through passages, hallways, and lobbies, as well as vertical circulation through stairwells, elevators, and ramps, is required throughout the building.
- Building design incorporates both natural and artificial illumination. Sunlight can provide adequate illumination with sufficient ventilation.

Furniture requirement:-

- Necessary furniture required right place installation.
- Sufficient space for furniture in the room must be considered.
- Furniture size should be considered.
- Roominess:-

- The term "roominess" refers to a layout that takes most advantage of a room's minimal or restricted size.
- Space must be used efficiently.
- A length-to-breadth ratio of 1.20 to 1.50 is possible.
- The ceiling height in a small space should be modest.
- A rectangular room, rather than a square room, is preferred.
- The building plan should be created with future requirements in mind.
- When developing a structure, consider the size of furniture that will be necessary for the rooms' practical utility.
- The kitchen features a platform, a cabinet, a dining table, a refrigerator, and a mill, among other things.
- The bedroom features a bed, a closet, side tables, and a dressing table, among other things. In the children's room, there is a bed, a study table, a cabinet, and a dressing table, among other things.

Privacy:-

- When it comes to residential building design, privacy is a crucial concern.
- The position of the central door should be avoided if you want additional seclusion.
- The term "grouping" alludes to the ease with which numerous rooms may be communicated and utilized.
- The kitchen and dining room should be in close proximity to one another.
- The pantry should be close to the kitchen.
- Toilets and urinals should be kept out of the kitchen.
- The kitchen and toilet are not visible from the drawing room.
- The bedroom is attached to the bathroom and is therefore less exposed to the drawing room.

Orientation:-

- Orientation refers to the placement of a building's layout on its site in relation to the directions.
- When determining the building's orientation, direct sunshine, wind, and rainfall, as well as their strength and kind of surrounds, are taken into account.

- The building's long walls should be oriented north and south.
- East and west should be the direction of the short walls.

Prospect:- A structure is considered to have potential when it has a decent and pleasant appearance from the outside. It's a term that refers to the outside view of a building's rooms. The outside walls and windows should be painted in a pleasing manner. Projected windows allow for more light and air to enter the space.

Aspect:- The planned arrangement of exterior wall doors and windows to gain sunshine, breeze, and a pleasant view of the environment outside is referred to as aspect.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The previous Chapter deal with literature review. We have highlighted the purpose of our work through this chapter and mentioned the similar research has been done in the past. In this chapter we will focus about some design criteria about RCC residential building according to BNBC 2017.

3.2 Procedure for analysis

SL.	Phase 1 Without Lateral Load	Phase 2 With Lateral Load
1	**INITIATING** Select an eight storied residential building	**INITIATING** Select the final model from phase 1
2	**MODELING** - Computer model - Material Assign - Load Assign	**MODELING** - Assign Lateral Load
3	**ANALYSIS** - Model Analysis	**ANALYSIS** - Model Analysis
4	**DESIGNING** - Beam & Column	**DESIGNING** - Beam & Column
5	**DETAILING** - Beam & Column	**DETAILING** - Beam & Column

3.3 Material properties

SL.	Property Name	Symbol	Value
1)	Compressive Strength of Concrete	f'_c	4 ksi
2)	Yield Strength of Steel	f_y	55 ksi
3)	Floor Finish	FF	18 psf
4)	Partition Wall	PW	30 psf
5)	Roof Slab Live Load	---	65 psf
6)	Floor Slab Live Load	---	101 psf
7)	Parapet Wall	---	150 psf

3.4 Section properties

Grade Beam size

Grade Beam Name	Size
GB 1	$18'' \times 24''$
GB 2	$15'' \times 18''$

Floor Beam Size

Floor Beam Name	Size
FB 1	$18'' \times 24''$
FB 2	$15'' \times 18''$

3.5 Slab properties

Section Name	Size
Slab	$\mathbf{5''}$
Stair Slab	$\mathbf{8''}$
Shear Wall	$\mathbf{10''}$

3.6 Load consideration

Load Name	Value
FF	18 psf
LL (on floor slab)	45 psf
LL (on stair)	101 psf
LL (on roof slab)	65 psf
Parapet	150 psf
PW	30 psf

3.7 Earthquake load consideration

Property Name	Symbol	Value
Seismic zone Factor	Z	0.20(zone=2)
Site Class	F	
Site coefficient	Fa=Fv	1.15=1.725
SDS&SD1		1.7557&0.9994
Occupancy Importance	I	1.25
Response Modification	R	6
System Over strength	Ω	2.5
Deflection Amplification	Cd	5
Time Period	T	1.137
0.2 Sec Spectral Accel	Ss	2.29
1 Sec Spectral Accel	SI	0.869
Long-Period Transition Period		2 sec

3.8 Wind load consideration

Property Name	Symbol	Value
Wind Speed	---	147.2 mph (For Dhaka)
Exposure Type	B	
Importance Factor	I	1
Topographical Factor	K_{zt}	1
Gust Factor	----	0.85
Directionality Factor	K_d	0.85
Windward Coefficient	C_{pw}	0.8
Leeward Coefficient	C_{pl}	0.5
Parapet Height		3.5feet

CHAPTER 4

Structural Load Analysis

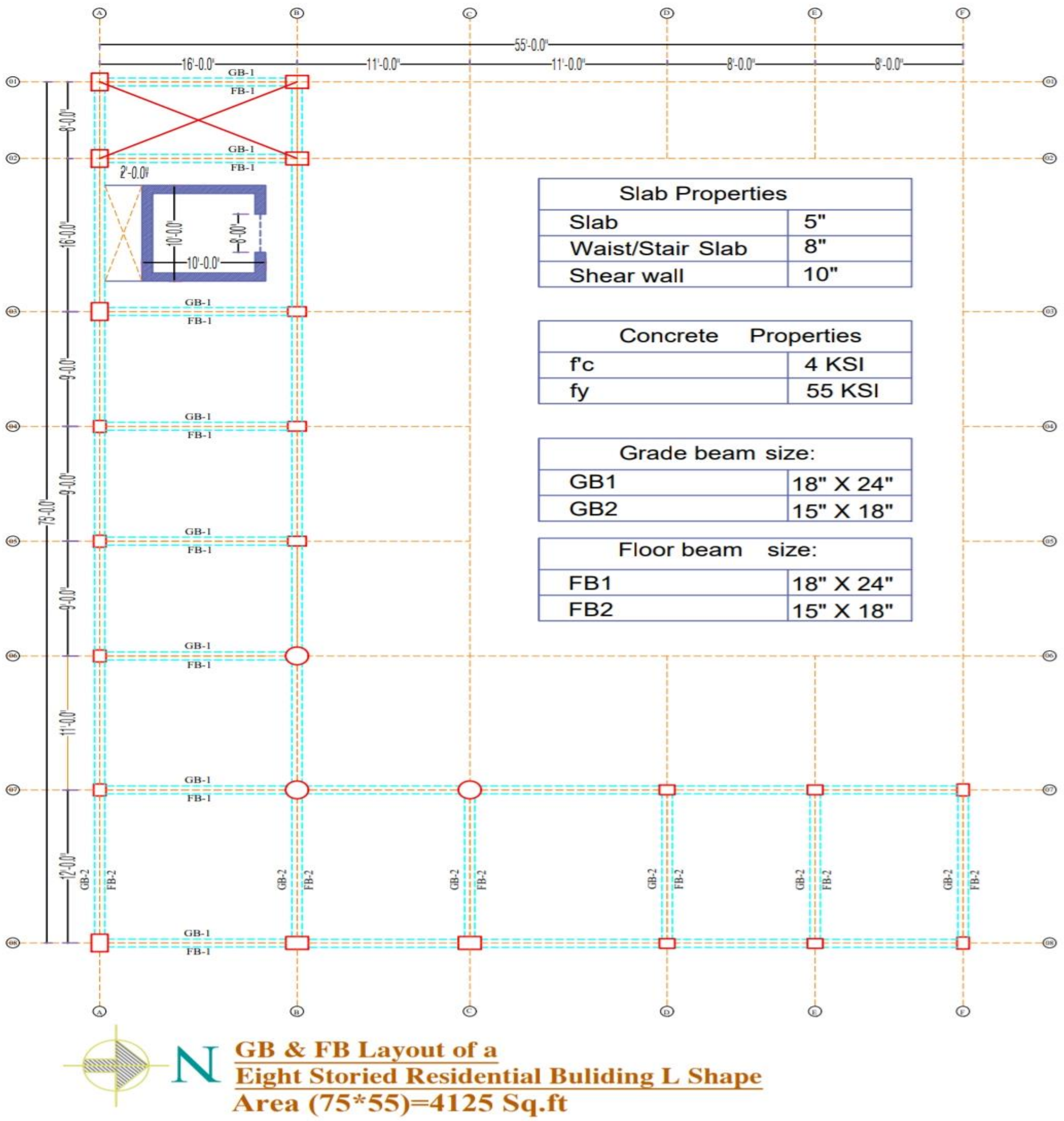


Fig. 4.1: Architectural plan of L shape building

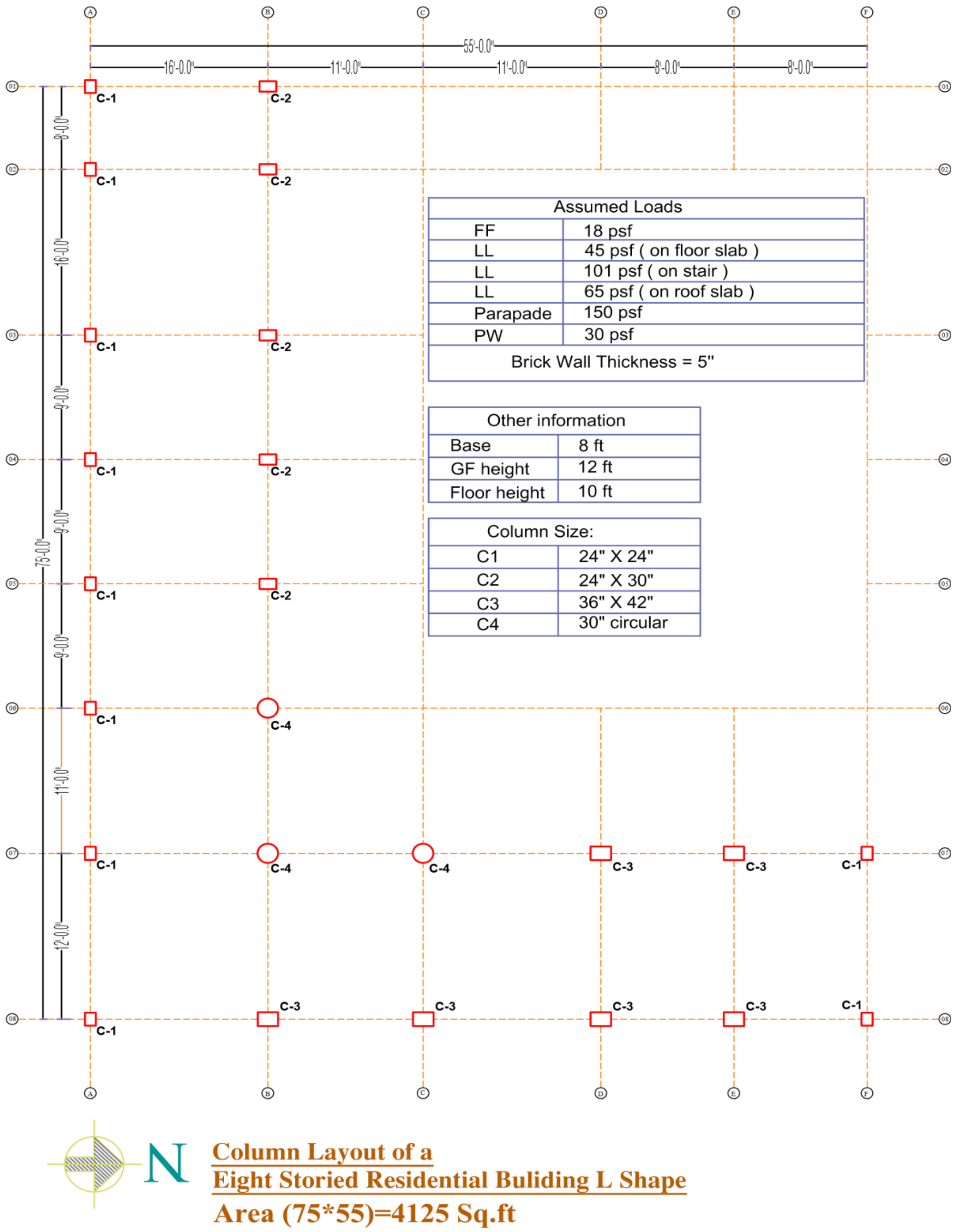


Fig 4.2: Layout of L shape residential building

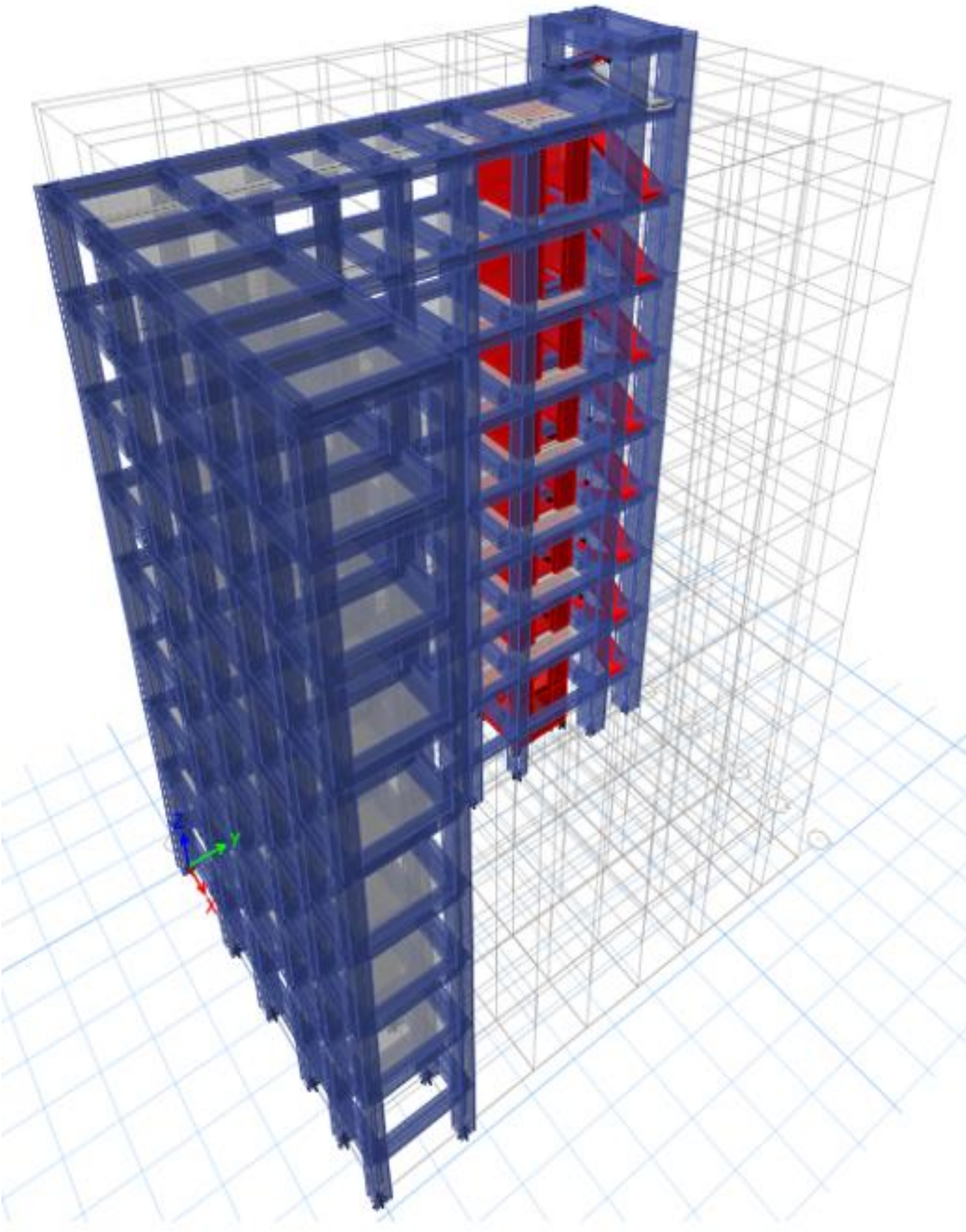


Fig 4.3: 3D view of L shape residential building

Fig. 4.4: Grid input in ETABS

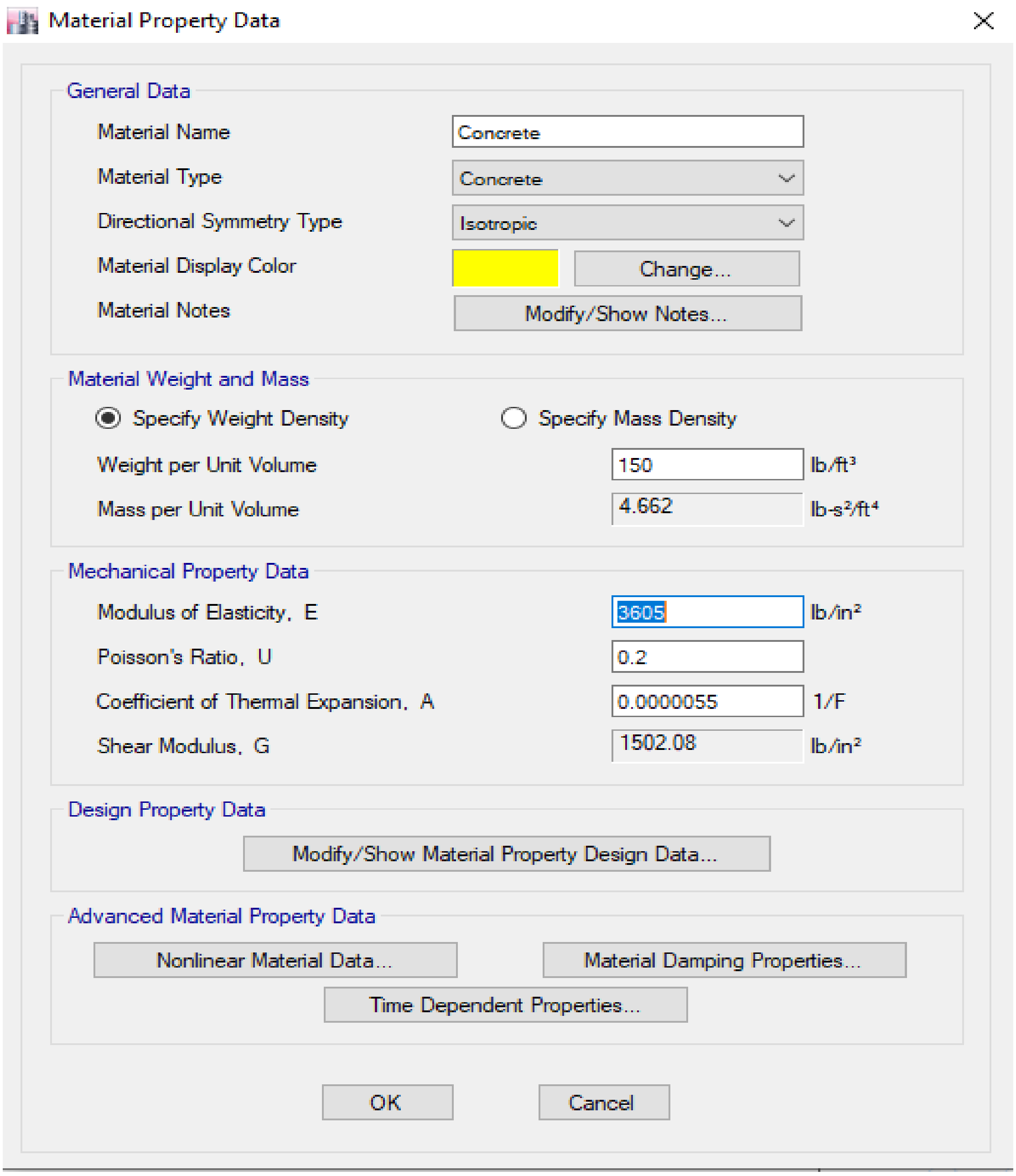
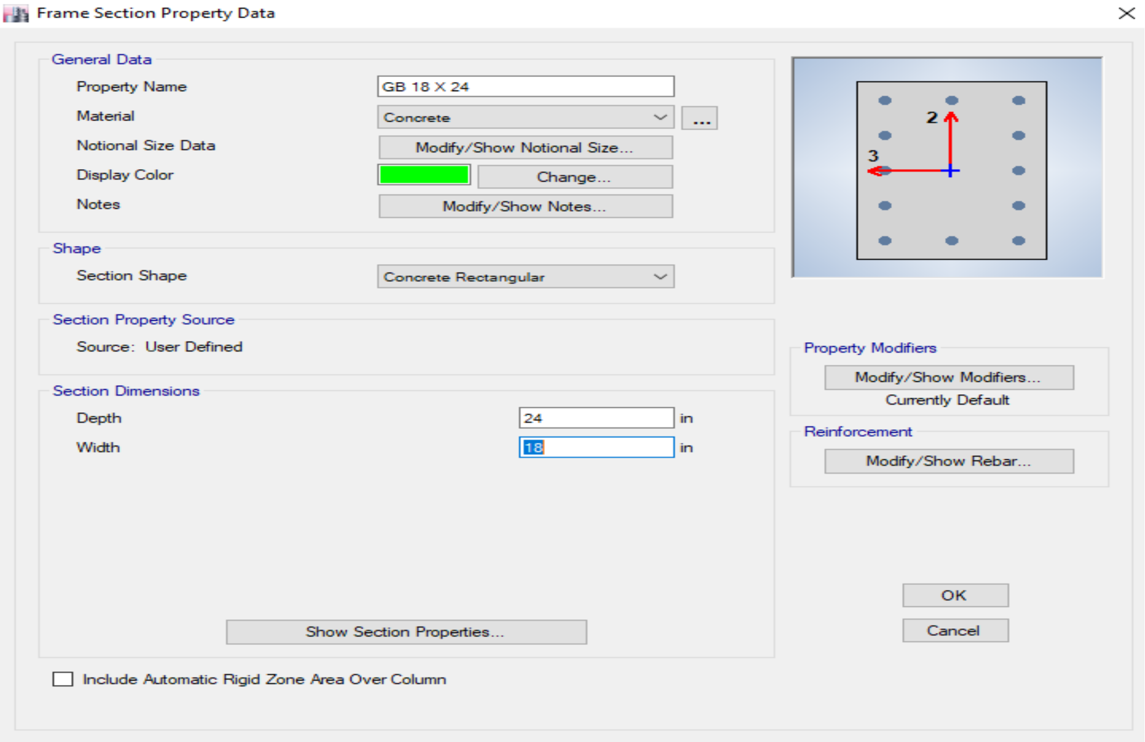


Fig. 4.5: Material properties application



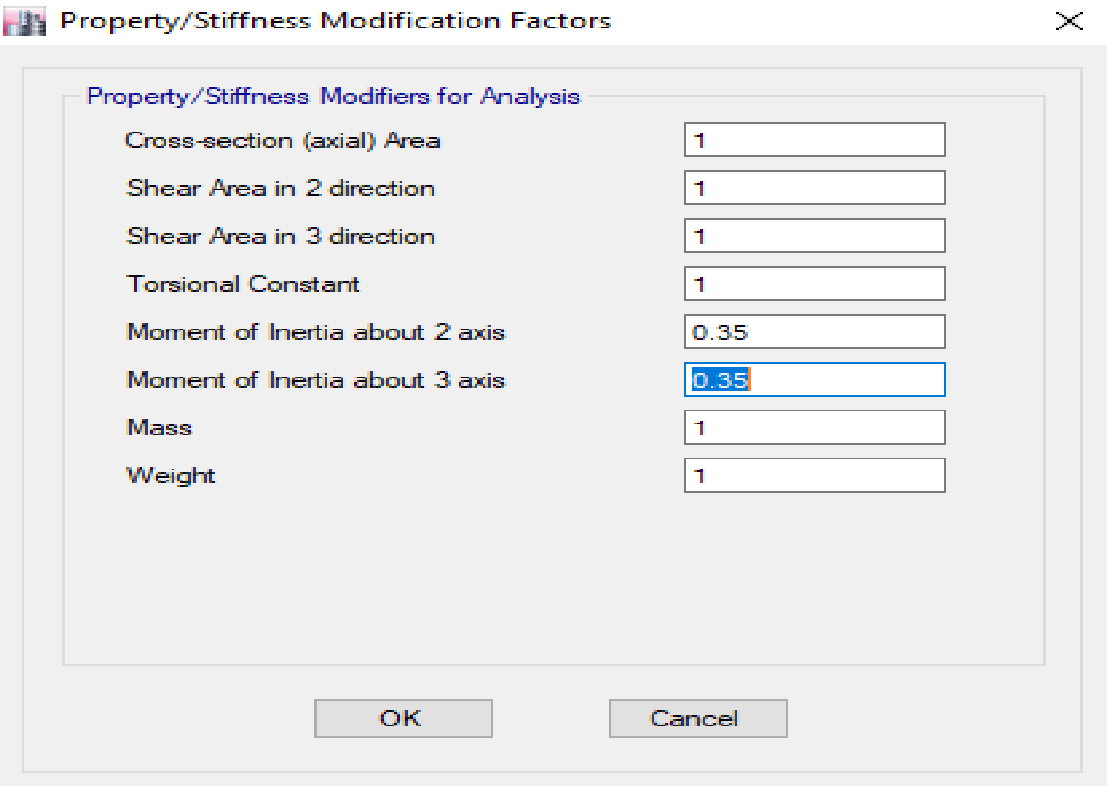


Fig. 4.6: Section properties application

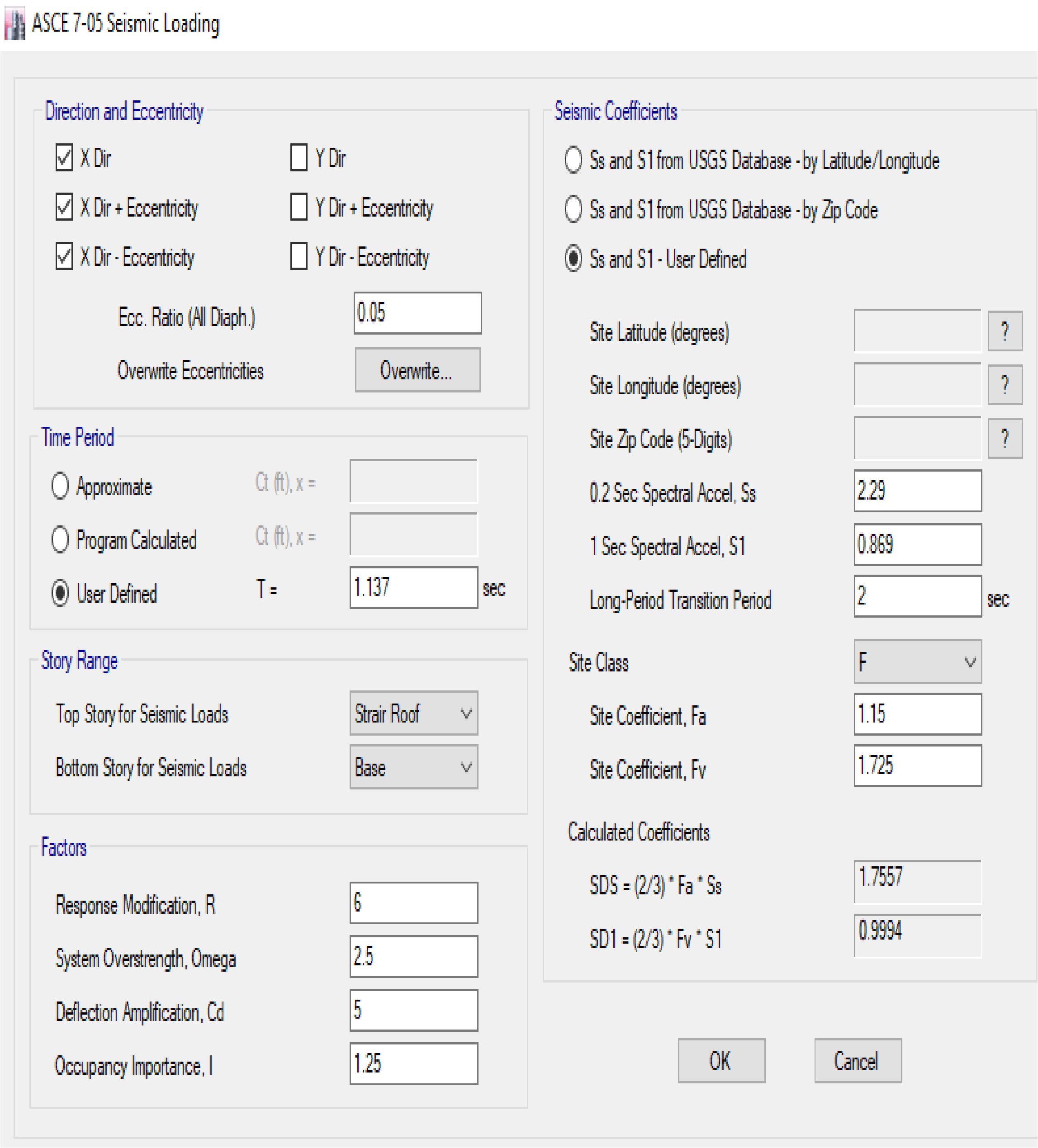


Fig. 4.7: Seismic load application

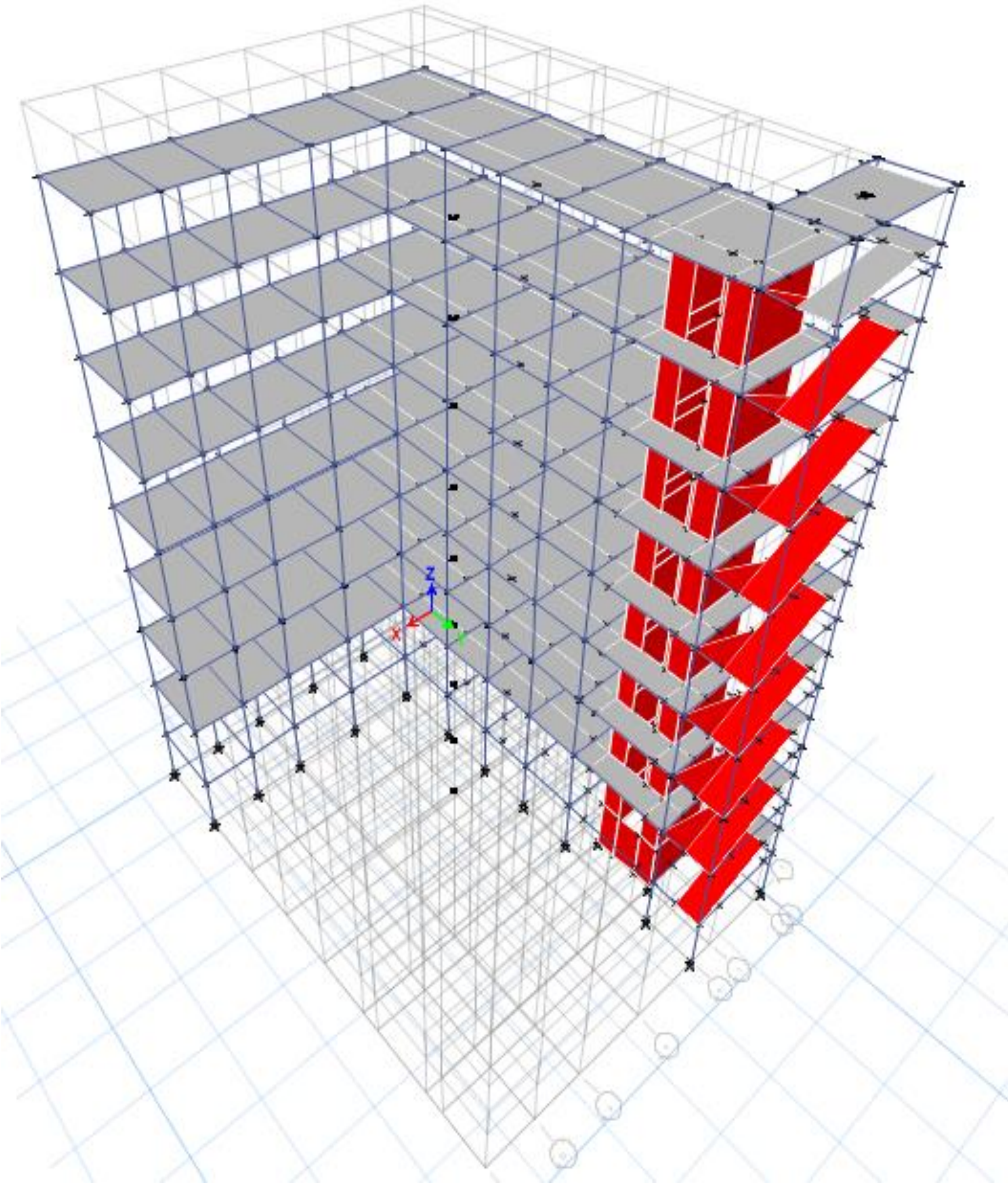


Fig. 4.8: Stair 8 shear wall application

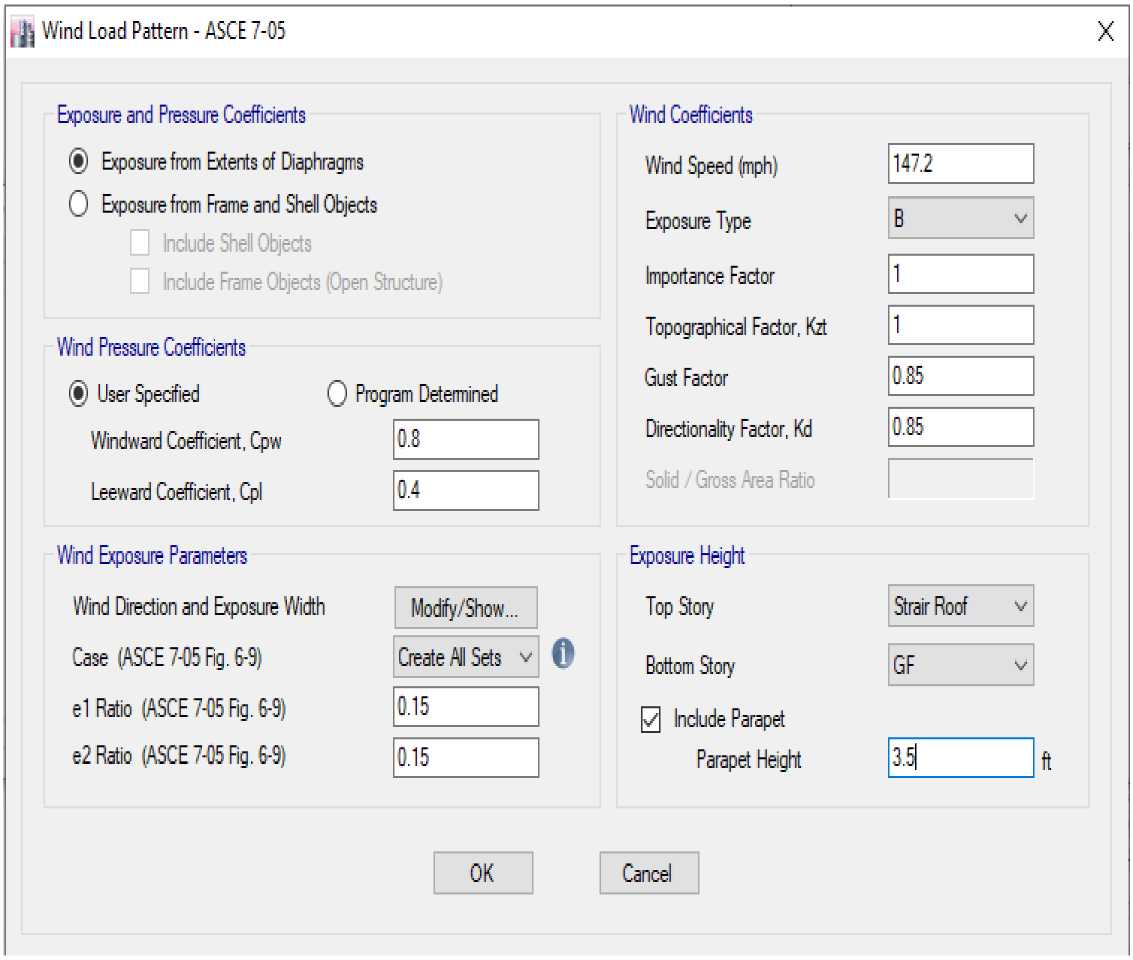


Fig. 4.9: Wind load application

CHAPTER 5

Results and Discussions

Analysis of Residential Building Using (ETABS)

5.1 Maximum storey displacement with lateral load

Table 5.1: Maximum storey displacement with lateral load

SL No.	Storey Name	Displacement (in) X Direction	Displacement (in) Y Direction
01	Base	0.035549	0.0405922
02	GF	0.4062845	0.38677
03	Storey 01	0.45964124	0.433479
04	Storey 02	0.55856177	0.487197
05	Storey 03	0.63744027	0.663551
06	Storey 04	0.75609639	0.722918
07	Storey 05	0.8939405	0.902921
08	Storey 06	0.91030209	1.029475
09	Storey 07	1.10458347	1.08516
10	Roof	1.2017357	1.22842
11	Stair Roof	1.4873883	1.5188425

5.2 Maximum storey displacement without lateral load

Table 5.2: Maximum storey displacement without lateral load

SL No.	Storey Name	Displacement (in) X Direction	Displacement (in) Y Direction
01	Base	0.164664	0.1805922
02	GF	0.2862845	0.23677
03	Storey 01	0.32964124	0.293479
04	Storey 02	0.44856177	0.387197
05	Storey 03	0.55744027	0.478783551
06	Storey 04	0.72609639	0.55878718
07	Storey 05	0.8539405	0.6087502921
08	Storey 06	0.88030209	0.800075
09	Storey 07	1.0258347	1.000816
10	Roof	1.1517357	1.17842
11	Stair Roof	1.2573883	1.288425

5.3 Maximum storey drift with lateral load

Table 5.3: Maximum storey drift with lateral load

SL No.	Storey Name	Drift X Direction	Drift Y Direction
01	Base	0.000062	0.000062
02	GF	0.000411	0.000411
03	Storey 01	0.900283	0.313937
04	Storey 02	0.776782	0.168919
05	Storey 03	1.011913	0.413446
06	Storey 04	0.896125	0.258696
07	Storey 05	0.935099	0.284147
08	Storey 06	0.921427	0.271125
09	Storey 07	1.005739	0.267695
10	Roof	0.584073	0.210082
11	Stair Roof	3.014445	0.518458

5.4 Maximum storey drift without lateral load

Table 5.4: Maximum storey drift without lateral load

SL No.	Storey Name	Drift X Direction	Drift Y Direction
01	Base	0	0
02	GF	0.000015	0.000004
03	Storey 01	0.000041	0.00001
04	Storey 02	0.000069	0.00002
05	Storey 03	0.000136	0.000063
06	Storey 04	0.000175	0.000086
07	Storey 05	0.000208	0.000104
08	Storey 06	0.000231	0.000117
09	Storey 07	0.000251	0.000127
10	Roof	0.000251	0.000121
11	Stair Roof	0	0

5.5 Storey overturning moment with lateral load

Table 5.5: Storey overturning moment with lateral load

SL No.	Storey Name	Overturning moment (kip-in) X Direction	Overturning moment (kip-in) Y Direction
01	Base	136407	-50997
02	GF	129972	-50997
03	Storey 01	116013	-48073
04	Storey 02	97555.610842	-41506
05	Storey 03	80080.786307	-34983
06	Storey 04	62682.801739	-28417
07	Storey 05	46127.85461	-21850
08	Storey 06	30654.019059	-15283
09	Storey 07	16512.832663	-8716.745725
10	Roof	4415.760816	-2152.26892
11	Stair Roof	44.8056	-44.8056

5.6 Storey overturning moment without lateral load

Table 5.6: Storey overturning moment without lateral load

SL No.	Storey Name	Overturning moment (kip-in) X Direction	Overturning moment (kip-in) Y Direction
01	Base	84150.423445	-50997
02	GF	84150.423424	-50997
03	Storey 01	78179.257846	-48073
04	Storey 02	67476.08114	-41506
05	Storey 03	57316.360434	-34983
06	Storey 04	46613.183728	-28417
07	Storey 05	35910.007022	-21850
08	Storey 06	25206.830316	-15283
09	Storey 07	14503.65361	-8716.745725
10	Roof	4248.331304	-2152.26892
11	Stair Roof	345.744	-44.8056

Graphical Representation

5.7 Storey Maximum Displacement

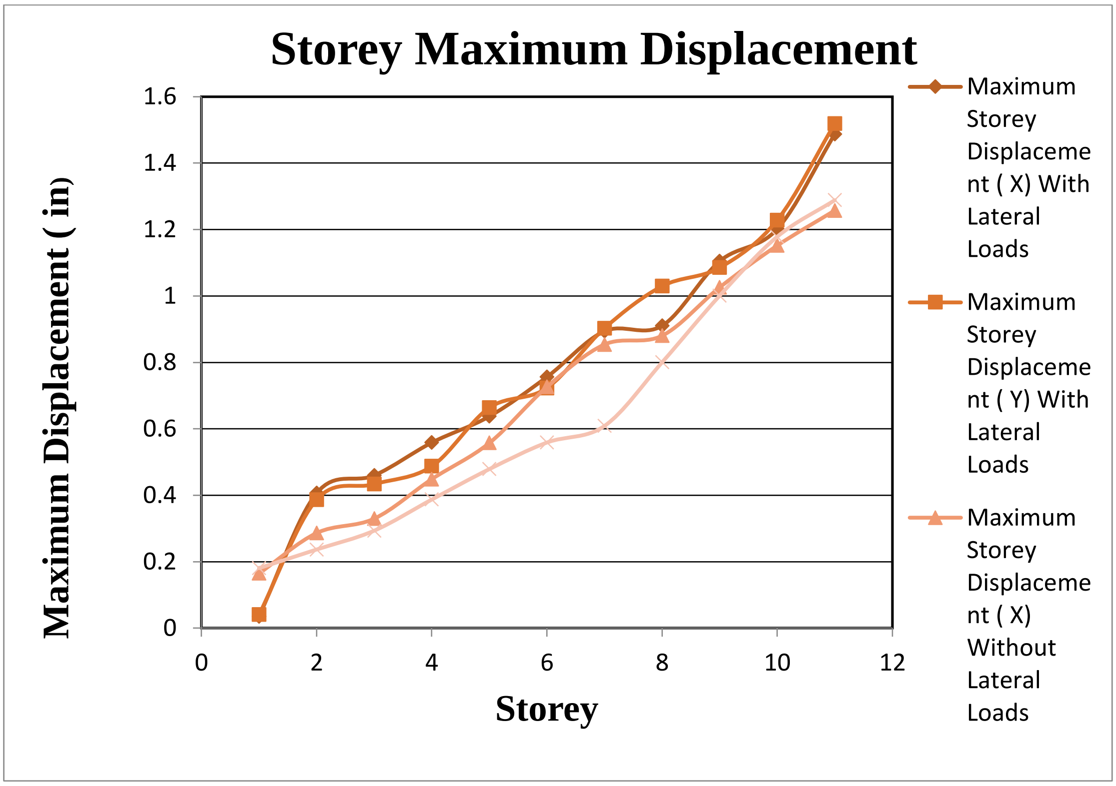


Fig. 5.1: Storey maximum displacement

5.8 Storey Maximum Drift

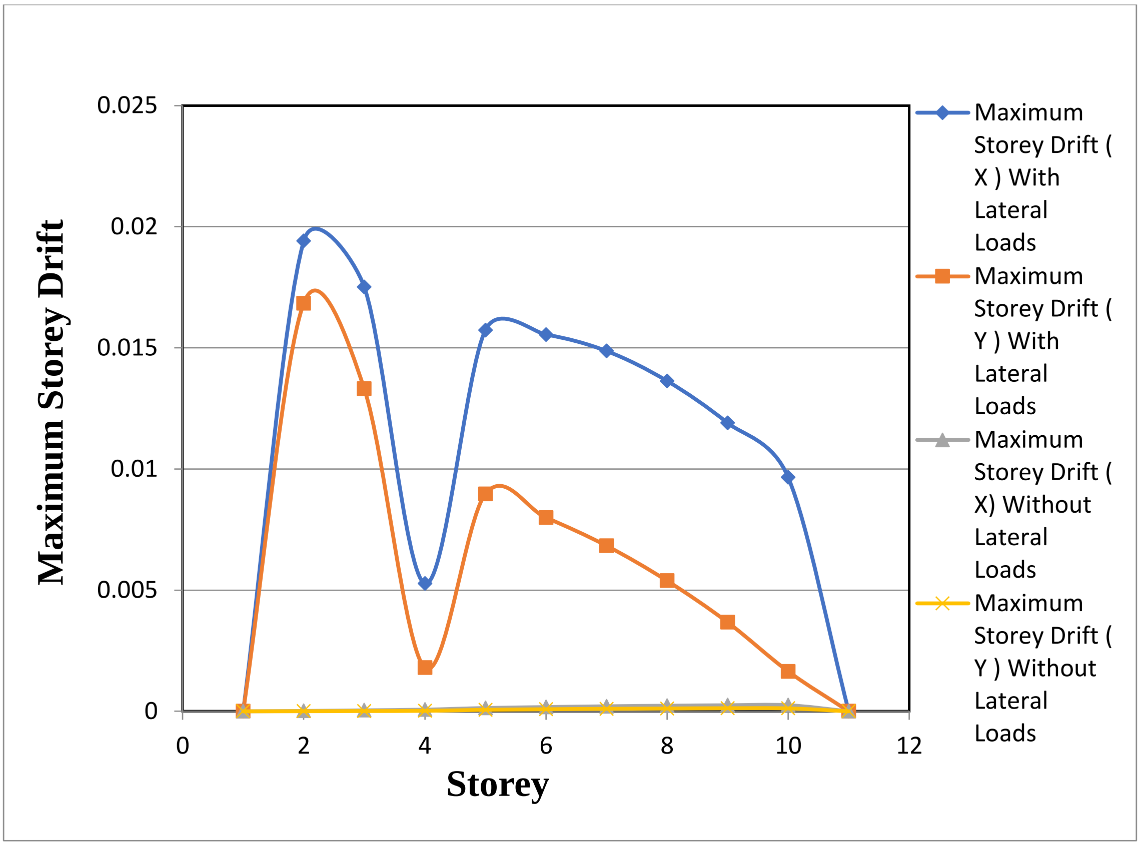


Fig. 5.2: Storey maximum drift

5.9 Storey Overturning Moment

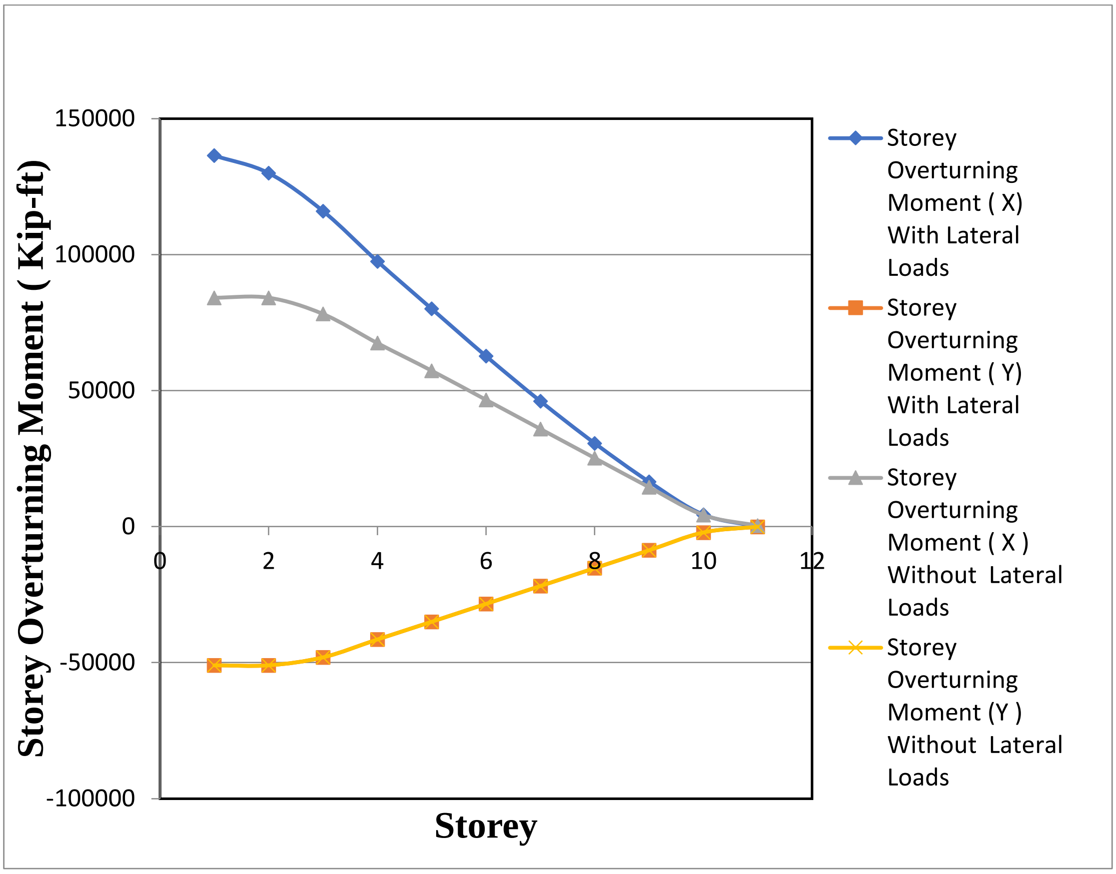


Fig. 5.3: Storey overturning moment

CHAPTER 6

CONCLUTION & RECOMMENDATION

- It has been found that maximum storey displacement is 15.6173 in for roof in X direction and 8.56842 in Y direction for roof with lateral load condition.
- It has been found that maximum storey displacement is 3.014445 in for stair roof in X direction and 0.518458 in Y direction for stair roof without lateral load condition.
- It has been found that maximum storey drift is 0.0194 for ground floor in X direction and 0.0168 Y directions for ground floor with lateral load condition.
- It has been found that maximum storey drift is 0.000251 for storey 7 in X direction and 0.000127 Y directions for storey 7 without lateral load condition.
- It has been found that maximum overturning moment is 136407 kip-in for base in X direction and -50997 kip-in Y direction for base with lateral load condition.
- It has been found that maximum overturning moment is 84150.423445 kip-in for base in X direction and -50997 kip-in direction for base without lateral load condition.
- Maximum storey displacement is found 15.617357 in for roof among X & Y direction.
- Maximum storey drift is found 0.19405 for ground floor among X & Y direction.
- Maximum overturning moment is found 136404 kip-in for base among X & Y direction.
- It has been found that storey displacement, storey drift & overturning moment is maximum between with lateral load and without lateral load.

RECOMMENDATION

- Lateral loads effect on RCC building can be performed by STAAD Pro software.
- Shear force, bending moment and other parameters may be computed by ETABS analysis and hand calculations.

REFERENCES

[1] Based on nonlinear dynamic time-history analyses. The Structural Design of Tall and Special Buildings, 21(4), 233- 248.

[2] UBC-1994

[3] V. Boonyapinyo, N. Choopool, & P. Warnitchai. (2008, October). Seismic Performance Evaluation of Reinforced-Concrete Buildings by Static Pushover and Nonlinear Dynamic Analyses. In The 14th World Conference on Earthquake Engineering October (pp. 12-17).

[4] W. T. Thwin, (2014). Seismic Response Evaluation of Reinforced Concrete Building with Time History Analysis

[5] Abhay Guleria. (Structural Analysis of a Multi-Story Building using ETABS for different Plan Configurations), International Journal of Engineering Research & Technology (IJERT). 2014; 3(5):2278-0181. ISSN: IJERTV3IS051552.

[6] Atol Vancouver, B.C World Conference on Earthquake Engineering, Vancouver, B.C, Canada August 1-6, 2004.

[7] A. M. Memari, A.Y. Motlagh, A. Scanlon. Seismic evaluation of an existing reinforced concrete framed tube building based on inelastic dynamic analysis. Engineering structures. 2000 Jun 30; 22(6):621-37.

[8] A. Alchalbi. (2000). Seismic evaluation & dynamic response analysis for existing reinforced concrete building. Individual studies by participants to the International Institute of Seismology and Earthquake Engineering, 36, 303-314.

Appendix A

Table 6.1: Response Reduction Factor, Deflection Amplification Factor and Height Limitations for Different Structural Systems

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
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
6. Ordinary reinforced concrete moment frames	3	3	2.5	NL	NP	NP
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

Table 6.2: Weight of Materials & Construction

Material / Component / Member	Weight per Unit Area (kN/m²)
Floor	
Asphalt, 25 mm thick	0.526
Clay tiling, 13 mm thick	0.268
Concrete slab (stone aggregate)*:	
solid, 100 mm thick	2.360
solid, 150 mm thick	3.540
Galvanized steel floor deck (excl. topping)	0.147-0.383
Magnesium oxychloride:	
normal (sawdust filler), 25 mm thick	0.345
heavy duty (mineral filler), 25 mm thick	0.527
Terrazzo paving 16 mm thick	0.431
Roof	
Acrylic resin sheet, corrugated:	
3 mm thick, standard corrugations	0.043
3 mm thick, deep corrugations	0.062
Aluminium, corrugated sheeting:	
(incl. lap and fastenings)	
1.2 mm thick	0.048
0.8 mm thick	0.028
0.6 mm thick	0.024
Aluminium sheet(plain):	
1.2 mm thick	0.033
1.0 mm thick	0.024
0.8 mm thick	0.019
Bituminous felt (5 ply) and gravel	0.431
Slates:	
4.7 mm thick	0.335
9.5 mm thick	0.671
Steel sheet, flat galvanized:	
1.00 mm thick	0.082
0.80 mm thick	0.067
0.60 mm thick	0.053
Steel, galvanized std. corrugated sheeting:	
(incl. lap and fastenings)	
1.0 mm thick	0.120
0.8 mm thick	0.096
0.6 mm thick	0.077
Tiles :	
terra-cotta tiles (French pattern)	0.575
concrete , 25 mm thick	0.527
clay tiles	0.6-0.9

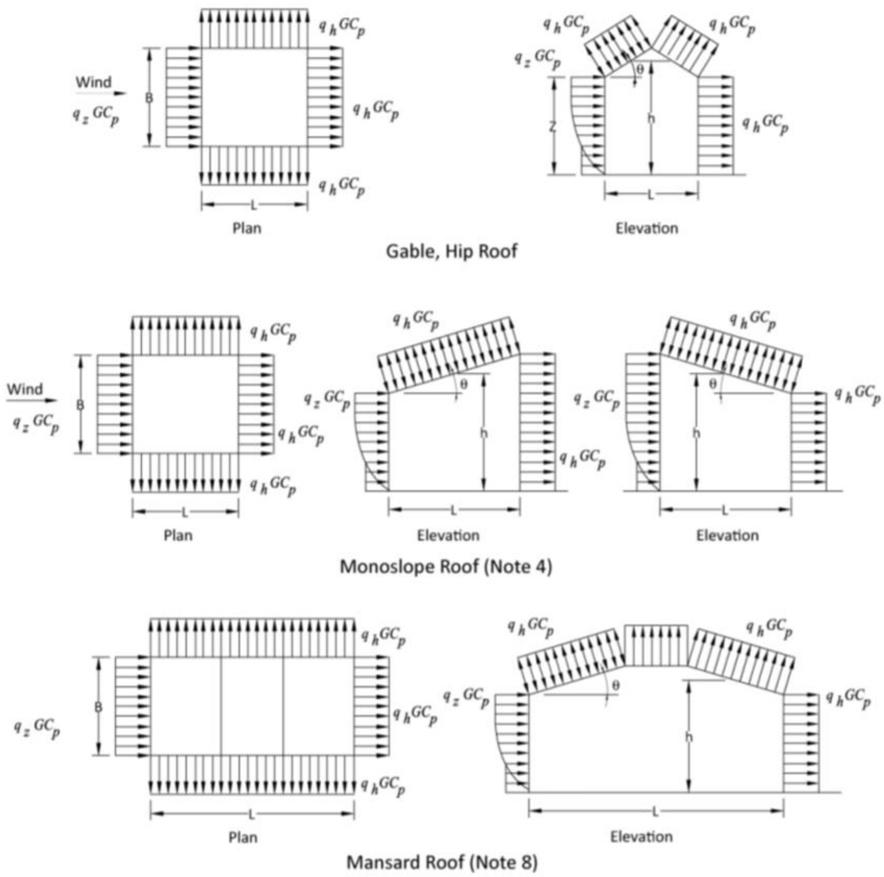
Material / Component / Member	Weight per Unit Area (kN/m²)
Walls and Partitions	
Acrylic resin sheet, flat, per mm thickness	0.012
Asbestos cement sheeting:	
4.5 mm thick	0.072
6.0 mm thick	0.106
Brick masonry work, excl. plaster:	
burnt clay, per 100 mm thickness	1.910
sand-lime, per 100 mm thickness	1.980
Concrete (stone aggregate)*:	
100 mm thick	2.360
150 mm thick	3.540
250 mm thick	5.900
Fibre insulation board, per 10 mm thickness	0.034
Fibrous plaster board, per 10 mm thickness	0.092
Glass, per 10 mm thickness	0.269
Hardboard, per 10 mm thickness	0.961
Particle or flake board, per 10 mm thickness	0.075
Plaster board, per 10 mm thickness	0.092
Plywood, per 10 mm thickness	0.061
Ceiling	
Fibrous plaster, 10 mm thick	0.081
Cement plaster, 13 mm thick	0.287
Suspended metal lath and plaster	0.480
(two faced incl. studding)	
Miscellaneous	
Felt (insulating), per 10 mm thickness	0.019
Plaster:	
Cement plaster, per 10 mm thickness	0.230
Lime plaster, per 10 mm thickness	0.191
PVC sheet, per 10 mm thickness	0.153
Rubber paving, per 10 mm thickness	0.151
Terra-cotta Hollow Block Masonry:	
75 mm thick	0.671
100 mm thick	0.995
150 mm thick	1.388

Table 6.3: Minimum Uniformly Distributed and Concentrated Live Loads

Occupancy or Use	Uniform kN/m²	Concentrated kN
Apartments (see Residential)		
Access floor systems		
Office use	2.40	9.0
Computer use	4.80	9.0
Armories and drill rooms	7.20	--
Assembly areas and theaters		
Fixed seats (fastened to floor)	2.90	--
Lobbies	4.80	--
Movable seats	4.80	--
Platforms (assembly)	4.80	--
Stage floors	7.20	--
Balconies (exterior)	4.80	--
On one- and two-family residences only, and not exceeding 19.3 m²	2.90	--
Bowling alleys, poolrooms, and similar recreational areas	3.60	--
Catwalks for maintenance access	2.00	1.33
Corridors		
First floor	4.80	--
Other floors, same as occupancy served except as indicated		
Dance halls and ballrooms	4.80	--
Decks (patio and roof)	Same as area served, or for the type of occupancy accommodated	
Dining rooms and restaurants	4.80	--
Dwellings (see *Residential*)	--	
Elevator machine room grating (on area of 2,580 mm²)	--	1.33
Finish light floor plate construction (on area of 645 mm²)	--	0.90
Fire escapes	4.80	--
On single-family dwellings only	2.00	--
Fixed ladders	See Sec 2.3.11	
Garages (passenger vehicles only), Trucks and buses	$2.0^{b,c}$	
Grandstands	See *Stadiums and arenas, Bleachers*	
Gymnasiums—main floors and balconies	4.80	--
Handrails, guardrails, and grab bars	See Sec 2.3.11	
Hospitals		
Operating rooms, laboratories	2.90	4.50
Patient rooms	2.00	4.50
Corridors above first floor	3.80	4.50
Hotels	See *Residential*	
Libraries		
Reading rooms	2.90	4.50
Stack rooms	7.20^{d}	4.50
Corridors above first floor	3.80	4.50

Table 6.4: Internal pressure coefficient, GCpi main wind force resistingsystem component and cladding - Method 2 (All Heights)

Enclosed, Partially Enclosed Buildings: Walls & Roofs



Wall Pressure Coefficients, C_p			
Surface	L/B	C_p	Use With
Windward Wall	All values	0.8	q_z
Leeward Wall	0-1	-0.5	q_h
	2	-0.3	
	≥ 4	-0.2	
Side Wall	All values	-0.7	q_h

Table 6.5: Site Classification Based on Soil Properties

Site Class	Description of soil profile up to 30 meters depth	Average Soil Properties in top 30 meters		
		Shear wave velocity, $\overline{V}_s$ (m/s)	SPT Value, $\overline{N}$ (blows/30cm)	Undrained shear strength, $\overline{S}_u$ (kPa)
SA	Rock or other rock-like geological formation, including at most 5 m of weaker material at the surface.	> 800	--	--
SB	Deposits of very dense sand, gravel, or very stiff clay, at least several tens of metres in thickness, characterised by a gradual increase of mechanical properties with depth.	360 – 800	> 50	> 250
SC	Deep deposits of dense or medium dense sand, gravel or stiff clay with thickness from several tens to many hundreds of metres.	180 – 360	15 - 50	70 - 250
SD	Deposits of loose-to-medium cohesionless soil (with or without some soft cohesive layers), or of predominantly soft-to-firm cohesive soil.	< 180	< 15	< 70
SE	A soil profile consisting of a surface alluvium layer with V_s values of type SC or SD and thickness varying between about 5 m and 20 m, underlain by stiffer material with V_s > 800 m/s.	--	--	--
S_1	Deposits consisting, or containing a layer at least 10 m thick, of soft clays/silts with a high plasticity index (PI > 40) and high water content	< 100 (indicative)	--	10 - 20
S_2	Deposits of liquefiable soils, of sensitive clays, or any other soil profile not included in types SA to SE or S_1	--	--	--

Table 6.6 Description of Seismic Zones

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 6.7: Seismic Zone Coefficient Z for Some Important Towns of Bangladesh

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		

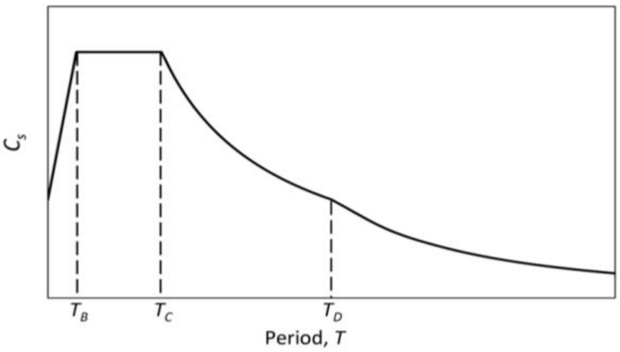


Fig. 6.4: Typical shape of the elastic response spectrum coefficient Cs

Table 6.8: Description of different site zones

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

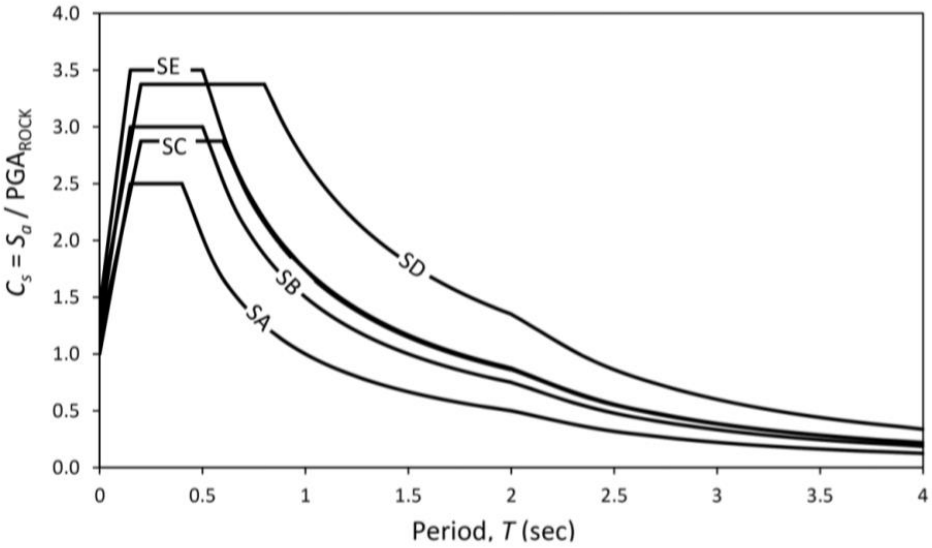


Fig. 6.5: Normalized design acceleration response spectrum for different site classes.

Appendix B

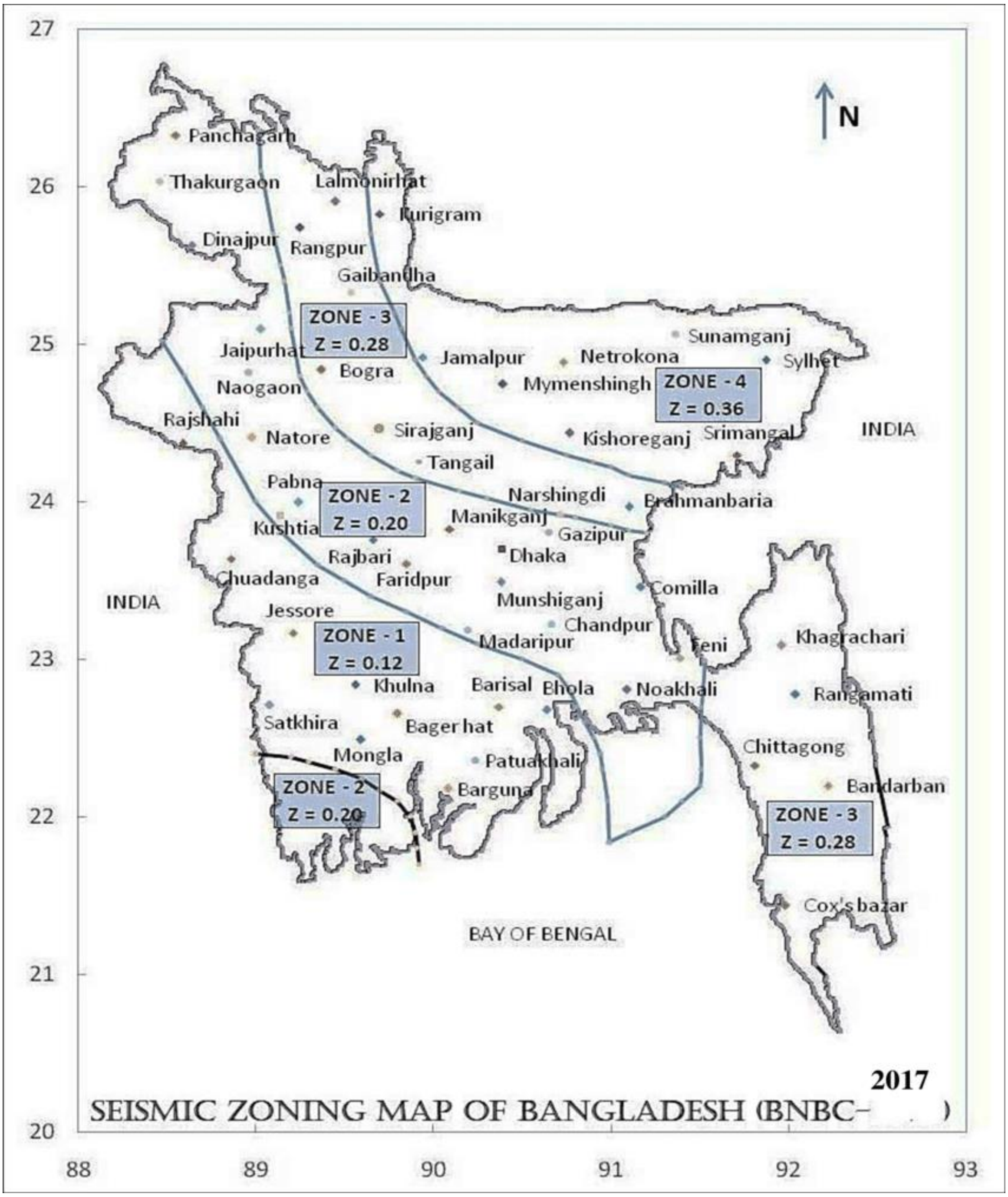
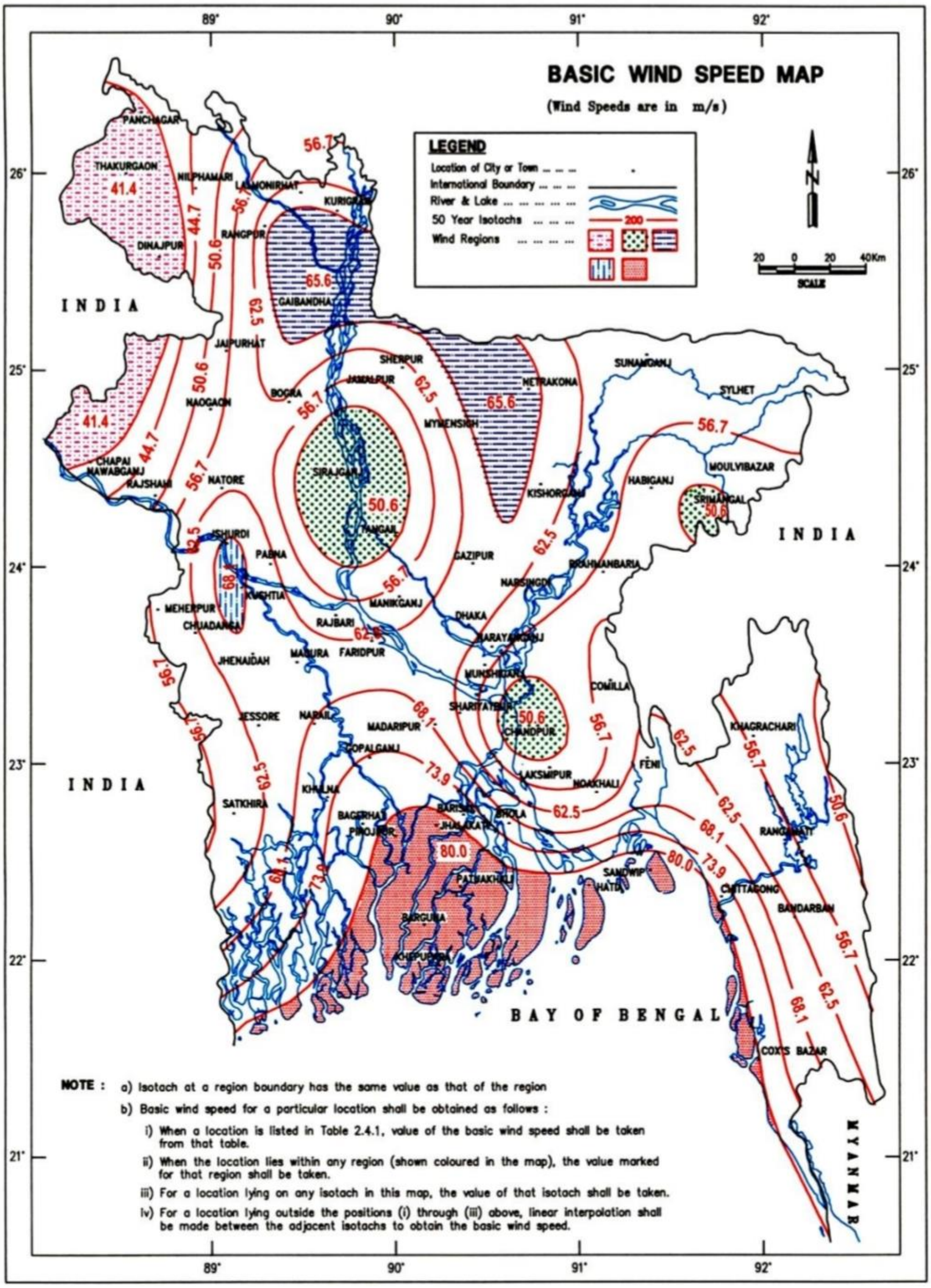


Fig. 6.1: Map



BASIC WIND SPEED MAP
(Wind Speeds are in m/s)
LEGEND
Location of City or Town
International Boundary
River & Lake
50 Year Isotachs
200
Wind Regions
20 0 20 40Km
SCALE
INDIA
BAY OF BENGAL
MYANMAR
PANCHAGAR
THAKURGAON
NILPHAMARI
LALMONIRHAT
KURIGRAM
DINAJPUR
RANGPUR
GAIBANDHA
JAIPURHAT
SHERPUR
JAMALPUR
NETRAKONA
SUNAMGANJ
SYLHET
BOGRA
NAOGAON
MYMENSINGH
CHAPAI NAWABGANJ
RAJSHAHI
NATORE
SIRAJGANJ
MOULVIBAZAR
HABIGANJ
KISHORGANJ
SRIMANGAL
ISHURDI
PABNA
TANGAIL
GAZIPUR
BRAHMANBARIA
NARSINGDI
MEHERPUR
KUSHTIA
CHUADANGA
MANIKGANJ
RAJBARI
DHAKA
NARAYANGANJ
JHENAIDAH
MAGURA
FARIDPUR
MUNSHIGANJ
COMILLA
JESSORE
NARAIL
MADARIPUR
SHARIATPUR
CHANDPUR
KHAGRACHARI
GOPALGANJ
LAKSMIPUR
NOAKHALI
FENI
SATKHIRA
KHULNA
BAGERHAT
PIROJPUR
BARISAL
JHALAKATI
BHOLA
RANGAMATI
SANDWIP
HATIA
CHITTAGONG
PATUAKHALI
BANDARBAN
BARGUNA
KHEPUPARA
COX'S BAZAR
41.4
44.7
50.6
56.7
62.5
65.6
68.1
73.9
80.0
NOTE : a) Isotach at a region boundary has the same value as that of the region
b) Basic wind speed for a particular location shall be obtained as follows :
i) When a location is listed in Table 2.4.1, value of the basic wind speed shall be taken from that table.
ii) When the location lies within any region (shown coloured in the map), the value marked for that region shall be taken.
iii) For a location lying on any isotach in this map, the value of that isotach shall be taken.
iv) For a location lying outside the positions (i) through (iii) above, linear interpolation shall be made between the adjacent isotachs to obtain the basic wind speed.

Fig. 6.2: Map

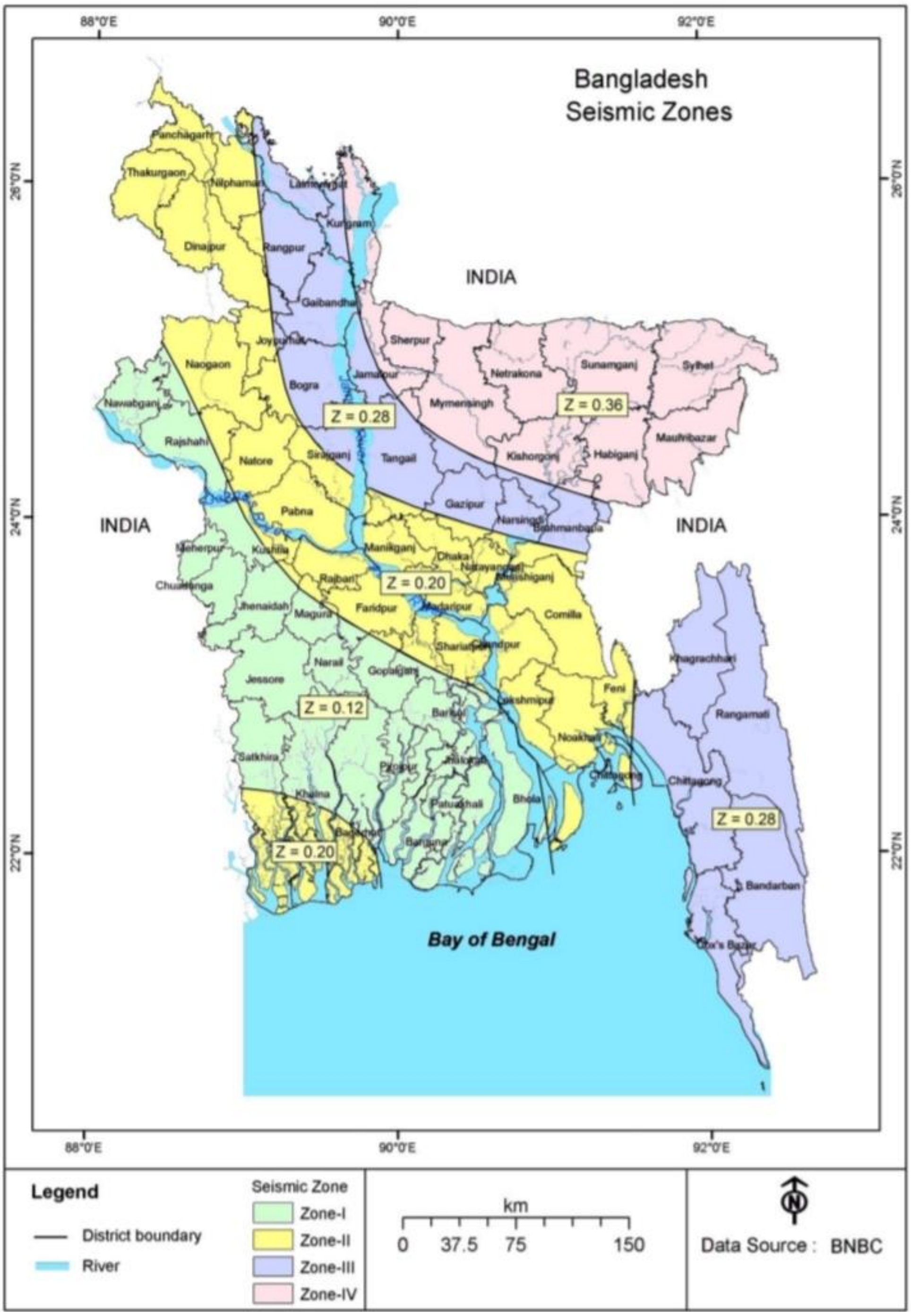

Bangladesh
Seismic Zones
INDIA
INDIA
INDIA
Z = 0.28
Z = 0.36
Z = 0.20
Z = 0.12
Z = 0.20
Z = 0.28
Bay of Bengal
88°0'E
90°0'E
92°0'E
26°0'N
24°0'N
22°0'N
Legend
District boundary
River
Seismic Zone
Zone-I
Zone-II
Zone-III
Zone-IV
km
0 37.5 75 150
Data Source : BNBC

Fig. 6.3: Map

THE END