

SEISMIC RESPONSE EVALUATION OF G+9 RESIDENTIAL
BUILDING IN DIFFERENT SEISMIC ZONES OF BANGLADESH
WITH AND WITHOUT SHEAR WALL ACCORDING TO BNBC
2020

BY

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A thesis submitted to the Department of Civil Engineering of Sonargaon University (SU)
in partial fulfillment for the degree of Bachelor of science in Civil Engineering



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Sonargaon University
147/I Green Road, Dhaka -1215, Bangladesh
Section-26B+27B
Semester: Fall 2025

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BOARD OF EXAMINERS

The Thesis Titled “SEISMIC RESPONSE EVALUATION OF G+9 RESIDENTIAL BUILDING IN DIFFERENT SEISMIC ZONES OF BANGLADESH WITH AND WITHOUT SHEAR WALL ACCORDING TO BNBC 2020” MD. ABUL KALAM AZAD (ID: BCE1903018033), SUMON SHIKDER (ID: CE2203027101), U HLA SHING MARMA (ID: CE2203027012), HABIBUR RAHMAN RAKIB (ID: CE2103024206), MD ALI AKBAR (ID: CE2203027117)

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to
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ABSTRACT

Bangladesh is located in a seismically active region and the ground shakes during an earthquake. As a result, the base of a building experiences movement. Therefore, it is necessary to ensure that structures are adequately designed to resist horizontal loads. By following BNBC guidelines the risk of failure in newly built infrastructure due to wind and earthquake loads can be minimized. According to the latest Bangladesh National Building Code 2020 (BNBC 2020), the country has been divided into four seismic zones: Zone-I (low seismic intensity), Zone-II (moderate), Zone-III (severe) and Zone-IV (very severe). Each zone has a different seismic coefficient. This paper compares seismic zone analysis of a multi-story (G+9) residential building across all four seismic zones, both with and without shear walls. The main objective is to examine how the building responds to earthquakes under the updated seismic zoning and to evaluate the effects of shear wall placement. Four locations representing the four seismic zones are considered: Rajshahi (Zone-I), Dhaka (Zone-II), Rangpur (Zone-III) and Sylhet (Zone-IV). Structural analysis is carried out using ETABS (Extended Three-Dimensional Analysis of Building Systems), focusing on story displacement, drift, stiffness and other key parameters. The results show that incorporating shear walls has a significant effect on building design, reducing displacement and improving overall structural stability.

Keyword: Building framing system, Shear wall, Seismic Zone, Base Shear, Drift, Stiffness, Storey Displacement

NOTATION

BNBC	Bangladesh National Building Code
Z	Seismic Zone
I	Structural Importance
R	Response Factor
T	Time period
V	Base Shear
EQX	Earthquake in X-direction
EQY	Earthquake in Y-direction
WX	Wind in X-direction
WY	Wind in Y-direction
OMRF	Ordinary Moment Resisting Frames
SMRF	Special Moment Resisting Frames
IMRF	Intermediate Moment Resisting Frames

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CHAPTER 1

INTRODUCTION

1.1 General

Bangladesh is a developing country. Our economic is increasing day by day. Our construction arena is progressing with our economic. Some of large constructions are built in this country in a recent era. In spite of construction growth, we need to consider the tectonic geometry of beneath the country.

An earthquake a shaking of the ground caused by the sudden breaking and movement of large sections (tectonic plates) of the earth's rocky outer most crust. The edges of the tectonic plates are marked by faults (or fractures). Most earthquakes occur along the fault lines when the plates slide past each other or collide against each other. Earthquakes can range in size from those that are so weak that they cannot be felt to those violent enough to toss people around and destroy whole cities. Hence, structure in such locations need to be suitably designed and detailed ensure stability, strength and serviceability with acceptable levels of safety under seismic effect.

Bangladesh is positioned at the juncture of several active tectonic plate boundaries. Moreover, it sits a top of the world's largest river delta at close to sea level, facing both the risk posed by a quake and secondary risks of tsunamis and flooding in the quake's aftermath (Seeber, 2012). Tectonic framework of Bangladesh and adjoining areas indicate that Bangladesh is suited adjacent to the plate margins of India and Eurasia where devastating earthquakes have occurred in the past. Bangladesh is surrounded by a number of tectonic blocks which have produced earthquakes in recent times. The present generation of people in Bangladesh hasn't witnessed any major earthquake. During the last seven or eight years, the occurrence and damage caused by some earthquakes (magnitude between 4 and 6) inside the country or near the countries border, has raised the awareness among the general people and the government as well. However, occurrences of the earthquake both inside and the of the country and around major cities indicate that earthquake hazard exists for the country in general and the cities in particular. Considerations of earthquakes forces in structural design, city planning and infrastructure development is therefore a perquisite for future disaster mitigation (American Museum of Natural History, 2013). Geographically Bangladesh is located close to the two

seduction zones created by two active tectonic plates: the Indian plate and the Eurasian plate. Moreover, the country's surrounded by the Himalayan Arc, the Shillong Plateau and the Dauki fault system in the north, the Burmese Arc and Arkan Yoma Anticlinorium in the east, and the Naga Disa nng Haflong thrust zone in the northeast (Ali M.H, 1998). The capital city in vulnerable to the earthquake as the country is in an active region in terms of vertical and horizontal movement of tremor.

1.2 Background of the study

Bangladesh is an earthquake prone country. So, all building must be earthquake resistant with proper planning and structural design. In BNBC 2006, the total area of the Bangladesh has been divided into three earthquake zones such as Zone-I, Zone-II and Zone-III. According to probable magnitudes of earthquake, Bangladesh has been divided into four seismic zones, namely major damage zone, moderate zone, minor zone and negligible zone (BNBC, 2020). But based on the severity of the probable intensity of the seismic ground motion and damages, Bangladesh has divided into four seismic zones i.e. Zone - 1, Zone - 2, Zone - 3 and Zone - 4.

Several studies have been carried out on seismic action in various aspects by different researches. But very few studies have been carried out on shear wall locations effects due to seismic load in Bangladesh. The seismic risk and construction cost of a same building analyzed and designed for different zones in Bangladesh followed by BNBC,1993 (Choudhury J.R, 1993) [3]. Very limited of studies have been done on this aspect. It needs to be explored to design earthquake resistant building and find out the required quantity of materials for four seismic zones in Bangladesh.

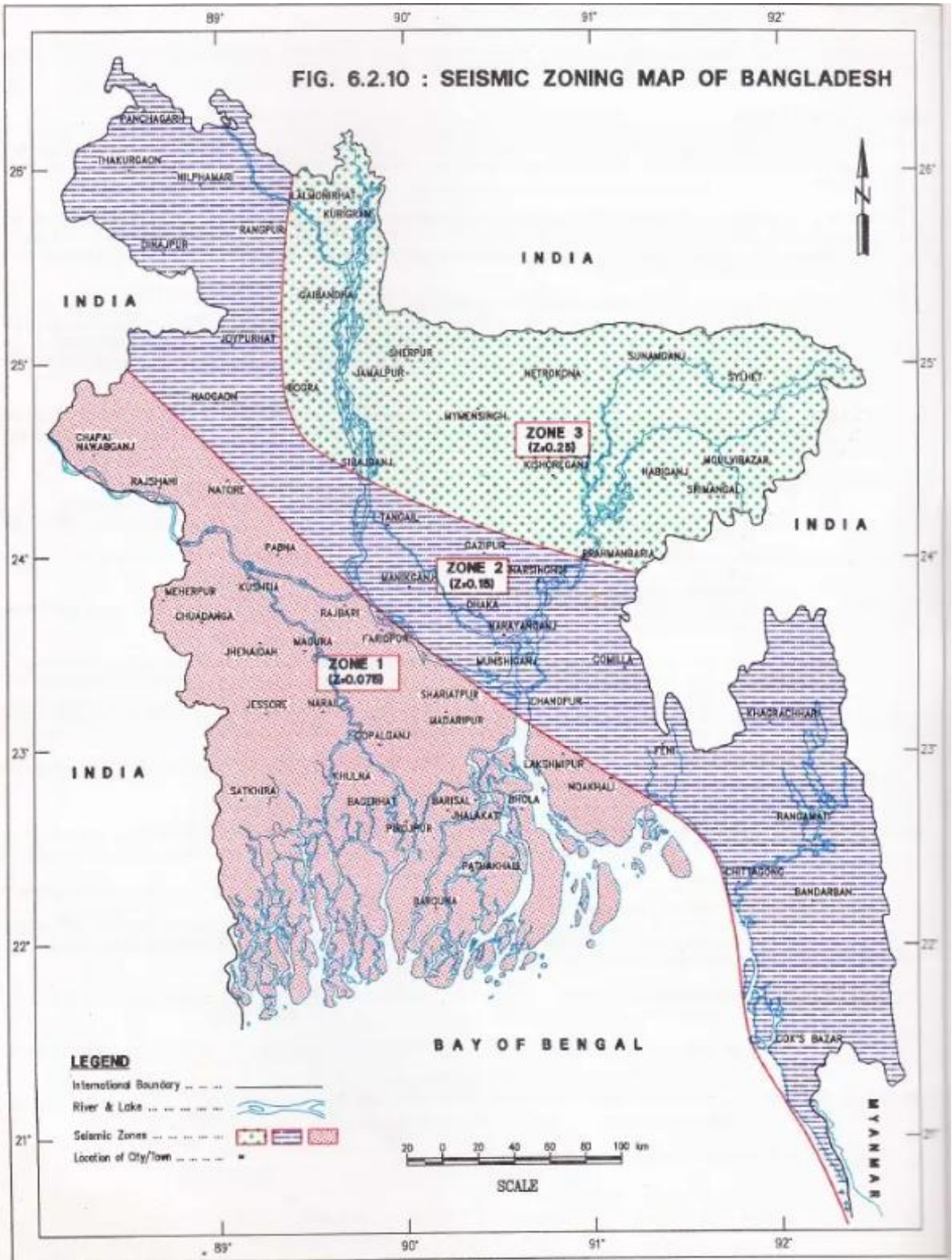


Figure 1.1 : Seismic Zoning map BNBC 2006

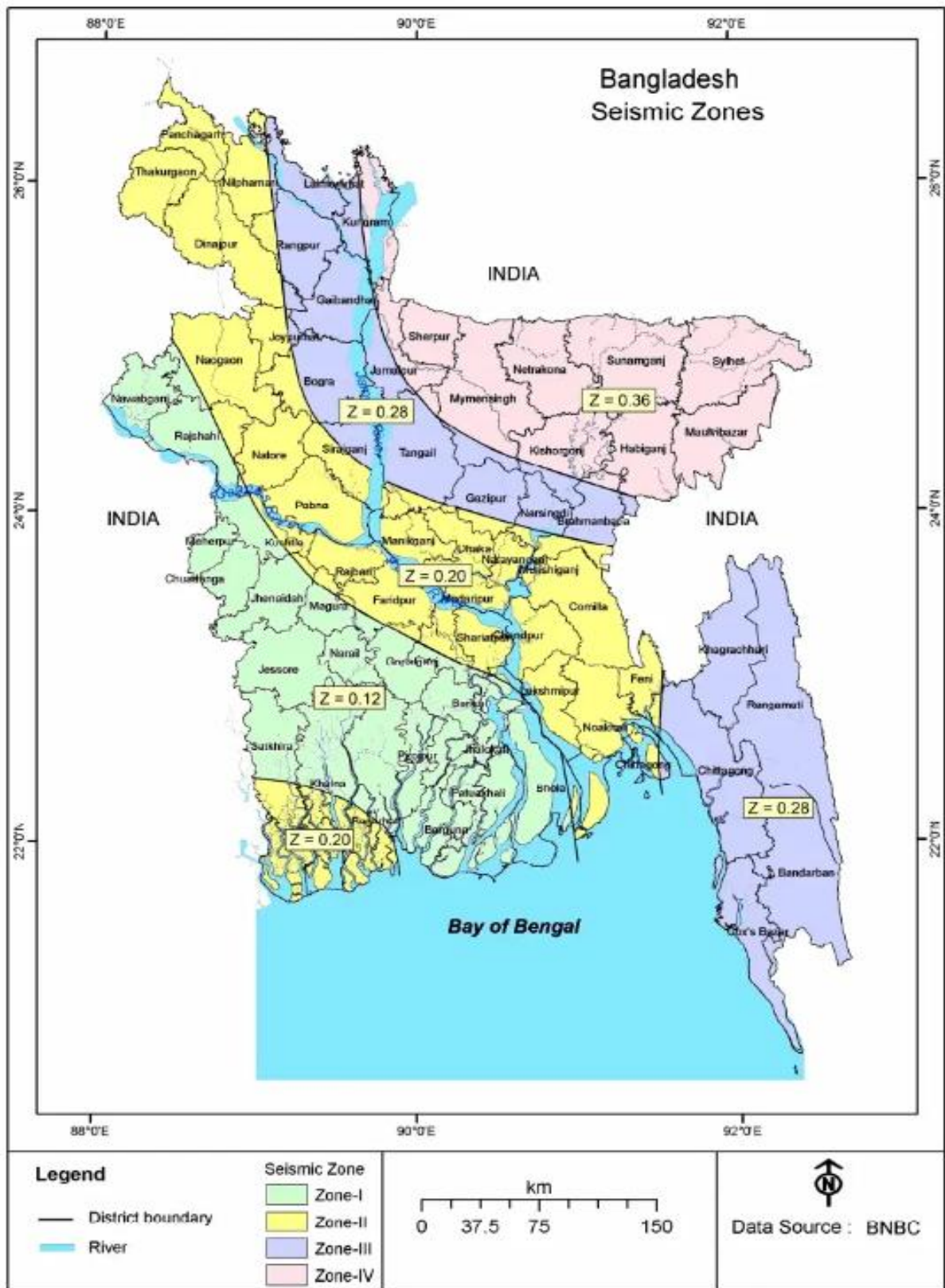


Figure 1.2 : Seismic Zoning map BNBC 2020

1.3 Objectives of the study

This research work is aimed at the overall study of the effects of the seismic zones on the high-rise buildings with or without the shear walls. These things lead to the following specific objectives:

- (i) To identify the effects of the zones co-efficient on the high-rise buildings in parameters with and without shear wall.

1.4 Outline of the study

This study has been conducted by considering approximately 3200 square feet (80ft x 40ft) layout plan of intermediate dual framing concrete structures. For structural analysis and design of this building under seismic considerations frame will consider as an intermediate reinforced concrete structure (dual system). Elevation of the building is considered G+9 that means ten (10) storied building. The structure will firstly analysis without shear walls i.e. column supported structure in the four seismic zones. Then the same structure will introduce with shear wall only in the lift core area in the four seismic zones then the parameters like drift ratio, stiffness, displacement will be considered of the structure. Again, the same structure will analysis with the shear wall in the outer periphery area and the effects will be record and finally will compare the results among the structured considered the location of the shear wall and the seismic zones. Architectural drawing and detailing will prepare by Auto CAD. Structural analysis and design of this structural will be carried out by ETABS 2016 software. Structural drawing and seismic detailing also will be prepared by Auto CAD. MS Excel will be used to find out the analysis results. Comparative study will be carried on the structural frames such as beams and columns, shear walls among four seismic zones. All of this comparison will be presented graphically.

CHAPTER 2

LITERATURE REVIEW

2.1 General

Bangladesh is a moderately seismic region. It is a known fact that earthquakes do not occur just anywhere. It tends to cluster around defined areas or lines. Bangladesh and its adjoining areas are situated in the northeast part of the Indian subcontinent where earthquakes frequently occur. This region lies along the border of Eurasian and Indo-Australian plates. The Plate Tectonic theory states that the earth's crust is composed of plates which move relative to one another because of natural forces acting on these plates. Ninety percent earthquakes occur along the boundary of these tectonic plates. Earthquake also occurs due to volcanic eruption, manmade activities such as reservoir induced, excavation; mining etc. This chapter reviews the seismic environment prevailing in Bangladesh as a part of the evaluation of seismic risk. Important tectonic features of Bangladesh and evolution of seismic zoning maps are also discussed. Short description of some historical earthquakes and some recent earthquakes are also presented. Structural system, seismic design philosophy, seismic detailing and seismic effect reduction technology are also discussed here.

2.2 Literature Review

Several studies have been carried out on seismic action in various aspects by different researches. But very few studies have been carried out on shear wall's location effects due to seismic load in Bangladesh. The seismic risk and construction cost of a same building analyzed and designed (Rahman, 2011) for different zones in Bangladesh followed by Bangladesh National Building Code (BNBC, 1993). Bangladesh has divided into four seismic zones according to BNBC - 2020 which was only three zones in previous BNBC. Present study will be carried out for a comparative study on effects of the shear location in the same structure for four seismic zones in Bangladesh will be followed by BNBC - 2020. Very limited of studies have been done on this aspect. It is helpful to an engineer to know the difference for a same structure in different seismic zones. Various researches carried out on seismic action are given below: (Huang, 2005) carried out research for seismic loss estimation for Sylhet city. Objective of the study was improving our understanding of seismic risk and supporting enforcement of

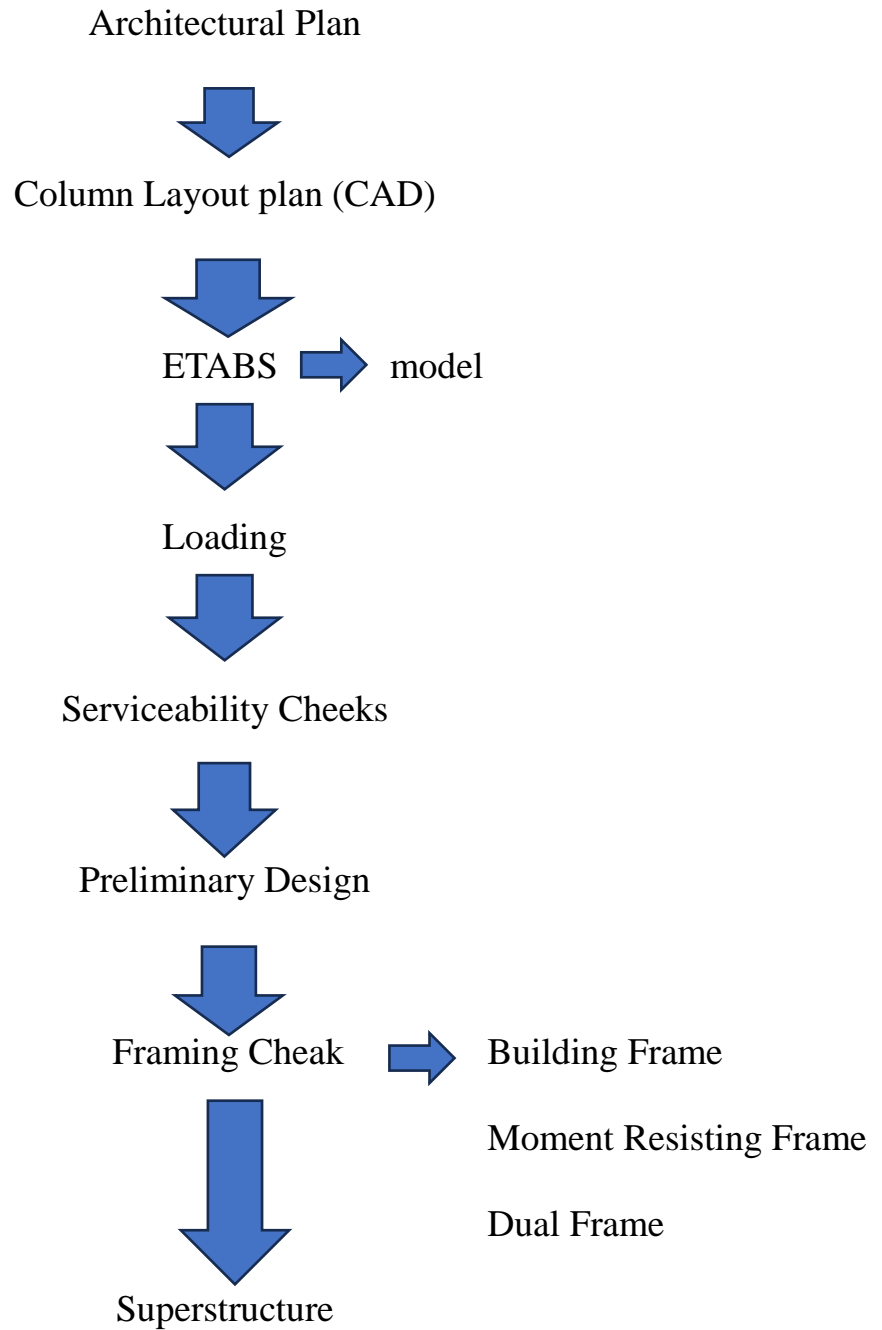
seismic provisions of building codes. (Haque, 2007), carried out a relationship between earthquake intensity and attenuation for Bangladesh and its surrounding area. The objective of this study was to find out re-estimate the earthquake intensity of major historical earthquake of Bangladesh on EMS and develop a relationship between intensity - attenuation for Bangladesh and its surrounding area. (Sharifuddin, 2001), conducted research work on earthquake hazards analysis for Bangladesh. The objective of the research work was to develop a homogeneous and complete earthquake catalogue and seismic hazard map.

To do this work, we first need an architectural plan. To design a building, which is what we need first, then we need to plan our column layout using CAD software. We need to arrange our layout plan correctly, where the axes are given in the correct size. Then we need to arrange our design software ETABS to model. One thing to keep in mind here is that no dimension is wrong. We have to apply loads according to BNBC 2020, where the self-load, dead load, live load, floor finish, wind load, earthquake load, and load combinations will be applied accordingly. Once the loads are applied properly, we will go to the serviceability check, after which the initial design will come. Everything we have done so far is under the scope of statistical analysis. After that, we have to think about the frame. We have talked about frames in BNBC, which is known as frame check. You cannot give all types of frames anywhere you want. The earthquake intensity in all areas is not the same, so BNBC Bangladesh has four zones. The frame will come from the seismic design category, then the final design will come. So far, the superstructure design part will be completed. BNBC has given us many checks. The purpose is to check how resilient the building is to earthquakes. Its impact is visible in our country. Its impact is constantly increasing. I wanted to show how stable a building is under a zone. Now, while showing it, I have had to use many parameters in the design, which is according to the code of Bangladesh. So, I think that considering the current situation, people's lives are at risk, using earthquake-resistant building design and technology will get rid of the risk.

If we consider the perspective of Bangladesh, we will see that some areas of Dhaka and Sylhet are earthquake zones where the building design will have to be done with special moment resisting frames. The cost of constructing the building will be much higher than other buildings, about one and a half times more, and we will have to design it properly keeping in mind the effects of earthquakes according to the design of the country.

CHAPTER 3

METHODOLOGY



3.1 Introduction

This chapter includes the design procedure of the structure at different seismic zones in the Bangladesh with a specific plan of a structure. The structure will analyze according to BNBC (Bangladesh National Building Code) 2020 gazette version of the building code in the Bangladesh. In the analyze we will follow the coefficients of wind effects and obviously earthquake factors depending on the height and zones coefficients

3.2 Plan and Story of the Structure

In this study we have chosen a typical building structure plan for analyze. The plan is regular shape and the plan consists of approximately 3616 square feet area. The plan contains a ground floor plan for using parking and other floor are typical for living. The story of the structure is considering as high-rise building of ten (10) storied as we mention it (G+9) storied building. The typical plan is shown following. Unit A=1116sft, Unit B=1023sft, Unit C =1023sft, common space= 454sft



Figure 3.1 : Typical floor plan

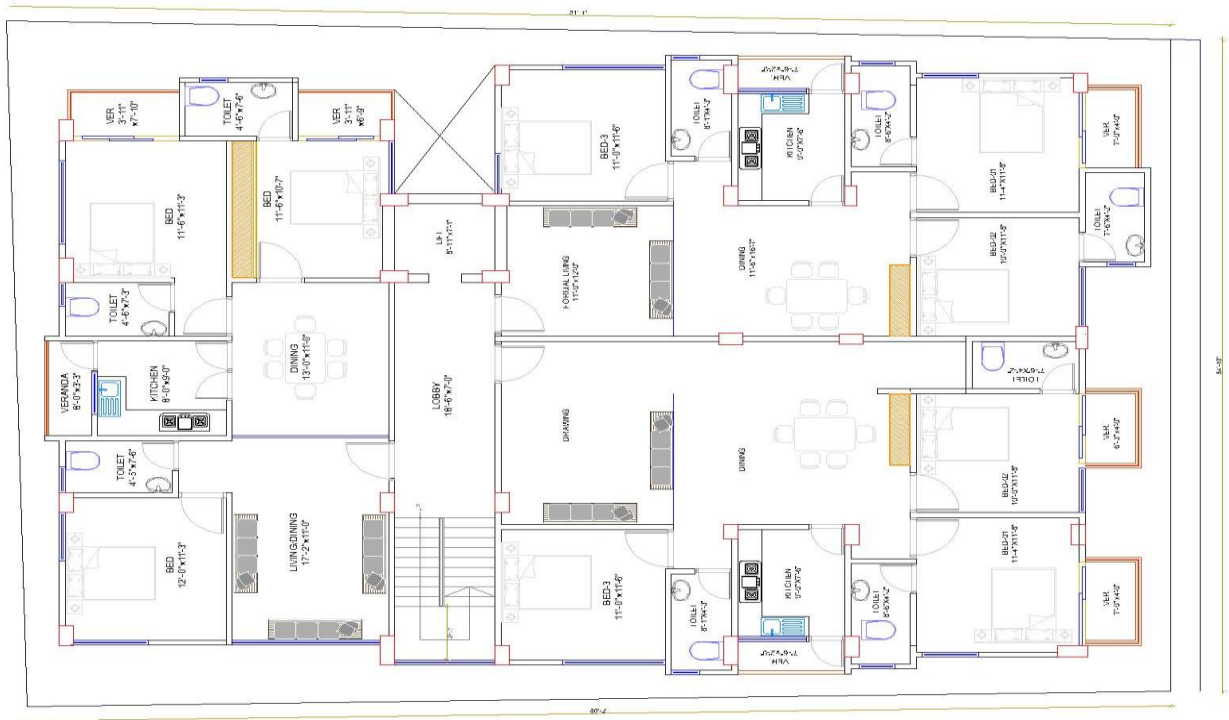


Figure 3.3 : No shear wall in the lift core, stair case and other corner

3.3 Design Consideration

To analyze the structure, we have followed the BNBC code. According to the BNBC code we consider the design parameter such as live load consideration, load combination, zone coefficient etc.

3.3.1 Live Load

Unlike dead load, live load refers to the transient or moving loads that structures experience due to human occupancy, furniture, vehicles, and other temporary factors. Live load vary in magnitude and location over time, as the intended use and occupancy of the structure influences them.

Table 3.1 : Live load from BNBC

Occupancy or use	Uniform KN/m²	Concentrated KN
Apartments (See Residential)		
Access floor system		
Office use	2.40	9.0
Computer use	4.80	9.0
Armories and drill room	7.20	--

BNBC

part VI

Chapter 2

Occupancy or use	Uniform KN/m²	Concentrated KN
Assembly area and theaters	2.90	---
Fixed seats (fastened to floor)	4.80	---
Lobbies	4.80	---
Movable (assembly)	7.20	---
Stage floor		
Balconies (exterior)	2.40	---
On one-and two- family residence	4.80	
Only, and not exceeding 19.3 m ²		

3.3.2 Wind Load

The basic wind speed is different in different areas of the country depending on the exposure category of the building. In this study we have consider four different areas of the country and these are followings

Table 3.2 : Basic wind speed (m/s)

S/L	Location	Basic wind speed, (m/s)
1	Rajshahi	49.2
2	Dhaka	65.7
3	Chattogram	80
4	Sylhet	61.1

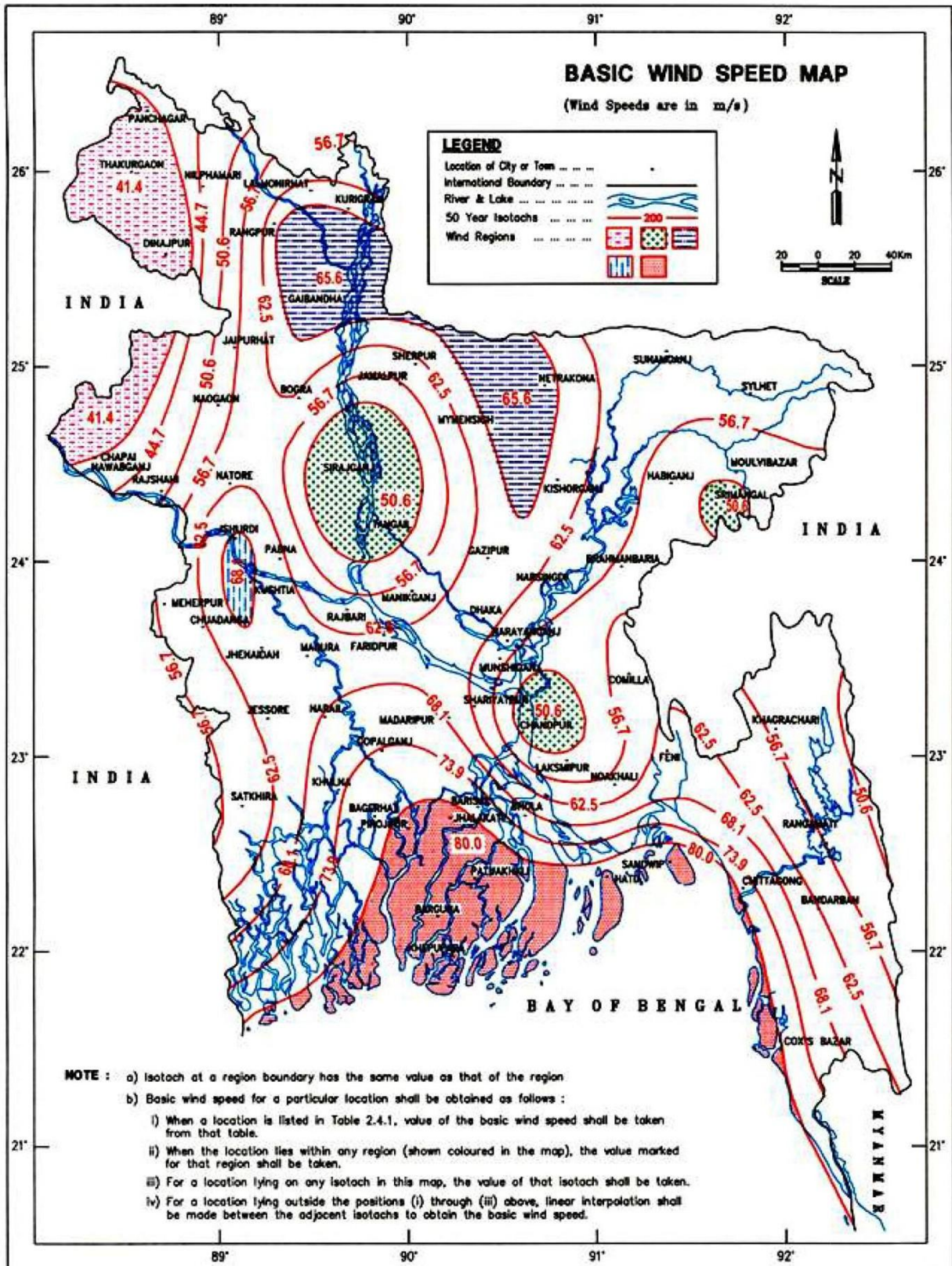


Figure 3.4 : Basic Wind speed map

3.3.3 Earthquake Load

The purpose of earthquake resistant design provisions in this code is to provide guidelines for the design and construction of new structures subject to earthquake ground motions in order to minimize the risk to life for all structure, to increase the expected performance of higher occupancy structure as compared to ordinary structure, and to improve the capability of essential structure to function after an earthquake. It is not economically feasible to design and construct building without any damage for a major earthquake event. The intent is therefor to allow inelastic deformation and structure damage at preferred location in the structure without endangering structure integrity and to prevent structure collapse during a major earthquake.

3.3.3.1 Seismic Zone, Z

Seismic zones are classified depending on the ground crust, tectonic plate beneath the earth crust. BNBC 2020 has classified the four types of seismic zones in the Bangladesh.

Previously we have shown the zone map in the study.

Table 3.3 : Seismic Zone Coefficient (Ref. BNBC)

Seismic Zone	Location	Seismic Intensity	Seismic Zone Coefficient, Z
1	Southwestern part including Barisal, Khulna, Jessore, Rajshahi	Low	.12
2	Lower center and Southwestern part including Noakhali, Dhaka, Pabna, Dinajpur, as well as Southwestern corner including Sundarbans	Moderate	.20
3	Upper central and Southwestern part including brahman aria, Sirajganj, Rangpur	Severe	.28
4	Southwestern part including Sylhet Mymensingh, Kuri gram	Very severe	.36

Site Classification Based on Soil Properties

Table 3.4 : Site Classification Based on Soil Properties

Site profile Class depth	Description of soil profile up to 30 meters	Average Soil Properties in top 30 meters		
		Shear wave shear velocity, V, (m/s) (kPa)	SPT Value, N (blows/30cm)	Undrained strength, 5, (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 meters in thickness, characterized 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 meters	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, values of type SC or SD and thickness varying between about 5 m and 20 m, underlain by	--	--	--

<p>S1 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</p>	<p>< 100 (indicative)</p>	<p>--</p>	<p>10-20</p>
<p>S2 Deposits of liquefiable soils, of sensitive clays, or any other soil profile not included in types SA to SE or Si</p>	<p>--</p>	<p>--</p>	<p>--</p>

Occupancy Category of Buildings and other Structures for Flood, Surge, Wind and Earthquake Loads

Nature of Occupancy Occupancy

Category

Buildings and other structures that represent a low hazard to human life in the event of failure, including, but not limited to: **I**

- . Agricultural facilities
- . Certain temporary facilities
- . Minor storage facilities

All buildings and other structures except those listed in Occupancy Categories I, III and IV

II

Buildings and other structures that represent a substantial hazard to human life in the

III

event of failure, including, but not limited to:

1. Buildings and other structures where more than 300 people congregate in one area
2. Buildings and other structures with day care facilities with a capacity greater than 150
3. Buildings and other structures with elementary school or secondary school facilities

with a capacity greater than 250

4. Buildings and other structures with a capacity greater than 500 for colleges or adult education facilities

5. Healthcare facilities with a capacity of 50 or more resident patients, but not having surgery or emergency Treatment facilities

6. Jails and detention facilities

Buildings and other structures, not included in Occupancy Category IV, with potential to cause a substantial economic impact and/or mass disruption of day-to-day civilian life in the event of failure, including, but not limited to:

- . Power generating stations"
- . Water treatment facilities
- . Sewage treatment facilities
- . Telecommunication centers

Buildings and other structures not included in Occupancy Category IV (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, hazardous waste, or explosives) containing sufficient quantities of toxic or explosive substances to be dangerous to the public if released.

In our study we consider the four different locations which is situated on the four seismic zone in the country for the better result of the study. The locations and the zones are following.

Table: 3.5 Zone Coefficient

SL NO	Location	Seismic Zone Coefficient, Z
1	Rajshahi	0.12
2	Dhaka	0.20
3	Chattogram	0.28
4	Sylhet	0.36

3.3.3.2 Structural Important Factor, I

This is the coefficient that accounts the importance of structure for post- earthquake activities. The earthquake lateral force is multiplied by factor called structure importance co-efficient and are designed for a higher level of force so that the possibility of this structure being undamaged during an earthquake remains higher. But in BNBC 2015(draft), importance co-efficient is denoted by I for all cases. In BNBC 2015, importance co-efficient is described for four different cases.

Table: 3.6 Importance Factor I (Ref. BNBC)

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

3.3.3.3 Response Modification Factor, R

Response Modification Factor is one of the seismic design parameters to consider nonlinear performance of the building structure during strong earthquake. Relying on this, many seismic design codes led to reduce loads. In other works, response modification factor is the ration of strength required to maintain the structure elasticity. In fact, the response modification factor (R) reflects the capability of a structure to dissipate energy through inelastic behavior. Systems undergoing inelastic response during severe earthquake incidence. In BNBC 1993, it is known as response modification coefficient. It is the factor by which the actual base shear force that would develop if the structure behavior truly elastic during earthquake is reduced to obtain design base shear. Response modification factor values for different structure systems described the following.

Seismic design category of building

Site class	Occupancy category I,II and III				Occupancy category IV			
	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
SA	B	C	C	D	C	C	C	D
SB	B	C	D	D	C	C	D	D
SC	B	C	D	D	C	C	D	D
SD	C	D	D	D	C	D	D	D
SE,S1,S2	D	D	D	D	D	D	D	D

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

Seismic Force-Resisting System	Response Reduction Factor, R	System Overstrength Factor,	Deflection Amplification Factor Cd	Seismic Design Category		
				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	NP	NL
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	NL	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	3.25	2	3.25	NL	NL	11
4. Ordinary steel concentrically braced frames	6	2.5	5	NL	NL	50
5. Special reinforced concrete shear walls						

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	NL
4. Special reinforced concrete moment frames	8	3	5.5	NL	NL	NL
	5	3	4.5	NL	NL	NP
5. Intermediate reinforced concrete moment frames	3	3	2.5	NL	NL	NP
6. Ordinary reinforced concrete moment frames						

D. DUAL SYSTEMS: SPECIAL MOMENT FRAMES CAPABLE OF RESISTING AT LEAST 25% OF PRESCRIBED SEISMIC FORCES (with bracing or shear wall)

1. Steel eccentrically braced frames	8	2.5	4	NL	NL	NL
2. Special steel concentrically braced frames	7	2.5	5.5	NL	NL	NL
3. Special reinforced concrete shear walls	7	2.5	5.5	NL	NL	NL
4. Ordinary reinforced concrete shear walls	6	2.5	5	NL	NL	NP

E. DUAL SYSTEMS: INTERMEDIATE MOMENT FRAMES CAPABLE OF RESISTING AT LEAST 25% OF PRESCRIBED SEISMIC FORCES (with bracing or shear wall)

1. Special steel concentrically braced frames	6	2.5	5	NL	NL	11
2. Special reinforced concrete shear walls	6.5	2.5	5	NL	NL	50
3. Ordinary reinforced masonry shear walls	3	3	3	NL	50	NP
4. Ordinary reinforced concrete shear walls	5.5	2.5	4.5	NL	NL	NP

Values for Coefficients to Estimate Approximate Period

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

Approximate Fundamental Period. The approximate fundamental period (T_a), in s, shall be determined from the following equation:

$$T_a = C_t h^n$$

where h is the height in ft above the base to the highest level of the structure and the coefficients C_t and n are determined from

Spectral Response Acceleration Parameter S_s and S_1 for Different Seismic Zone

Parameters	Zone-1	Zone-2	Zone-3	Zone-4
S_s	0.3	0.5	0.7	0.9
S_1	0.12	0.2	0.28	0.36

Site Coefficient F_a for Different Seismic Zone and Soil Type

Soil Type	Zone-1	Zone-2	Zone-3	Zone-4
SA	1.0	1.0	1.0	1.0
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
SE	1.4	1.4	1.4	1.4

Site Coefficient F_v for Different Seismic Zone and Soil Type

Soil Type	Zone-1	Zone-2	Zone-3	Zone-4
SA	1.0	1.0	1.0	1.0
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
SE	1.75	1.75	1.75	1.75

Site Dependent Soil Factor and Other Parameters Defining Elastic Response

Soil Type	S	$T_b(S)$	$T_c(S)$	$T_d(S)$
SA	1.0	0.15	0.40	2.0
SB	1.2	0.15	0.50	2.0
SC	1.15	0.20	0.60	2.0
SD	1.35	0.20	0.80	2.0
SE	1.4	0.15	0.50	2.0

Table 3.7: Response Reduction Factors (Ref. BNBC)

Frame Systems	Response Reduction Factors, R
Special Steel Concentrically braced frames	6
Special reinforced concrete shear wall	6.5
Ordinary reinforced masonry shear wall	3
Ordinary reinforced concrete shear wall	5.5

3.3.3.4 Base Shear, V

Base shear is an estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure. Calculations of base shear (V) depend on soil conditions at the site and proximity to potential sources of seismic activity (such as geological faults). Probability of significant seismic ground motion and the level of ductility and over strength associated with various structural configurations and the total weight of the structure are also responsible for base shear variations. Base shear also depends on the fundamental (natural) period of vibration of the structure when subjected to dynamic loading Base share,

$$V = S_a \times W$$

$$\text{Here, } S_a = 2 \text{ ZICs} / 3R$$

Notation

- S_a Spectrum acceleration
- Z Seismic zonal coefficient
- I Structural importance factor
- C_s Normalized response spectrum acceleration
- R Response modification factor

3.3.4 Load Combination

Provisions of this Section shall apply to all construction materials permitting their use in proportioning structural members by allowable stress/strength design method. When this method is used in designing structural members, all loads listed herein shall be considered to act in the following combinations. The combination that produces the most unfavorable effect shall be used in design.

Basic Load combination:

1. $1.4(D+F)$
2. $1.2(D+F+T) + 1.6(L+H)+0.5(L_r \text{ or } R)$
3. $1.2D+1.6(L_r \text{ or } R) + (L \text{ or } 0.8W)$
4. $1.2D + 1.6W+L+0.5(L_r \text{ or } R)$
5. $1.2D+1.0E+1.0L$
6. $0.9D + 1.6W + 1.6H$
7. $0.9D + 1.0E+1.6H$

3.3.5 Drift

Drift is defined as the lateral displacement. Story drift is the drift of one level of a multistory building relative to the level below. Inter story drift is the difference between the roof and floor displacements of any given story as the building sways during the earthquake, normalized by the story height. Lateral deflection is the predicted movement of a structure under lateral loads and story drift is defined as the difference in lateral deflection between two adjacent stories during an earthquake or large lateral forces. The design story drift of each story shall not exceed the allowable story drift as obtained from table for any story

Table 3.8: Allowable story drift limit

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

3.3.6 Story Displacement

Story Displacement is the lateral displacement of the story relative to the base. Story displacement is the absolute value of displacement of the story under action of the lateral forces. The overall sway (horizontal deflection) at the top level of the building or structure due to wind loading shall be limited to 1/500times of the total height of the building above ground.

3.4 Model

Same size of structural elements is considered for four seismic zones in Bangladesh. So, the quantity of materials is varying for same structure in different seismic zones in Bangladesh. It is discussed in chapter four. The models are run in three types structure i.e. without shear wall, shear wall at the lift core area and the shear wall at the outer area in the four specific location Chattogram, Dhaka, Sylhet and Rajshahi.

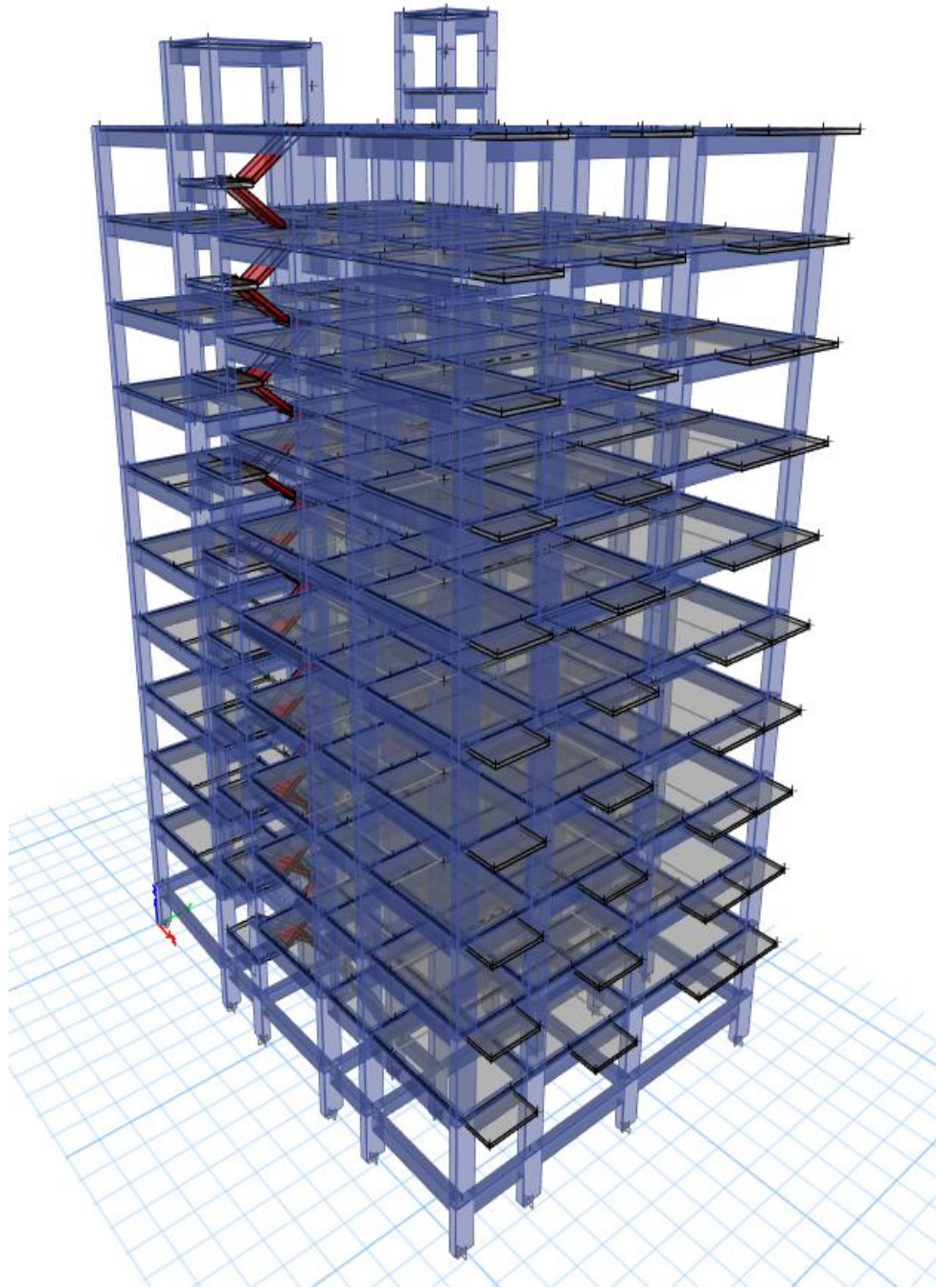


Figure 3.5 : ETABS models without shear wall

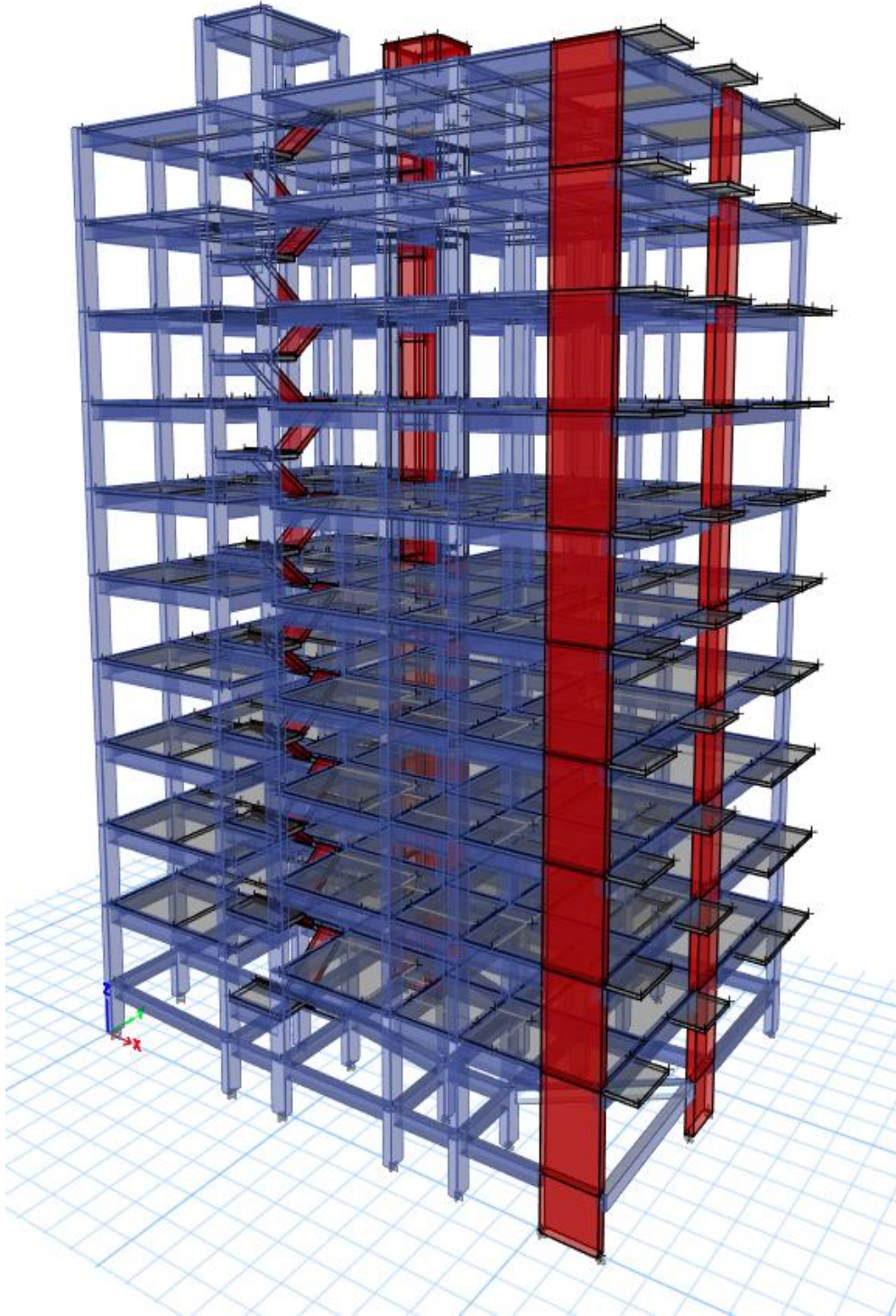


Figure 3.6 : ETABS models with shear wall

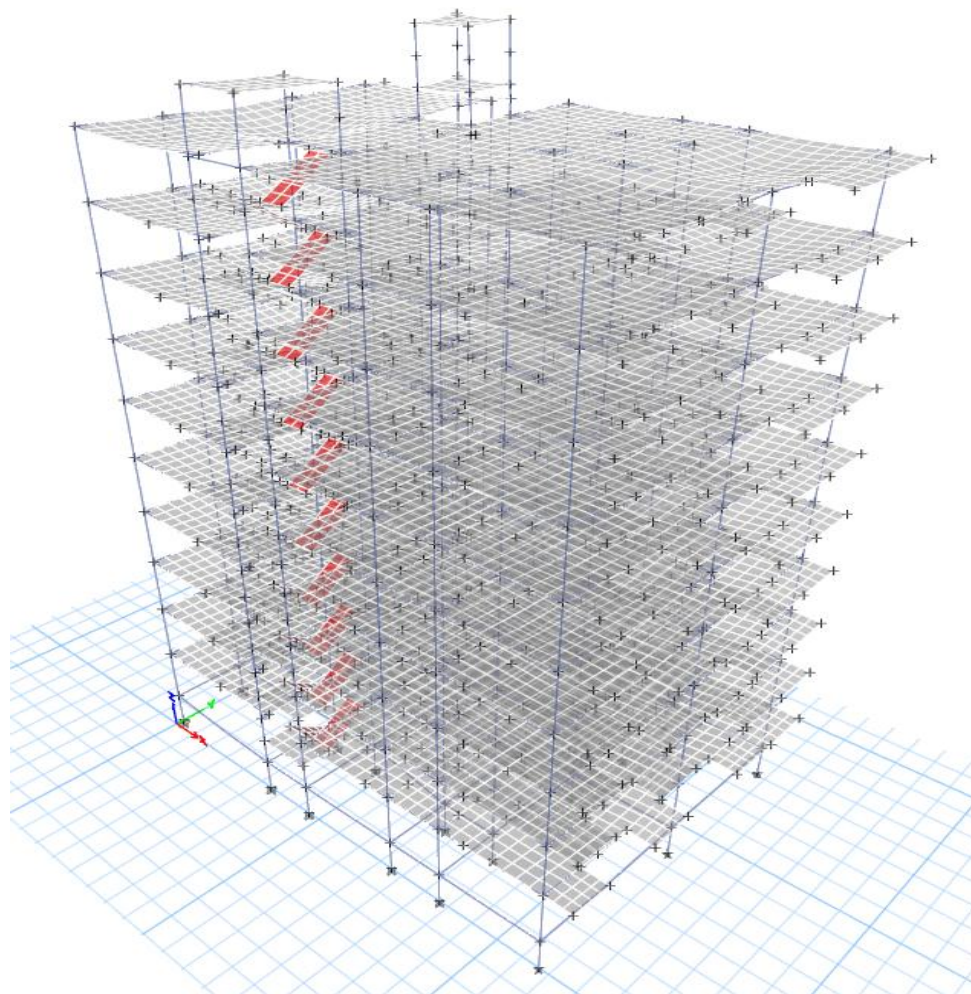
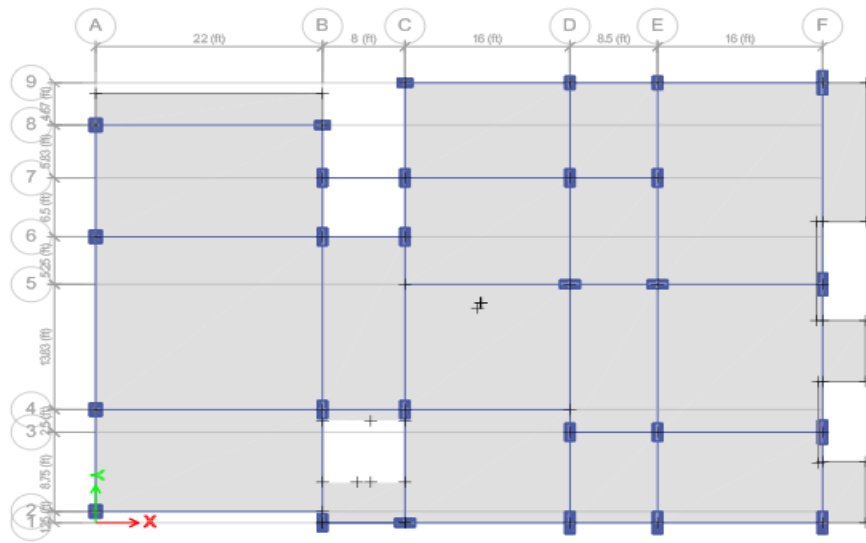


Figure 3.7 : Analysis of the structural without shear wall

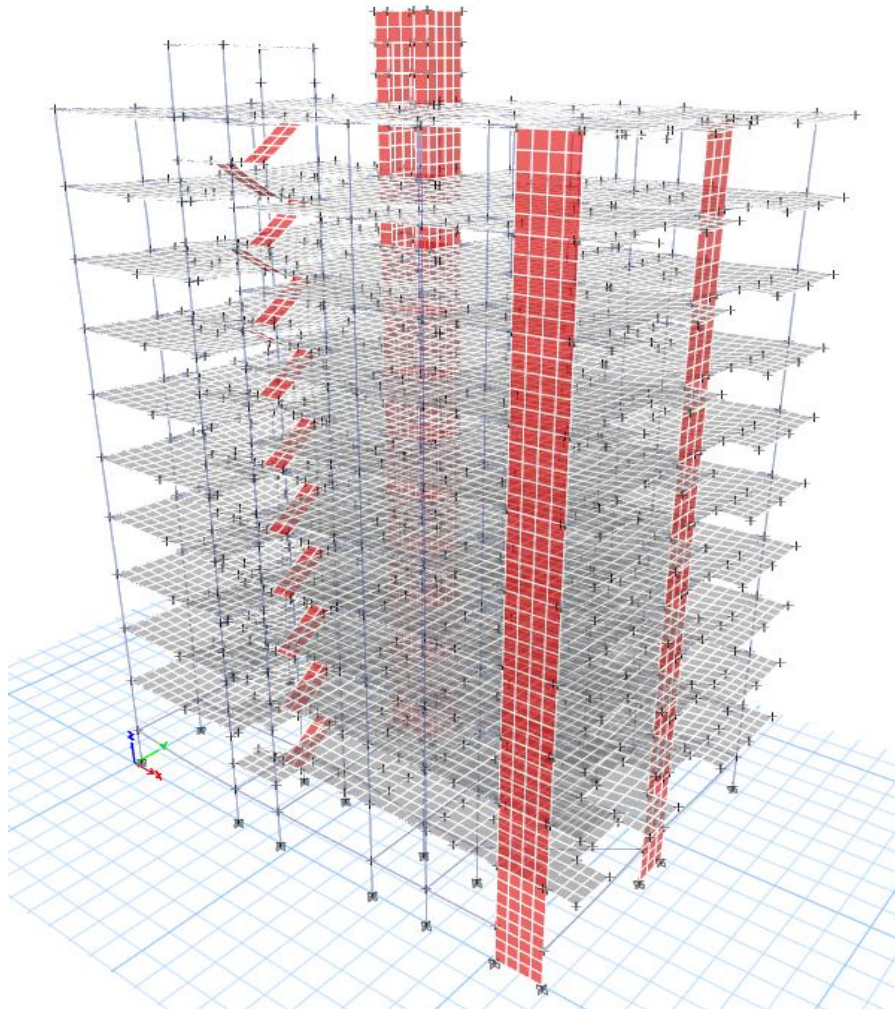
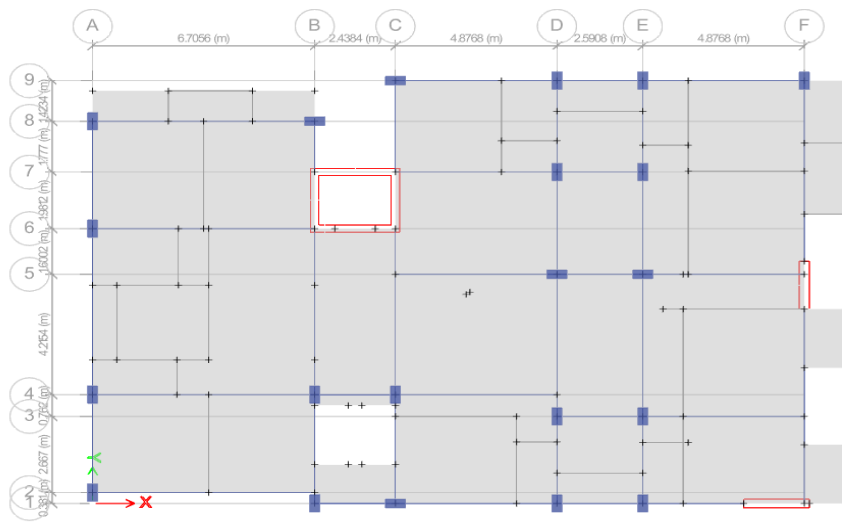


Figure 3.8 : Analysis of the structural with shear wall

CHAPTER 4

TEST RESULTS AND ANALYSIS

4.1 Introduction

Analysis and design has been carried out for ten story building heights of buildings (100 feet) is selected for this comparative study different for four seismic zones in Bangladesh. At first comparisons are carried out on analysis results such as story displacement, story drift and base shear in four seismic zones in Bangladesh. Comparisons also carried out on design results of those structures. The variation of the design parameters are observed of the structures and compared the results among the four seismic zones.

4.2 Result Analysis

The structure (100 feet height) is analyzed as an intermediate moment resisting frames (dual system). Loads are considered as per BNBC, 2020 which has been already discussed in chapter three. Results have compared on story displacement, story drift, base share, required reinforcements for four seismic zones in Bangladesh.

4.2.1 Story Drift

In general, to find the story drift of level "X", you would take the story displacement of level "X", and subtract it from the story displacement of level "X-1". For example, the story drift of level 4 is equal to the total story displacement of level 4 minus the story displacement of level 3

4.2.1 Story Displacements

Story displacement for lateral loads at X and Y directions are shown in Figure 4.1 for four seismic zones. For the shear wall in the lift core area the max displacement are in zone W_x - 0.33, 0.46 in and the displacement in zones W_y for the zones 0.64 , 0.80

Story displacement for lateral loads at X and Y directions are shown in Figure 4.2 for four seismic zones. For the without shear wall in the lift core area the max displacement are in zone W_x 0.95, 0.85 in and the displacement in zones W_y for the zones 1.13, 1.10

Story Drift for seismic without shear wall

E Diaphragm Center Of Mass Displacements

File Edit Format-Filter-Sort Select Options

Units: As Noted Hidden Columns: No Sort: Step Number ASC

Filter: ([Output Case] = 'EX')

	Story	Diaphragm	Output Case	Case Type	Step Type	Step Number	UX in	UY in	RZ rad
	RF	D1	EX	LinStatic	Step By Step	1	3.283801	0.030791	-0.000681
	9F	D1	EX	LinStatic	Step By Step	1	3.157466	0.031436	-0.000682
	8F	D1	EX	LinStatic	Step By Step	1	2.963599	0.030145	-0.000666
	7F	D1	EX	LinStatic	Step By Step	1	2.710294	0.028468	-0.000631
	6F	D1	EX	LinStatic	Step By Step	1	2.407859	0.026378	-0.000579
	5F	D1	EX	LinStatic	Step By Step	1	2.066821	0.023957	-0.000512
	4F	D1	EX	LinStatic	Step By Step	1	1.69759	0.021267	-0.000433
	3F	D1	EX	LinStatic	Step By Step	1	1.310273	0.018357	-0.000344
	2F	D1	EX	LinStatic	Step By Step	1	0.914688	0.015149	-0.000243
	1F	D1	EX	LinStatic	Step By Step	1	0.517806	0.011145	-0.000135

For **Seismic**

Importance Factor	I	1
Deflection Amplification Factor	C _d	2.5
Occupancy Category	OC	2 0.02

STORY	STORY Height	Diaphragm Center of Mass Displacement δ_x	$\delta_x = \frac{C_d \delta_{se}}{I}$	$\Delta_x = \delta_x - \delta_{x-1}$	Drift Ratio	Limit	Check
RF	10 ft	3.28 in	8.2095025	0.3188375	0.002631979	2.40 in	OK
9F	10 ft	3.16 in	7.893665	0.4846075	0.004038896	2.40 in	OK
8F	10 ft	2.96 in	7.4089975	0.6332625	0.005277187	2.40 in	OK
7F	10 ft	2.71 in	6.775735	0.7560875	0.006300729	2.40 in	OK
6F	10 ft	2.41 in	6.0196475	0.852595	0.007104958	2.40 in	OK
5F	10 ft	2.07 in	5.1670525	0.9230775	0.007692313	2.40 in	OK
4F	10 ft	1.70 in	4.243975	0.9682925	0.008069104	2.40 in	OK
3F	10 ft	1.31 in	3.2756825	0.9889625	0.008241354	2.40 in	OK
2F	10 ft	0.91 in	2.28672	0.992205	0.008268375	2.40 in	OK
1F	10 ft	0.52 in	1.294515			2.40 in	

E Diaphragm Center Of Mass Displacements

File Edit Format-Filter-Sort Select Options

Units: As Noted Hidden Columns: No Sort: Step Number ASC

Filter: ([Output Case] = 'EY')

	Story	Diaphragm	Output Case	Case Type	Step Type	Step Number	UX in	UY in	RZ rad
	RF	D1	EY	LinStatic	Step By Step	1	0.040017	2.335307	-0.000426
	9F	D1	EY	LinStatic	Step By Step	1	0.038975	2.225759	-0.000402
	8F	D1	EY	LinStatic	Step By Step	1	0.036056	2.075274	-0.000372
	7F	D1	EY	LinStatic	Step By Step	1	0.032749	1.885951	-0.00034
	6F	D1	EY	LinStatic	Step By Step	1	0.029188	1.664467	-0.000307
	5F	D1	EY	LinStatic	Step By Step	1	0.025444	1.418255	-0.000275
	4F	D1	EY	LinStatic	Step By Step	1	0.021576	1.154725	-0.000243
	3F	D1	EY	LinStatic	Step By Step	1	0.017646	0.881065	-0.000213
	2F	D1	EY	LinStatic	Step By Step	1	0.013607	0.604406	-0.000184
	1F	D1	EY	LinStatic	Step By Step	1	0.009135	0.332094	-0.000147

For **Seismic**

Importance Factor	I	1
Deflection Amplification Factor	C _d	2.5
Occupancy Category	OC	2 0.02

STORY	STORY Height	Diaphragm Center of Mass Displacement δ_x	$\delta_x = \frac{C_d \delta_{se}}{I}$	$\Delta_x = \delta_x - \delta_{x-1}$	Drift Ratio	Limit	Check
RF	10 ft	2.34 in	5.8382675	0.27387	0.00228225	2.40 in	OK
9F	10 ft	2.23 in	5.5643975	0.3762125	0.003135104	2.40 in	OK
8F	10 ft	2.08 in	5.188185	0.4733075	0.003944229	2.40 in	OK
7F	10 ft	1.89 in	4.7148775	0.55371	0.00461425	2.40 in	OK
6F	10 ft	1.66 in	4.1611675	0.61553	0.005129417	2.40 in	OK
5F	10 ft	1.42 in	3.5456375	0.658825	0.005490208	2.40 in	OK
4F	10 ft	1.15 in	2.8868125	0.68415	0.00570125	2.40 in	OK
3F	10 ft	0.88 in	2.2026625	0.6916475	0.005763729	2.40 in	OK
2F	10 ft	0.60 in	1.511015	0.68078	0.005673167	2.40 in	OK
1F	10 ft	0.33 in	0.830235			2.40 in	

Figure 4.0 : Story Drift for seismic without shear wall

Story Drift for seismic with shear wall

E Diaphragm Center Of Mass Displacements

File Edit Format-Filter-Sort Select Options

Units: As Noted Hidden Columns: No Sort: Step Number ASC

Filter: ([Output Case] = 'EX')

	Story	Diaphragm	Output Case	Case Type	Step Type	Step Number	UX in	UY in	RZ rad
	RF	D1	EX	LinStatic	Step By Step	1	1.018015	0.006463	2.5E-05
	9F	D1	EX	LinStatic	Step By Step	1	0.929347	0.006257	4.7E-05
	8F	D1	EX	LinStatic	Step By Step	1	0.832805	0.005997	6.5E-05
	7F	D1	EX	LinStatic	Step By Step	1	0.727923	0.005628	7.7E-05
	6F	D1	EX	LinStatic	Step By Step	1	0.615589	0.005131	8.3E-05
	5F	D1	EX	LinStatic	Step By Step	1	0.49831	0.004516	8.3E-05
	4F	D1	EX	LinStatic	Step By Step	1	0.379824	0.003782	7.6E-05
	3F	D1	EX	LinStatic	Step By Step	1	0.265035	0.002923	6.3E-05
	2F	D1	EX	LinStatic	Step By Step	1	0.160121	0.001947	4.4E-05
	1F	D1	EX	LinStatic	Step By Step	1	0.072927	0.000974	2.2E-05

For Seismic	Importance Factor	I	1
	Deflection Amplification Factor	C _d	5
	Occupancy Category	OC	2

STORY	STORY Height	Diaphragm Center of Mass Displacement δ_{se}	$\delta_x = \frac{C_d \delta_{se}}{I}$	$\Delta_x = \delta_x - \delta_{x-1}$	Drift Ratio	Limit	Check
RF	10 ft	1.02 in	5.090075	0.44334	0.0036945	2.40 in	OK
9F	10 ft	0.93 in	4.646735	0.48271	0.004022583	2.40 in	OK
8F	10 ft	0.83 in	4.164025	0.52441	0.004370083	2.40 in	OK
7F	10 ft	0.73 in	3.639615	0.56167	0.004680583	2.40 in	OK
6F	10 ft	0.62 in	3.077945	0.586395	0.004886625	2.40 in	OK
5F	10 ft	0.50 in	2.49155	0.59243	0.004936917	2.40 in	OK
4F	10 ft	0.38 in	1.89912	0.573945	0.004782875	2.40 in	OK
3F	10 ft	0.27 in	1.325175	0.52457	0.004371417	2.40 in	OK
2F	10 ft	0.16 in	0.800605	0.43597	0.003633083	2.40 in	OK
1F	10 ft	0.07 in	0.364635			2.40 in	

E Diaphragm Center Of Mass Displacements

File Edit Format-Filter-Sort Select Options

Units: As Noted Hidden Columns: No Sort: Step Number ASC

Filter: ([Output Case] = 'EY')

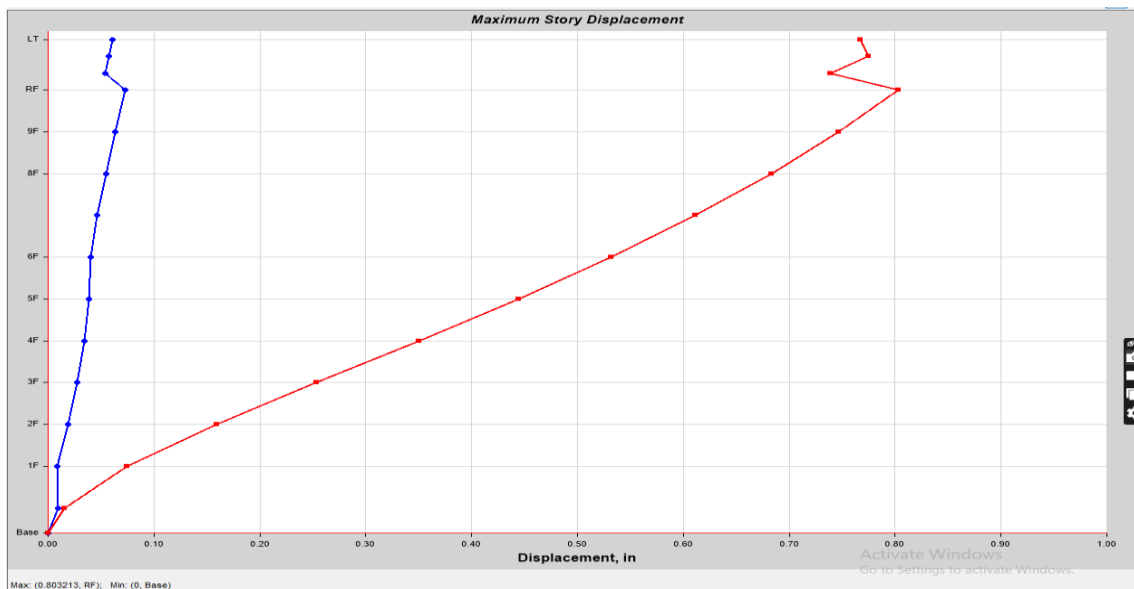
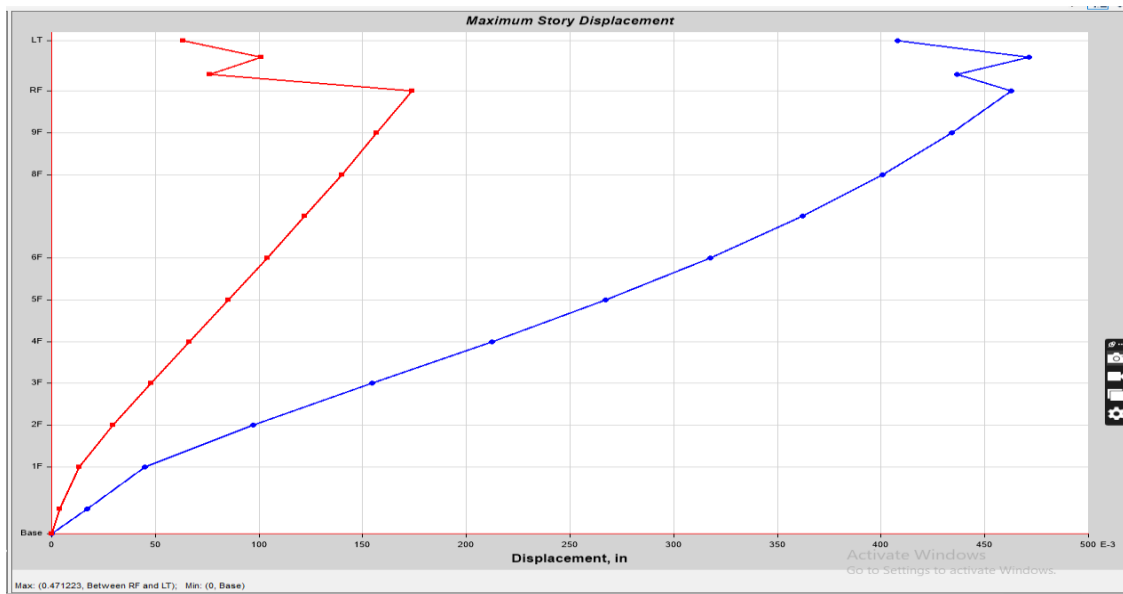
	Story	Diaphragm	Output Case	Case Type	Step Type	Step Number	UX in	UY in	RZ rad
	RF	D1	EY	LinStatic	Step By Step	1	0.00733	0.961699	-0.000138
	9F	D1	EY	LinStatic	Step By Step	1	0.007195	0.887193	-0.000109
	8F	D1	EY	LinStatic	Step By Step	1	0.006658	0.803815	-8.2E-05
	7F	D1	EY	LinStatic	Step By Step	1	0.005987	0.710136	-5.9E-05
	6F	D1	EY	LinStatic	Step By Step	1	0.005215	0.606786	-3.8E-05
	5F	D1	EY	LinStatic	Step By Step	1	0.004385	0.496097	-2.1E-05
	4F	D1	EY	LinStatic	Step By Step	1	0.003519	0.38171	-7E-06
	3F	D1	EY	LinStatic	Step By Step	1	0.002617	0.268559	3E-06
	2F	D1	EY	LinStatic	Step By Step	1	0.001675	0.163143	7E-06
	1F	D1	EY	LinStatic	Step By Step	1	0.00076	0.074307	6E-06

For Seismic	Importance Factor	I	1
	Deflection Amplification Factor	C _d	5
	Occupancy Category	OC	2

STORY	STORY Height	Diaphragm Center of Mass Displacement δ_{se}	$\delta_x = \frac{C_d \delta_{se}}{I}$	$\Delta_x = \delta_x - \delta_{x-1}$	Drift Ratio	Limit	Check
RF	10 ft	0.96 in	4.808495	0.37253	0.003104417	2.40 in	OK
9F	10 ft	0.89 in	4.435965	0.41689	0.003474083	2.40 in	OK
8F	10 ft	0.80 in	4.019075	0.468395	0.003903292	2.40 in	OK
7F	10 ft	0.71 in	3.55068	0.51675	0.00430625	2.40 in	OK
6F	10 ft	0.61 in	3.03393	0.553445	0.004612042	2.40 in	OK
5F	10 ft	0.50 in	2.480485	0.571935	0.004766125	2.40 in	OK
4F	10 ft	0.38 in	1.90855	0.565755	0.004714625	2.40 in	OK
3F	10 ft	0.27 in	1.342795	0.52708	0.004392333	2.40 in	OK
2F	10 ft	0.16 in	0.815715	0.44418	0.0037015	2.40 in	OK
1F	10 ft	0.07 in	0.371535			2.40 in	

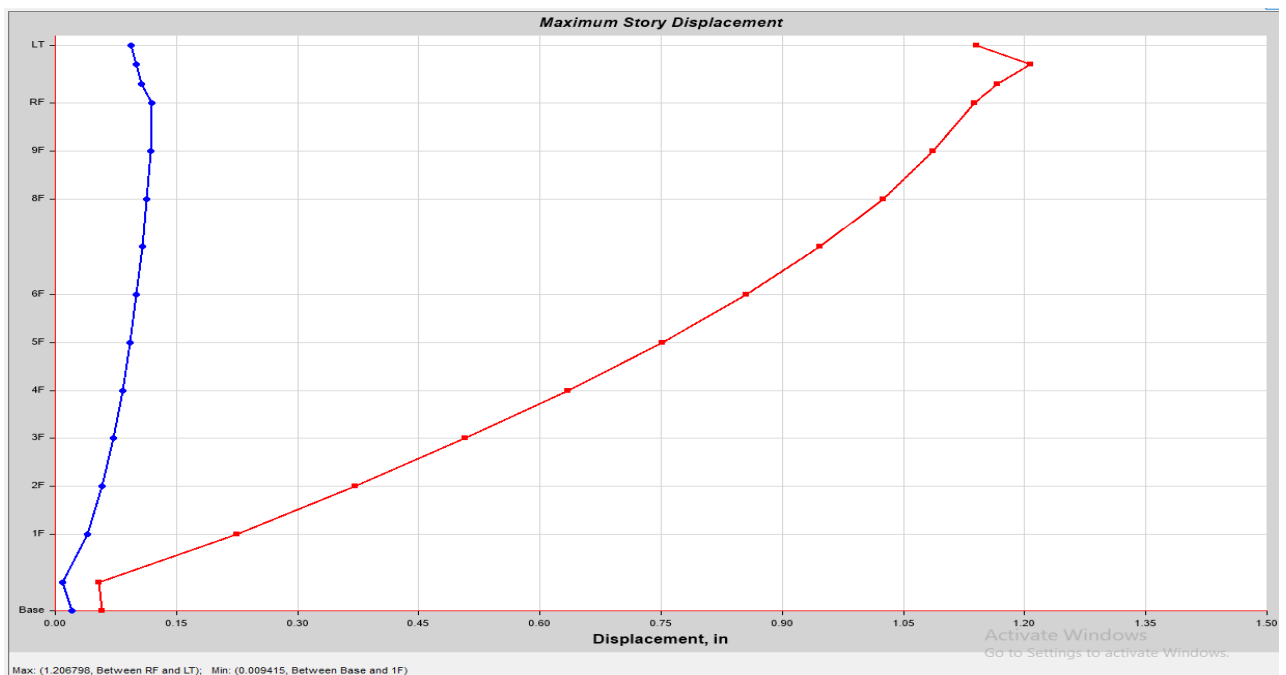
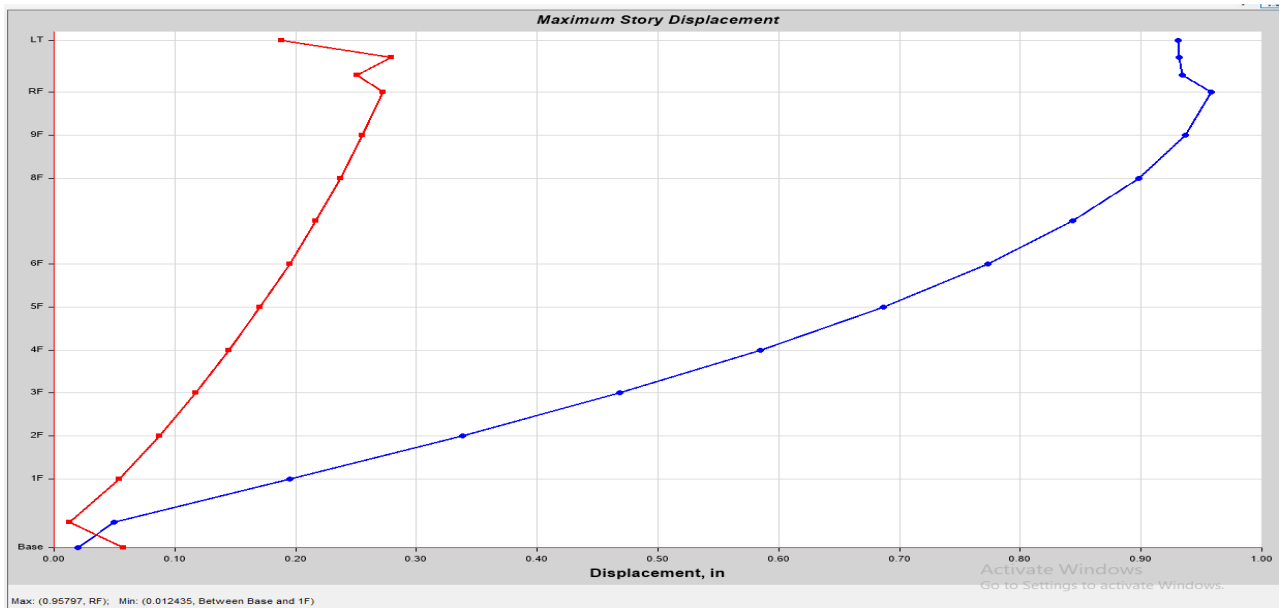
Figure 4.1 : Story Drift for seismic with shear wall

Story displacement for wind with shear wall



1. Drift / Displacement Check for Wind						
Procedure						
Deformed Shape > Combo > D+0.5L+0.7Wx > Apply > see Delta 1 & 2						
Deformed Shape > Combo > D+0.5L+0.7Wy > Apply > see Delta 1 & 2						
Input						
Building Height	H		100	ft		
Displacement at node 1 for Wx	Δ_1		0.33			
Displacement at node 2 for Wx	Δ_2		0.46			
Displacement at node 1 for Wy	Δ_1		0.64			
Displacement at node 2 for Wy	Δ_2		0.8			
Calculations & Results						
Lateral Load	Building Height in ft	H	Δ_1	Δ_2	Allowable Drift Limit , H/500	Check
Wx	100	1200	0.33	0.46	2.4	OK
Wy	100	1200	0.64	0.8	2.4	OK

Figure 4.2 : story displacement for wind with shear wall



Input						
Building Height	H			100 ft		
Displacement at node 1 for Wx	Δ_1			0.95		
Displacement at node 2 for Wx	Δ_2			0.85		
Displacement at node 1 for Wy	Δ_1			1.13		
Displacement at node 2 for Wy	Δ_2			1.1		
Calculations & Results						
Lateral Load	Building Height in ft	H	Δ_1	Δ_2	Allowable Drift Limit , H/500	Check
Wx	100	1200	0.95	0.85	2.4	OK
Wy	100	1200	1.13	1.1	2.4	OK

Figure 4.3 : story displacement for wind without shear wall

4.2.2.2 : Torsional Irregularity for seismic impact without shear wall

Filter: ([Output Case] = 'EX')

	Story	Output Case	Case Type	Step Type	Step Number	Direction	Maximum in	Average in	Ratio
	RF	EX	LinStatic	Step By Step	1	X	3.487028	3.288588	1.06
	9F	EX	LinStatic	Step By Step	1	X	3.358978	3.160076	1.063
	8F	EX	LinStatic	Step By Step	1	X	3.16027	2.966147	1.065
	7F	EX	LinStatic	Step By Step	1	X	2.896558	2.712707	1.068
	6F	EX	LinStatic	Step By Step	1	X	2.578754	2.410073	1.07
	5F	EX	LinStatic	Step By Step	1	X	2.21811	2.068781	1.072
	4F	EX	LinStatic	Step By Step	1	X	1.825596	1.699249	1.074
	3F	EX	LinStatic	Step By Step	1	X	1.411711	1.311587	1.076
	2F	EX	LinStatic	Step By Step	1	X	0.986533	0.915618	1.077
	1F	EX	LinStatic	Step By Step	1	X	0.557727	0.518323	1.076
	RF	EX	LinStatic	Step By Step	2	X	3.690064	3.313452	1.114
	9F	EX	LinStatic	Step By Step	2	X	3.555124	3.184646	1.116
	8F	EX	LinStatic	Step By Step	2	X	3.345387	2.989827	1.119
	7F	EX	LinStatic	Step By Step	2	X	3.066568	2.734881	1.121
	6F	EX	LinStatic	Step By Step	2	X	2.730211	2.430205	1.123
	5F	EX	LinStatic	Step By Step	2	X	2.34826	2.086421	1.125
	4F	EX	LinStatic	Step By Step	2	X	1.932358	1.714017	1.127
	3F	EX	LinStatic	Step By Step	2	X	1.493637	1.32316	1.129
	2F	EX	LinStatic	Step By Step	2	X	1.042801	0.923715	1.129
	1F	EX	LinStatic	Step By Step	2	X	0.588235	0.522735	1.125
	RF	EX	LinStatic	Step By Step	3	X	3.283992	3.263724	1.006
	9F	EX	LinStatic	Step By Step	3	X	3.162832	3.135507	1.009
	8F	EX	LinStatic	Step By Step	3	X	2.975153	2.942466	1.011
	7F	EX	LinStatic	Step By Step	3	X	2.726548	2.690532	1.013
	6F	EX	LinStatic	Step By Step	3	X	2.427297	2.389941	1.016
	5F	EX	LinStatic	Step By Step	3	X	2.087959	2.051141	1.018
	4F	EX	LinStatic	Step By Step	3	X	1.718833	1.68448	1.02
	3F	EX	LinStatic	Step By Step	3	X	1.329784	1.300013	1.023
	2F	EX	LinStatic	Step By Step	3	X	0.930265	0.907522	1.025
▶	1F	EX	LinStatic	Step By Step	3	X	0.527219	0.513912	1.026

	Story	Output Case	Case Type	Step Type	Step Number	Direction	Maximum in	Average in	Ratio
▶	RF	EY	LinStatic	Step By Step	1	Y	2.524582	2.344426	1.077
	9F	EY	LinStatic	Step By Step	1	Y	2.403709	2.233491	1.076
	8F	EY	LinStatic	Step By Step	1	Y	2.239986	2.082431	1.076
	7F	EY	LinStatic	Step By Step	1	Y	2.036345	1.892486	1.076
	6F	EY	LinStatic	Step By Step	1	Y	1.800348	1.670371	1.078
	5F	EY	LinStatic	Step By Step	1	Y	1.539798	1.423536	1.082
	4F	EY	LinStatic	Step By Step	1	Y	1.26237	1.159403	1.089
	3F	EY	LinStatic	Step By Step	1	Y	0.975417	0.885165	1.102
	2F	EY	LinStatic	Step By Step	1	Y	0.685681	0.607937	1.128
	1F	EY	LinStatic	Step By Step	1	Y	0.397003	0.334914	1.185
	RF	EY	LinStatic	Step By Step	2	Y	2.531385	2.313686	1.094
	9F	EY	LinStatic	Step By Step	2	Y	2.416814	2.203906	1.097
	8F	EY	LinStatic	Step By Step	2	Y	2.257647	2.054719	1.099
	7F	EY	LinStatic	Step By Step	2	Y	2.053332	1.867076	1.1
	6F	EY	LinStatic	Step By Step	2	Y	1.810811	1.647542	1.099
	5F	EY	LinStatic	Step By Step	2	Y	1.538445	1.403473	1.096
	4F	EY	LinStatic	Step By Step	2	Y	1.244669	1.142216	1.09
	3F	EY	LinStatic	Step By Step	2	Y	0.937749	0.870905	1.077
	2F	EY	LinStatic	Step By Step	2	Y	0.626476	0.596655	1.05
	1F	EY	LinStatic	Step By Step	2	Y	0.330787	0.326972	1.012
	RF	EY	LinStatic	Step By Step	3	Y	2.953176	2.375166	1.243
	9F	EY	LinStatic	Step By Step	3	Y	2.81642	2.263076	1.245
	8F	EY	LinStatic	Step By Step	3	Y	2.628181	2.110142	1.245
	7F	EY	LinStatic	Step By Step	3	Y	2.391869	1.917895	1.247
	6F	EY	LinStatic	Step By Step	3	Y	2.116423	1.693201	1.25
	5F	EY	LinStatic	Step By Step	3	Y	1.811096	1.443599	1.255
	4F	EY	LinStatic	Step By Step	3	Y	1.484977	1.176589	1.262
	3F	EY	LinStatic	Step By Step	3	Y	1.146773	0.899425	1.275
	2F	EY	LinStatic	Step By Step	3	Y	0.804529	0.61922	1.299
	1F	EY	LinStatic	Step By Step	3	Y	0.463218	0.342856	1.351

4.2.2.3 : Torsional irregularity check from BNBC without shear wall

for Ex				
Story	Maximum in	Average in	Ratio	Check
RF	3.48703	3.28859	1.06	OK
9F	3.35898	3.16008	1.063	OK
8F	3.16027	2.96615	1.065	OK
7F	2.89656	2.71271	1.068	OK
6F	2.57875	2.41007	1.07	OK
5F	2.21811	2.06878	1.072	OK
4F	1.8256	1.69925	1.074	OK
3F	1.41171	1.31159	1.076	OK
2F	0.98653	0.91562	1.077	OK
1F	0.55773	0.51832	1.076	OK
RF	3.69006	3.31345	1.114	OK
9F	3.55512	3.18465	1.116	OK
8F	3.34539	2.98983	1.119	OK
7F	3.06657	2.73488	1.121	OK
6F	2.73021	2.43021	1.123	OK
5F	2.34826	2.08642	1.125	OK
4F	1.93236	1.71402	1.127	OK
3F	1.49364	1.32316	1.129	OK
2F	1.0428	0.92372	1.129	OK
1F	0.58824	0.52274	1.125	OK
RF	3.28399	3.26372	1.006	OK
9F	3.16283	3.13551	1.009	OK
8F	2.97515	2.94247	1.011	OK
7F	2.72655	2.69053	1.013	OK
6F	2.4273	2.38994	1.016	OK
5F	2.08796	2.05114	1.018	OK
4F	1.71883	1.68448	1.02	OK
3F	1.32978	1.30001	1.023	OK
2F	0.93027	0.90752	1.025	OK
1F	0.52722	0.51391	1.026	OK

for Ey				
Story	Maximum in	Average in	Ratio	Check
RF	2.52458	2.34443	1.077	OK
9F	2.40371	2.23349	1.076	OK
8F	2.23999	2.08243	1.076	OK
7F	2.03635	1.89249	1.076	OK
6F	1.80035	1.67037	1.078	OK
5F	1.5398	1.42354	1.082	OK
4F	1.26237	1.1594	1.089	OK
3F	0.97542	0.88517	1.102	OK
2F	0.68568	0.60794	1.128	OK
1F	0.397	0.33491	1.185	OK
RF	2.53139	2.31369	1.094	OK
9F	2.41681	2.20391	1.097	OK
8F	2.25765	2.05472	1.099	OK
7F	2.05333	1.86708	1.1	OK
6F	1.81081	1.64754	1.099	OK
5F	1.53845	1.40347	1.096	OK
4F	1.24467	1.14222	1.09	OK
3F	0.93775	0.87091	1.077	OK
2F	0.62648	0.59666	1.05	OK
1F	0.33079	0.32697	1.012	OK
RF	2.95318	2.37517	1.243	Limit Exceed
9F	2.81642	2.26308	1.245	Limit Exceed
8F	2.62818	2.11014	1.245	Limit Exceed
7F	2.39187	1.9179	1.247	Limit Exceed
6F	2.11642	1.6932	1.25	Limit Exceed
5F	1.8111	1.4436	1.255	Limit Exceed
4F	1.48498	1.17659	1.262	Limit Exceed
3F	1.14677	0.89943	1.275	Limit Exceed
2F	0.80453	0.61922	1.299	Limit Exceed
1F	0.46322	0.34286	1.351	Limit Exceed

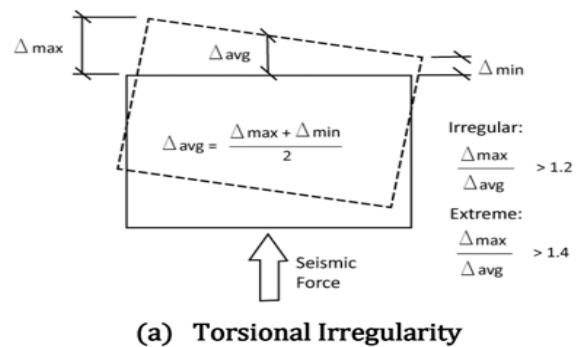
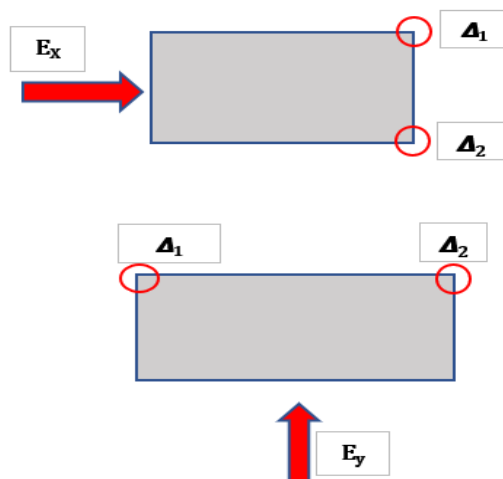


Figure 4.4 Torsional irregularity check from BNBC without shear wall

4.2.2 : Torsional Irregularity for seismic impact with shear wall

Filter: ([Output Case] = 'EX')

	Story	Output Case	Case Type	Step Type	Step Number	Direction	Maximum in	Average in	Ratio
	RF	EX	LinStatic	Step By Step	1	X	1.083466	1.021304	1.061
	9F	EX	LinStatic	Step By Step	1	X	0.998435	0.932448	1.071
▶	8F	EX	LinStatic	Step By Step	1	X	0.903491	0.835521	1.081
	7F	EX	LinStatic	Step By Step	1	X	0.797369	0.73019	1.092
	6F	EX	LinStatic	Step By Step	1	X	0.681088	0.617444	1.103
	5F	EX	LinStatic	Step By Step	1	X	0.557396	0.499859	1.115
	4F	EX	LinStatic	Step By Step	1	X	0.430207	0.381172	1.129
	3F	EX	LinStatic	Step By Step	1	X	0.304534	0.266217	1.144
	2F	EX	LinStatic	Step By Step	1	X	0.186846	0.161055	1.16
	1F	EX	LinStatic	Step By Step	1	X	0.086106	0.073431	1.173
	RF	EX	LinStatic	Step By Step	2	X	1.019153	1.017213	1.002
	9F	EX	LinStatic	Step By Step	2	X	0.937098	0.927826	1.01
	8F	EX	LinStatic	Step By Step	2	X	0.846096	0.830565	1.019
	7F	EX	LinStatic	Step By Step	2	X	0.745085	0.725148	1.027
	6F	EX	LinStatic	Step By Step	2	X	0.635025	0.612561	1.037
	5F	EX	LinStatic	Step By Step	2	X	0.518496	0.495363	1.047
	4F	EX	LinStatic	Step By Step	2	X	0.399172	0.377284	1.058
	3F	EX	LinStatic	Step By Step	2	X	0.28177	0.263147	1.071
	2F	EX	LinStatic	Step By Step	2	X	0.172345	0.158984	1.084
	1F	EX	LinStatic	Step By Step	2	X	0.079187	0.072436	1.093
	RF	EX	LinStatic	Step By Step	3	X	1.147779	1.025395	1.119
	9F	EX	LinStatic	Step By Step	3	X	1.059773	0.937069	1.131
	8F	EX	LinStatic	Step By Step	3	X	0.960886	0.840477	1.143
	7F	EX	LinStatic	Step By Step	3	X	0.849654	0.735231	1.156
	6F	EX	LinStatic	Step By Step	3	X	0.72715	0.622328	1.168
	5F	EX	LinStatic	Step By Step	3	X	0.596296	0.504354	1.182
	4F	EX	LinStatic	Step By Step	3	X	0.461242	0.38506	1.198
	3F	EX	LinStatic	Step By Step	3	X	0.327299	0.269287	1.215
	2F	EX	LinStatic	Step By Step	3	X	0.201347	0.163126	1.234
	1F	EX	LinStatic	Step By Step	3	X	0.093024	0.074426	1.25

Filter: ([Output Case] = 'EY')

	Story	Output Case	Case Type	Step Type	Step Number	Direction	Maximum in	Average in	Ratio
▶	RF	EY	LinStatic	Step By Step	1	Y	1.022892	0.964178	1.061
	9F	EY	LinStatic	Step By Step	1	Y	0.93556	0.889232	1.052
	8F	EY	LinStatic	Step By Step	1	Y	0.840434	0.805359	1.044
	7F	EY	LinStatic	Step By Step	1	Y	0.736293	0.711239	1.035
	6F	EY	LinStatic	Step By Step	1	Y	0.623765	0.607502	1.027
	5F	EY	LinStatic	Step By Step	1	Y	0.505271	0.496483	1.018
	4F	EY	LinStatic	Step By Step	1	Y	0.38467	0.381835	1.007
	3F	EY	LinStatic	Step By Step	1	Y	0.269777	0.268503	1.005
	2F	EY	LinStatic	Step By Step	1	Y	0.166189	0.163003	1.02
	1F	EY	LinStatic	Step By Step	1	Y	0.076892	0.074188	1.036
	RF	EY	LinStatic	Step By Step	2	Y	1.017004	0.954298	1.066
	9F	EY	LinStatic	Step By Step	2	Y	0.948437	0.880681	1.077
	8F	EY	LinStatic	Step By Step	2	Y	0.868316	0.798136	1.088
	7F	EY	LinStatic	Step By Step	2	Y	0.774919	0.705322	1.099
	6F	EY	LinStatic	Step By Step	2	Y	0.66894	0.602859	1.11
	5F	EY	LinStatic	Step By Step	2	Y	0.552907	0.493057	1.121
	4F	EY	LinStatic	Step By Step	2	Y	0.430676	0.379524	1.135
	3F	EY	LinStatic	Step By Step	2	Y	0.307419	0.267149	1.151
	2F	EY	LinStatic	Step By Step	2	Y	0.190043	0.162376	1.17
	1F	EY	LinStatic	Step By Step	2	Y	0.088321	0.073995	1.194
	RF	EY	LinStatic	Step By Step	3	Y	1.15419	0.974057	1.185
	9F	EY	LinStatic	Step By Step	3	Y	1.058194	0.897783	1.179
	8F	EY	LinStatic	Step By Step	3	Y	0.952912	0.812582	1.173
	7F	EY	LinStatic	Step By Step	3	Y	0.836861	0.717156	1.167
	6F	EY	LinStatic	Step By Step	3	Y	0.710753	0.612144	1.161
	5F	EY	LinStatic	Step By Step	3	Y	0.577336	0.49991	1.155
	4F	EY	LinStatic	Step By Step	3	Y	0.440968	0.384146	1.148
	3F	EY	LinStatic	Step By Step	3	Y	0.307581	0.269858	1.14
	2F	EY	LinStatic	Step By Step	3	Y	0.184923	0.163629	1.13
	1F	EY	LinStatic	Step By Step	3	Y	0.083298	0.074381	1.12

4.2.2.1 : Torsional irregularity check from BNBC with shear wall

for Ex				
Story	Maximum in	Average in	Ratio	Check
RF	1.05522	1.02833	1.026	OK
9F	0.97152	0.93906	1.035	OK
8F	0.87839	0.84168	1.044	OK
7F	0.77464	0.73582	1.053	OK
6F	0.66117	0.62241	1.062	OK
5F	0.5406	0.50401	1.073	OK
4F	0.41674	0.38439	1.084	OK
3F	0.29455	0.26845	1.097	OK
2F	0.18042	0.16239	1.111	OK
1F	0.0831	0.07407	1.122	OK
RF	1.05466	1.02742	1.027	OK
9F	0.95598	0.93747	1.02	OK
8F	0.84996	0.83956	1.012	OK
7F	0.73698	0.73335	1.005	OK
6F	0.62155	0.61979	1.003	OK
5F	0.50709	0.50143	1.011	OK
4F	0.38997	0.38202	1.021	OK
3F	0.27488	0.26649	1.031	OK
2F	0.16786	0.16102	1.042	OK
1F	0.07708	0.07341	1.05	OK
RF	1.11026	1.02925	1.079	OK
9F	1.02407	0.94065	1.089	OK
8F	0.92762	0.8438	1.099	OK
7F	0.81955	0.73828	1.11	OK
6F	0.70079	0.62503	1.121	OK
5F	0.5741	0.5066	1.133	OK
4F	0.44351	0.38675	1.147	OK
3F	0.31421	0.2704	1.162	OK
2F	0.19298	0.16375	1.178	OK
1F	0.08912	0.07474	1.193	OK

for Ey				
Story	Maximum in	Average in	Ratio	Check
RF	1.02289	0.96418	1.061	OK
9F	0.93556	0.88923	1.052	OK
8F	0.84043	0.80536	1.044	OK
7F	0.73629	0.71124	1.035	OK
6F	0.62377	0.6075	1.027	OK
5F	0.50527	0.49648	1.018	OK
4F	0.38467	0.38184	1.007	OK
3F	0.26978	0.2685	1.005	OK
2F	0.16619	0.163	1.02	OK
1F	0.07689	0.07419	1.036	OK
RF	1.017	0.9543	1.066	OK
9F	0.94844	0.88068	1.077	OK
8F	0.86832	0.79814	1.088	OK
7F	0.77492	0.70532	1.099	OK
6F	0.66894	0.60286	1.11	OK
5F	0.55291	0.49306	1.121	OK
4F	0.43068	0.37952	1.135	OK
3F	0.30742	0.26715	1.151	OK
2F	0.19004	0.16238	1.17	OK
1F	0.08832	0.074	1.194	OK
RF	1.15419	0.97406	1.185	OK
9F	1.05819	0.89778	1.179	OK
8F	0.95291	0.81258	1.173	OK
7F	0.83686	0.71716	1.167	OK
6F	0.71075	0.61214	1.161	OK
5F	0.57734	0.49991	1.155	OK
4F	0.44097	0.38415	1.148	OK
3F	0.30758	0.26986	1.14	OK
2F	0.18492	0.16363	1.13	OK
1F	0.0833	0.07438	1.12	OK

Figure 4.5 Torsional irregularity check from BNBC with shear wall

4.2.3 Stiffness

Stiffness for the structure with shear wall has shown in figure 4.5. In this figure, the maximum stiffness

Ration show the table

Filter: ([Output Case] = 'EX')

	Story	Output Case	Case Type	Step Type	Step Number	Shear X kip	Drift X in	Stiff X kip/in	Shear Y kip	Drift Y in	Stiff Y kip/in	Irregular	Modifier
▶	LT	EX	LinStatic	Step By Step	1	0.729	0.037356	19.5141	2.394E-05	0.001002	0	No	
	ST	EX	LinStatic	Step By Step	1	1.502	0.037191	40.3953	4.175E-05	0.000997	0	No	1
	LB	EX	LinStatic	Step By Step	1	2.639	0.036969	71.3805	5.45E-05	0.000981	0	No	1
	RF	EX	LinStatic	Step By Step	1	34.629	0.088809	389.931	0.013	0.003622	0	No	1
	9F	EX	LinStatic	Step By Step	1	73.585	0.097984	750.9887	0.033	0.002224	0	No	1
	8F	EX	LinStatic	Step By Step	1	106.56	0.107995	986.7164	0.055	0.001586	0	No	1
	7F	EX	LinStatic	Step By Step	1	133.916	0.114784	1166.671	0.078	0.004048	0	No	1
	6F	EX	LinStatic	Step By Step	1	156.031	0.118714	1314.3473	0.102	0.006242	0	No	1
	5F	EX	LinStatic	Step By Step	1	173.309	0.118687	1460.2189	0.126	0.008416	0	No	1
	4F	EX	LinStatic	Step By Step	1	186.181	0.114955	1619.6034	0.15	0.010302	0	No	1
	3F	EX	LinStatic	Step By Step	1	195.121	0.105162	1855.42	0.173	0.01197	0	No	1
	2F	EX	LinStatic	Step By Step	1	200.653	0.087623	2289.9482	0.194	0.012208	0	No	1
	1F	EX	LinStatic	Step By Step	1	203.388	0.059784	3403.1572	0.21	0.00881	0	No	1
	GB	EX	LinStatic	Step By Step	1	203.61	0.013967	14577.5152	0.212	0.002128	0	No	1

Filter: ([Output Case] = 'EY')

	Story	Output Case	Case Type	Step Type	Step Number	Shear X kip	Drift X in	Stiff X kip/in	Shear Y kip	Drift Y in	Stiff Y kip/in	Irregular	Modifier
▶	LT	EY	LinStatic	Step By Step	1	0	0.00051	0	0.758	0.032947	22.9922	No	1
	ST	EY	LinStatic	Step By Step	1	1.026E-05	0.000457	0	1.562	0.032994	47.3566	No	1
	LB	EY	LinStatic	Step By Step	1	3.83E-05	0.00043	0	2.748	0.032803	83.7582	No	1
	RF	EY	LinStatic	Step By Step	1	0.016	0.001216	0	36.15	0.083094	435.0522	No	1
	9F	EY	LinStatic	Step By Step	1	0.037	0.002109	0	77.03	0.092632	831.5688	No	1
	8F	EY	LinStatic	Step By Step	1	0.059	0.003053	0	111.815	0.101889	1097.4194	No	1
	7F	EY	LinStatic	Step By Step	1	0.082	0.004463	0	140.843	0.112199	1255.2978	No	1
	6F	EY	LinStatic	Step By Step	1	0.106	0.005623	0	164.466	0.11995	1371.1254	No	1
	5F	EY	LinStatic	Step By Step	1	0.13	0.006426	0	183.085	0.123755	1479.2603	No	1
	4F	EY	LinStatic	Step By Step	1	0.154	0.007097	0	197.05	0.122254	1611.8083	No	1
	3F	EY	LinStatic	Step By Step	1	0.176	0.007606	0	206.869	0.113784	1818.0886	No	1
	2F	EY	LinStatic	Step By Step	1	0.196	0.007464	0	213.032	0.093036	2289.7857	No	1
	1F	EY	LinStatic	Step By Step	1	0.211	0.006399	0	216.136	0.063926	3381.0139	No	1
	GB	EY	LinStatic	Step By Step	1	0.213	0.001686	0	216.396	0.015227	14210.9397	No	1

Figure 4.6 : Stiffness for Seismic with shear wall

4.2.3.1 : Stiffness check for BNBC 2020

Story	Stiffness	$\frac{K_i}{K_{i+1}}$	Check	$\frac{K_i}{K_{i+1} + K_{i+2} + K_{i+3}}$	Check
		0.7		0.8	

Input					
LT	19.5141				
ST	40.3953	2.070057	OK		
LB	71.3805	1.7670496	OK		
RF	389.931	5.4627104	OK	8.91	OK
F9	750.9887	1.9259528	OK	4.490603	OK
F8	986.7164	1.3138898	OK	2.441763	OK
F7	1166.671	1.1823772	OK	1.645024	OK
F6	1314.3473	1.1265792	OK	1.357621	OK
F5	1460.2189	1.1109841	OK	1.263262	OK
F4	1619.6034	1.1091511	OK	1.232813	OK
F3	1855.42	1.1456014	OK	1.266738	OK
F2	2289.9482	1.234194	OK	1.391997	OK
F1	3403.1572	1.4861285	OK	1.770949	OK
	14577.515	4.2835268	OK	5.793522	OK
			-		-
			-		-
			-		-
			-		-
			-		-

Story	Stiffness	$\frac{K_i}{K_{i+1}}$	Check	$\frac{K_i}{K_{i+1} + K_{i+2} + K_{i+3}}$	Check
		0.7		0.8	

Input					
LT	22.9922				
ST	47.3566	2.0596811	OK		
LB	83.7582	1.76867	OK		
RF	435.0522	5.1941446	OK	8.469158	OK
F9	831.5688	1.911423	OK	4.406308	OK
F8	1097.4194	1.3196977	OK	2.438025	OK
F7	1255.2978	1.1438633	OK	1.59299	OK
F6	1371.1254	1.092271	OK	1.291773	OK
F5	1479.2603	1.0788658	OK	1.191721	OK
F4	1611.8083	1.0896042	OK	1.177739	OK
F3	1818.0886	1.1279807	OK	1.222328	OK
F2	2289.7857	1.2594467	OK	1.399295	OK
F1	3381.0139	1.4765635	OK	1.773357	OK
	14210.94	4.2031592	OK	5.69281	OK
			-		-
			-		-
			-		-
			-		-

4.2.3.2: Stiffness without shear wall has showing 4.6 in the figure the maximum stiffness ration shows the table

	Story	Output Case	Case Type	Step Type	Step Number	Shear X kip	Drift X in	Stiff X kip/in	Shear Y kip	Drift Y in	Stiff Y kip/in	Irregular	Modifier
▶	LT	EX	LinStatic	Step By Step	1	1.767	0.040971	43.1319	0.001	0.001283	0	No	1
	ST	EX	LinStatic	Step By Step	1	2.336	0.041409	56.4179	0.002	0.001266	0	No	1
	LB	EX	LinStatic	Step By Step	1	4.596	0.038	120.9339	0.004	0.001232	0	No	1
	RF	EX	LinStatic	Step By Step	1	69.39	0.143073	484.9945	0.022	0.004041	0	No	1
	9F	EX	LinStatic	Step By Step	1	147.1	0.204725	718.5278	0.046	0.004322	0	No	1
	8F	EX	LinStatic	Step By Step	1	212.683	0.256521	829.1031	0.072	0.008698	0	No	1
	7F	EX	LinStatic	Step By Step	1	266.951	0.30249	882.5126	0.1	0.012647	0	No	1
	6F	EX	LinStatic	Step By Step	1	310.762	0.341177	910.8525	0.13	0.016134	0	No	1
	5F	EX	LinStatic	Step By Step	1	345.019	0.369431	933.9189	0.162	0.019159	0	No	1
	4F	EX	LinStatic	Step By Step	1	370.685	0.387581	956.4072	0.196	0.021861	0	No	1
	3F	EX	LinStatic	Step By Step	1	388.8	0.394957	984.4101	0.234	0.024351	0	No	1
	2F	EX	LinStatic	Step By Step	1	400.496	0.397295	1008.0549	0.277	0.02627	0	No	1
	1F	EX	LinStatic	Step By Step	1	407.006	0.400831	1015.4043	0.328	0.029022	0	No	1
	GB	EX	LinStatic	Step By Step	1	407.671	0.117693	3463.8407	0.344	0.008214	0	No	1

	Story	Output Case	Case Type	Step Type	Step Number	Shear X kip	Drift X in	Stiff X kip/in	Shear Y kip	Drift Y in	Stiff Y kip/in	Irregular	Modifier
▶	LT	EY	LinStatic	Step By Step	1	0.001	0.002467	0	1.757	0.045315	38.784	No	1
	ST	EY	LinStatic	Step By Step	1	0.001	0.002411	0	2.323	0.045029	51.5916	No	1
	LB	EY	LinStatic	Step By Step	1	0.003	0.001884	0	4.568	0.042655	107.0792	No	1
	RF	EY	LinStatic	Step By Step	1	0.019	0.004693	0	68.917	0.117519	586.4294	No	1
	9F	EY	LinStatic	Step By Step	1	0.047	0.005927	0	145.937	0.156858	930.3762	No	1
	8F	EY	LinStatic	Step By Step	1	0.075	0.006457	0	210.784	0.193589	1088.8246	No	1
	7F	EY	LinStatic	Step By Step	1	0.105	0.006754	0	264.281	0.223751	1181.1371	No	1
	6F	EY	LinStatic	Step By Step	1	0.136	0.006899	0	307.29	0.24661	1246.0573	No	1
	5F	EY	LinStatic	Step By Step	1	0.167	0.006804	0	340.723	0.263332	1293.8913	No	1
	4F	EY	LinStatic	Step By Step	1	0.199	0.006507	0	365.55	0.273471	1336.7031	No	1
	3F	EY	LinStatic	Step By Step	1	0.233	0.006402	0	382.816	0.276474	1384.6391	No	1
	2F	EY	LinStatic	Step By Step	1	0.269	0.009155	0	393.663	0.27208	1446.8674	No	1
	1F	EY	LinStatic	Step By Step	1	0.307	0.023051	0	399.348	0.263244	1517.0283	No	1
	GB	EY	LinStatic	Step By Step	1	0.315	0.008391	0	399.86	0.073367	5450.1456	No	1

Figure 4.7 : Stiffness for the seismic without shear wall

4.2.3.3 : Stiffness check for BNBC 2020 without shear wall

Story	Stiffness	$\frac{K_i}{K_{i+1}}$	Check	$\frac{K_i}{K_{i+1} + K_{i+2} + K_{i+3}}$	Check
		0.7		0.8	

Input					
LT	43.1319				
ST	56.4179	1.3080319	OK		
LB	120.9339	2.1435378	OK		
RF	484.9945	4.0104098	OK	6.599052	OK
F9	718.5278	1.4815174	OK	3.254466	OK
F8	829.1031	1.1538915	OK	1.877985	OK
F7	882.5126	1.0644184	OK	1.302521	OK
F6	910.8525	1.0321127	OK	1.124443	OK
F5	933.9189	1.025324	OK	1.068366	OK
F4	956.4072	1.0240795	OK	1.052044	OK
F3	984.4101	1.0292793	OK	1.054281	OK
F2	1008.0549	1.0240193	OK	1.05198	OK
F1	1015.4043	1.0072907	OK	1.033009	OK
	3463.8407	3.4112921	OK	3.454778	OK
			-		-
			-		-
			-		-
			-		-

Story	Stiffness	$\frac{K_i}{K_{i+1}}$	Check	$\frac{K_i}{K_{i+1} + K_{i+2} + K_{i+3}}$	Check
		0.7		0.8	

Input					
LT	38.784				
ST	51.5916	1.330229	OK		
LB	107.0792	2.0755162	OK		
RF	586.4294	5.4765949	OK	8.909827	OK
F9	930.3762	1.5865102	OK	3.745978	OK
F8	1088.8246	1.1703057	OK	2.011518	OK
F7	1181.1371	1.0847818	OK	1.359906	OK
F6	1246.0573	1.0549642	OK	1.168055	OK
F5	1293.8913	1.0383883	OK	1.103997	OK
F4	1336.7031	1.0330876	OK	1.077672	OK
F3	1384.6391	1.0358614	OK	1.071522	OK
F2	1446.8674	1.0449419	OK	1.081034	OK
F1	1517.0283	1.0484916	OK	1.091856	OK
	5450.1456	3.592646	OK	3.759988	OK
			-		-
			-		-
			-		-
			-		-
			-		-

4.2.4 Base Shear

Base shear is an estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure. Calculations of base shear (V) depend on soil conditions at the site. Proximity to potential sources of seismic activity (such as geological faults) Figure 4.10,4.11 shows the total base shear of this selected structure are percentage of weight, respectively in four seismic zones.

	Output Case	Case Type	Step Type	Step Number	FX kip	FY kip	FZ kip	MX kip-ft	MY kip-ft	MZ kip-ft
▶	Dead	LinStatic			0	0	5111.127	119712.2949	-191104.752	-1.004E-06
	Live	LinStatic			0	0	588.858	14952.9936	-23326.286	0
	FF	LinStatic			0	0	845.117	20058.4252	-31507.425	0
	PW	LinStatic			0	0	2075.747	51572.0182	-76783.6368	1.507E-06
	LIVE>3KN	LinStatic			0	0	1666.291	36643.8623	-58494.8147	-3.4E-06
	RL	LinStatic			0	0	0	0	0	0
	RL1	LinStatic			0	0	69.117	1691.2487	-2593.5674	0
	EX	LinStatic	Step By Step	1	-215.86	0	0	-1.523E-06	-16822.047	5092.0684
	EX	LinStatic	Step By Step	2	-215.86	0	0	-1.991E-06	-16822.047	5577.2659
	EX	LinStatic	Step By Step	3	-215.86	0	0	-1.056E-06	-16822.047	4606.871
	EY	LinStatic	Step By Step	1	0	-222.372	0	17287.0264	1.421E-06	-8208.0299
	EY	LinStatic	Step By Step	2	0	-222.372	0	17287.0264	1.148E-05	-8977.2593
	EY	LinStatic	Step By Step	3	0	-222.372	0	17287.0264	-8.635E-06	-7438.8005
	WX+	LinStatic			-175.636	0	0	-1.123E-06	-10793.0806	4266.2097
	WX-	LinStatic			175.636	0	0	1.123E-06	10793.0806	-4266.2097
	WY+	LinStatic			0	-292.562	0	17900.8779	3.874E-06	-10934.4986
	WY-	LinStatic			0	292.562	0	-17900.8779	-3.874E-06	10934.4986

FROM ETABS				
PROCEDURE				
Table > Analysis > Result Reactions > Base Reaction (ETABS 2016)				
Table > Analysis Result > Structure Output > Base Reaction (ETABS 2020)				
Input				
DEAD LOAD	DL	=	5111.13	kip
PARTITION WALL LOAD	PW	=	2075.75	kip
FLOOR FINISH	FF	=	845.117	kip
LIVE LOAD > 3KN	LL	=	1666.29	kip
LIVE LOAD < 3KN	LL	=	588.858	kip
Roof LIVE LOAD	LL	=	69.117	kip
MAXIMUM EARTHQUAKE LOAD,	EQmax	=	215.86	kip
Calculations & Results				
				Base Shear =
DL	LL	Total Vertical Load	EQmax	(Lateral/Vertical)
8031.99	997.639	9029.63	215.86	2.39%

From Hand Calculations- BNBC 2020				
Input				
Zone Coefficient	Z	=	0.2	
Importance Factor	I	=	1	
	Ct	=	0.0466	
Height of Building	hn	=	32.3 m	
Site Coefficient	S	=	1.15	
Response Reduction Factor, R		=	6.5	
	m	=	0.9	
Time Period	T	=	1.06384	(Ct x hn ^m)
	Cs	=	1.62149	
	Sa	=	0.03326	
	Sa _(min)	=	0.01695	
Base Shear, Sa=V/W		=	3.33%	
* if Base Shear varies at a large number between Etabs & Hand Calculations Then Check the Model				

Figure: 4.8 Base shear in II Zone with shear wall

	Output Case	Case Type	Step Type	Step Number	FX kip	FY kip	FZ kip	MX kip-ft	MY kip-ft	MZ kip-ft
▶	Dead	LinStatic			0	0	4813.734	112132.2411	-178199.4676	2.124E-06
	Live	LinStatic			0	0	588.858	14952.9936	-23326.286	6.24E-07
	FF	LinStatic			0	0	845.117	20058.4252	-31507.425	0
	PW	LinStatic			0	0	1972.765	49812.0076	-69852.8856	1.765E-06
	LIVE>3KN	LinStatic			0	0	1666.291	36643.8623	-58494.8147	0
	RL	LinStatic			0	0	0	0	0	0
	RL1	LinStatic			0	0	69.117	1691.2487	-2593.5674	0
	EX	LinStatic	Step By Step	1	-382.963	0	0	-2.858E-06	-30260.7356	9026.9442
	EX	LinStatic	Step By Step	2	-382.963	0	0	-4.259E-06	-30260.7356	9923.1747
	EX	LinStatic	Step By Step	3	-382.963	0	0	-1.457E-06	-30260.7356	8130.7138
	EY	LinStatic	Step By Step	1	0	-382.963	0	30260.7355	-6.693E-07	-13957.0213
	EY	LinStatic	Step By Step	2	0	-382.963	0	30260.7355	0	-15336.0503
	EY	LinStatic	Step By Step	3	0	-382.963	0	30260.7355	-1.28E-06	-12577.9924
	WX+	LinStatic			-175.636	0	0	-1.1E-06	-10793.0809	4266.2098
	WX-	LinStatic			175.636	0	0	1.1E-06	10793.0809	-4266.2098
	WY+	LinStatic			0	-292.562	0	17900.8781	0	-10934.4986
	WY-	LinStatic			0	292.562	0	-17900.8781	0	10934.4986

FROM ETABS				
PROCEDURE				
Table > Analysis > Result Reactions > Base Reaction (ETABS 2016)				
Table > Analysis Result > Structure Output > Base Reaction (ETABS 2020)				
Input				
DEAD LOAD	DL	=	4813.734	kip
PARTITION WALL LOAD	PW	=	1972.765	kip
FLOOR FINISH	FF	=	845.117	kip
LIVE LOAD > 3KN	LL	=	1666.291	kip
LIVE LOAD < 3KN	LL	=	588.858	kip
Roof LIVE LOAD	LL	=	69.117	kip
MAXIMUM EARTHQUAKE LOAD,	EQmax	=	382.963	kip
Calculations & Results				
	DL	LL	Total Vertical Load	EQmax (Lateral/Vertical)
	7631.616	997.6393	8629.255	382.963 4.44%
				Base Shear =

From Hand Calculations- BNBC 2020				
Input				
Zone Coefficient	Z	=	0.2	
Importance Factor	I	=	1	
	Ct	=	0.0466	
Height of Building	hn	=	32.3 m	
Site Coefficient	S	=	1.15	
Response Reduction Factor, R		=	3	
	m	=	0.9	
Time Period	T	=	1.06384	(Ct x hn ^m)
	Cs	=	1.62149	
	Sa	=	0.07207	
	Sa _(min)	=	0.01695	
Base Shear, Sa=V/W		=	7.21%	
* if Base Shear varies at a large number between Etabs & Hand Calculations Then Check the Model				

Figure: 4.9 Base shear in II Zone without shear wall

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 General

Bangladesh is located in a tectonically active region close to the plate boundaries of the Indian plate and the Eurasian plate. The effect of earthquake is more severe in an underdeveloped and a densely populated country like Bangladesh than any other developed countries. According to building codes, earthquake resistant structures are intended to withstand the largest earthquake of a certain probability that is likely to occur at their location. This means the loss of life should be minimized by preventing collapse of the buildings for rare earthquakes while the loss of the functionality should be limited for more frequent ones. Accurate historical information on earthquakes is very important in evaluating the seismicity of Bangladesh in close coincidences with the geotectonic elements. The aim of this study is to give an idea of the structural engineer about the costing of same structure in four seismic zones in Bangladesh. It may insist to contract proper seismic resistance building in four seismic zones of Bangladesh. To fulfill the aim of the study two different heights (150 feet and 80 feet) of building are considered as individual buildings are analyzed and designed separately, for four seismic loads as per BNBC-2020. All these buildings are analysis considered intermediate moment resisting frame (dual system) with constant wind load. Selected structures are designed by using ETABS - 2016 considering seismic loads as per BNBC 2015 in four seismic zones of Bangladesh. Seismic detailing of various structural elements is done based on BNBC 2015. Finally, structural drawing is prepared of these building for cost estimation. The following conclusions could be done as per height of the structures.

5.2 Conclusion

After an extensive and systematical study, the following conclusions could be derived as per height of the structure.

1. The Story Displacements are varying with the location of shear wall and it is controlled with the use of shear wall rather than without shear wall.
2. Drift are also same as the story displacement of the structure i.e. drift is minimum while using shear wall rather than without shear wall.

3. Stiffness is increased by using shear wall rather than without shear wall.
4. Base shear is increasing with the zone change, but remains the same with shear wall and without shear wall.

5.3 Recommendation

This research can be done in many of the following ways:

1. The study can also be effective while considering the beam and column effects of four zones.
2. The variations of reinforcement in beam and column with zones can also be studied.
3. The cost evaluation of the structure can also be studied with zone coefficient.

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