COMPARISON OF WIND AND SEISMIC EFFECTS ON HIGH RISE MULTI-STORIED BUILDINGS FOR TWO SELECTED ZONES IN BANGLADESH BY USING ETABS

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

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Section: 17B

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DECLARATION

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

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Dedicated

to

"Our Respectful Teachers & Parents"

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ABSTRACT

This study aims at the comparison of provisions of seismic and wind load analysis given in BNBC 2020. The revised BNBC 2020 has divided the seismic zones of Bangladesh into four different categories such as Zone-I, Zone-II, Zone-III and Zone-IV respectively. They have different seismic zone coefficients. Finally, structural analysis and design of a typical G+9 storey residential building situated in two selected seismic zones is conducted to investigate the seismic behavior of that building under revised seismic zones and seismic zone coefficients. In this study, the maximum story displacement of Zone 3 (Chittagong) to Zone 4 (Sylhet) high rise multistory structure is 0%, 127.57%, 58.34% and 58.14% for load EQX, EQY, WLX and WLY respectively. And the maximum story drift of Zone 3 (Chittagong) to Zone 4 (Sylhet) high rise multistory structure is 0%, 147%, 57.81%, and 56.45% for load EQX, EQY, WLX and WLY respectively. The deflection of various members, inter storey drift, lateral displacement of the whole structure and stress of all members, inter storey lateral displacement of the whole structure and stress of all members were checked comparison with limiting value of the design criteria. After the preliminary design, the various cross section of beams and column and beam which the volume of concrete and quantity of steel is saved to precise amount and maximize the usable floor area by satisfying the design criteria.

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CHAPTER 1
INTRODUCTION

1.1 General

People's lives and property are at risk during earthquakes. Therefore, it is essential now to predict the strength of an earthquake and prepare for it to avoid or minimize damage. It should be noted here that strengthening the building against seismic load increases its cost, so this work was done.

The increase in population by which land deficit occurs and to control that, high-rise buildings are opted. These types of high-rise buildings are affected by the natural calamities. Calamities like earthquakes are the most dangerous by means of the damage and chaos caused to the structural components and they cannot be controlled. These natural calamities cause property damage and interruptions in development of the normal lifecycle. Since it’s a global concern, most of the analysis should be carried out and provided with the results to prep the structure in order to attain time period. A seismic wave is the cause of ground motions that are much larger on the soil surface than on the rock base. Structures located on such sites sustain more damage than sites located closer to the rock surface. The seismic effect on any structure is determined by the seismic zone coefficient, response reduction factor, soil characteristics, structure importance, and so on. It is necessary to be aware of the most recent earthquake codes in order to design an earthquake-resistant structure. In most small and moderate-sized buildings, the dynamic effects of earthquake loads are typically analyzed as an equivalent static load. Recent earthquakes in Bangladesh's urban areas have highlighted the importance of pushing to strengthen these seismically deficient structures and making progress in developing various strengthening and rehabilitation techniques to improve the seismic performance of structures.

1.2 Background of the Study

It is indicated that a significant number of structures are completely or partially harmed as a result of earthquakes, and it is now critical to decide seismic reactions over such structures. Structural analysis is a branch of engineering that focuses on the assurance of structures with the goal of anticipating the reactions of genuine structures such as structures, spans, trusses, and so on before developing any structure, basic outlining necessitates basic investigation and seismic examination. In order to meet the needs of this growing population in a constrained space, the building's height has been reduced to medium to tall. As a result, seismic examination study and planning quake protection structures are required to ensure safety against seismic powers of multistory working. Displacement of structure begins from the purposes of a shortcoming during an earthquake. Geometry, mass brokenness, and structure solidity are the most common causes of shortcoming. That is why in general, structures fail during earthquakes due to vertical abnormality.

The initial goal of this research is to investigate seismic reaction in two different zones of structure for static and dynamic examination in standard minute opposing casing. We considered a residential building with (G+9) stories for the seismic Investigation. The method for establishing the base plan loads that must be acquired for dead loads, forced burdens, and other outside loadings attaches the basic necessities relating to the basic security of structures. The total structure was analyzed on a computer using the ETABS software. In this paper, an analysis done for (G+9=10) RCC building under seismic loads for Chittagong District (Zone III), and Sylhet District (Zone IV). Numerous load combinations are observed in accordance with BNBC 2020.

1.3 Objectives

1. To analyze a high-rise multi-story residential building for two different seismic zone in Bangladesh.
2. To compare the wind load effect on high-rise multi-story structures for two different zone in Bangladesh according to BNBC 2020 by using ETABS.
3. To compare the seismic effect on high-rise multi-story structures for two different zone in Bangladesh according to BNBC 2020 by using ETABS.

1.4 Organization of the Thesis

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

Chapter 2: Literature Review: This part discusses the previous analysis history about earthquake or seismic wave, recent research on seismic zone, methods for analyzing a frame structures, software used for analysis.

Chapter 3: Methodology: This chapter discusses the analytical process in details step by step. seismic design requirements as per BNBC-2020, wind load and wind load code provisions as per BNBC-2020, seismic load and seismic load code provisions as per BNBC-2020. The Zonal Parameters, Load principles and types of load acting on the structure are also discussed in this chapter. Different floor plan view and building analysis image are also shown in this chapter.

Chapter 4: Results and Discussion: This chapter describes the results of the proposed buildings load and material properties, building load calculation.. Overall and zone to zone maximum story drift and maximum story displacement analysis data and results are also discussed in this chapter.

Chapter 5: Conclusions and Future Work: This chapter summarizes the conclusions and major contributions of this study and provides recommendations for future studies.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

Millions of people have died due to natural disasters, more than half have died in earthquakes and the rest due to weather and climate-related hazards. The poorest nations paid the highest price in terms of disaster deaths. Therefore, new advanced, ideal and inexpensive techniques should be used for the design and construction of structures. Due to the rapid urbanization of a large number of multi-story buildings, many existing RCC buildings in seismic zones are not earthquake proof. To meet the demands of this growing population in the limited the land, the height of the building is turned from medium to high. Today, due to the dramatic increase in urban population, land scarcity, and high cost, multi-story buildings are widespread in urban areas around the world. The challenge, however, is that as the height of the structure increases, the lateral loads are affected. These lateral loads are mainly presented in the form of wind load and seismic load. Therefore, an effective design approach and advanced construction techniques are applied to protect buildings from wind load and seismic load. Much research and studies have been done to improve the performance of tall buildings against these loads. The most important and effective design approach among these methods is to change the geometry of the building floor plan and, furthermore, it is very simple and does not require many more techniques. In the past, a rectangular plan shape was mainly adopted, but today many more different plan shapes are used. Therefore, it is necessary to examine the behavior of buildings with different floor plans and compare them against various parameters to find the most suitable floor plan.

2.2 Previous Background of the Study

U.Muhib et.al (2022) studied the comparative study of seismic load on residential building. For analysis he used ETABS software with four different zones and wind speeds. He performed analysis on 18m building. Evaluation of load patterns and lateral forces according to BNBC 2020 codes were assigned and to investigate the seismic behavior of that building under revised seismic zones and seismic zone coefficients. The deflection of various members, inter storey drift, lateral displacement of the whole structure and stress of all members, inter storey lateral displacement of the whole structure and stress of all members were checked comparison with limiting value of the design criteria.

C.Alamin et.al (2021) studied the comparative study of seismic load on multi-storied (G+9) residential building for four different zones in Bangladesh. For analysis he used ETABS software with four different zone co-efficient and wind speeds. He performed analysis on 39m building. Evaluation of load patterns and lateral forces according to BNBC 2020 codes were assigned and to investigate the seismic behavior of that building under revised seismic zones and seismic zone coefficients. The deflection of various members, inter storey drift, lateral displacement of the whole structure and stress of all members, inter storey lateral displacement of the whole structure and stress of all members were checked comparison with limiting value of the design criteria.

2.3 Methods for Analyzing a Frame Structure

There are some methods to analysis a frame. Method of analysis of statistically indeterminate portal frames:

1. Method of flexibility coefficients
2. Slope displacements methods (iterative methods)
3. Moment distribution method
4. Cantilever method
5. Portal method
6. Matrix method

2.3.1 Methods of Flexibility Co-efficient

The flexibility coefficient is popularly used to implement the macroevolution of shape, safety, and economy for arch dam. The method of consistent deformations, or sometimes referred to as the force or flexibility method, is one of the several techniques available to analyze indeterminate structures. The following is the procedure that describes the concept of this method for analyzing externally indeterminate structures with single or double degrees of indeterminacy. The method of analysis is Comprised of reducing the hyper static structure to a determinate structure form by removing the redundant support (or) introducing adequate cuts (or) hinges.

Limitations:

It is not applicable for degree of redundancy>3

2.3.2 Slope Displacement Equations

The slope deflection method is a structural analysis method for beams and frames introduced in 1914 by George A. Many. The slope deflection method was widely used for more than a decade until the moment distribution method was developed.

By forming slope deflection equations and applying joint and shear equilibrium conditions, the rotation angles (or the slope angles) are calculated. Substituting them back into the slope deflection equations, member end moments are readily determined.

Displacement is used for those cases which are given below:

1. General Case
2. Stiffness Coefficients
3. Stiffness Coefficients Derivation
4. Fixed-End Moments
5. Pin-Supported End Span
6. Typical Problems
7. Analysis of Beams
8. Analysis of Frames: No Sideway
9. Analysis of Frames: Sideway
10. A solution of simultaneous equations makes methods tedious for manual computations.
11. This method is not recommended for frames larger than two bays and two stories.

2.3.3 Moment Distribution Method

The moment distribution method is a structural analysis method for statically indeterminate beams and frames developed by Hardy Cross. It was published in 1930 in an ASCE journal. The method only accounts for flexural effects and ignores axial and shear effects. From the 1930s until computers began to be widely used in the design and analysis of structures, the moment distribution method was the most widely practiced method.

In the moment distribution method, every joint of the structure to be analyzed is fixed to develop the fixed-end moments. Then each fixed joint is sequentially released, and the fixed-end moments are distributed to adjacent members until equilibrium is achieved. The moment distribution method in mathematical terms can be demonstrated as the process of solving a set of simultaneous equations by means of iteration.

2.3.4 Cantilever Method

The Cantilever Method was devised to calculate and analyze shear forces and moments developed indifferent members, as beams and columns, of a frame or structure due to lateral loads. The lateral loads include wind load and earthquake load which must be taken into consideration while designing the buildings.

The assumptions which are assumed in this method are that the point of contra flexure is located at the mid-point of the vertical members as well as horizontal members and that the direct stresses in the columns are proportional to their distances from the centroid axis. The frame is analyzed in stepwise fashion, and the details can then be described by the diagram at the end. The method is quite versatile and can be used to analyze frame of any number of stores or floors.

The position of the centriole axis is determined by using the areas of the end columns and intermediate columns. The method is considered as one of the two approximate methods for indeterminate structural analysis of frames for lateral loads.

2.3.5 Portal Method

A portal frame is often used in a structure to transfer the laterally directed loads applied along the sides to the supports at the base of the frame. Portal frames are often designed such that they can confidently withstand lateral loads. This results in many portal frames being statically indeterminate externally; because of the frames ability to support horizontal loading, this type of frame is commonly used in structures like buildings, factories, and bridges.

The approximate analysis of portal frames can be investigated through the portal method. Before the analysis, there are necessary assumptions to be made:

1. A point of inflection is located at the center of each member of the Portal frame.
2. For each story of the frame, the interior columns bear twice as much shear as the exterior columns.
3. Lateral forces resisted by frame action.
4. Inflection points at mid-height of columns.
5. Inflection points at mid-span of beams.
6. Column shear is based on tributary area.
7. Overturn is resisted by exterior columns only.

2.3.6 Matrix Method

As one of the methods of structural analysis, the direct stiffness method, also known as the matrix stiffness method, is particularly suited for computer-automated analysis of complex structures including the statically indeterminate type. It is a matrix method that makes use of the members' stiffness relations for computing member forces and displacements in structures. The direct stiffness method is the most common implementation of the finite element method (FEM). In applying the method, the system must be modeled as a set of simpler, idealized elements interconnected at the nodes. The material stiffness properties of these elements are then, through matrix mathematics, compiled into a single matrix equation which governs the behavior of the entire idealized structure. The structure's unknown displacements and forces can then be determined by solving this equation. The direct stiffness method forms the basis for most residential and free source finite element software.

2.4 Software Used:

This project is mostly based on software, and it is essential to know the details about these softwares.

List of softwares used

1. ETABS 2018 (18.1.1)
2. Auto CAD 2020
3. Microsoft Word Document 2013

2.4.1 ETABS 2018 (18.1.1)

ETABS is powerful design software licensed by CSI. ETABS stands for Extended Three-dimensional Analyses of Building Systems. Any object which is stable under a given loading can be considered as structure. The innovative and revolutionary new ETABS is the ultimate integrated software package for the structural analysis and design of buildings. Incorporating 40 years of continuous research and development, this latest ETABS offers unmatched 3D object-based modeling and visualization tools, blazingly fast linear and nonlinear analytical power, sophisticated and comprehensive design capabilities for a wide-range of materials, and insightful graphic displays, reports, and schematic drawings that allow users to quickly and easily decipher and understand analysis and design results.

Nowadays most of the high-rise buildings are designed by ETABS which makes a compulsion for a civil engineer to know about this software. This software can be used to carry RCC, steel, bridge, truss etc. according to various country codes.

2.4.2 AutoCAD 2020

AutoCAD is a commercial software application for 2D and 3D computer-aided design (CAD) and drafting available since 1982 as a desktop application and since 2010 as a mobile web- and cloud based appmarketedasAutoCAD360.

Developed and marketed by Autodesk, Inc., AutoCAD was first released in December 1982, running on microcomputers with internal graphics controllers. Prior to the instruction of AutoCAD, most commercial CAD programs ran on mainframe computers or minicomputers, with each CAD operator (user) working at a separate graphics terminal.

AutoCAD is used across a wide range of industries, by architects, project managers, engineers, designers, and other professionals. We used AutoCAD for drawing the plan and elevation of the building. We also used AutoCAD to show the reinforcement details and design details of staircase, retaining wall, beam, slab, water tank, foundation etc. AutoCAD is a very easy software to learn and much user friendly for anyone to handle and can be learned quickly. Learning of certain commands is required to draw in AutoCAD.

CHAPTER 3
METHODOLOGY

3.1 Introduction

In this chapter methodology of the work has been discussed. Required data for analysis and model built-up with AutoCAD (2020) and ETABS (2018) are discussed details here. Analysis has been done for Zone-3 (Chittagong) and Zone-4(Sylhet). Design data are picked from BNBC-2020.

3.2 Different Types of Loads in Structure

Structural members must be designed to support specific loads. Loads are those forces for which a given suture should be proportioned. In general, loads may be classified as

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

3.2.1 Dead Load

Consist of the permanent construction material loads compressing the roof, floor, wall, and foundation systems, finishes and fixed equipment. Dead load is the total load of all the components of the building that generally do not change over time, such as the concrete columns, concrete floors bricks, roofing material etc. In ETABS, assignment of dead load is automatically done by giving the property of the member. In load case we have option called self-weight which automatically calculates weights using the properties of material i.e., density. In this study, dead loads on the slab consist of self-weight of slab, floor finish and partition wall. Total vertical load applied on the slab is 25 psf as floor finish and 30 psf as random wall in addition to self-weight of slab.

3.2.2 Live Load

Live loads are produced by the use and occupancy of a building. Loads include those from human occupants, furnishings, no fixed equipment, storage, and construction and maintenance activities. As required to adequately define the loading condition, loads are presented in terms of uniform area loads, concentrated loads, and uniform line loads. In ETABS, we assign live load in terms of U.D.L. We have to create a load case for live load and select all the slabs to carry such load. Since the 12 structures of the present study are intended for residential use, the live load considered in the building is 42 psf for floor & roof top and 100 psf for staircase.

3.2.3 Wind Load

Building and other structure, including the Main Wind–force Resisting System (MWFRS) and all components and cladding therefore, shall be designed and constructed to resist wind load as specified here.

Allowed procedures: The design wind load for buildings and other structures, including the MWFRS and component and cladding elements therefore, shall be determined using one of the following procedure:

Method 1: Simplified procedure specified for building and structure meeting the requirements specified therein;

Method 2: Analytical procedure specified for building and structure meeting the requirements specified therein;

Method 3: Wind tunnel procedure.

Buildings and their components are to be designed to withstand the code-specified wind loads. Calculation of wind loads is important in design of the wind force-resisting system, including structural members, components, and cladding, against shear, sliding, overturning, and uplift actions. Design wind load is calculated from sustained wind pressure, zone co-efficient, a building surface at any height z above ground according to BNBC 2020.

$$qz=Cc\ Ci\ Cz\ V^2b \text{.................... (If Vb=km/h)..............................(i)}$$

qz = Sustained wind pressure at height z, kN/m²

CI = Structure importance Coefficient

Cc= Velocity to pressure conversion coefficient

Cz = Combined height and exposure coefficient (Calculate based on height)

Vb = Basic wind speed, km/h

Velocity pressure:

Velocity pressure(qz) evaluated at height z shall be calculated by the following equation:

$$qz = (0.0006130\ v^2)\ Kz\ Kzt\ Kd\ I, \ldots (kN/m^2),\ V \text{ in m/s} \ldots\ldots (ii)$$

From the above equation, design wind pressure, pz is calculated as followed

Pz = CGCpQz........................ (If Vb=km/h)……………………………. (iii)

Pz = CtCGCpQz..................... (If Vb=mile/h)…………………………... (iv)

Pz=Design wind pressure at height z, kN/m^2

Co = Gust coefficient (calculated based on building height)

Cp = Pressure coefficient

qz=Sustained wind pressure at height z, KN/m^2

Ct= in plain train local topography coefficient =1

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

Fz = {PzAz}……………………………………………………………………. (v)

Fz =Total wind force, KN

Pz = Design wind pressure (kN/m^2)

AZ = Projected frontal Area, m

Basic Wind Equation p= q x G x Cp ……………………………………….. (vi)

p = Wind Pressure

q = Velocity Pressure

G = Gust Effect Factor

Cp = Pressure Coefficient / Shape Factor

Wind Loads (BNBC-2020)

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

Critical Load Condition: Values of external and internal pressures shall be combined algebraically to determine the most critical load.

Tributary Areas Greater than 65 m^2 : Component and cladding elements with tributary areas greater than 65 m2 shall be permitted to be designed using the provisions for MWFRSs.

Main wind-force resisting systems

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

p= q GCp – qi (GCpi) (kN/m²)……………………………………. (vii)

Where,

p= qz for windward walls evaluated at height z above the ground

q= qh for leeward walls, side walls, and roofs, evaluated at height h

qi= qh for windward walls, side walls, leeward walls, and roofs of enclosed Buildings and for negative

Internal pressure evaluation in partially enclosed buildings.

qi= qz for positive internal pressure evaluation in partially enclosed buildings where height zis defined as the level of the highest opening in the building that could Affect the positive internal pressure. For buildings sited in wind-borne debris regions, glazing that is not impact resistant or protected with an impact resistant covering, shall be treated as an opening in accordance with Sec

For positive internal pressure evaluation, qi may conservatively be evaluated at

h= (Qi= qh)

G = gust effect factor

Cp = external pressure coefficient

GCpi= internal pressure coefficient

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

p=qh [(GCpf-(GCpi)] (kN/m²)………………………………….. (Viii)

Where,

qh = velocity pressure evaluated at mean roof height h using exposure

GCpf = external pressure coefficient

Gcpi = internal pressure coefficient

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

P = qGfCp-qi (GCpi) (kN/m²)…………………………….. (ix)

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

Pp = QpGCpn [kN/mm²)……………………………………. (x)

Where,

Pp = Combined net pressure on the parapet due to the combination of the net pressures from the front and back parapet surfaces. Plus (and minus) signs signify net pressure acting toward (and Away from) the front (exterior) side of the parapet

Qp = Velocity pressure evaluated at the top of the parapet

GCpn = Combined net pressure coefficients

= +1.5 for windward parapet

= -1.0 for leeward parapet

Table 3.1 : Basic Wind Speeds, V, for selected Location in Bangladesh

Basic Wind Speeds, V, For Selected Locations in Bangladesh (BNBC 2020)

Location	Basic Wind Speed (m/s)	Location	Basic Wind Speed (m/s)
Angarpota	47.8	Lalmonirhat	63.7
Bagerhat	77.5	Madaripur	68.1
Bandarban	62.5	Magura	65.0
Barguna	80.0	Manikganj	58.2
Barisal	78.7	Meherpur	58.2
Bhola	69.5	Maheshkhali	80.0
Bogra	61.9	Moulvibazar	53.0
Brahmanbaria	56.7	Munshiganj	57.1
Chandpur	50.6	Mymensingh	67.4
Chapai Nawabganj	41.4	Naogaon	55.2
Chittagong	80.0	Narail	68.6
Chuadanga	61.9	Narayanganj	61.1
Comilla	61.4	Narsinghdi	59.7
Cox's Bazar	80.0	Natore	61.9
Dahagram	47.8	Netrokona	65.6
Dhaka	65.7	Nilphamari	44.7
Dinajpur	41.4	Noakhali	57.1
Faridpur	63.1	Pabna	63.1
Feni	64.1	Panchagarh	41.4
Gaibandha	65.6	Patuakhali	80.0
Gazipur	66.5	Pirojpur	80.0
Gopalganj	74.5	Rajbari	59.1
Habiganj	54.2	Rajshahi	49.2
Hatiya	80.0	Rangamati	56.7
Ishurdi	69.5	Rangpur	65.3
Joypurhat	56.7	Satkhira	57.6
Jamalpur	56.7	Shariatpur	61.9
Jessore	64.1	Sherpur	62.5
Jhalakati	80.0	Sirajganj	50.6
Jhenaidah	65.0	Srimangal	50.6
Khagrachhari	56.7	St. Martin's Island	80.0
Khulna	73.3	Sunamganj	61.1
Kutubdia	80.0	Sylhet	61.1
Kishoreganj	64.7	Sandwip	80.0
Kurigram	65.6	Tangail	50.6
Kushtia	66.9	Teknaf	80.0
Lakshmipur	51.2	Thakurgaon	41.4

3.2.4 Earthquake Load (BNBC-2020)

Earthquake loading as per BNBC-2020 has been calculated by the program and it has been applied to the mass center of the building. This 'Equivalent Static Analysis' of seismic vibration is based on the concept of replacing the inertia forces at various 'lumped masses' (i.e., story levels) by equivalent horizontal forces that are proportional the weight of the body (therefore its mass) and its displacement (therefore its acceleration). The summation of these concentrated forces is balanced by a 'base shear' at the base of the structure.

Design Base Shear:

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

$$V=Sa\ W$$

Where,

Sa = Lateral seismic force coefficient calculated

W = Total seismic weight of building defined.

Alternatively, for building with natural period less than or equal to 2.0 sec , the seismic design base share can be calculated using ASCE 7 -05 with seismic design parameters as given in Appendix C. However, the minimum value of Sa should not be less than 0.044 SDSI. The values of SDS are provided in Appendix C.

Structure Period

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

Method A:

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

$$C=Ct\ (hn)^{m}$$

Where,

Ct = 0.0724 for steel moment resisting frames

= 0.0731 for reinforced concrete moment resisting frames, and eccentric braced steel frames.

= 0.0466 for reinforced concrete moment

= 0.0488 for all other structural systems

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

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

$$Ac = \sum Ae[0.2+ (De/hn)2\ ] \text{..............................(xi)}$$

Where,

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

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

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

The value of De/hn should not exceed 0.9

Method B:

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

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

$$T = {}^{2r}\sqrt{\sum_{i=1}^{n} \omega.\delta^2/\mathrm{g}\ \sum_{i=1}^{n} f.\delta} \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(xii)}$$

Table 3.2 : Seismic Zone Coefficient, Z

Seismic Zone	Zone Co-efficient
1	0.12
2	0.20
3	0.28
4	0.36

Table 3.3 : Structural Importance Coefficient, I

Structure Importance Category	Structure Importance Coefficient	
	I	I'
I Essential Facilities	1.25	1.50
II Hazardous Facilities	1.25	1.50
III Special Occupancy Strictures	1.00	1.00
IV Standard Occupancy Structures	1.00	1.00
V Low-risk Structures	1.00	1.00

Table 3.4: 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 3.5: Seismic zone coefficient Z for some Important Towns in 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		

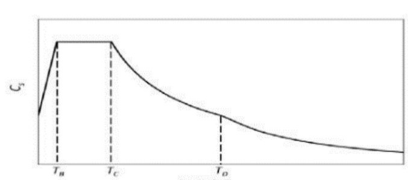

Fig. 3.1: Typical shape of the elastic response spectrum coefficient Cs

Table 3.6: Site Dependent Soil Factor and Other Parameters Defining Elastic Response Spectrum

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

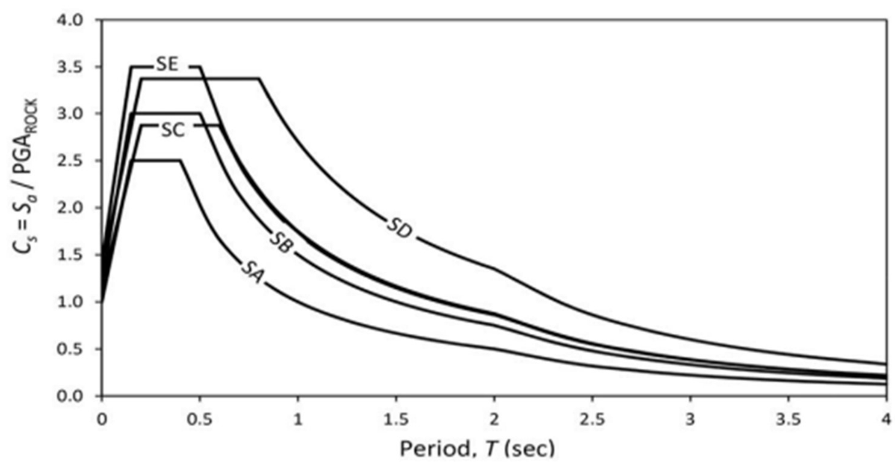

Fig. 3.2: Normalized design acceleration response for different site classes

Building Categories

Important factor

Table 3.7: Importance Factors for Buildings and Structures for Earthquake Design

Occupancy Category	Importance Factor I
I,II	1.0
III	1.25
IV	1.50

Fig. 3.3: Seismic zoning map of Bangladesh

Table 3.8: Seismic Design Category of Buildings

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

Table 3.9: Values for Coefficients to Estimate Approximate Period

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

Table 3.10: 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

Seismic Force–Resisting System	Response Reduction Factor, R	System Overstrength Factor, Ω_o	Deflection Amplification Factor, C_d	Seismic Design Category B	Seismic Design Category C	Seismic Design Category D
				Height limit (m)		
4. Special reinforced concrete moment frames	8	3	5.5	NL	NL	NL
5. Intermediate reinforced concrete moment frames	5	3	4.5	NL	NL	NP
5. 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
E. DUAL SYSTEMS: INTERMEDIATE MOMENT FRAMES CAPABLE OF RESISTING AT LEAST 25% OF PRESCRIBED SEISMIC FORCES (with bracing or shear wall)						
1. Special steel concentrically braced frames	6	2.5	5	NL	NL	11
2. Special reinforced concrete shear walls	6.5	2.5	5	NL	NL	50
3. Ordinary reinforced masonry shear walls	3	3	3	NL	50	NP

Seismic Force–Resisting System	Response Reduction Factor, R	System Overstrength Factor, Ω_o	Deflection Amplification Factor, C_d	Seismic Design Category B	Seismic Design Category C	Seismic Design Category D
				Height limit (m)		
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

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

Notes:

1. Seismic design category, NL = No height restriction, NP = Not permitted. Number represents maximum allowable height (m).
2. Dual Systems include buildings which consist of both moment resisting frame and shear walls (or braced frame) where both systems resist the total design forces in proportion to their lateral stiffness.
3. See Sec. 10.20 of Chapter 10 of this Part for additional values of R and C_d and height limits for some other types of steel structures not covered in this Table.
4. Where data specific to a structure type is not available in this Table, reference may be made to Table 12.2-1 of ASCE 7-05.

Table 3.11: Parameter S_1 and S_s for Different Seismic Zones

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

$S_1 = 0.4S_S$, not independent of S_S, as in ASCE 7-05

S_1 = MCE-level PGA = Z, Seismic Zone Coefficient

3.3 Load Groups

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

1. **Load Group 1:** Uniformly distributed live loads arising from the occupancies and 2 uses of assembly occupancies or areas with uniformly distributed live load of 5.0 kN/m or less, machinery and equipment for which specific live load allowances have been made. Special roof live load and printing plants, vaults, strong room and armories, shall be classified under Load Group 1. Reduction of live load shall not be allowed for members or portions thereof under this load group and a reduction factor, R-1.0 shall be applied for 2.
2. **Load Group 2:** Uniformly distributed live loads resulting from occupancies or uses of (i) assembly areas with uniformly distributed Live load greater than 5.0 kN/m, and (ii) storage, mercantile, Industrial and retail stores, shall be classified under Load Group 2. Live load reduction factor, 1.0 <R< 0.7 shall be applied to this load group depending on the tributary area of the floors or roof supported by the member as specified.
3. **Load Group 3:** Uniformly distributed live loads arising due to all other occupancies and uses except those of Load Group I and Load Group 2, shall be grouped into Load Group 3. Live load reduction factor, 1.0 <R<0.5 as specified, shall be applied to tributary areas under this load group.

Tributary Area:

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

a) Tributary Area for Wall, Column, Pier, Footing and the like: Tributary areas of these members shall consist of portions of the areas of all floors, roof or combination thereof that Contribute live loads to the member concerned.
b) Tributary Area for Beam, Girder, Flat plate and Flat slab: Tributary area for such a member shall consist of the portion of the roof or a floor at any single level that contributes loads to the member concerned.

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

Exposure A: Urban and sub-urban areas, industrial areas, wooded areas, hilly or other terrain covering at least 20 per cent of the area with obstructions of 6 meters or more in height and extending from the site at least 500 meters or 10 times the height of the structure, whichever is greater.

Exposure B: Open terrain with scattered obstructions having heights generally less than 10m extending 800 m or more from the site in any full quadrant. This category includes airfields, open park lands, sparsely built up outskirts of towns, flat open country and grasslands.

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

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

3.4 Load Combinations

As per BNBC 2020, Chapter 2- Part 6 (Clause 11027.5), following load cases must be considered for analysis:

U= 1.4 DL
U= 1.2 DL + LL
U= 1.2 DL + 1.6 LL
U= 1.2 DL + 0.8 WL
U= 1.2 DL + LL + 1.6 WL
U= 1.2 DL + LL+ EQX + 0.3 EQY
U= 1.2 DL + LL+ 0.3 EQX + EQY
U= 0.9 DL + 1.6 WL
U= 0.9 DL + EQX + 0.3 EQY
U= 0.9 DL +0.3 EQX + EQY

Earthquake load and Wind Load must be considered for +X, -X, +Y and —Y directions. Thus, +EL and + WL above implies 28 cases, and in all, 31 cases as per Table 3.6 must be considered. All 31 load combinations are analyzed using software.

3.5 Design Data

The building model under this study has (G+9=10) ten stories with a constant floor height of 10 feet. Two areas are used for analysis, and the equal length and width along the two horizontal directions are kept constant in each area for ease of use. Use different ZONE FACTOR values and explain their corresponding effects in the results. Other details are as follows:

Table 3.12: Zonal Parameter and its Various Details

PARAMETER	ZONE III (CHITTAGONG)	ZONE IV (SYLHET)
Seismic Zone factor, Z	0.28	0.36
Basic wind speed	179 Mph	137 Mph
Response reduction factor	12	12
Importance factor, I	1	1
Importance coefficient R	6.5	6.5
Site co-efficient, S	1.15	1.15
Cd classes of soil de end	5	5
n Nutrient availability Soil	2.5	2.5
Ss Spectral Acceleration	0.3	0.3
Soil condition o inion	Good	Good
Slab thickness	5 inches	5 inches
Floor finish	25 psf	25 psf
All Steel Fy	60000 psi	60000 psi
All Concrete Fc Column	4000 psi	4000 psi
All Concrete Fc Beam	3500 psi	3500 psi
All Concrete Fc Slab	3000 psi	3000 psi
Diaphragms	Rigid	Rigid
Poisson's ration of Concrete	0.15	0.15
Moment of inertia for Column	1	1
Torsional Constant Column	1	1
Moment of inertia for Beam	1	1
Torsional Constant Beam	1	1

3.5.1 Dead Load

- Floor finish for floor & stair = 25 psf
- Floor finish for stair room, car parking= 25 psf
- Parapet wall load calculation = 25psf

3.5.2 Live Load

- For floor = 78.33 psf (with partition wall)
- For floor = 42 psf (no partition wall)
- For stair = 100.22 psf (20.88 X 4.80)
- For car parking slab = 50 psf
- For stair room = 15 psf

3.5.3 Seismic and Wind Load

❖ **Seismic Zone 3 (Chittagong District)**

- Coefficient Z= 0.28
- Importance Coefficient (Essential facilities), I = 1
- Exposure Condition = B
- Wind Pressure in chittagong, Vb = 80.0 m/s or 179 mph
- Windward coefficient = 0.80
- Leeward coefficient = 0.50

❖ **Seismic Zone 4 (Sylhet District)**

- Coefficient, Z = 0.36
- Importance Coefficient (Essential facilities), 1= 1
- Exposure Condition = B
- Wind Pressure in Sylhet, Vb = 61.1 m/s or 137 mph
- Windward coefficient = 0.80
- Leeward coefficient = 0.50

3.6 Plan Details

- Height of building: 108 ft.
- Length of building: 53 ft.
- Width of building: 48 ft.
- Total floors: 10 nos

❖ **Ground Floor**

- Total floor area = 2544 ft
- Total floor height = 10 ft.

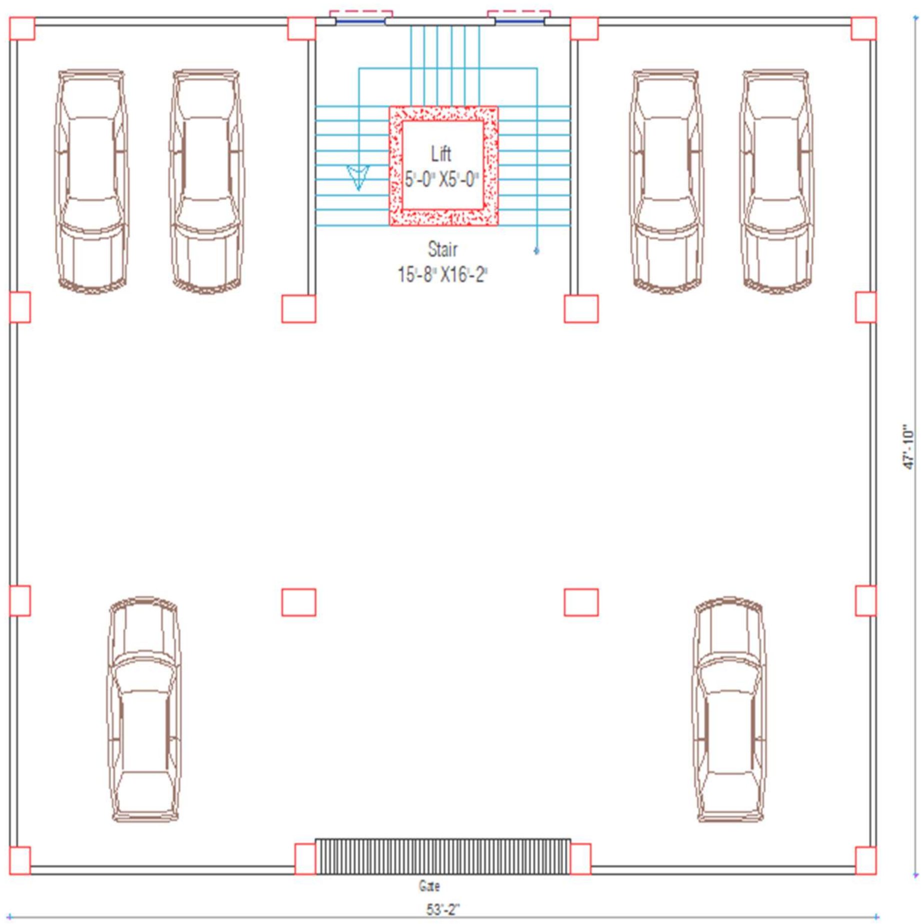

Fig. 3.4: Ground floor plan for Both Structures

❖ **Typical Floor Plan**

- Total floor area = 2544 ft
- Total floor height = 10 ft.

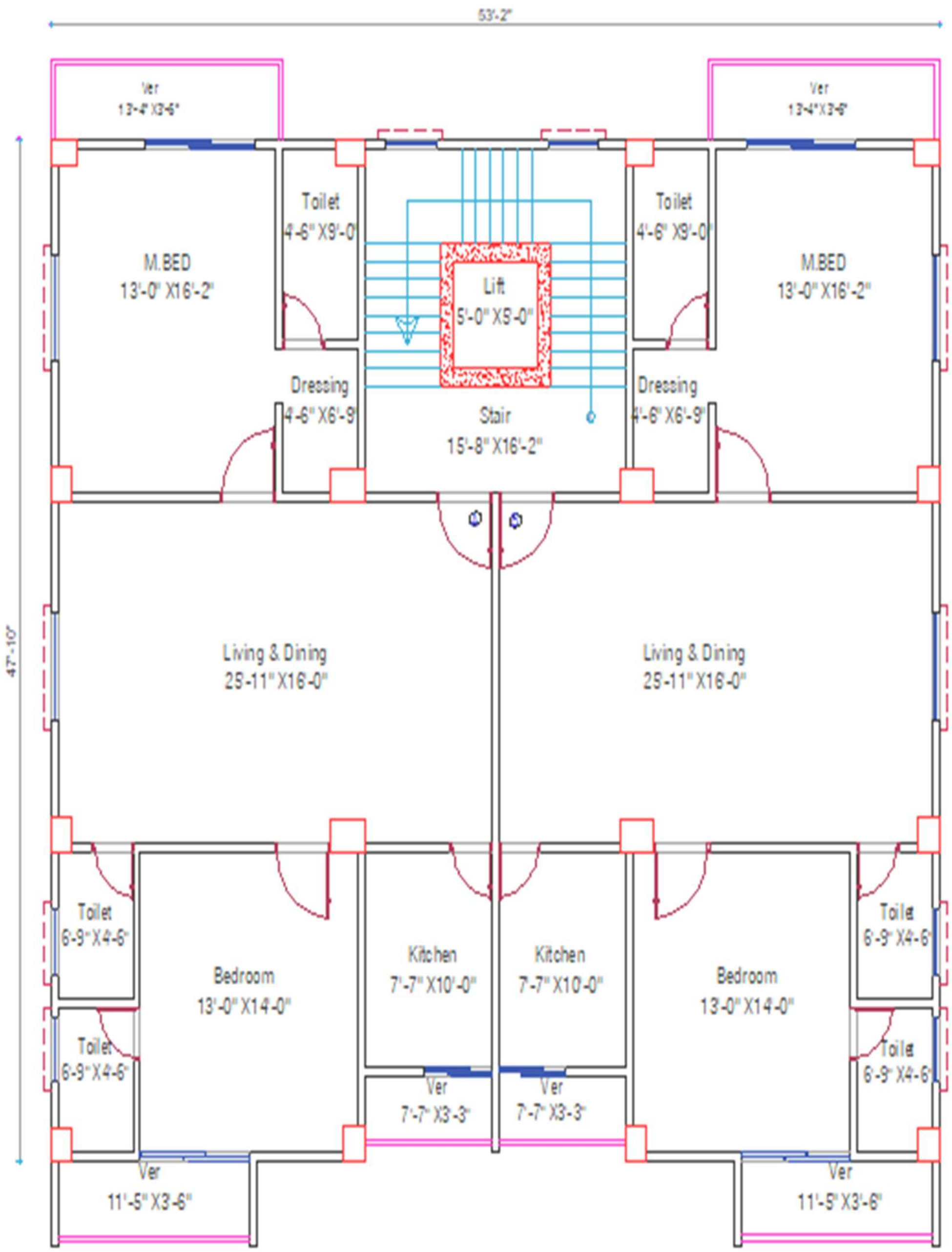

Fig. 3.5: Typical Floor Plan for Both Structures

3.6.1 Column & Beam Layout

- **For Both Structures**

<u>Column & Beam Size</u>

Column 01= 15x18	Beam(FB)= 15x20
Column 01= 15x20	Beam(FB)= 18x24
Column 01= 18x24	Beam(GB)= 15x20
	Beam(FB)= 18x24

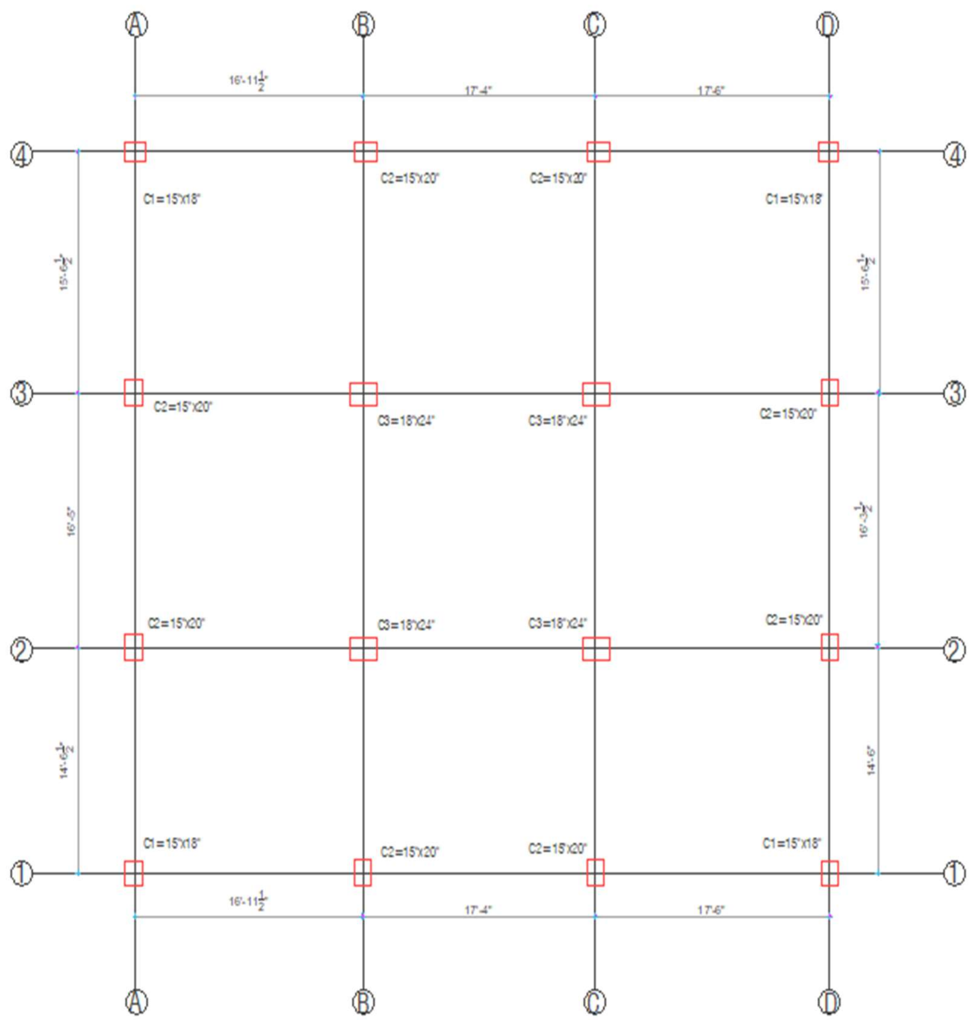

Fig. 3.6: Column & Beam Layout

3.6.2 Beam Section

❖ **For Both Structures**

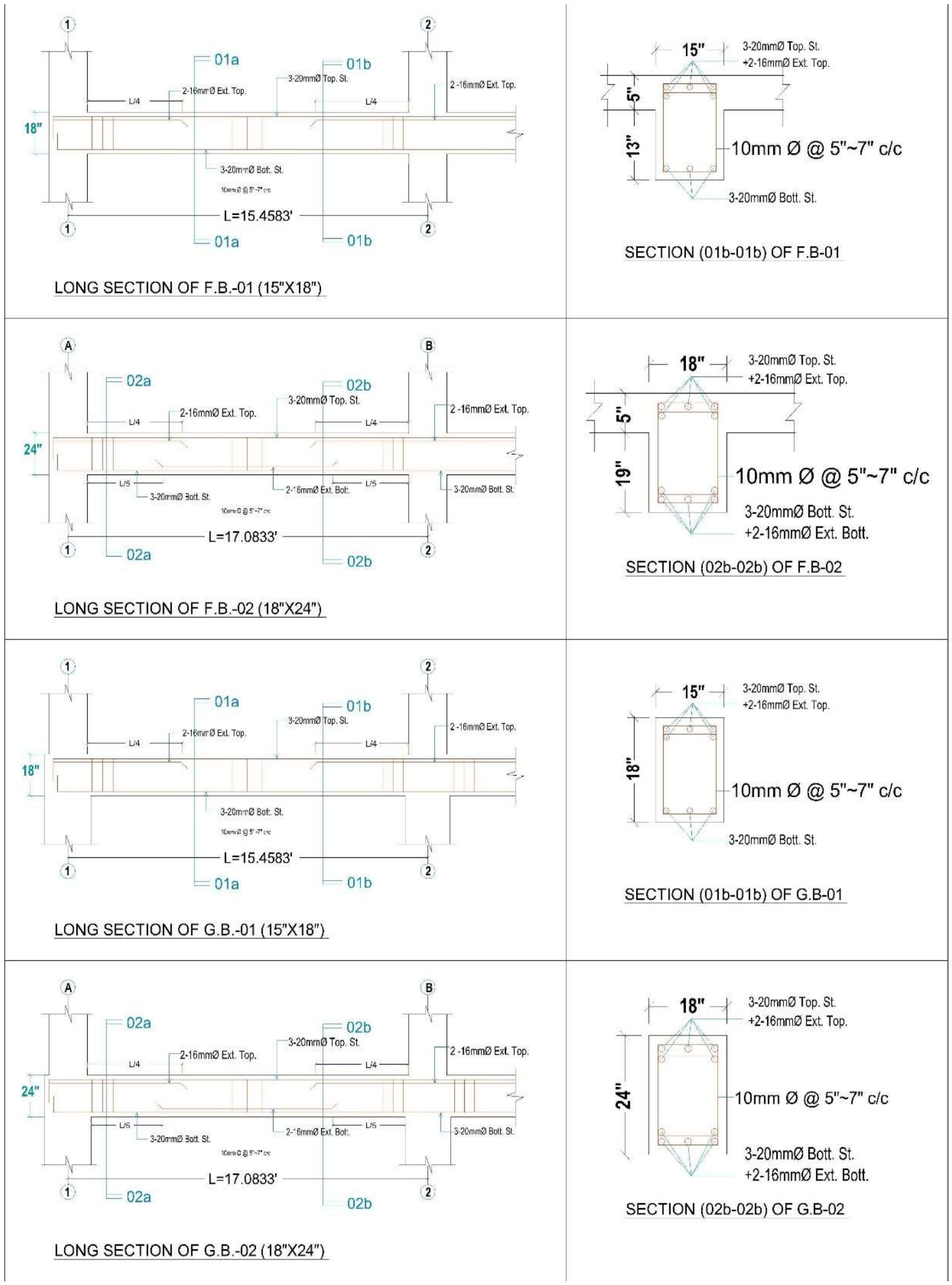

Fig. 3.7: Beam Section for Both Structures

3.7 Modelling with EATBS

3.7.1 Model Initialization

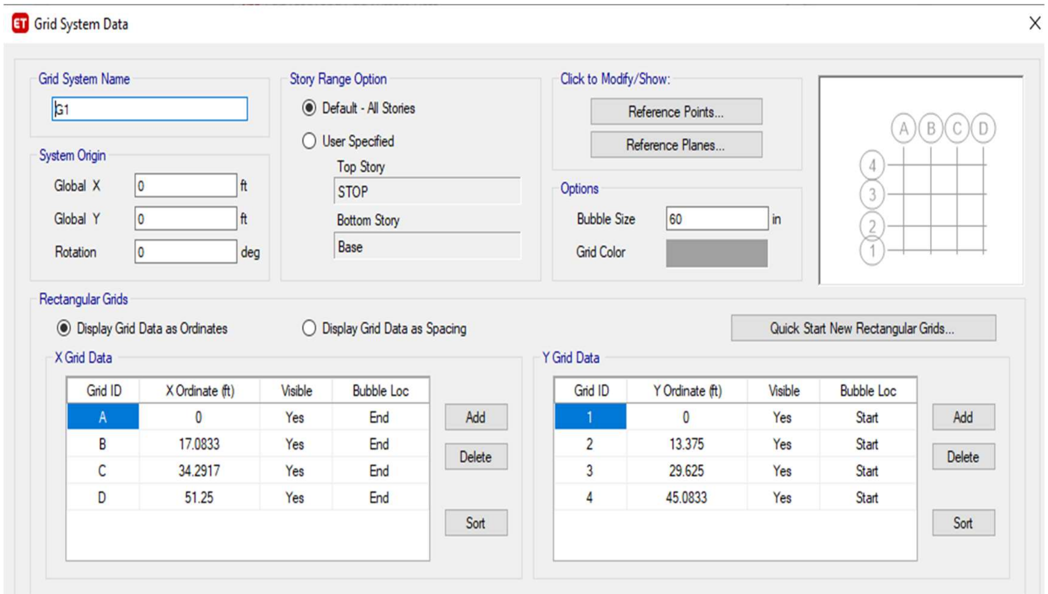

Fig. 3.8 : Grid System Data

- File> New model
- If it is uniform grid then file up the “Uniform grid Spacing” Box
- Input number of grid in X,Y direction
- Take number of Stories
- Change unit to kip-ft.
- Input typical of stories
- Input bottom story height
- If the grid is not uniform, then go to the Custom Grid Spacing
- Edit Grid
- Cheek Spacing
- Cheek glue to grid lines
- Input spacing of grid in X,Y direction
- OK

3.7.2 Define Materials Properties

❖ **Materials Properties**

i. Concrete

ii. Modify if need

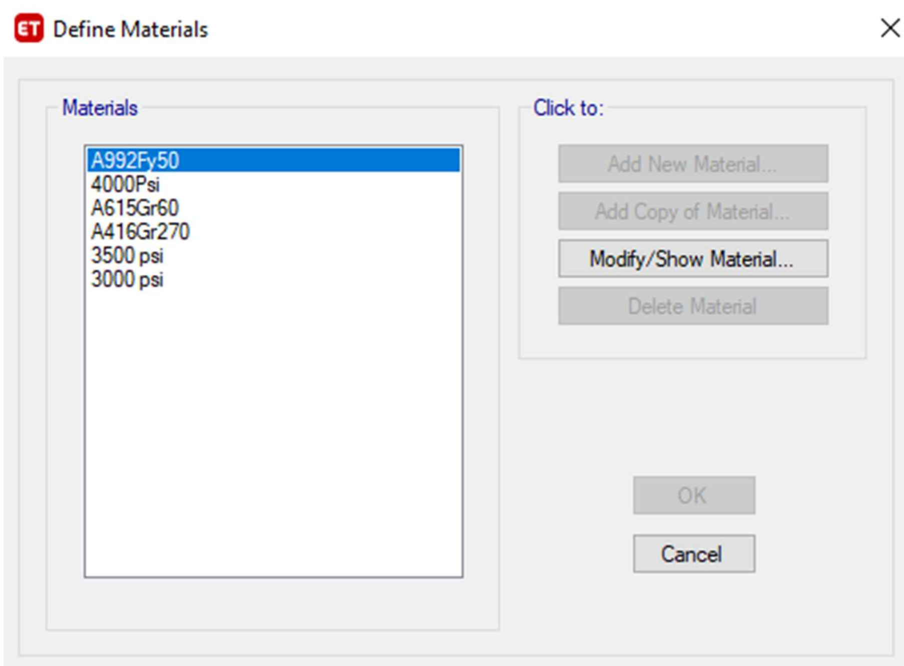

Fig. 3.9: Define Materials

3.7.3 Define Section Properties

❖ **Frame Section**

i. Select all existing property

ii. Delete all

iii. Add rectangle/Circle

iv. For beam

v. Select Reinforcement

vi. Then select beam

vii. Define all frame section in this process

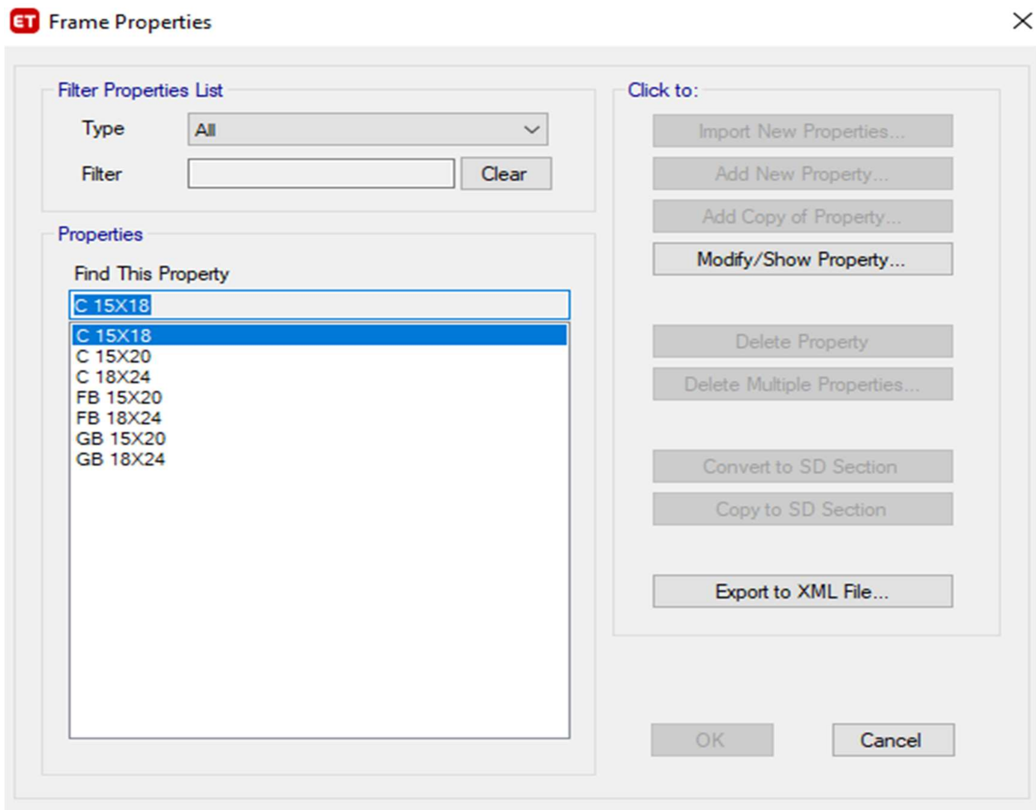

Fig. 3.10: Frame Properties Initialization for Both Structures

3.7.4 Define Frame Section Property of Columns

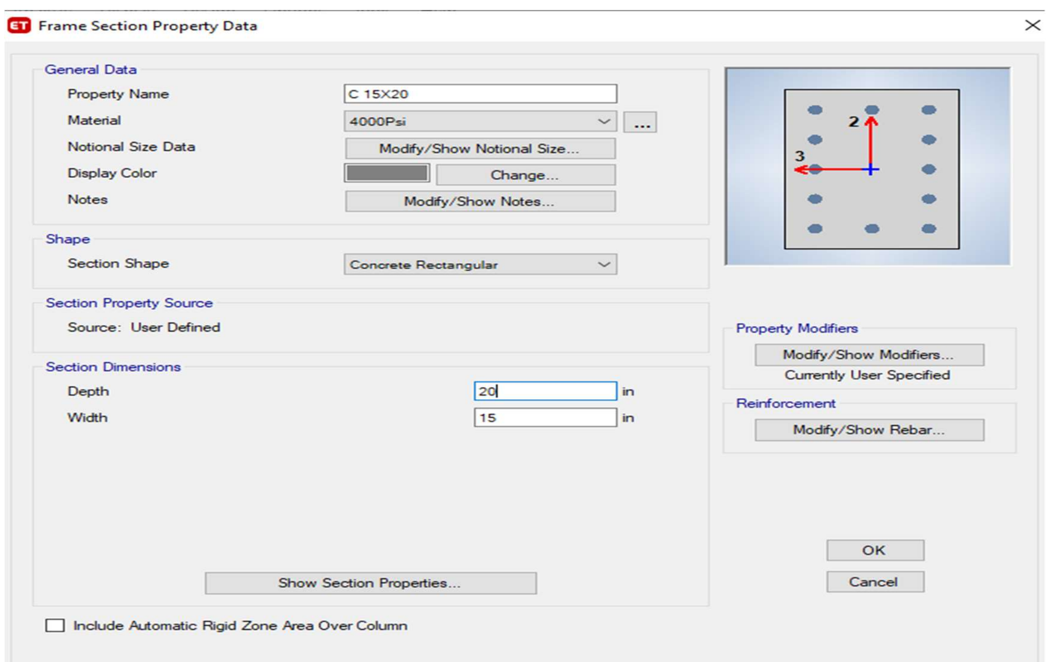

Fig. 3.11: Frame Section Property of Columns for Both Structures

3.7.5 Define Frame Section Property of Beam

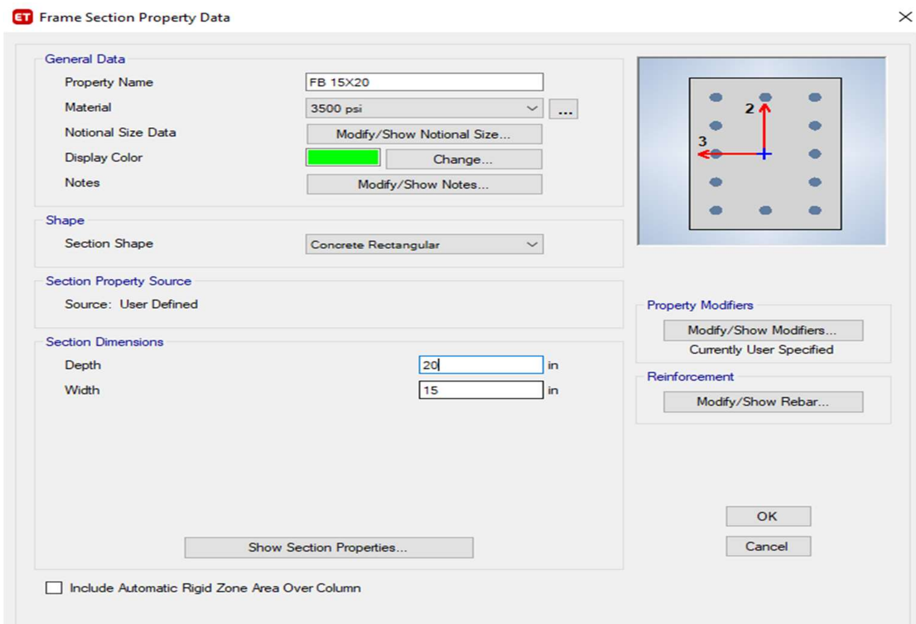

Fig. 3.12: Frame Section Property of Beam for Both Structures

3.7.6 Define Slab Property

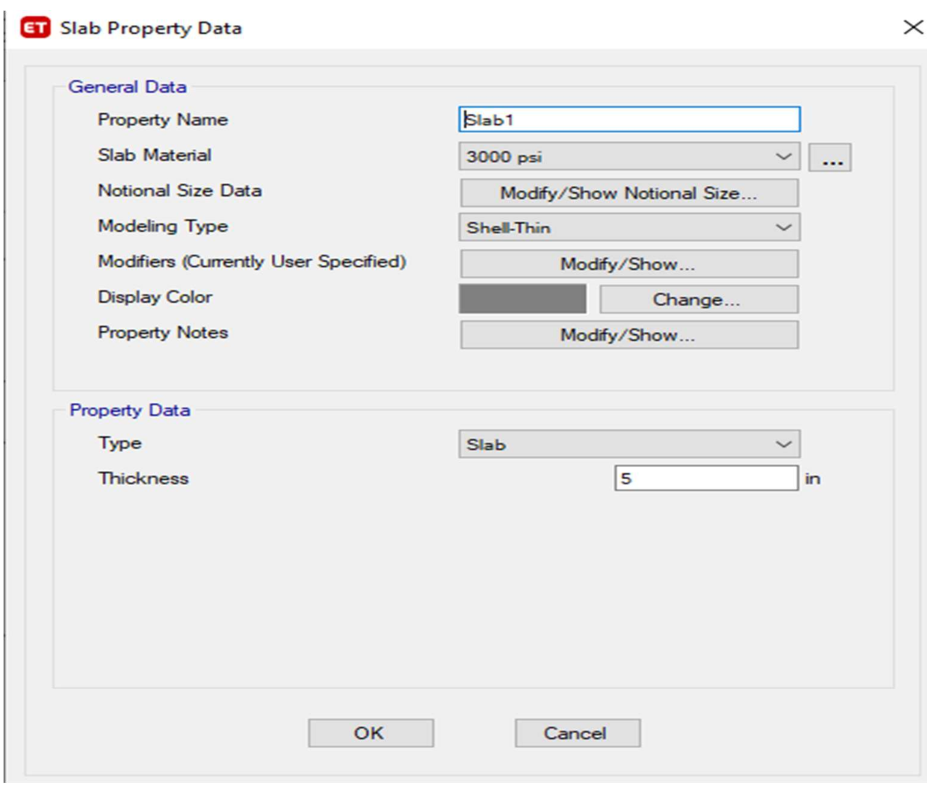

Fig. 3.13: Slab Property Data

3.7.7 Display Grid Data

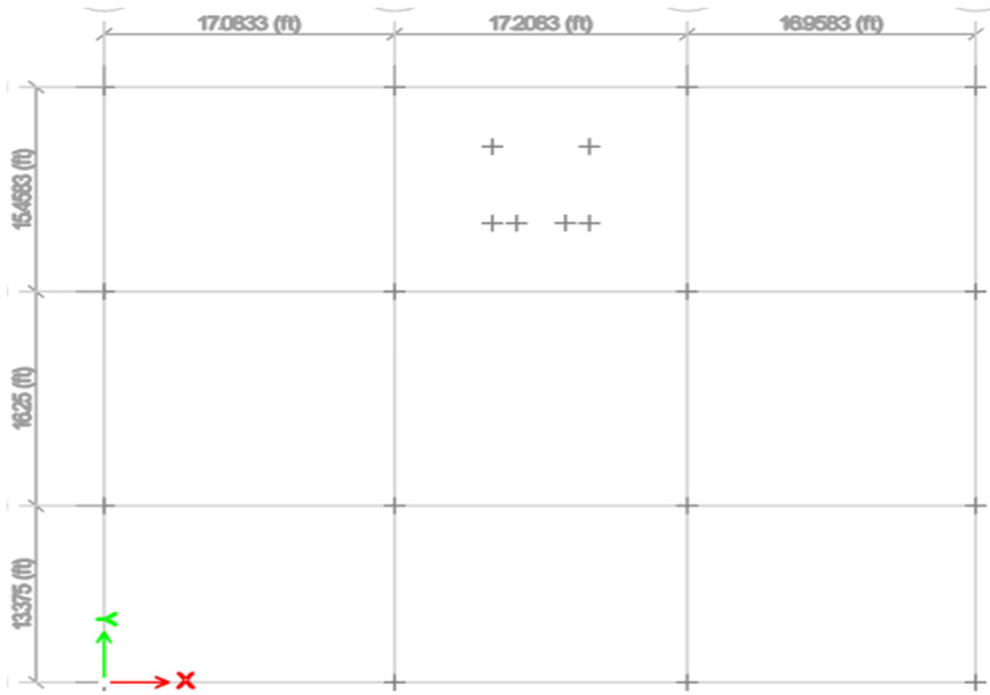

Fig. 3.14 : Proposed Grid Data of the model for Both Structure

3.7.8 Structure Need to Complete the Following Steps

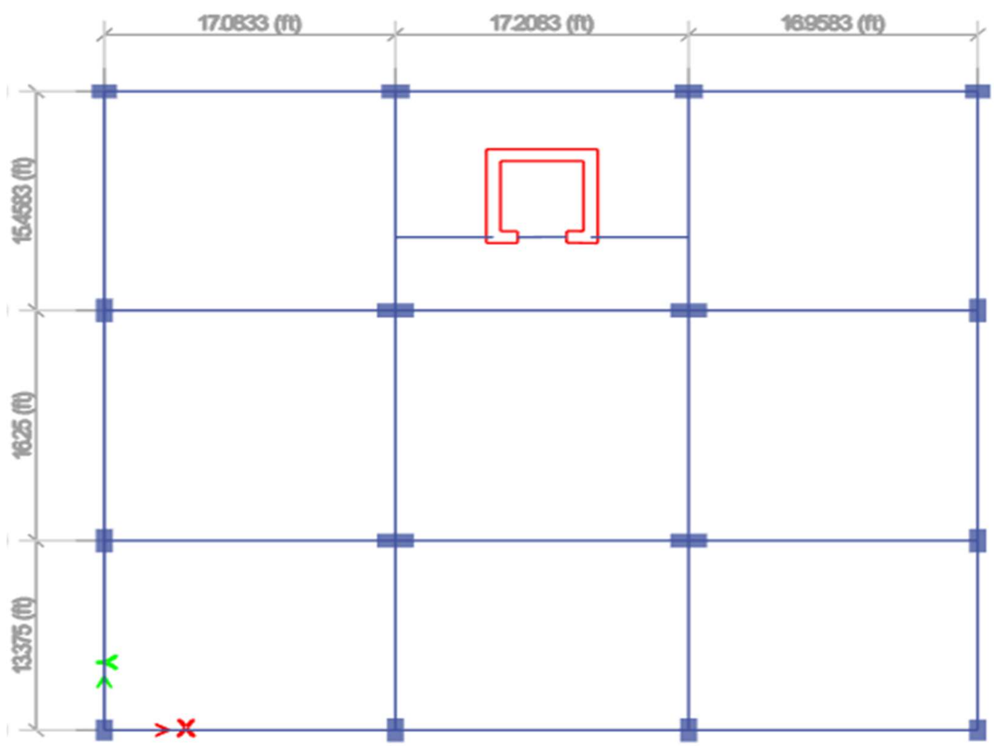

Fig. 3.15: Plan for the 2D Model

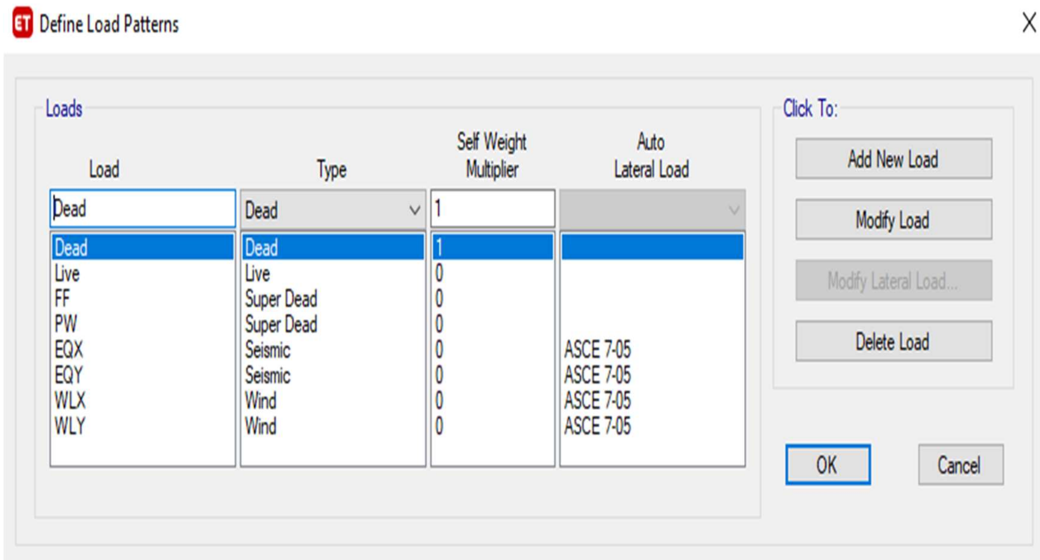

Fig. 3.16 : Load Pattern Assign for Both Model

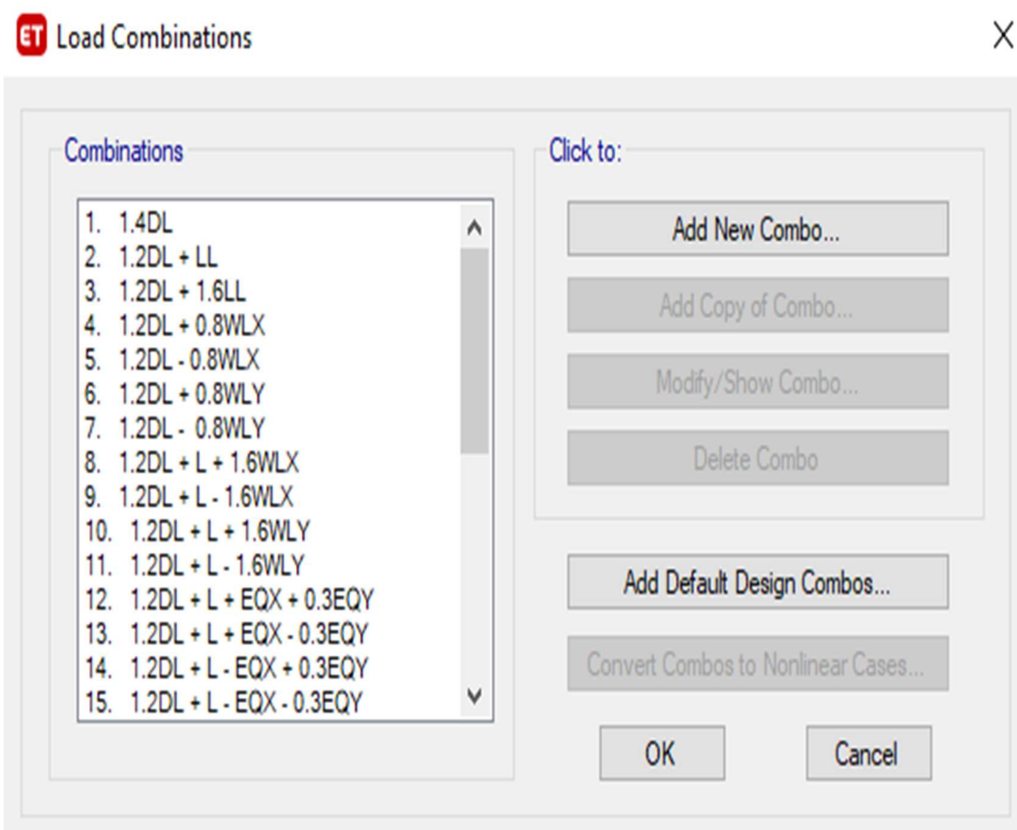

Fig. 3.17: Assign Load Combination for both Model

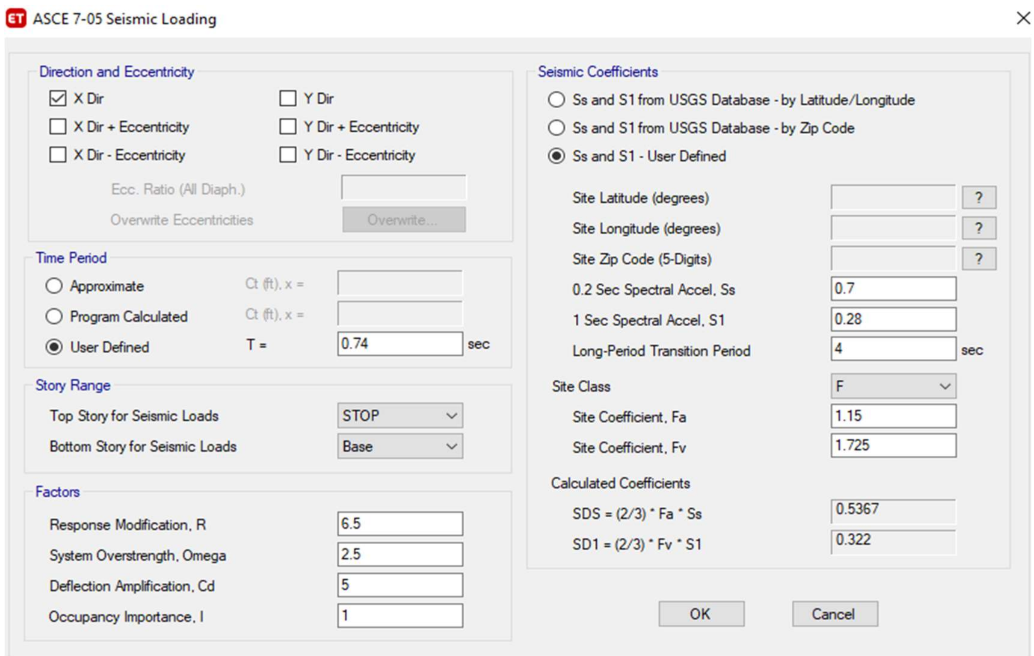

Fig. 3.18: Define Seismic Load Pattern- ASCE7-05 For Zone III(Chittagong)

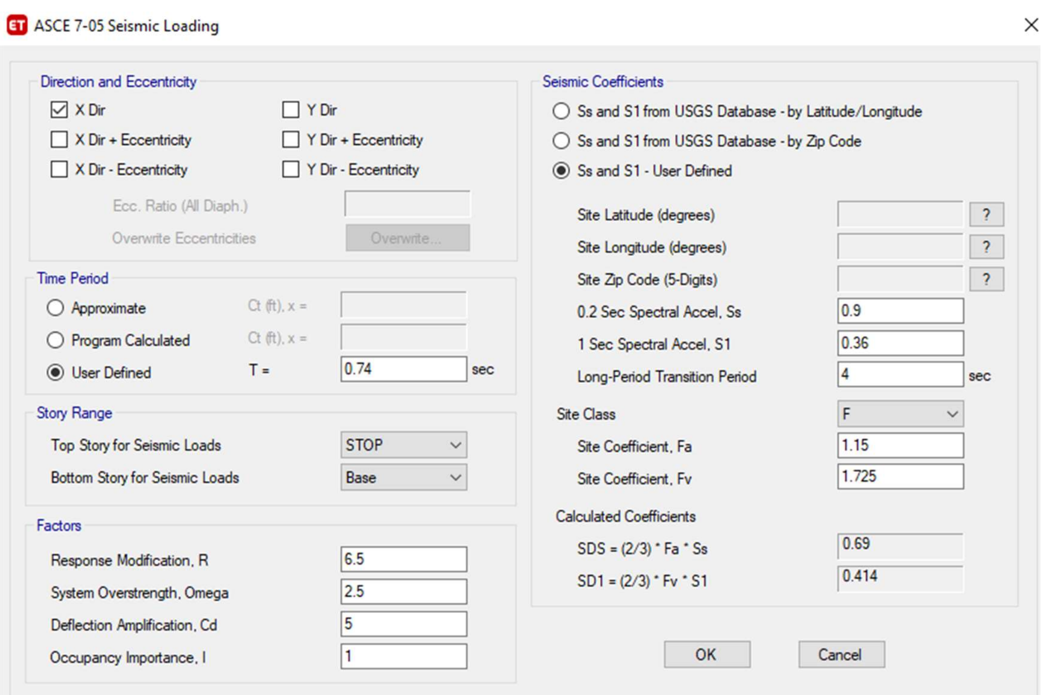

Fig. 3.19: Define Seismic Load Pattern- ASCE7-05 For Zone IV(Sylhet)

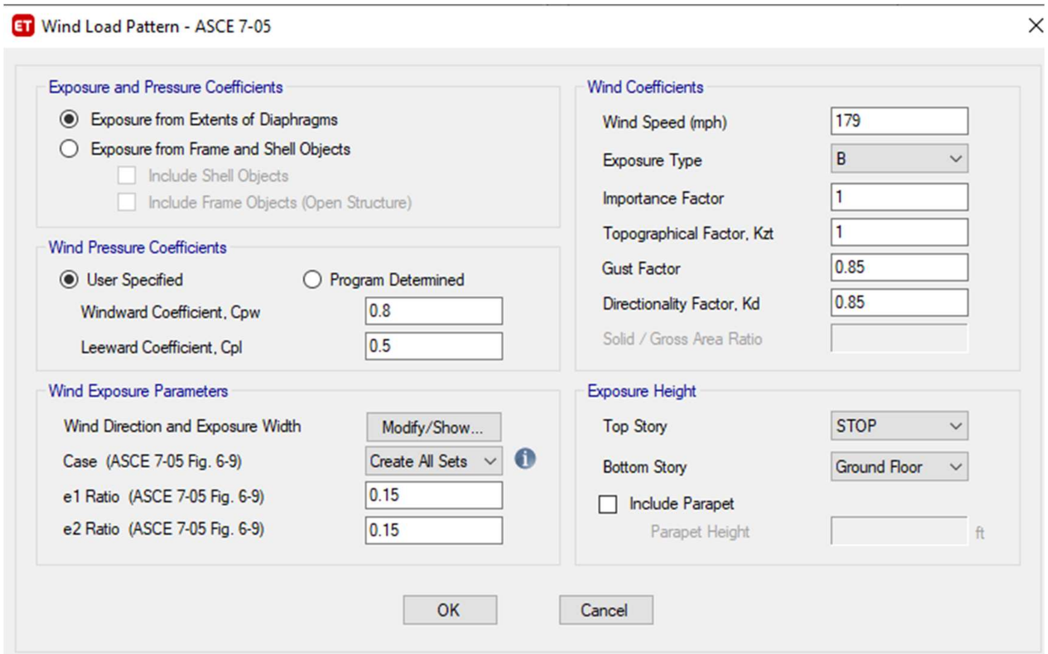

Fig. 3.20: Define Wind Load Pattern- ASCE7-05 for Zone III (Chittagong)

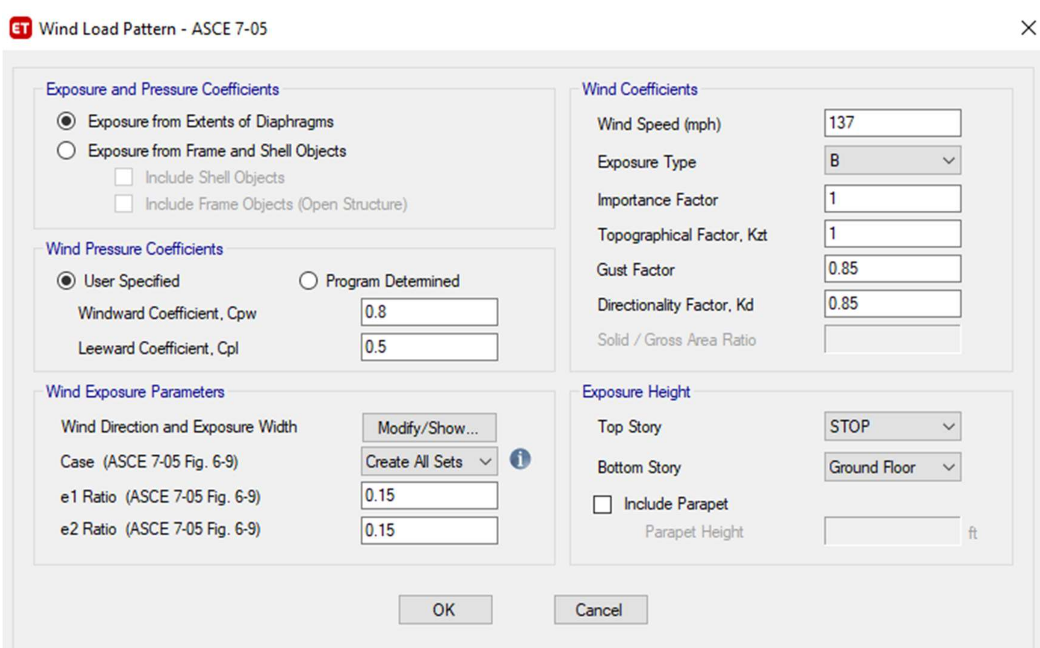

Fig. 3.21: Define Wind Load Pattern- ASCE7-05 for Zone IV (Sylhet)

❖ **Etabs 3D Model**

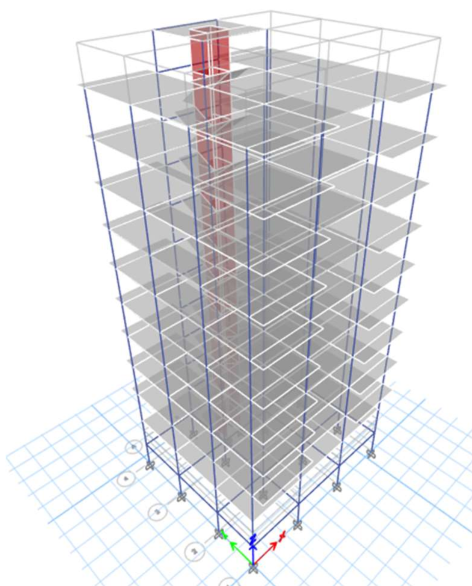

Fig. 3.22: 3D Model of Chittagong

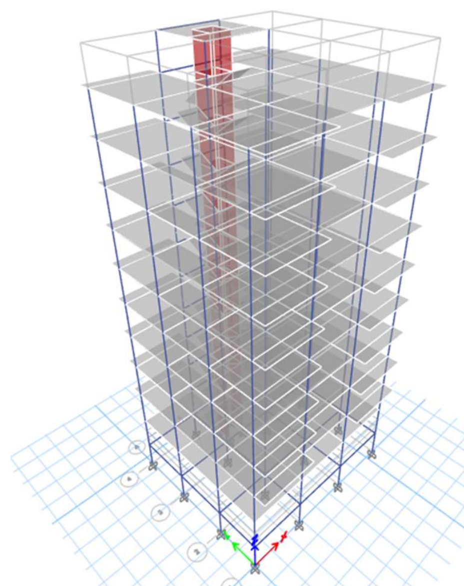

Fig. 3.23: 3D Model of Sylhet

3.7.9 Deflect Shape of the Model:

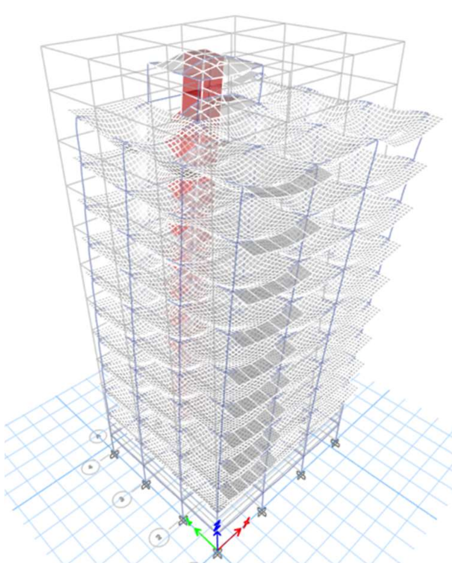

Fig. 3.24: Deflect Shape of Chittagong Model

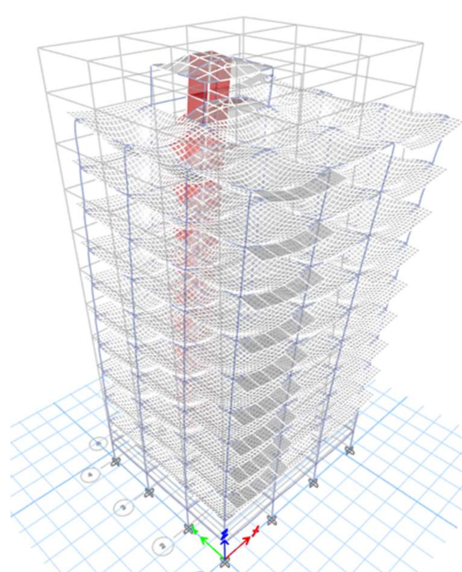

Fig. 3.25: Deflect Shape of Sylhet Model

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Introduction

In this chapter result output of the model has been shown and discussed. From the result comparison it is seen that comparisons of zone 3 (Chittagong) & zone 4 (Sylhet) building according to BNBC 2020 using by ETABS have huge difference in designing methods and formulas.

4.2 Drift and Building Separation for Displacement (BNBC-2020)

Drift the Limitation: Story drift is the displacement of one level relative to the level above or below due to the design lateral forces. Except otherwise permitted in story drift shall include both translation and torsional deflections and confirm the following requirements:

a) Story drift, A shall be limited as follows:

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

$\Delta \leq 0.004h$ for $T > 0.7$ sec

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

Where h= height of the building or Structure. The period T used in calculation shall be the same as that used for determining the base shear.

Table 4.1: Maximum Story Displacement

Load Type	Zone III (Chittagong)	Zone IV (Sylhet)
EQX	0	0
EQY	4.898071	6.248585
WLX	3.557497	2.075678
WLY	2.476056	1.43789

Table 4.2: Increase of Displacement Due to BNBC 2022

Load Type	Increase of Displacement (%)
EQX	0%
EQY	127.57%
WLX	58.34%
WLY	58.14%

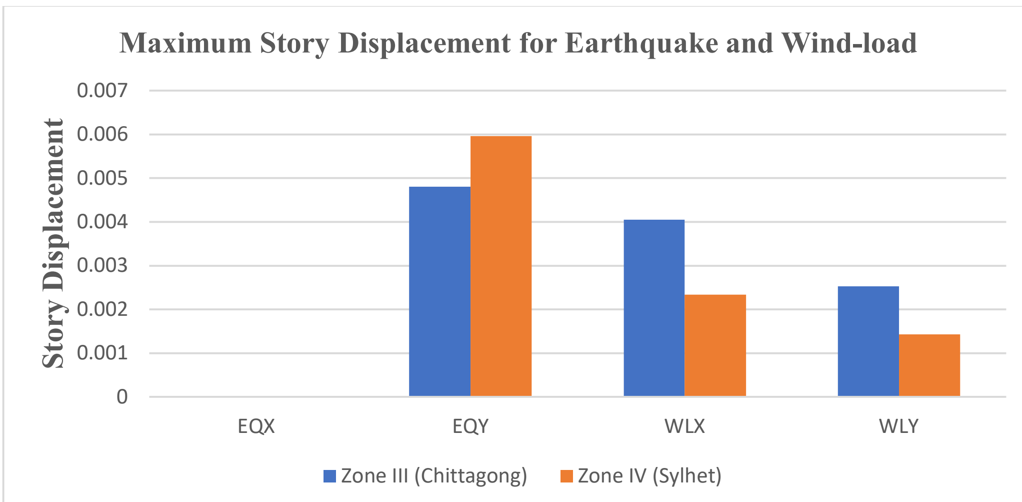

Fig. 4.1: Maximum Story Displacement

4.3 Drift and Building Separation for Drift (BNBC-2020)

Drift the Limitation: Story drift is the horizontal displacement of one level of a building or structure relative to the level above or below due to the design gravity (dead and live loads) or lateral force (e.g., wind and seismic loads). Calculate story drift shall include both translation and torsional deflections and confirm the following requirements:

a) Story drift, A for loads other than seismic loads, shall be limited as follows:

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

$\Delta \leq 0.004h$ for $T > 0.7$ sec

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

Where h= height of the building or Structure. The period T used in calculation shall be the same as that used for determining the base shear.

Table 4.3: Maximum Story Drift

Load Type	Zone III (Chittagong)	Zone IV (Sylhet)
EQX	0	0
EQY	0.004806	0.005963
WLX	0.004054	0.002344
WLY	0.002533	0.00143

Table 4.4: Increase of Displacement Due to BNBC 2022

Load Type	Increase of Displacement (%)
EQX	0%
EQY	147%
WLX	57.81%
WLY	56.45%

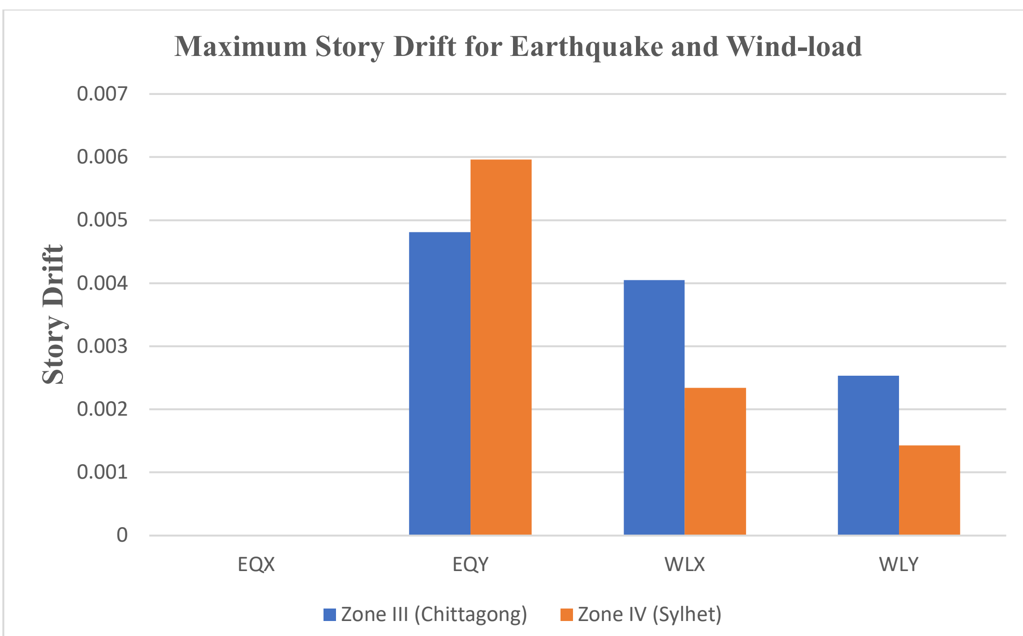

Fig. 4.2: Maximum Story Drift

4.4 Result Comparison and Discussion

Finally, we get this result for lateral load:

1. Seismic effect on X-direction of Zone 4 (Sylhet) Building is greater than Zone 3 (Chittagong) Building.
2. Seismic effect on Y-direction of Zone 4 (Sylhet) Building is greater than Zone 3 (Chittagong) Building.
3. Wind effect on X-direction Zone 3 (Chittagong) Building is greater than Zone 4 (Sylhet) Building.
4. Wind effect on Y-direction Zone 3 (Chittagong) Building is greater than Zone 4 (Sylhet) Building.

The decision-making parameters for structural analysis and design are tremor and wind forces, story drift, wind and seismic shear and base shear for seismic forces according to BNBC 2020. In this study, the maximum story displacement of zone 3 (Chittagong) to zone 4 (Sylhet) multistory structure is 0%, 127.57%, 58.34% and 58.14% for load EQX, EQY, WLX and WLY respectively. And the maximum story drift of zone 3 (Chittagong) to zone 4 (Sylhet) multistory structure is 0%, 147%, 57.81%, and 56.45% for load EQX, EQY, WLX and WLY respectively. The comparison of the aforesaid design parameters is depicted graphically, and relevant tables are presented in this research article. In comparison of wind load and seismic effect on zone 3 (Chittagong) and zone 4 (Sylhet) multistory structures, the requirements of BNBC 2020 usually result in a less cost-effective design with a higher safety margin.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

From the study it is observed that:

1. Effect of wind and seismic is very important for building design.
2. The lateral displacement due to the seismic of the high-rise multi-story structures analysis in zone 4 (Sylhet) building is more than the lateral displacement of the structure analysis in zone 3 (Chittagong) building by the BNBC-2020 code.
3. The lateral displacement due to the wind load of the high-rise multi-story structures analysis in zone 3 (Chittagong) buildings is more than the lateral displacement of the structure analysis in zone 4 (Sylhet) buildings by the BNBC2020 code.
4. The building is analyzed linearly for seismic design.
5. All loads are taken according to BNBC-2020 code provided.
6. The building does not analyze non-linearly for seismic loads.

5.2 Recommendations for Future Study

1. In this study, only the ETABS software is used for the analysis.
2. If the analysis results compare with the actual hand calculation data, then more reliable results will be found. It should be done in the future work.
3. The case study conducted in this research is for two districts of Bangladesh. However, the different seismic zone coefficient and wind varies for different parts of Bangladesh. Similar study can be performed for other parts of Bangladesh especially for different area and different seismic zones.
4. Similar study can be performed for other types of buildings such as steel frames, ordinary moment resisting frames and masonary structures etc. located in different in places with different site conditions.
5. A more realistic analysis of a high-rise structure under earthquake load can be achieved using the dynamic analysis method.

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