COMPARATIVE ZONE ANALYSIS OF A MOMENT RESISTING HIGH-RISE STRUCTURE ACCORDING TO BNBC 2020

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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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(Spring-2025)

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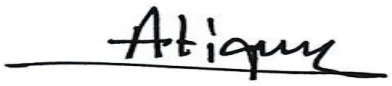
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DECLARATION

It is stated that the thesis work on "Comparative zone analysis of a moment resisting high rise structure according to BNBC 2020" has been performed under the supervision of Zeba Fariha, Lecturer, Department of Civil Engineering, Sonargaon University (SU), Dhaka. To the best of our knowledge and belief, the thesis report contains on material previously published or written by another person expect where due referee is made in the report itself.

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Dedicated

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"Our Respectful Teachers & Parents"

ACKNOWLEDGEMENTS

First and foremost, we want to express gratefulness and humbleness to Almighty Allah for his unlimited kindness, blessing and giving us the ability strength to complete the thesis work. We would like to express our utmost gratitude to our supervisor, Zeba Fariha (Lecturer, Department of Civil Engineering) for all the help provided us to prepare the thesis paper. Her advice and research proficiency has made working on this thesis an Invaluable experience. She extended her helping hand by providing constant encouragement, inspiration, suggestions, and facilities along with constructive criticism in the form of valuable suggestions. It has been a pleasure working with her. Finally, we would like to give our gratitude to all of our teachers at the University for their Cooperation and dedicated teaching for the achievement of the degree of B.Sc. in Civil Engineering. The cooperation and assistance of all the officers and staff of the Sonargaon University Bangladesh are healthfully acknowledged.

ABSTRACT

The Bangladesh National Building Code (BNBC) specifies and regulates the general specifications for structure, architecture and design parameters in Bangladesh. In the last three decades, Civil Engineering techniques, knowledge, and materials as well as design parameters have been modified as per requirement. Therefore, BNBC 2020 was written to reflect the transition. In this study, a systematic and parametric structural analysis of a Nine-storied (High rise) residential building was analyzed (ETABS 21.0.0 software) by using BNBC 2020. In this project lateral load (Earthquake and Wind) affects structural analysis of high-rise infrastructure for Zone I, II, III & IV. The decision-making parameters for structural analysis 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 base shear is 0.162 for Zone IV, Maximum lateral deflection is 2.37 inch which is exceed, this model is torsional irregularity for zone IV and maximum story drift data is 3.26 Inch for Zone IV for EQX, EQY, WX and WY respectively. The comparison of the aforesaid analysis parameters is depicted graphically, and relevant tables are presented in this research article. In comparison of wind load and seismic effect on Different zone high rise structures, the requirements of BNBC 2020 usually result in a higher safety and less cost-effective design margin.

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CHAPTER 1

Introduction

1.1 Background and Motivations

Building is the key to social progress of the country. Without construction of building, one nation can't progress. For example, to make digital nation we need computer but to place this computer we need buildings. Many things which are related to development of buildings. Every human has desire to own comfortable hotness. It can be assumed or say or calendared that on an average generally one spends his two third life times in the house. So, the serenity envies sense of the responsible. Man needs house to protect them from various kind of danger, animal and Natural disaster. These are the few reasons which are responsible that the person does utmost effort and spend hard earned saving in owning houses. To archive safety for human live, every engineering portable meets the current seismic requirement during design and construction. In Bangladesh there are many buildings which do not meet the current seismic and wind load requirement and suffer extensive damage during the earthquake and wind load in Bangladesh during design and construction phases.

The reinforced concrete structure (RCC), susceptible to seismic excitation, should be suitable for strength, ductility, and stiffness to meet earthquake- resistant design criteria. The arrangement of the fundamental building elements for rigidity and durability can regulate the reaction behavior of laterally loaded structures, and the damage recorded in earthquake structures was primarily due to their erroneous placement. Considering the increasing population, as well as lack of horizontal expansion, is not a reasonable solution. When houses and apartments are designed there are various structural issues occur such as lateral loads, side moving, and stiffness and so on. In general, not only earthquake load affects, but also wind load is prominent for high-rise structures. Hence, different loads and corresponding effects on structures need to be considered for multiple floors. The lateral load impact is extremely important to take earthquake and wind loads

into account. Bangladesh is near the Himalayas, the highest mountain range in the world, and is well inside an active tectonic area and susceptible to significant earthquakes. Lists of some major earthquakes affecting in Bangladesh has been illustrated in Table 1. In an Impoverished and heavily populated nation such as ours, the after-effects of an earthquake are harder than in other industrialized countries. Where high-rise structures have been built, several structural issues occur, such as the influence of lateral load, lateral moving, and rigidity on structure. In general, not only tremors are significant for high-rise buildings, but also wind loads. Therefore, understanding numerous loads and their influence on structures is crucial for a tall building. The influence of lateral loads, such as earthquake and wind loads, is critical to consider.

In Bangladesh and other underdeveloped nations, the approach of earthquakes and wind analysis is used in a static analysis because of the lack of modern modeling and computing installations. With the increase in the number of high-rise structures, the code for design, detailing, and construction is increasingly significant.

Significant improvements were made in BNBC 2020 to incorporate knowledge and advances in structural engineering during the last two decades. BNBC 1993 has been modified and published as BNBC 2020 considering the guidelines of other international building standards.

Generally various types of building structure build in our country. The purpose of the study is to designs & analysis of nine-storied reinforced concrete residential building for earthquake and wind performance which is situated in Dhaka value of high-rise building. At First preliminary planning is done using RAJUK standard rule and regulation of building construction and then detailed evaluation is carried out to design the components under concern code which is Bangladesh National Building Code (BNBC). For applying earthquake loads and wind load, equivalent static lateral force method is used according to BNBC 2020.The reinforcement details of the building were not available as it is not designed. Design is prepared applying Dead, Live, Seismic and Wind loads in both span of the structure. This helps in estimating the reinforcement of each component of the building i.e. Slab, Column, Beam, Footing using hand calculation procedure later from governing moments, axial and shear effects. ETABS 21.0.0 (Extended 3D Analysis of Building Structure) is used for analyzing and designing the building. This study tries to compare wind load and earthquake analysis for low strength and high strength material structures by BNBC 2020.

1.2 Major earthquakes affect

Major earthquakes affecting in Bangladesh chart is here given. The maximum earth quake 8.3 in 15th January 1934 at Bihar Nepal Border

Table 1.1: List of major earthquakes affecting Bangladesh

Date	Name of Earthquake	Magnitude	Epicenter
8 July,1918	Srimangal earthquake border	7.3	Bangladesh Tripura
9 September,1923 Border (Meghalaya)	Meghalaya earthquake	7.1	Bangladesh India
2September,1930	Dubai earthquake	7.1	Daiquiri
6 March,193	India Bangladesh earthquake Border	7.6	India Bangladesh
15 January,1934	Bihar Nepal Earthquake	8.3	Bihar Nepal border
11 February,1936	Bihar earthquake	7.5	North Bihar
16 August,1938	Manipur Earthquake Bangladesh	7.2	Monipur near of
23 October,1943	Assam earthquake	7.2	Hojai Assam
21 March, 1994	Monipur-Mayanmar earthquake	7.4	Monipur
21 November,1997	Bandarban earthquake	7.1	Mizoram-Mayanmar border
26 December,2004	Cox's Bazar earthquake	7.0	Bonda

The Bangladesh National Building Code (BNBC) was developed in 1993 to offer recommendations for the development and implementation of modern projects that are prone to tremors, will cause a reduction of threat for all buildings. Relative research is interesting to search at the provisions of this code and to see whether adjustments to the latest upgrade code might be made to identify the changes in design and analysis of the various structures. With the development of tall buildings, the global regulations that control infrastructure design, detailing, and construction are updated regularly to reflect new practices. Wind is a dynamic occurrence that changes rapidly and depends on time and speed. It is due to wind movement from a high-pressure condition to a low pressure.

Bangladesh National Building Code (BNBC) was initially published in 1993, and anticipated wind provision has been modified in BNBC 2017. The previously created Bangladesh Building Code (BNBC) was formally implemented in the year 2006 and was not amended fora long time. In seismic analysis and design of buildings, attention for the combination of earthquakes and wind force has become extremely important since constructions in the unfavorable circumstances like as tectonically strong zones may inevitably be constructed. A comparative study was performed to observe the important modifications among the BNBC 1993 and the proposed BNBC 2012 in terms of compared to the old one. Again, this research study will create a pathway to compare with wind load and earthquake analysis for low rise and high-rise multistory structures by latest code BNBC 2020.The world in determining how many factors of safety against wind disaster are imposed considering the economic aspects and population of our country.

1.2.1 Research Objectives

The objectives of the study are:

- To Compare deflection drift or others structural parameter with different limitation value of different Zone as per BNBC 2020.
- To Analyses different environmental load (Wind Load & Seismic Load) effects on high rise multistory structures for different Zone as per BNBC 2020.

1.2.2 General Approach

- Getting an architectural design of a RCC Residential nine -storied building for different zone.
- Project on RCC Residential Building in Khulna, Dhaka, Tangail & Sylhet and different zone.
- To establish the structural system for the ground and repeated floors of the building.
- Analysis of building, wind resisting system, and type of foundations Will be determined taking into consideration the architectural drawings.

1.3 Statement of project Salient features

Project information given below

Table 1.2: Statement of project Salient features

Utility of Building	Residential Purpose
1. Number of Stories	Nine Storied
2. Shape of Building	Rectangle
3.Number of Staircase & Lift	
4.Shear wall	01
5.Types of Construction	R.C.C framed Structure
6. Types of Walls	Bricks wall

1.4 Geometric Details

Below given project geometric details

Table 1.3: Statement of project Geometric Details

1.Ground Floor	13ft
2.Floor to Floor height	10ft
3.Height of plinth	3 ft

CHAPTER 2
Literature Review

2.1 Introduction

Many researchers' advances in earthquake & wind engineering research have taken place over the last two decades. Researchers have done some different comparison with this earth quack & wind load and their result is discussed below.

2.2 Previous Background of the Study

The Bangladesh National Building Code (BNBC) has not been updated since its inception in 1993.Earthquake design provisions is important, since Bangladesh is located in a seismically active region not far from the boundary of the Indian Plate and Eurasian Plate. Many advances in earthquake engineering research have taken place over the last two decades.

John D. Holmes et.al (2008) analyzed low, medium, and high-rise structures. Tall buildings have a significant amount of resonant dynamic response to wind that complicates the evaluation of base shear. Bending moments, and accelerations at the top of the building. The coefficient of variation for both wind and crosswind reactions were relatively small, ranging from 14% to 18%. Juliya Mir nova, et.al. (2020) the paper presented a study on the Wind impact on low-rise buildings when placing high-rises into the existing development. The purpose of the study is to model wind flows to determine maximum aerodynamic wind effects on multi-story buildings and their surroundings. In this study, numerical experiments on modeling the distribution of wind flow in a virtual wind tunnel for an existing low-rise building have been carried out. Based on their results, an increasing coefficient in the

Hemil M. Chauhan et.l. (2011) presented a study on the comparative study of wind forces on high rise buildings. For analysis he used ETABS software with four terrain categories and six different wind speeds. He performed the analysis on 60m and 120m building. In static analysis, both buildings give almost same values of shear forces & bending moments. ARE present code gives increased values of base shear compared to IS Draft code. IS Draft code gives more accurate and more direct than present code for estimating response parameters such as acceleration and forces.

Valsson Varghese et.al. (2013) presents the comparative study of special moment reinforced building over ordinary moment reinforced building with seismic and wind effect. The forces on OMRF structure are comparatively much higher than that of SMRF structure. It is safer to design a ductile detailing structure than the non - ductile detailing structure. The quantity of steel is found to be more in case of

SMRF than that of OMRF. Athanase Ndikokubwayo et.al., (2014) presented a study on the extensive study lateral and base shear forces acting on 20 stories building in Bujumbura city during the seismic Activity using the E-TABS software for analysis. He observed that the seismic shear forces and lateral forces can reach 2000 kN and 230 kN respectively.

Wind has two aspects-the first beneficial one is that its energy can be utilized to generate power, sail boats and cool down the temperature on a hot day and on the other hand, the parasitic one is that it loads any and every object that comes in its way. The importance of wind energy is emerging in India ever since the need of taller buildings due to scarcity of land. Recently there has been a considerable increase in number of taller buildings both residential and commercial. As the height of the structure increases, the forces acting on the structure also increases along with the height of the building and affects the rigidity and stability of the structure so it becomes necessary to design the structure preferably for lateral forces, story drift, moments. Therefore, it is very important for the structure to have sufficient strength against vertical loads along with adequate stiffness to resist the lateral loads.

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 Comprises 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 1914by 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 tens 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 midpoint of the vertical members as well as horizontal members and that the direct stresses in the columns are proportional to their distances from the centric 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 controlee 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's

We use here Etabs and Auto CAD software for Design.

ETABS 2021 version 21.0.0

Auto CAD 2022

2.4.1 ETABS 21.0.0

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 45 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.

Now a day's 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.

CHAPTER 3

Methodology

3.1 Introduction:

In this chapter methodology of the work has been discussed. This project is mostly based on software,

1. ETABS (21.0.0)
2. Auto CAD 2020

Required data for analysis and model built-up with ETABS (21.0.0) are discussed details here. Analysis has been done for Zone-I, II, III, IV (Khulna, Dhaka, Tangail, 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 spas floor finish and 30psf 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 has to create a load case for live load and select all the slabs to carry such load. Since the structures of the present study are intended

for residential use, the live load considered in the building is 45 psf floor & roof top and staircase 100 psf.

3.2.3 Wind Load (Institute, 2020)

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 herein.

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 procedures:

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. Calculating 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 a building surface at any height z above ground according to BNBC 2020.

$Qz = Cc\ Ci\ Cz\ V^2 b$.....(If Vb=km/h.....(i)

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

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:

$qz = (0.0006130v^2) Kz\ Kzt$ Kd I,.(kN/㎡), V in m/s. .....(ii)

From the above equation, design wind pressure, pzis 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

Co=Gust coefficient (calculated based on building height)
Cp=Pressure coefficient
Qz=Sustained wind pressure at height z, KN/㎡2

Ct= in plain train local topography coefficient

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/$m2$)

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 ㎡: Component and cladding elements with tributary areas greater than 65 ㎡ 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=qGCp-qi(GCpi)(..KN/m^2) .....(vii)

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

Table 3.1 Basic Wind Speeds, V, for Selected Locations in Bangladesh

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

h_n =height in meters above the base to level n.

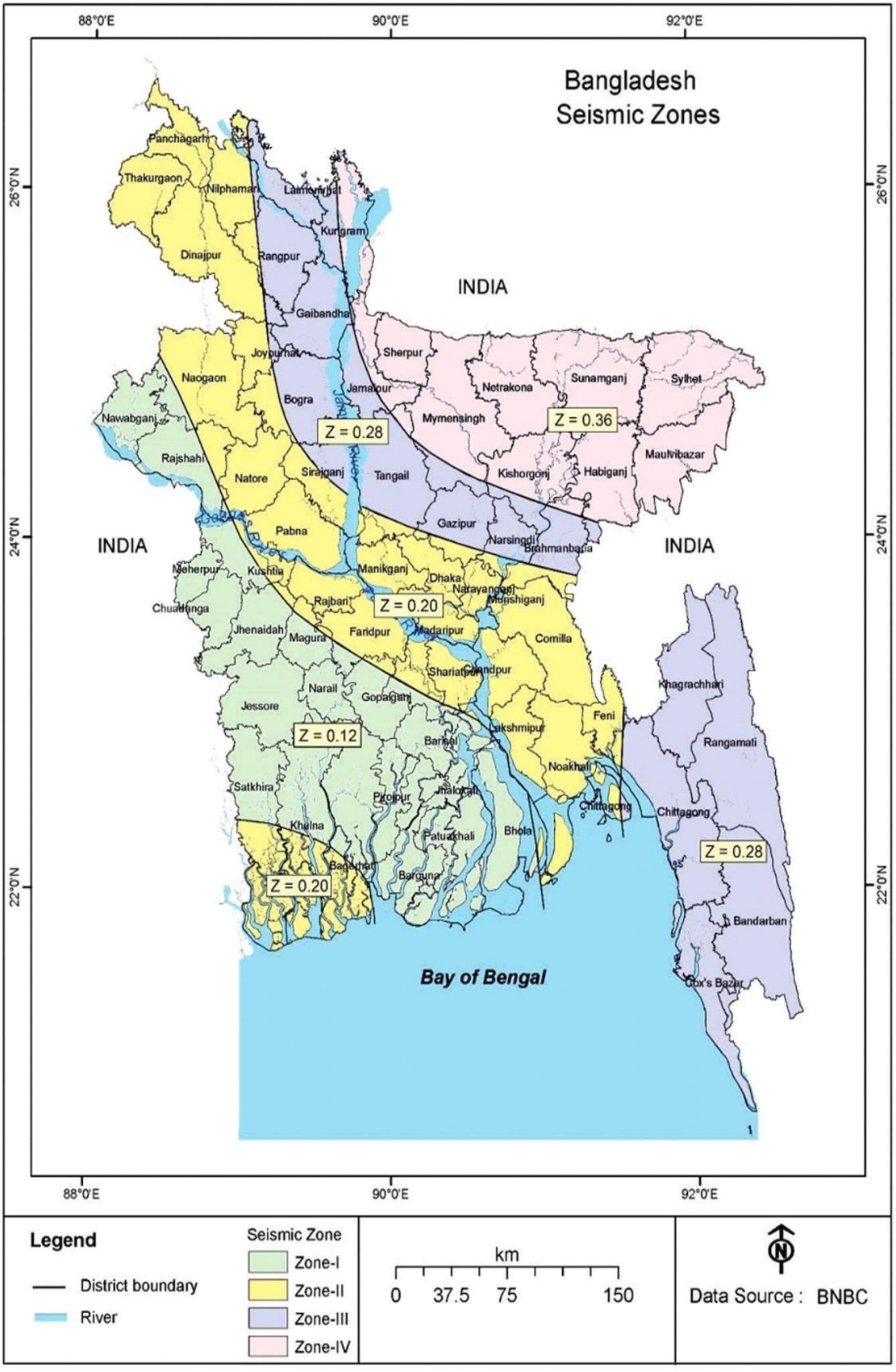


Figure: 3.1: Bangladesh Seismic Zone

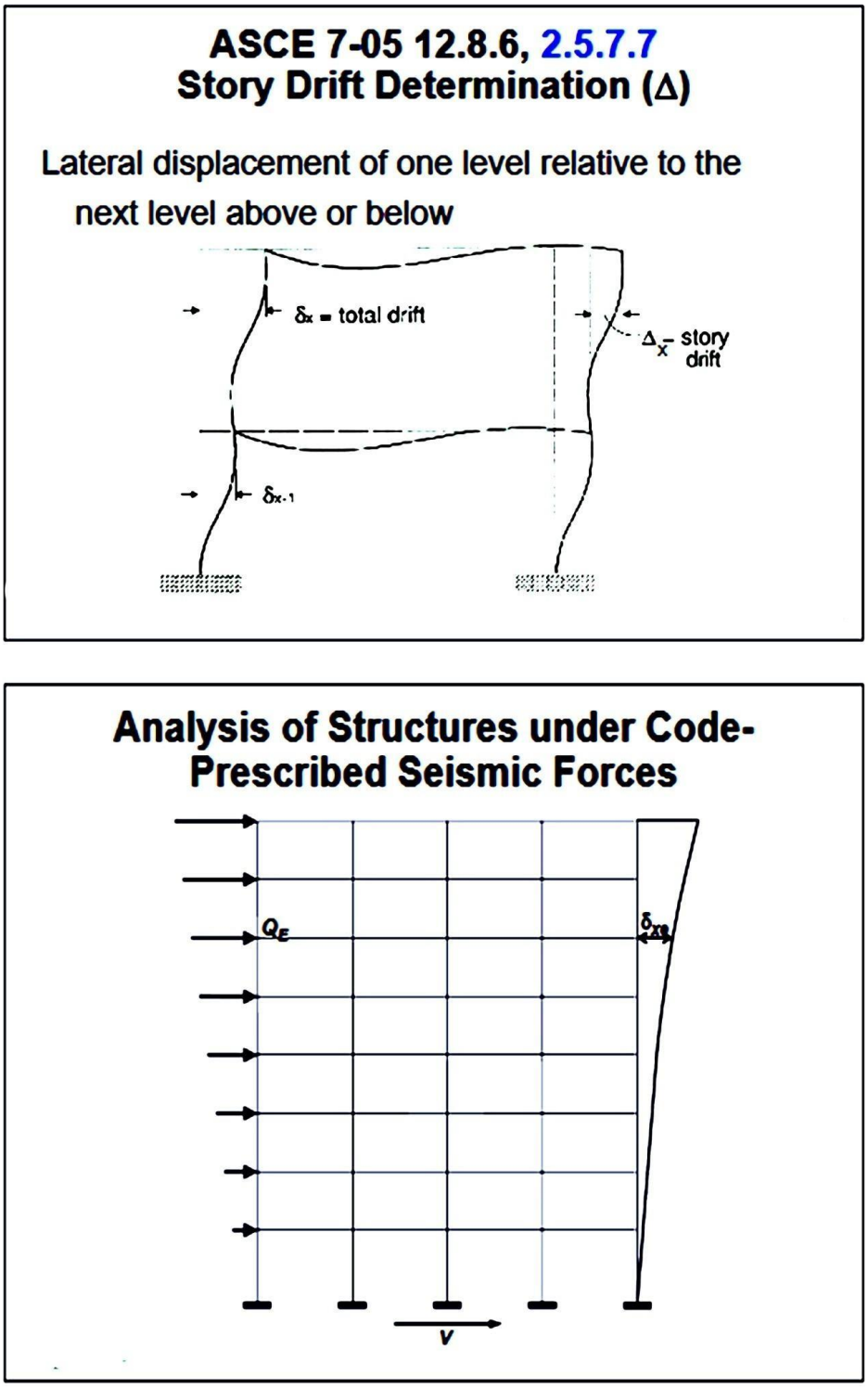


Figure: 3.2: Story Drift Determination

Table 3.2.: Site Dependent Soil Factor and Other Parameters Defining Elastic Response Spectrum

Soil type	S	Tb(s)	Tc(s)	Tb(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 3.3: Importance Factor for Wind Load

Occupancy Category1 or Importance Class	Non-Cyclone Prone Regions and Cyclone Prone Regions with 0.87V 38-44 m/s	Cyclone Prone Regions with V > 44 m/s
I	0.87	0.77
II	1	1
III	1.15	1.15
IV	1.15	1.15

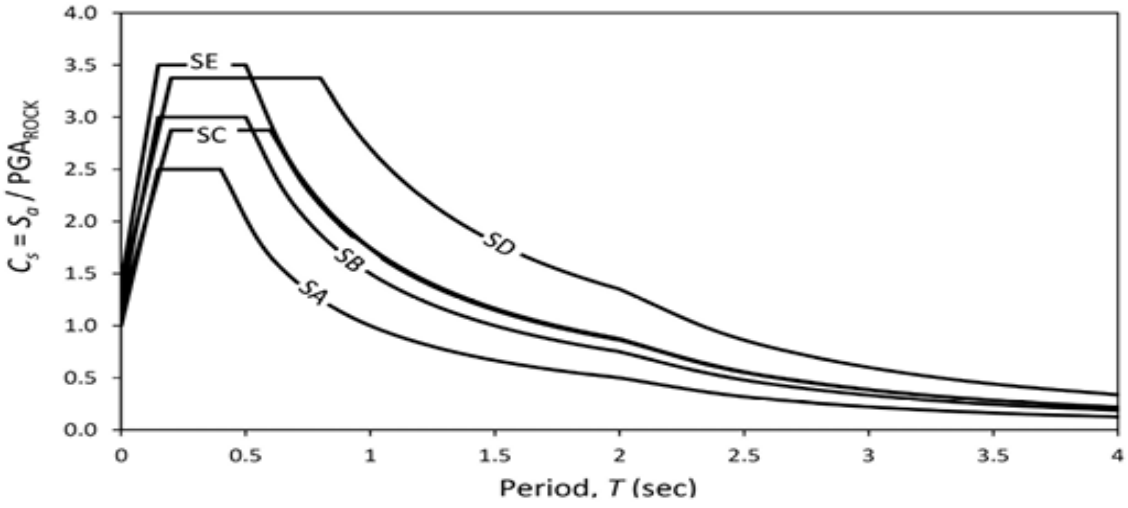


Figure: 3.3: Normalized design acceleration response spectrum for different site classes.

Building Categories

It is a Residential high rise building.

Important factor

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

Table 3.4: Site Classification Based on Soil Properties

Site Class	Description of soil profile up to 30 meters depth	Average Soil Properties in top 30 meters		
		Shear wave velocity, (m/s)	SPT Value, (blows/30cm)	Undrained shear strength, (kPa)
SA	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	SE A soil profile consisting of a surface alluvium layer with Vs values of type SC or SD and thickness varying	….	…	…

	between about 5 m and 20 m, underlain by stiffer material with V s> 800 m/s.			
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	< 100 (indicative)	…	10 - 20
S2	Deposits of liquefiable soils, of sensitive clays, or any other soil profile not included in types SA to SE or S1	…..	…	….

Table 3.5: Importance Factors for Buildings and Structures for Earthquake design

Occupancy Category	**Importance factor I**
1,11	1.00
III	1.25
IV	1.50

3.5.1 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 assembly occupancies or arras 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.

Load Group 2**:** Uniformity distributed live loads resulting from Occupancies or uscs 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.

2. 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:

1 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.

a) 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. lands, sparsely built-up outskirts of towns, flat open country and grasslands.

Exposure B: Flat and unobstructed open terrain, coastal areas and riven ides faring larger besides 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.

Table 3.6: 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, S_1, S_2	D	D	D	D	D	D	D	D

Table 3.7: 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。	Deflection Amplification Factor, Cd	Seismic Design B	Seismic Design C	Seismic Design D
				Height limit(m)		
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

Load Combinations: For Check

As per BNBC 2020

$U = Dl + LL$

$U = DL + .25\ LL$

$U = DL + 0.5LL$

$U = DL + .5LL + .7WX$

$U = DL + .5LL - .7WX$

U=DL + .5LL+.7WY

U=DL + .5LL-.7WY

Earthquake load and Wind Load must be considered for +X, -X, +Y and -Y directions. Thus, EL and +WL above implies 24 cases, and in all, 26 cases as per Table 3.6 must be considered. All 26 load combinations are analyzed using software.

3.2.6 Design data

The Design data has given below

Table 3.8: Load Consideration

Load Consideration: BNBC 2020 for Zone I, II, III & IV	
3,5.1. Dead Load: SW	
Floor Finish (FF)	:25 psf
Concrete Unit Weight	:150 psf(3ft)
Parapet wall	:450 1b/ft(9.5ft)
Partition wall (PW)	
3.5.2. Live Load	:2KN/m2 or 41.76 psf
Floor:4.8KN/m' or	:100 psf
Stair:4.8KN/m' or	:100 psf
Roof Over	:312 psf(5.5 ft)
Head Water Tank	

3.2.7 Wind Pressure (BNBC 2020): Khulna

Zone (I)

Basic Wind speed V	:164 mph
Structural Important Coefficient	:0.77
Expose Category	: A
Gust Factor	:0.85
Directionally Factor, Kd	:0.85

Zone (II) Dhaka

Basic Wind speed V	:147 mph
Structural Important Coefficient	:1.0
Expose Category	: A
Gust Factor	:0.85
Directionally Factor, Kd	:0.85

Zone (III) Tangail

Basic Wind speed V	:114 mph
Structural Important Coefficient	:1.15
Expose Category	: A
Gust Factor	:0.85
Directionally Factor, Kd	:0.85

Zone (IV) Shyllet

Basic Wind speed V	:137 mph
Structural Important Coefficient	:1.15
Expose Category	: A
Gust Factor	:0.85
Directionally Factor, Kd	:0.85

3.2.8. Earthquake Category Base Shear (BNBC 2020)

Seismic Zone: Zone I

Seismic Zone factor (Z)	:0.12
Response Modification Coefficient, R	:6.5
Deflection Amplification, Cd	:5
Structural Importance Factor (I)	:1.0
Dependent Soil Factor	:1.35
Spectral Response Acceleration, S	:0.2
Time Period, T	:0.60 sec
Lateral seismic force coefficient, Sa	:0.054
Normalized acceleration response spectrum, Cs	3.375
Seismic Design Category	C
Location	Khulna
Site Class (N value below 15)	:SD

Seismic Zone: Zone II

Seismic Zone factor (Z)	:0.20
Response Modification Coefficient, R	:6.5
Deflection Amplification, Cd	:5
Structural Importance Factor (1)	:1.0
Dependent Soil Factor	:1.35
Time Period, T	:0.60 sec
Lateral seismic force coefficient, Sa	:0.09
Normalized acceleration response spectrum, Cs	3.375
Seismic Design Category	:D
Location	Dhaka
Site Class (N value below 15)	:SD

Seismic Zone: Zone III

Seismic Zone factor (Z)	:0.28
Response Modification Coefficient, R	:6.5
Deflection Amplification, Cd	:5
Structural Importance Factor (1)	:1.0
Dependent Soil Factor	:1.35
Time Period, T	:0.60 sec
Normalized acceleration response spectrum, Cs	3.375
Lateral seismic force coefficient, Sa	:0.126
Seismic Design Category	D
Location	Tangail
Site Class (N value below 15)	:SD

Seismic Zone: Zone IV

Seismic Zone factor (Z)	:0.36
Response Modification Coefficient, R	:6.5
Deflection Amplification, Cd	:5
Structural Importance Factor (1)	:1.0
Dependent Soil Factor	:1.35
Time Period, T	:0.60 sec
Normalized acceleration response spectrum, Cs	3.375
Lateral seismic force coefficient, Sa	:0.162
Seismic Design Category	D
Location	Sylhet
Site Class (N value below 15)	:SD

Material Properties:

Unit weight of concrete	: 150 lb/ft
For slab, fc	:3500 psi

For beam, fc’	:3500 psi
For Column and shear wall: fc'	:4000 psi
Steel: Yield strength of Steel, fy	:72 ksi

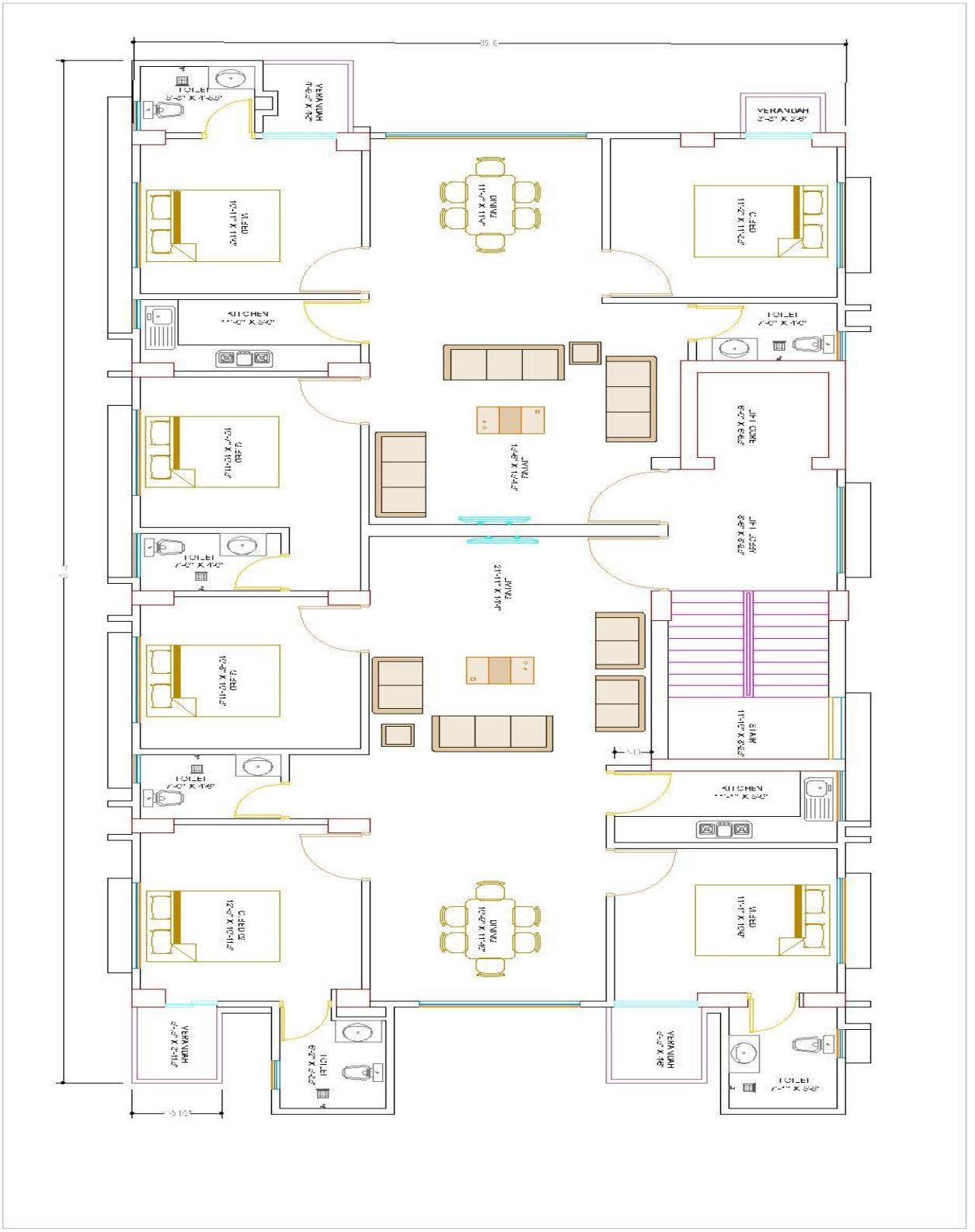


Figure 3.4: Auto CAD model 1st to 8th floor

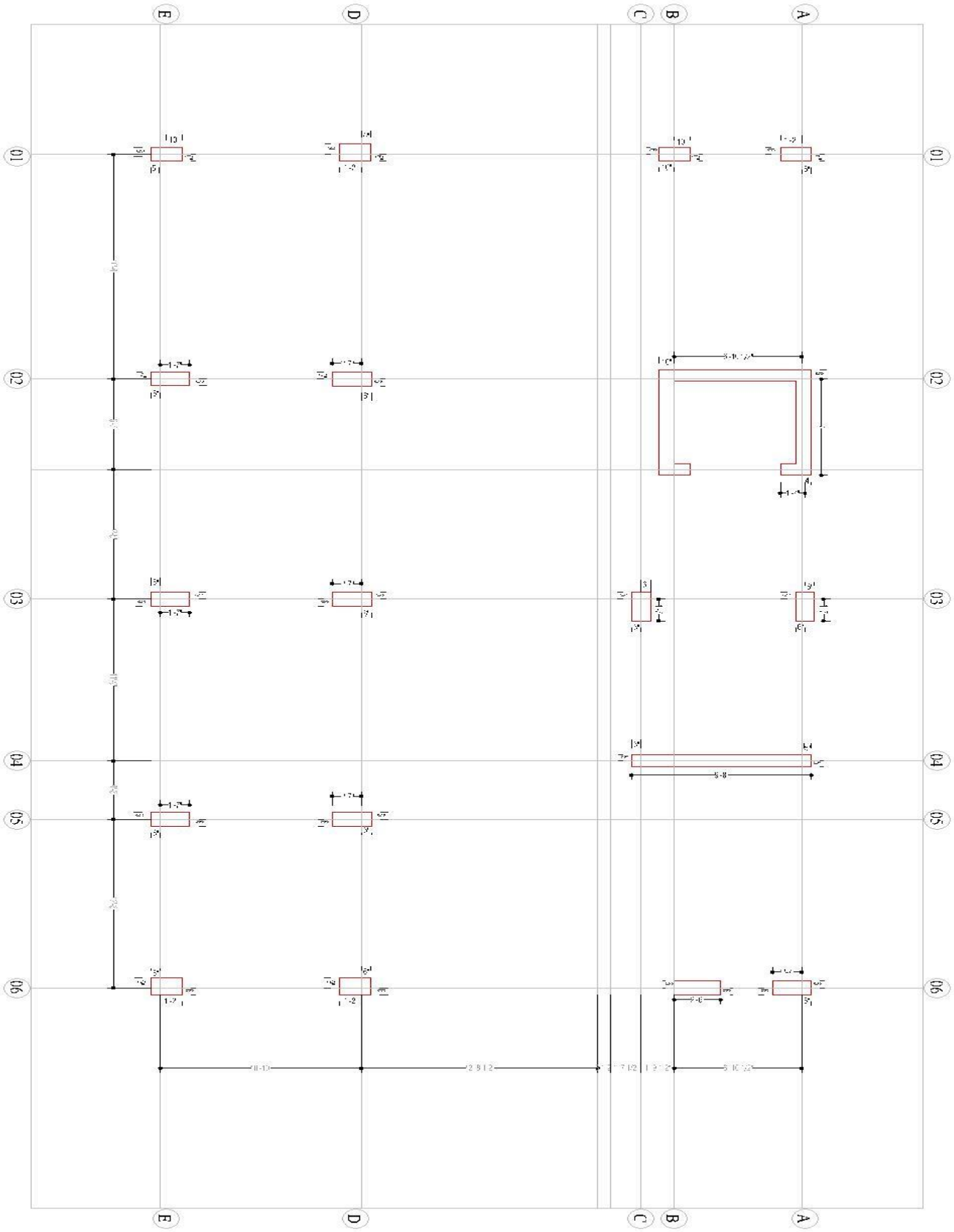


Figure 3.5: Auto Cad Column Layout Model

3.2.9 Auto CAD 2022:

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, 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 learn quickly. Learning of certain commands is required to draw in AutoCAD.

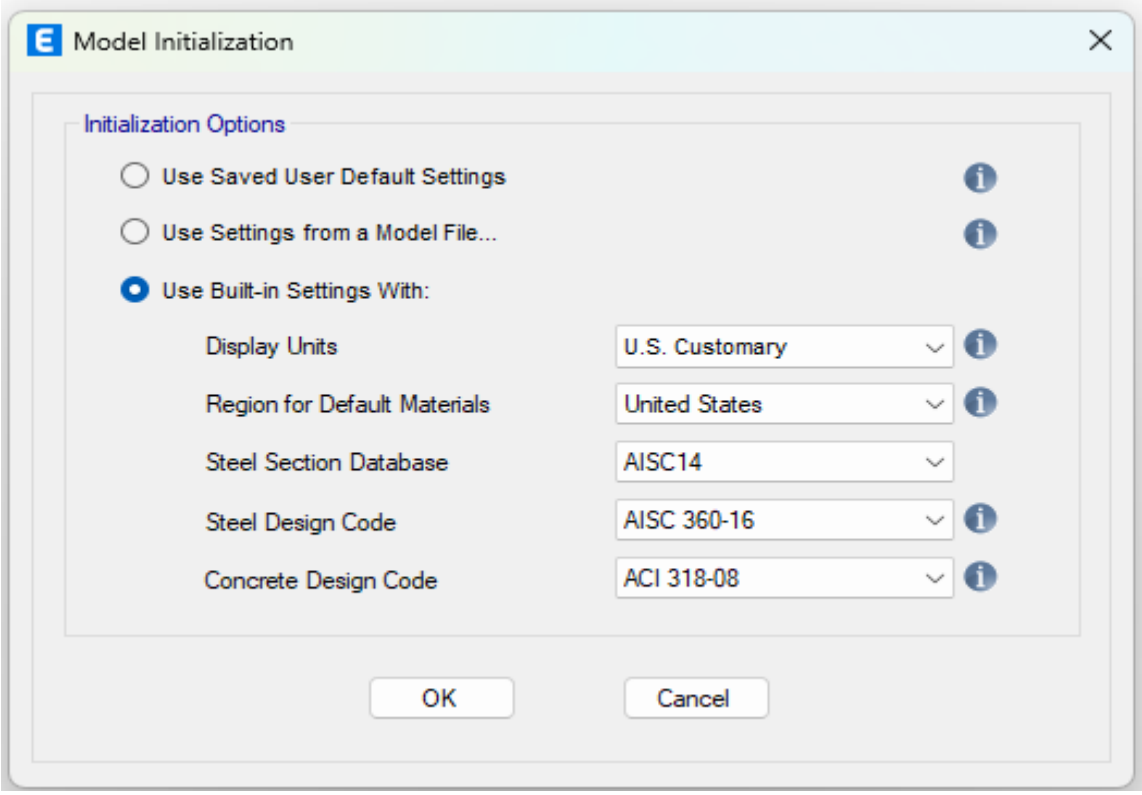


Figure 3.6: Modelling With EATBS

 File> New model

 U.S Customary

 United State

 Concrete Design Code ACI 318-08

 OK

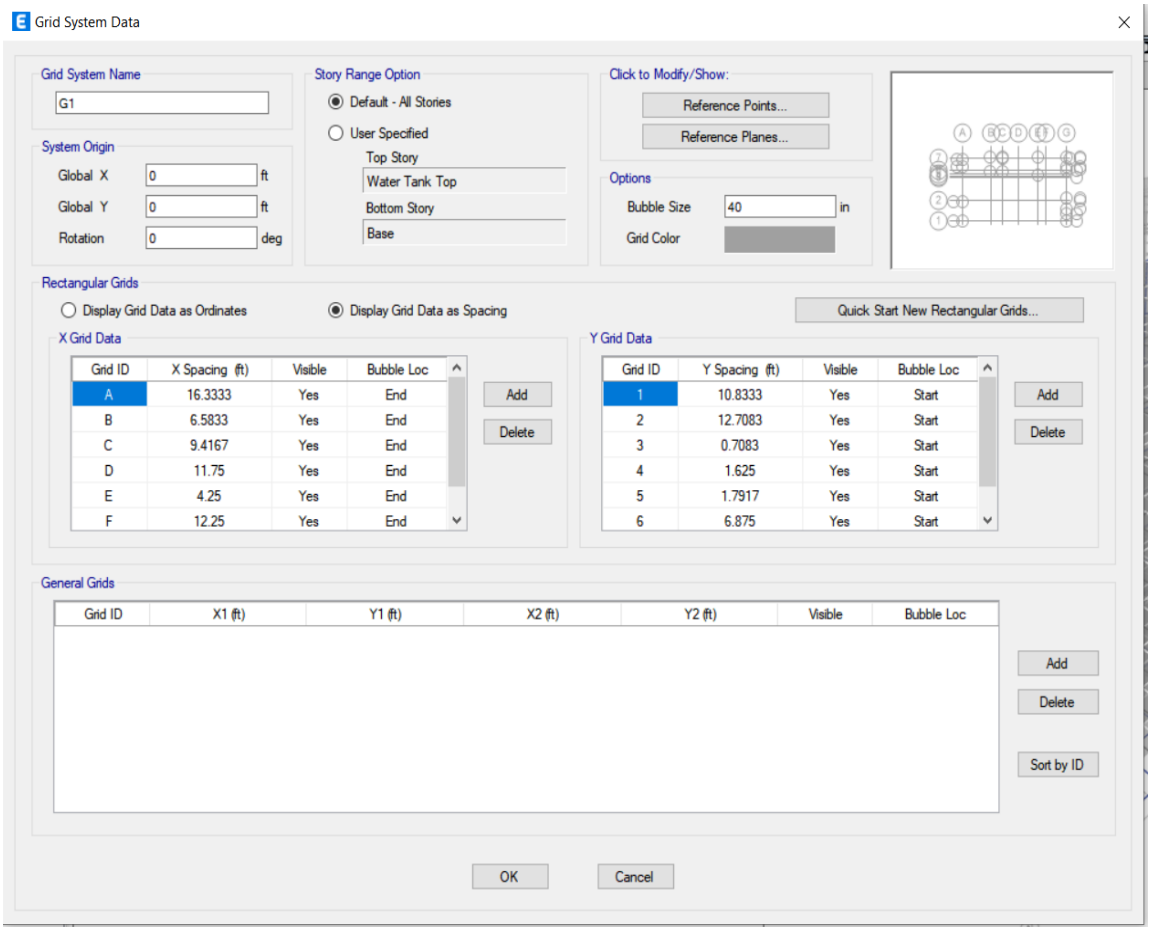


Figure:3.7 Grid Selection of the Model

 File> New model
 If it is uniform grid then file up the “Uniform grid Spacing" Box
 Input number of grids in X, Y direction
 Take number of Stories
 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

 Input spacing of grid in X, Y direction
 OK

3.9.2 Define Materials Properties and Frame Section:

•Materials Properties

I. Concrete

ii. Modify if need

 Frame Section

I. Select all existing property

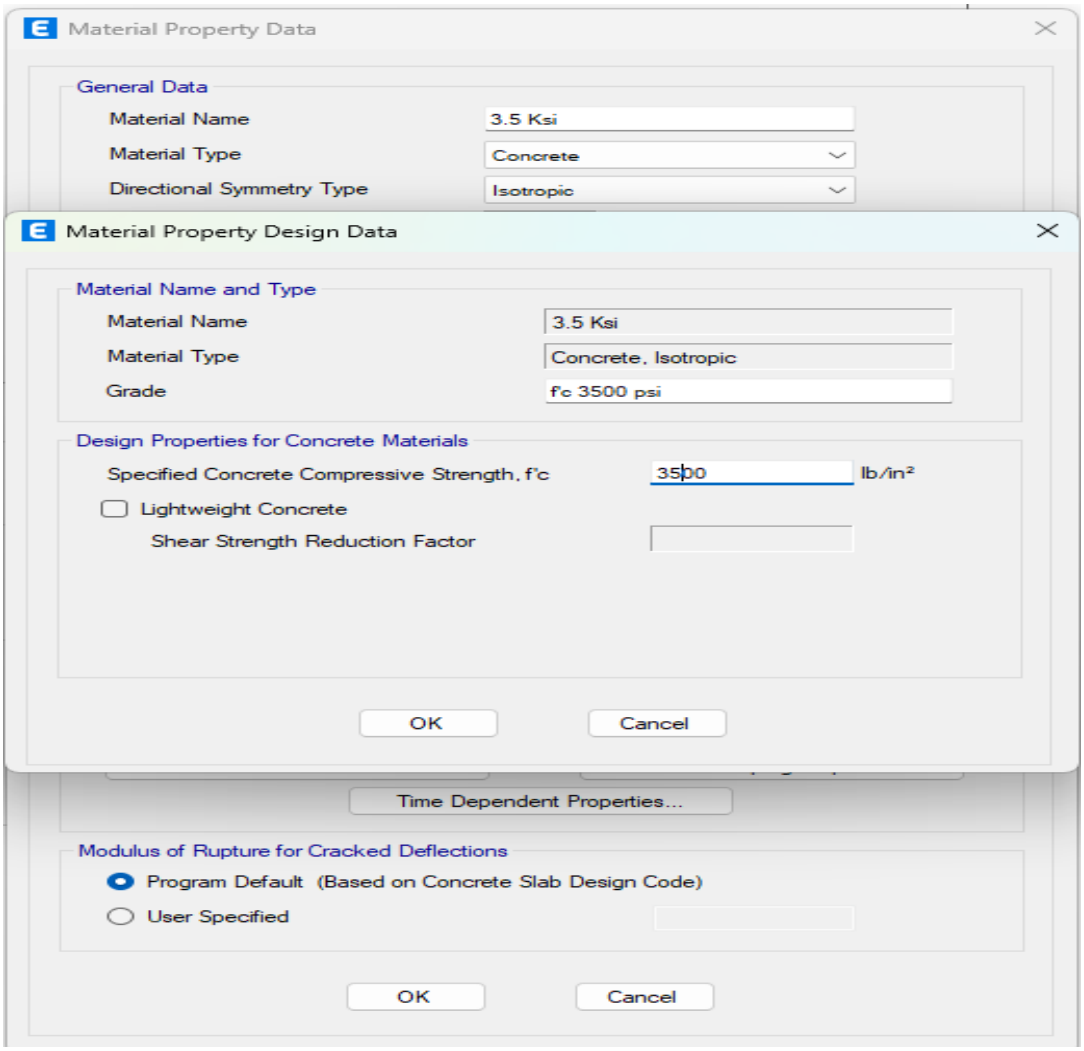
ii. Delete all

iii. Add rectangle

iv. For beam

v. Select Reinforcement

VI. Then select beam



vii. Define all frame section in this process

Figure: 3.8 Material Property of the Model

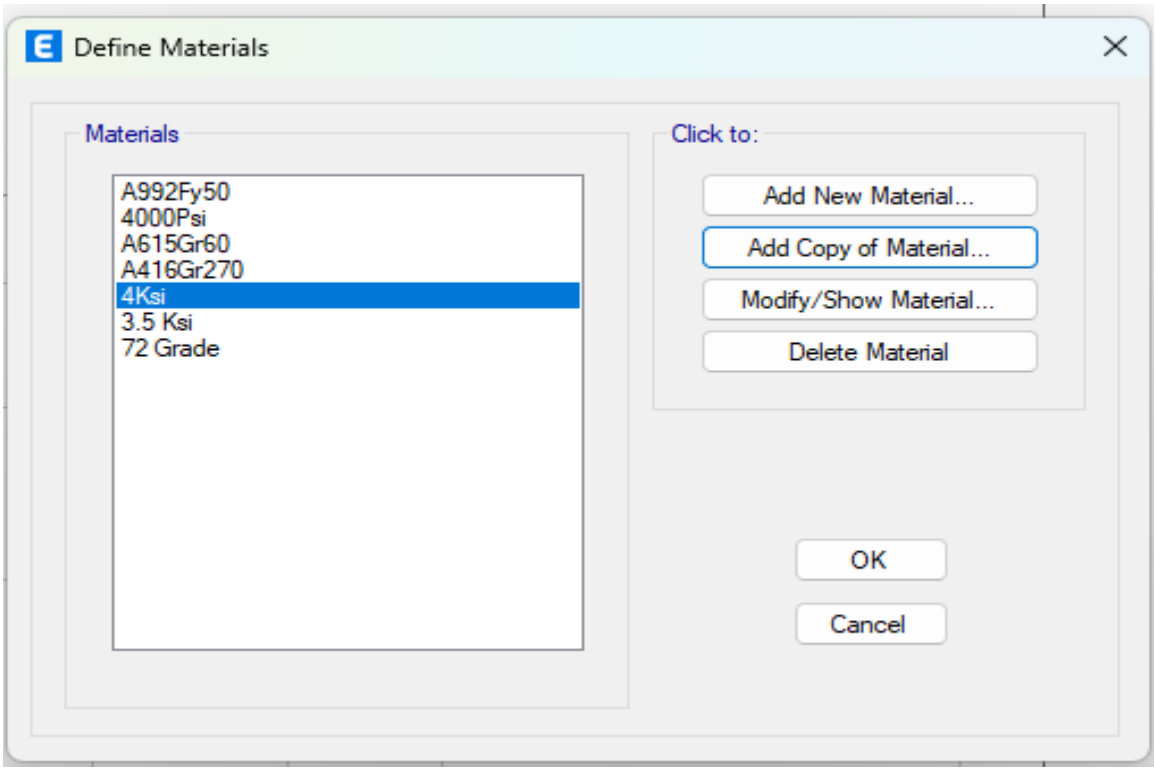


Figure: 3.9 Material Property of the Model

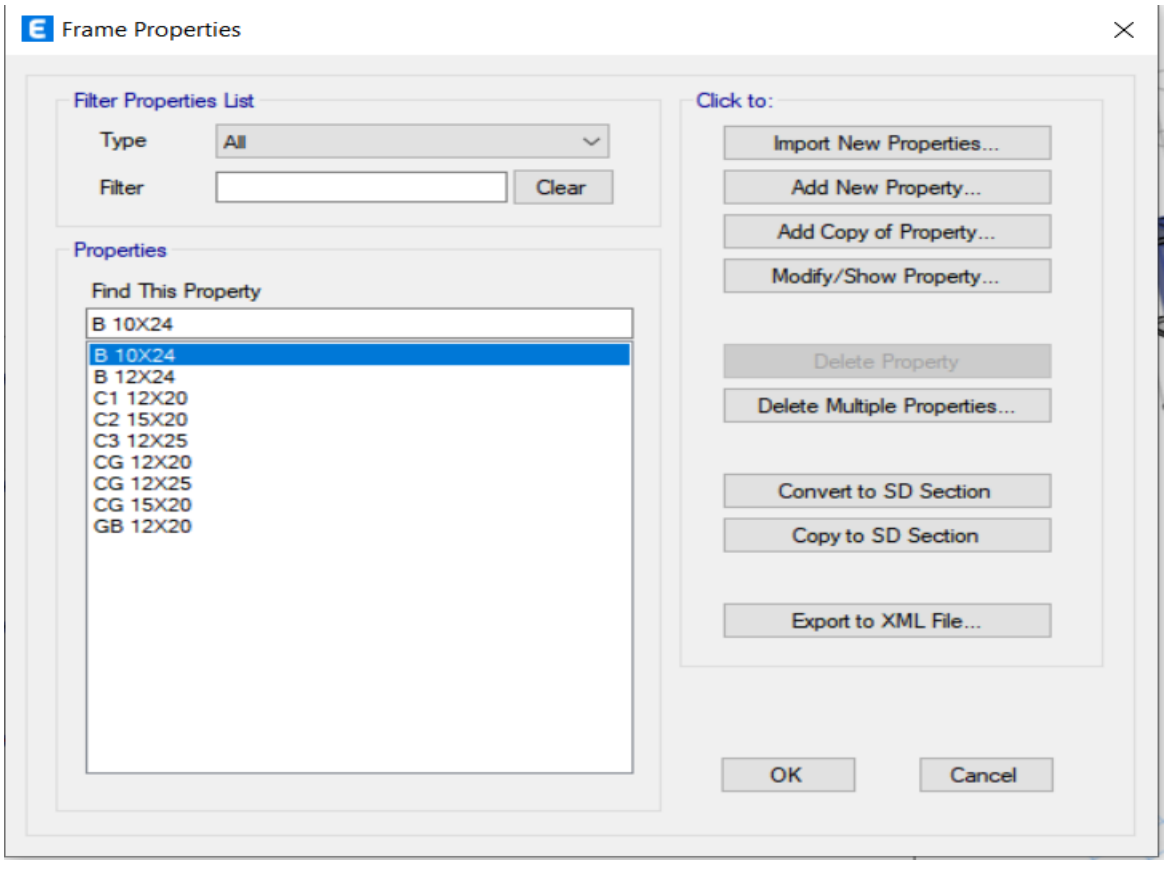


Figure: 3.10 Frame Property of the Model

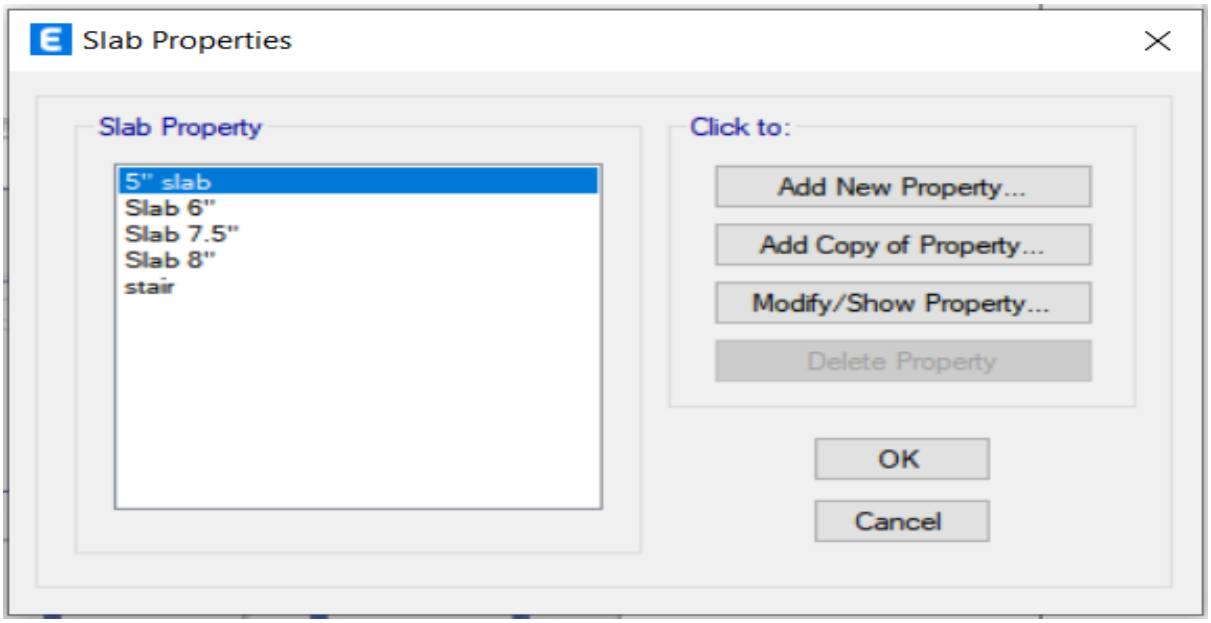


Figure:3.11 Slab property

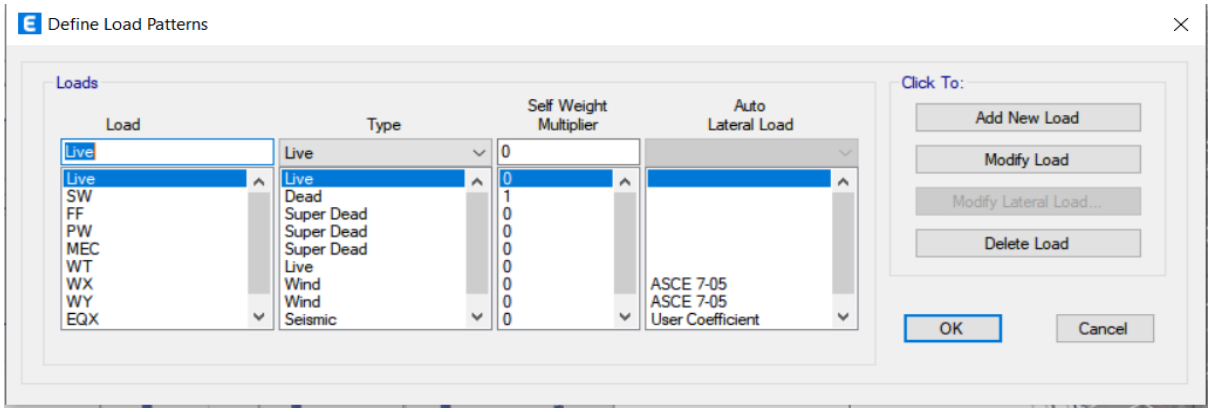
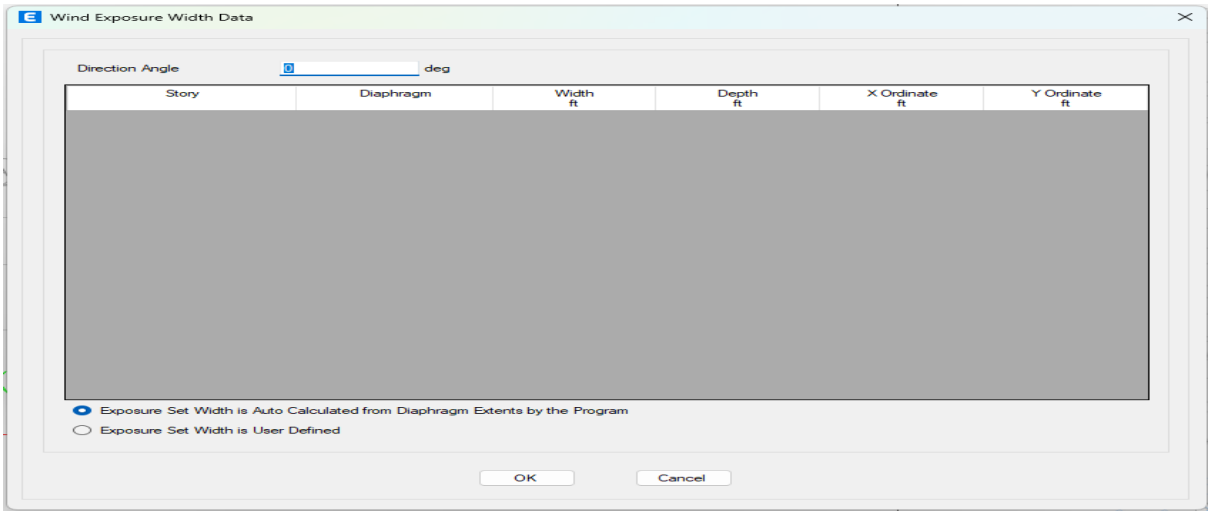


Figure: 3.12 Load Pattern



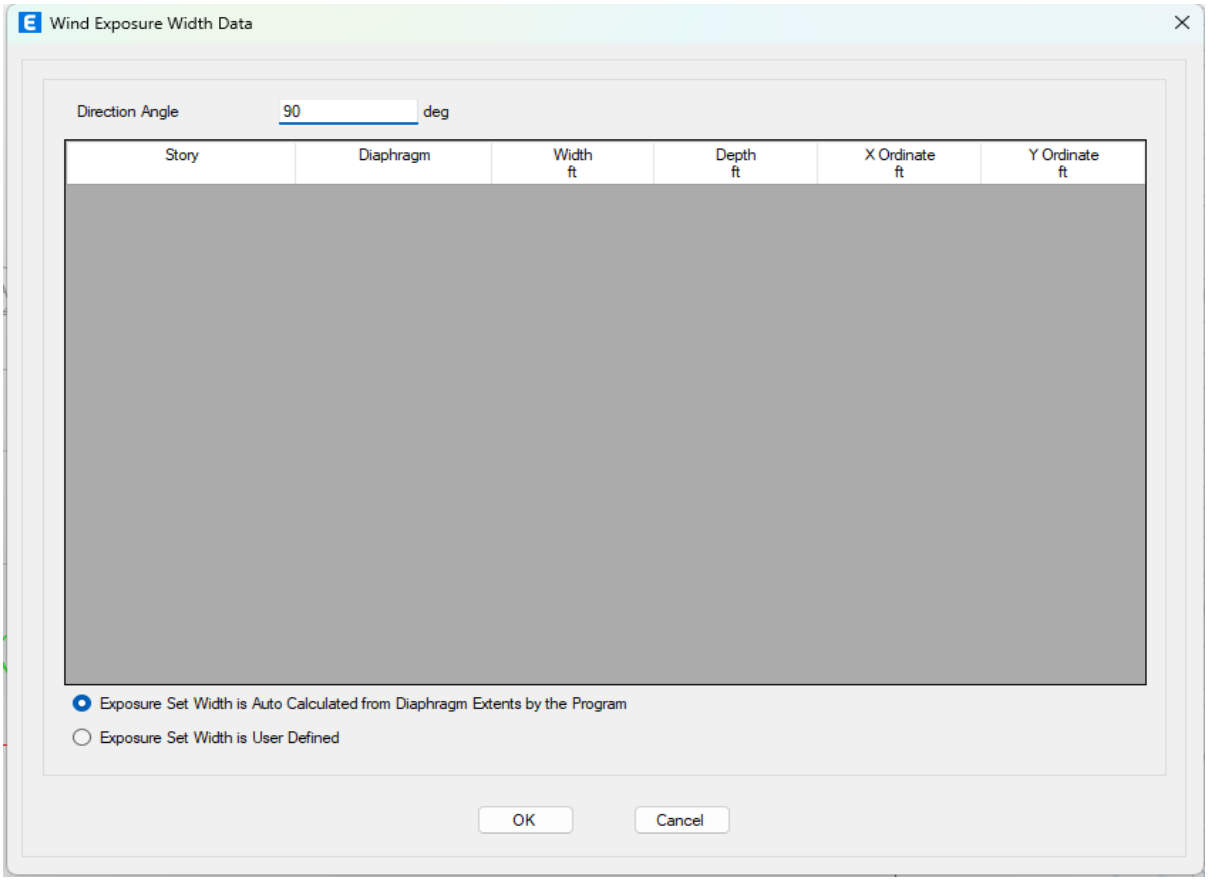


Figure: 3.13 Wind Load X direction for 0°

Figure: 3.14 Wind Load Y direction for 90°

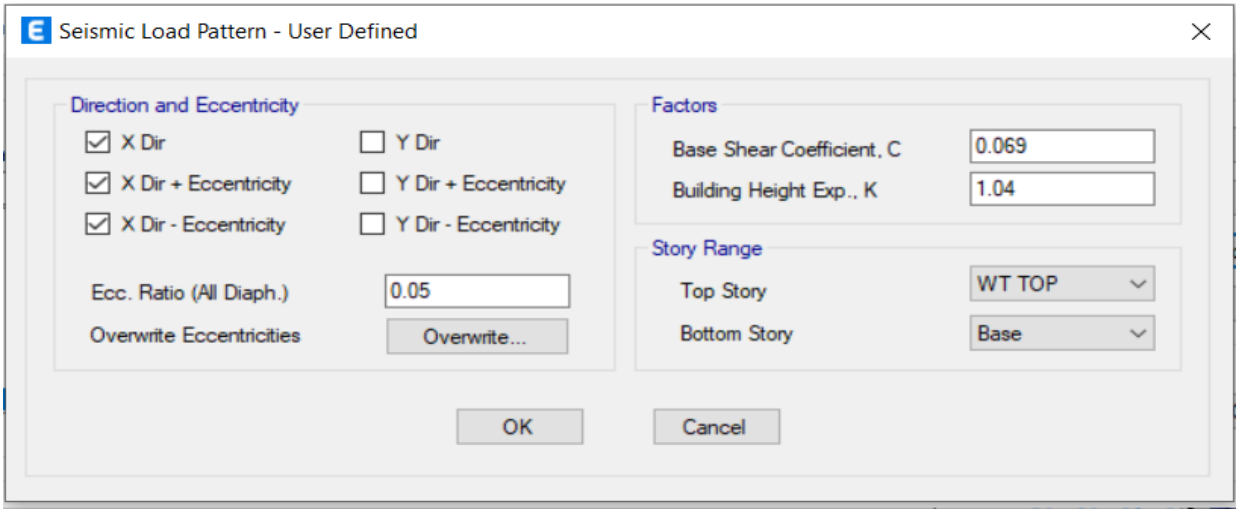


Figure: 3.15 Seismic load defined X direction

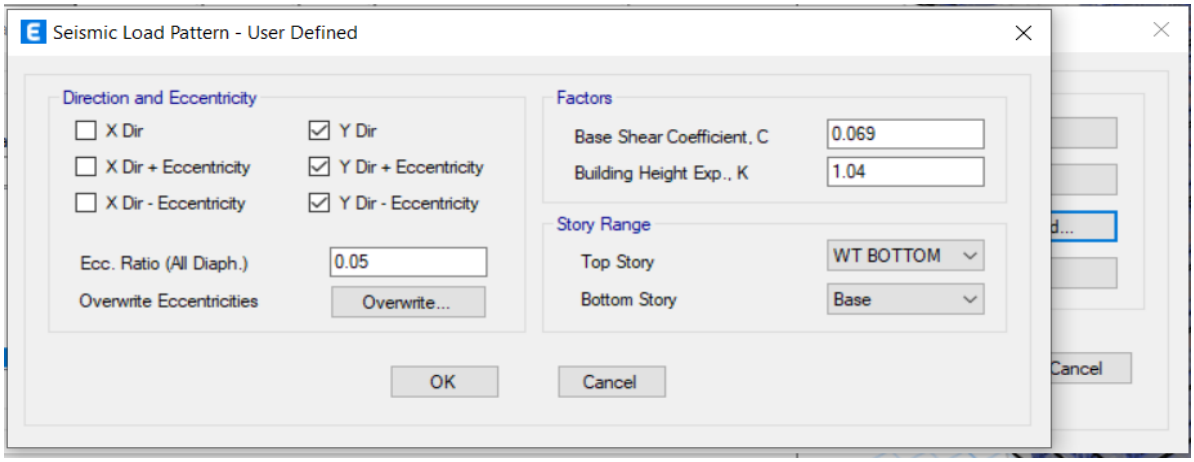


Figure: 3.16 Seismic load defined X direction

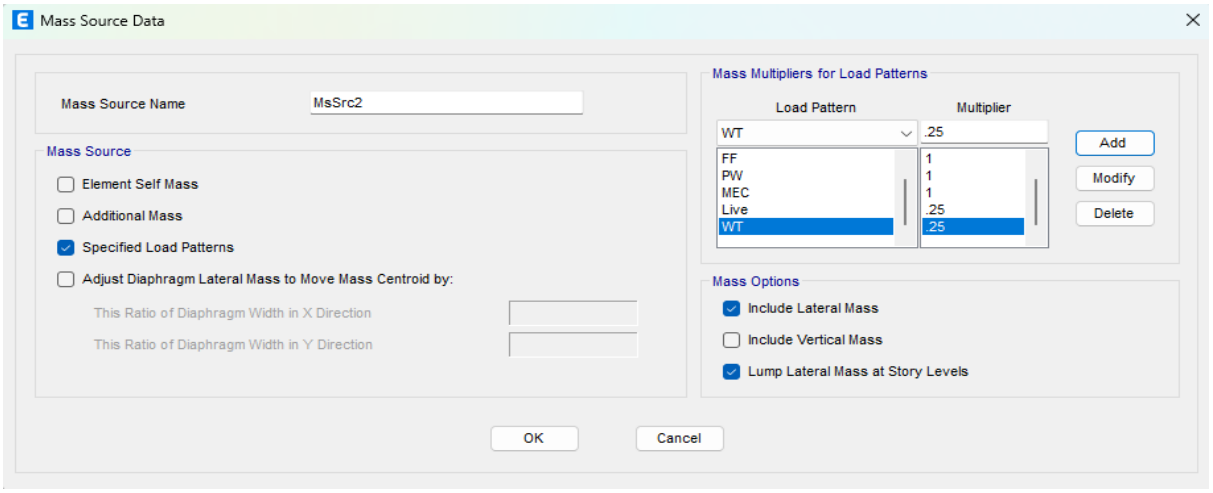
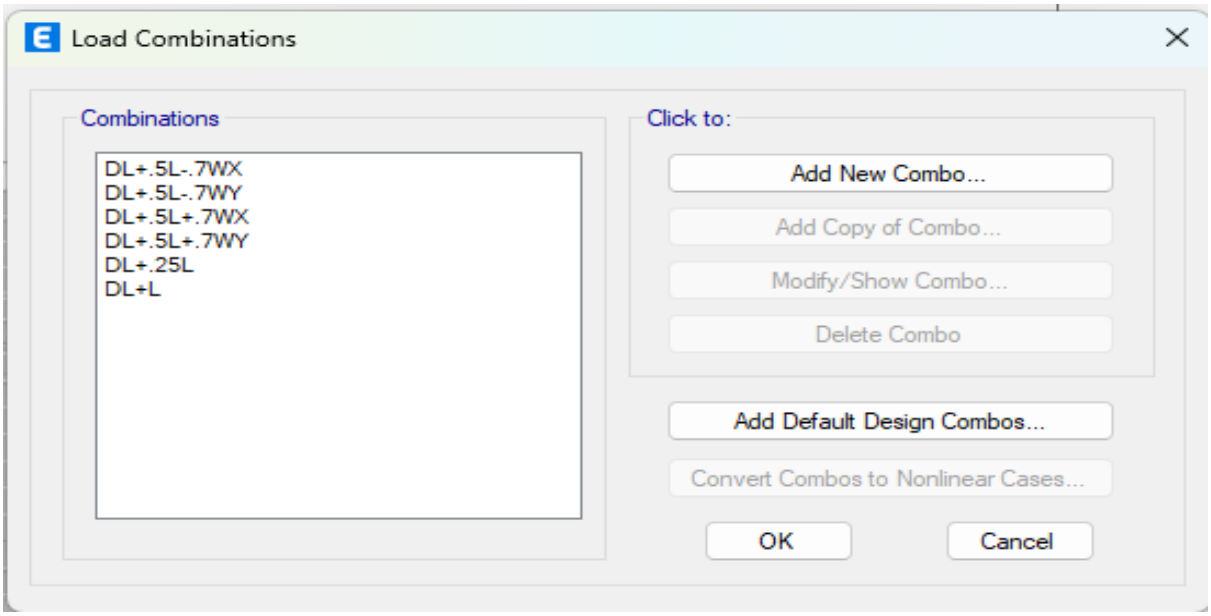


Figure: 3.17 Mass source

Figure: 3.18 Load Combination for check



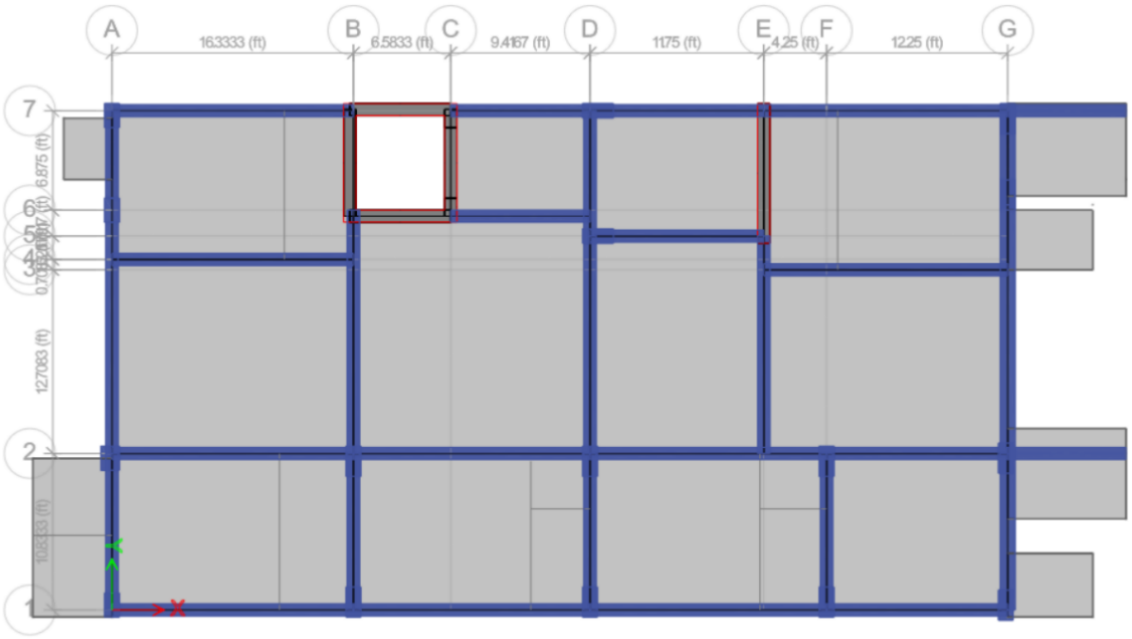
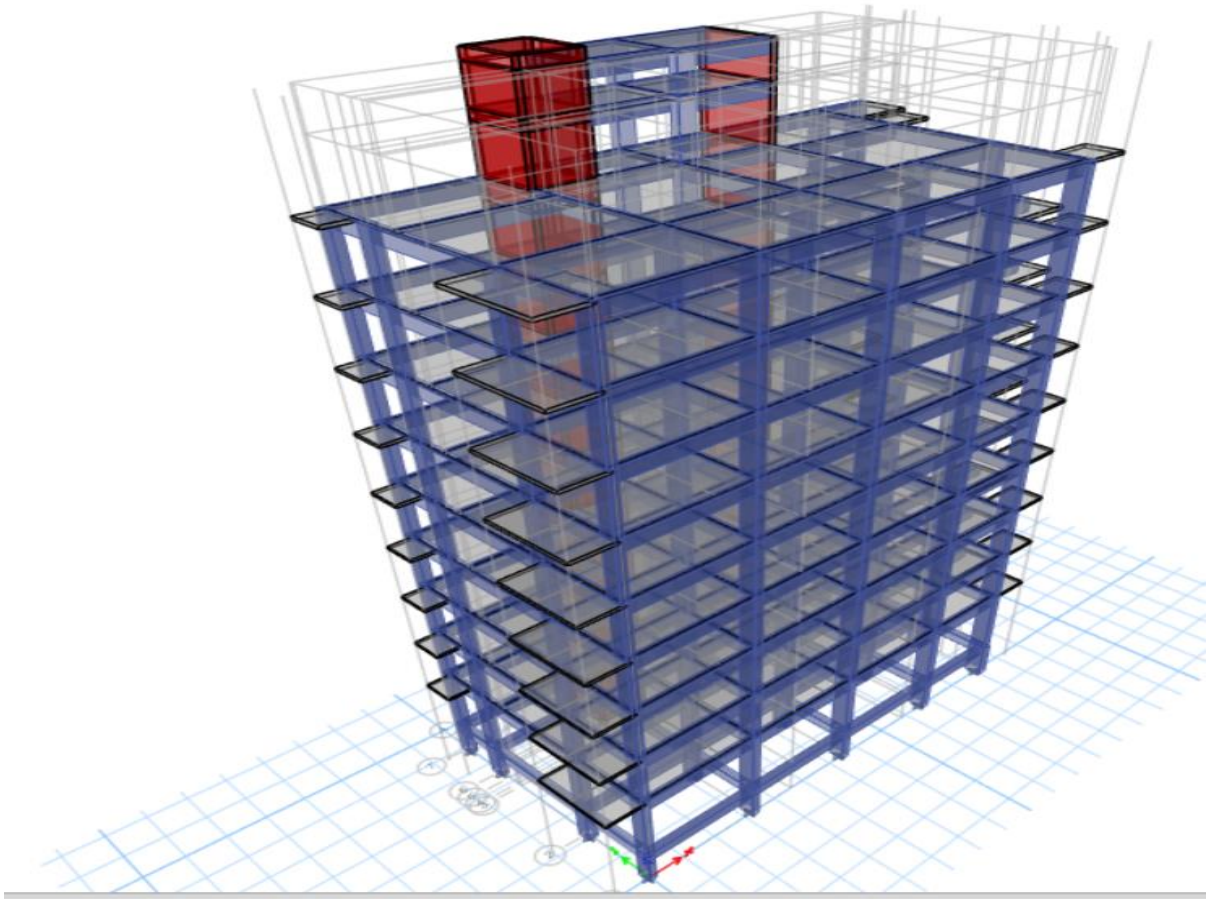


Figure: 3.19 Plan for the 2D Model



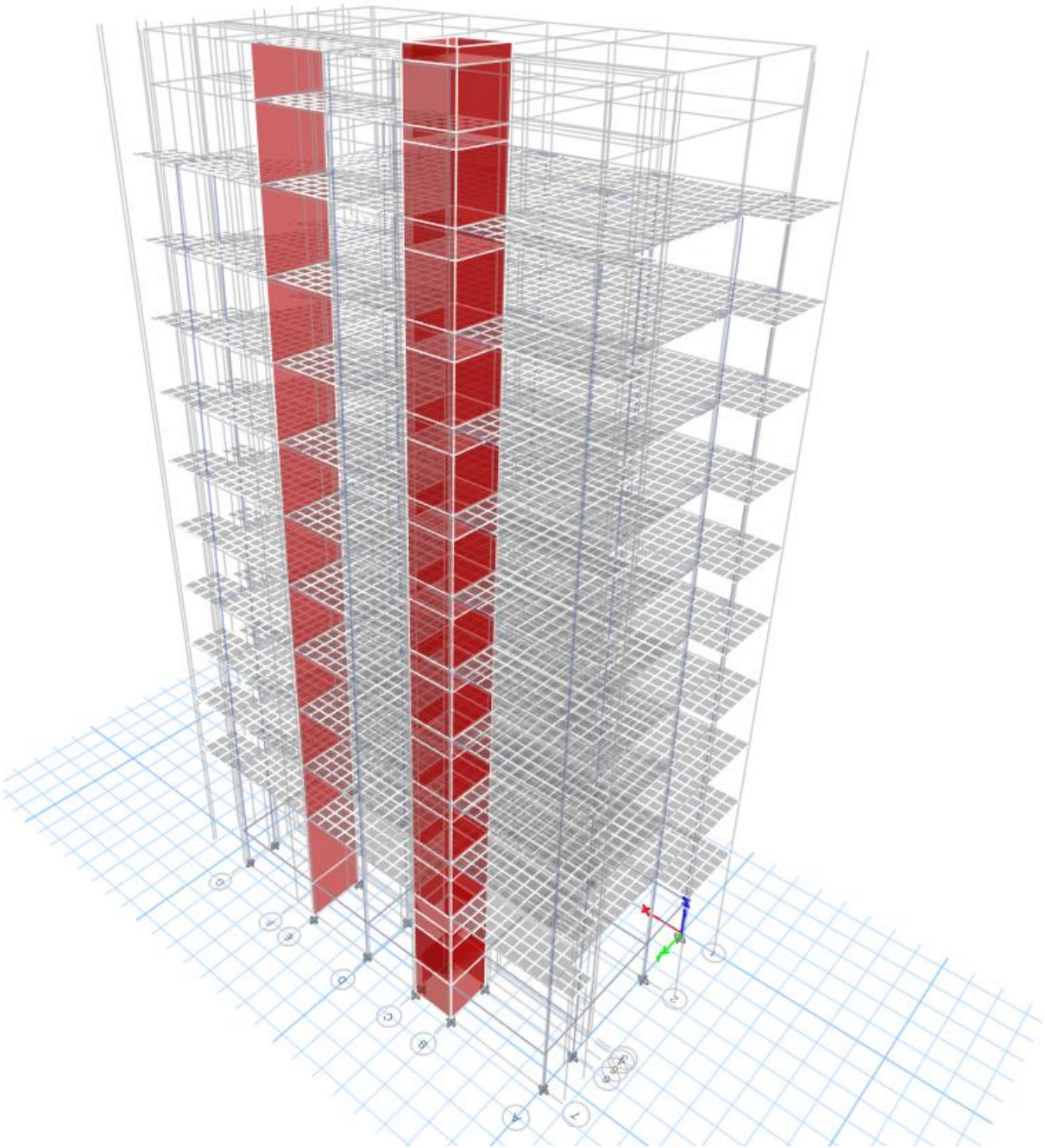


Figure: 3.20 Plan for the 3D Model

Figure: 3.21 Plan for the displace Model

3.3.0. Deflect Shape of The Model

To check error in data input for lateral load click Display - show table and select the item and cheek the earth quack load in X, Y direction. To show deflect Shape select the 3D view window & click show deformed shape icon from display window.

CHAPTER 4

Result And Discussion

4.1 Introduction

In this chapter result output of the has been shown and discussed. From the rest comparison it is seen that Difference for zone I, II, III & IV according to BNBC 2020 using by ETABS.

4.1.1 Base Shear Check

$$V = Sa\ W$$

The design basis earthquake (DBE) ground motion is selected at a ground shaking level that is 2/3 of the maximum considered earthquake (MCE) ground motion. The effect of local soil conditions on the response spectrum is incorporated in the normalized acceleration response spectrum Cs. The spectral acceleration for the design earthquake is given by the following equation:

$$S_a = \frac{2}{3}\frac{ZI}{R}C_s$$

Sa= Design spectral acceleration (in units of) which shall not be less than .067*BZIS*

Cs= Normalized acceleration response spectrum, which is a function of structure (building) period and soil type (site class) as defined by Equations.

$$C_s = 2.5S\eta \quad \text{for} \quad T_B \le T \le T_C$$

Table 4.1 : Base Shear Check

Zone	Lateral seismic force coefficient, Sa, As Per BNBC 2020	Fz for (D+.25L)	Fx or Fy for EQX & EQY	Lateral seismic force coefficient, Sa, Calculate by Etabs (For Earth Quack Load EQX & EQY) (Fz/Fx or Fy)
Zone I	0.054	7728.52	415.483	0.05376
Zone II	0.090	7728.52	692.472	0.089599
Zone III	0.126	7728.52	969.46	0.1254539
Zone IV	0.162	7728.52	1246.449	0.161279

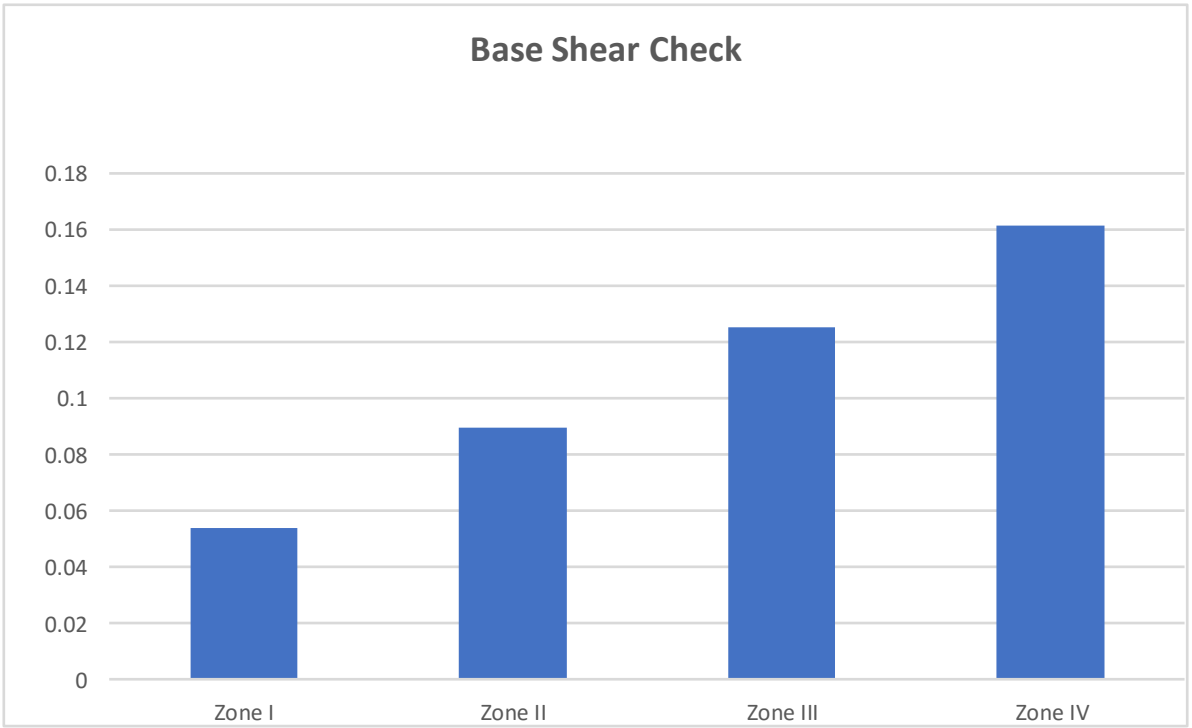


Figure: 4.1 Zone wise Base shear chart

4.1.2 Deflection Checks for Serviceability

Sway limitation

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

For serviceability limit state against lateral deflection of buildings and structures due to wind effect, the following combination shall be used

Load Combination =D + 0.5L (+/-) 0.7W

Table 4.2: Top deflection checks for serviceability

Zone	Limitation (inch)	Ux (max)	Uy (max)
Zone I	2.232”	0.78	2.12
Zone II	2.232”	1.26	2.15
Zone III	2.232”	1.20	1.95
Zone IV	2.232”	1.26	2.37

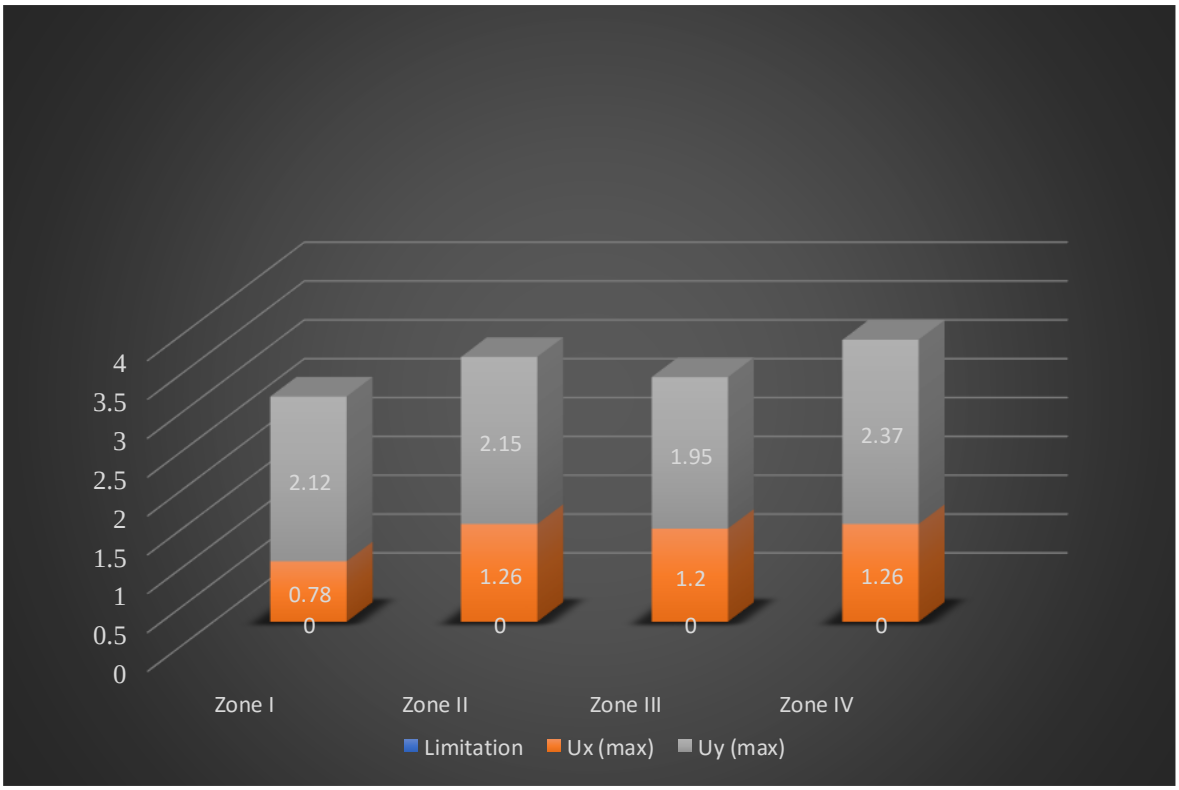


Figure: 4.2 Zone wise serviceability chart

4.1.3 For Beam Deflection Check

Construction	L	W^f	$D^g + L^d$
Roof members:[e]			
Supporting plaster ceiling	$l/360$	$l/360$	$l/240$
Supporting non-plaster ceiling	$l/240$	$l/240$	$l/180$
Not supporting ceiling	$l/180$	$l/180$	$l/120$
Floor members	$l/360$	-	$l/240$
Exterior walls and interior partitions			
With brittle finishes	-	$l/240$	
With flexible finishes	-	$l/120$	
Farm buildings	-		$l/180$
Greenhouses	-		$l/120$

Table 4.3: Beam Deflection allowable limitation

Table 4.4: Beam deflection Check

Zone	Limitation Live Load(inch)	Limitation (D+L) (inch)	Actual Deflection for Live Load(inch)	Actual Deflection for (D+L) (inch)
Zone I	0.54	0.82	0.11	0.54
Zone II	0.54	0.82	0.11	0.54
Zone III	0.54	0.82	0.11	0.54
Zone IV	0.54	0.82	0.11	0.54

4.1.4 Torsion irregularity Check

To be considered for rigid floor diaphragms, when the maximum story drift (Δ) at one end of the structure is more than 1.2 times the average Δavg= (Δmax+ Δmin)/2 of the story drifts at the two ends of the structure. If Δmax >1.4Δavg then the irregularity is termed as extreme torsional irregularity.

Table 4.5: Torsion irregularity check

Zone	(Δmax/Δavg) < 1.20 EQX	(Δmax/Δavg) <1.20 EQY
Zone I	1.07	1.18
Zone II	1.13	1.198
Zone III	1.99	2.51
Zone IV	2.59	3.22

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

Table 4.6: Site Allowable story Drift

4.1.5 Story Drift

Story drift refers to the relative lateral displacement between two adjacent floors in a building under lateral loads, such as those induced by wind or seismic activity. This measure is crucial for assessing the building's structural performance and ensuring that it remains within acceptable limits to prevent damage to both structural and non-structural elements.

Table 4.7: Story Drift Check

Zone	Occupancy Category II 0.020*h*sx (allow)	Story Drift EQX	Story Drift EQY
Zone I	3.12	1.17	1.09
Zone II	3.12	1.96	1.81
Zone III	3.12	2.74	2.54
Zone IV	3.12	3.52	3.26

Summary Description

Zone I, II, Iii & IV all model we have analyzed for story drift, base shear, Beam Displacement, tortional irregularity. We have found zone 4 is very critical for earth quack load.

CHAPTER 5

Conclusion And Recommendation

5**.1 Conclusions and Future Works From the study is observed that**.

1. When we are going from zone 1 to zone 4 or if we see deflection value from zone 1 to zone 4 the value of deflection is increasing because pie seismic activities. From Serviceability deflection check we see in zone 1 Ux (max) 0.78 & Uy (Max) 2.12 which is in limit 2.232 but in Zone 4 the value is increased for seismic coefficient and where Ux (max) 1.26 & Uy (max) 2.37 which is out of limit.

2. When we are going for Torsional Irregularity Check we see we see in EQX value 1.07 and EQY value 1.18 but in Zone 4 the value is increased for seismic coefficient and where EQX 2.59 & EQY 3.59 which is out of limit 1.2.

3. Similarly when we see story drift data we see EQX value 1.17 and EQY value 1.09 but in Zone 4 the value is increased for seismic coefficient and where EQX 3.52 & EQY 3.26 which is out of limit 3.12 due to seismic coefficient effect.

5.2 Limitations and Recommendations for Future Works

1. The building is fully analyzed for seismic loads wind loads by preliminary and detailed design procedure.

2. In this study, only the ETABS software is used for the analysis.

3. 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

4. The building is not designed

for any expansion (Horizontally or vertically) in future.

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[14]. REVIEW PAPER ON SEISMIC RESPONSES OF MULTISTORED RCC BUILDING WITH MASS IRREGULARITY Sagar R Padol1 , Rajashekhar S. Talikoti2 1PG Student, Late G. N. Sapkal College of Engineering,Nashik,Maharashtra, India 2Head of Department, Late G. N. Sapkal College of Engineering, Nashik, Maharashtra, India.