A COMPARISON OF WIND LOAD AND SEISMIC EFFECT ON LOW RISE AND HIGH-RISE MULTISTORY STRUCTURES ACCORDING TO BNBC 2020 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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Sonargaon University

147/I, Green Road, Dhaka-1215, Bangladesh

Section: 16D

Summer-2022

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It is stated that the thesis work on **"A comparison of wind load and seismic effect on low rise and high-rise multistory structures according to BNBC 2020 by using ETABS"** has been performed under the supervision of TAMANNA HAQUE HIMI, 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.

We further undertake to indemnify the university against any loss or damage arising from breach of the foregoing obligations.

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Dedicated

To

"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, TAMANNA HAQUE HIMI (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 structural, 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 Six-story(Low rise) and Ten-Story(High rise) residential building was analyzed (ETABS 19.0 software) by using BNBC 2020.In this project lateral load (Earthquake and Wind) affects structural analysis and design of high-rise infrastructure for Dhaka city. 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 low rise to high rise multistory structure is 121.84%, 287.05%, 219.72% and 450% for load EQX, EQY, WX and WY respectively. And the maximum story drift of low rise to high rise multistory structure is 60.44%, 66.58%, 113.08%, and 100.488% for load EQX, EQY, WX and WY 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 low rise and high-rise multistory structures, the requirements of BNBC 2020 usually result in a less cost-effective design with a higher safety margin.

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CHAPTER 01

INTRODUCTION

1.1 Introduction & Background

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 meet 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 (RC), 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 are 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 builds in our country. The purpose of the study is to designs & analysis of six-storied reinforced concrete residential building for earthquake and wind performance which is situated in Dhaka value of low rise and 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 19.0.1 (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 rise and high-rise multistory structures by BNBC 2020.

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	Dubri earthquake	7.1	Dabigiri
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 for a 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 Research Objectives

The objectives of the study are:

- To compare of wind load effect on low rise and high-rise multistory structures according to BNBC 2020 by using ETABS.
- To compare of seismic effect on low rise and high-rise multistory structures according to BNBC 2020 by using ETABS.

1.3 General Approach

- Getting an architectural design of a RCC Residential Six –storied building.
- Project on RCC Residential Building in Dhaka.
- 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.

1.4 Statement of project Salient features:

Table 1.2: Statement of project Salient features

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

Geometric Details:

Table 1.3: Statement of project Geometric Details

1.Ground Floor	10 ft
2.Floor to Floor height	10 ft
3.Height of plinth	2.5 ft

CHAPTER 02

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 these 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 are 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 cross-wind reactions was relatively small, ranging from 14% to 18%. Juliya Mironova, 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.al. (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. IS 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 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 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 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's:

2.4.1 ETABS 19.0.1:

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.

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.

2.4.2 AutoCAD 2021:

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

CHAPTER 03

METHODOLOGY

3.1 Introduction:

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

1. ETABS 2019 (19.0.1)
2. Auto CAD 2021

Required data for analysis and model built-up with ETABS (19.0.1) are discussed details here. Analysis has been done for Zone-2 (Dhaka). 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 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 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. 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.

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

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

C_I = 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, q_z evaluated at height z shall be calculated by the following equation:

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

From the above equation, design wind pressure, pzis calculated as followed

$P_z = C_G C_p Q_z$........................ (If Vb=km/h)……………………………. (iii)

$P_z = C_t C_G C_p Q_z$..................... (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)

A_Z = 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 m^2 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/m^2)……………………………………. (vii)

Where,

q= 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:

$$p=qh\ [(GCpf-(GCpi)]\ (kN/m^2)\ldots\ldots \text{(Viii)}$$

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:

$$P = qGfCp-q_i\ (GCpi)\ (kN/m^2)\ldots\ldots \text{(ix)}$$

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:

$$Pp = QpGCpn\ [kN/mm^2)\ldots\ldots \text{(x)}$$

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

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:

$$V = S_a W$$

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 -02 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.

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:

$$Ac = \sum Ae[0.2+ (De/hn)^2] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (xi)$$

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

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

Table 3.1: Seismic Zone Coefficient, Z

Seismic Zone	**Zone coefficient**
1	0.12
2	0.20
3	0.28
4	0.36

Table 3.2: 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 6.2.14: Description of Seismic Zones

Seismic Zone	Location	Seismic Intensity	Seismic Zone Coefficient, Z
1	Southwestern part including Barisal, Khulna, Jessore, Rajshahi	Low	0.12
2	Lower Central and Northwestern part including Noakhali, Dhaka, Pabna, Dinajpur, as well as Southwestern corner including Sundarbans	Moderate	0.20
3	Upper Central and Northwestern part including Brahmanbaria, Sirajganj, Rangpur	Severe	0.28
4	Northeastern part including Sylhet, Mymensingh, Kurigram	Very Severe	0.36

Table 6.2.15: Seismic Zone Coefficient Z for Some Important Towns of Bangladesh

Town	Z	Town	Z	Town	Z	Town	Z
Bagerhat	0.12	Gaibandha	0.28	Magura	0.12	Patuakhali	0.12
Bandarban	0.28	Gazipur	0.20	Manikganj	0.20	Pirojpur	0.12
Barguna	0.12	Gopalganj	0.12	Maulvibazar	0.36	Rajbari	0.20
Barisal	0.12	Habiganj	0.36	Meherpur	0.12	Rajshahi	0.12
Bhola	0.12	Jaipurhat	0.20	Mongla	0.12	Rangamati	0.28
Bogra	0.28	Jamalpur	0.36	Munshiganj	0.20	Rangpur	0.28
Brahmanbaria	0.28	Jessore	0.12	Mymensingh	0.36	Satkhira	0.12
Chandpur	0.20	Jhalokati	0.12	Narail	0.12	Shariatpur	0.20
Chapainababganj	0.12	Jhenaidah	0.12	Narayanganj	0.20	Sherpur	0.36
Chittagong	0.28	Khagrachari	0.28	Narsingdi	0.28	Sirajganj	0.28
Chuadanga	0.12	Khulna	0.12	Natore	0.20	Srimangal	0.36
Comilla	0.20	Kishoreganj	0.36	Naogaon	0.20	Sunamganj	0.36
Cox's Bazar	0.28	Kurigram	0.36	Netrakona	0.36	Sylhet	0.36
Dhaka	0.20	Kushtia	0.20	Nilphamari	0.12	Tangail	0.28
Dinajpur	0.20	Lakshmipur	0.20	Noakhali	0.20	Thakurgaon	0.20
Faridpur	0.20	Lalmanirhat	0.28	Pabna	0.20		
Feni	0.20	Madaripur	0.20	Panchagarh	0.20		

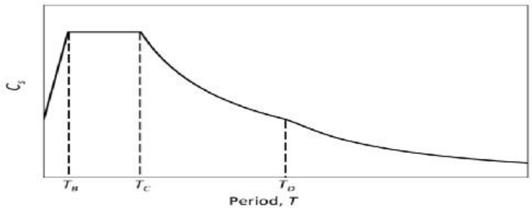

Figure 6.2.25 Typical shape of the elastic response spectrum coefficient C_s

Table 3.5: 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

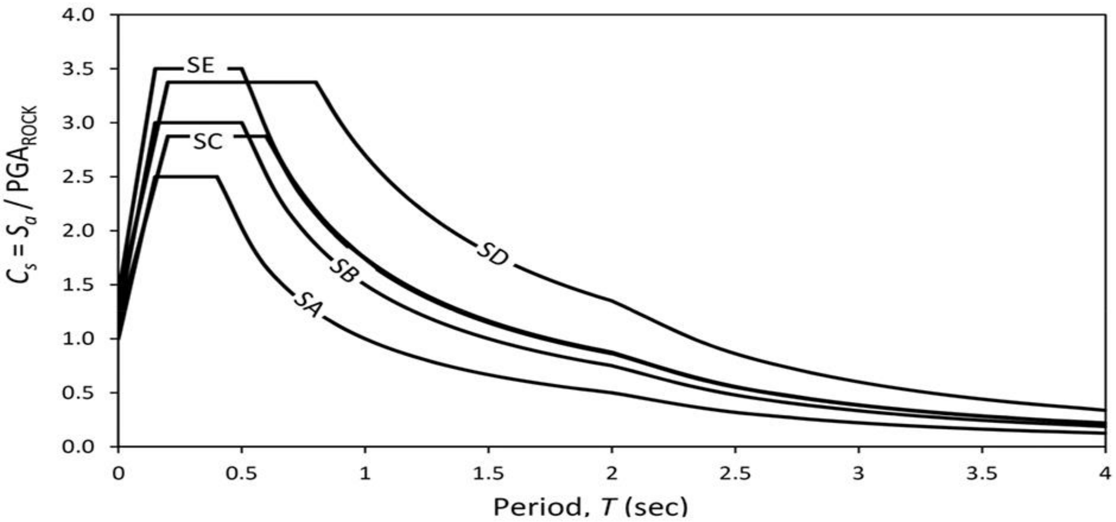

Figure: 3.2: Normalized design acceleration response spectrum for different site classes.

Building Categories

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 3.6: Importance Factors for Buildings and Structures for Earthquake design

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

Table 3.7: Site Dependent Soil Factor and Other Parameters Defining Elastic Response Spectrum

Soil Type	S	TB(S)	TC (S)	TD (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 3.8: Importance Factors for Buildings and Structures for Earthquake Design

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

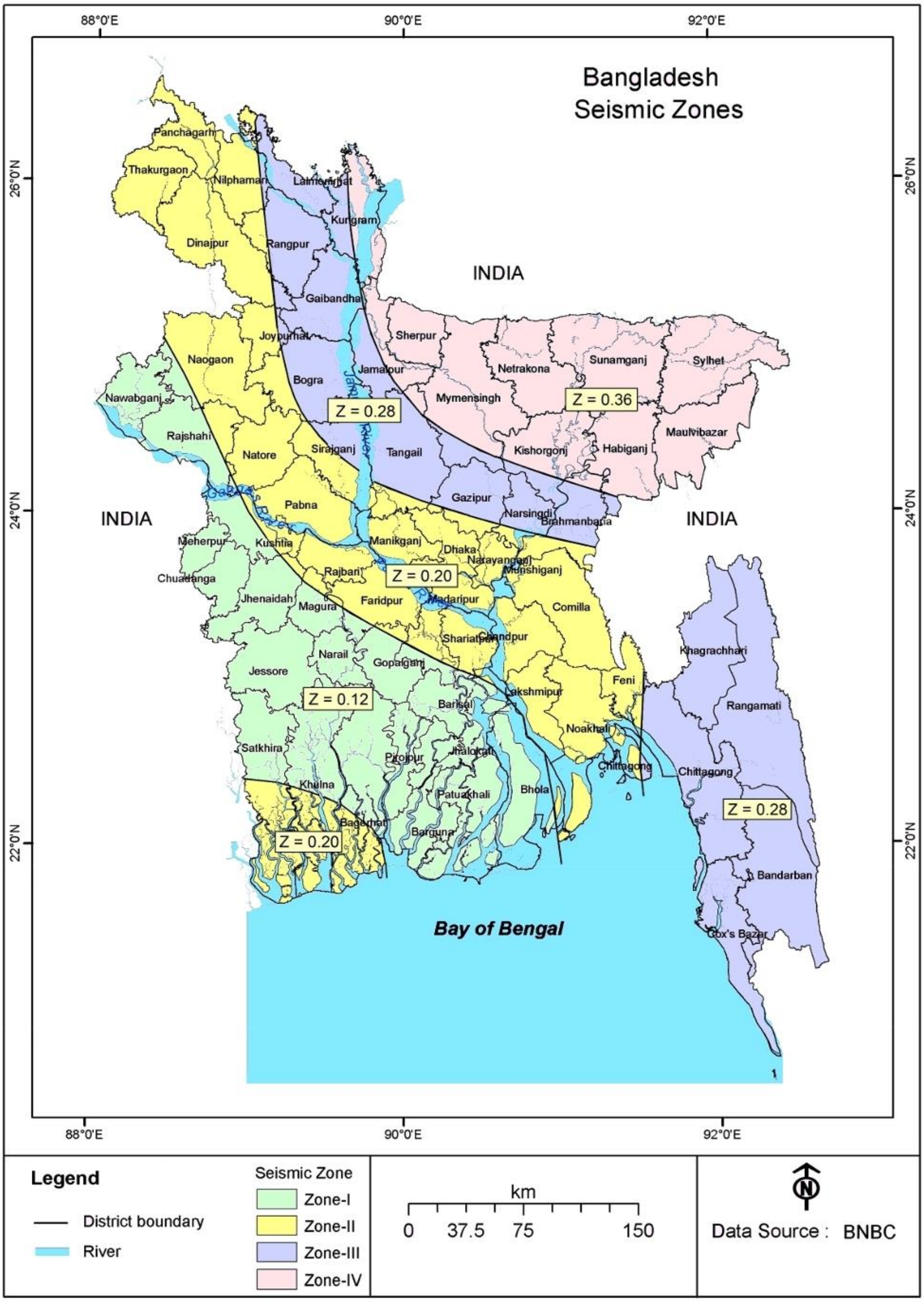

Figure: 3.3 Seismic zoning map of Bangladesh

Table 3.9: 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 3.10: Values for Coefficients to Estimate Approximate Period

Structure Type	C_t	m	
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 3.11: Response Reduction Factor, Deflection Amplification Factor and Height Limitations for Different Structural Systems

Seismic Force–Resisting System	Response Reduction Factor,	System Over strength Factor,	Deflection Amplification Factor,	Seismic Design Category	Seismic Design Category	Seismic Design Categ

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.

BNBC-2020 Table 6.C.1: Parameters S_S and S_1 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**: Uniformity 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 D.L

U= 1.4 D.L+ 1.7 L.L

U= 1.05 D.L + 1.275 L.L+ 1.4025 E.L

U= 1.05 D.L+1.4025 EL

U= 0.9 D.L+1.43 EL

U= 1.05 D.L + 1.275 L.L+ 1.275 WL

U= 1.05 D.L+ 1.275 W.L

U= 0.9 D.LE 1.3 W.L

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 26load combinations are analyzed using software.

3.5 Design data:
Load Consideration: BNBC 2020 for Zone 2.

3.5.1. Dead Load: (for Zone -2)

Floor Finish (FF)	: 25 psf
Random Wall (RW)	: 30 psf
Parapet wall	: 150 psf(3ft)
Partition wall (PW)	:450 1b/ft(9.5ft)

3.5.2. Live Load:

Floor	: 2KN/m2 or 41.76 psf
Stair	: 4.8KN/m'or 100 psf
Roof Over	: 4.8KN/m'or 100 psf
Head Water Tank	: 312 psf (6 ft)

3.5.3 Wind Pressure (BNBC 2020)

Location	: Dhaka
Basic Wind speed V	: 147 mph
Structural Important Coefficient	: 1.0
Expose Category	: B
Gust Factor	: 0.85
Directionally Factor, KD	: 0.85

3.5.4. Earthquake Category Base Shear (BNBC 2020)

Seismic Zone	: Zone II
Seismic Zone factor (Z)	: 0.20
Response Modification Coefficient, R	: 5
System Over strength. 'Ω (omega)	: 3
Deflection Amplification, Cd	: 4.5
Structural Importance Factor (1)	: 1.0
Spectral Response Acceleration, Ss'	: 0.5
Spectral Response Acceleration, Si	: 0.2
Site Coefficient, Fa	: 1.15
Site Coefficient, Fv	: 1.725
Time Period, T	: 0.78 sec

Material Properties:

Unit weight of concrete	: 150 lb/ft

Compressive Strength:

For slab, fc	: 4000 psi
For beam, fc'	: 4000 psi
For Column: fc'	: 4000 psi
Steel: Yield strength of Steel, fy	: 60 ksi

3.6 Auto CAD Model

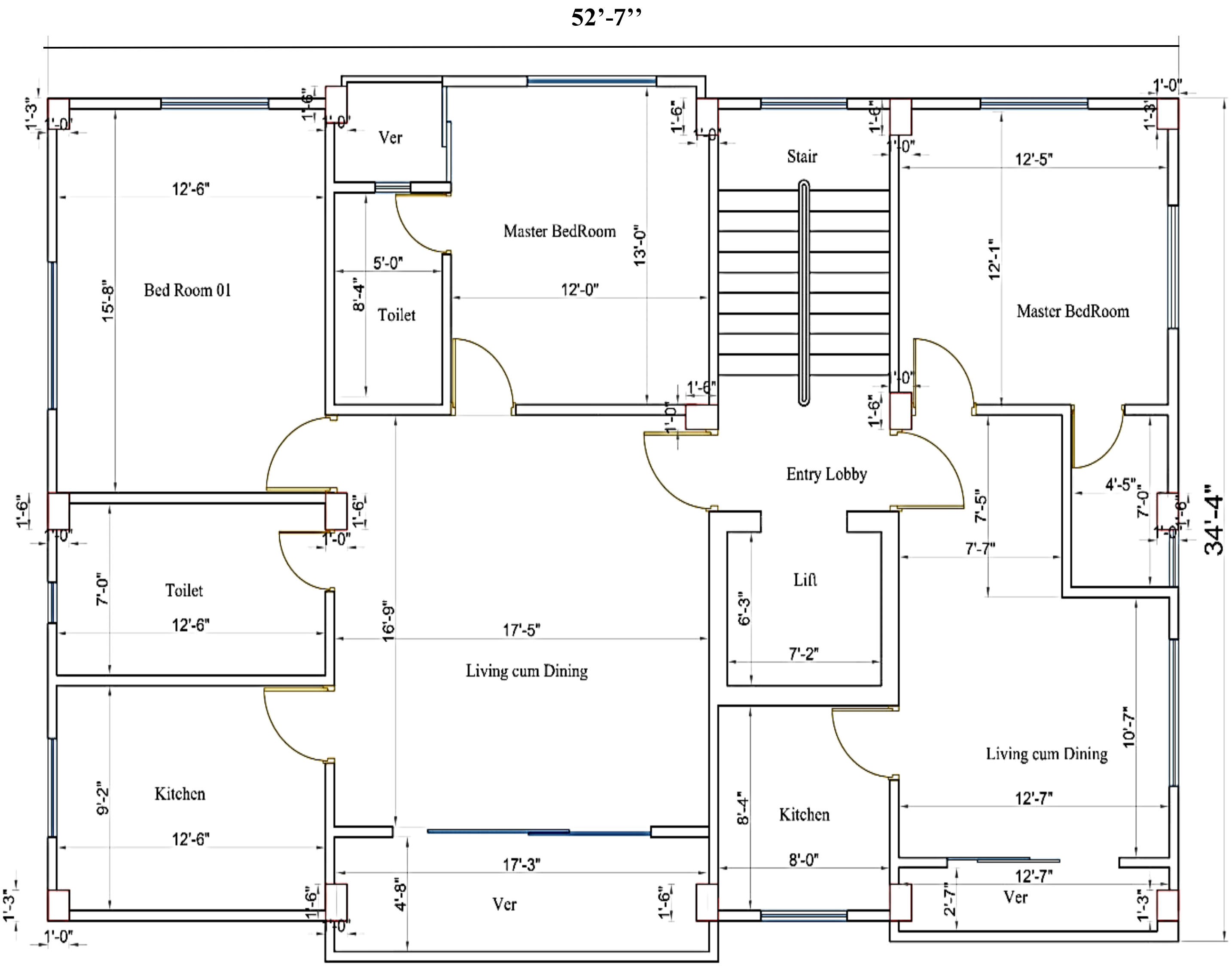

Figure: 3.5 Architectural Plan for both option

3.7 Column & Beam Layout

Option 01: low rise building (6 story)

<u>**Column & Beam size**</u>**:**

Column 01: 12x16

Column 02: 12x20

Beam (FB): 12x16

Beam (GB): 12x18

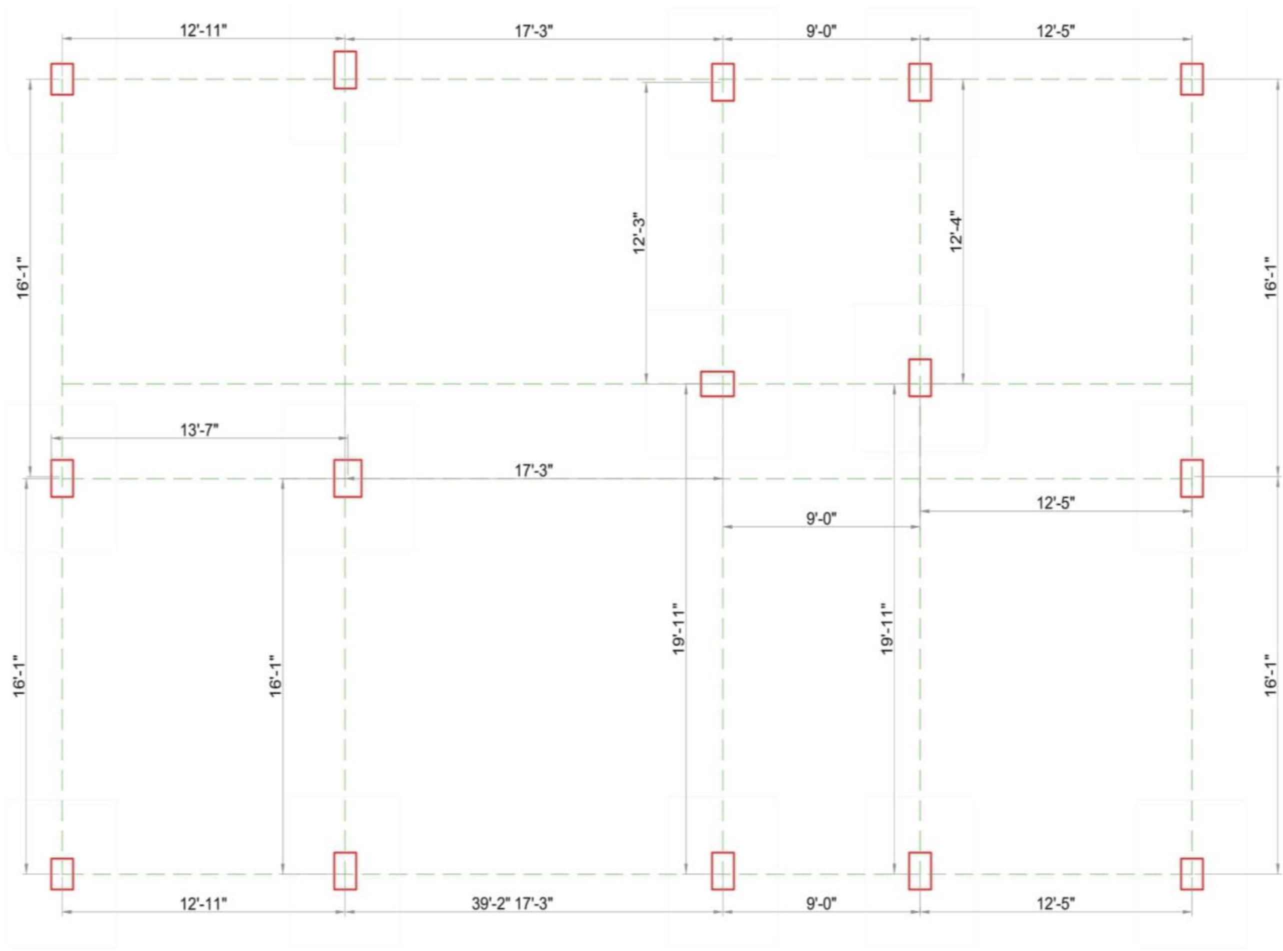

Fig: 3.6 Column & Beam Layout (low rise)

3.7.1 Column & Beam Layout

Option 02: High rise building (10 story)

<u>Column & Beam size:</u>

Column 01: 12x16 Beam (GB): 12x20

Column 03: 12x20 Beam (GB): 12x18

Column 04: 12x24 Beam (FB): 12x16

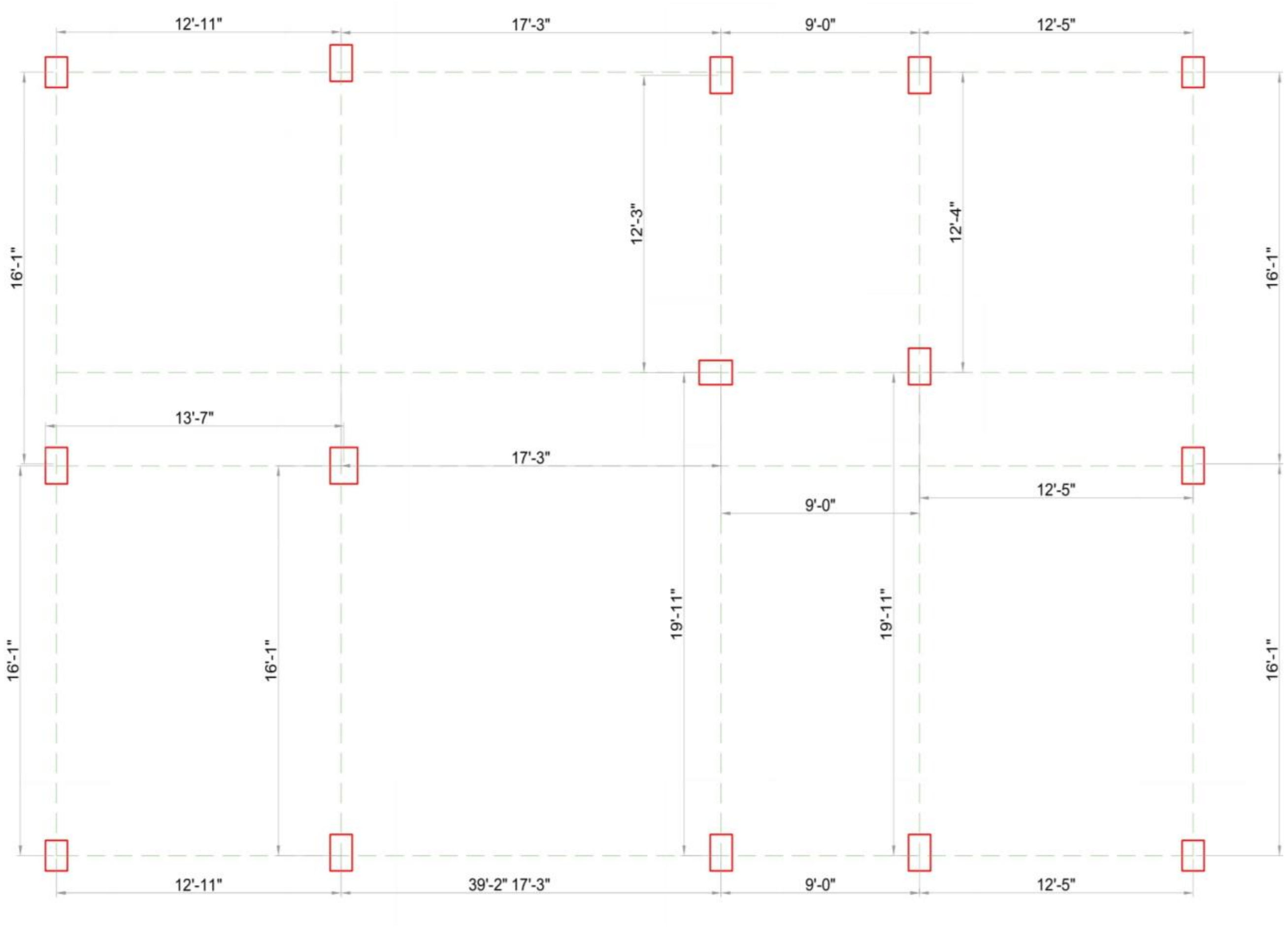

Fig: 3.7 Column & Beam Layout (high rise)

3.8 Beam Section:

Option 1: Low Rise Building (6 Story) Beam Section:

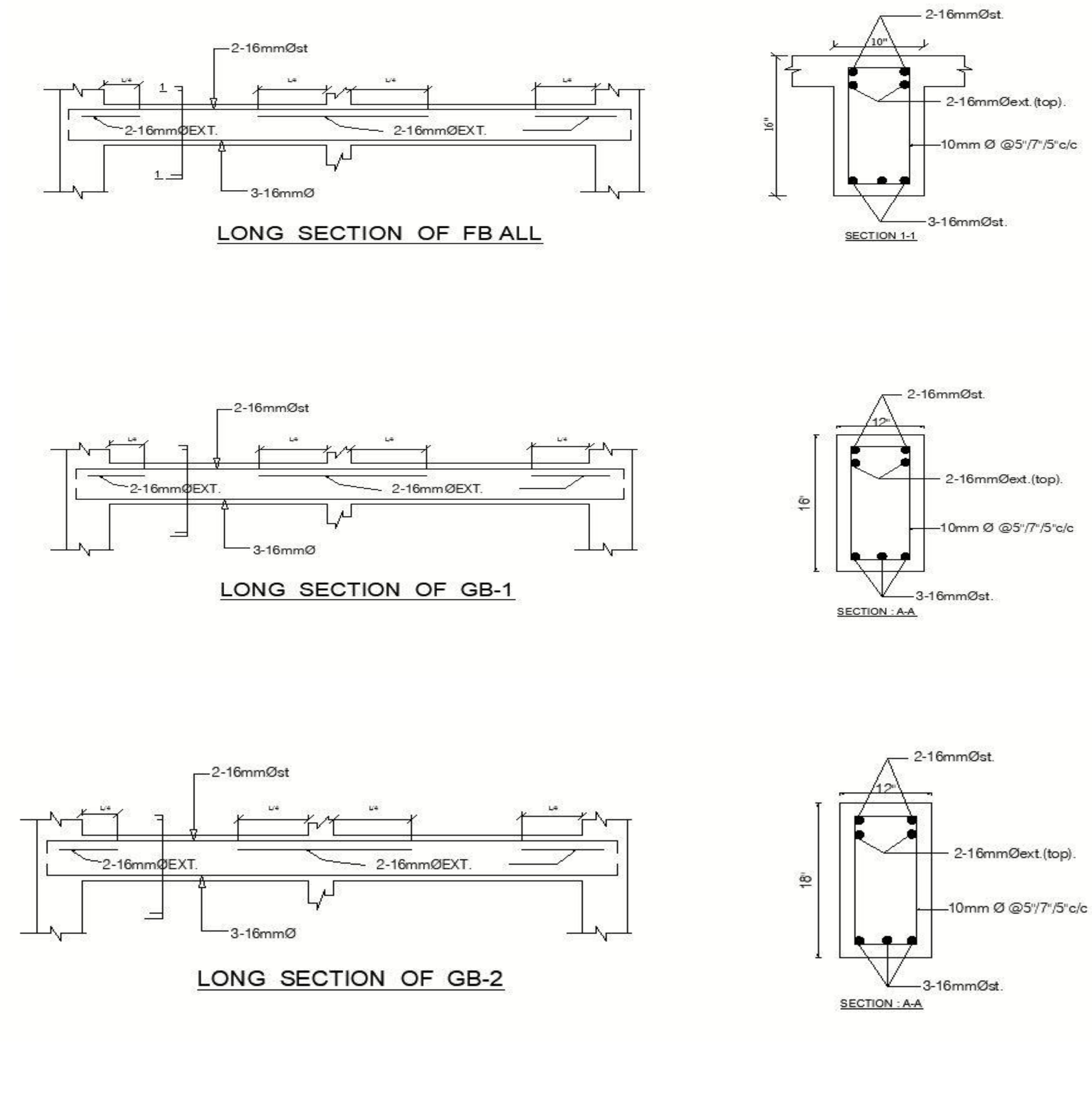

Fig: 3.8 Low rise Building beam section

3.8.1 Beam Section:

Option 2: High Rise Building (10 Story) Beam Section:

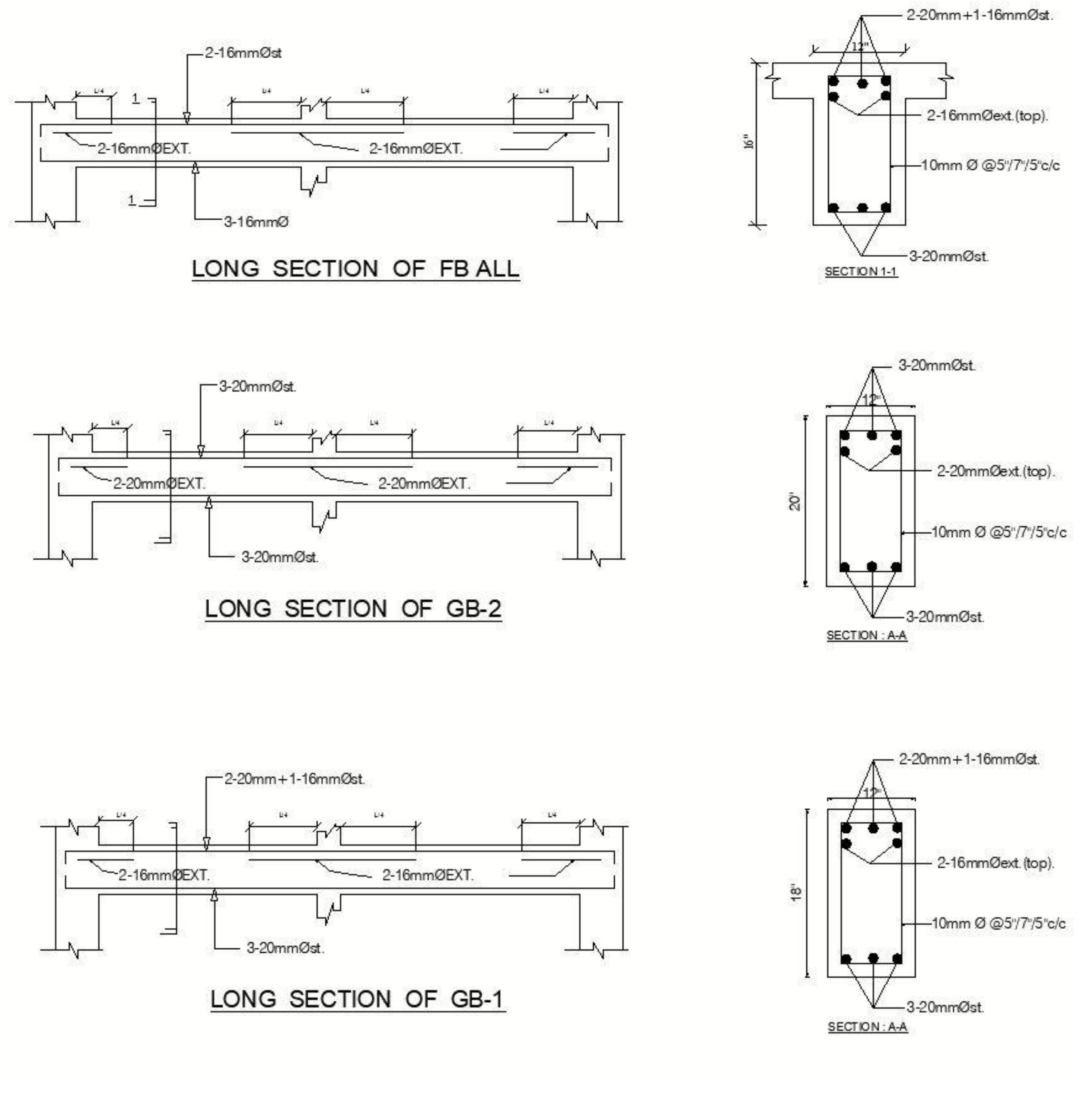

Fig: 3.9 High rise Building beam section

3.9: Modelling with EATBS:

3.9.1 Model Initialization

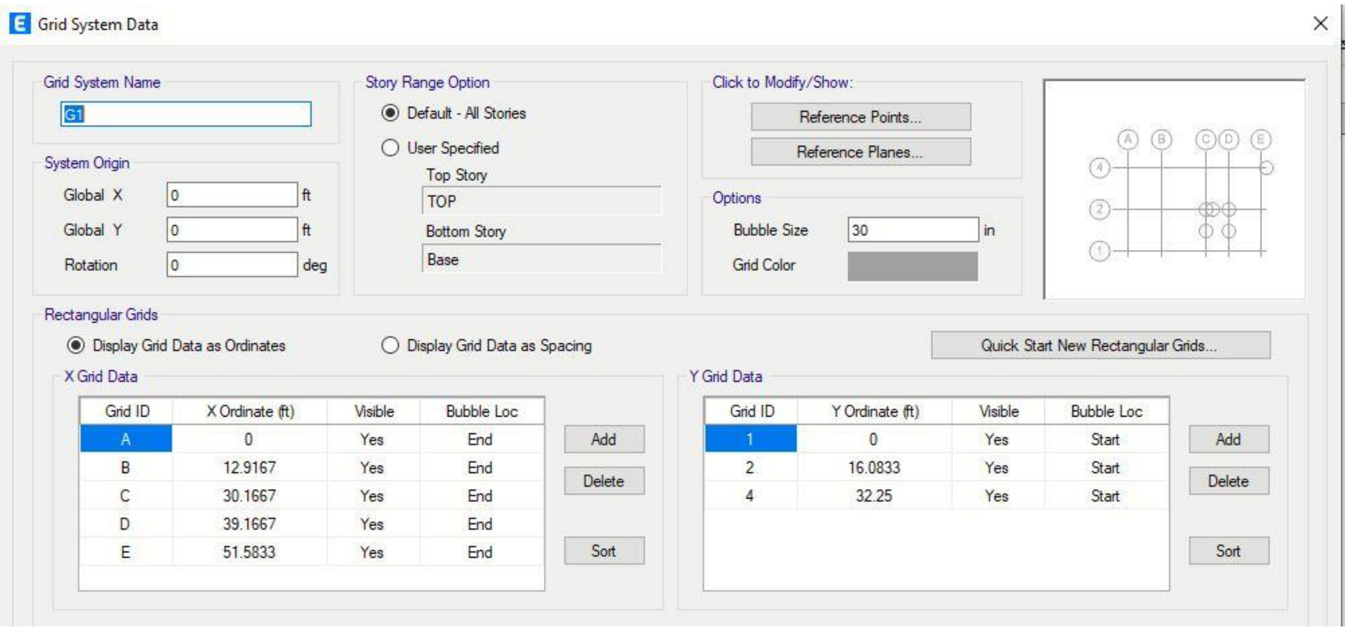

Fig: 3.10 Grid selection of the Model

- 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

3.9.2 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/Circle
  iv. For beam
  v. Select Reinforcement
  vi. Then select beam
  vii. Define all frame section in this process

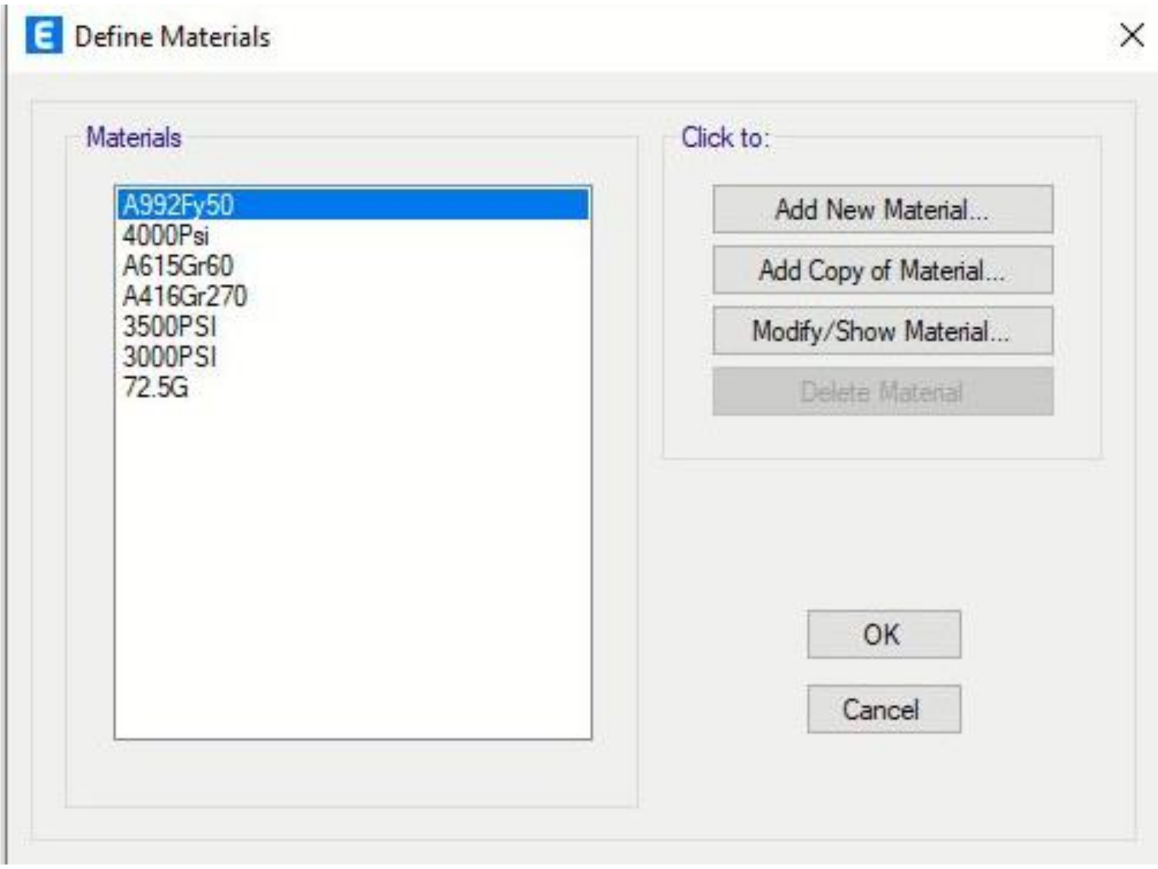

Fig: 3.11 Define Materials

3.9.3 Frame Properties:

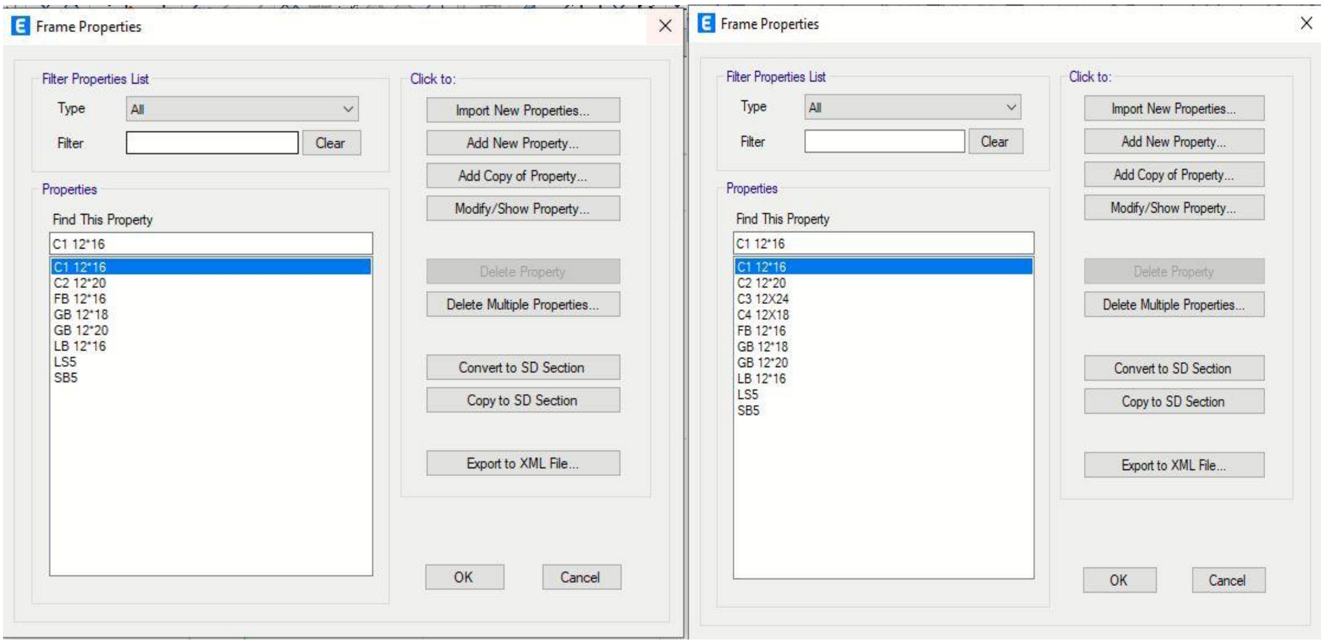

Fig: 3.12 Frame Property Initialization for both Section

3.9.4 Frame Section Property of Columns for Low Rise Building

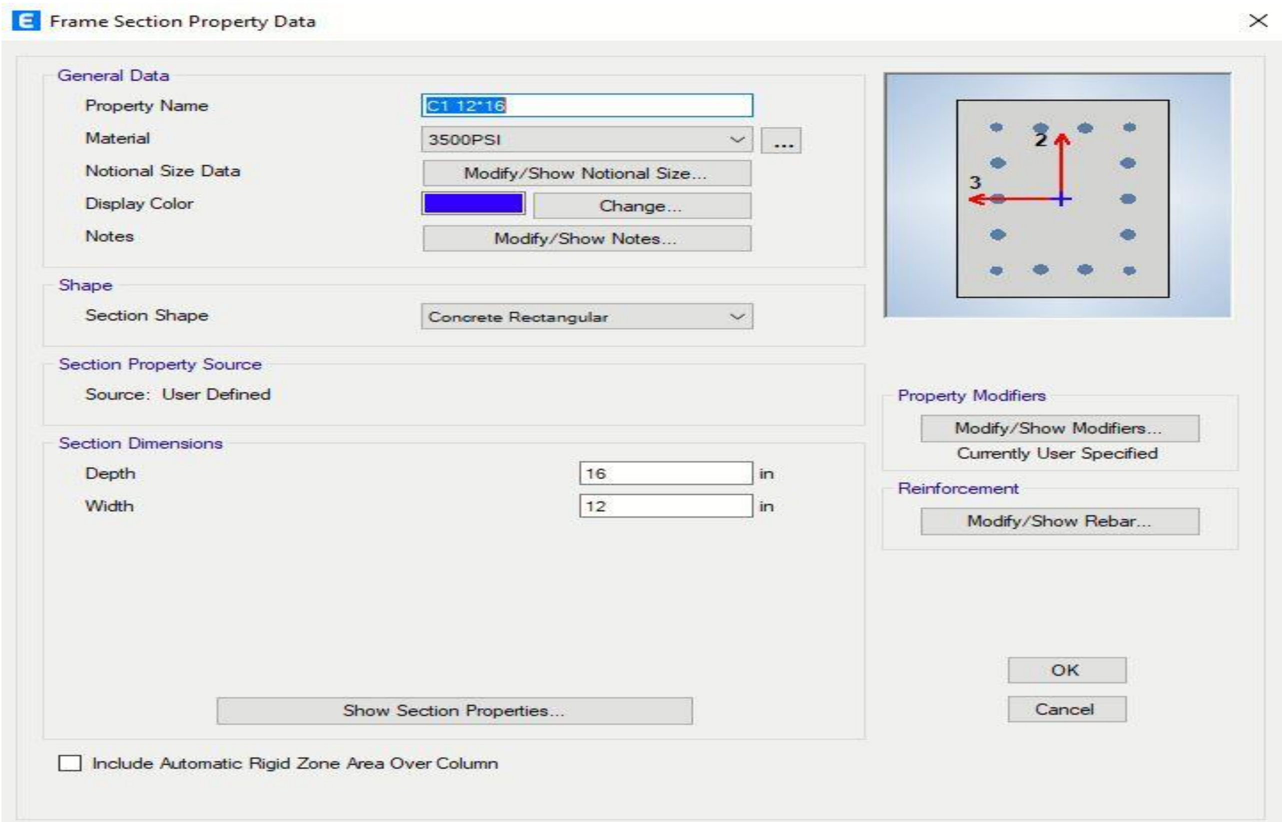

Fig: 3.13 Frame Section Property of Columns for Low Rise Building

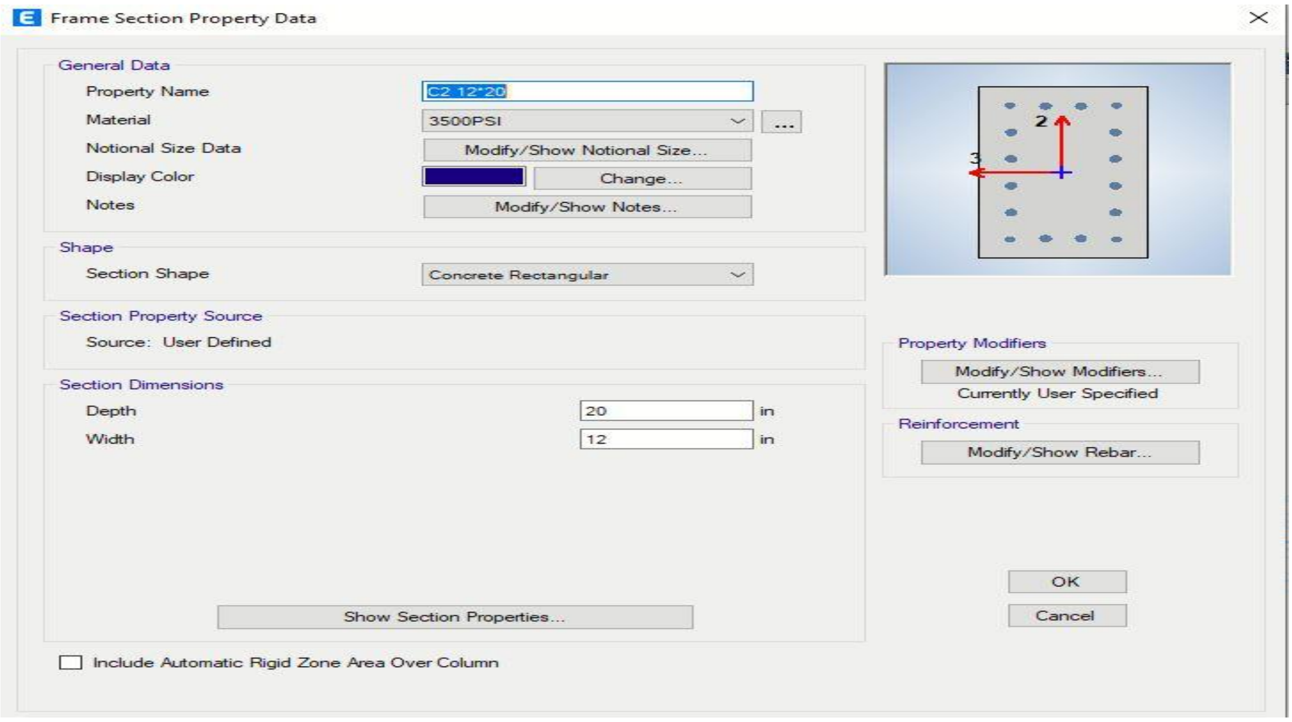

Fig: 3.14 Frame Section Property of Columns for Low Rise Building

3.9.5 Frame Section Property of Columns for High Rise Building

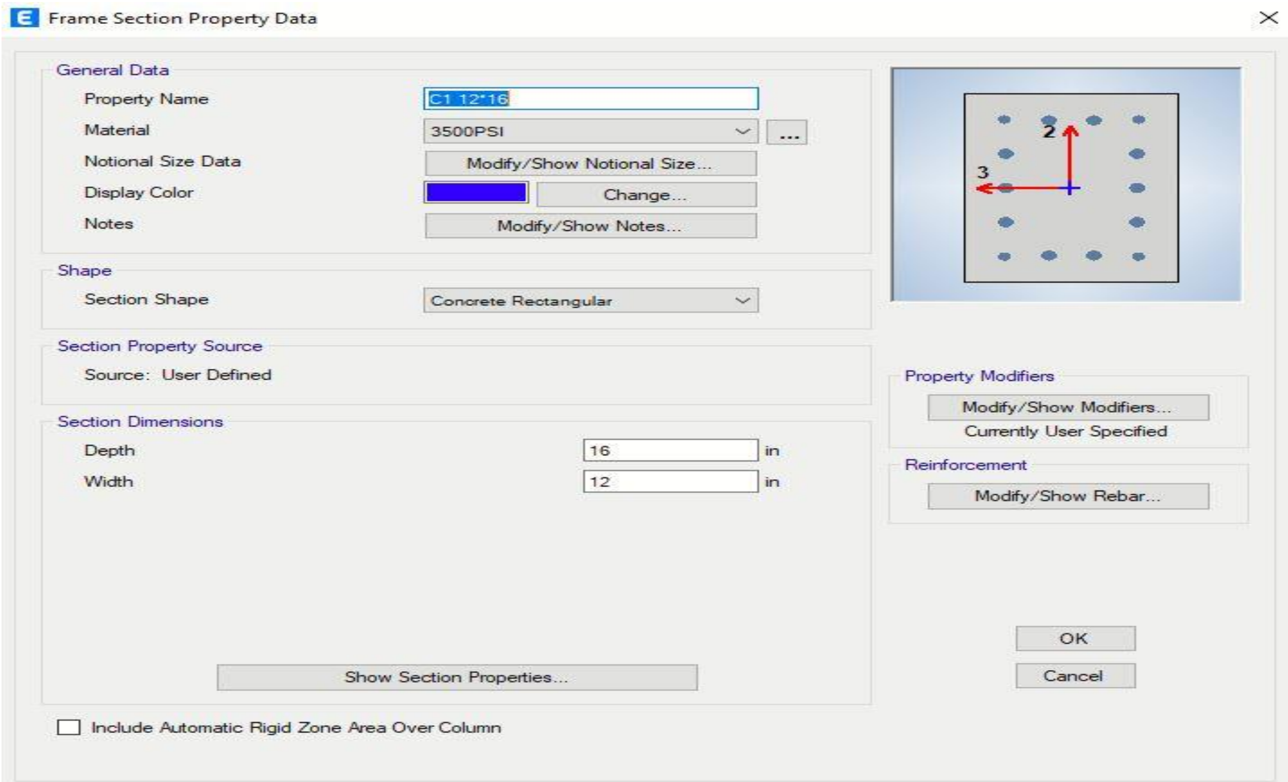

Fig: 3.15 Frame Section Property of Columns for High Rise Building

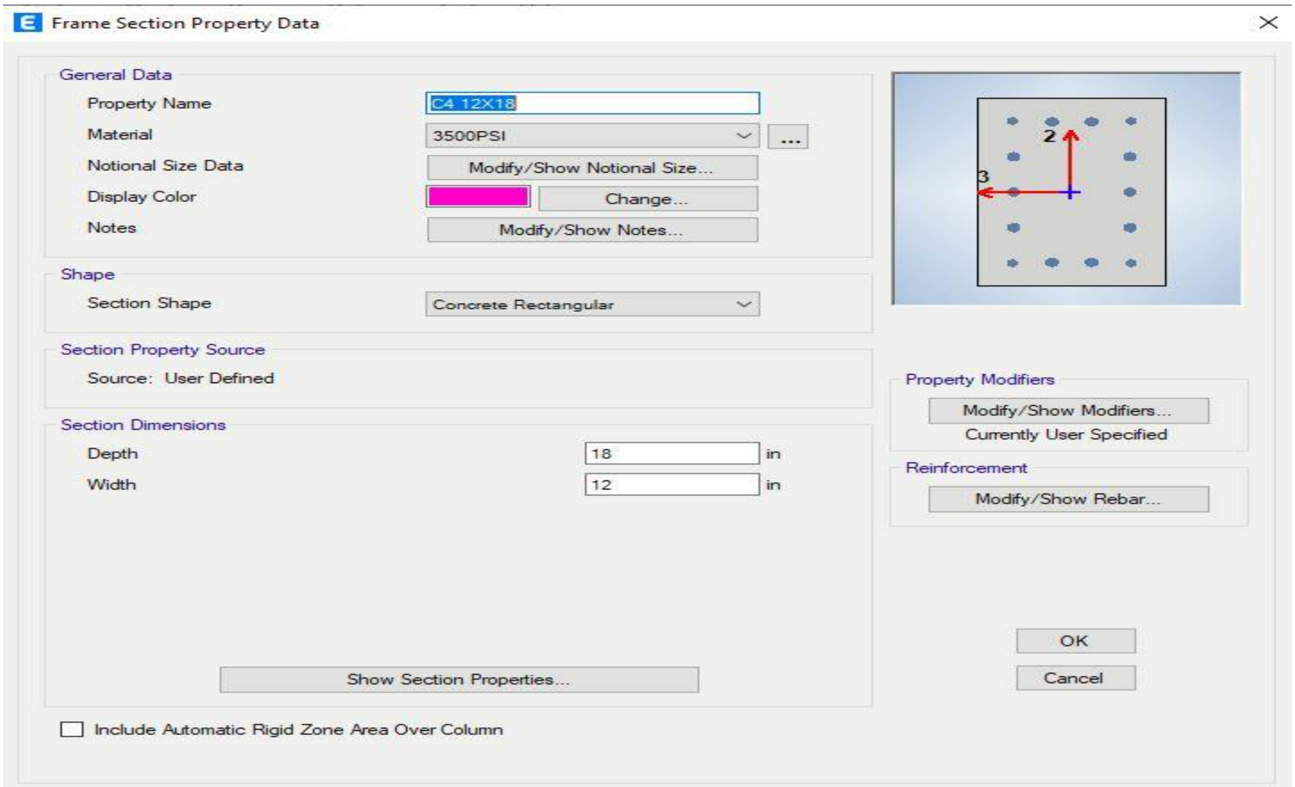

Fig: 3.16 Frame Section Property of Columns for High Rise Building

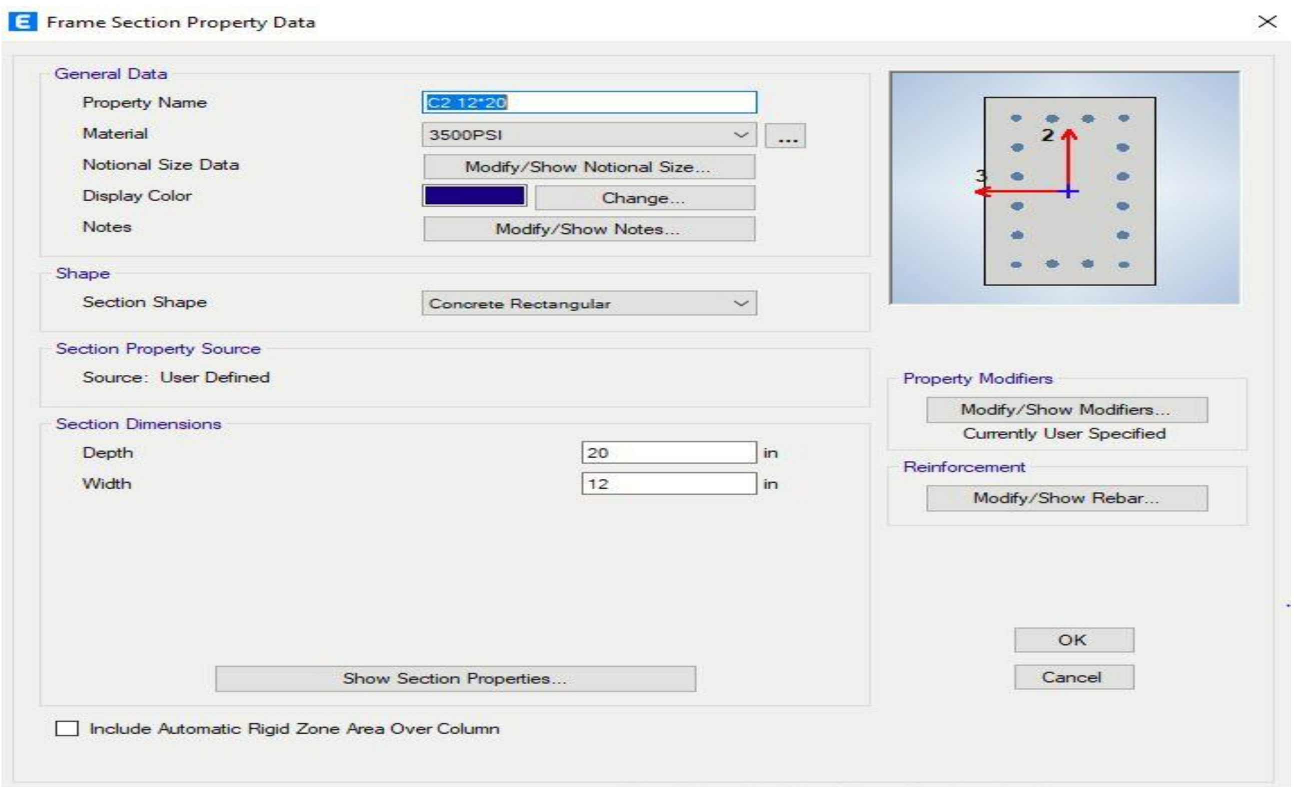

Fig: 3.17 Frame Section Property of Columns for High Rise Building

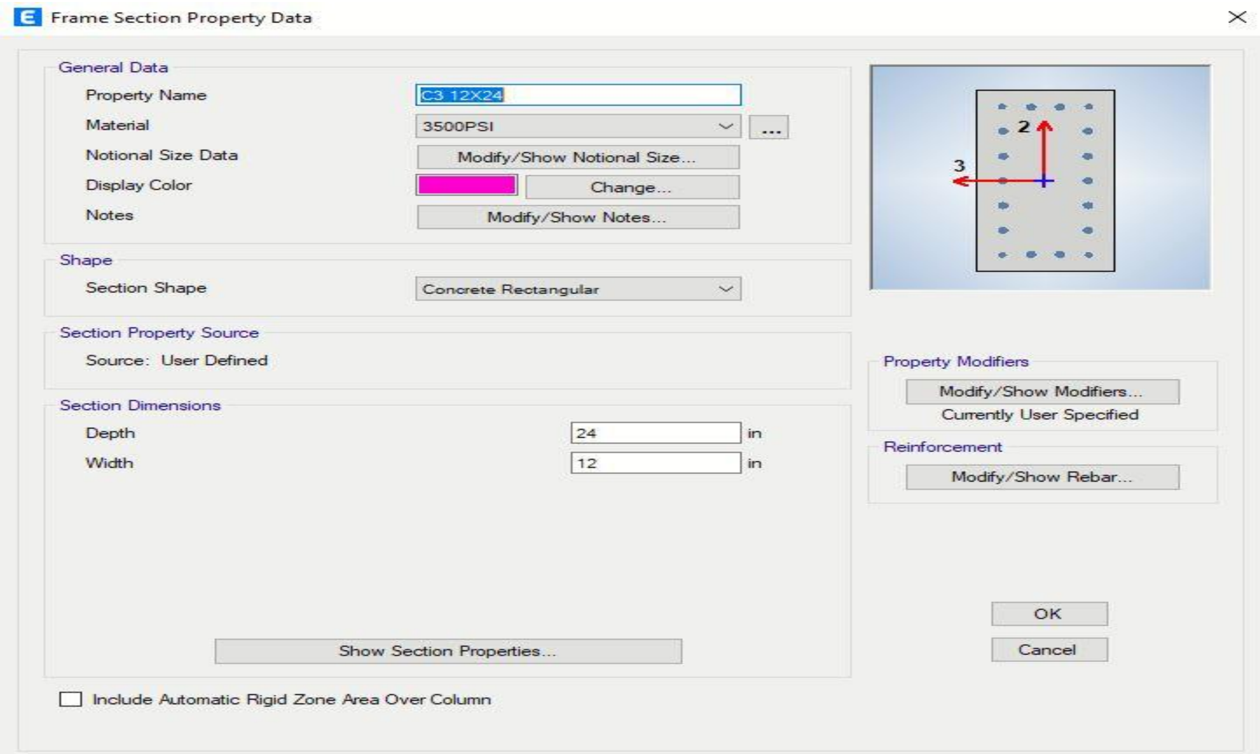

Fig: 3.18 Frame Section Property of Columns for High Rise Building

3.9.6 Display Grid Data

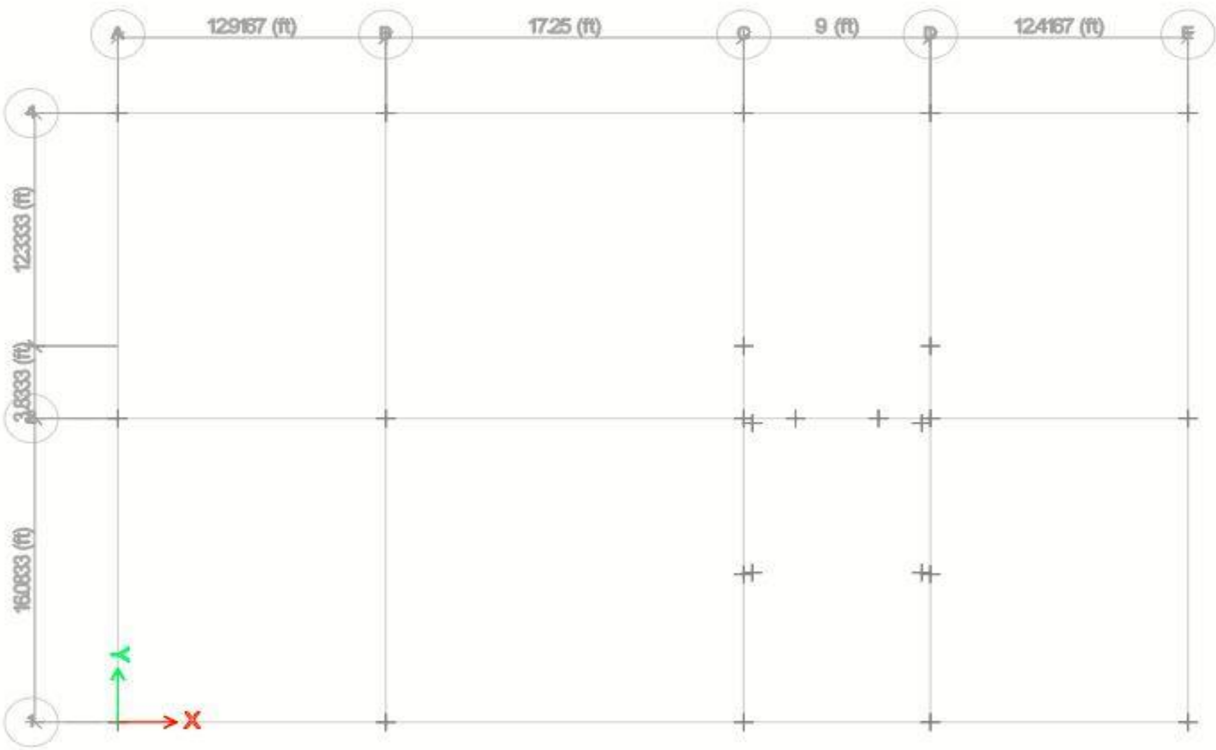

Figure: 3.19 proposed Grid Data of the model for Both Structure

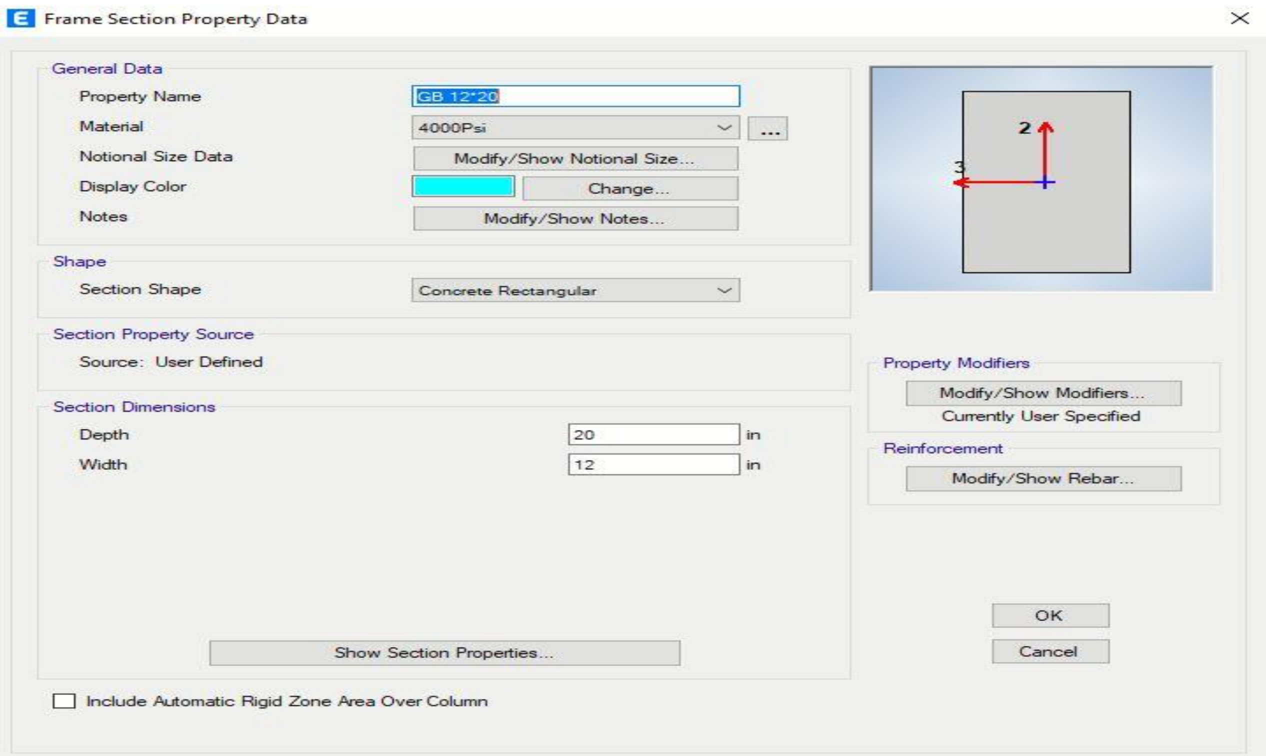

Fig: 3.20 Define Beam property

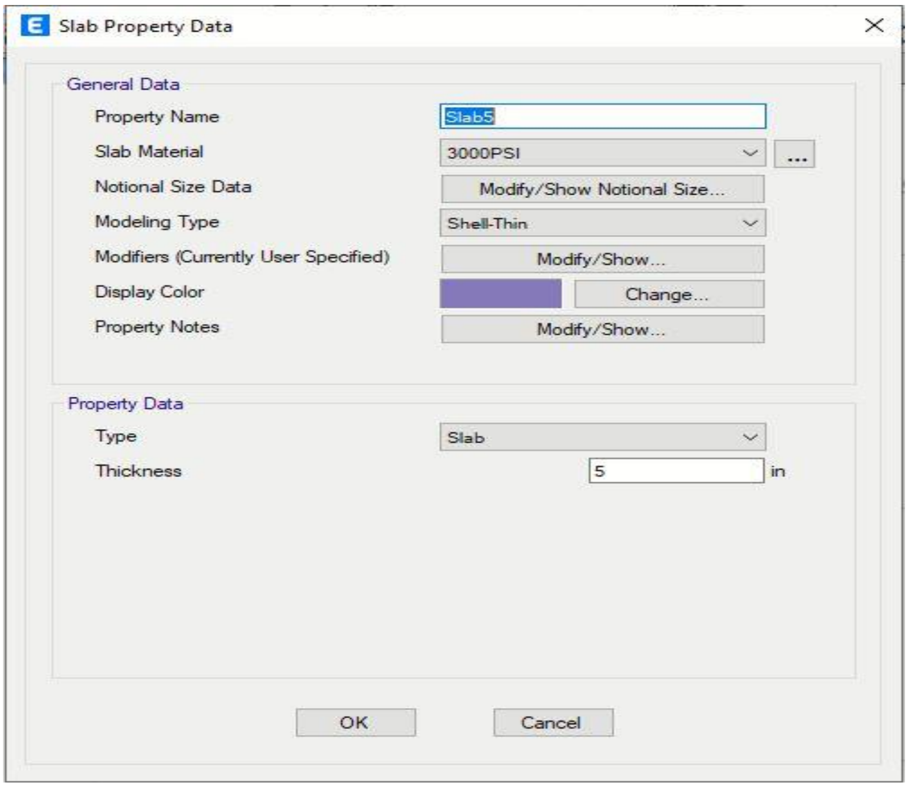

Fig: 3.21 Slab property

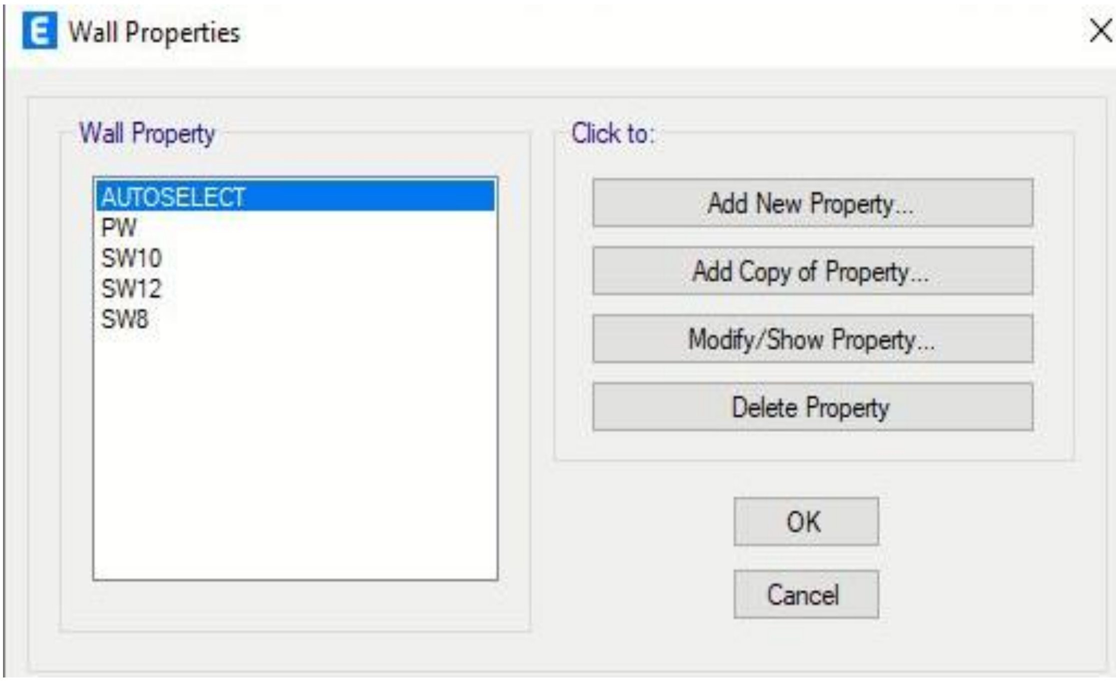

Fig: 3.22 Wall property

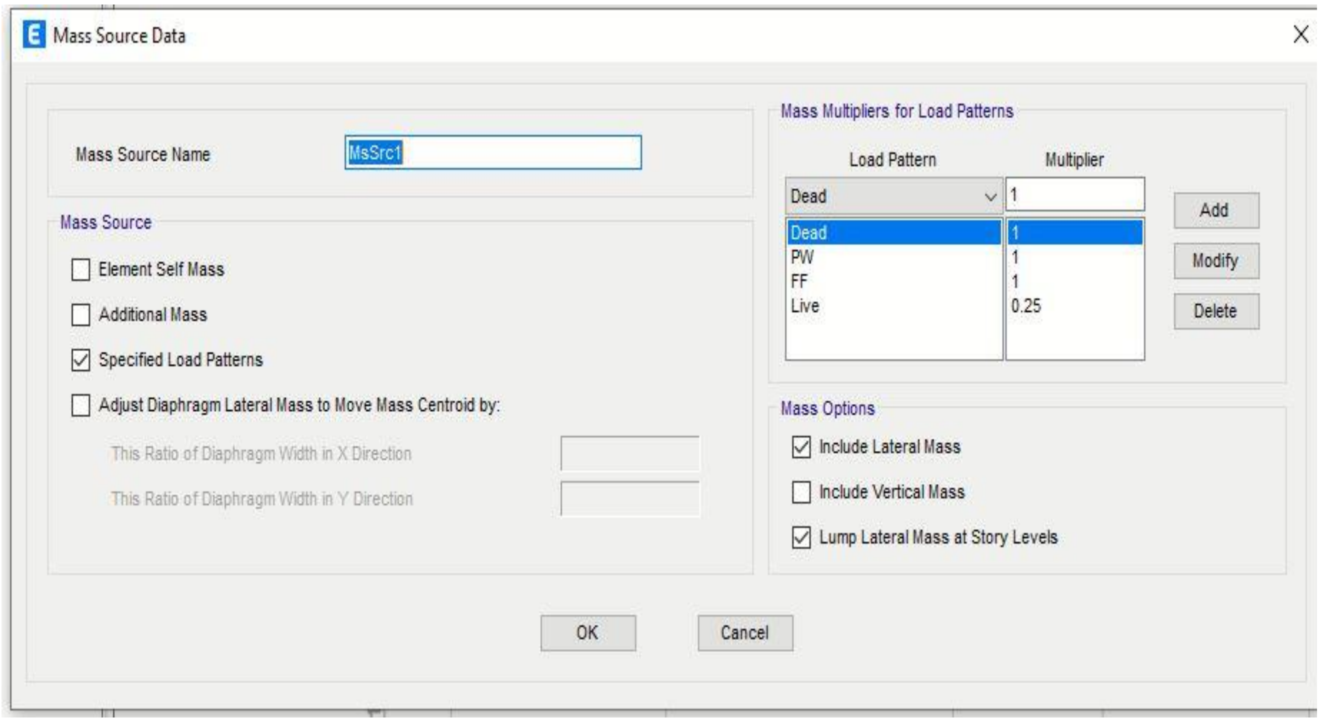

Fig: 3.22 Mass Source

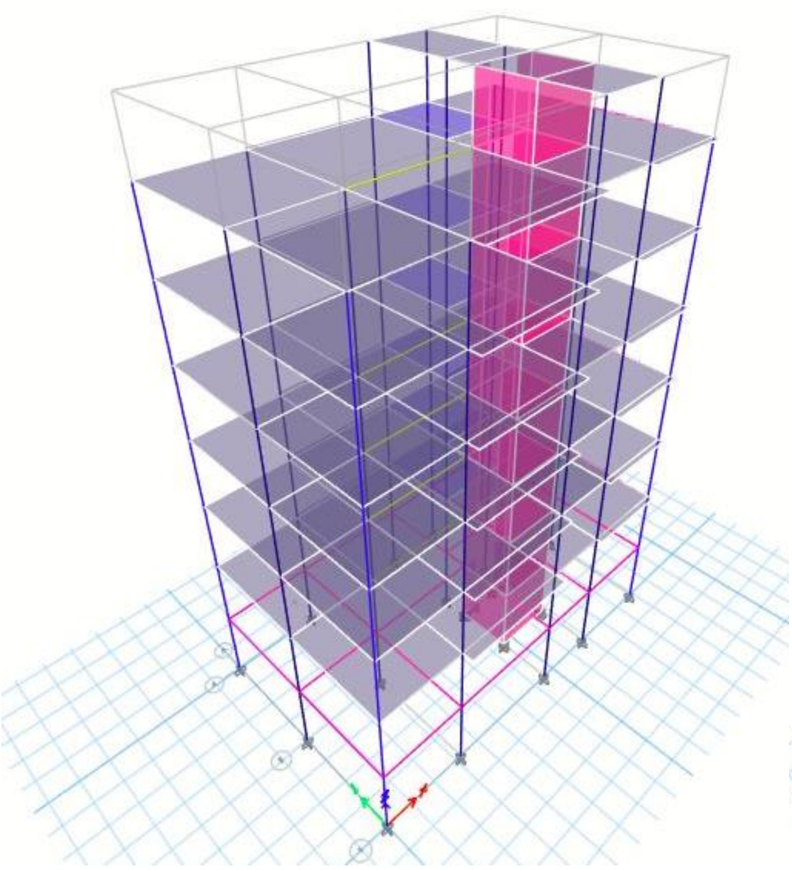

Fig: 3.23 3D Model (6 Story)

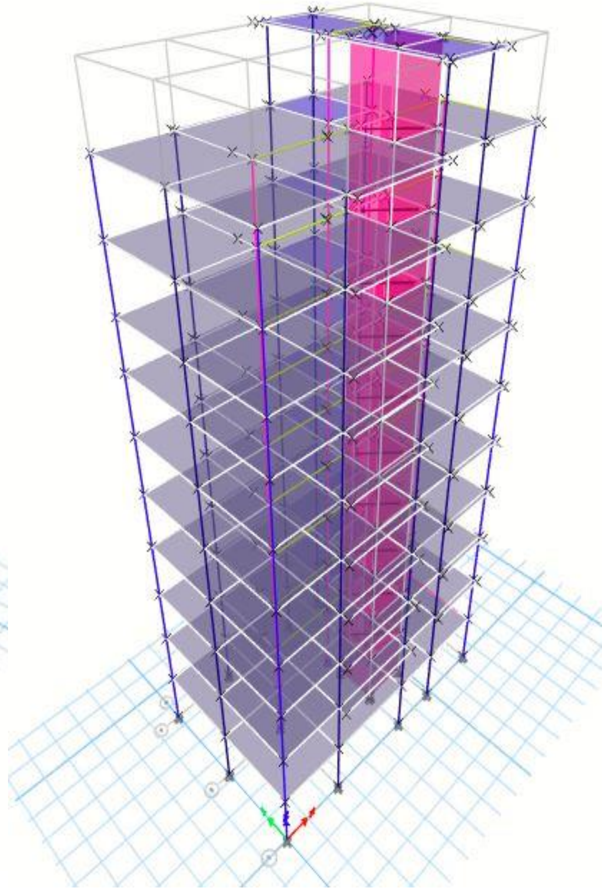

Fig: 3.24 3D Model (10 Story)

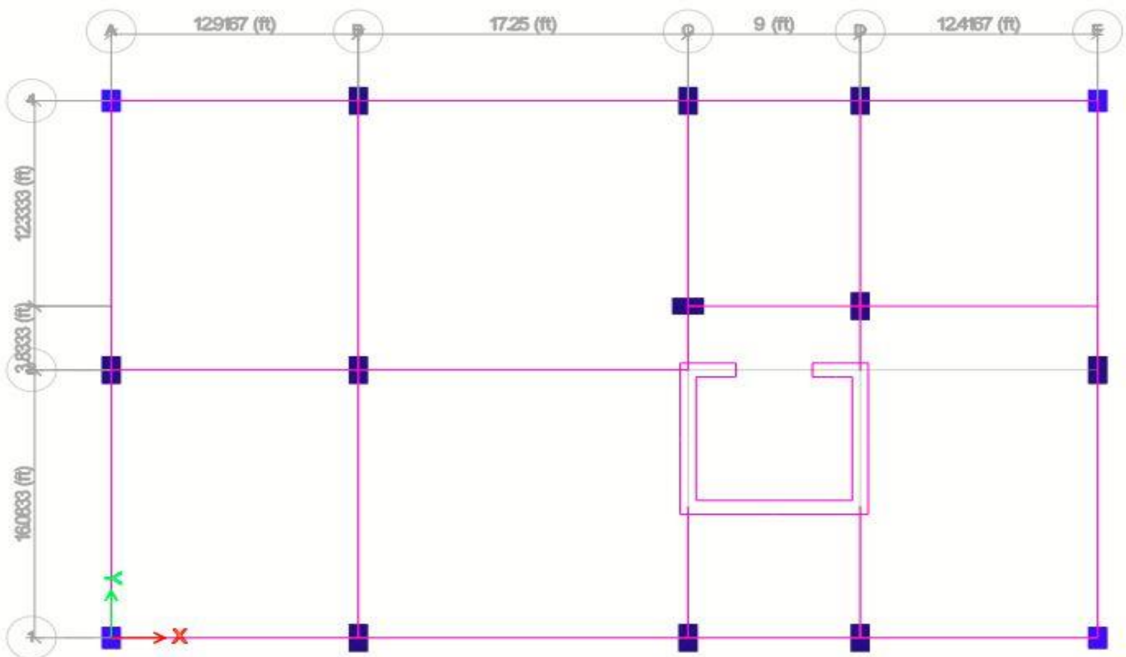

Fig: 3.25 Plan for the 2D Model

3.9.7 Structure Need to complete the following steps.

1. Open the ETABS window
2. Click new from main bar
3. Chose default from new model initialization window
4. Modify data from Building Plan Grid system and story data definition window
5. Click set plan view icon frim main toolbar and select plan view
6. Define load cases

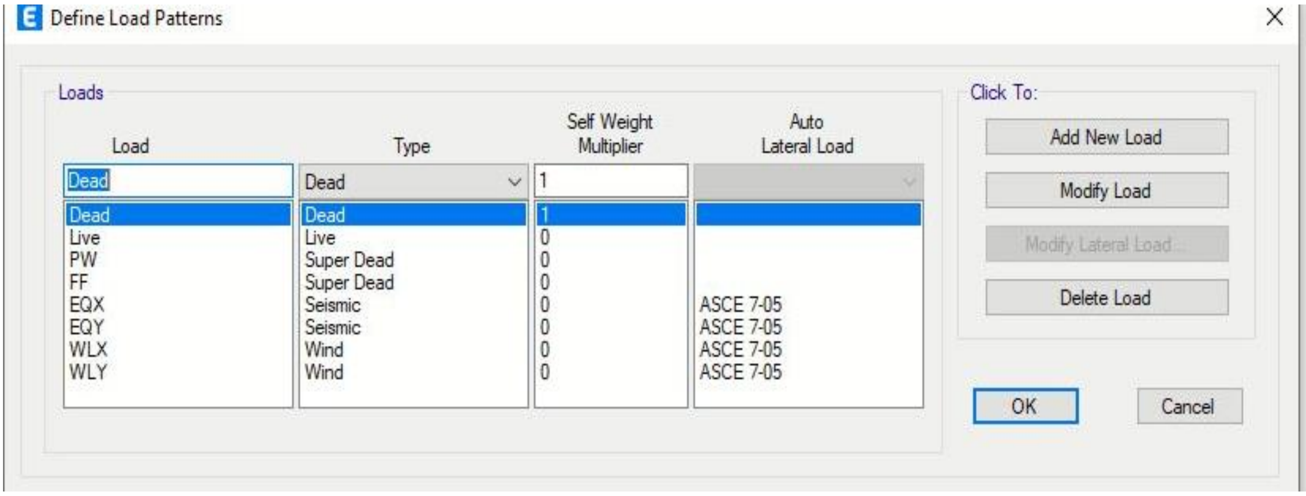

Fig: 3.26 Load pattern Assign for the model.

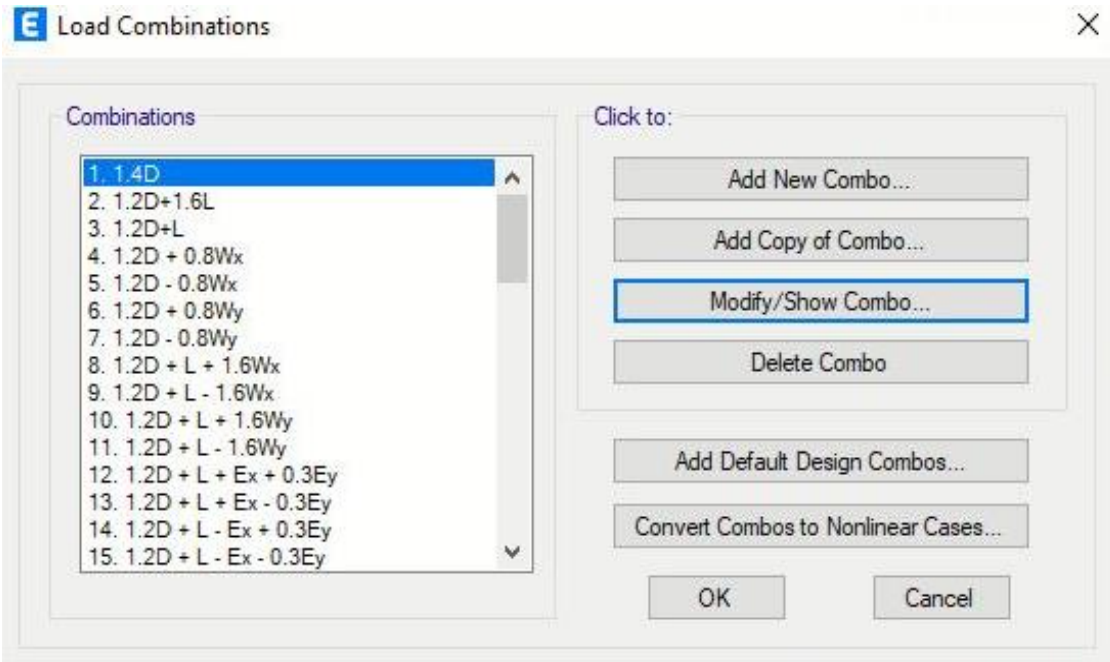

Fig: 3.27 Load Combination Assign for the model.

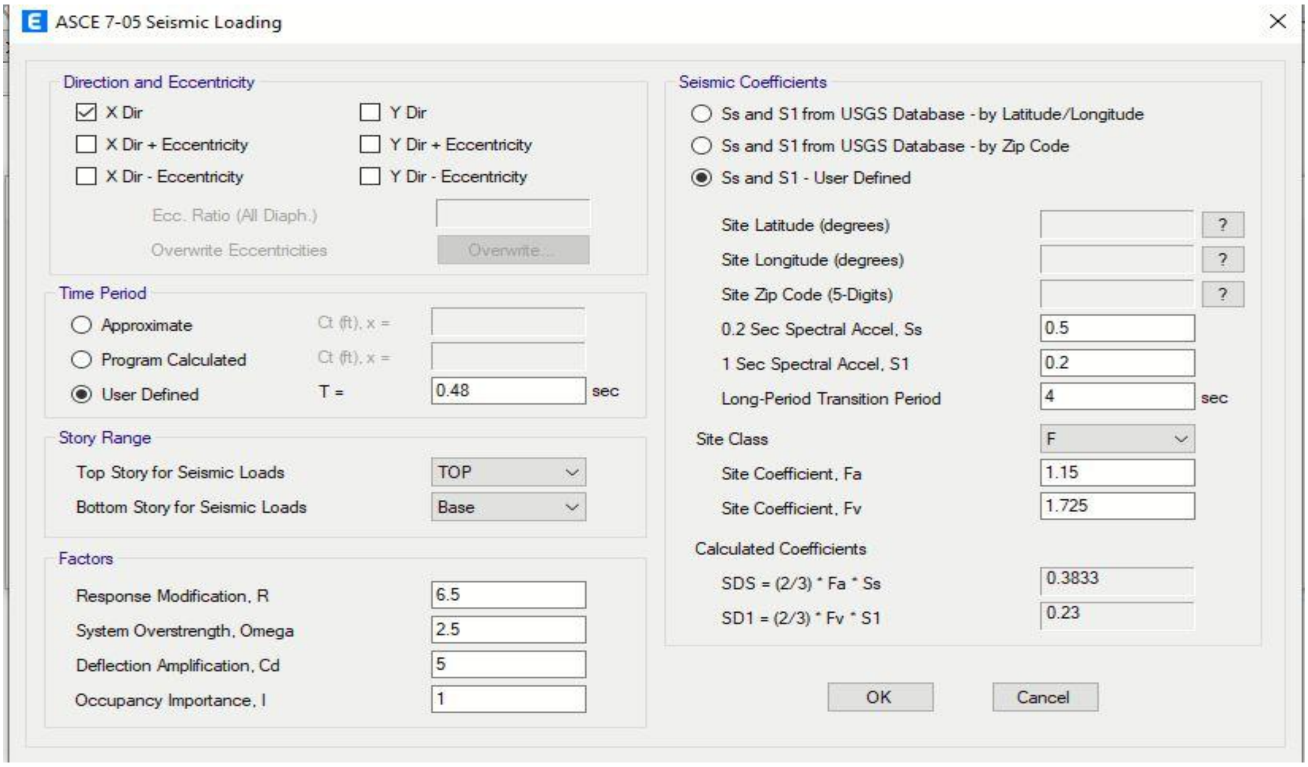

Fig: 3.28 Define seismic load pattern –ASCE7-05

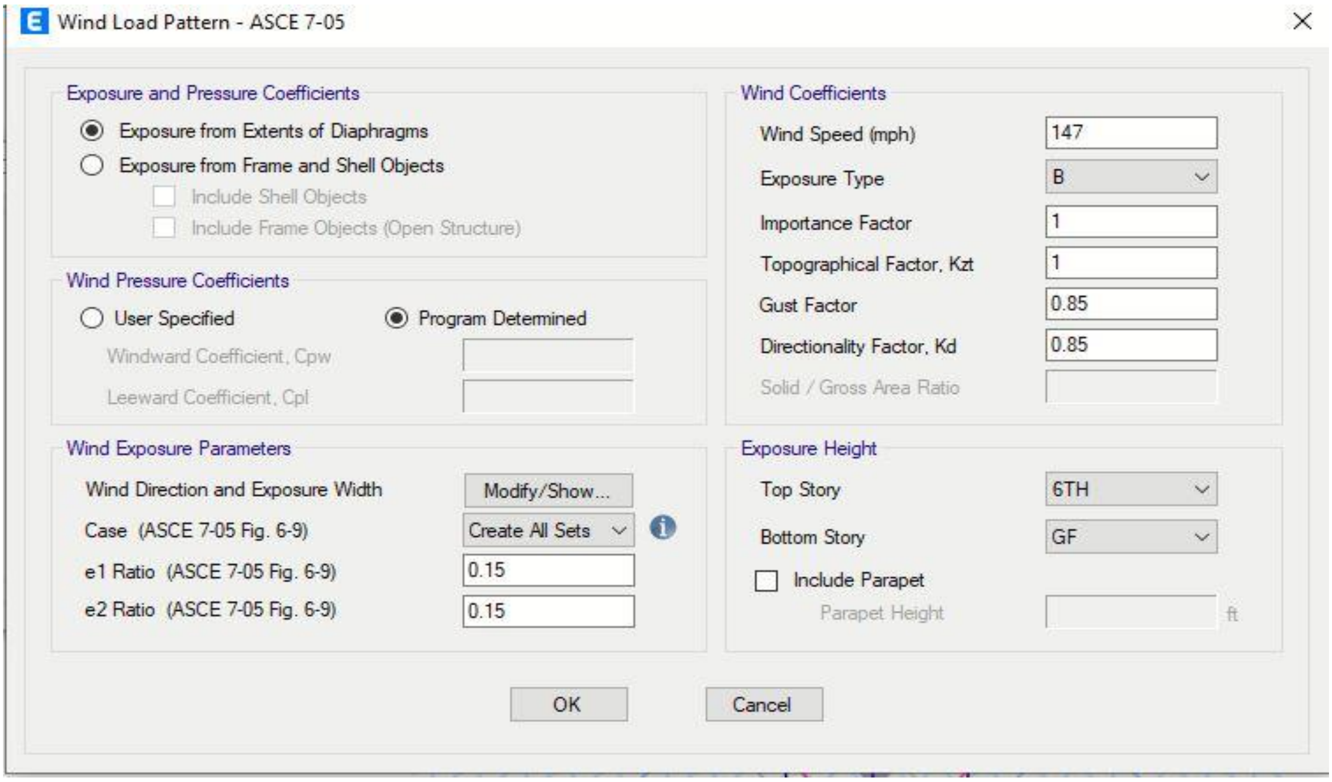

Fig: 3.29 Define Wind load pattern –ASCE7-05

ETABS 3D MODEL:

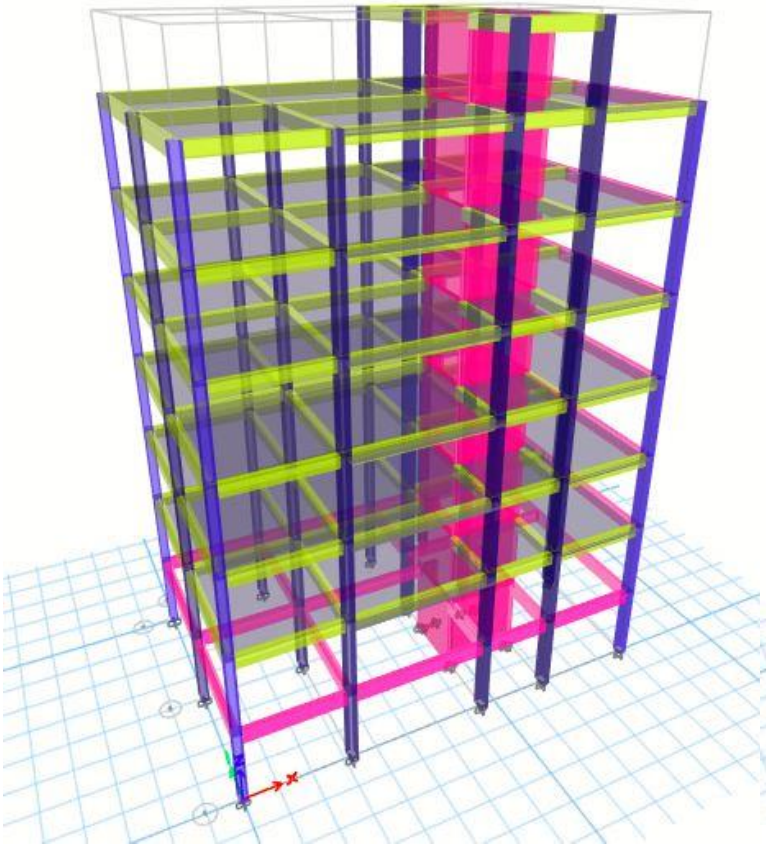

Fig: 3.30 Final 3D model of low rise

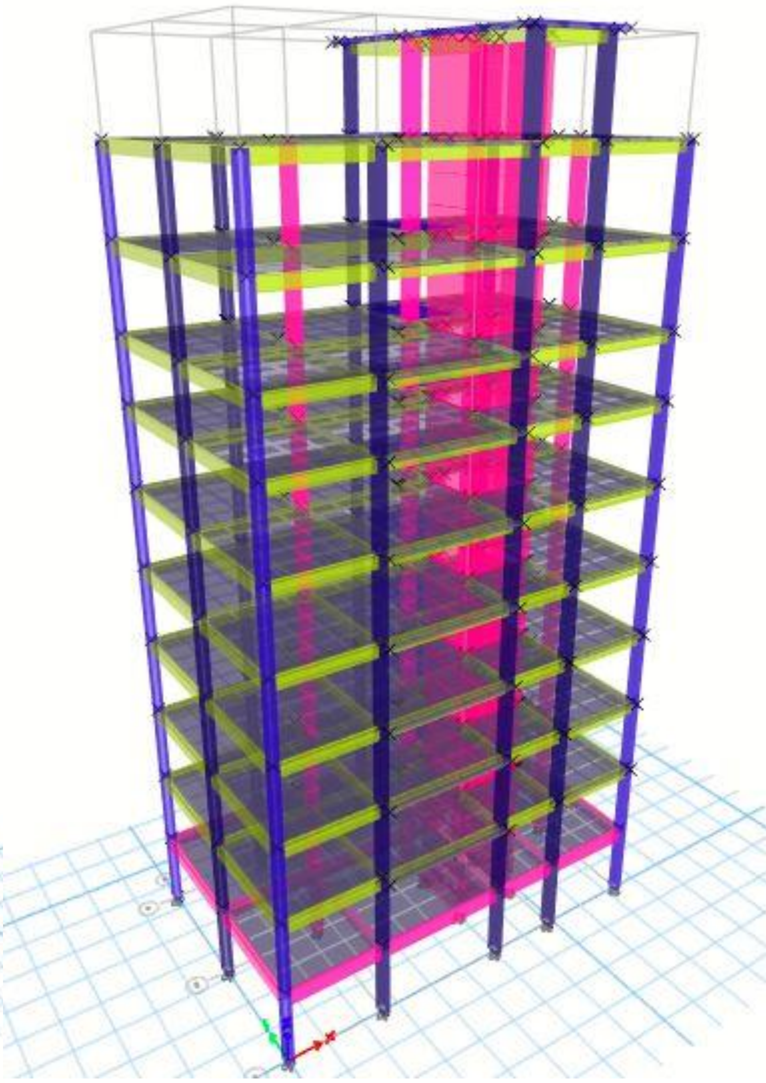

Fig: 3.31 Final 3D model of high rise

3.9.6 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.

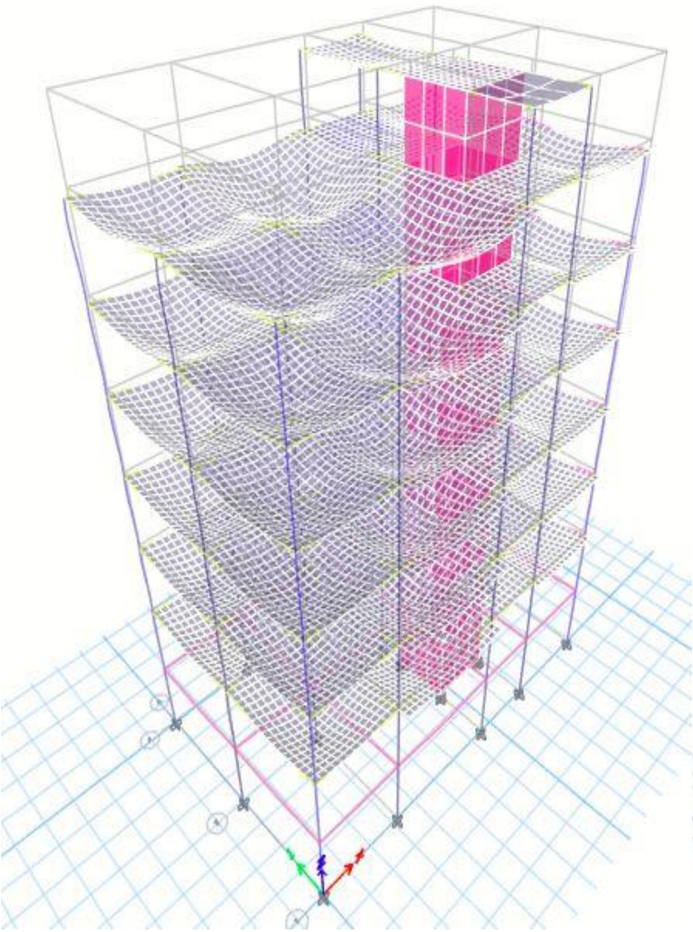

Fig: 3.32 Deflected Shape of the model low rise

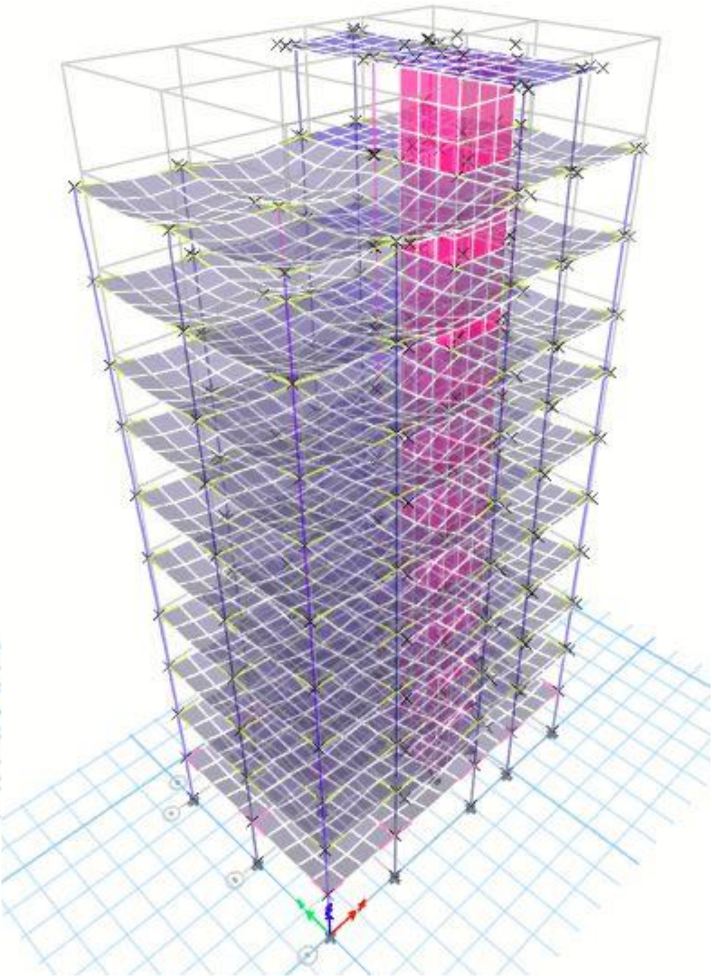

Fig: 3.33 Deflected Shape of the model high rise

CHAPTER 04

RESULT 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 low rise & high rise building according to BNBC 2020 using by ETABS have huge difference in designing methods and formulas.

4.2 Drift and Building Separation (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 4.2.1: Maximum Story Displacement

Load Type	Low Rise	High Rise
EQX	2.218237	4.921069
EQY	0.981499	3.798915
WX	0.763556	2.441302
WY	0.511336	2.81499

Table 4.2.2: Increase of Displacement Due to BNBC 2020

Load Type	Increase of Displacement (%)
EQX	121.84
EQY	287.05
WX	219.72
WY	450.51

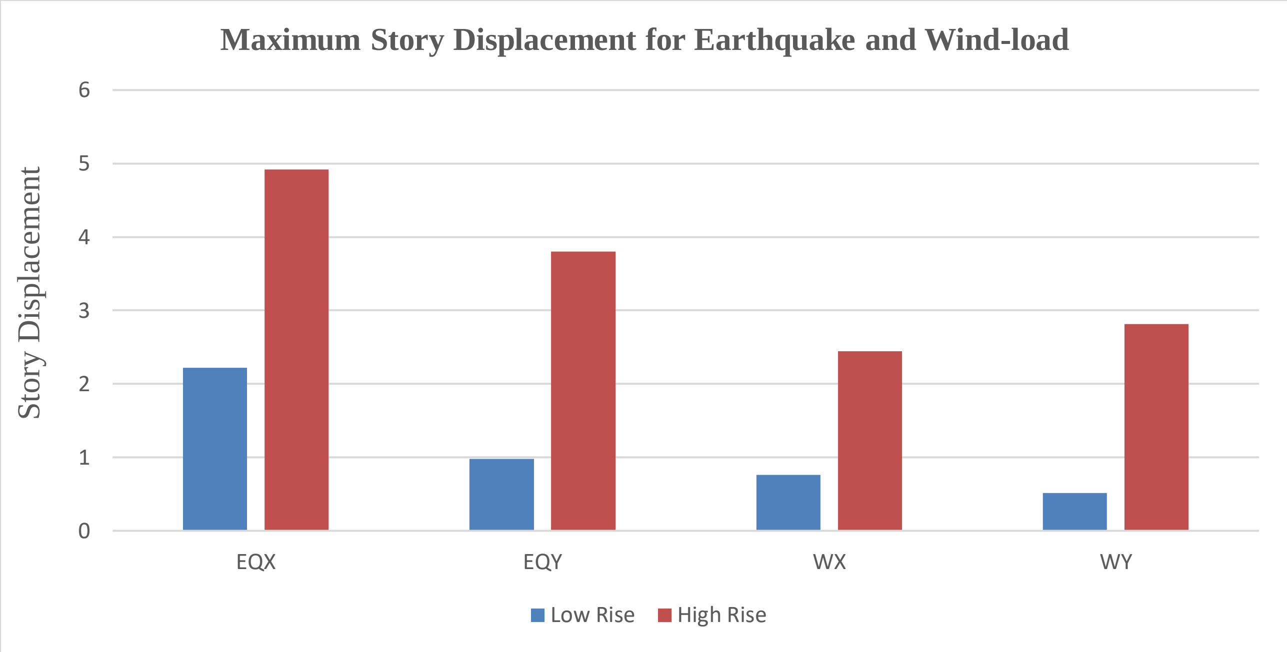

Figure 4.1: Maximum Story Displacement for Earthquake and Wind-load (Dhaka)

4.3 Drift and Building Separation (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 earthquake loads). Calculate story drift shall include both translation and torsional deflections and confirm the following requirements:

a) Story drift, A for loads other than earthquake 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 4.3.1: Maximum Story Drift

Load Type	Low Rise	High Rise
EQX	0.003165	0.005078
EQY	0.00258	0.004298
WX	0.0012	0.002557
WY	0.001639	0.003286

Table 4.3.2: Increase of Displacement Due to BNBC 2020

Load Type	**Increase of Drift (%)**
EQX	60.44
EQY	66.58
WX	113.08
WY	100.488

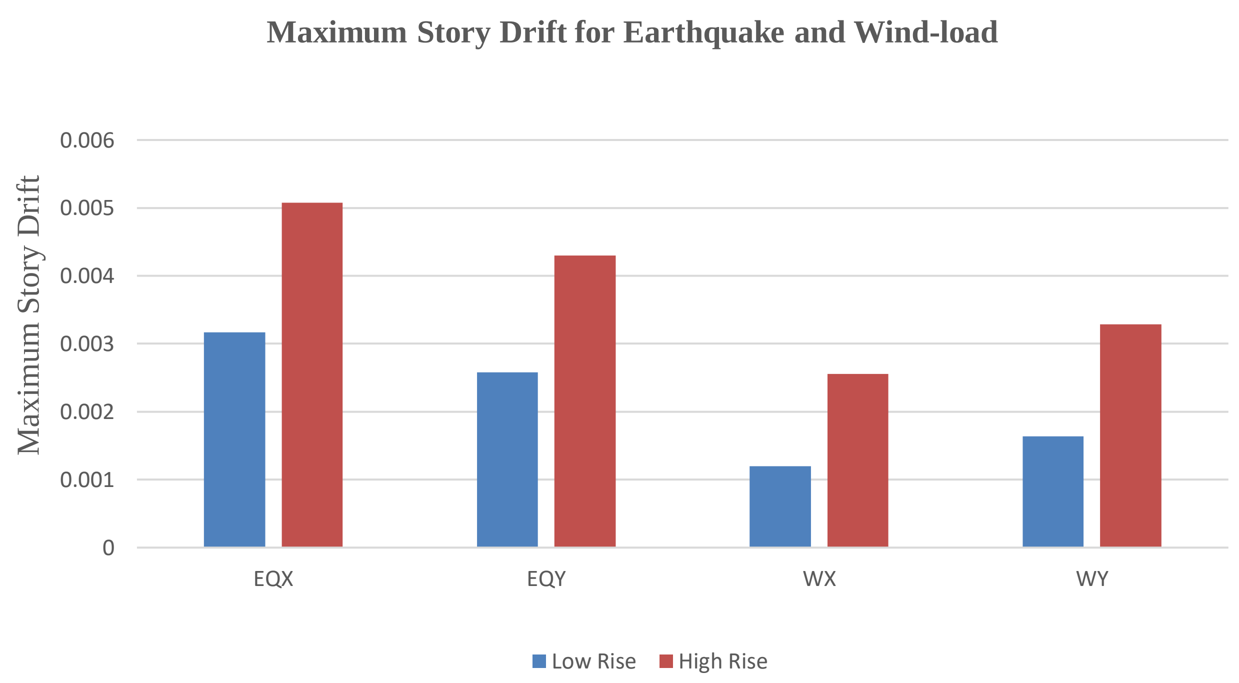

Figure 4.2: Maximum Story Drift for Earthquake and Wind-load (Dhaka)

4.4: Result Comparison and Discussion

Finally, we get this result for lateral load

1. Earthquake effect on X-direction of High Rise Building is greater than Low rise Building.
2. Earthquake effect on Y-direction of High Rise Building is greater than Low rise Building
3. Wind effect on X-direction High Rise Building is greater than Low rise Building.
4. Wind effect on X-direction High Rise Building is greater than Low rise 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 low rise to high rise multistory structure is 121.84%, 287.05%, 219.72% and 450% for load EQX, EQY, WX and WY respectively. And the maximum story drift of low rise to high rise multistory structure is 60.44%, 66.58%, 113.08%, and 100.488% for load EQX, EQY, WX and WY 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 low rise and high-rise multistory structures, the requirements of BNBC 2020 usually result in a less cost-effective design with a higher safety margin.

CHAPTER 5

CONCLUSION AND RECOMMANDATION

5.1 Conclusions and Future Works

From the study is observed that.

1. Effect of owning an earthquake is very important for building design
2. The lateral displacement due to the earthquake of the structure analysis in high-rise buildings is more than the lateral displacement of the structure analysis in low-rise buildings by the BNBC-2020 code.
3. The lateral displacement due to the wind load of the structure analysis in high-rise buildings is more than the lateral displacement of the structure analysis in low-rise buildings by the BNBC-2020 code.
4. The value of inter-story drift is slightly greater than the structural analysis in high-rise buildings compared to the low-rise buildings by the BNBC-2020 code.
5. The building is analyzed linearly for seismic design.
6. All loads are taken according to BNBC code provided.
7. The building does not analyze non-linearly for seismic loads.

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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