

# **A COMPARISON BETWEEN LOW RISE AND HIGH-RISE MULTISTORY STRUCTURES DUE TO LATERAL LOADS 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.



**Departments of Civil Engineering**

Sonargaon University

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

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## DECLARATION

It is stated that the thesis work on “**A comparison between low rise and high-rise multistory structures due to lateral loads by using ETABS**” has been performed under the supervision of ZEB A FARIHA, Lecturer, Department of Civil Engineering, Sonargaon University (SU), Dhaka. To the best of our knowledge and belief, the thesis report contains no material previously published or written by another person except where due reference 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 of all, 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 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 G+5 -story (Low rise) and G+12-Story (High rise) residential building was analyzed (ETABS 16.0 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

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### 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 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 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 16.0.1 (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

<b>Date</b>	<b>Name of Earthquake</b>	<b>Magnitude</b>	<b>Epicenter</b>
12 September 2007	Tsunami due earthquake(Cox`s Bazar)	8.5	Benkula, Sumatra
26 December,2004	Cox`s Bazar earthquake	7.0	Bonda
21 November,1997	Bandarban earthquake	7.1	Mizoram-Mayanmar border
21 March, 1994	Monipur-Mayanmar earthquake	7.4	Monipur

2September,1930	Dubri earthquake	7.1	Dabigiri
6 March,1932	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
07 August, 1918	Kishoreganj earthquake	7.2	Kishoreganj
04 February,1762	Rakhaine Earthquake	8.8	Rakhine

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 and Overview

### The objectives of the study are:

- To compare wind load effect on Six-storied low rise and thirteen-storied 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

<b>Utility of Building</b>	<b>Residential Purpose</b>	
1. Number of Stories	Six Storied	Thirteen 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

Ground Floor	10 ft
Floor to Floor height	10 ft
Height of plinth	2.5 ft

## CHAPTER 02

### LITERATURE REVIEW

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#### 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 earthquake & 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.

1. John D. Holmes (et.al)(2009) The paper describes a comparison of wind load calculations on three buildings with different wind loading codes and standards from the Asia-Pacific Region. He performed an analysis on the low, medium, and high rise structures. The tall building has a significant amount of resonant dynamic response to wind which complicates the evaluation of base shear, bending moments and acceleration at the top of the building. The coefficients of variation for both along- wind and cross- wind responses were relatively small in the range of 14% to 18%.
2. M. Chauhan (et.al.)(2011) The paper presented a study on the comparative study of wind forces on high rise buildings. For analysis he used E- TABS 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.
3. Valsson Varghese (et.al.)(2013) The paper 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 more safe 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.
4. Athanase Ndikokubwayo (et.al.)(2014) The paper 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.
5. 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-store buildings and their surroundings. It also aims at improving the expression for defining maximum wind load depending on the building height and the distance to it. In this study numerical experiments on modelling the distribution of wind flows in a virtual wind tunnel for an existing low-rise building have been carried out. Based on their results, an increasing coefficient in the expression for determining the wind load depending on the height of a multi-store building and the distance to it is proposed. The results obtained can be used in determining wind loads during the reconstruction of low-rise buildings and their verification calculations when placing multi-store and high-rise buildings in existing buildings.

6. K. R. C. Reddy, (et.al.) [1] The purpose of this research is to present a comparative study of wind and earthquake loads to decide the design loads of a multistoried building. The significance of research is to estimate the design loads of a structure when subjected to wind and earthquake loads in every earthquake zone. The research design made use of equivalent lateral load method for the calculation of the forces on the structures . Research considered the wind load as stochastic and time dependent. It estimated wind load based on the design wind speed of that zone with a variation of 20%. He made the analysis on the low, medium and high rise buildings . The wind forces are constant up to the third floor and has increased beyond third floor at a constant rate. The wind pressure increased as the height of the building increased. As zone factor increases the earthquake forces also increased gradually. He concluded that wind loads are more critical than the earthquake loads.
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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

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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.

#### **2.4 Software Used:**

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

##### **List of software's used**

1. ETABS 2016.

#### **2.4.1 ETABS 16:**

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.

## CHAPTER 03

### METHODOLOGY

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#### **3.1 Introduction:**

In this chapter methodology of the work has been discussed. Required data for analysis and model built-up with AutoCAD and ETABS (2016) 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

- **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.

- **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.

• **Wind Load:**

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

$$q_z = C_e C_i C_z V_b^2 \dots \dots \dots \text{(If } V_b = \text{km/h)} \dots \dots \dots \text{(i)}$$

$q_z$  = Sustained wind pressure at height z, kN/m<sup>2</sup>

$C_i$  = Structure importance Coefficient

$C_e$  = Velocity to pressure conversion coefficient

$C_z$  = Combined height and exposure coefficient (Calculate based on height)

$V_b$  = Basic wind speed, km/h

**Velocity pressure:**

Velocity pressure,  $q_z$  evaluated at height z shall be calculated by the following equation:

$$q_z = (0.0006130 v^2) K_z K_{zt} K_d I, \dots \text{(kN/m}^2\text{)}, V \text{ in m/s} \dots \dots \dots \text{(ii)}$$

**From the above equation, design wind pressure,  $p_z$  is calculated as followed**

$$P_z = C_G C_p Q_z \dots \dots \dots \text{(If } V_b = \text{km/h)} \dots \dots \dots \text{(iii)}$$

$$P_z = C_t C_G C_p Q_z \dots \dots \dots \text{(If } V_b = \text{mile/h)} \dots \dots \dots \text{(iv)}$$

$P_z$  = Design wind pressure at height  $z$ ,  $\text{kN/m}^2$

$C_o$  = Gust coefficient (calculated based on building height)

$C_p$  = Pressure coefficient

$q_z$  = Sustained wind pressure at height  $z$ ,  $\text{KN/m}^2$

$C_t$  = in plain terrain local topography coefficient = 1

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

$$F_z = \{P_z A_z\} \dots \dots \dots \text{(v)}$$

$F_z$  = Total wind force, KN

$P_z$  = Design wind pressure ( $\text{kN/m}^2$ )

$A_z$  = Projected frontal Area, m

**Basic Wind Equation  $p = q \times G \times C_p$  .....** (vi)

$p$  = Wind Pressure

$q$  = Velocity Pressure

$G$  = Gust Effect Factor

$C_p$  = 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<sup>2</sup>:** Component and cladding elements with tributary areas greater than 65 m<sup>2</sup> 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:

$$p = q G C_p - q_i (G C_{pi}) \text{ (kN/m}^2\text{)} \dots \dots \dots \text{(vii)}$$

Where,

$q = q_z$  for windward walls evaluated at height  $z$  above the ground

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

$q_i = q_h$  for windward walls, side walls, leeward walls, and roofs of enclosed Buildings and for negative

Internal pressure evaluation in partially enclosed buildings.

$q_i = q_z$  for positive internal pressure evaluation in partially enclosed buildings where height  $z$  is 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,  $q_i$  may conservatively be evaluated at  $h = (Q_i = q_h)$

$G$  = gust effect factor

$C_p$  = external pressure coefficient

$G C_{pi}$  = internal pressure coefficient

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

$$p = q_h [(G C_{pf} - (G C_{pi}))] \text{ (kN/m}^2\text{)} \dots \dots \dots \text{ (Viii)}$$

Where,

$q_h$  = velocity pressure evaluated at mean roof height  $h$  using exposure

$G C_{pf}$  = external pressure coefficient

$G c_{pi}$  = internal pressure coefficient

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

$$P = q G_f C_p - q_i (G C_{pi}) \text{ (kN/m}^2\text{)} \dots \dots \dots \text{ (ix)}$$

**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:

$$P_p = Q_p G C_{pn} \text{ [kN/mm}^2\text{)} \dots \dots \dots \text{ (x)}$$

Where,

$P_p$  = 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

$Q_p$  = Velocity pressure evaluated at the top of the parapet

$G C_{pn}$  = Combined net pressure coefficients

= +1.5 for windward parapet

= -1.0 for leeward parapet

- **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 -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

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

Alternatively, the value of Ct for buildings with concrete or masonry shear walls may be taken as  $0.031/\sqrt{A_c}$ . The value of Ac shall be obtained from the relation:

$$A_c = \sum A_e [0.2 + (D_e/h_n)^2] \dots \dots \dots (xi)$$

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

$$T = \frac{2\pi}{\sqrt{\sum_{i=1}^n \omega_i \cdot \delta_i^2 / g \sum_{i=1}^n f_i \cdot \delta_i}} \dots \dots \dots (xii)$$

**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 Structures	1.00	1.00
<b>IV Standard Occupancy Structures</b>	1.00	1.00
V Low-risk Structures	1.00	1.00



**Table 3.3: Design Factor Condition**

Zone	2 (Dhaka)
Soil Type	SC
Occupancy Factor	I, II
Structure Importance	1.0
R	8
$\Omega$	3

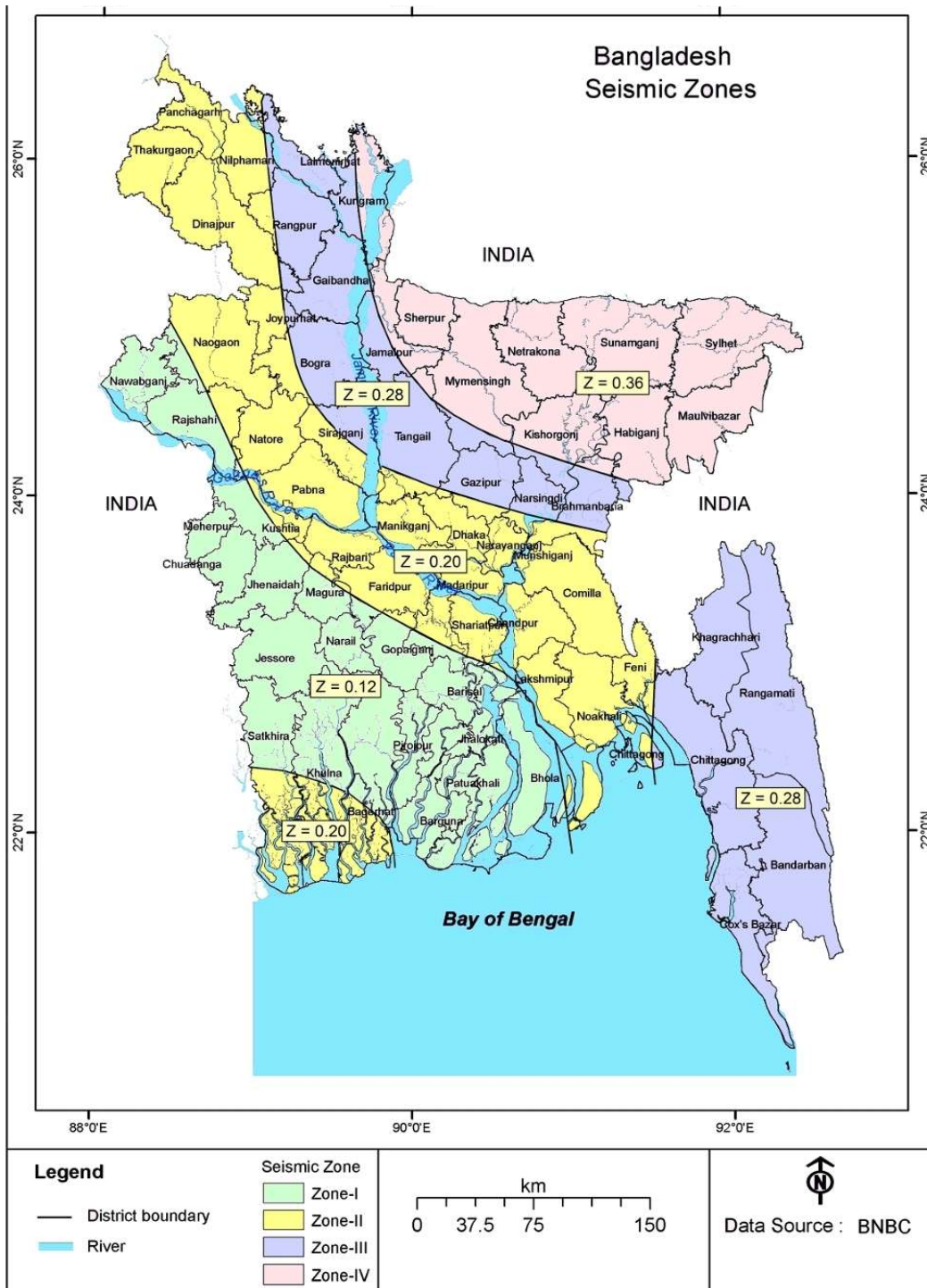


Figure: 3.1 Seismic zoning map of Bangladesh

**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.

- **Dead Load: (for Zone -2)**

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

- **Live Load:**

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

- **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

- **Earthquake Category Base Shear (BNBC 2020)**

Seismic Zone	: Zone II
Seismic Zone factor (Z)	: 0.20
Response Modification Coefficient, R	: 5
System Over strength. ' $\Omega$ (omega)	: 3
Deflection Amplification, Cd	: 4.5
Structural Importance Factor (I)	: 1.0
Spectral Response Acceleration, S <sub>s</sub> '	: 0.5
Spectral Response Acceleration, S <sub>i</sub>	: 0.2
Site Coefficient, F <sub>a</sub>	: 1.15
Site Coefficient, F <sub>v</sub>	: 1.725
Time Period, T	: 0.78 sec

#### **Material Properties:**

Unit weight of concrete	: 150 lb/ft
-------------------------	-------------

#### **Compressive Strength:**

For slab, f <sub>c</sub>	: 4000 psi
For beam, f <sub>c</sub> '	: 4000 psi
For Column: f <sub>c</sub> '	: 4000 psi

<b>Steel:</b> Yield strength of Steel, f <sub>y</sub>	: 60 ksi
---	----------

3.6 Auto CAD Model

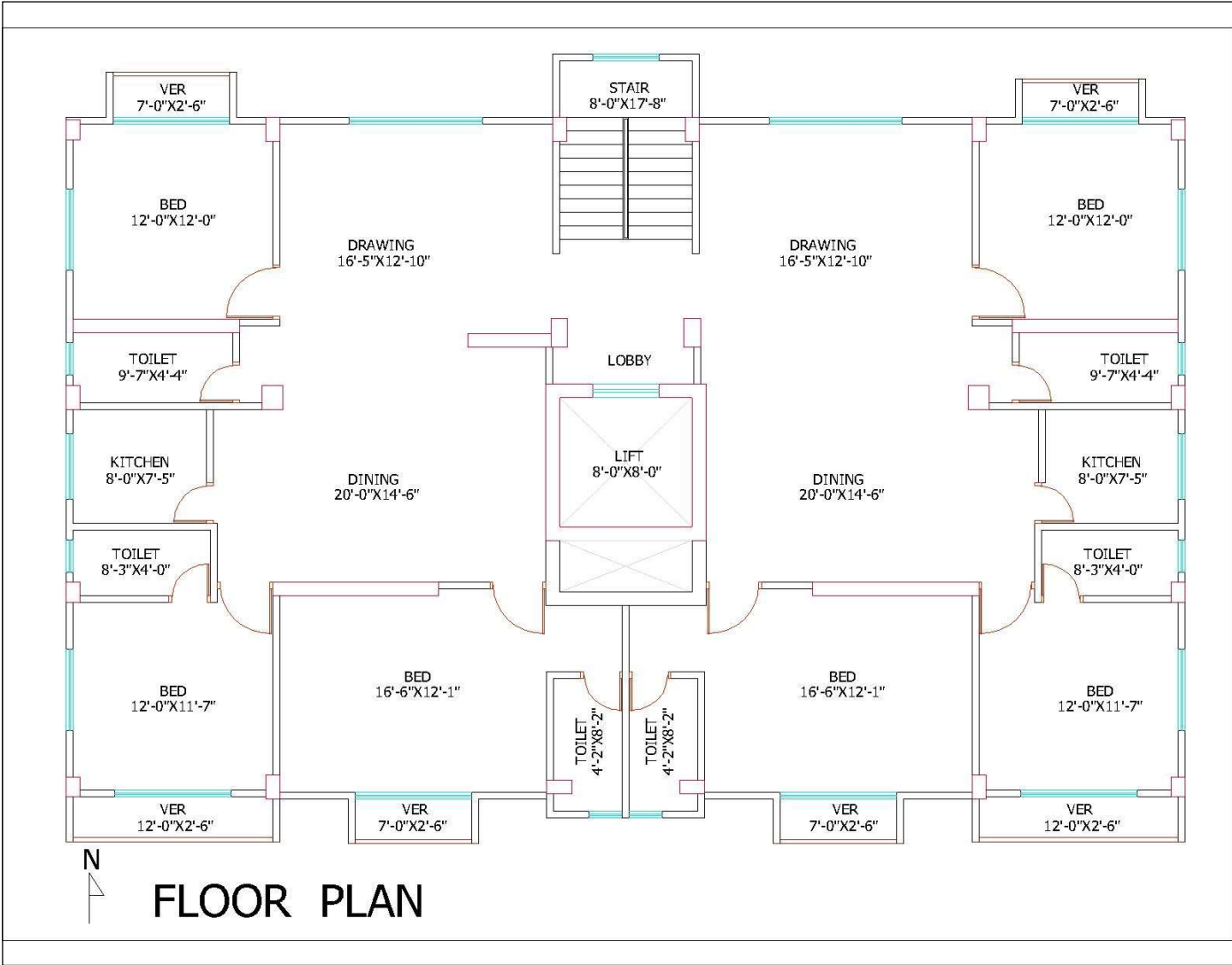


Figure: 3.2 Architectural Plan for both option

### 3.7 Column & Beam Layout

#### Option 01: low rise building (6 story)

#### Column & Beam size:

Column 01: 12x16

Beam (FB): 12x16

Column 02: 12x20

Beam (GB): 12x18

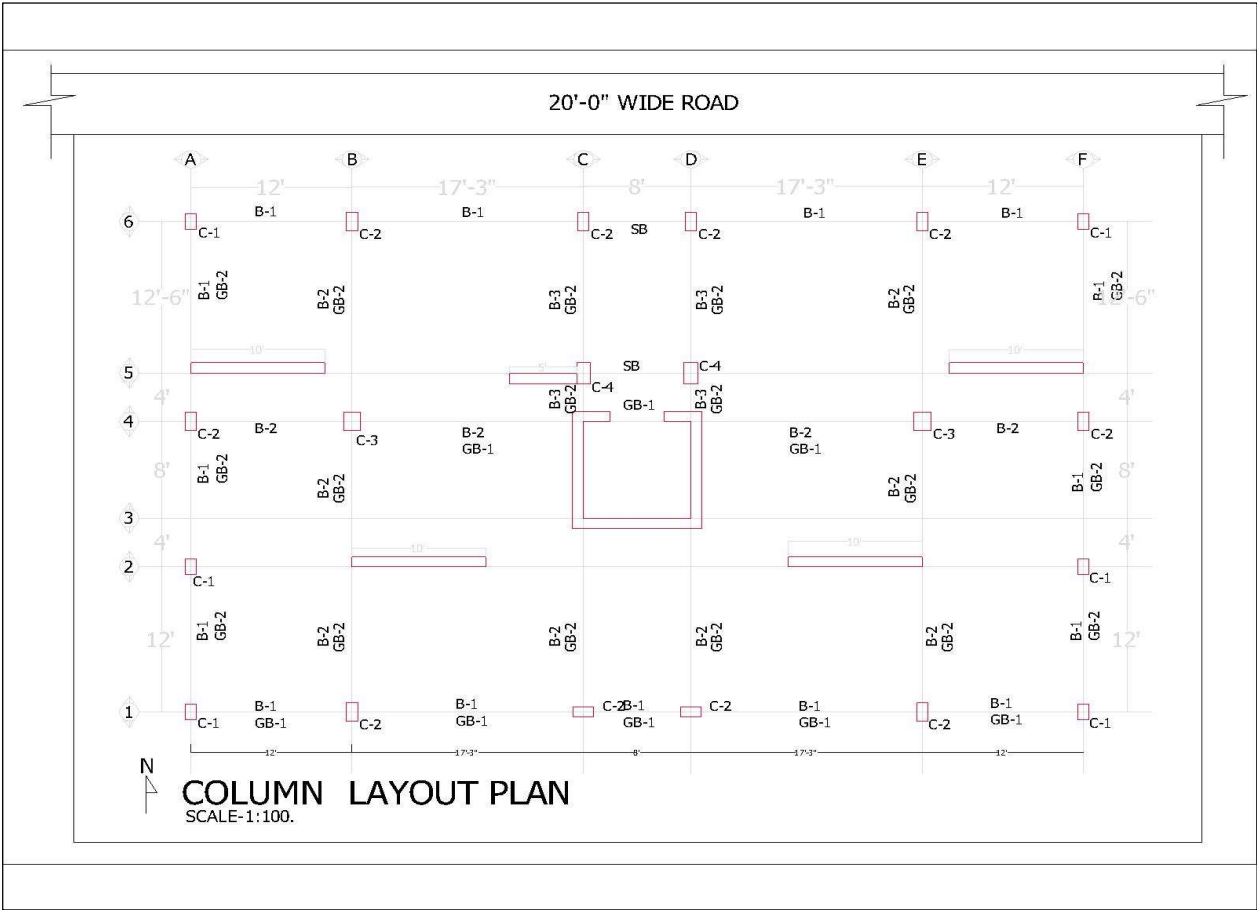


Fig: 3.3 Column & Beam Layout (low rise)





**3.8 Beam Section:**

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

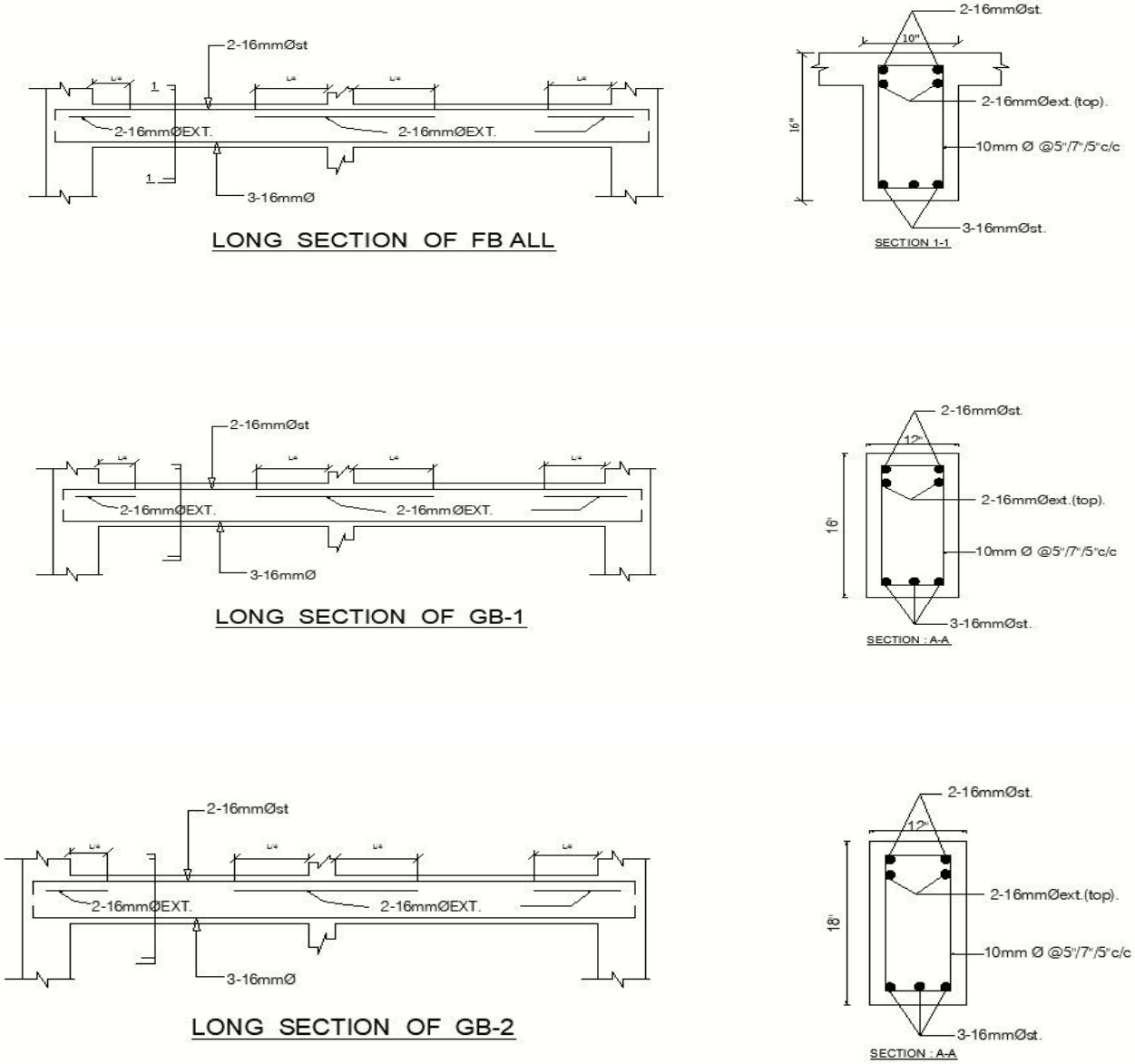


Fig: 3.5 Low rise Building beam section

- **Beam Section:**

**Option 2: High Rise Building (13 Story) Beam Section:**

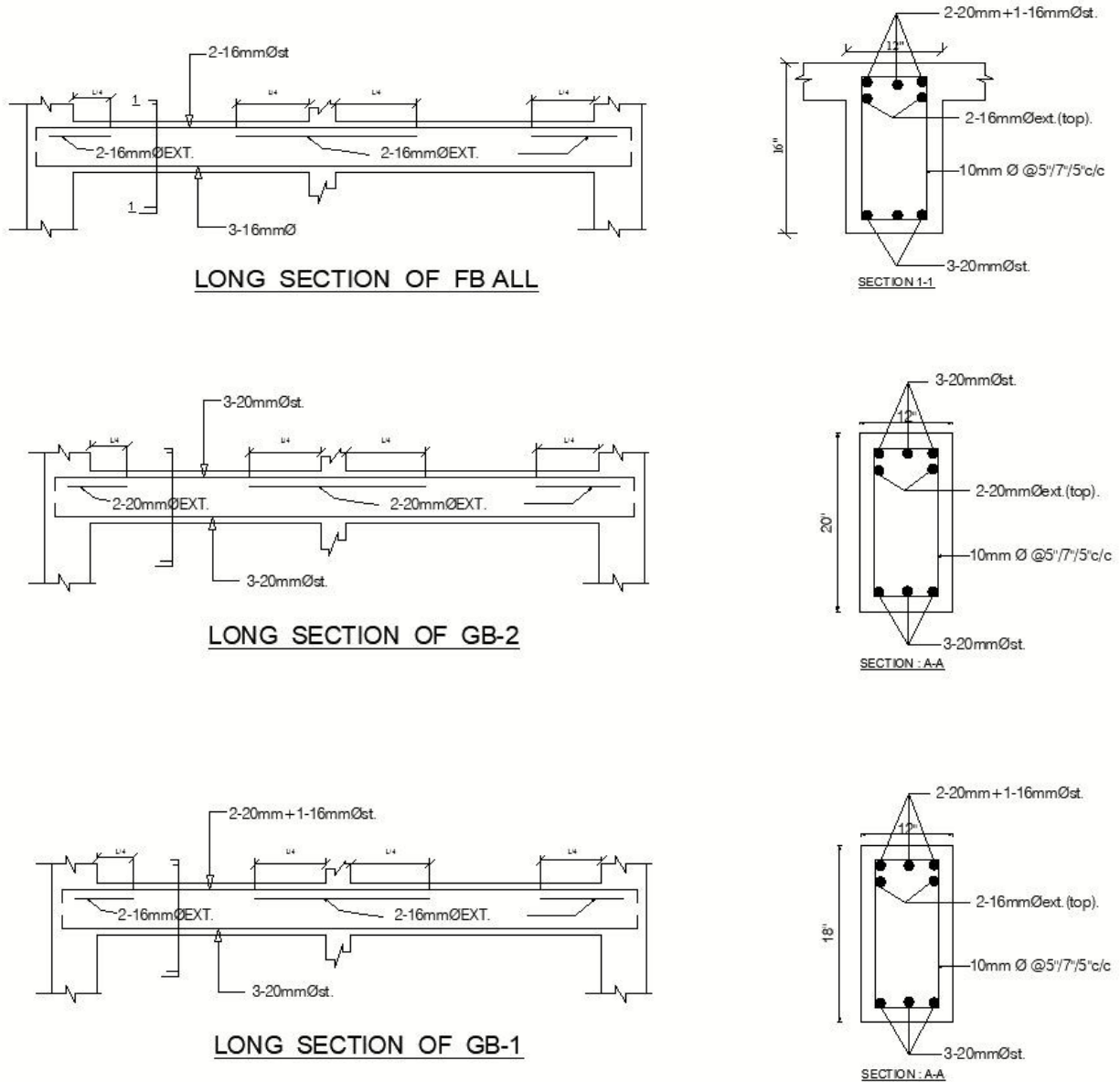


Fig: 3.6 High rise Building beam section

### 3.9: Modelling with EATBS:

- **Model Initialization**

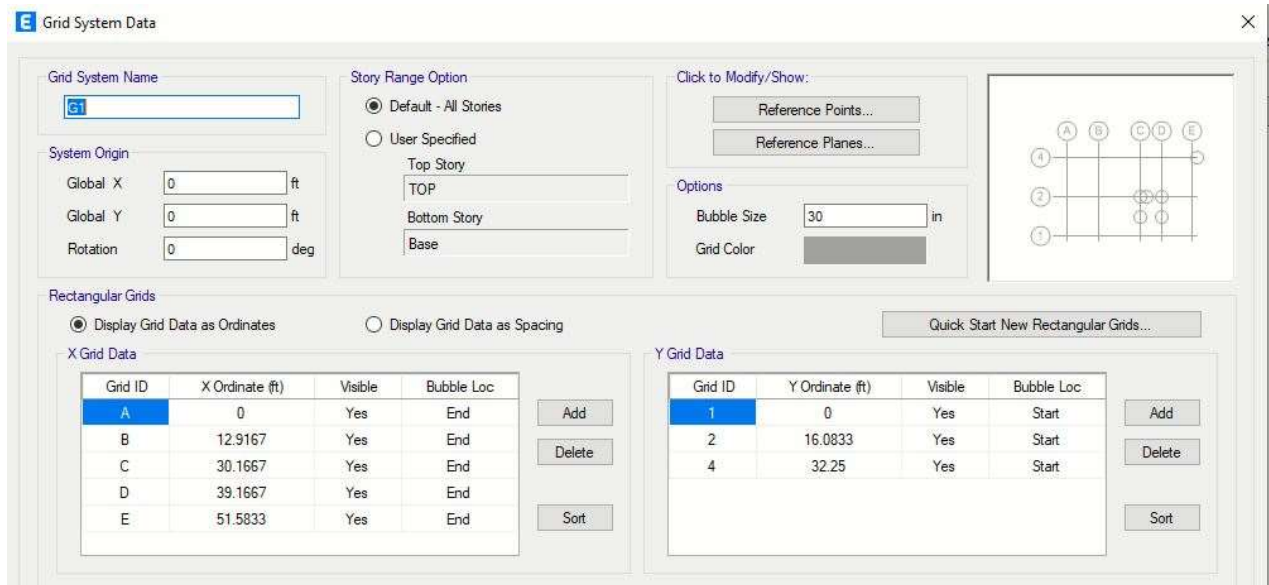


Fig: 3.7 Grid selection of the Model

- ❖ File> New model
- ❖ If it is uniform grid then file up the “Uniform grid Spacing” Box
- ❖ Input number of 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
- ❖ Check Spacing
- ❖ Check glue to grid lines
- ❖ Input spacing of grid in X,Y direction
- ❖ OK

❖ **Define Materials Properties and Frame Section:**

**1 .Materials Properties**

- i. Concrete
- ii. Modify if need

**2. 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

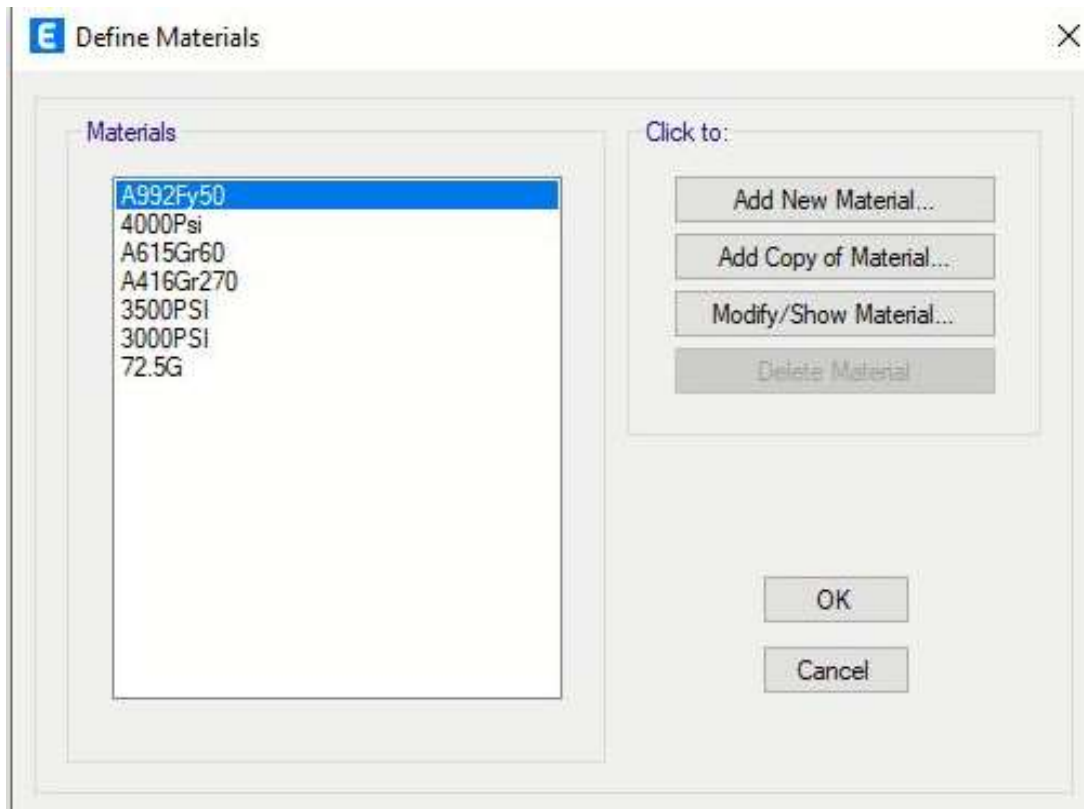


Fig: 3.8 Define Materials

❖ **Frame Properties:**

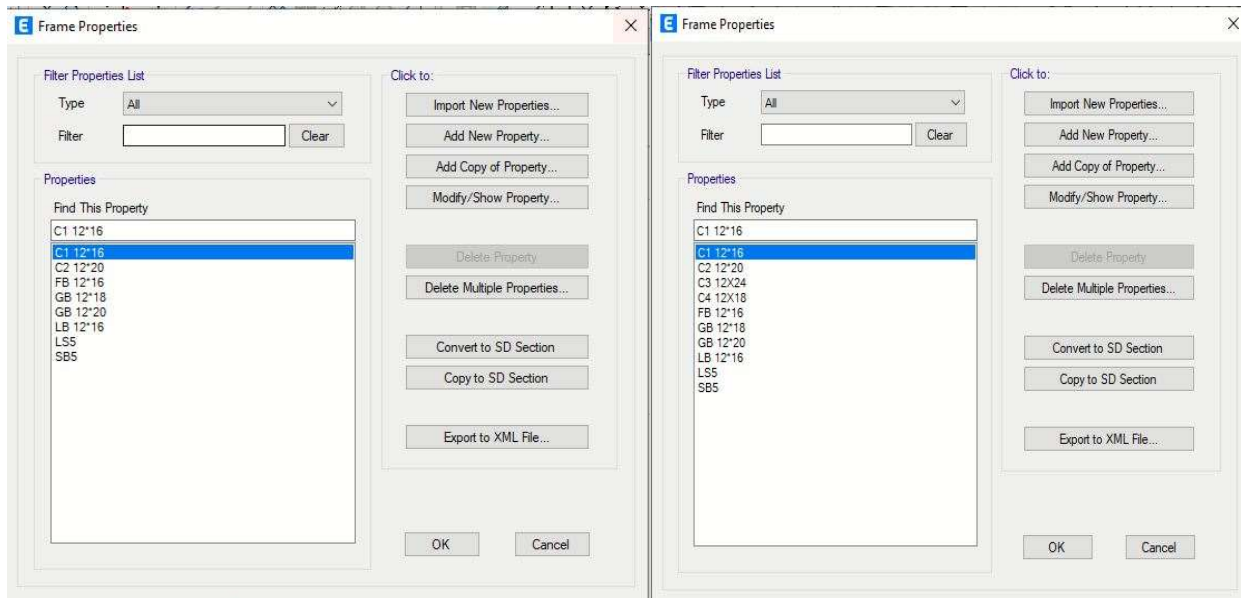


Fig: 3.9 Frame Property Initialization for both Section

- **Frame Section Property of Columns for Low Rise Building**

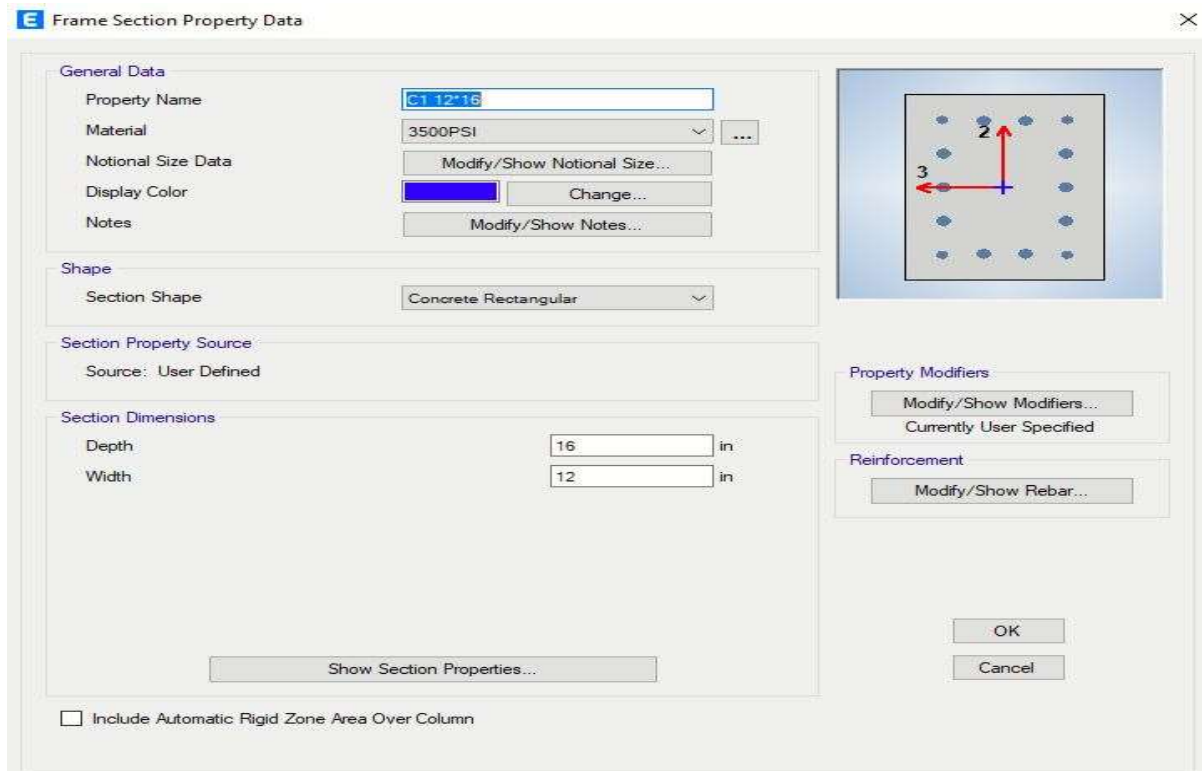


Fig: 3.10 Frame Section Property of Columns for Low Rise Building

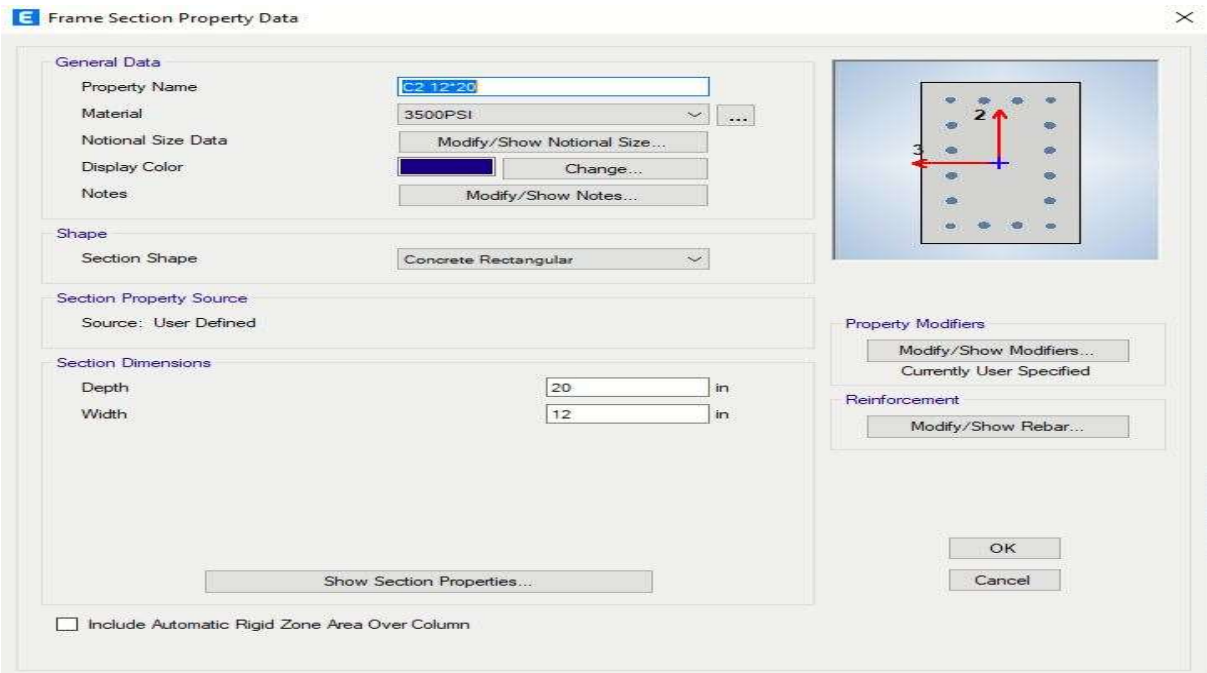


Fig: 3.11 Frame Section Property of Columns for Low Rise Building

- **Frame Section Property of Columns for High Rise Building**

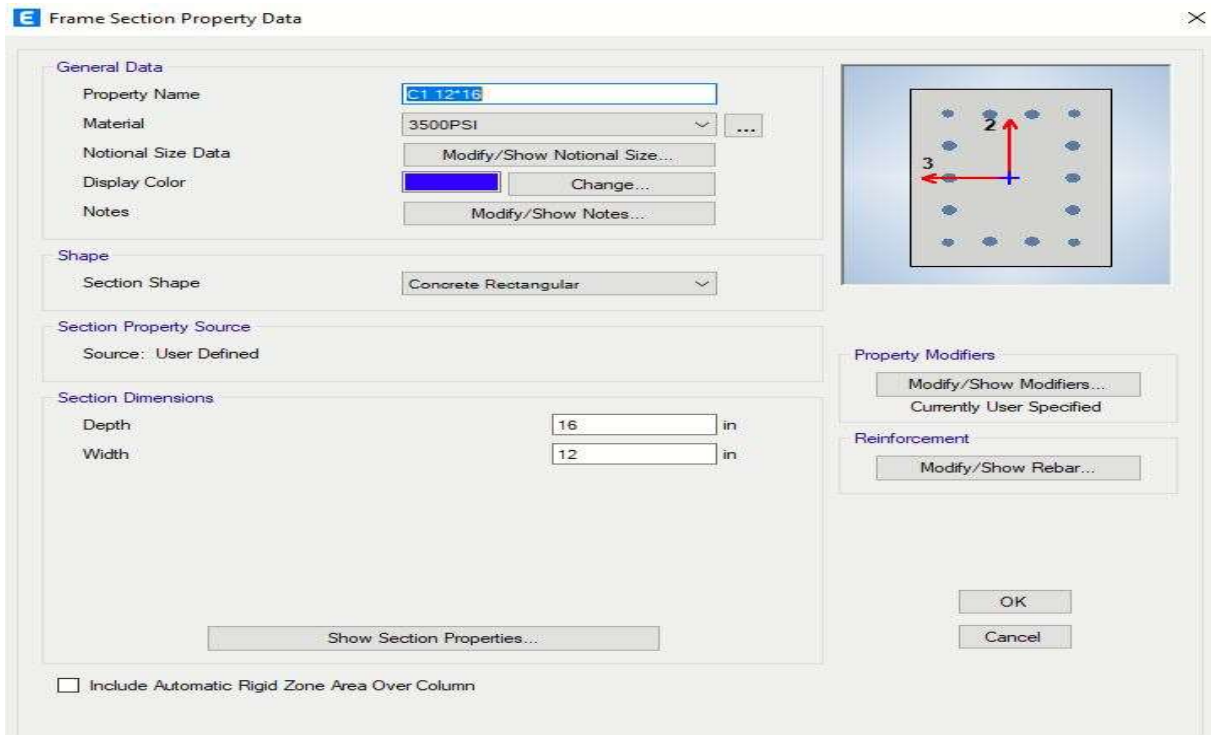


Fig: 3.12 Frame Section Property of Columns for High Rise Building

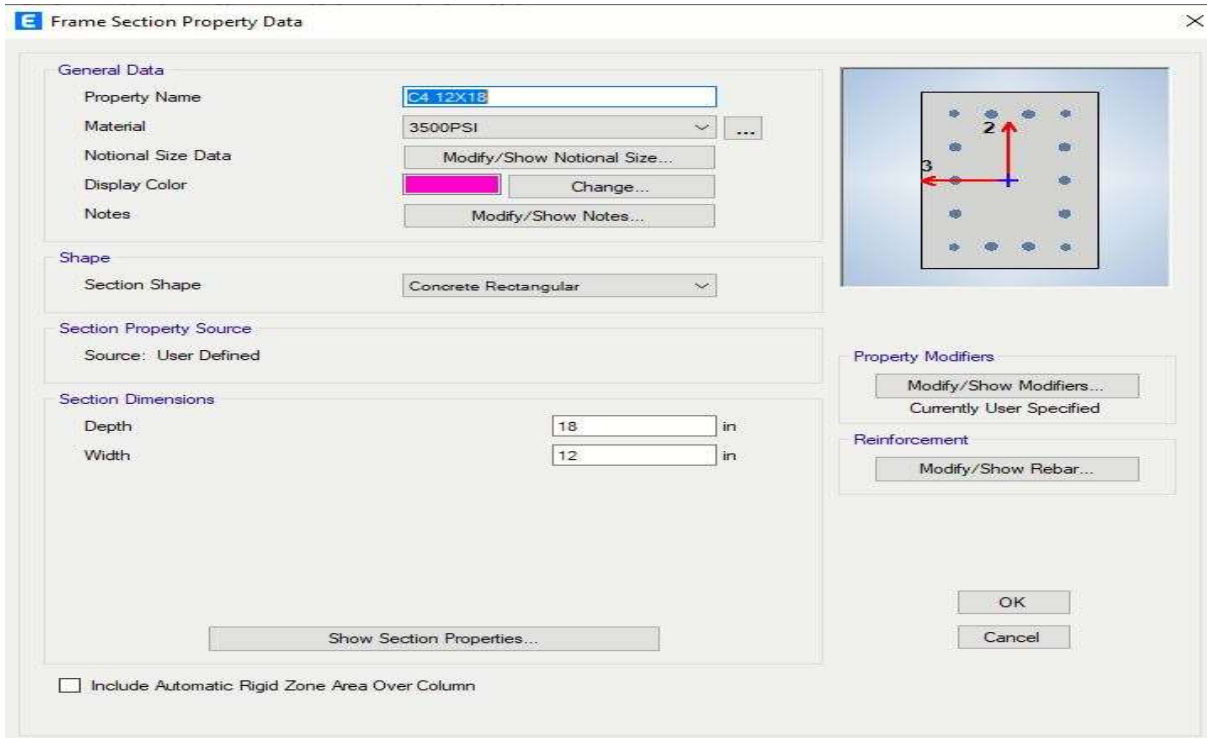


Fig: 3.13 Frame Section Property of Columns for High Rise Building

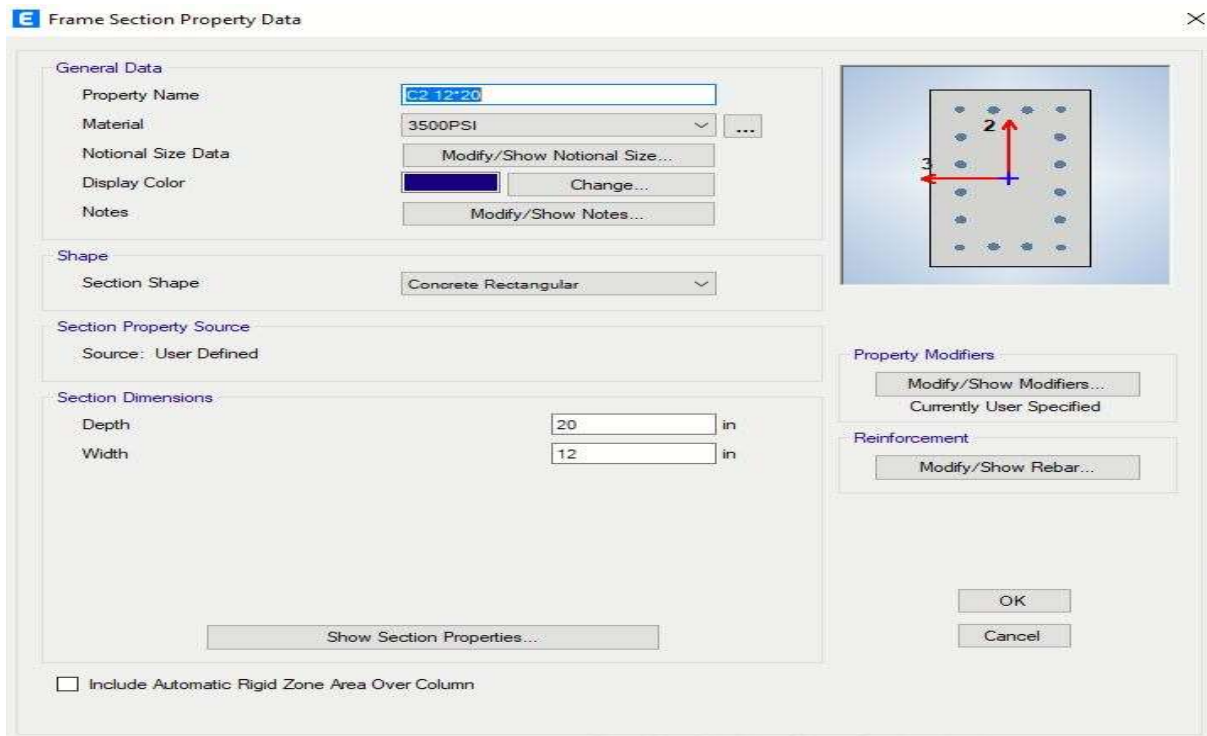


Fig: 3.14 Frame Section Property of Columns for High Rise Building

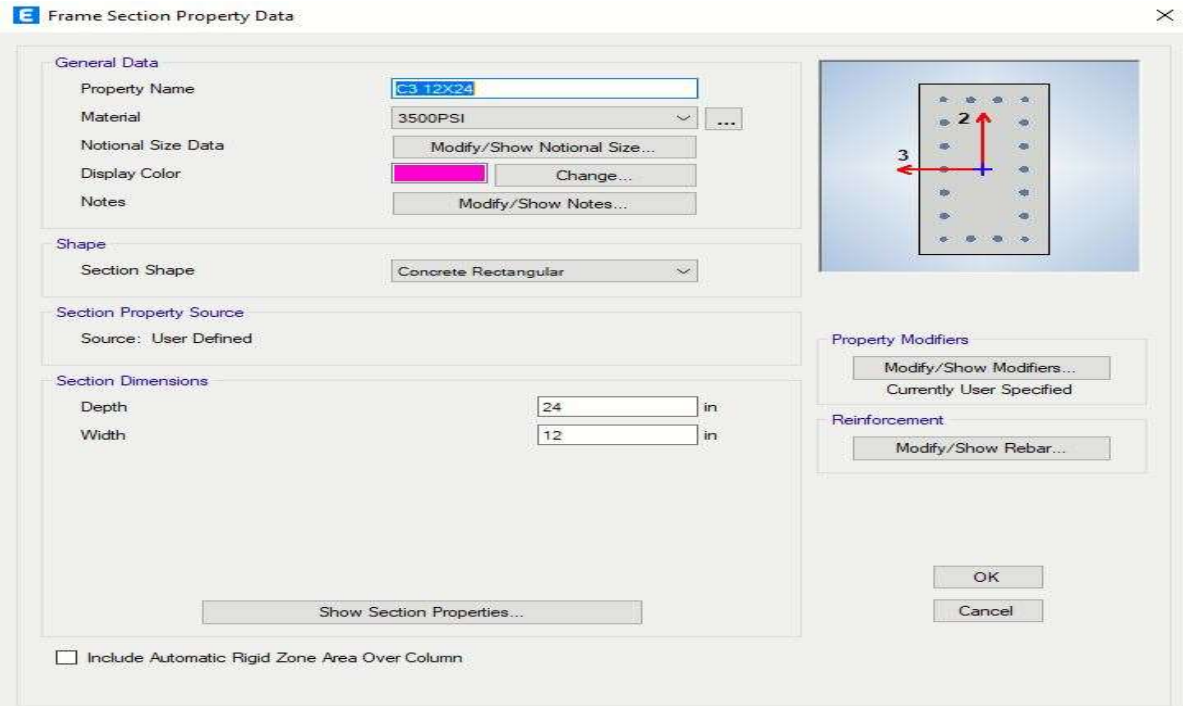


Fig: 3.15 Frame Section Property of Columns for High Rise Building

- **Display Grid Data**

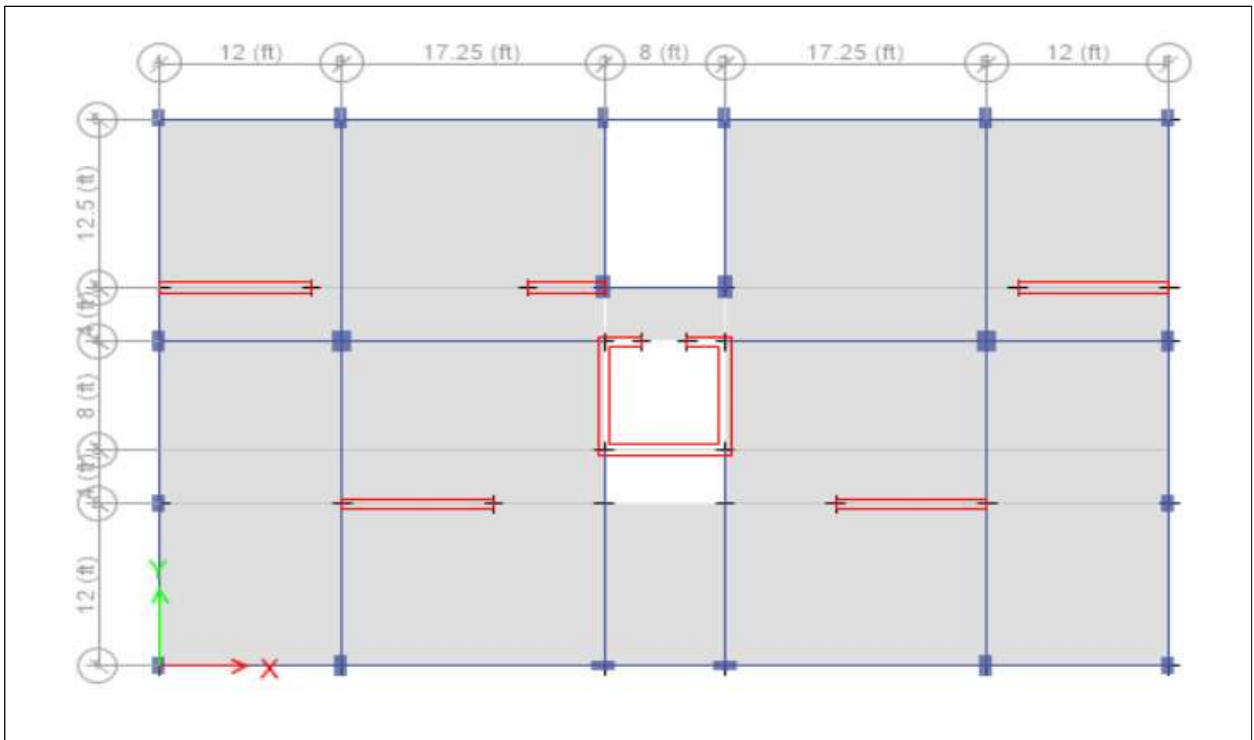


Figure: 3.16 proposed Grid Data of the model for Both Structure



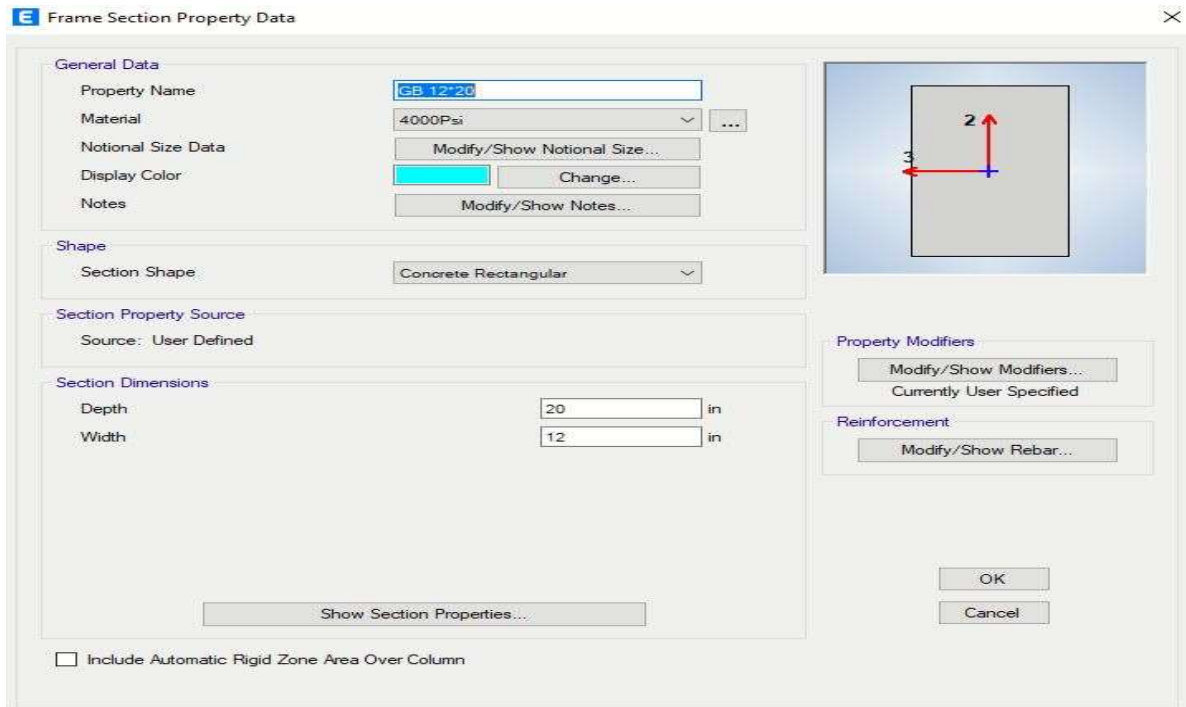


Fig: 3.17 Define Beam property

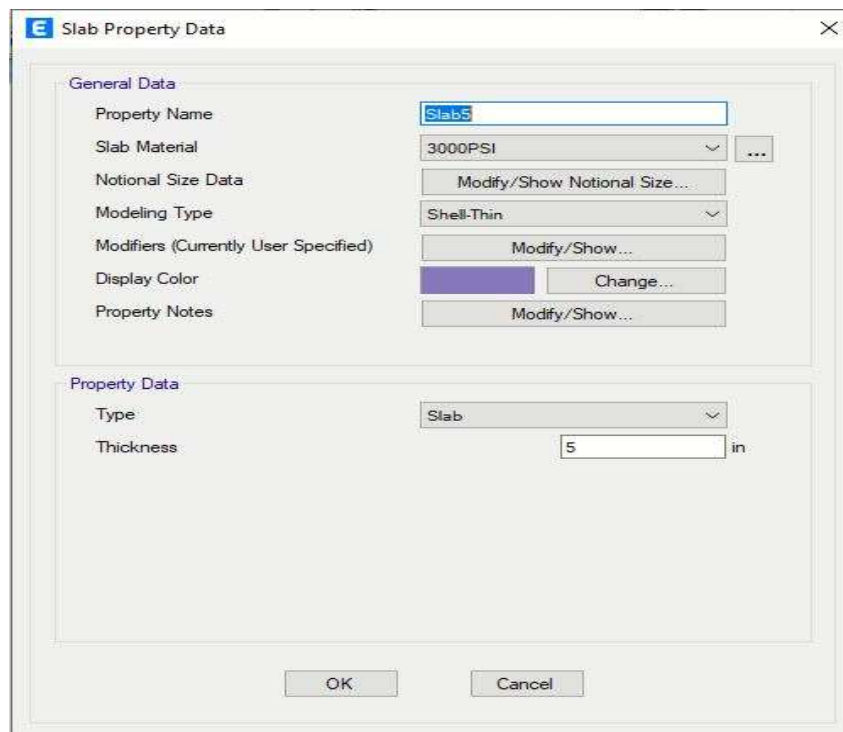


Fig: 3.18 Slab property

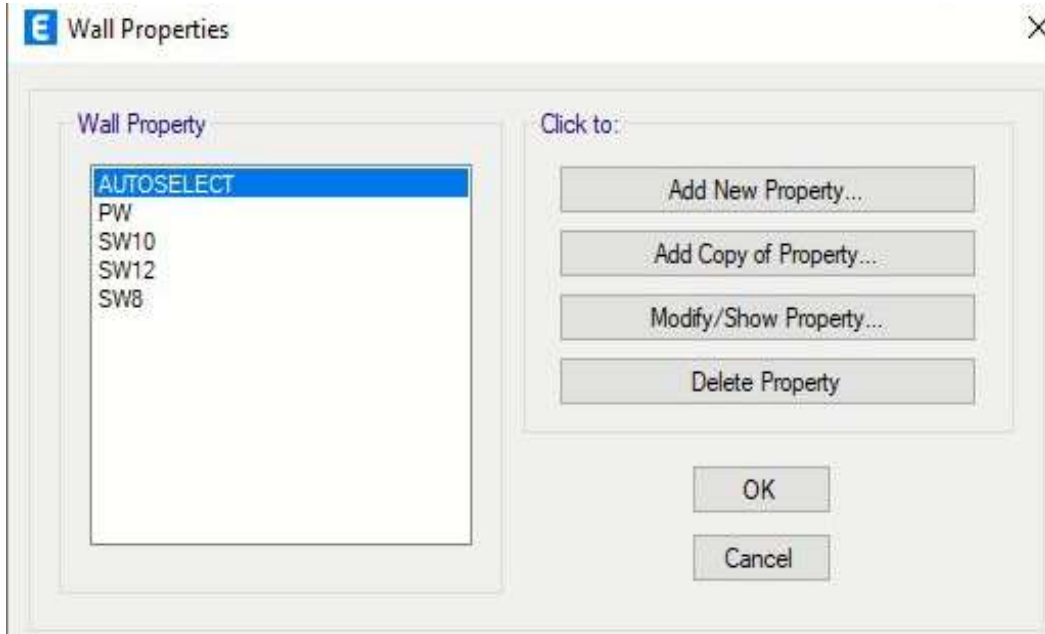


Fig: 3.19 Wall property

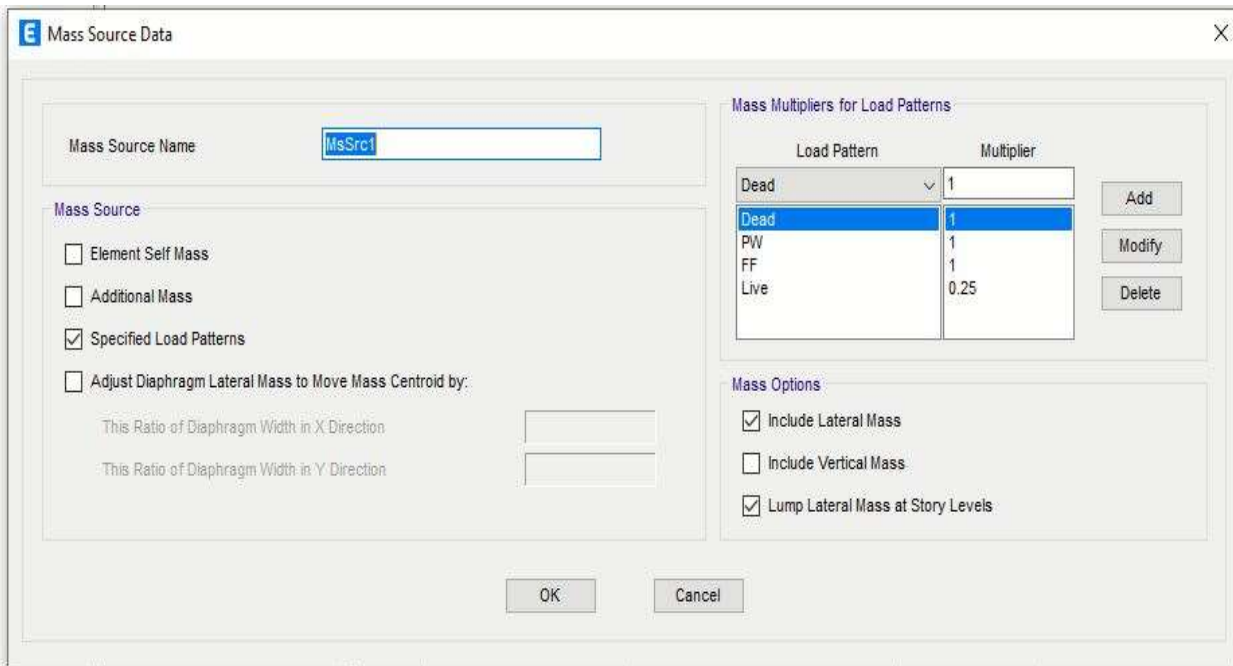


Fig: 3.20 Mass Source

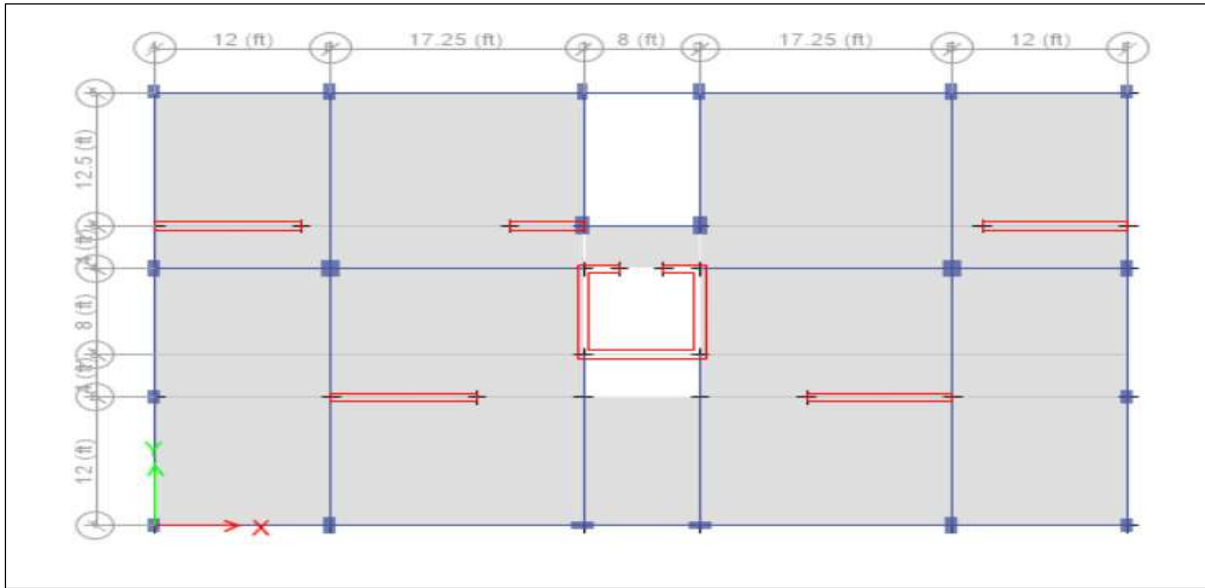


Fig: Grid Plan Display

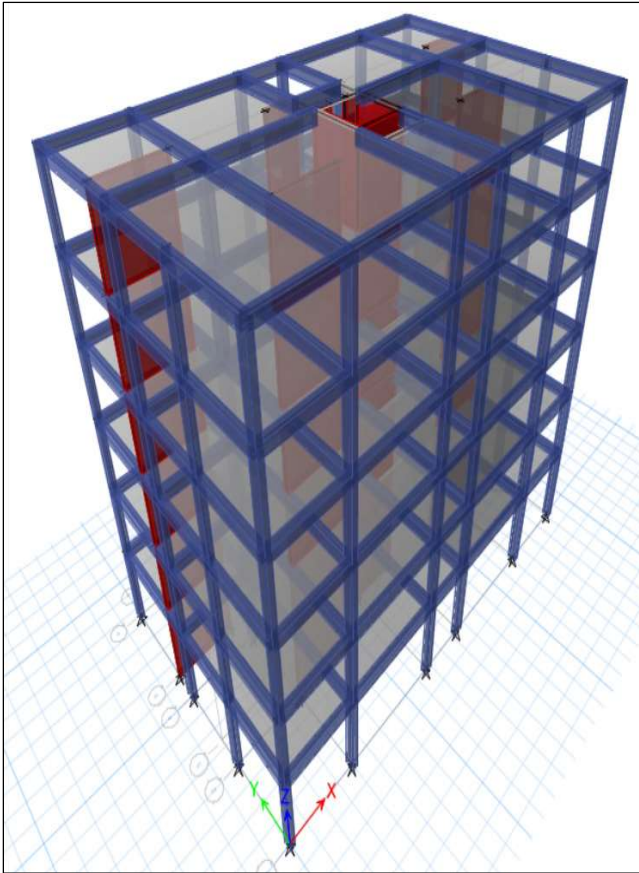


Fig: 3.21 3D Model (6 Story)

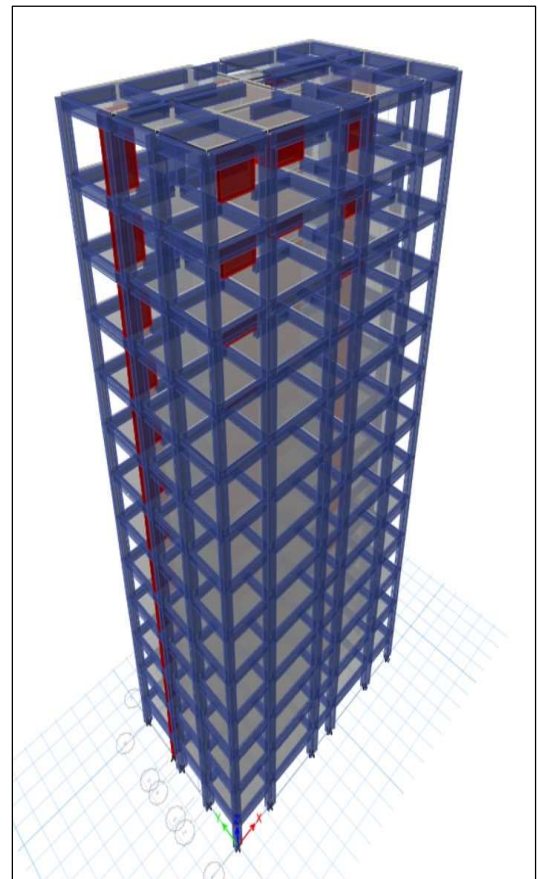


Fig: 3.22 3D Model (13 Story)

❖ **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 firm main toolbar and select plan view
6. Define load cases

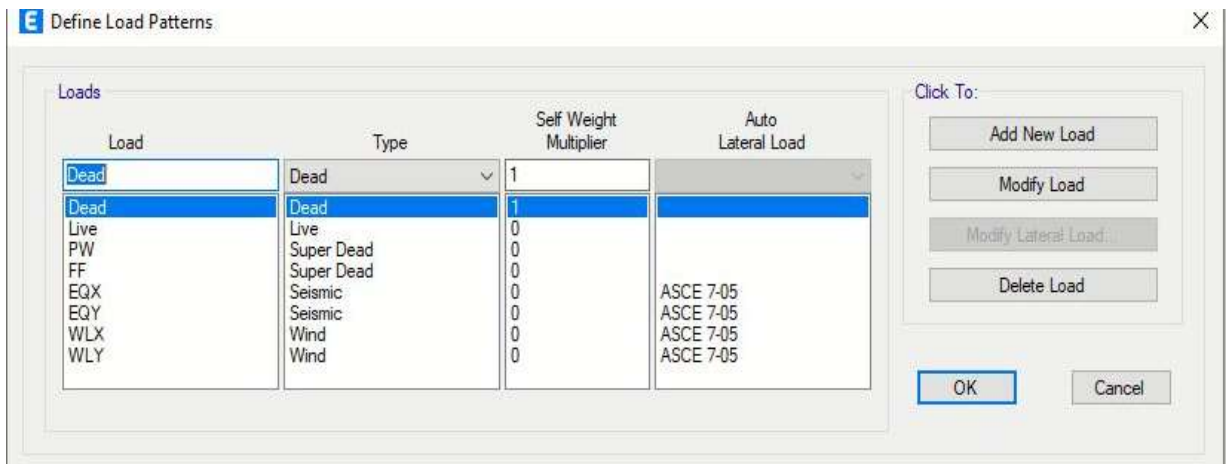


Fig: 3.23 Load pattern Assign for the model.

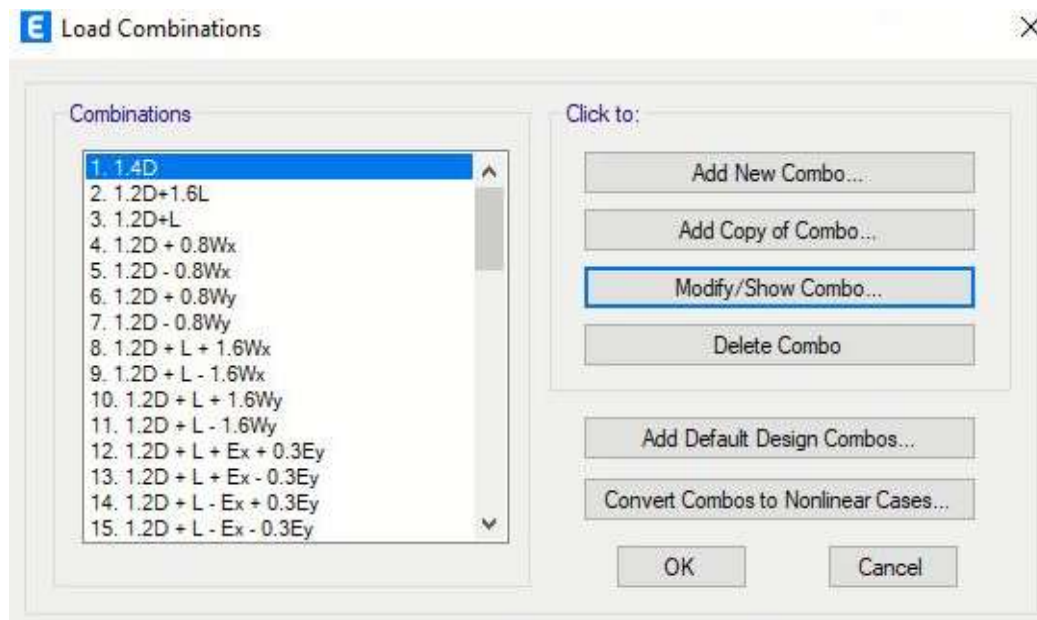


Fig: 3.24 Load Combination Assign for the model.

**ASCE 7-05 Seismic Loading**

**Direction and Eccentricity**

X Dir       Y Dir  
 X Dir + Eccentricity       Y Dir + Eccentricity  
 X Dir - Eccentricity       Y Dir - Eccentricity

Ecc. Ratio (All Diaph.)

Overwrite Eccentricities

**Time Period**

Approximate      Ct (R), X =   
 Program Calculated      Ct (R), X =   
 User Defined      T =  sec

**Story Range**

Top Story for Seismic Loads   
Bottom Story for Seismic Loads

**Factors**

Response Modification, R   
System Overstrength, Omega   
Deflection Amplification, Cd   
Occupancy Importance, I

**Seismic Coefficients**

Ss and S1 from USGS Database - by Latitude/Longitude  
 Ss and S1 from USGS Database - by Zip Code  
 Ss and S1 - User Defined

Site Latitude (degrees)  ?  
Site Longitude (degrees)  ?  
Site Zip Code (5-Digits)  ?  
0.2 Sec Spectral Accel, Ss   
1 Sec Spectral Accel, S1   
Long-Period Transition Period  sec

Site Class   
Site Coefficient, Fa   
Site Coefficient, Fv

**Calculated Coefficients**

SDS = (2/3) \* Fa \* Ss   
SD1 = (2/3) \* Fv \* S1

Fig: 3.25 Define seismic load pattern –ASCE7-05

**Wind Load Pattern - ASCE 7-05**

**Exposure and Pressure Coefficients**

Exposure from Extents of Diaphragms  
 Exposure from Frame and Shell Objects  
 Include Shell Objects  
 Include Frame Objects (Open Structure)

**Wind Pressure Coefficients**

User Specified       Program Determined

Windward Coefficient, Cpw   
Leeward Coefficient, Cpl

**Wind Exposure Parameters**

Wind Direction and Exposure Width   
Case (ASCE 7-05 Fig. 6-9)    
e1 Ratio (ASCE 7-05 Fig. 6-9)   
e2 Ratio (ASCE 7-05 Fig. 6-9)

**Wind Coefficients**

Wind Speed (mph)   
Exposure Type   
Importance Factor   
Topographical Factor, Kzt   
Gust Factor   
Directionality Factor, Kd   
Solid / Gross Area Ratio

**Exposure Height**

Top Story   
Bottom Story   
 Include Parapet  
Parapet Height  ft

Fig: 3.26 Define Wind load pattern –ASCE7-05



**ETABS 3D MODEL:**

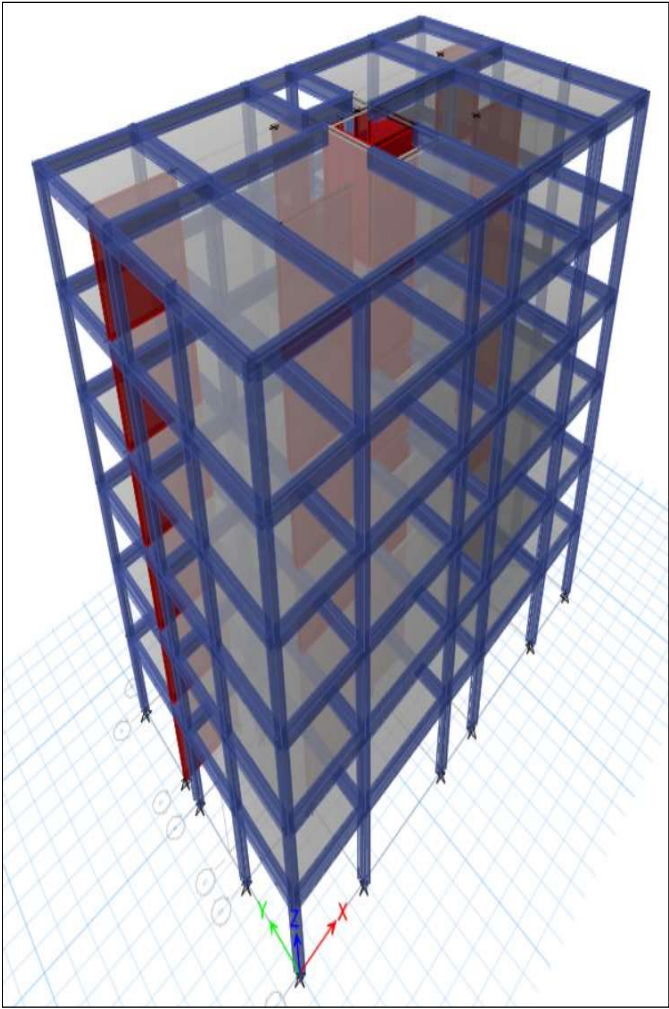


Fig: 3.27 Final 3D model of low rise

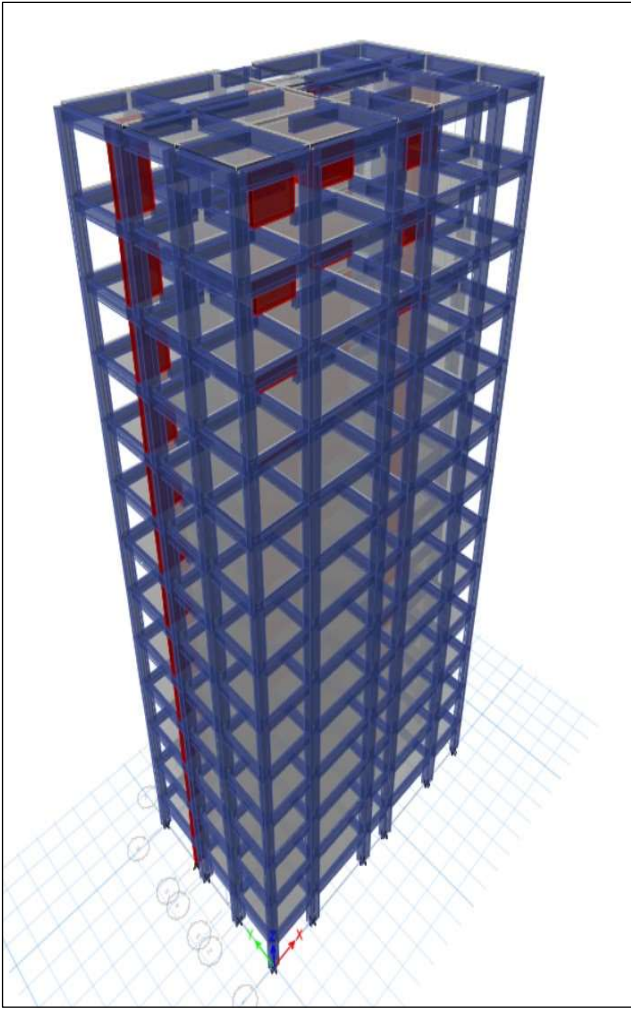


Fig: 3.28 Final 3D model of high rise

❖ **DEFLECT SHAPE OF THE MODEL:**

To check error in data input for lateral load click Display – show table and select the item and check 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.

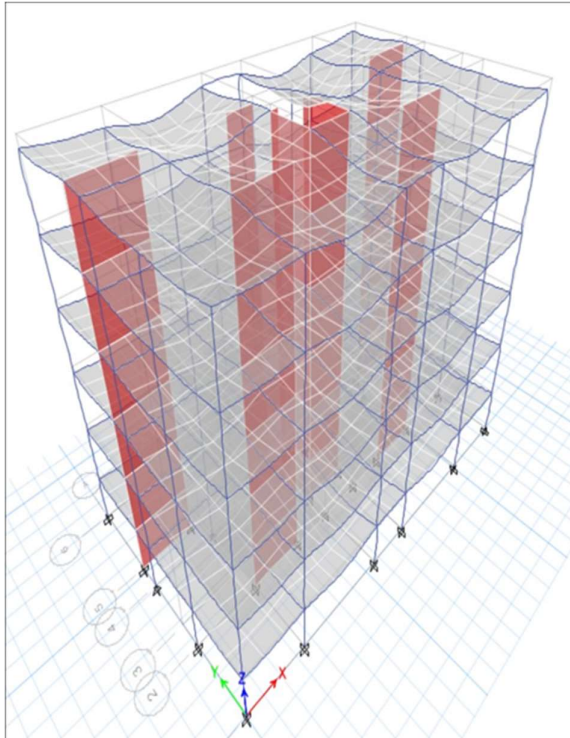


Figure 2.29: Deflected Shape of the model low Rise

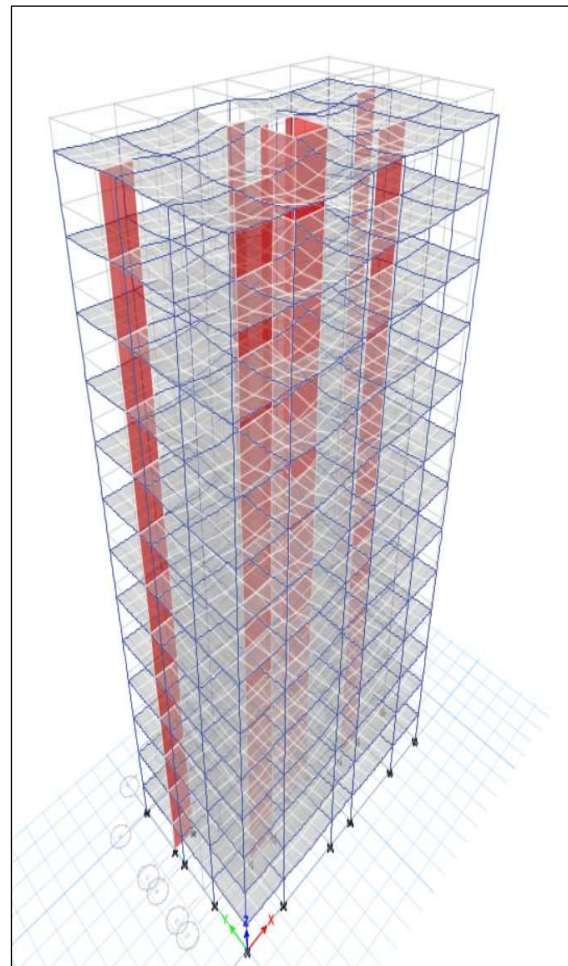


Figure 2.30: Deflected Shape of the model low Rise

## CHAPTER 04

### RESULT AND DISCUSSION

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#### 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:

$$\Delta \leq 0.005h \quad \text{for } T < 0.7 \text{ sec}$$

$$\Delta \leq 0.004h \quad \text{for } T > 0.7 \text{ sec}$$

$$\Delta \leq 0.0025h \text{ for unreinforced masonry structures}$$

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

**Table 4.1: Maximum Story Displacement**

Load Type	Low Rise (in)	High Rise (in)
EQX	2.218	4.921
EQY	0.981	3.799
WX	0.764	2.441
WY	0.511	2.815

**Table 4.2: Increase of Displacement Due to BNBC 2020**

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



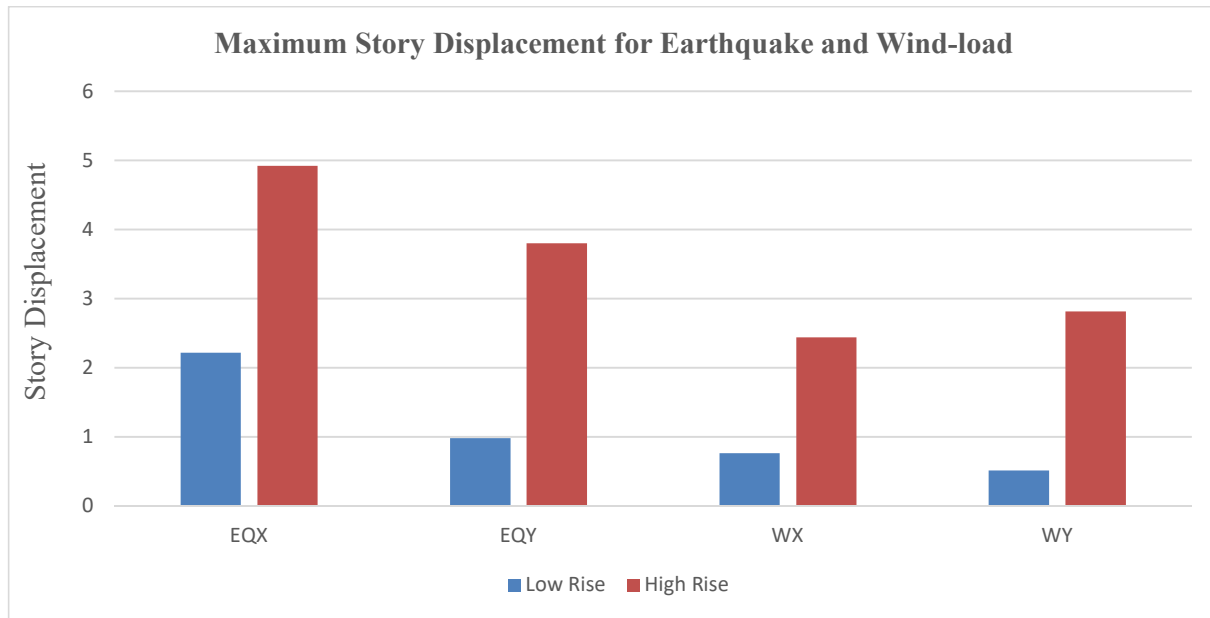


Figure 4.1: Maximum Story Displacement for Earthquake and Wind-load (Dhaka)

#### 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:

$$\Delta \leq 0.005h \quad \text{for } T < 0.7 \text{ sec}$$

$$\Delta \leq 0.004h \quad \text{for } T > 0.7 \text{ sec}$$

$$\Delta \leq 0.0025h \text{ for unreinforced masonry structures}$$

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

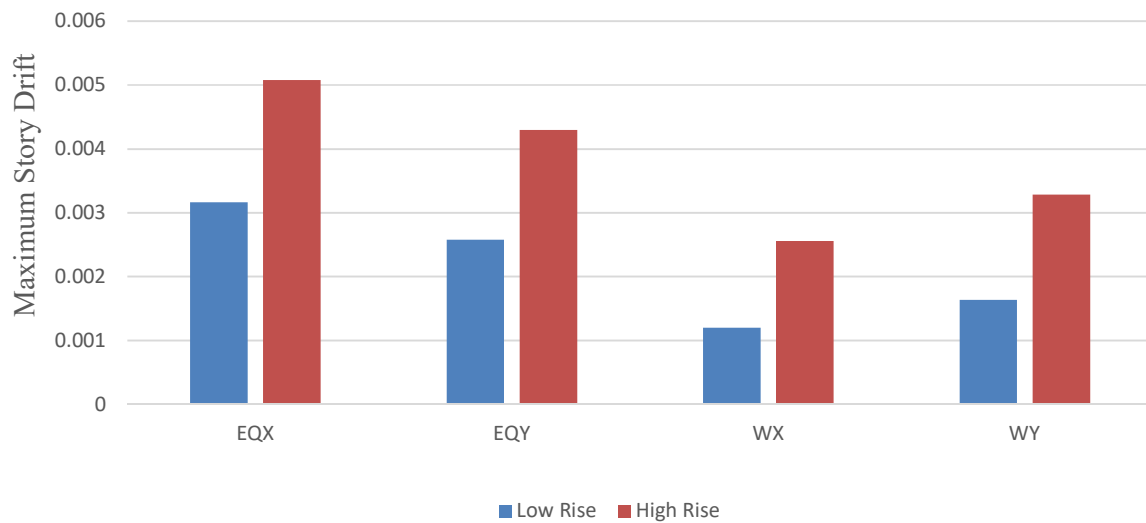
**Table 4.3: Maximum Story Drift**

Load Type	Low Rise (in)	High Rise (in)
EQX	0.037	0.060
EQY	0.030	0.051
WX	0.014	0.030
WY	0.014	0.039

**Table 4.4: Increase of Drift Due to BNBC 2020**

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

**Maximum Story Drift for Earthquake and Wind-load**



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

#### 4.4 Result Comparison and Discussion

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 2.218, 0.981, 0.764, 0.511 into high rise multistory structure is 4.921, 3.799, 2.441, 2.815 for load EQX, EQY, WX and WY respectively.

The maximum story **drift** of low rise 0.037, 0.030, 0.014, 0.014 in to high rise multistory structure is 0.060, 0.051, 0.030, 0.039 in for load EQX, EQY, WX and WY respectively.

The Comparison Show that high rise value double than low rise value. 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 RECOMMENDATION

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#### 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. Earthquake effect on X-direction of High-Rise Building is greater than Low rise Building.  
Earthquake effect on Y-direction of High-Rise Building is greater than Low rise Building
5. Wind effect on X-direction High Rise Building is greater than Low rise Building.  
Wind effect on X-direction High Rise Building is greater than Low rise Building

#### 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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Tarek A.Awida (et.al.,) [5] The paper presented a study on the extensive study for the structural behavior of low / medium / high rise office buildings.

Three-dimensional finite element techniques through ETABS software are used in conducting analysis for structures considering the plan building with different heights ranging from five to fifty typical office stories are investigated in this study. Building slenderness ratios (H/B) of 1.27, 2.04

Ashik S. Parasiya (et.al.,) [8] The paper presents a comparative analysis of Brace framed with conventional lateral load resisting frame in reinforced concrete structure.