SEISMIC PERFORMANCE ASSESSMENT OF MOMENT-RESISTING HIGH-RISE STRUCTURES UNDER BNBC 2020 PROVISIONS.

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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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147/1, Green Road, Dhaka-1215, Bangladesh

Section: 25A

Fall-2025

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DECLARATION

It is stated that the thesis work on "Seismic Performance Assessment of Moment-Resisting High-Rise Structures under BNBC 2020 Provisions" has been performed under the supervision of Hemlita Mondal (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"

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ABSTRACT

The Bangladesh National Building Code (BNBC) specifies and regulates the general specifications for structure, architecture and design parameters in Bangladesh. In the last three decades, Civil Engineering techniques, knowledge, and materials as well as design parameters have been modified as per requirement. Therefore, BNBC 2020 was written to reflect the transition. In this study, a systematic and parametric structural analysis of a Nine-storied (High rise) residential building was analyzed (ETABS 21.0.0 software) by using BNBC 2020. In this project lateral load (Earthquake) affects structural analysis of high-rise infrastructure for Zone (II). The decision-making parameters for structural analysis of seismic shear and base shear for seismic forces according to BNBC 2020. In this study, the maximum base shear is 0.20 for Zone (II). The comparison of the aforesaid analysis parameters is depicted graphically, and relevant tables are presented in this research article. In comparison of seismic effect on Different zone high rise structures, the requirements of BNBC 2020 usually result in a higher safety and less cost-effective design margin.

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CHAPTER 1
INTRODUCTION

1.1 Background and Motivations

Building is the key to social progress of the country. Without construction of building, one nation can't progress. For example, to make digital nation we need computer but to place this computer we need buildings. Many things which are related to development of buildings. Every human has desire to own comfortable homes. 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 at most effort and spend hard earned saving in owning houses. To archive safety for human live, every engineering portable meets the current seismic requirement during design and construction. In Bangladesh there are many buildings which do not meet the current seismic load requirement and suffer extensive damage during the earthquake in Bangladesh during design and construction phases.

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

In Bangladesh and other underdeveloped nations, the approach of earthquakes analysis is used in a static analysis because of the lack of modern modeling and computing installations. With the increase in the number of high-rise structures, the code for design, detailing, and construction is increasingly significant. Significant improvements were made in BNBC 2020 to incorporate knowledge and advances in structural engineering during the last two decades. BNBC 1993 has been modified and published as BNBC 2020 considering the guidelines of other international building standards. Generally various types of building structure build in our country. The purpose of the study is to designs & analysis of nine-storied reinforced concrete residential building for earthquake and wind performance which is situated in Dhaka value of high-rise building. At First preliminary planning is done using RAJUK standard rule and regulation of building construction and then detailed evaluation is carried out to design the components under concern code which is Bangladesh National Building Code (BNBC). For applying earthquake loads and wind load, equivalent static lateral force method is used according to BNBC 2020.The reinforcement details of the building were not available as it is not designed. Design is prepared applying Dead, Live, Seismic and Wind loads in both span of the structure. This helps in estimating the reinforcement of each component of the building i.e. Slab, Column, Beam, Footing using hand calculation procedure later from governing moments, axial and shear effects. ETABS 21.0.0 (Extended 3D Analysis of Building Structure) is used for analyzing and designing the building. This study tries to compare different seismic performance assessment of moment-resisting high-rise structure under BNBC 2020.

1.2 Major earthquakes affect in Bangladesh

Table 1-1: Earthquakes affect

Date	Time (Dhaka)	Magnitude	Location
Jan 4, 2016	05:05 am	6.7	180 km East from Sylhet
Nov 26, 2021	05:45 am	6.2	180 km ENE from Chattogram
April 28, 2021	08:20 am	6.0	217 km NNE from Sylhet
April 16, 2020	05:45 pm	5.9	231 km ENE from Chattogram
Jan 3, 2017	03:09 pm	5.7	167 km ENE from Dhaka
June 22, 2020	04:40 am	5.6	174 km ENE from Chattogram
Oct 10, 2020	11:38 pm	5.5	166 km E from Sylhet
Nov 21, 2025	10:15 am	5.7	27 Km NE From Dhaka

1.3 Research objectives of the study

- **Seismic Modeling and Analysis:** To model a high-rise moment-resisting frame structure using Finite Element software and analyze its behavior under the updated seismic zoning and soil classification parameters specified in **BNBC 2020**.

- **Response Evaluation:** To evaluate critical seismic response parameters—including base shear, story displacement, overturning moments, and inter-story drift—using both **Equivalent Static Force** and **Response Spectrum Analysis** methods.

- **Performance Verification:** To assess the structural adequacy and safety of the building by comparing the analysis results against the allowable serviceability and ultimate limit state requirements mandated by the **BNBC 2020** provisions.

1.4 Statement of project Salient features

Project information given below

Table 1-2: Statement of project Salient features

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

Table 1-3: Geometric Details

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

The following table lists zone coefficients for some important towns of Bangladesh. The most severe earthquake prone zone, Zone 4 is in the northeast which includes Sylhet and has a maximum PGA value of 0.36g. According to this to-be-published code, Dhaka district falls in the seismic intensity zone with Z=0.20.

Table 1-4: Seismic Zone Coefficient Z for Some Important Towns of Bangladesh

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

Table 1-5: Summary of Borehole Information

Area	Borehole* Designation	Approximate R.L. (Reduced Level) of EGL** (ft)	Borehole Termination Depth Below EGL** (ft)
Project Site*	BH-01*	0.0	120
	BH-02*	-10.3	100
	BH-03*	-10.3	120
	BH-04*	-9.3	100
	BH-05*	-9.3	100
	BH-06*	-9.3	100
	BH-07*	-9.3	100
	BH-08*	-1.3	120

1.5 Conclusion, discussion & recommendation

Following conclusion, discussion and recommendation may be drawn regarding subsoil formation (as obtained from *limited number of boreholes, eight,* for this project) of the project area.

a. Encountered sub-surface deposits at this site are shown, in detail, in the *eight* borehole logs, BH-01 through BH-08, (please see "Borehole Logs", in Appendix-A3 of this report) as drilled at this project site (please see "Borehole Location Plan", in Appendix-A2, of this report for location of boreholes).

b. The site topography has significant elevation difference generally varying from about *zero to ten feet* down from existing site adjacent road level (existing site adjacent road level is used as the Assumed Vertical Datum, AVD, for this project. Please see appendix A1 (A1a: Site Vicinity Map) and A2 (Borehole Plan: Location & Depth), presented in this report, for further details.

c. From the observations, identifications and measurements of the significant level differences of the site and ERA personnel's knowledge/experience regarding local geology, it becomes apparent that the location of the building premises is generally situated at "TEK-BIDE" formation; a "TEK" or "CHALA" or "KANDI", is a local term used to define upper hillock-type land formation and "BIDE" is also a local term used to define lower valley/depression-type formation typically common within various locations of Modhupur Tract geological formation.

d. From a cursory site vicinity geological study, we understand that, in a broader sense, the site lies within a geologically distinct area located around the southern fringe of the Madhupur Tract (a Pleistocene terrace land comprised of northern Madhupur Garh and southern Bhawal Garh), a large uplifted area in the central part of Bangladesh (Geological Map of Bangladesh, 2001). According to the surface geological features of this publication, surficial geology of this area may fall into rm (Residual deposit of Madhupur clay residuum) Unit or ase (Alluvial deposit of Alluvial silt and clay) Unit. ase (Alluvial deposits of silt and clay) Unit or rm (Residual deposits of Madhupur clay residuum) Unit.

From our geotechnical investigation conducted it **became evident** that the general surface geological feature of the project site matches with the anticipated one, except near surface anthropogenic filling soil and generally falls into the category of **rm (Residual deposits of Madhupur clay residuum)** Unit.

e. Investigated site falls in the district of Dhaka (Please refer to Appendix-A1c: Seismic Zoning Map of Bangladesh) which again falls into the seismic intensity zone with **Z = 0.20 (Zone 2)** and has a maximum **PGA value of 0.15g.**

f. As per provided project information, we understand that a **6-Storied Building** is planned to be constructed at the project site.

g. From prevailing sub-surface stratigraphic conditions, especially from highly erratic topography and subsurface stratigraphy and field SPT N-values (in conjunction with laboratory test data) as obtained within the relatively shallow depths of most of the borehole locations (except only at the location of boreholes BH-01 and BH-08) and the knowledge of extent of conventionally (in general) estimated induced column loading for a **6-Storied Building**, it becomes evident that shallow footings to be founded at variable near-surface-depths below EGL would not be a feasible option. Near surface deposits are generally consisted of cohesive deposits overlying cohesionless deposits (primarily within the shallow footing-base shear-failure-zone). These encountered cohesive deposits at the top exhibit **very soft to soft to medium stiff** consistencies. Punching shear failure would most likely be the governing shear failure criterion in this case. Moreover, below-shallow-foundation bearing significant bearing stress influence zone are likely to exhibit enormous compressibility due to the presence of predominant deposits of **COHESIVE SOIL** having very soft to soft consistencies.

h. Therefore, bearing capacities are not evaluated for shallow foundation system for this particular project at these particular site.

i. For these prevailing sub-surface stratigraphic conditions as mentioned in the subsection (g) above, **footing system would not be a suitable foundation option** for this particular proposed development without any ground improvement.

j. Thereby, **deep foundation system consisting of bored or driven piles may become a feasible option** for the proposed development at this site.

k. If considerations regarding shallow spread/continuous foundation system as have been described in the above sub-sections do not become feasible due to constructability, stability of adjacent existing foundation system, economy or any other reason (may also become deemed necessary if initial/preliminary planning is revised and much higher column loads are estimated), pile foundation system may have to be incorporated in that case.

l. Allowable unit skin friction and end bearing capacities for axial compression for bored and driven piles are evaluated from EGL according to the classical equations and are provided in Appendices A5 and A7, respectively.

m. Pile design charts (PDC) are developed for soil conditions as obtained at different borehole locations of this project. Allowable axial compression loads for single piles with respect to depths are depicted for different pile dimensions as are conventionally used for bored and driven piles. These charts are provided in Appendices A6 and A8 for bored and driven piles, respectively. These values can be rationally utilized for design purposes.

n. *It should be noted* that these pile capacities are estimated in consideration to factor of safety **2.5** for both skin frictional and end bearing resistance.

o. The following tabulated summarized pile capacities can be utilized in designing **Bored ACIP (Auger-Cast-In-Situ) or Situ Pile** foundation system for the **Proposed 6-Storied Building.**

Table 1-6: Interpreted recommended Capacity for Bored Pile or ACIP (Auger-Cast-In-Situ) Pile

Pile Type	**Location**	**R.L. of Pile Tip (feet)**	**Length of Pile (feet)**	**Allowable Axial (Compression) Capacity of Single Pile (kips)**		
				18-inch Dia Pile	**20-inch Dia Pile**	**24-inch Dia Pile**
Bored Pile or ACIP (Auger-Cast-In-Situ) Pile or Situ Pile	Entire Site (Consisting of boreholes BH-01 through BH-08) R.L. of Anticipated Pile Cap Bottom = -12.0	-40.0	28.0	25	30	35
		-45.0	33.0	35	40	50
		-50.0	38.0	50	60	75
		-55.0	43.0	70	80	105
		-60.0	48.0	80	90	115
		-65.0	53.0	90	105	135
		-70.0	58.0	110	125	165
		-75.0	63.0	125	150	190
		-80.0	68.0	140	160	205
		-85.0	73.0	165	190	240
		-90.0	78.0	195	220	270

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CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

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

2.2 Methods for seismic performance assessment

a) Prescribed Analysis Method
b) Key Assessment Parameters
c) Software & Tool

(a) Prescribed Analysis Method

The BNBC 2020 requires dynamic analysis for high-rise structure in most cases the primary methods are **Equivalent static force procedure (ESFP)** this is a simplified linear static method that is generally suitable for low to medium-rise building with regular configuration. For high-rise building especially those with irregularities, this method has limitations and dynamic analysis is preferred or required. **Response spectrum Analysis (RSA)** this is a linear dynamic analysis method widely used for multi-story buildings. It uses a design response spectrum based on the seismic zone site class and importance factor of the structure to determine the maximum seismic response. This method is often considered sufficient for a wide range of high-rise structure. **Time History Analysis (THA)** this is a more advanced and detailed nonlinear dynamic analysis method. It involves subjecting a structural model to ground motion records that are representative of the sites seismic hazard. This method provides more comprehensive insights onto the dynamic behavior and is particularly useful for very tall or complex structures where non linear behavior is expected.

(b) Key Assessment Parameter

Regardless of the analysis method used, the performance assessment involves evaluating specific structure parameters against the limits specified in the BNBC 2020. **Maximum Story Displacement** The total lateral movement of each floor level. **Maximum Story Drift** The relative displacement between adjacent floors, which is a critical parameter for controlling structural and non-structural damage. The code specifies permissible limits for story drift. **Base shear** The total calculated lateral force at the base of the structure. **Overturning Moment** The Moment generated at the base due to lateral forces.

Torsional Effects Irregular buildings are more prone to torsional effects, which must be specifically addressed in the analysis. **Member Force and Reinforcement** the analysis result are used to determine axial force, share force, and bending moments in beams and columns to ensure adequate reinforcement is provided according to the codes detailing requirements for moment resisting frame.

(c) Software's

We use here Etabs and Auto CAD software for Design.

ETABS 2022 version 22.0.0 Auto CAD 2022

ETABS 22.0.0

ETABS is powerful design software licensed by CSI. ETABS stands for Extended Three-Dimensional Analyses of Building Systems. Any object which is stable under a given loading can be considered as structure. The innovative and revolutionary new ETABS is the ultimate integrated software package for the structural analysis and design of buildings. Incorporating 45 years of continuous research and development, this latest ETABS offers unmatched 3D object-based modeling and visualization tools, blazingly fast linear and nonlinear analytical power, sophisticated and comprehensive design capabilities for a wide range of materials, and insightful graphic displays, reports, and schematic drawings that allow users to quickly and easily decipher and understand analysis and design results.

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

CHAPTER 3
METHODOLOGY

3.1 Introduction

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

a) ETABS (22.0.0)
b) Auto CAD 2022

Required data for analysis and model built-up with ETABS (22.0.0) are discussed details here. Analysis has been done for Zone- II (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 spas floor finish and 30psf as Random wall in addition to self-weight of slab.

3.2.2 Live Load

Live loads are produced by the use and occupancy of a building. Loads include those from human occupants, furnishings, no fixed equipment, storage, and construction and maintenance activities. As required to adequately define the loading condition, loads are presented in terms of uniform area loads, concentrated loads, and uniform line loads. In ETABS we assign live load in terms of U.D.L. we has to create a load case for live load and select all the slabs to carry such load. Since the structures of the present study are intended for residential use, the live load considered in the building is 45 psf floor & roof top and staircase 100 psf.

3.2.3 Wind Load (Institute, 2020)

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

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

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

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

Method 3: Wind tunnel procedure.

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

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.

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 -05 with seismic design parameters as given in Appendix C. However, the minimum value of Sa should not be less than 0.044 SDSI. The values of SDS are provided in Appendix C

Structure Period

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

Method A:

For all buildings the value of T may be approximated by the following formula: C=Ct(hn)m

Where,

Ct=0.0724 for steel moment resisting frames

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

=0.0466 for reinforced concrete moment

=0.0488 for all other structural systems

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

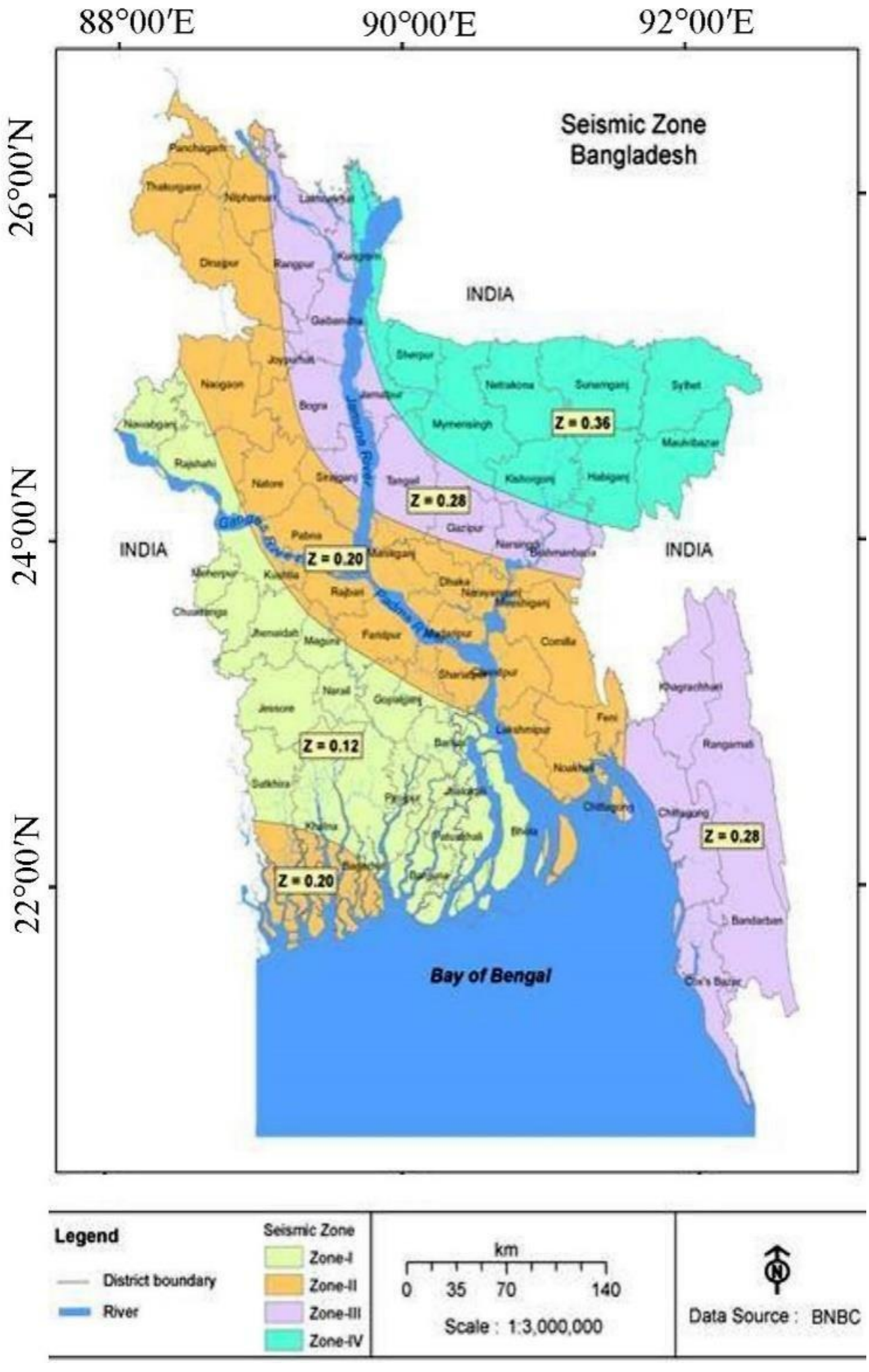
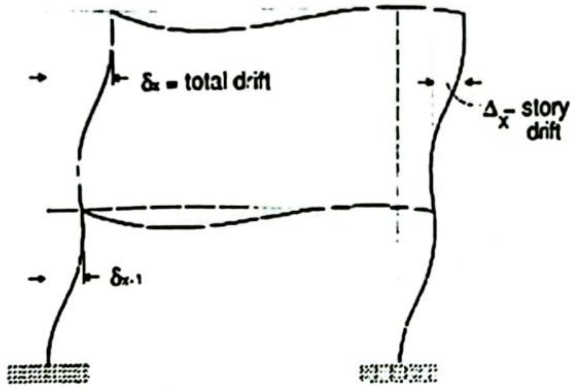


Figure 3-1: Bangladesh Seismic Zone

ASCE 7-05 12.8.6, 2.5.7.7

Story Drift Determination (Δ)

Lateral displacement of one level relative to the next level above or below



Analysis of Structures under Code Prescribed Seismic Forces

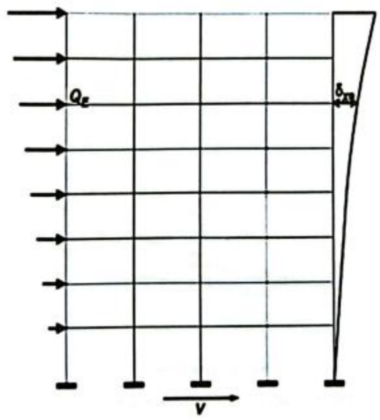


Figure 3-2: Story Drift Determination

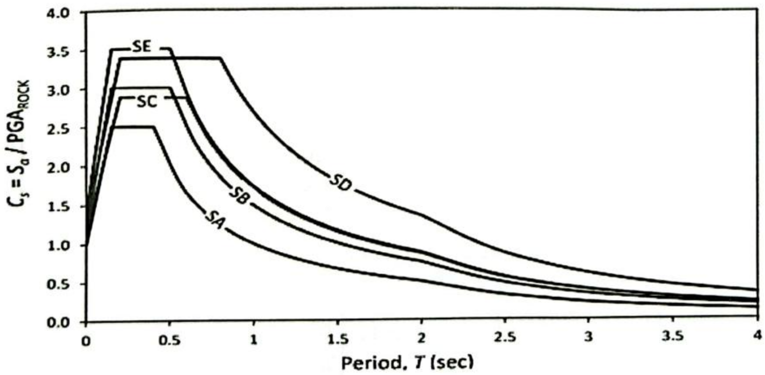


Figure 3-3: Normalized design acceleration response spectrum for different site classes. Building Categories, it is a Residential high-rise building.

Table 3-1: Importance Factors for Buildings and Structures for Earthquake design

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

3.2.5 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 education factors assembly occupancies or arras with Uniformly distributed live load of 5.0 kN/m, machinery and equipment for which specific live load allowances have been made, Special roof live load and printing plants, vaults, strong room and armories, shall be classified under

Load Group 1. Reduction of live load shall not be allowed for members or portions thereof under this load group and a reduction factor, R-1.0 shall be applied for 2.

Load Group 2: Uniformity distributed live loads resulting from Occupancies or 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. 2. Load Group 3: Uniformly distributed live loads arising due to all other occupancies and uses except those of Load Group I and Load Group 2, shall be grouped into

Load Group 3. Live load reduction factor, 1.0 <R<0.5 as specified, shall be applied to tributary areas under this load group. Tributary Area: The tributary area of a structural member supporting floors or roof shall be determined as follows: 1 Tributary Area for Wall, Column, Pier, Footing and the like: Tributary areas of these members shall consist of portions of the areas of all floors, roof or combination thereof that

Contribute live loads to the member concerned.

(a) Tributary Area for Beam, Girder, Flat plate and Flat slab: Tributary area for such a member shall consist of the portion of the roof or a floor at any single level that contributes loads to the member concerned.

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

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

Exposure B: Flat and unobstructed open terrain, coastal areas and riven ides faring larger besides of water, over 1.5 km or more in width.

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

Table 3-2: Seismic Design Category of Buildings

Site Class	**Occupancy Category I, II, 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 3-3: Response Reduction Factor, Deflection Amplification Factor and Height Limitations for Different Structural Systems

Seismic Force-Resisting System	Response Reduction Factor, R	System Overstrength Factor, Ω_0	Deflection Amplification Factor, Cd	Seismic Design B (Height limit, m)	Seismic Design C (Height limit, m)	Seismic Design D (Height limit, m)
1. Special steel concentrically braced frames	6.0	2.5	5.0	NL	NL	11
2. Special reinforced concrete shear walls	6.5	2.5	5.0	NL	NL	50
3. Ordinary reinforced masonry shear walls	3.0	3.0	3.0	NL	50	NP
4. Ordinary reinforced concrete shear walls	5.5	2.5	4.5	NL	50	NP

Load Combinations: For Check

As per BNBC 2020

U=DL+ LL

U=DL+.25 LL

U= DL + 0.5LL

U=DL + .5LL+.7WX

U=DL + .5LL-.7WX

U=DL + .5LL+.7WY

U=DL + .5LL-.7WY

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

3.2.6 Design data

The Design data has given below

Table 3-4: Load Consideration (BNBC 2020 for Zone II)

Load Type	**Value**
Floor Finish (FF)	25 psf
Concrete Unit Weight	135 psf (3 ft)
Parapet Wall	450 lb/ft (9.5 ft)
Partition Wall (PW)	3.2 psf
Live Load	2 kN/m² or 41.76 psf
Floor	100 psf
Stair	100 psf
Roof Over	312 psf (5.5 ft)
Head Water Tank	—

Table 3-5: Given wind load analysis (Zone II – Dhaka)

Parameter	**Value**
Basic Wind Speed V	147 mph
Structural Important Coefficient	1.0
Expose Category	A
Gust Factor	0.85
Directionality Factor, Kd	0.85

3.2.7 Earthquake Category Base Shear (BNBC 2020)

Seismic Zone: Zone II

Seismic Parameters (Dhaka, Zone II, Site Class SD)

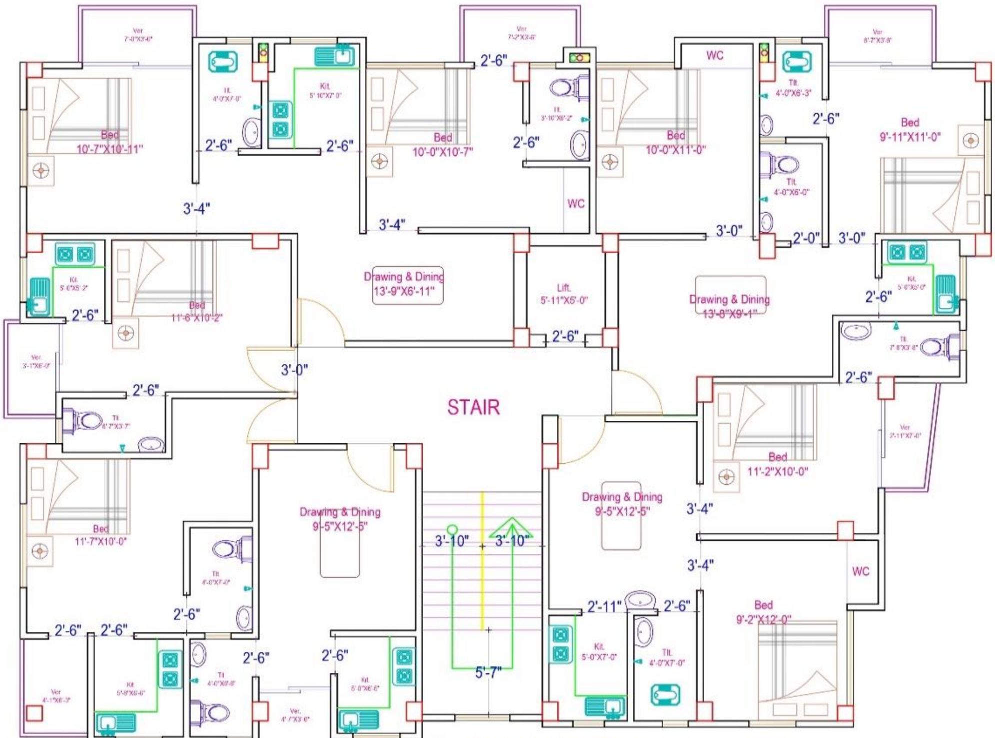
Table 3-6: Seismic Parameters (Dhaka, Zone II, Site Class SD)

Parameter	**Value**
Seismic Zone Factor (Z)	0.20
Response Modification Coefficient, R	6.5
Deflection Amplification, Cd	5
Structural Importance Factor (I)	1.0
Dependent Soil Factor	1.35
Time Period, T	0.60 sec
Lateral Seismic Force Coefficient, Sa	0.09
Normalized Acceleration Response Spectrum, Cs	3.375
Seismic Design Category	D
Location	Dhaka
Site Class (N value below 15)	SD

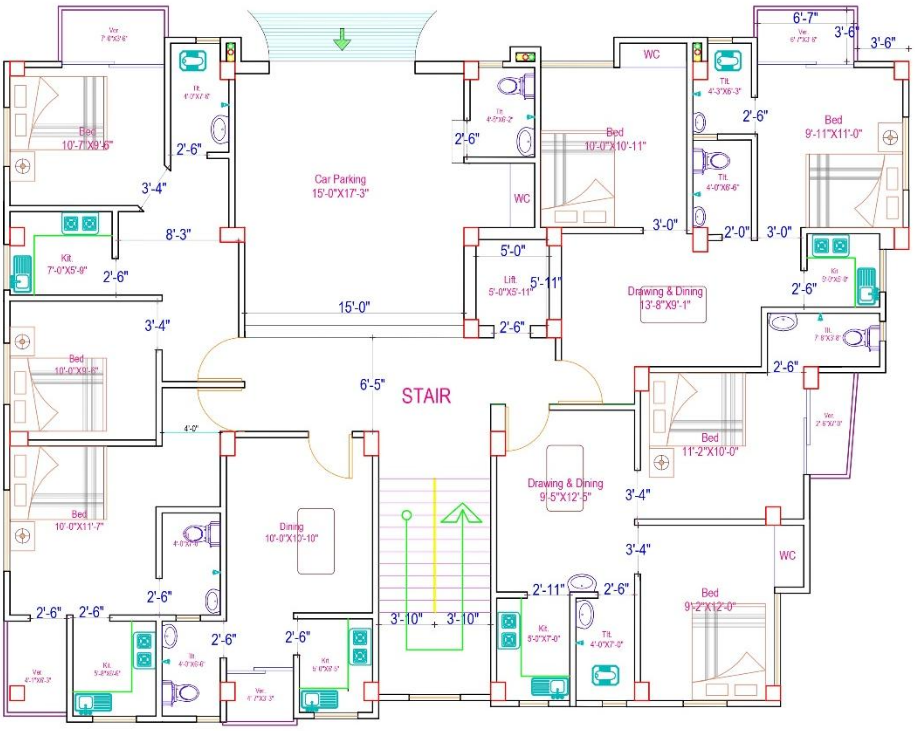
Material Properties

Table 3-7: Material Properties

Property	**Value**
Unit Weight of Concrete	135 lb/ft^3
For Slab (fc′)	3000 psi
For Beam (fc′)	3000 psi
For Column & Shear Wall (fc′)	3000 psi
Steel Yield Strength (fy)	60 ksi



Typical Floor Plan



G. Floor Plan

Figure 3-4: Auto CAD 2D model ground floor to 5th floor

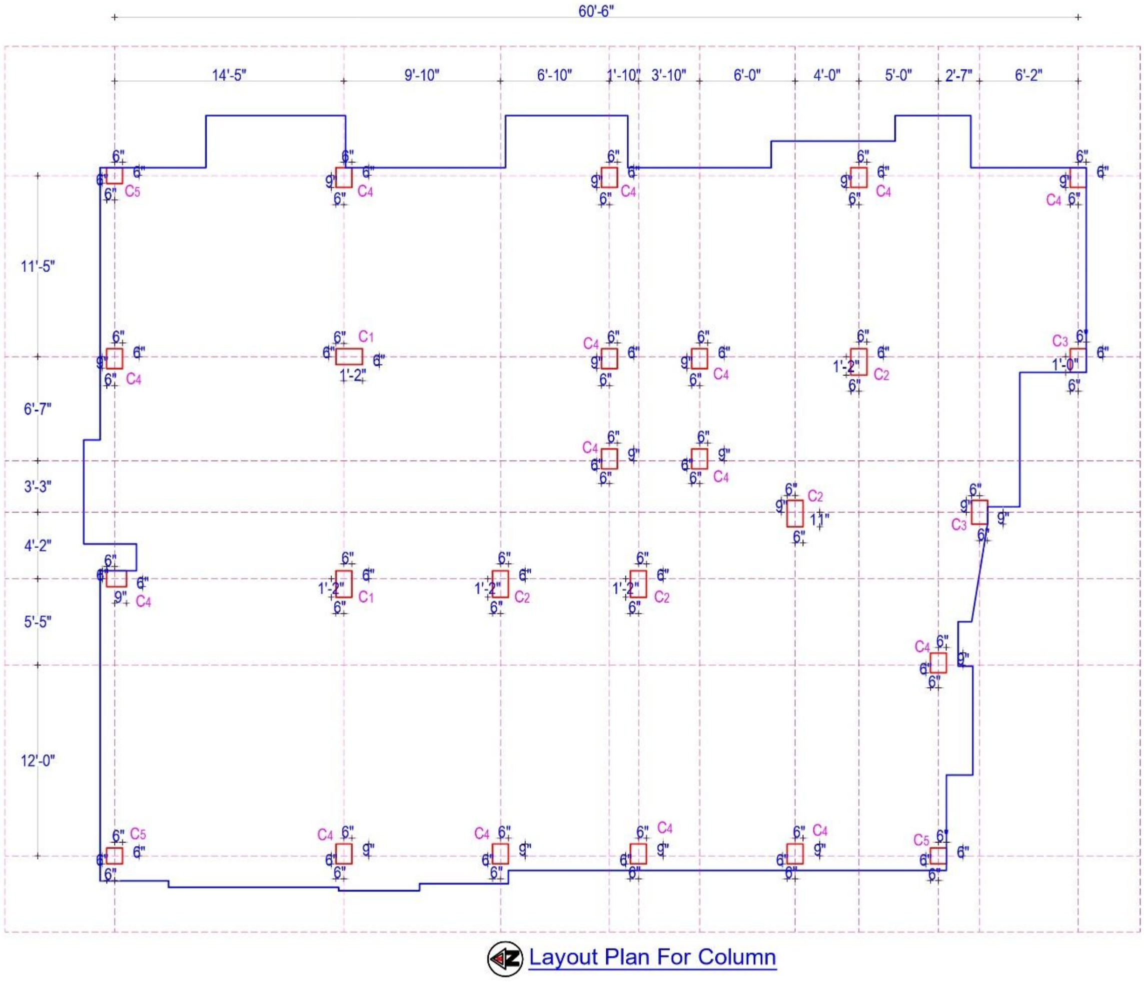


Figure 3-5: Auto Cad Column Layout

3.2.8 Auto CAD 2022: AutoCAD is a commercial software application for 2D and 3D computer-aided design (CAD) and drafting available since 1982 as a desktop application and since 2010 as a mobile web-and cloud based appmarketedasAutoCAD360. Developed and marketed by Autodesk, Inc., AutoCAD was first released in December 1982, running on microcomputers with internal graphics controllers. Prior to the instruction of AutoCAD, most commercial CAD programs ran on mainframe computers or minicomputers, with each CAD operator (user) working at a separate graphics terminal. AutoCAD is used across a wide range of industries, by architects, project managers, engineers, designers, and other professionals. We used AutoCAD for drawing the plan, elevation of the building. We also used AutoCAD to show the reinforcement details and design details of staircase, retaining Wall, beam, slab, water tank, foundation etc. AutoCAD is a very easy software to learn and much user friendly for anyone to handle and can be learn quickly. Learning of certain commands is required to draw in AutoCAD.

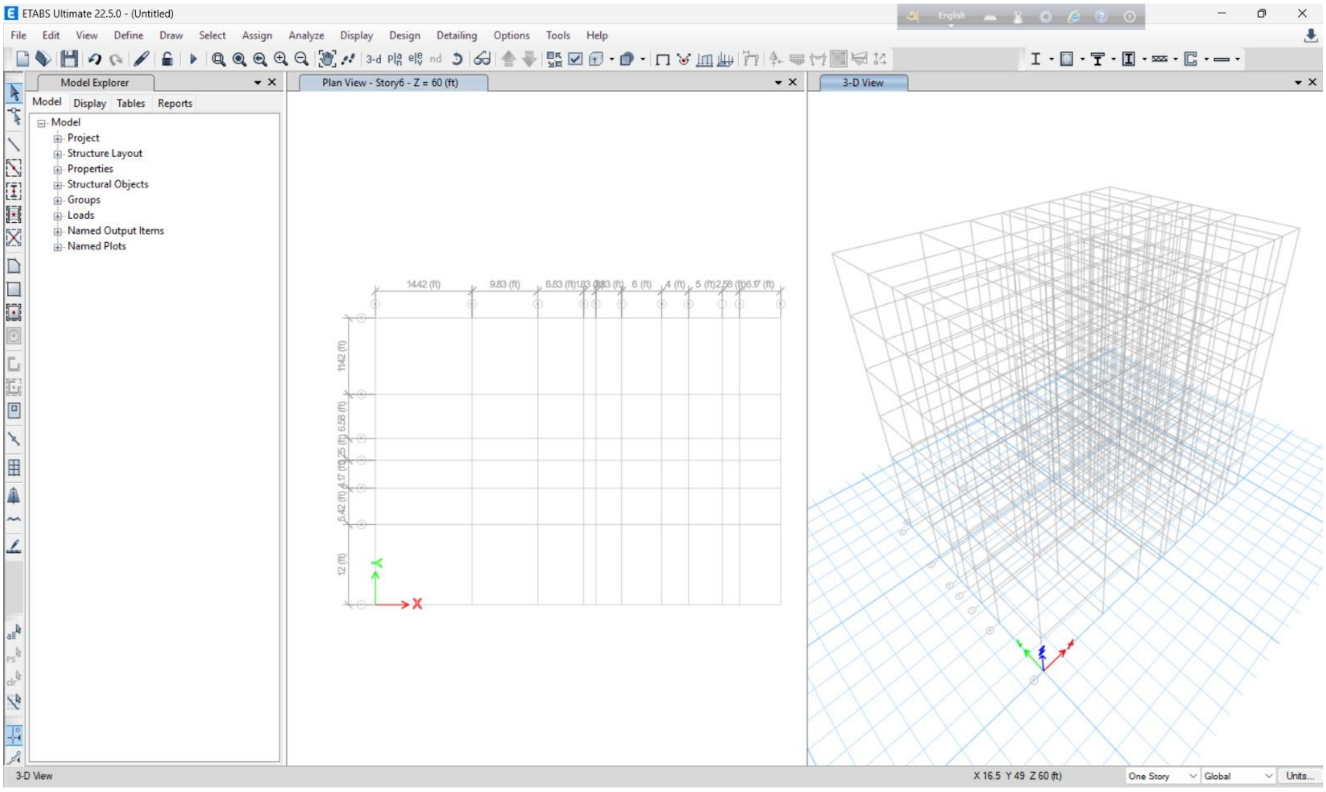


Figure 3-6: Modelling With EATBS

- File>New model
- U.S Customary
- United State
- Concrete Design Code ACI 318-08
- OK
- Input spacing of grid in X, Y direction
- OK

3.2.9 Define Materials Properties and Frame Section:

• Materials Properties

I. Concrete

II. Modify if need

- Frame Section

I. Select all existing property

II. Delete all

III. Add rectangle

IV. For beam

V. Select Reinforcement

VI. Then select beam

VII. Define all frame section x in this process

3.2.10 Define Materials Properties and Frame Section:

Materials Properties

i. Concrete

ii. Modify if need

Frame Section

I. Select all existing property

II. Delete all

III. Add rectangle

IV. For beam

V. Select Reinforcement

VI. Then select beam

VII. Define all frame section x in this process

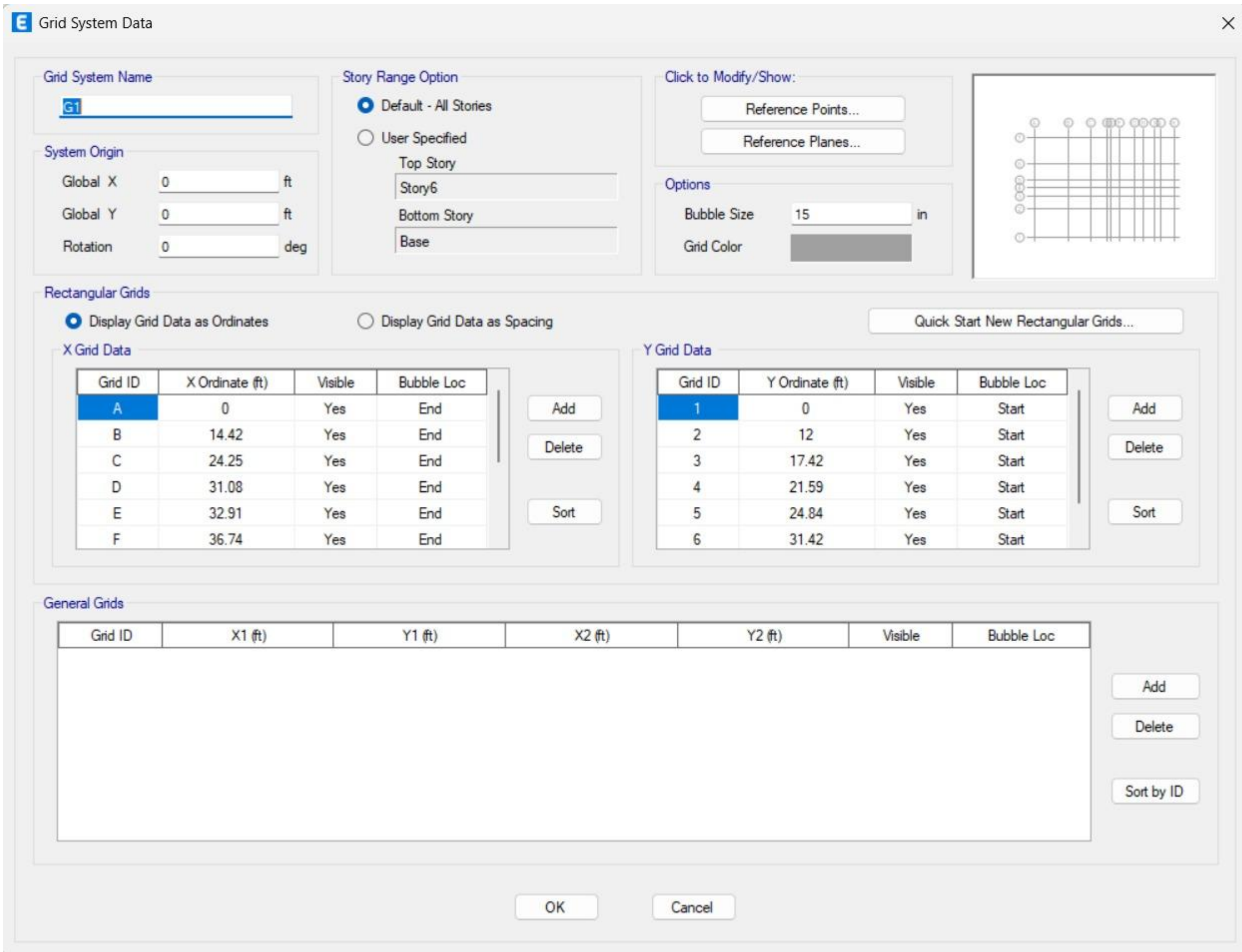


Figure 3-7: Grid Selection of the Model

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

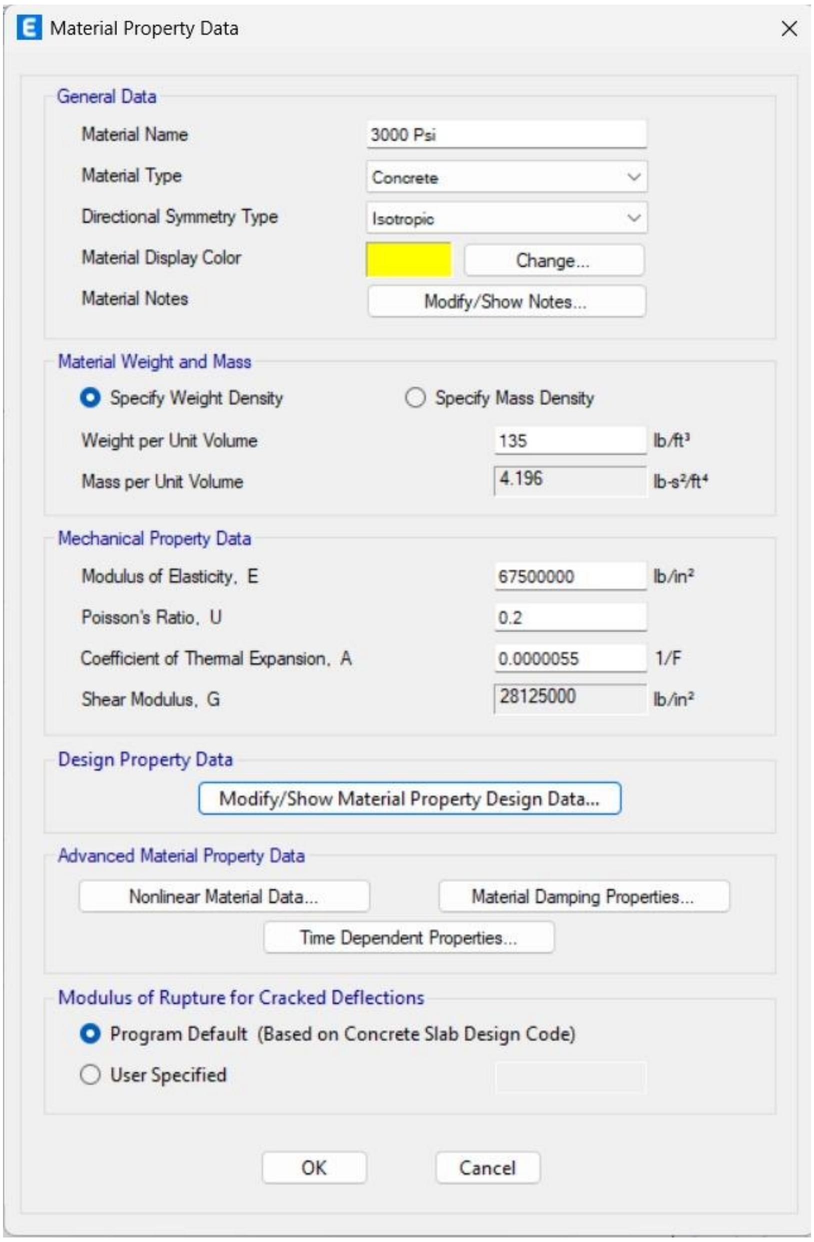


Figure 3-8: Material Property of the Model

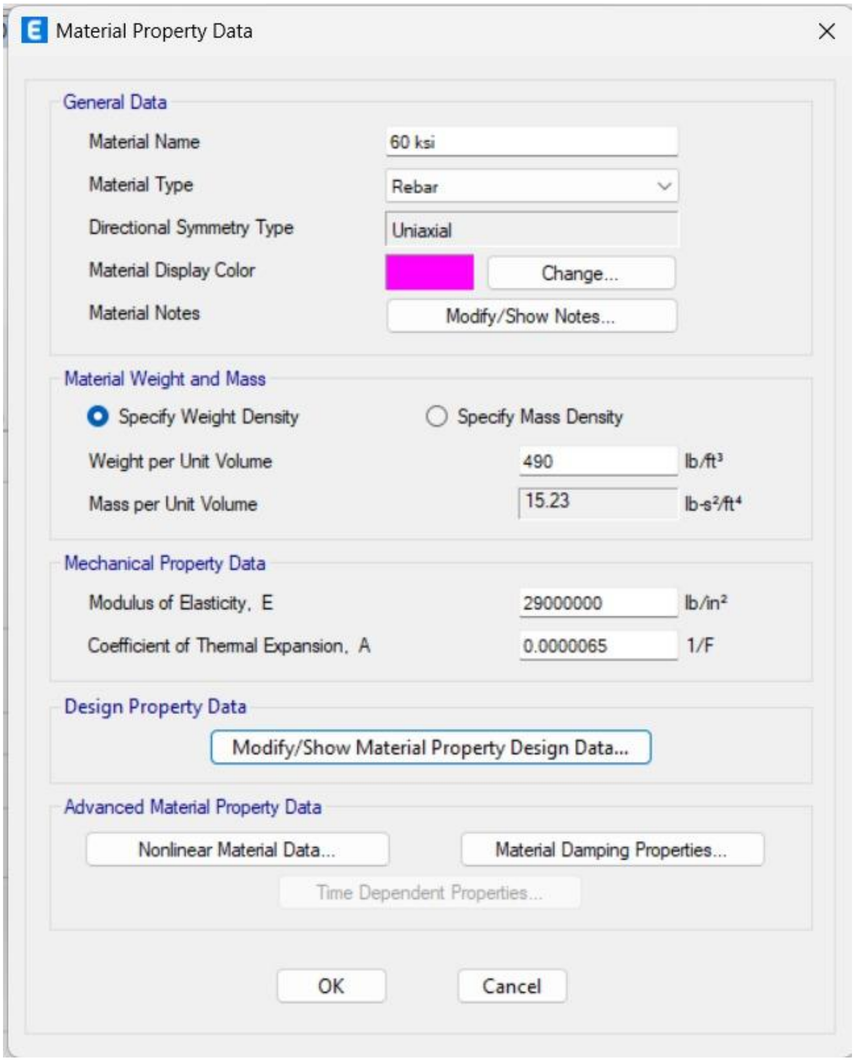


Figure 3.9: Material Property of the Model

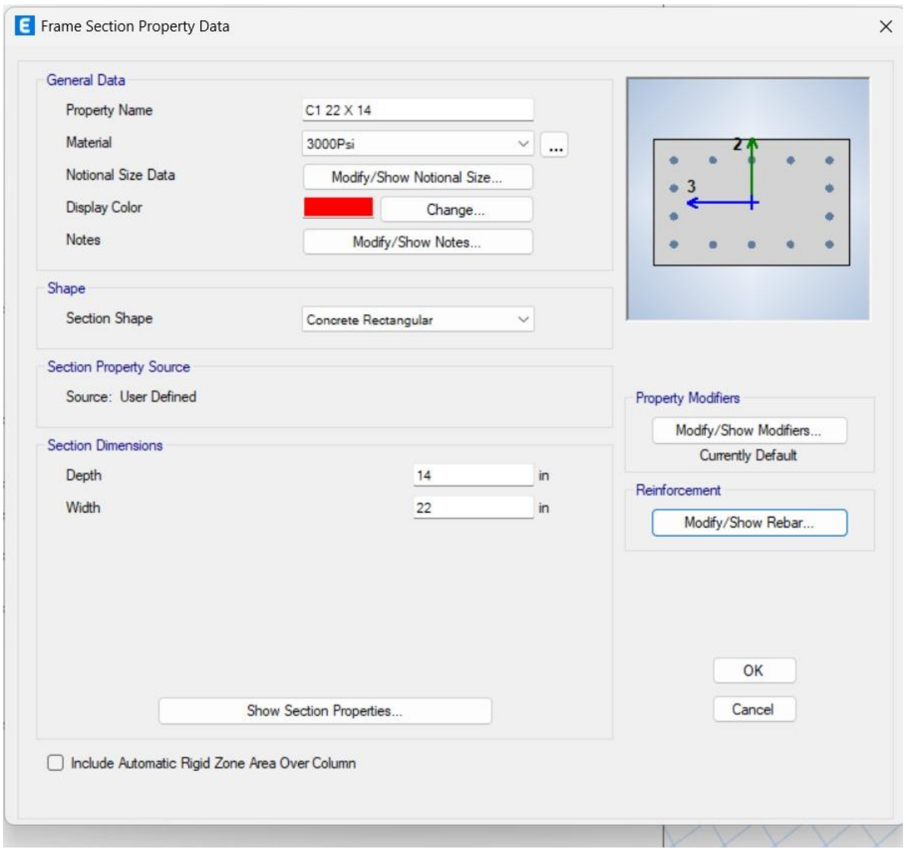


Figure 3-10: Frame Section Property Data

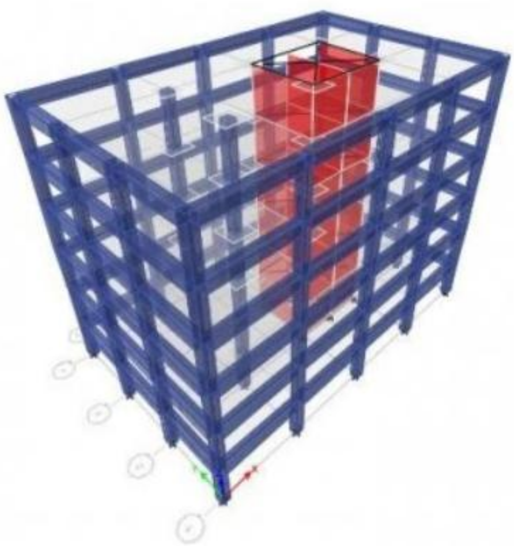


Figure 3-11: Plan for the 3D Model

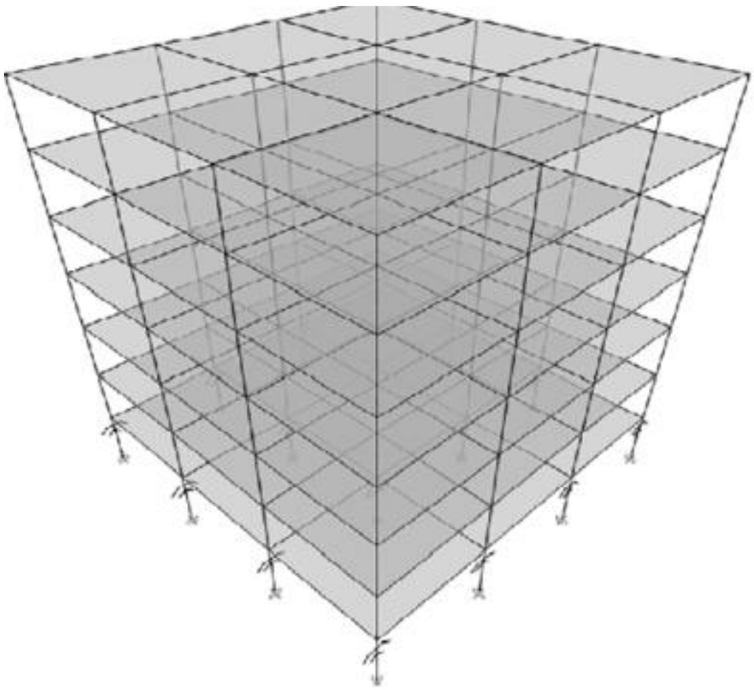


Figure 3-12: Plan for the displace Model

3.3.0. Deflect Shape of The Model

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

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

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

4.1.1 Base Shear Check

$$V = Sa\ W$$

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

$$Sa = \frac{2}{3}\frac{ZI}{R}\ CS$$

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

Cs= Normalized acceleration response spectrum, which is a function of structure

(building) period and soil type (site class) as defined by Equations.

$$C = 2.5S\eta \ for\ T_B \leq T \leq T_C$$

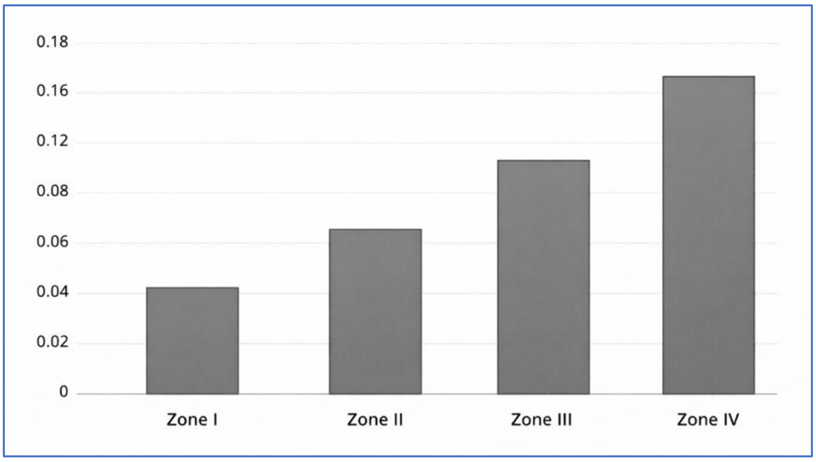


Figure 4-1: Base Shear Check

Table 4-1: Seismic Force Coefficient Table (BNBC 2020 & ETABS)

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

4.1.2 Deflection Checks for Serviceability

Sway limitation

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

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

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

Table 4-2: Top deflection checks for serviceability

Zone	Limitation (inch)	Ux (max)	Uy (max)
Zone I	2.232”	0.78	2.12
Zone II	2.232”	1.26	2.15
Zone III	2.232”	1.2	1.95
Zone IV	2.232”	1.26	2.37

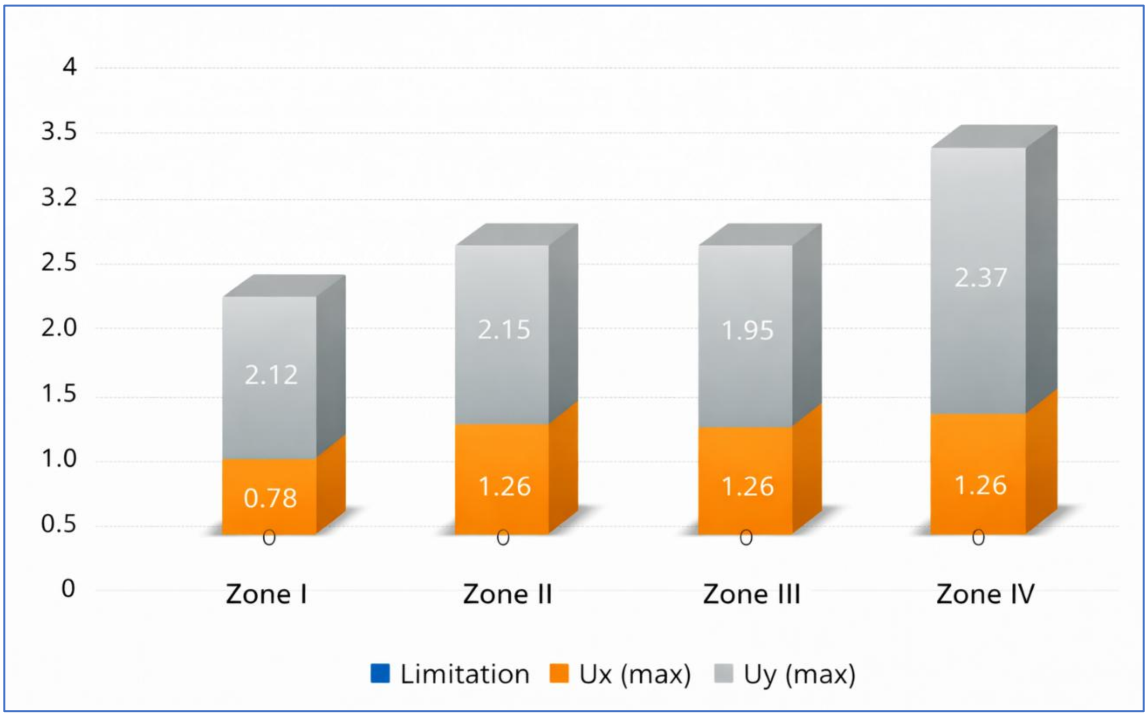


Figure 4-2: Zone wise serviceability chart

4.1.3 For Beam Deflection Check

Table 4-3: Beam Deflection Check

Construction	L	Wl	D + L
Roof members: Supporting plaster ceiling	l/360	l/360	l/240
Roof members: Supporting non-plaster ceiling	l/240	l/240	l/180
Roof members: Not supporting ceiling	l/180	l/180	l/120
Floor members	l/360	-	l/240
Exterior walls and interior partitions: With brittle finishes	-	l/240	-
Exterior walls and interior partitions: With flexible finishes	-	l/120	-
Farm buildings	-	-	l/180
Greenhouses	-	-	l/120

Table 4-4: Beam Deflection allowable limitation

Structural Element / Loading Condition	Allowable Deflection
Beams – Roof Members (not supporting plaster ceiling)	L / 180
Beams – Roof Members (supporting plaster ceiling)	L / 240
Beams – Floor Members (general, not supporting brittle finishes)	L / 240
Beams – Floor Members (supporting plaster or brittle finishes)	L / 360
Cantilevers – Roof (not supporting finishes)	L / 180
Cantilevers – Floor or Roof (supporting brittle finishes)	L / 240
Beams – Pedestrian bridges (comfort requirement)	L / 500 to L / 800
Beams – Bridges (AASHTO standard)	L / 800

Table 4-5: Beam deflection Check

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

4.1.4 Torsion irregularity Check

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

Table 4-6: Torsion irregularity check

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

Table 4-7: Site Allowable story Drift

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

4.1.5 Story Drift

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

Table 4-8: Story Drift Check

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

Summary Description

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

CHAPTER 5
CONCLUSION AND FUTURE WORKS

5.1 Conclusions

Based on the comparative analysis of the moment-resisting high-rise structure under BNBC 2020 provisions, the following conclusions are drawn:

1. **Impact of Seismic Zonation:** There is a significant increase in seismic demands when transitioning from Zone 1 to Zone 4. Lateral deflection, torsional irregularity, and story drift values rise sharply due to the increase in the seismic zone coefficient (Z) and associated seismic activities.
2. **Serviceability and Deflection:** In Zone 1, the maximum displacements (Ux = 0.78$ in, Uy = 2.12 in) remain within the allowable limit of **2.232 in**. However, in Zone 4, the structure fails the serviceability check, with Uy reaching **2.37 in**, exceeding the permissible limit.
3. **Torsional Irregularity:** The structure exhibits regular behavior in Zone 1 (Indices < 1.2). In contrast, Zone 4 induces severe torsional irregularity, with coefficients reaching **2.59 (EQX)** and **3.59 (EQY)**, which drastically exceed the code-specified limit of **1.2**.
4. **Story Drift:** Similar to deflection, story drift values in Zone 1 are well within limits (1.17). In Zone 4, the drift increases significantly to **3.52 (EQX)** and **3.26 (EQY)**, violating the maximum allowable drift limit of **3.12**.

5.2 Recommendations

To enhance the reliability of this research and guide future studies, the following recommendations are proposed:

1. **Validation via Manual Calculation:** Future researchers should validate the software-generated results by comparing them with manual hand calculations to ensure the accuracy and reliability of the analysis.
2. **Cross-Verification with Software:** It is recommended to perform the same analysis using alternative Finite Element Analysis tools (such as SAP2000 or STAAD.Pro) to cross-verify the results obtained from ETABS.
3. **Expansion Analysis:** Future studies should investigate the structural feasibility of vertical or horizontal expansion to understand the building's reserve capacity for future modifications.

5.3 Limitations

The study was conducted with the following constraints and limitations:

1. **Software Dependency:** The analysis relies exclusively on **ETABS** software. No comparative analysis with other structural software packages was conducted in this study.
2. **Scope of Design:** The building design is strictly limited to the current geometric configuration. It does not account for any provision for future horizontal extensions or vertical additions (stories).
3. **Verification Method:** The results presented are based solely on computational simulations; a comprehensive manual verification of the complex high-rise lateral load distribution was not included in the scope of this specific study.

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[13] ANALYSIS AND DESIGN OF COMMERCIAL BUILDING USING ETABS Ragy Jose1, Restina Mathew2, Sandra Devan3, Sankeerthana Venu4, Mohith Y S5 1,2,3,4UG Students. Department of Civil Engineering, KVG College of Engineering, Sullia D.K 5Assistant Professor, Department of Civil Engineering, KVG College of Engineering, Sullia.

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