DESIGN AND ANALYSIS OF RESIDENTIAL BUILDING AT DIFFERENT SEISMIC ZONE IN BANGLADESH 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

Department of Civil Engineering
Sonargaon University
147/I, Green Road, Dhaka-1215, Bangladesh

Section: 14 B

Semester -Year Fall -2021

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Dedicated

To

"MY PARENTS"

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ABSTRACT

The construction of buildings requires ideas and cautious plans. The design can be difficult for retail developers, since they tend to prefer the universe and horizontal instead of vertical. However, the great value of land and high-level traffic of high-density urban centers tend to design vertical structures. Developers will build housing characteristics designed to be resold to lease income. In recent years, it is a construction of limited natural resources, costs, time and structures that are susceptible to stress to the center of the city. Hence, according to the need of rentable spaces, owner desires, aesthetics, cost, safety and comfort, architects and engineers are now facing the challenges of structural design to accommodate people's total daily life in one single structure. As outcomes, Multiplan and multifunctional structures are now being constructed with different types of concrete floor systems considering lateral load impact.

The earthquake occurs in the form of seismic waves that causes structural damage of the earthquake cortex movement, which affects the behavior of the components of the components, the underlying soil and the general behavior of the system. When an earthquake occurs, the behavior of the building depends on the distribution of the mass, intensity and rigidity. . So here, the analysis is carried out for seismic response and stability against extreme environmental condition of (G+9=10 storey) residential building using BNBC 2020 at zone-I (Barisal), zone-II (Dhaka) and Zone-III (Chittagong) and Zone-IV (Sylhet) in Bangladesh by thorough response spectrum method and time history method in ETABS. The parameters like storey drift, storey displacement and Base shear are observed for specified zones. Among four different seismic zone the maximum displacement at zone-1.

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CHAPTER 1
INTRODUCTION

1.1.1GENERAL:

Earthquakes are a real threat to people's lives and property. The recent earthquake in Dhaka city is the best proof that it is time to consider seismic load in building model analysis. Therefore, it is a must now to predict the strength of the earthquake and prepare for it to avoid damage [1]. So, preventing earthquake and reduction strategy is a global concern today [2]. When the height of building increases, the toughness of the structure becomes more significant. With the increase in number of stories install structures, faces various loading effects with very high loading values due to lateral loads like earthquake forces and strong wind. An earthquake is the most dangerous by means of the damage and chaos caused to the structural components and they cannot be controlled. To design an earthquake resistant structure, it is mandatory to know the update codes Dynamic effects of earthquake loads are usually analyzed as an equivalent static load in most small and moderate-sized buildings [3].

In recent years, people are shifting to urban places due to their jobs and for daily living ease, which is resulting dense population in cities. So, number of structures and building requirement is higher these days in cities. It has increased threat on agriculture lands near and around cities. Since land is limited, there is a need for vertical improvement in the form of high structures and it will save agriculture lands growing food items [4]. Thus, multi-storied buildings are important to be considered. All over Bangladesh communication facilities are increasing rapidly. Communication opportunity satisfies commercial and residential efforts. Bangladesh being a small but hugely populated country.

1.1.2Background and Motivations: -

It has been observed that the study of the structural systems for the lateral load due to the seismic power is required. The safety levels and minimum structure damage are the best requirements of high-rise construction requirements [5].To meet these requirements, the structure must have sufficient lateral resistance, lateral rigidity and sufficient ductility. Among the various structural systems, seismic knowledge of the soil, the height of the sea surface, the cyclone air route, etc. It can be a point for the designer. Therefore, it is necessary to observe and review the behavior of these structural systems in seismic effects. Therefore, it has been proposed to study the behavior of the seismic strip of reinforced concrete frameworks. Our study is to compare the seismic response of above structural systems in various parameters.

Parameters taking into account the comparison is the method of respect for the spectrum and the time history method.

We need careful ideas and plans to build a residential building. This design is difficult for retail developers due to spatial restrictions and tends to prefer vertical instead of horizontal [6]. However, the massive land values of dense urban centers and high levels of traffic bound designers to make vertical designs. In the history of the architectural structure, changes in technology are absent. However, these types of buildings are difficult to organize to depress the active advantage of structural and mechanical systems.

In this paper, an analysis done using ETABS for (G+9=10 storey) RC building under seismic loads for Zone I, Zone II, Zone III and Zone IV regions. Numerous load combinations are observed in according to BNBC 2020. A study is done to carry out dynamic analysis of four buildings in four different zones and comparing results for different types of moments, forces and displacements and seismic analysis of multi-storied buildings carried out using ETABS. The different parameters taken are mass irregularity, different soil, wind speed & earthquake loads etc.

1.1.3Objectives: -

The study was carried out with the following objectives: -

i. To achieve basic knowledge about ten storied Residential building at four different Seismic zones in Bangladesh.
ii. To compare Maximum Displacement and drift subjected to seismic load among four Different Zone.
iii. Monitoring the base shear reaction subjected to seismic loading in structure.
iv. To determine the performance levels for the design of different concrete frames according to BNBC seismic provisions.

1.1.4Organization of the thesis: -

The thesis consists of five chapters.

- **Chapter 1**
- Presents an introduction to the study. It includes the research background, objectives.
- **Chapter 2**
- Deals with Theoretical Background. It illustrates the structural systems, Seismic zone map, methodology load considerations, Seismic Parameters, load factor.
- **Chapter 3**

  Deals with abstract of ETABS, Experimental setup, it illustrates architectural planning and structural formation of selected building, structural modeling, and structural analysis.

- **Chapter 4**

  Deals with analysis and discussion of all data obtained from the design program performed in chapter 3 to compare evaluate and draw findings and conclusions of the research work.

- **Chapter 5**

  Deals with conclusions and recommendations of the research work.

CHAPTER 2

LITERATURE REVIEW

2.1.1 Introduction

P. S. Kumbhare, A. C. Saoji . They worked on the impact of earthquake on buildings that are of middle height like neither a tall structure nor a short structure. They built up few models having different location of shear wall. They considered dual frame system and normal frame system. Analysis is done by utilizing ETABS software. For the correlation different values of all parameters are taken and make final results. They investigate that the building with dual system have more strength and stability [12].

Suruchi Mishra, Rizwanullah work on comparison of regular and irregular buildings with and without shear wall and they have found that buildings with shear wall hare more stable and have greater strength [13].

Though many researchers have investigated various seismic properties of buildings, still the number of researchers is not quite enough specially in Bangladesh. Therefore, for practical application users may get limited information about different seismic properties of high-rise buildings at different zones in Bangladesh. For this reason analysis of high rise building at difference zones in Bangladesh become necessary. Encouraged by their work, we became interested in work of ETABS.

2.1.2 Seismic Design Requirements for RCC Beam Design for Buildings;

 # Material Strength

- Minimum specified compressive strength of all types of concrete, fc' = 4000psi
- Maximum specified yield strength of reinforcement, Fy = 60,000psi

 # Clear Span of Beam for Buildings

- Clear span > four times the effective depth i.e., ln >4d

 # Sectional dimensions of the beam for Buildings

- Width-to-depth ratio ≥ 0.3 i.e. b/h ≥0.3
- Minimum width ≥ 10inch
- Minimum width of the beam ≤ [width of the supporting column + 1.5h [7].

 # Main reinforcement

- ρ min ≥200/Fy
- ρ max ≤0.0250

- Two continuous bars should be at both top and bottom of the member.
- At any section, the top or bottom steel should not be less than ¼ of the steel for the maximum (–ve) moment at the supports.
- At each support, min bottom (+ve) steel must be equal to ½ of the (–ve) moment steel [7].

 # Splicing of Main Reinforcement

- Splice shall not be used (i) within joints (ii) within 2h from the column face.
- Splices are to be confined by hoops or spiral reinforcement with maximum spacing or pitch of d/4 or 4 inch whichever is smaller.

 # Transverse reinforcement details

- Total required steel area Av= $\dfrac{\dfrac{V_u}{\phi}}{f_y \times d} \times s$

- Confinement reinforcement is provided in the form of hoops.
- Hoops are required over a distance 2h (h = depth of beam) from faces of both supports.
- First hoop will be placed at 2 inches from face of support.
- Maximum hoop spacing is the smaller of the followings:

i) d/4

ii) 8 x diameter of smallest longitudinal bar

iii) 24 x diameter of the hoop bar

iv) 12 inches

Where hoops are not required (beyond confinement zone and splicing), stirrups with seismic hooks at both ends (detail A) shall be spaced not more than d/2 throughout the length of the member.

2.1.3 Seismic Considerations for Column Design for Buildings

Material Strength

- Minimum compressive strength of all types of concrete, fc'= 4,000psi
- Maximum yield strength of reinforcement, fy = 60,000psi
- Normal density concrete is preferable, wc = 140~150 psf [8]

Sectional dimensions of the column

- Width-to-depth ratio ≥ 0.4 i.e., b/h≥ 0.4 • Least dimension ≥ 12inch

Main reinforcement ratio

- ρ min =0.01
- ρ max = 0.06

Preferable ρ =0.04

Splicing of the Main reinforcement

- Lap splice shall be used only within the center of the column.
- Welded splices may be used at any section of column, provided that:

a) They are used only alternate longitudinal bars at a section

b) The distance between splices along the longitudinal axis of reinforcement ⩾ 24''[9]

- Splices are to be confined by hoops or spiral reinforcement with maximum spacing or pitch of d/4 or 4 inch whichever is smaller.

- Splice length:

Splice length = 1.3 ld (class B splice)

Where, ld = development length of the bar

$$l_d \geq \begin{cases} \dfrac{0.04 A_b f_y}{\sqrt{f_c'}}, \ A_b = \text{Bar area} \\ 0.0004 d_b f_y \\ 12'' \end{cases}$$

Transverse reinforcement

a) **Circular hoops**: steel ratio of circular/spiral hoops,

$$\rho_s \geq \begin{cases} 0.12 \dfrac{f_c'}{f_{yh}} \\ 0.45\left(\dfrac{A_g}{A_{ch}} - 1\right)\dfrac{f_c'}{f_{yh}} \end{cases}$$

Where,

fyh = yield strength of hoop reinforcement.

Ach = core area of column section measured to the outside of hoop reinforcement**.**

b) **Closed hoops**: Total cross-sectional area of closed hoops,

$$A_{sh} \geq \begin{cases} 0.09\, s_o h_c \dfrac{f_c^{'}}{f_{yh}} \\ 0.3 s_o h_c \left(\dfrac{A_g}{A_{ch}} - 1 \right) \dfrac{f_c^{'}}{f_{yh}} \end{cases}$$

Here,

h_C = cross-sectional dimension of column core measured center-to-center of hoop reinforcement.

s_O = vertical spacing of hoop reinforcement**.**

- **Confinement length**: confinement reinforcement is to be provided over a length lo from each joint face..

$$l_o \geq \begin{cases} \dfrac{1}{6}(clearspan\ of\ the\ column) \\ depth\ of\ member \\ 18'' \end{cases}$$

First hoop will be placed at 2 inches from the join

2.1.4 Definition: -

The following definitions shall provide the meaning of certain terms used in this chapter.

Wind Loads

The actual intensity wind pressure depends on a number of factors like angle of incidence of the wind, roughness of surrounding area, effects of architectural features, i.e., shape of the structure etc. and lateral resistance of the structure. Apart from these, the maximum design wind load pressure depends on the duration and amplitude of the gusts and the probability of occurrence of an exceptional wind in the lifetime of building [10]

Code Provisions for Wind Load

The minimum design wind load on buildings and components is determined based on the velocity of the wind, the shape and size of the building and the terrain exposure condition of the site. Provisions to the calculation of design wind loads for the primary framing system and for the individual structural components of the buildings. Provisions are included for forces due wind response of regular shaped building, caused by the common windstorms including cyclones, thunderstorms and nonwestern [11]

Basic Wind Speed

The basic wind speed for the design is taken from basic wind speed map of Bangladesh (BNBC, 1993), where it is in km/h for any location in Bangladesh, having isobaths (contour line on a map) representing the fastest-mile wind speed at 10 meters above the ground with terrain exposure B for a 50 years' recurrence interval. The minimum value of the basic wind speed set in the map is 130 km / h and maximum 260 km/h.

Storey,

The space between any two floor levels including the roof of a building. Store-x is the storey below level x.

Soft story,

Story in which the lateral stiffness is less than 70 per cent of the stiffness of the story above.

Weak storey,

Storey in which the lateral strength is less than 80 per cent of that of the storey above.

Base Shear,

Total design lateral force or shear at the base of a structure.

Diaphragm,

A horizontal or nearly horizontal system acting to transmit lateral forces to the vertical resisting elements. The team ''diaphragm'' includes horizontal bracing systems.

Space Frame,

A three-dimensional structural system without bearing walls composed of members interconnected so as to function as a complete self-contained unit with or without the aid of horizontal diaphragms or floor bracing system.

Building Frame System,

An essentially complete space frame which provides support for loads.

Horizontal Bracing System,

A horizontal truss system that serves the same function as a floor or roof diaphragm.

Moment Resisting Frame,

A frame in which members and joints are capable of resisting forces primarily by flexure.

Primary Framing System,

That Part of the structural system assigned to resist lateral forces.

Bearing wall system,

A structural without a complete vertical load carrying space frame.

Braced Frame,

An essentially vertical truss system of the concentric or eccentric type which is provided to resist lateral forces.

Shear wall,

A Wall designed to resist lateral forces parallel to the plane of the wall (sometimes referred to as vertical diaphragm or structural wall).

Storey Shear, Vx

The summation of design lateral forces above the storey under consideration.

Strength,

The usable capacity of an element or a member to resist the load as prescribed in these provisions.

Vertical Load- carrying frame,

A space frame designed to carry all vertical loads.

2.1.5 Seismic zone map: -

The seismic zoning map of Bangladesh is provided in fig, based on the severity of the probable intensity of seismic ground motion and damages, Bangladesh has been divided into three seismic zones, zone 1, zone 2, zone 3 and zone 4.

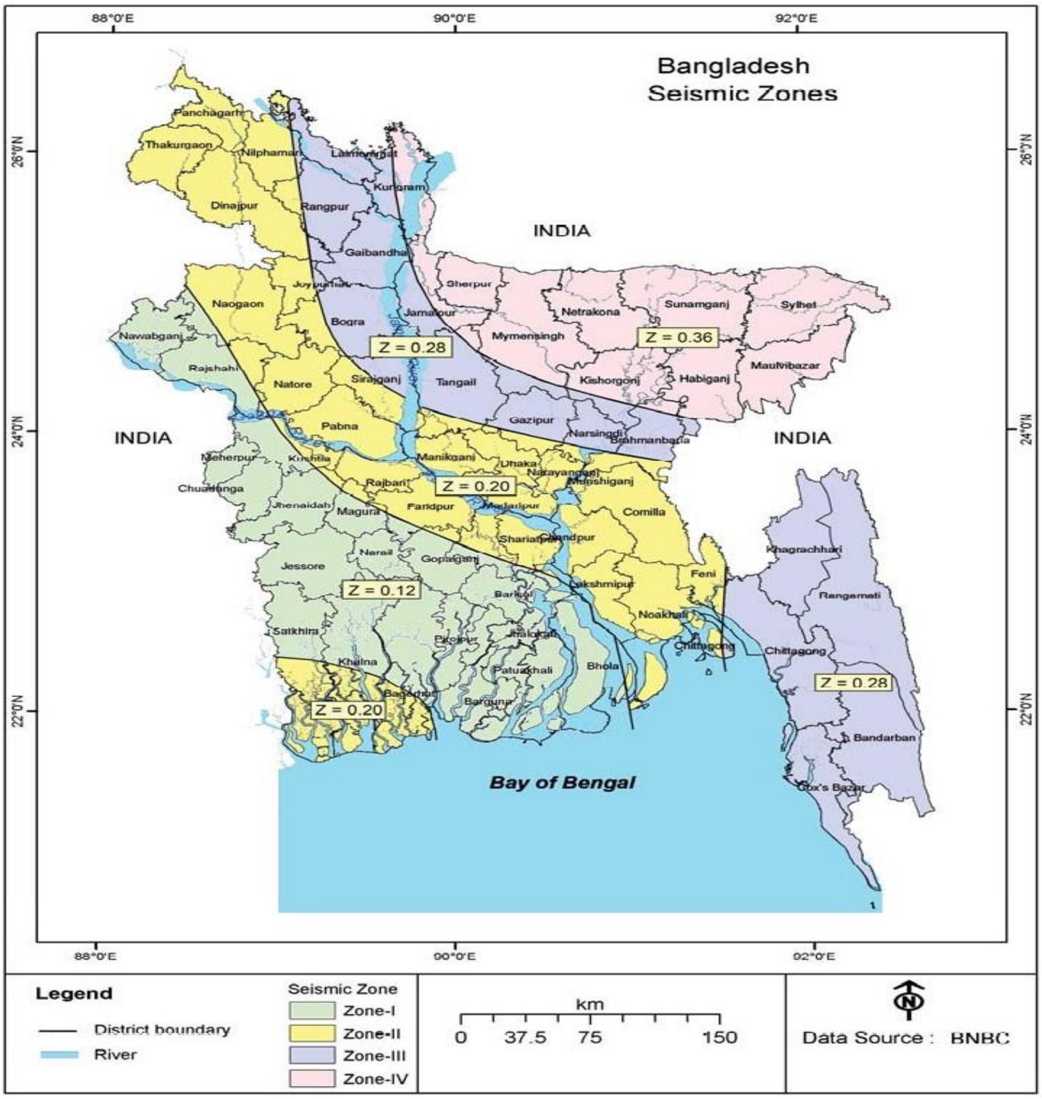


Figure-2.1.2: Seismic Zoning Map in Bangladesh.

Light green is Barisal Zone I value, Z=0.12	**Safest**
Turmeric Yellow is Dhaka Zone II value, Z=0.20	**Moderate**
Light Purple is Chittagong Zone III value, Z=0.28	**Risky**
Deep green is Sylhet Zone IV value, Z=0.36	**Alarming**

2.1.6 Outline of Methodology: -

The method of calculation of seismic loading BNBC 2020, In the present study, analysis of ten multi-storied building in Four seismic zones for wind and earthquake forces is carried out.3D model is prepared for ten multi-storied building using ETABS.

2.1.7 Design Base Shear: -

V = ZIC/ R x W,

V= Base shear.

Z = Seismic zone factor.

I = Structure importance factor.

W = Total dead load? Some Specified live loads.

R = Response modification coefficients.

C = Numerical coefficient, C=1.25S/T^2/3

S= Site coefficient for soil characteristics.

T = Time period.

2.1.8 Seismic zone (z): -

On the basis of distribution of earthquake epicenters, ground motion attenuation, geophysical and tectonic data available from within as well as outside of the country, Bangladesh was mapped dividing into three generalized seismic zones in BNBC 2020.

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

Table 2.1: Seismic zone (z)

2.1.9 Structure importance Coefficient (I): -

In BNBC 2020, structure importance co-Efficient is different for structural and non-structural components and equipment and denoted by I. But in BNBC 2020 importance co-Efficient is denoted by me for all cases

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

Table 2.2: - Structure importance Coefficient (I)

Importance Factors for Buildings and Structures for Earthquake design

2.1.10 Response Reduction factor (R): -

In BNBC 2020, it is known as response Modification coefficient. It is the factor by which the actual base shear force that would develop if the structure behaved truly elastic during earth quake is reduced to obtain design base shear. This reduction is allowed to account for the beneficial effects of inelastic deformation that can occur in a structure during a major earthquake. The value of response modification factor is significantly reduced in BNBC 2020 or different structural system.

MOMENT RESISTING FRAME SYSTEMS (no shear wall)

1. Special steel moment frames	8	3	5.5	NL	NL	NL
2. Intermediate steel moment frames	4.5	3	4	NL	NL	35
3. Ordinary steel moment frames	3.5	3	3	NL	NL	NP

Seismic Force–Resisting System	Response Reduction Factor ,R	System Over strength Factor,Ω_o	Deflection Amplification Factor,C_d	Seismic Design Category B	C	D
				Height limit(m)		
4.Specialreinforcedconcrete Moment frames	8	3	5.5	NL	NL	NL
5.Intermediatereinforced Concrete moment frames	5	3	4.5	NL	NL	NP
5.Ordinaryreinforced Concrete moment frames	3	3	2.5	NL	NP	NP

Table 2.3: -MOMENT RESISTING FRAME SYSTEMS

2.1.11 Seismic Weight (w): -

Seismic weight is the total dead load of building or structure, including partition walls, and applicable portions of other imposed loads. In BNBC 2020a minimum of 25 % of the floor live load shall be applicable irrespective of live load. Total weights of permanent equipment's are considered in both codes.

2.1.12 Time period (T): -

The fundamental building period is simply the inverse of the building frequency at which it wants to vibrate when set in motion by some sort of disturbance (in building design, typically a seismic or wind event) based on the system's mass and stiffness characteristics.

$T = Ct\ (h_n)^{m\ (0.90)}$

C_t= 0.0466 for steel moment resisting frames.

= 0.0724 for reinforced concrete moment resisting frames.

= 0.0488 for all other structural systems.

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

2.1.13 Soil factors (S): -

This is termed as site coefficient in BNBC 2020. The amount of ground motion amplification depends on wave propagation characteristics of soils, which can be estimated from the measurements of shear wave velocity. Soft soils with slower shear wave velocities generally produce greater amplification than stiff soils with faster shear wave velocities. The site classes are defined mainly in terms of soil profile depth and shear wave velocity in the existing code.

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

Soil type	S	T_B(s)	T_C(s)	T_D(s)
SA	1.0	0.15	0.40	2.0
SB	1.2	0.15	0.50	2.0
SC	1.15	0.20	0.60	2.0
SD	1.35	0.20	0.80	2.0
SE	1.4	0.15	0.50	2.0

Table 2.4: -Soil Factor.

2.1.14 Load consideration: -

Dead load and live load are gravity loads act vertically. Earthquake and wind load acts horizontally. These loads are basic loads to be considered for building design. BNBC 2020 is followed for load considerations.

Dead load

Dead load is the vertical load due to the weight of permanent structural and nonstructural components of a building such as walls, floors, ceilings, permanent partitions and fixed service equipment's etc. Dead load for a structural member shall be assessed based on the forces due to:

- weight of the member itself,
- weight of all materials of construction incorporated into the building to be supported permanently by the member,
- weight of permanent partitions,
- Weight of fixed service equipment's and Net effect of pre-stressing.

Live load

Live load is the load superimposed by the use or occupancy of the building not including the environmental loads such as wind load, rain load, earthquake load or dead load. The live loads used for the structural design of floors, roof and the supporting members shall be the greatest applied loads arising from the intended use or occupancy of the building, or from the stacking of materials and the use of equipment and propping during construction, but shall not be less than the minimum design live loads set out by the provisions of any standard code. For live Load Considerations BNBC. 2020.

2.1.15 Lateral Loads: -

Seismic lateral forces on primary framing systems shall be determined by using either the equivalent static force method or the dynamic response method complying with the restrictions given below:

a) The equivalent static force method may be used for the following structures:

i) All Structures, regular or irregular, in Seismic Zone 1 and Structure Importance Category in Seismic Zone 2, except case b (IV) below. ii) Regular structures less than 75 meters in height with lateral force resistance provided by structural systems listed in BNBC except case below. iii) Irregular structures not more than 20 meters in height.

b) The dynamic response method may be used for all classes of structure, but shall be used for the structures of the following types. i) Structures 75 meters or more in height except as permitted by case above. ii) Structures having a stiffness, weight or geometric vertical irregularity of type I, II, III as defined in BNBC. iii) Structures over 20 meters in height in Seismic Zone 3 not having the same structural system throughout their height. iv) Structures regular or irregular, located on soil type S4 as defined in BNBC. Lateral loads are wind load and earth quake load. The minimum design wind load on buildings and components thereof shall be determined based on the velocity of the wind, the shape and size of the building and the terrain exposure condition of the site as set forth by the provisions of BNBC 2020. Minimum design earthquake forces for buildings, structures or components thereof shall be determined in accordance with the provisions of BNBC 2020. For primary framing systems of buildings or structures, the design seismic lateral forces shall be calculated by the equivalent static force method. Overall design of buildings and structures to resist seismic ground motion and other forces shall comply with the applicable design requirements.

2.1.16 Load Combinations: -

Buildings, foundations and structural members shall be investigated for adequate strength to resist the most unfavorable effect resulting from the various combinations of loads provided in this section. The most unfavorable effect of loads may also occur when one or more of the contributing loads are absent or act in the reverse direction. Loads such as F, H, or S shall be considered in design when their effects are significant. Floor live loads shall not be considered where their inclusions result in lower stresses in the member under consideration. The most unfavorable effects from both wind and earthquake loads shall be considered where appropriate, but they need not be assumed to act simultaneously.

2.1.17 Story Drift and Top Deflection: -

Lateral deflection or drift is the magnitude of displacement at the top of a building relative to its base. The ratio of the total lateral deflection to the building height, or the story deflection to the story height, is referred to as the deflection index. In the absence of code limitations in the past, buildings were designed for wind loads shall not exceed 1/500 times the total Height of the building above ground.

As per BNBC 2006, story drift, shall be limited as follows,

(i) $0.04h/R < 0.005h$; for $T < 0.7$ second.

(ii) $0.03h/R < 0.004h$; for $T \geq 0.7$ second.

(iii) $0.0025h$ for unreinforced masonry structure.

Where,

h= height of the building or structure,

T= fundamental period of vibration in seconds of the structure for the direction under consideration and

R= response modification factor shall be applicable only when earthquake forces are present.

2.1.18 Point Displacement coefficient method: -

Another procedure for calculating demand displacement is 'Displacement Coefficient Method' which provides a direct numerical process for calculating the displacement demand. Displacement Coefficient Method has not been explored. Performance analysis of the structures under this thesis was made using Capacity Spectrum Method.

Seismic performance evaluation: -

The essence of virtually all seismic evaluation procedures is a comparison between some measures of the "demand" that earthquake place on structure to a measure of the "capacity" of the building to resist the induced effects. Traditional design procedures characterize demand and capacity as forces. Base shear (total horizontal force at the lowest level of the building) is the normal parameter that is used for this purpose. The base shear demand that would be generated by a given earthquake, or intensity of ground motion is calculated, and compares this to the base shear capacity of the building. If the building were subjected to a force equal to its base shear capacity some deformation and yielding might occur in some structural elements, but the building would not collapse or reach an otherwise undesirable overall level of damage. If the demand generated by the earthquake is less than the capacity then the design is deemed acceptable.

2.1.19 Longitudinal Reinforcement: -

(a)The reinforcement ratio, shall not be less than 0.01 and shall not exceed 0.06.

(b)Lap splices are permitted only within the Centre half of the member length and shall be designed as tension splices. Welded splices and mechanical connections conforming to through are allowed for splicing the reinforcement at any section provided not more than alternate longitudinal bars are spliced at a section and the distance between splices is 600 mm or more along the longitudinal axis of the reinforcement.

CHAPTER 3

METHODOLOGY

3.1.1 Abstract of ETABS: -

ETABS stand for Extended Three-Dimensional Analysis of Building Systems. ETABS integrates every aspect of the engineering design process. In the present situations of construction industry, the buildings that are being constructed are gaining significance, in general, those with the best possible outcomes which are referred to members like beams and columns in multi storied R.C structures. This software mainly used for structures like high rise buildings, steel and concrete structures. The paper aims to analyze a high-rise building of 10 floors by considering seismic load in three seismic zone, dead and live loads. The design criteria for high-rise buildings are strength, serviceability and stability. The version of the software used is ETABS 18.1.0. In the present study, we are mainly determining the effects of lateral loads on maximum longitudinal Reinforcement, maximum displacement and Base shear on structural system are subjected and also comparing the results of seismic zones 1, 2, 3& 4.

Structural analysis is the determination of the effects of loads on physical structures and their components. The results of the analysis are used to verify a structure's fitness for use, often precluding physical tests. Structural analysis is thus a key part of the engineering design of structures. ETABS is an engineering software product that caters to multi-story building analysis and design. It is a sophisticated, yet easy to use, special purpose analysis and design program developed specially for bending systems. ETABS provides an initiative and powerful graphical interface coupled with unmatched modelling, analytical and design procedures; all integrated using a common database. Although quick and easy for simple structures, ETABS can also handle the largest and most complex building models, including a wide range of nonlinear behaviors, makes it the tool of choice for structural engineers in the building industry. Now-a-day ETABS computer analysis has become popular for designing different types of structures. Through this study it was tried to compare the results of manual analysis and computer software analysis (ETABS) for different structural sections and provide utmost safety for residential structures.

3.1.2 Steps in Modeling: -

Initial setup of standard codes and Country codes. Display units: Kip-ft. Creation of Grid points & Generation of structure. File → new model → Custom Grid Spacing → Edit Gird. After getting opened with ETABS we select a new model and a window appears where we had entered the grid dimensions and story dimensions of our building. Defining of material property. Define → Material Properties → Add New Material here we had first defined the material property by selecting define menu material properties. We add new material for our structural components (beams, columns, slabs) by giving the specified details in defining. Define Frame Sections. Define → Frame Sections → Add Rectangular Section After defining the property, we define section size by selecting frame sections & added the required section for beams, columns etc. Slab Details define → Wall/Slab Section → Add New Slab, We have to define the slab properties after defining frame sections. Assigning of Property after defining the property we draw the structural components using command menu. After defining the columns and beams, the columns and beams are placed on the grid lines, using various "line object" options under the command "Draw". Defining of loads Define → Static Load Cases → Add New Load /In ETABS all the load considerations are first defined and then assigned. The loads in ETABS are defined as using static load cases. Assigning of Supports Select Plan Level →Base →Select all columns Assign →Joint Points →Restraints →Fixed Support By keeping the selection at the base of the structure and selecting all the columns we assigned supports by going to assign menu joint\frame Restraints (supports) fixed. Assigning Loads then Slab Loads Select slabs → Assign →Shell area loads →Uniform.

3.1.3 1st floor Plan.

Typical Floors (1st Floor ~ 9th Floor)

- Floor height 10'-0".
- Total floor area is = 2182 X 9 = 19638 ft^2.
- Connected with other floors by one Stair.

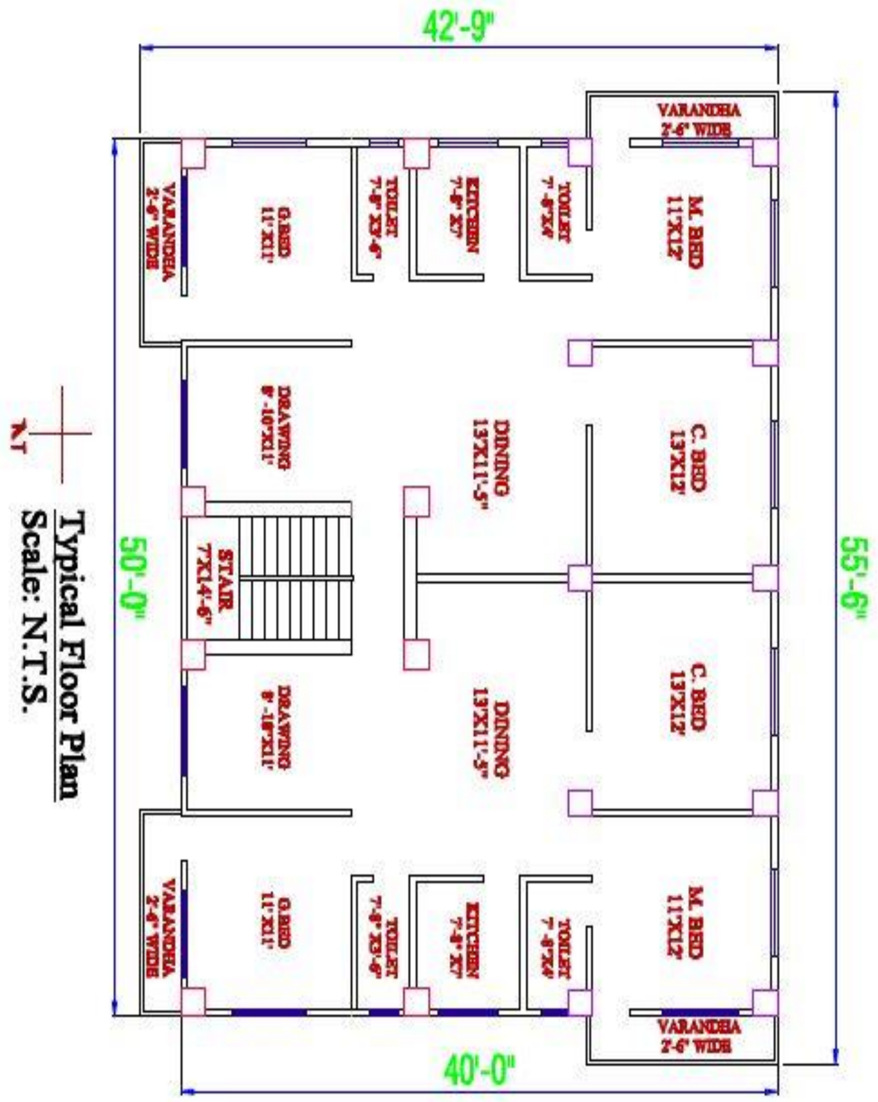


Figure 3.1: 1st Floor Plan.

3.1.4 Ground Floor Plan.

Ground Floor:

- 2' above from road level and connected with other floors by one Stair & eight-person lift.
- Total floor area is = 2182 ft^2.Total floor height 10'-0"

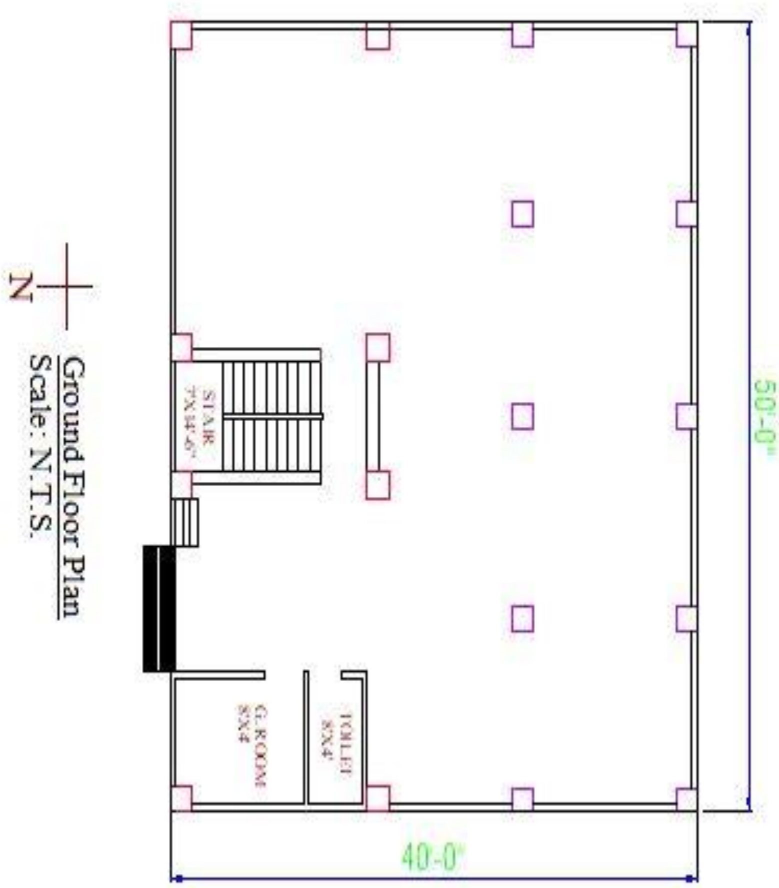


Figure3.1.4: Ground Floor Plan.

3.1.5 Column Layout plan.

- **Column Size**

Zone-1 C1=18"x18"C2=18"x22"

Zone-2 C1=18"x18"C2=18"x20"

Zone-3 C1=18"x20"C2=20"x20"

Zone-4 C1=18"x18"C2=18"x20"

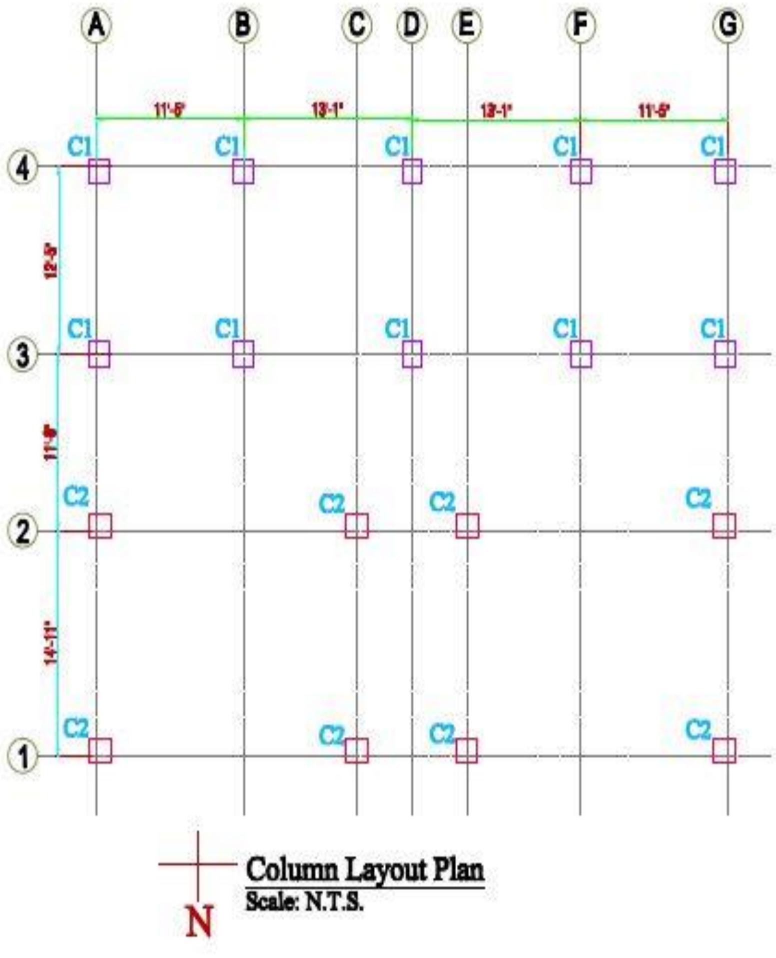


Figure 3.1.5: Column Layout.

3.1.6 Beam Layout.

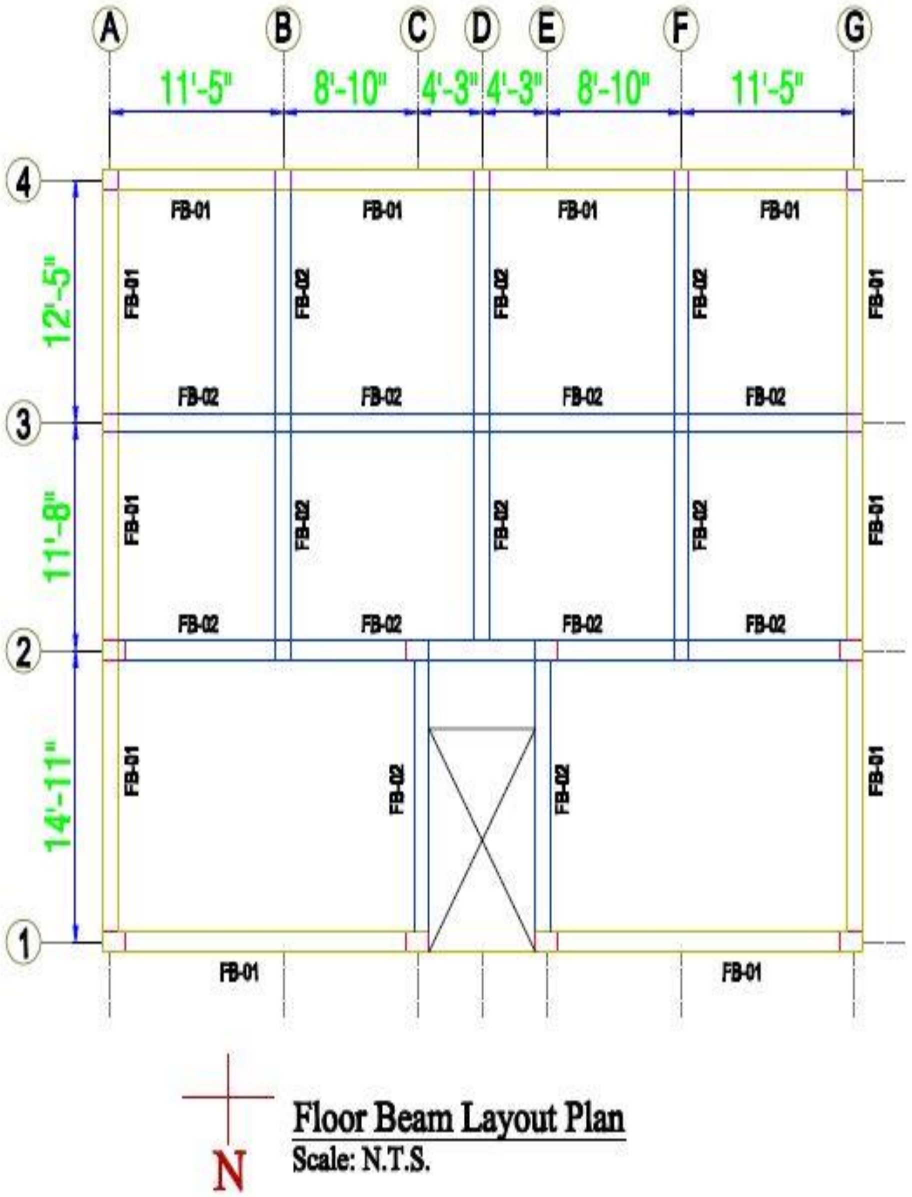


Figure 3.1.6: Beam Layout.

3.1.7 Frame Sections & Assign Load as per BNBC 2020

Frame Section

- **Column Size**

Zone-1 C1=18”x18”

C2=18”x22”

Zone-2 C1=18”x18”

C2=18”x20”

Zone-3 C1=18”x20”

C2=20”x20”

Zone-4 C1=18”x18”

C2=18”x20”

- **Beam Size:**

Zone-1

B1 =18”x24”

B2= 18”x28”

Zone-2

B1 =18”x24”

B2= 18”x25”

Zone-3

B1 =18”x24”

B2= 18”x32”

Zone-4

B1 =18”x24”

B2= 18”x28”

- **Grade Beam:**

  Zone-1

  GB1 = 16”x28”

  GB2 = 16”x26”

  Zone-2

  GB1 = 14”x24”

  GB2 = 16”x26”

  Zone-3

  GB1 = 16”x30”

  GB2 = 18”x30”

  Zone-4

  GB1 = 14”x28”

  GB2 = 14”x24”

- **Slab thickness:**

  T= 5”

- **Building Height:**

  H=106’

<u>Assign Load</u>

Live Load = 40psf

Stair Case Live Load = 100psf

Dead Load = 128psf

Floor Finishing = 25psf

Partition Wall = 55psf

Concrete Compressive Strength, f’c = 4 ksi

Tensile Strength of steel, fy = 60 ksi.

3.1.8 Seismic Zoning: -

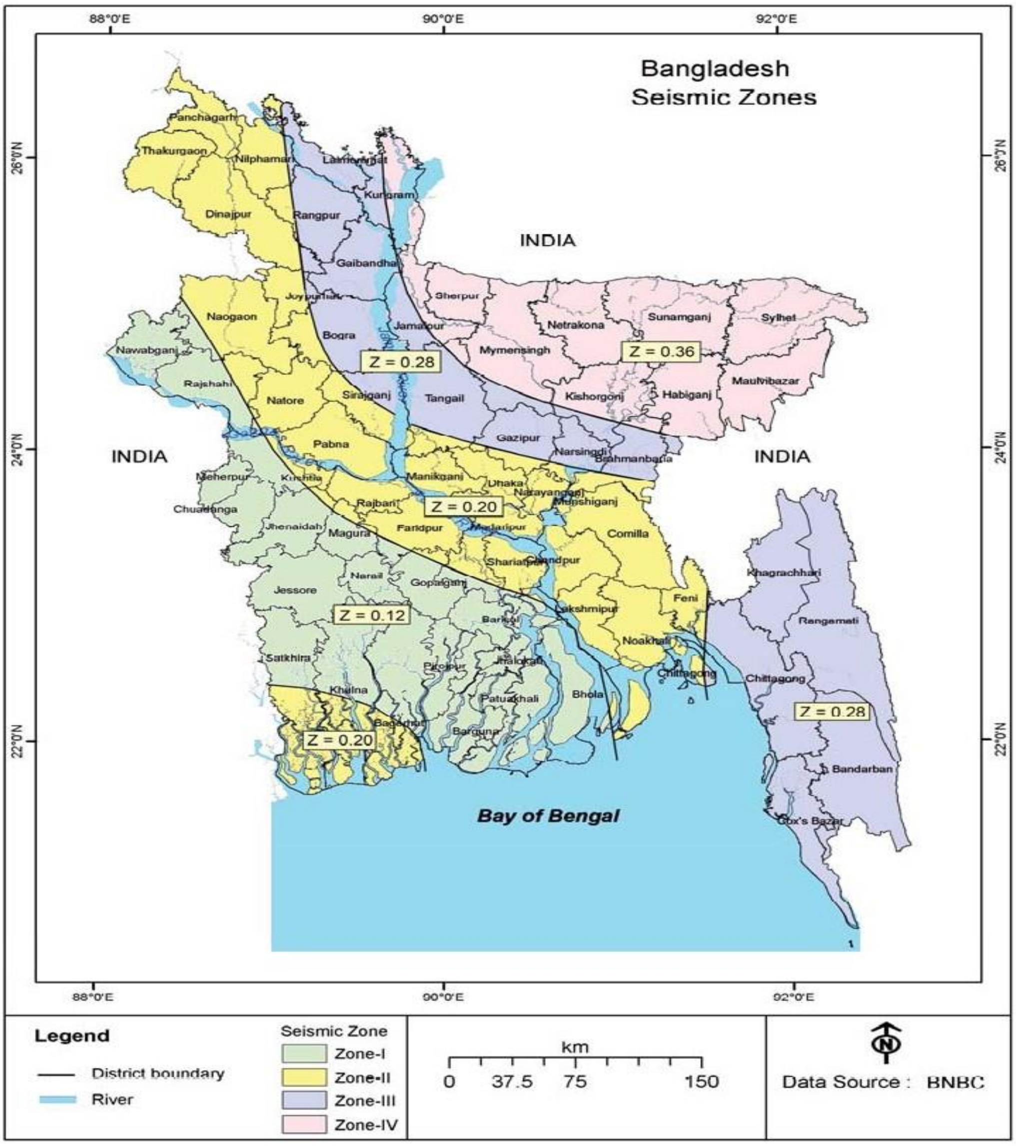


Figure 3.1.8-: Seismic Zoning Map in Bangladesh.

- **Zone 1-**
  - Barisal
- **Zone2-**
  - Dhaka
- **Zone 3-**
  - Chittagong
- **Zone 4-**
  - Sylhet

3.1.9 **Seismic Data**:

Zone 1=0.12

Zone 2=0.20

Zone 3=0.28

Zone-4=0.36

Structure importance factor, **I**=1.0

Site coefficient for soil characteristics, **S**=1.215

Response modification coefficients ‘’R’’

For, Zone 1 = 5

Zone 2 = 8

Zone 3 = 8

Zone 4 = 8

Time period, **T**=1.06

Wind Load (BNBC -2020)

(i)Wind Speed =65.7 m/s (Barishal)
(ii)Wind Speed =61.1 m/s (Dhaka)
(iii)Wind Speed=80.0 m/s (Chittagong)
(iv)Wind Speed=78.7 m/s (Sylhet)
Exposure Category:
Barisal-C
Dhaka-C
Chittagong-D
Sylhet-D
Pressure Co-efficient,
Cp :1.51 (Cpx) ,1.27 (Cpy) .

CHAPTER 04

Results and Discussion

4.1.1<u>Introduction</u>

This Chapter has been systemically arranged in the following manner:

4.1.2Details of Loads and Material Properties:

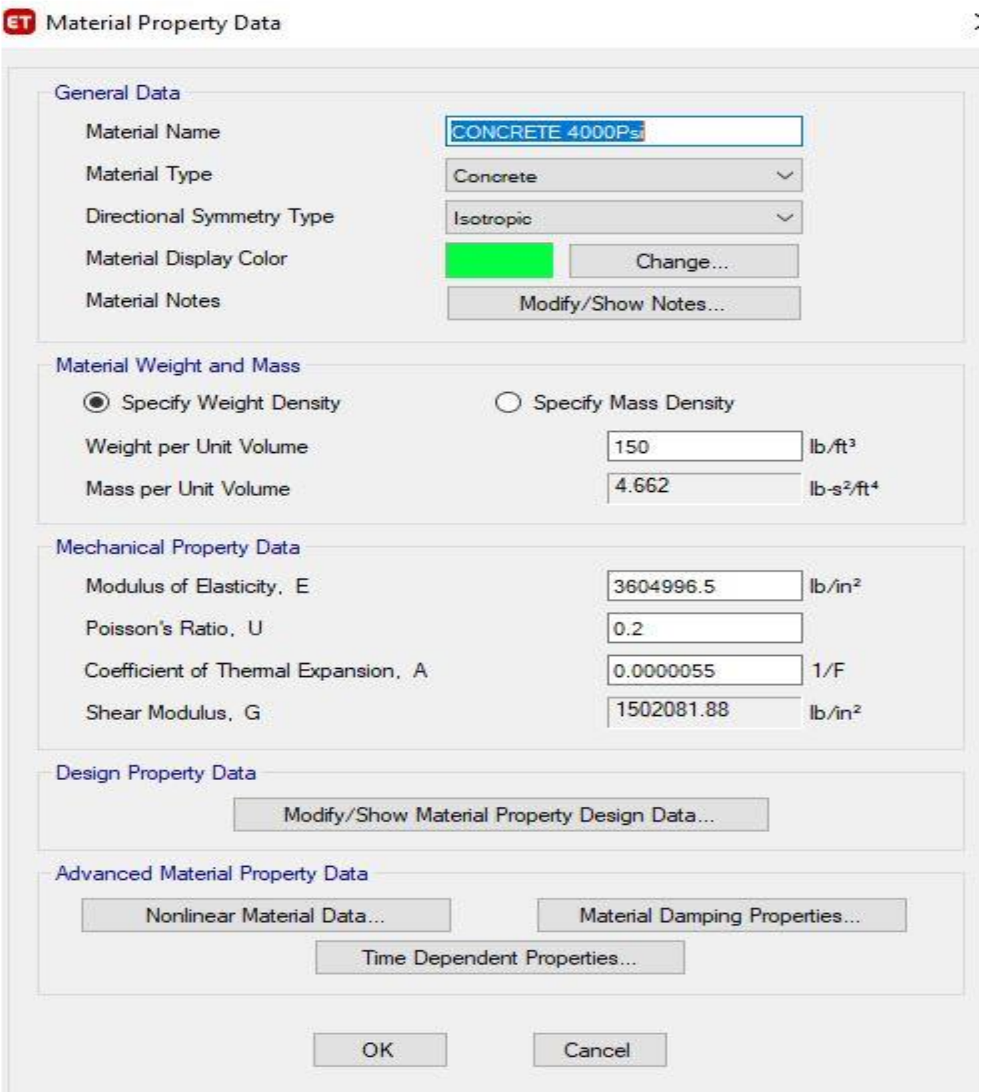


Figure4.1.2: Loads and Material Properties.

4.1.3 Grid Line Modeling:

Gridlines are aligned to the center of internal walls and outer face of external walls. This arrangement allows for a fixing of the position of the four corners of the building and footprint to meet planning requirements by authority.

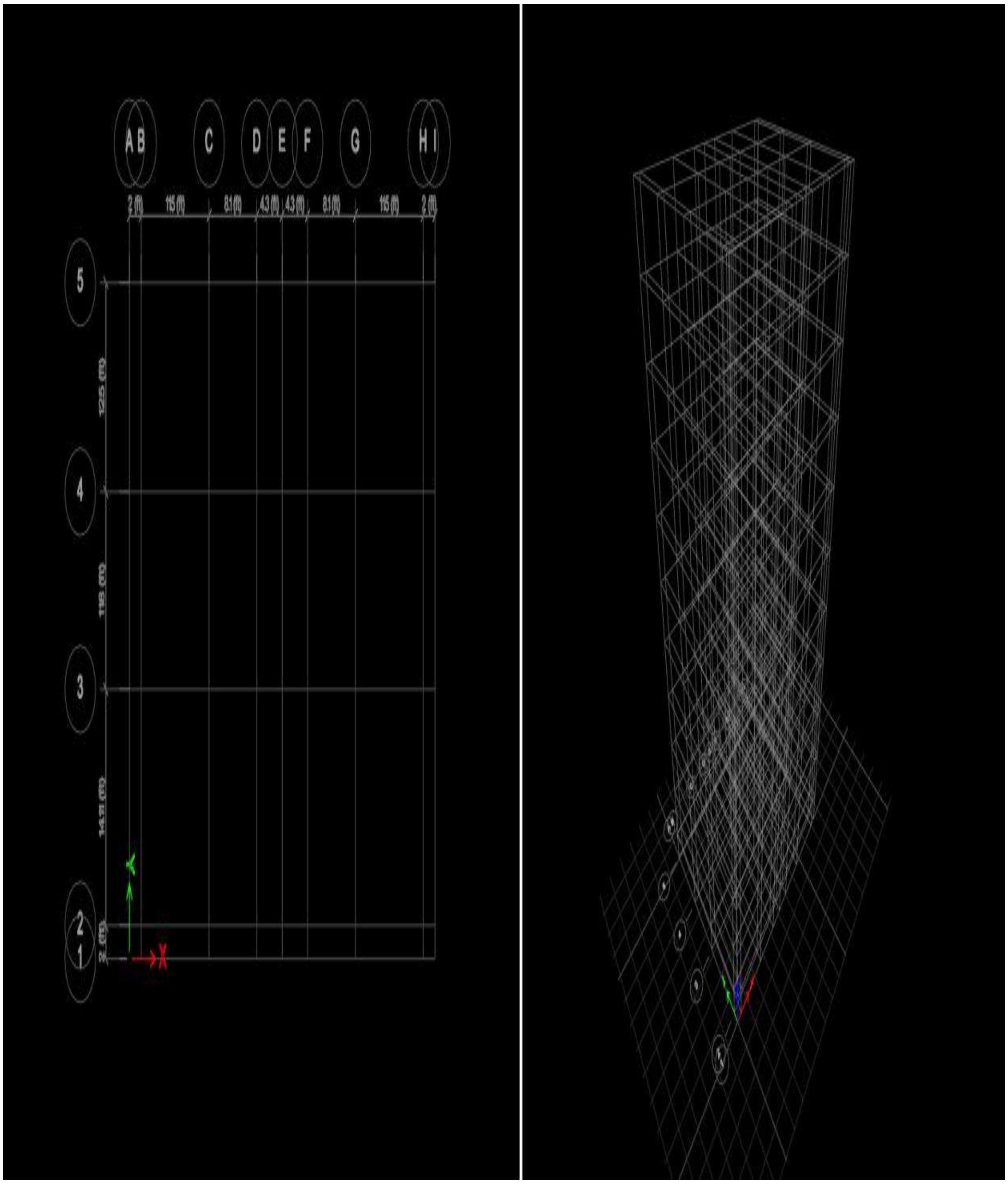


Figure4.1.3: Grid line modeling.

4.1.4 Column Layout plan in ETABS:

There are 18 columns and two types of columns are here.

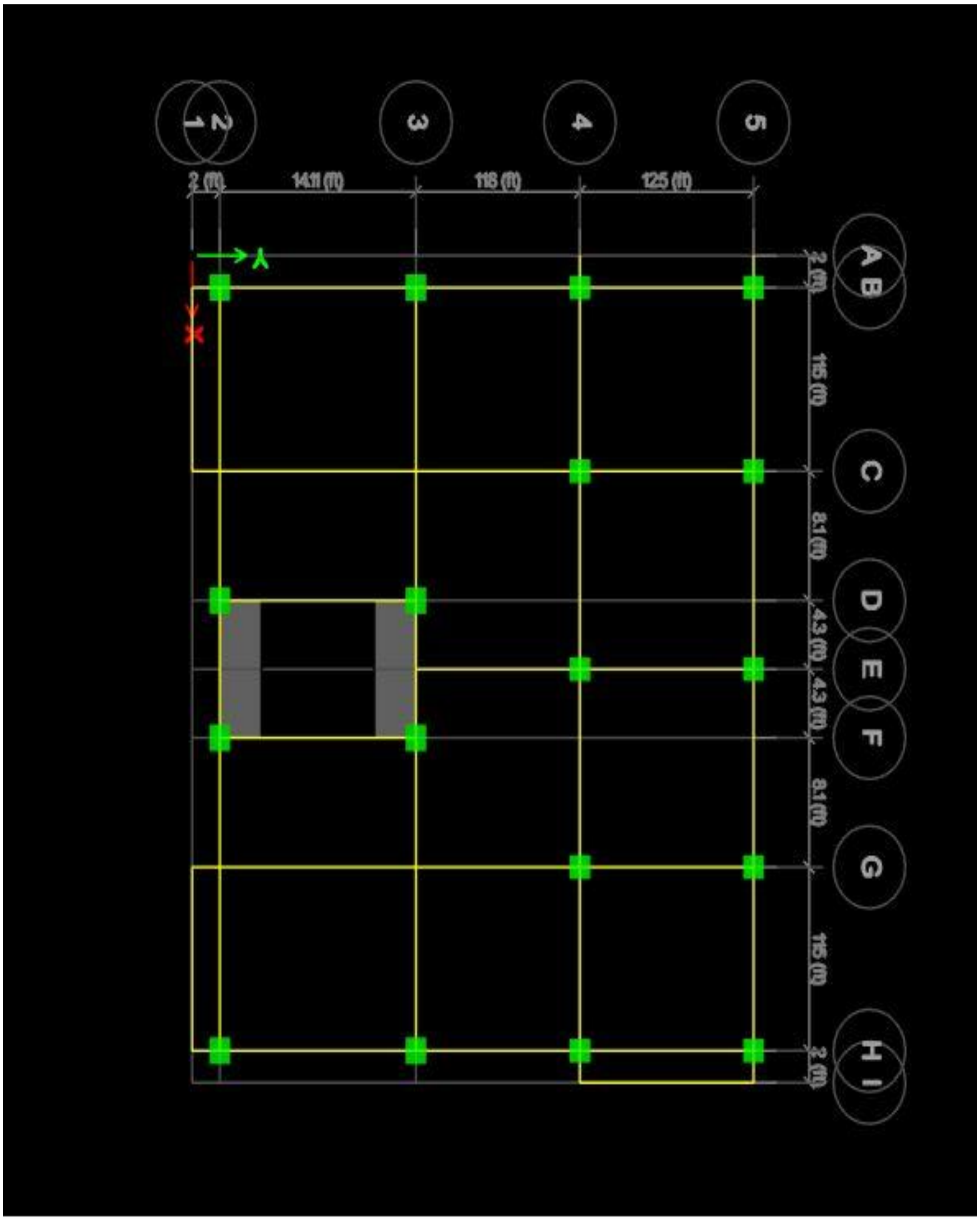


Figure4.1.4: Column Layout plan in ETABS

4.1.5 Drawing of Column, Beam, Grade beam, Slab, Stair.

It is shown here are columns, beam, grade beam, slab, stair and 3D design.

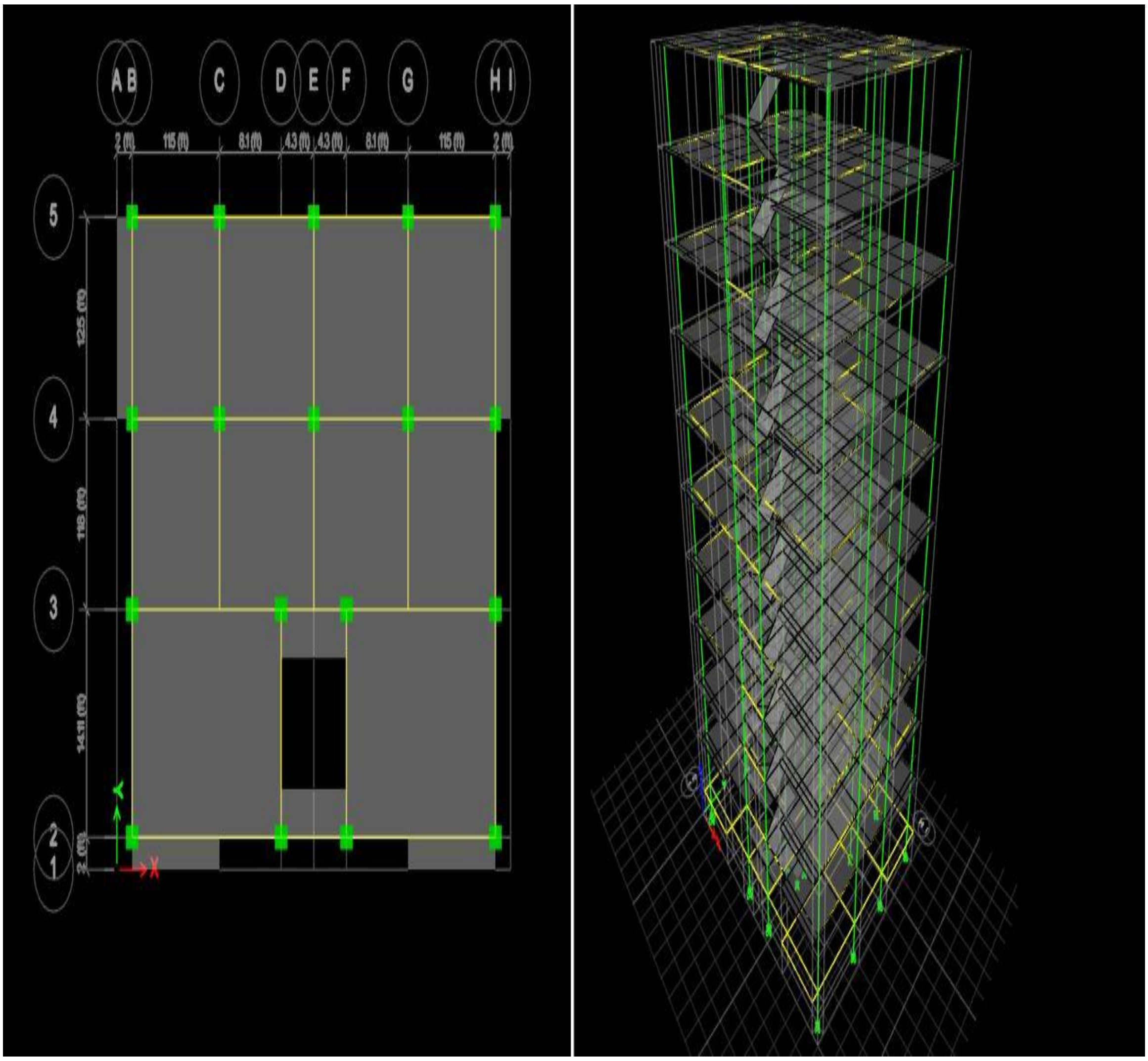


Figure4.1.5: Drawing of Column, Beam, Grade beam, Slab, Stair.

4.1.6 Load combinations: As per BNBC 2020

(1) 1.4D

(2) 1.2D+1.6L

(3) 1.2D+L

(4) 1.2D+0.8Wx

(5) 1.2D-0.8Wx

(6) 1.2D+0.8Wy

(7) 1.2D-0.8Wy

(8) 1.2D+L+1.6Wx

(9) 1.2D+L-1.6Wx

(10) 1.2D+L+1.6Wy

(11) 1.2D+L-1.6Wy

(12) 1.2D+L+EX+0.3Ey+⅄D

(13) 1.2D+L+ Ex-0.3Ey+⅄D

(14) 1.2D+L- Ex+0.3Ey+⅄D

(15) 1.2D+L- Ex-0.3Ey+⅄D

(16) 1.2D+L+ Ey+0.3Ex+⅄D

(17) 1.2D+L+ Ey-0.3Ex+⅄D

(18) 1.2D+L-Ey+0.3Ex+⅄D

(19) 1.2D+L-Ey-0.3Ex+⅄D

(20) 0.9D+1.6Wx

(21) 0.9D-1.6Wx

(22) 0.9D+1.6Wy

(23) 0.9D-1.6Wy

(24) 0.9D+Ex+0.3Ey-⅄D

(25) 0.9D+Ex-0.3Ey-⅄D

(26) 0.9D-Ex+0.3Ey-⅄D

(27) 0.9D-Ex-0.3Ey-⅄D

(28) 0.9D+Ey+0.3Ex-⅄D

(29) 0.9D+Ey-0.3Ex-⅄D

(30) 0.9D-Ey+0.3Ex-⅄D

(31) 0.9D-Ey-0.3Ex-⅄D

4.1.7 Analyzing

Run has been shown to analyze the design.

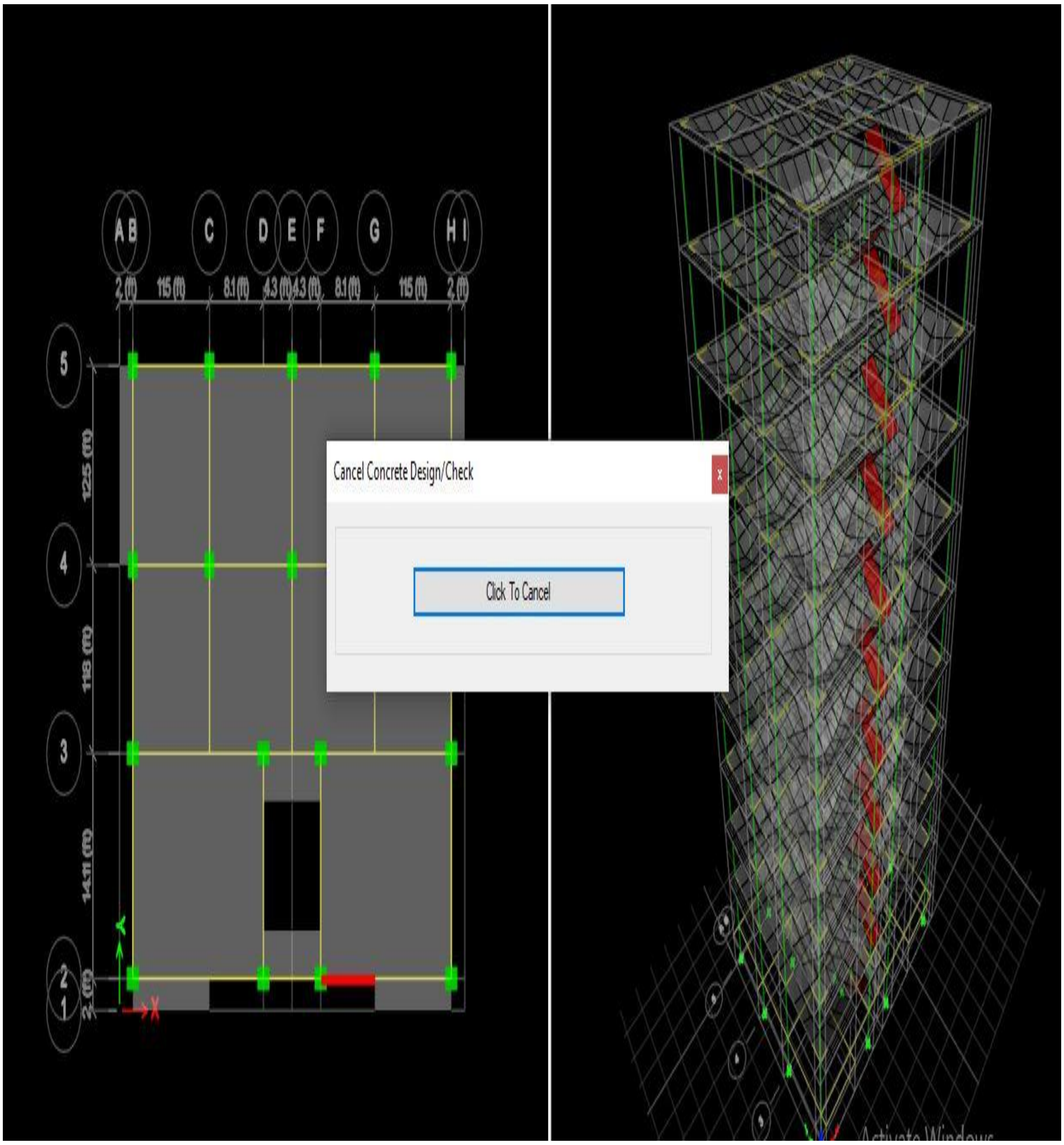


Fig 4.1.7: Analyzing**.**

4.1.8 After Analyze:

After input all the values beam and column run correctly, the beam and column doses not fail.

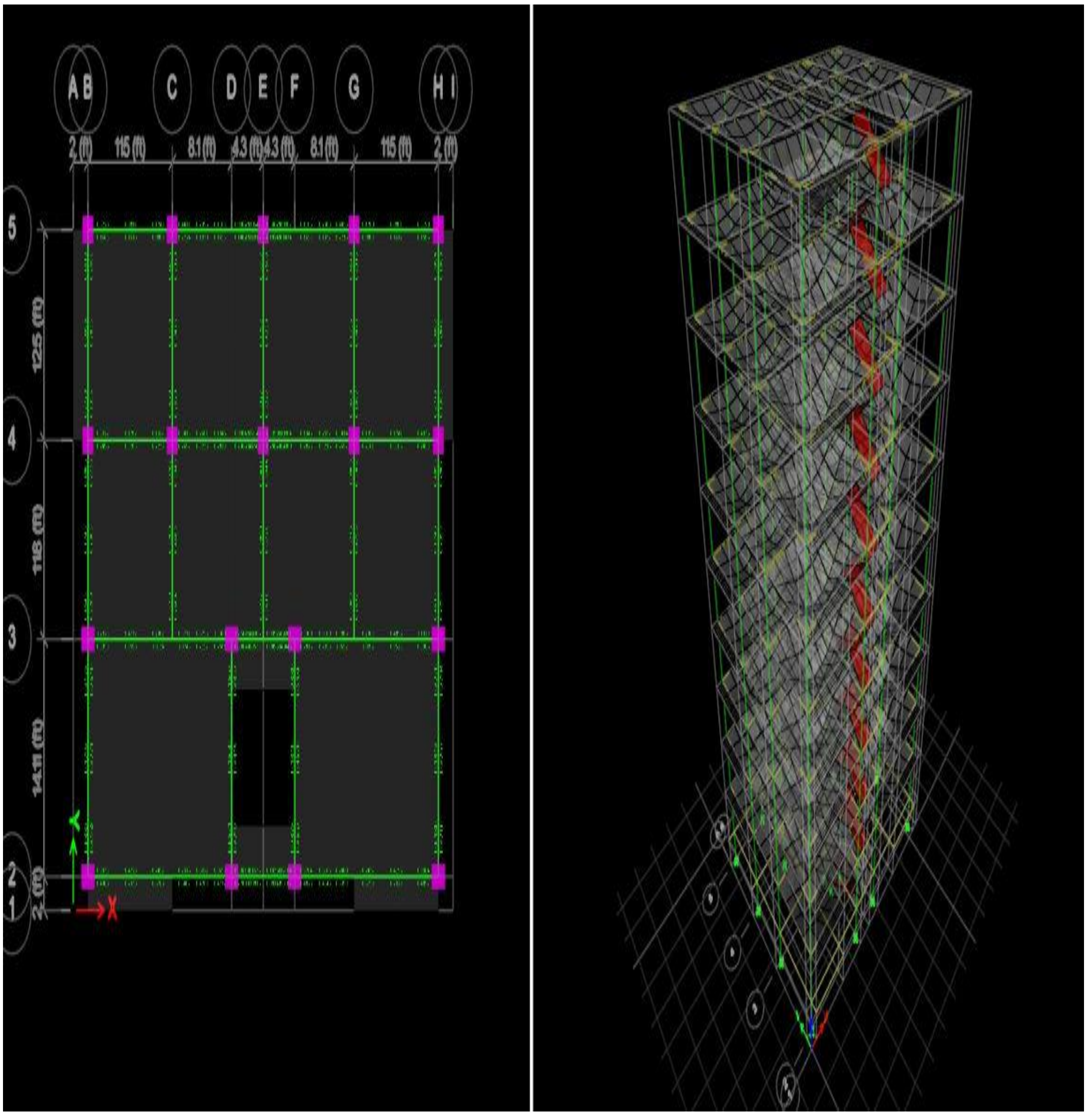
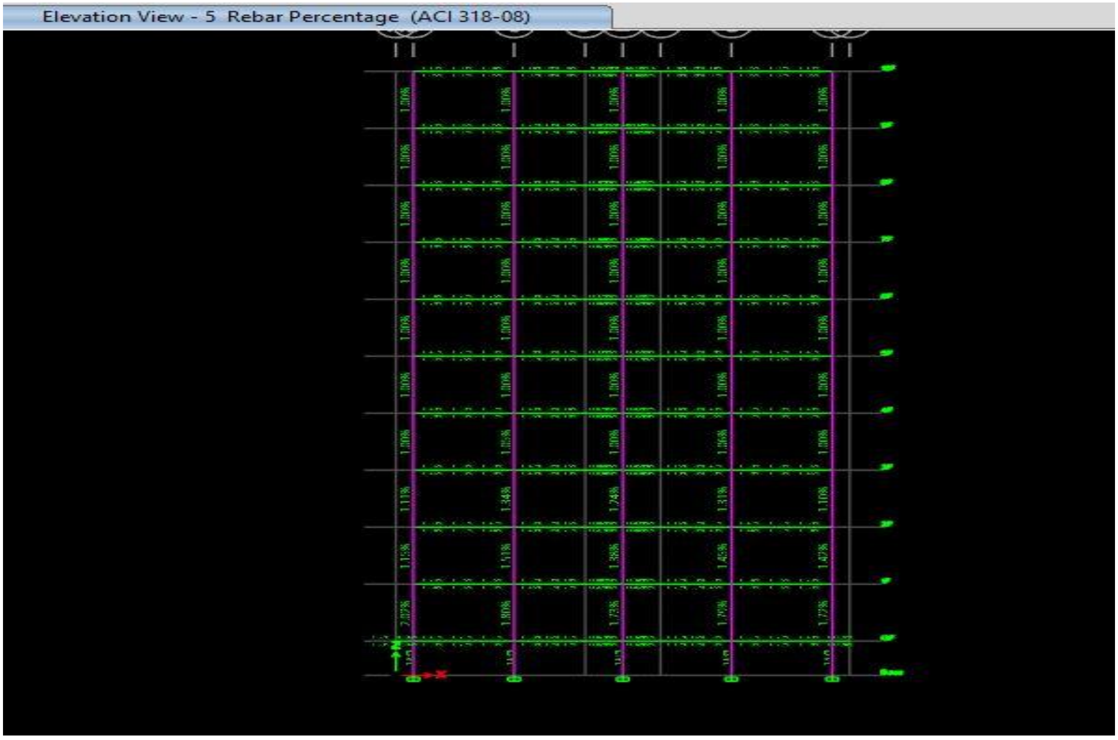


Fig4.1.8: After Analyze.

4.1.9 Column P-M-M Interaction Ratios & Rebar Percentage

To check the rebar percentage are all values is correct and to check column P-M-M interaction ratio.



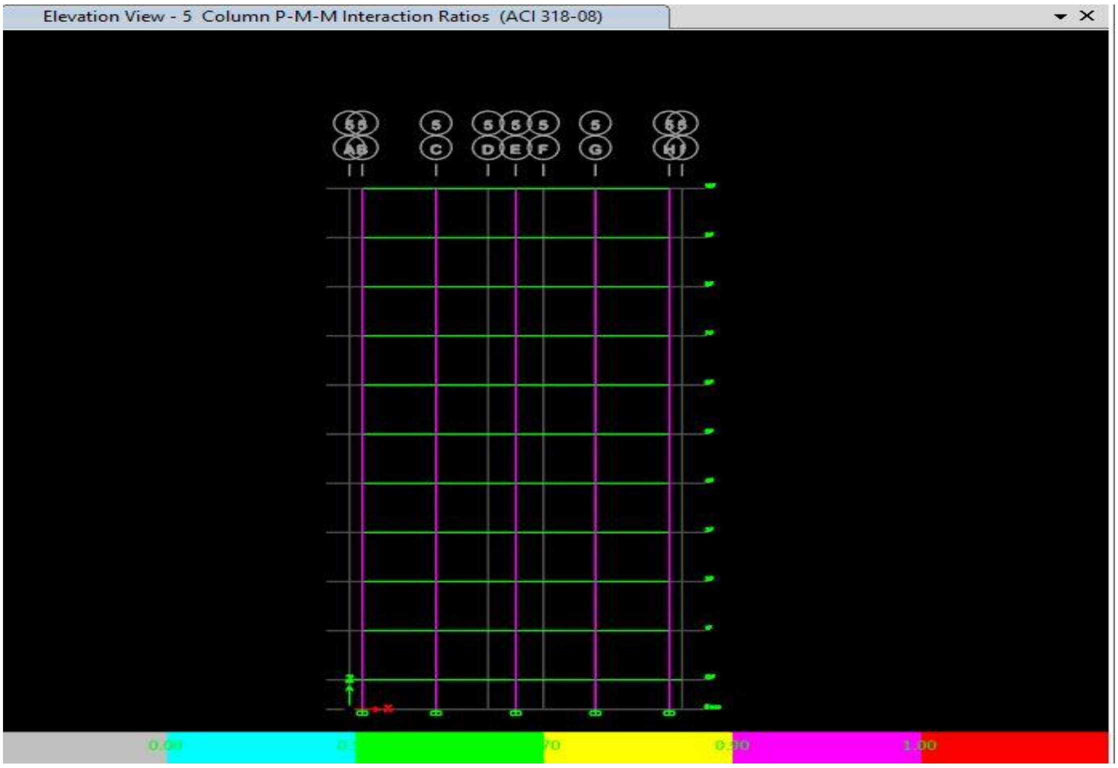


Figure4.1.9: Column P-M-M Interaction Ratios & Rebar Percentage.

4.1.10 Software Modeling, Analysis and Check (Zone-1)

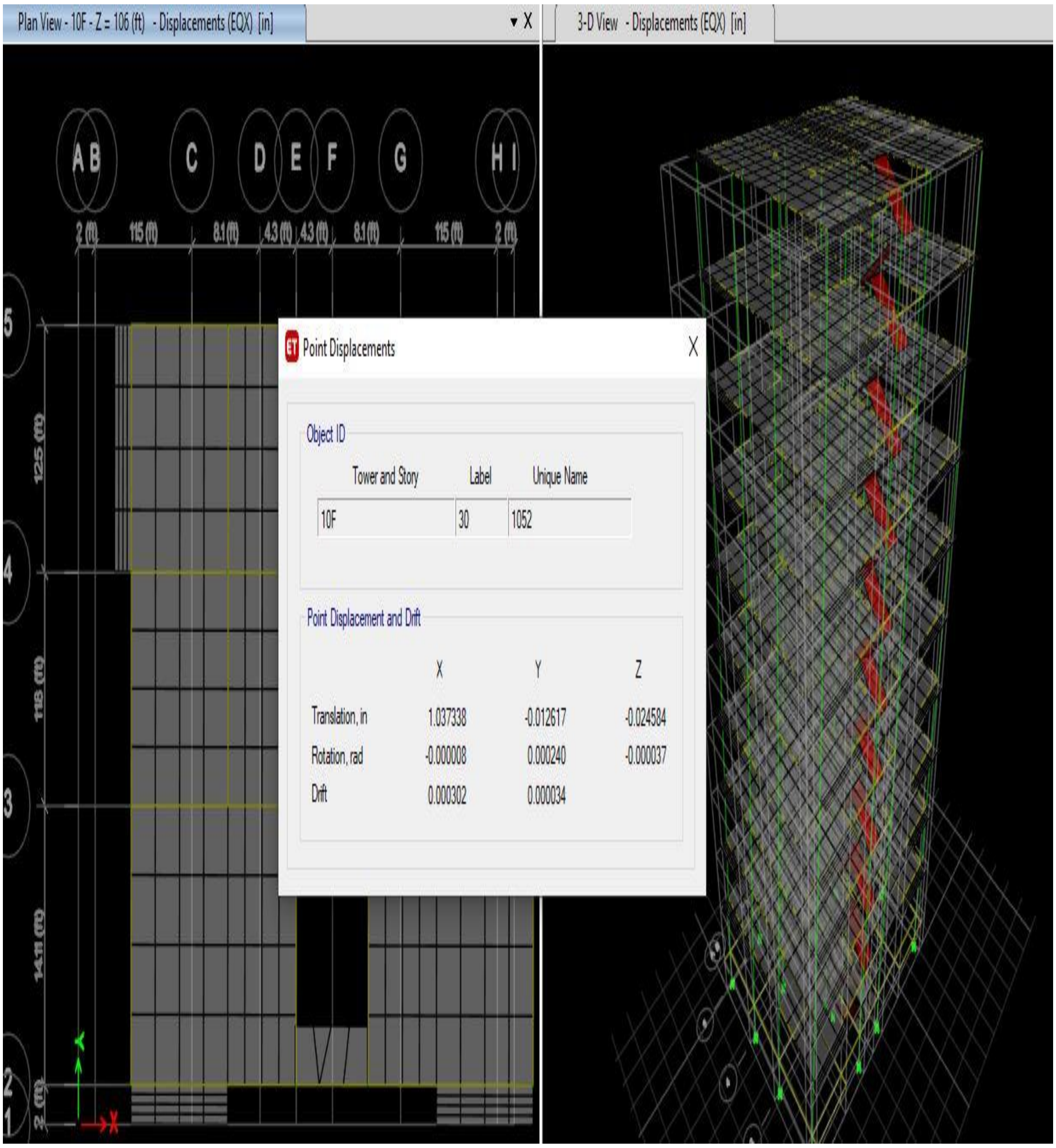


Figure4.1.10: Analysis and Check (Zone-1).

Max point Displacement=1.03 ft

Displacement Shape (EQX –Direction)

4.1.11 Software Modeling, Analysis and Check (Zone-1)

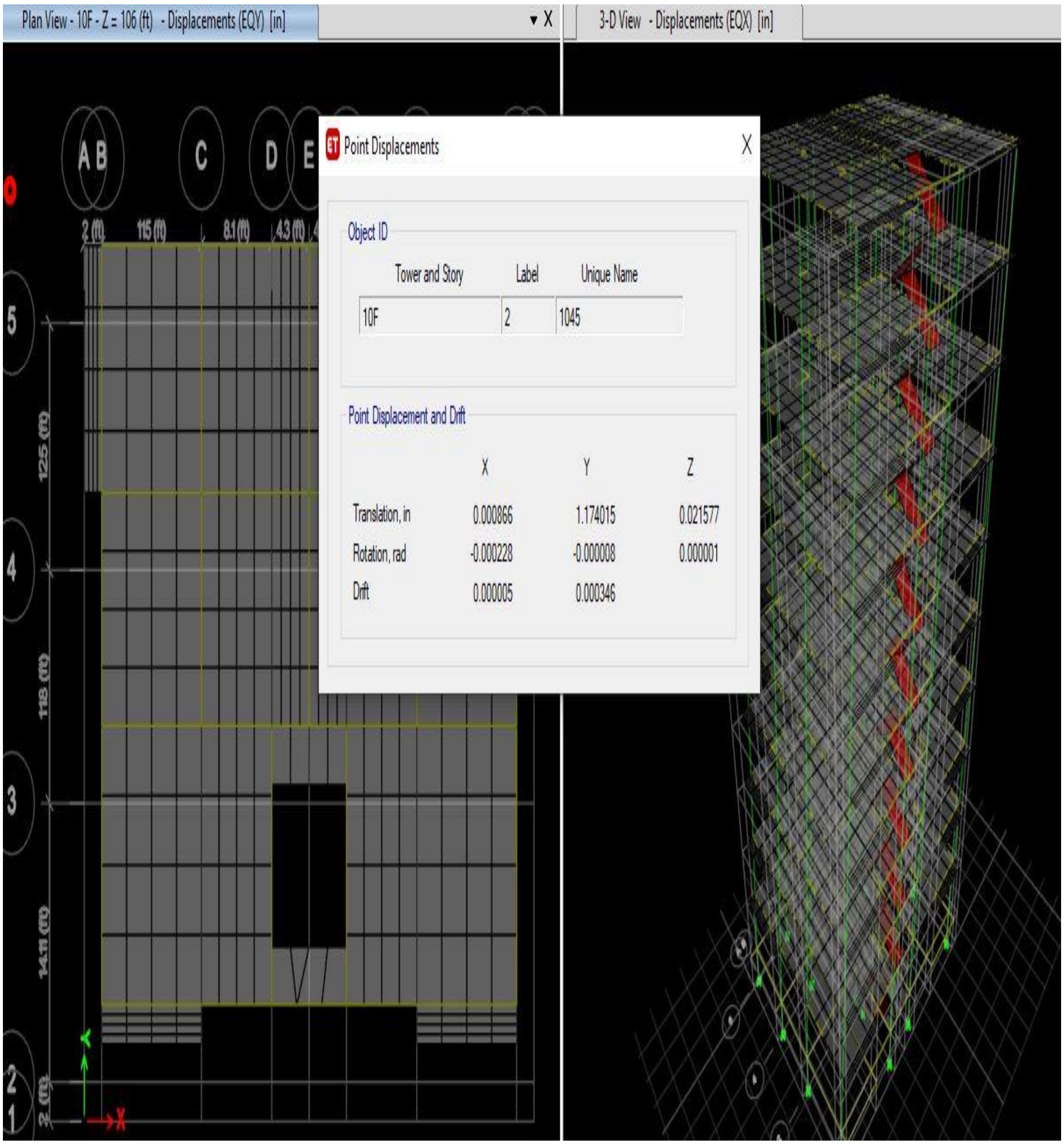


Figure4.1.11: Analysis and Check (Zone-1)

Max point Displacement=1.174 ft

Displacement Shape (EQY –Direction)

4.1.12 Software Modeling, Analysis and Check (Zone-2)

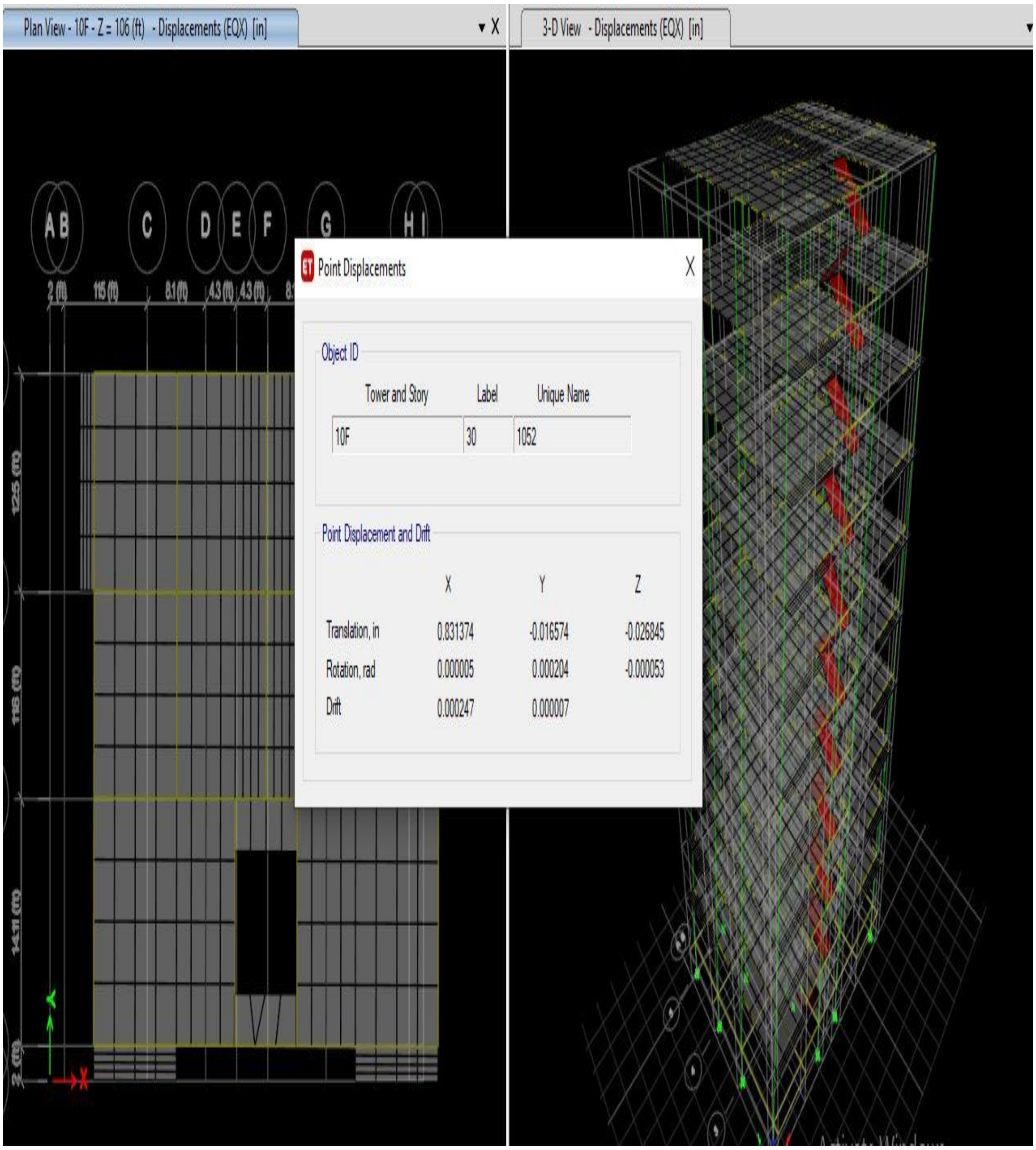


Figure4.1.12: Analysis and Check (Zone-2)

Max point Displacement=0.83 ft

Displacement Shape (EQX –Direction)

4.1.13 Software Modeling, Analysis and Check (Zone-2)

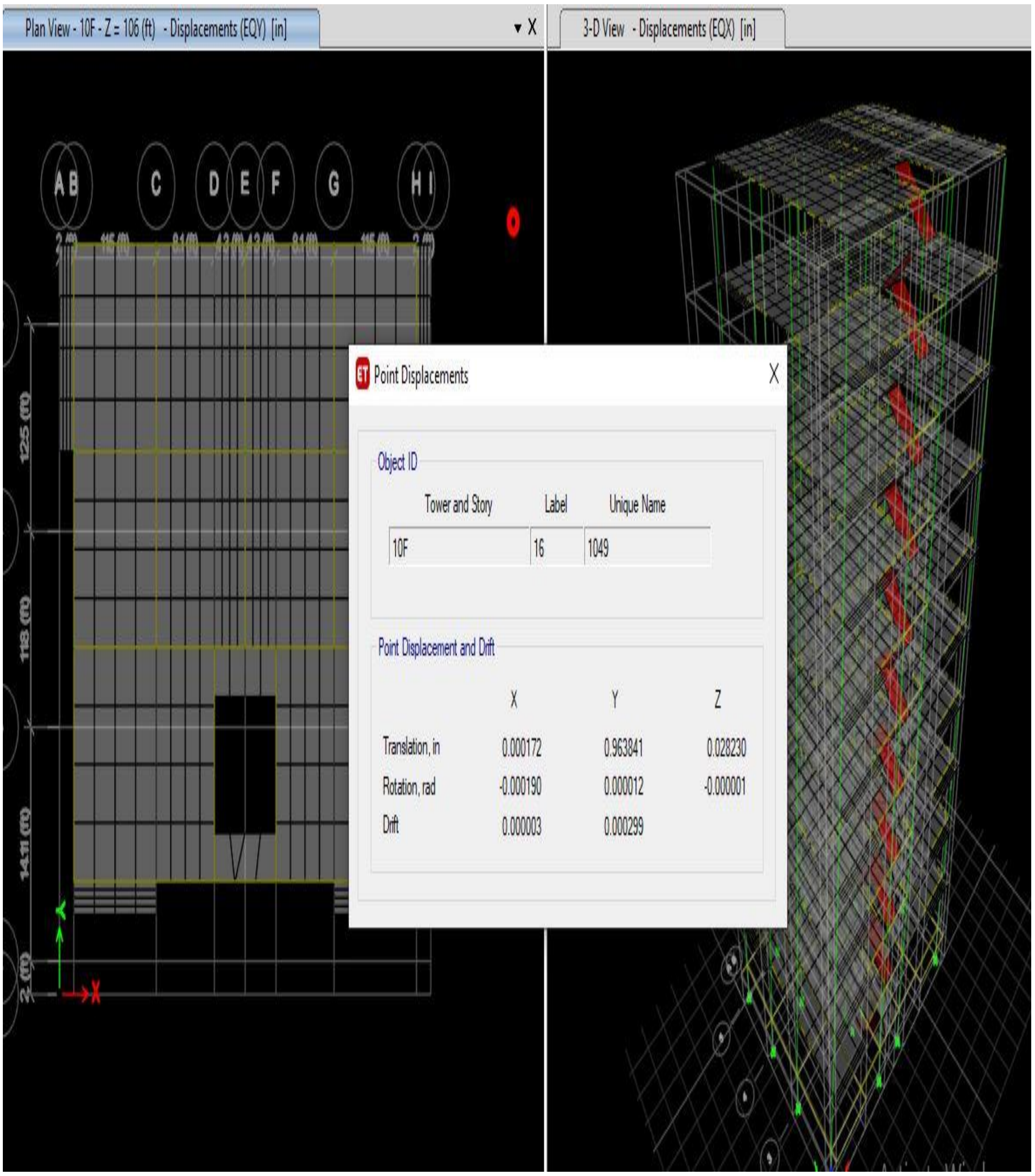


Figure4.1.13: Analysis and Check (Zone-2)

Max point Displacement=0.96 ft

Displacement Shape (EQY –Direction)

4.1.14 Software Modeling, Analysis and Check (Zone-3)

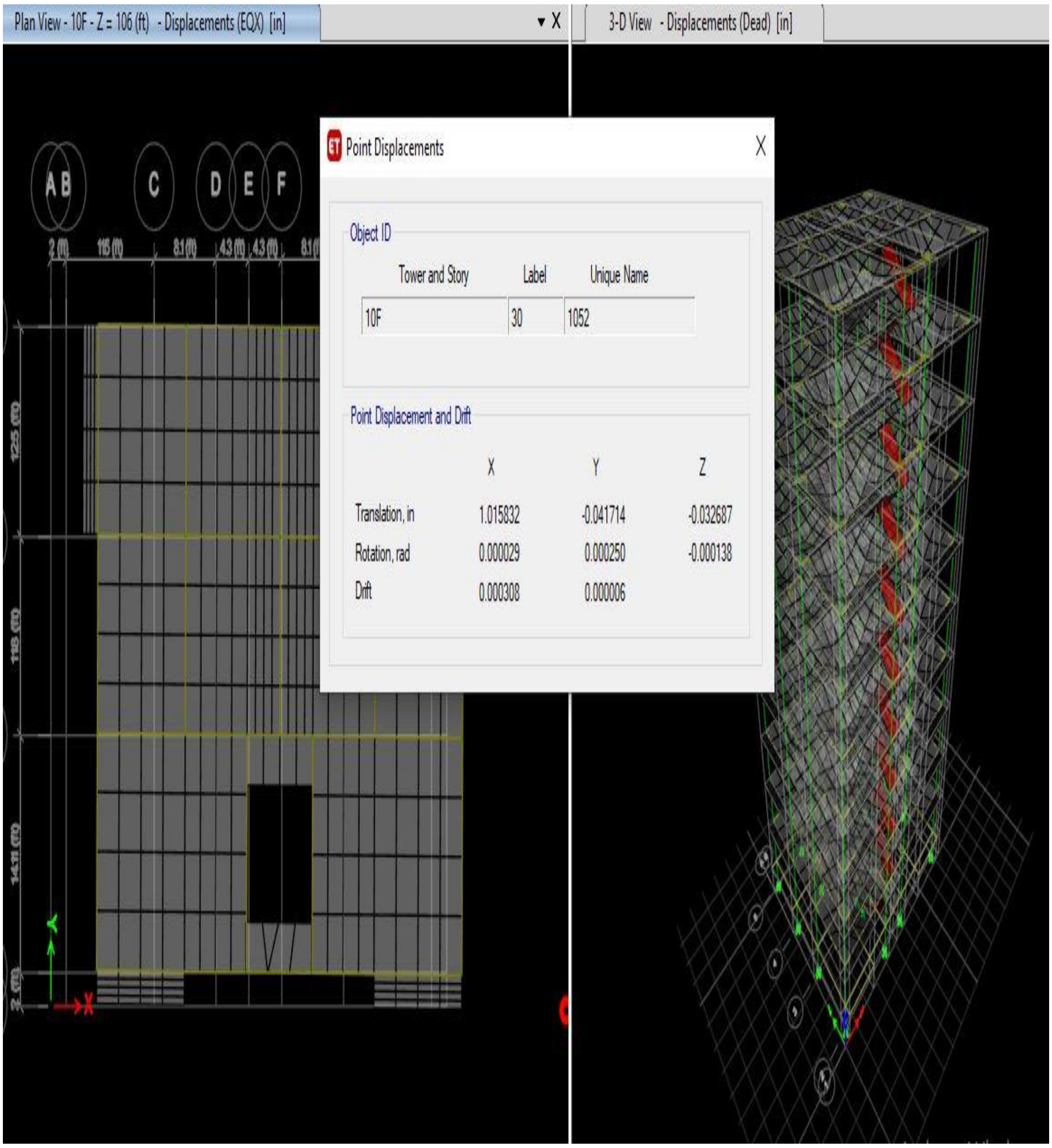


Figure4.1.14: Analysis and Check (Zone-3)

Max point Displacement=1.01 ft

Displacement Shape (EQX –Direction)

4.1.15 Software Modeling, Analysis and Check (Zone-3)

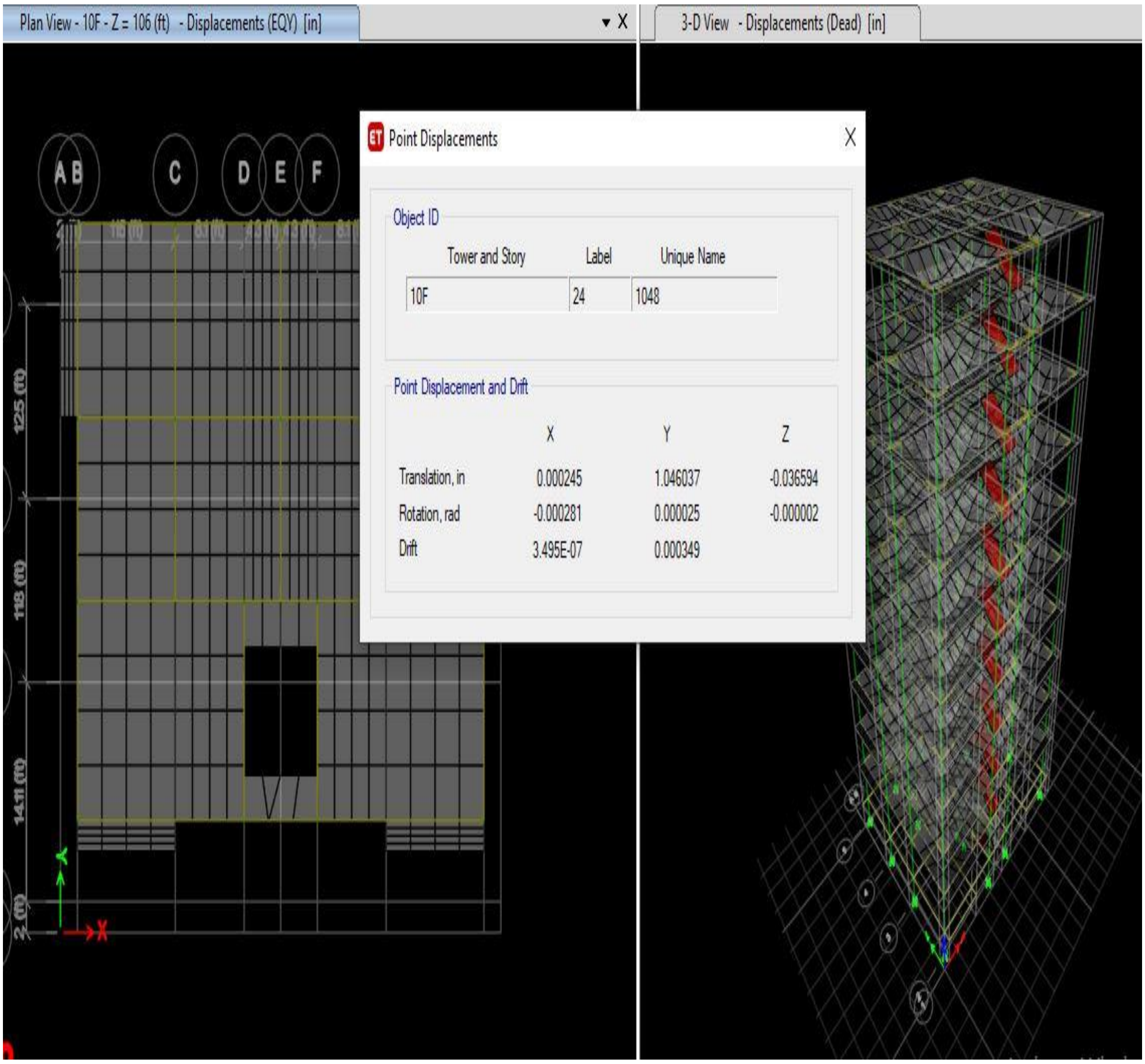


Figure4.1.15: Analysis and Check (Zone-3)

Max point Displacement=1.04 ft

Displacement Shape (EQY –Direction)

4.1.16 Software Modeling, Analysis and Check (Zone-4)

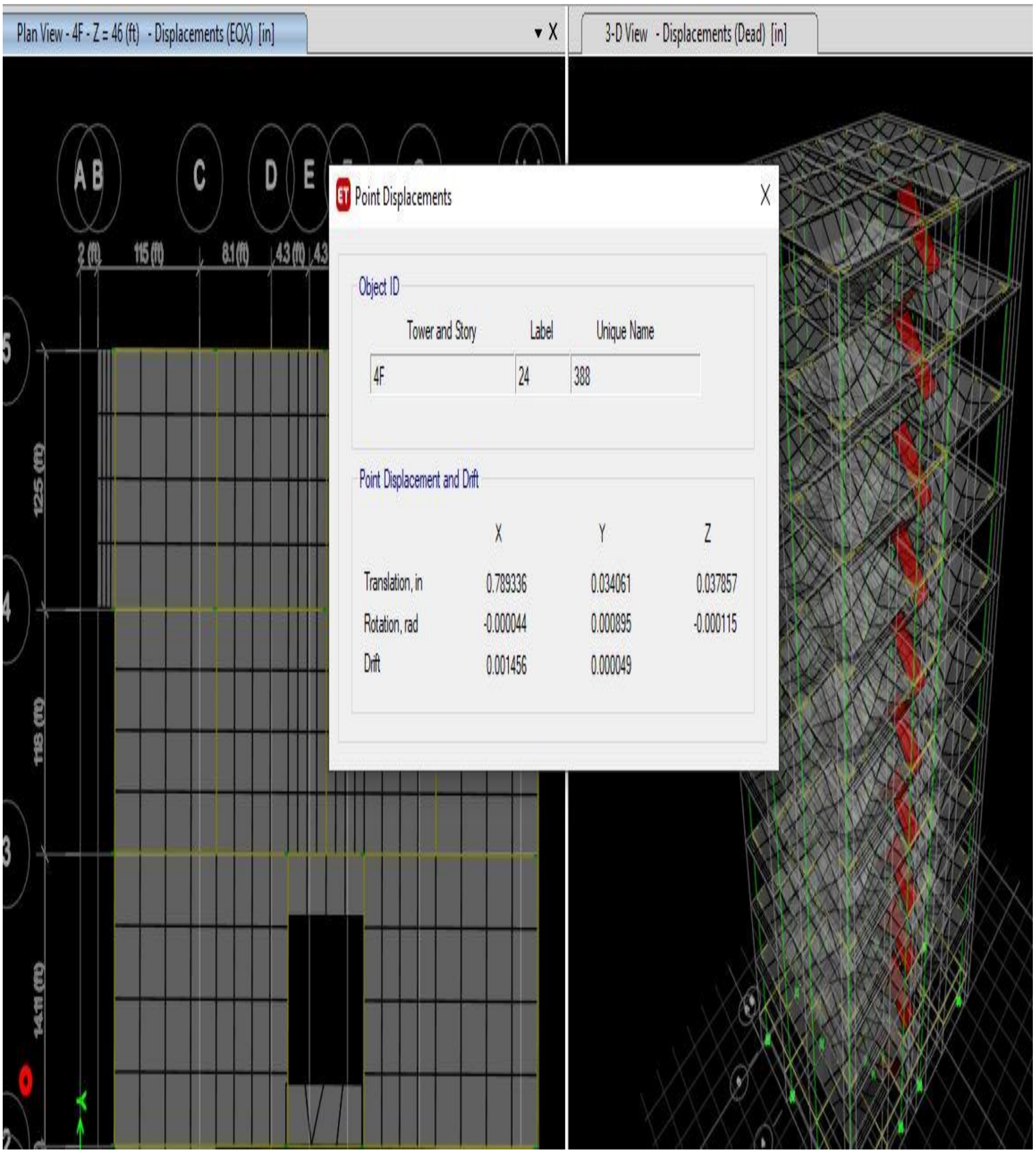


Figure4.1.16: Analysis and Check (Zone-4)

Max point Displacement= 0.78 ft

Displacement Shape (EQX –Direction)

4.1.17 Software Modeling, Analysis and Check (Zone-4)

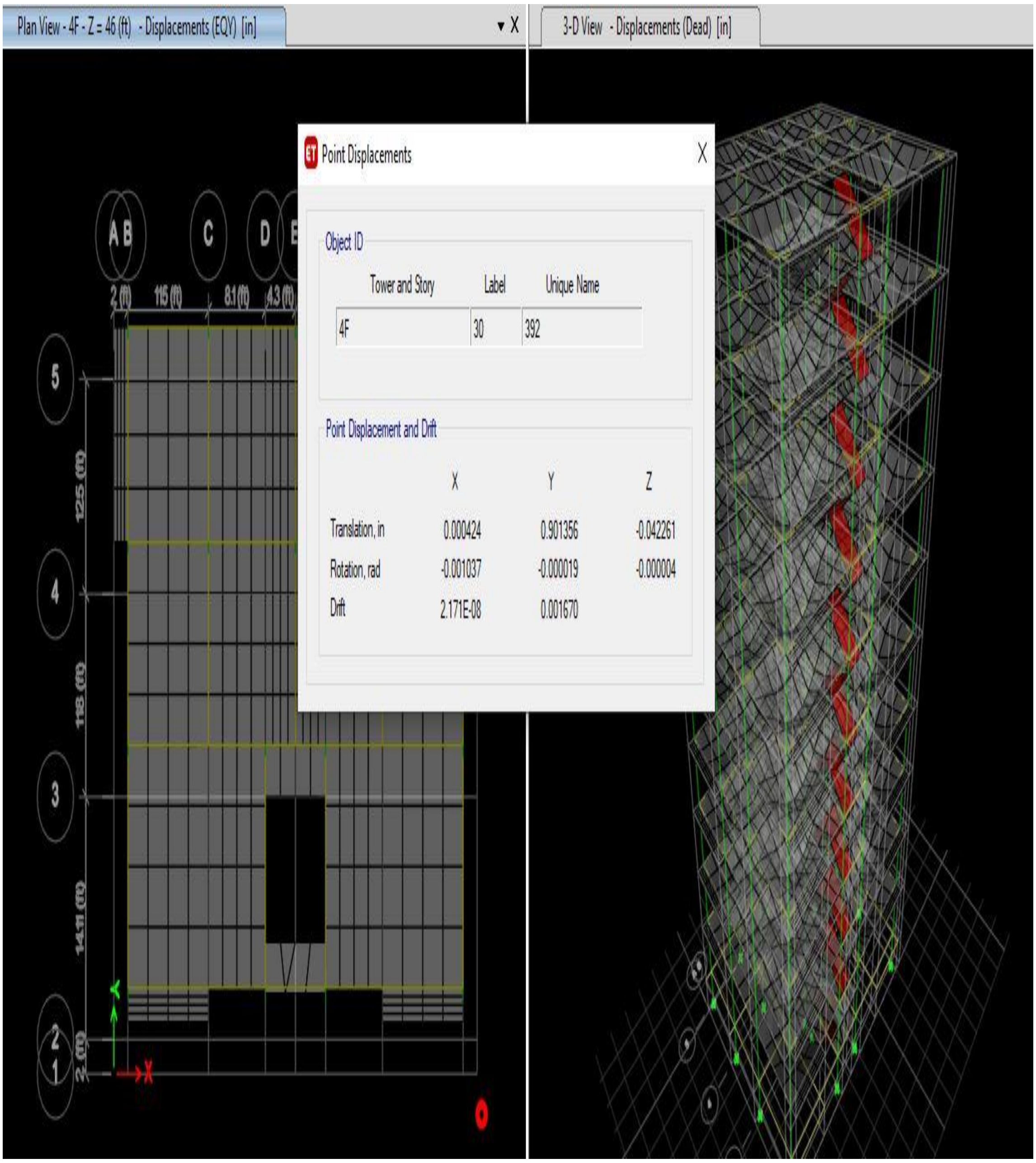


Figure4.1.17: Analysis and Check (Zone-4)

Max point Displacement=0.90 ft

Displacement Shape (EQY –Direction)

4.1.18 Ten Storied Building Drift Details

Building story drift is the sideways deflection of the upper floor relative to the sideways deflection of the bottom floor for a given story. It can also be defined as the sideways or lateral deflection between two adjacent stories.

4.1.19 Barisal (Zone I)

Floors	Drift X	Drift Y
Roof	0.000363	0.000352
9F	0.00051	0.000522
8F	0.000642	0.00069
7F	0.000764	0.000846
6F	0.000872	0.000986
5F	0.000978	0.001109
4F	0.00107	0.001213
3F	0.00114	0.001292
2F	0.001177	0.001333
1F	0.001058	0.001197
GF	0.00041	0.000471

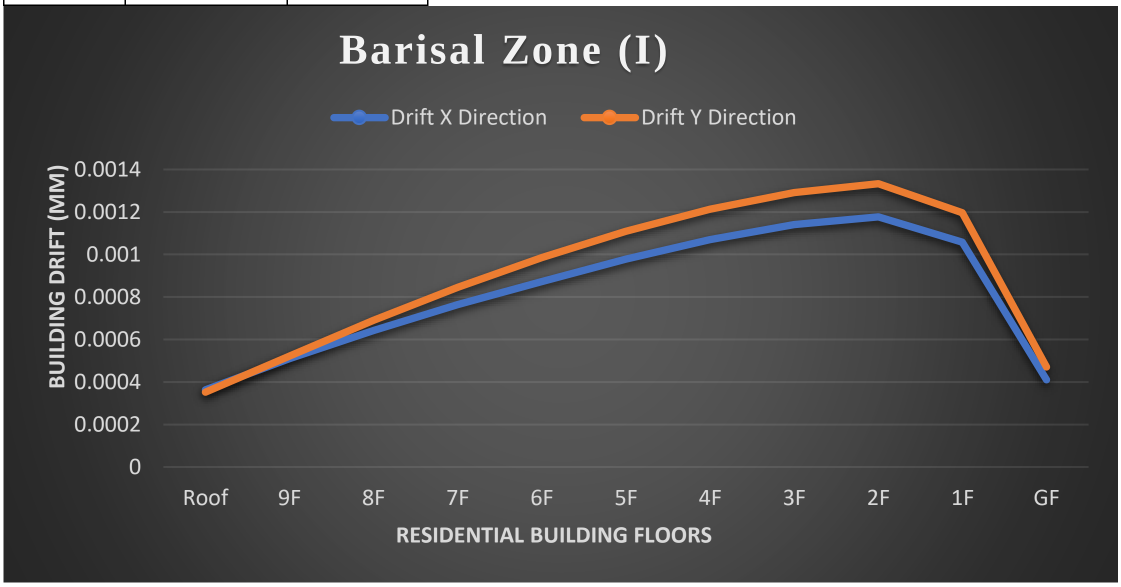


Fig 4.1.19 Drift Graph of Barisal Zone I

The highest drift in X axis is 2nd Floor (0.001177 mm) and the lowest drift is Roof (0.000363 mm).

The highest drift in Y axis is 2nd Floor (0.001333 mm) and the lowest drift is Roof (0.000352 mm).

4.1.20 Dhaka (Zone II)

Floors	Drift X	Drift Y
Roof	0.000263	0.000299
9F	0.000381	0.000438
8F	0.000488	0.00057
7F	0.000593	0.000692
6F	0.000689	0.000801
5F	0.000773	0.000896
4F	0.000843	0.000975
3F	0.000897	0.001036
2F	0.000931	0.001075
1F	0.000888	0.001022
GF	0.000353	0.000408

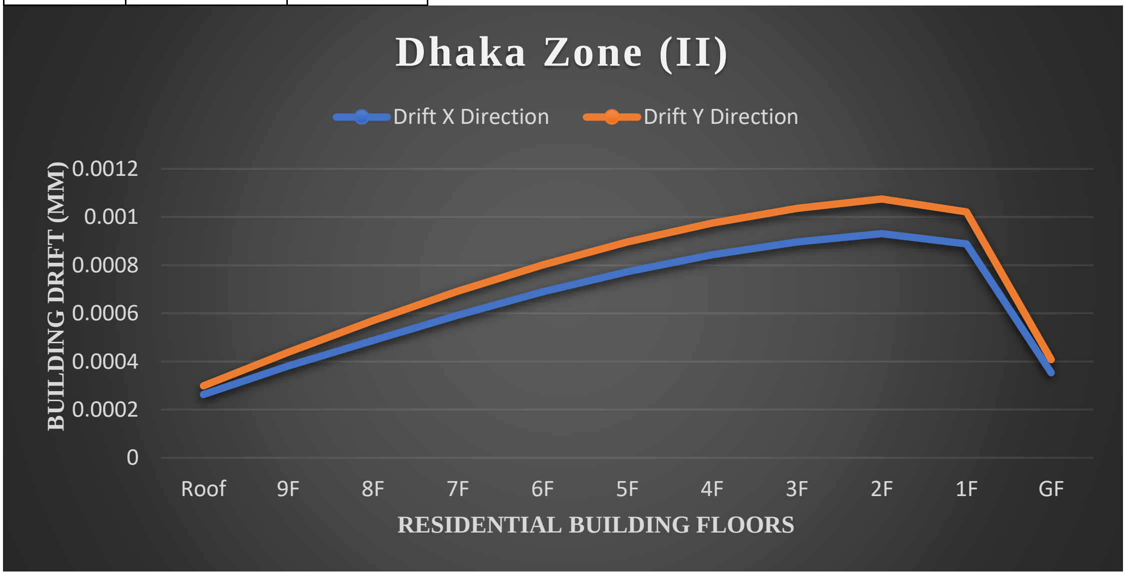


Fig 4.1.20 Drift Graph of Dhaka Zone II

The highest drift in X axis is 2nd Floor (0.000931mm) and the lowest drift is Roof (0.000263 mm)

The highest drift in Y axis is 2nd Floor (0.001075 mm) and the lowest drift is Roof (0.000299 mm)

4.1.21 Chittagong (Zone III)

Floors	Drift X	Drift Y
Roof	0.000308	0.000352
9F	0.000457	0.000499
8F	0.000599	0.000638
7F	0.000729	0.000765
6F	0.000846	0.000878
5F	0.000947	0.000975
4F	0.001032	0.001055
3F	0.001096	0.001114
2F	0.001137	0.001149
1F	0.001068	0.00106
GF	0.00041	0.000406

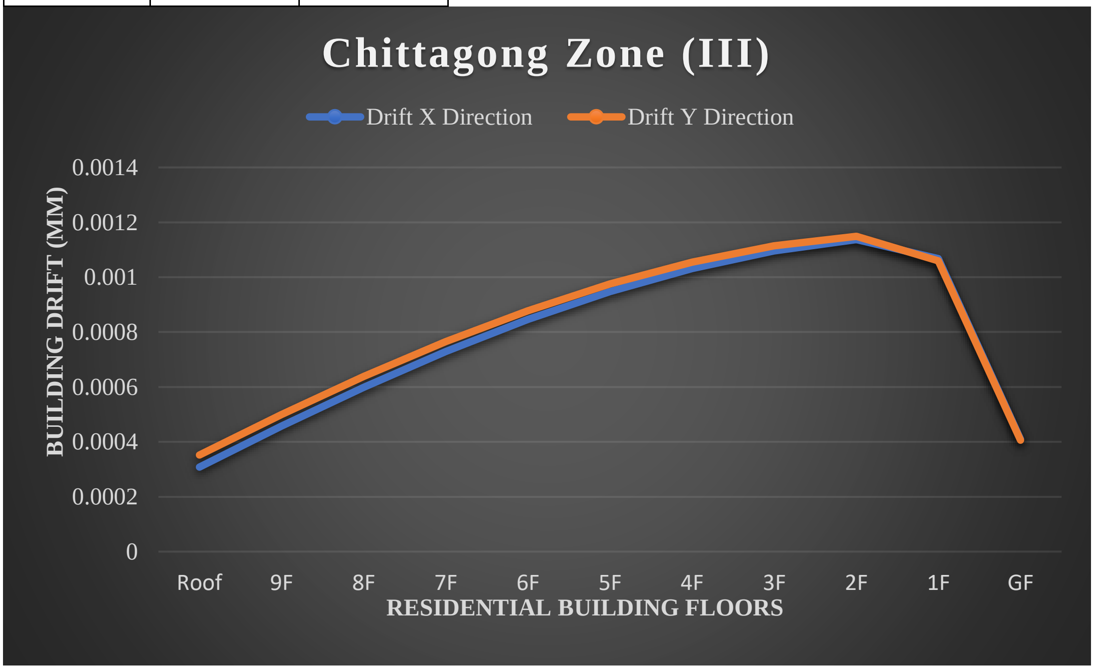


Fig 4.1.21 Drift Graph of Chittagong Zone III

The highest drift in X axis is 2nd Floor (0.001137 mm) and the lowest drift is Roof (0.000308 mm)

The highest drift in Y axis is 2nd Floor (0.001149 mm) and the lowest drift is Roof (0.000352 mm)

4.1.22 Sylhet (Zone IV)

Floors	Drift X	Drift Y
Roof	0.000439	0.000526
9F	0.000643	0.000763
8F	0.000843	0.000988
7F	0.001027	0.001194
6F	0.001192	0.001379
5F	0.001336	0.001538
4F	0.001456	0.00167
3F	0.001548	0.001772
2F	0.001608	0.001841
1F	0.001579	0.001801
GF	0.000644	0.000743

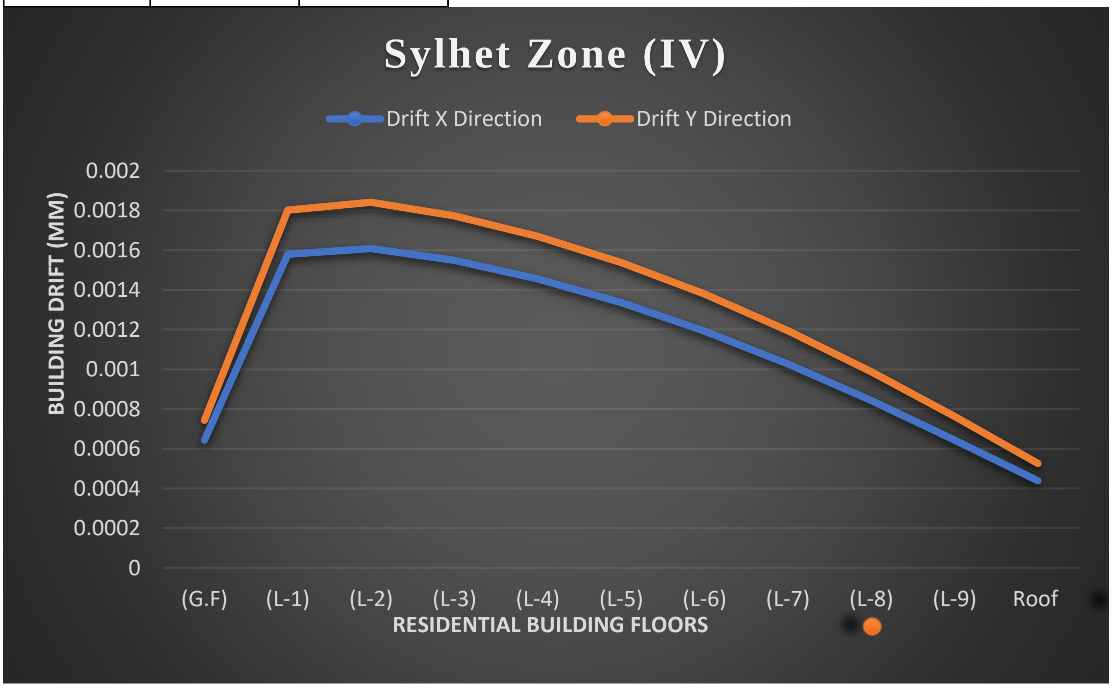


Fig 4.1.22 Drift Graph of Sylhet Zone IV

The highest drift in X axis is 2^{nd} Floor (0.001608 mm) and the lowest drift is Roof (0.000439 mm)

The highest drift in Y axis is 2^{nd} Floor (0.001608 mm) and the lowest drift is Roof (0.000526 mm)

4.1.23 Overall drift Graph in One Glance for all Zones:

Drift is detected by monitoring its statistical properties. It defines the slow change in the response of gauge. Story drift is the displacement of one level related to the other level above or below. Here all drift limit is considered according to seismic and wind forces including the combination of loads mentioned earlier. The variance in different floors happen due to the seismic provision of the structure. Although the variation between the Load Combination & Direct Load case is not much.

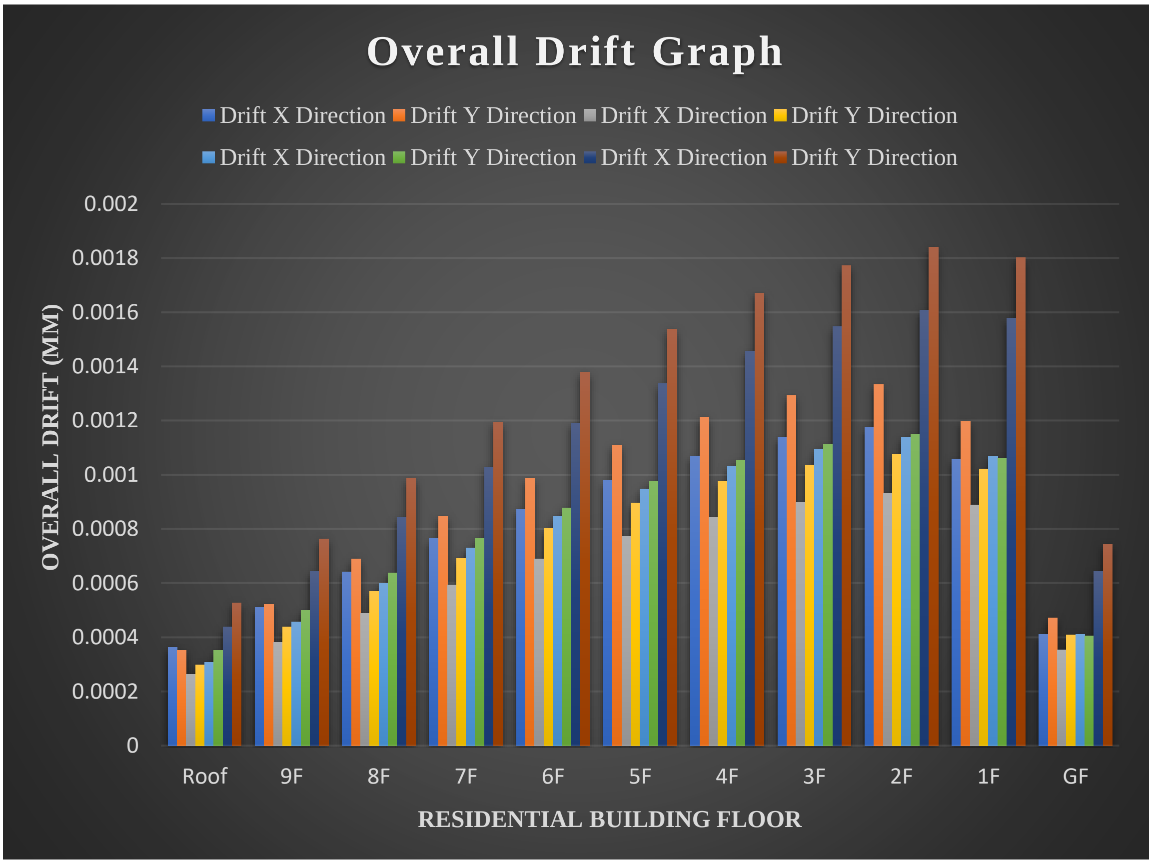


Fig 4.1.23 Overall Drift Graph for all Zones

The highest overall drift in EX axis is 2nd Floor (0.001177 mm) in Barisal Zone I

The highest overall drift in EY axis is 2nd Floor (0.001333 mm) in Barisal Zone I

The highest overall drift in EX axis is 2nd Floor (0.000931mm) in Dhaka Zone II

The highest overall drift in EY axis is 2nd Floor (0.001075 mm) in Dhaka Zone II

The highest overall drift in EX axis is 2nd Floor (0.001137 mm) in Chittagong Zone III

The highest overall drift in EY axis is 2nd Floor (0.001149 mm) in Chittagong Zone III

The highest overall drift in EX axis is 2nd Floor (0.001608 mm) in Sylhet Zone IV

The highest overall drift in EY axis is 2nd Floor (0.001608 mm) in Sylhet Zone IV

4.1.24 Overall Highest Drift & Overall Lowest Drift:

Overall Highest Drift		**Overall Lowest Drift**	
EX direction	**EY direction**	**EX direction**	**EY direction**
Sylhet Zone IV	Sylhet Zone IV	Dhaka Zone I	Barisal Zone I
2nd Floor (0.001608 mm)	2nd Floor (0.001608 mm)	2nd Floor (0.000931mm)	2nd Floor (0.001075 mm)

4.1.25 Building Displacement:

4.1.26 Barisal Zone I:

Floors	EX	EY
Roof	26.348	29.833
9F	25.427	28.766
8F	24.037	27.196
7F	22.192	25.112
6F	19.924	22.551
5F	17.277	19.561
4F	14.296	16.193
3F	11.035	12.507
2F	7.561	8.573
1F	3.975	4.51
GF	0.75	0.863

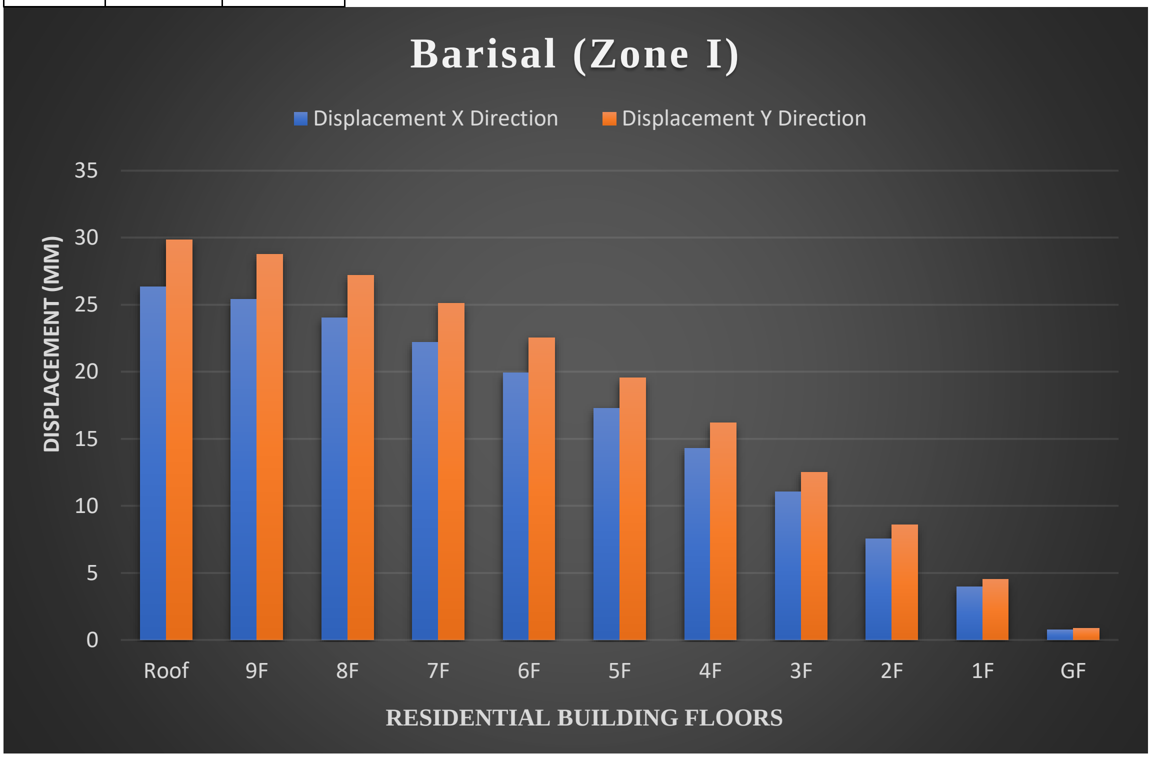


Fig 4.1.26 Displacement Graph of Barisal Zone I

The Highest Displacement in EX direction is Roof floor (26.348) and the lowest in ground floor (0.75)

The Highest Displacement in EY direction is Roof floor (29.833) and the lowest in ground floor (0.863)

4.1.27 Dhaka (Zone II):

Floors	EX	EY
Roof	21.117	24.489
9F	20.365	23.587
8F	19.239	22.263
7F	17.759	20.533
6F	15.952	18.431
5F	13.851	15.995
4F	11.494	13.267
3F	8.923	10.297
2F	6.19	7.139
1F	3.353	3.862
GF	0.654	0.747

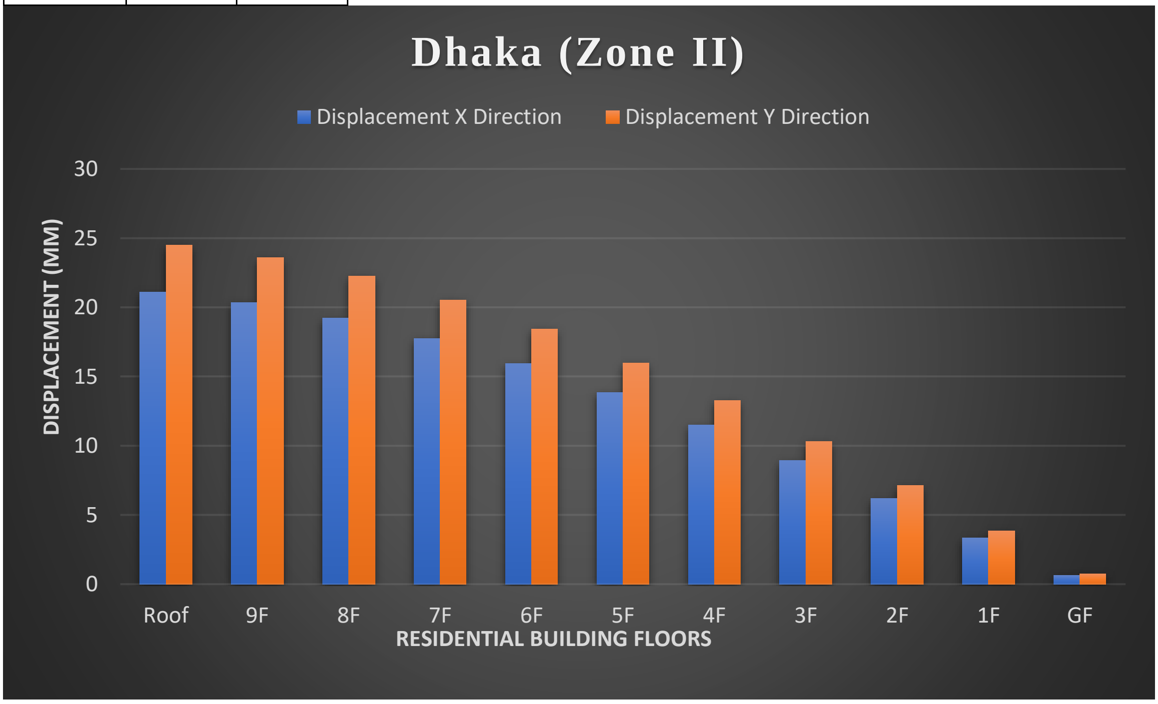


Fig 4.1.27 Displacement Graph of Dhaka Zone II

The Highest Displacement in EX direction is Roof floor (21.117) and the lowest in ground floor (0.654)

The Highest Displacement in EY direction is Roof floor (24.489) and the lowest in ground floor (0.747)

4.1.28 Chittagong Zone III:

Floors	EX	EY
Roof	25.802	26.571
9F	24.863	25.506
8F	23.469	23.995
7F	21.644	22.057
6F	19.422	19.731
5F	16.845	17.057
4F	13.958	14.086
3F	10.813	10.87
2F	7.472	7.475
1F	4.005	3.973
GF	0.769	0.744

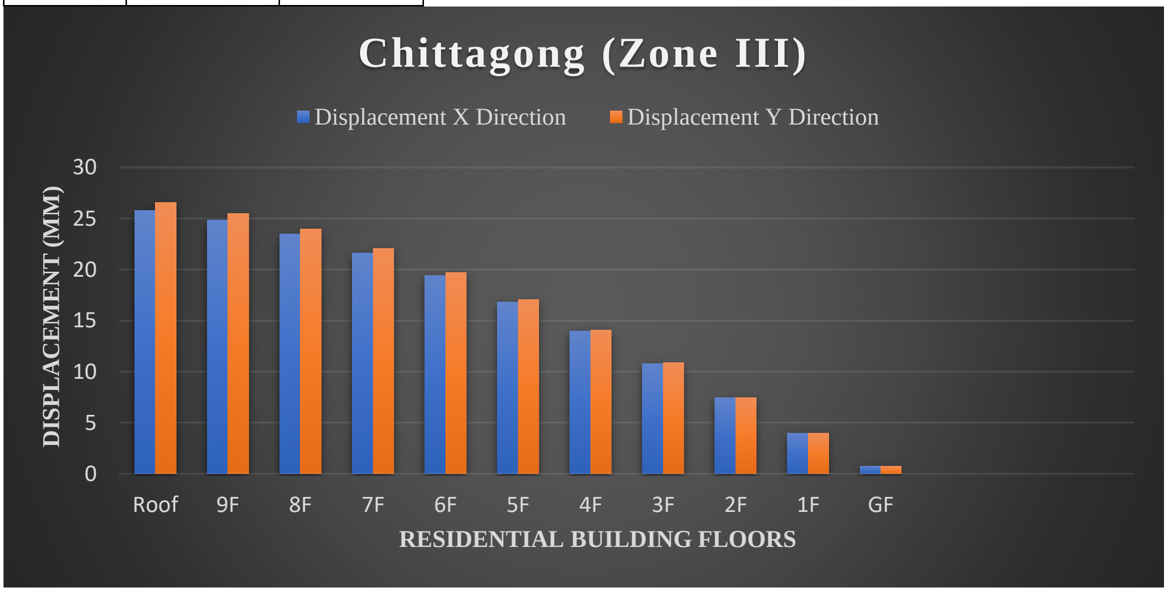


Fig 4.1.28 Displacement Graph of Chittagong Zone III

The Highest Displacement in EX direction is Roof floor (21.117) and the lowest in ground floor (0.654) The Highest Displacement in EY direction is Roof floor (24.489) and the lowest in ground floor (0.747)

4.1.29 Sylhet Zone IV:

Floors	EX	EY
Roof	36.728	42.36
9F	35.412	40.77
8F	33.453	38.461
7F	30.884	35.462
6F	27.755	31.832
5F	24.121	27.637
4F	20.049	22.952
3F	15.612	17.861
2F	10.894	12.459
1F	5.992	6.849
GF	1.192	1.36

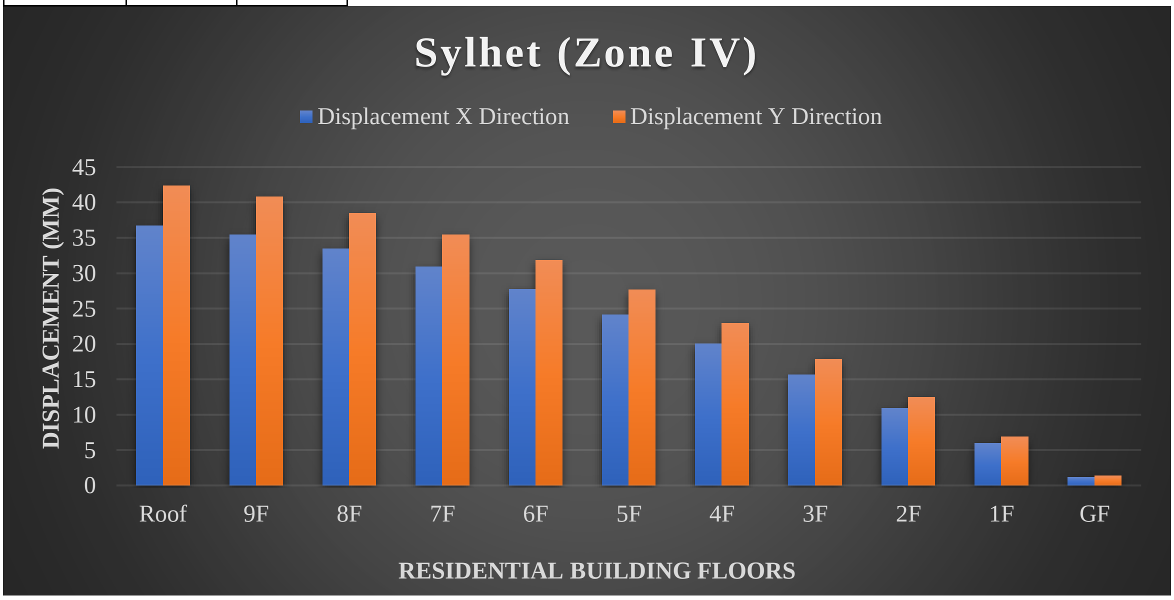


Fig 4.1.29 Displacement Graph of Sylhet Zone IV

The Highest Displacement in WX direction is Roof floor (36.728) and the lowest in ground floor (1.192)
The Highest Displacement in WY direction is Roof floor (42.36) and the lowest in ground floor (1.36)

4.1.30: Ten Storied Building Displacement Overall Data:

Zone	EX (Max)	EY (Max)
Barisal (Zone I)	26.348	29.833
Dhaka (Zone II)	21.117	24.489
Chittagong (Zone III)	25.802	26.571
Sylhet (Zone IV)	36.728	42.36

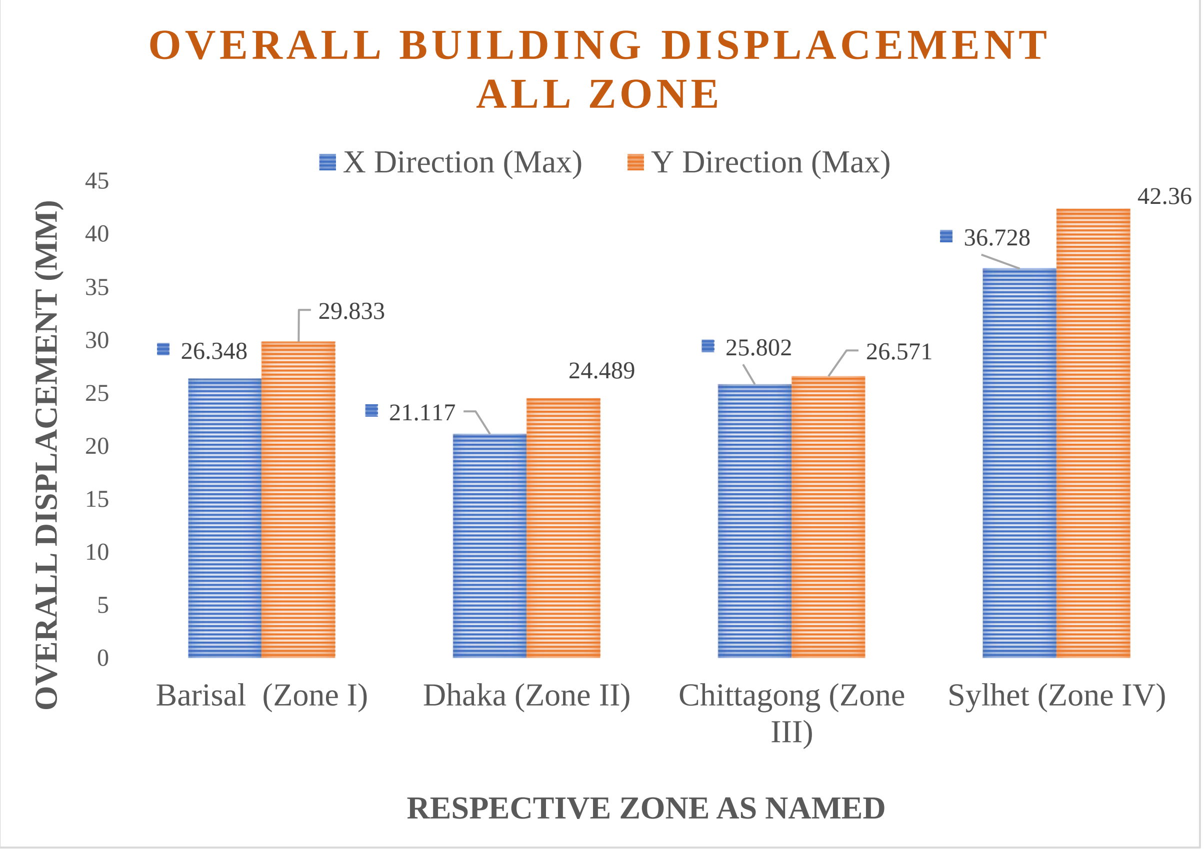


Fig 4.1.30 Overall Displacement Graph.

Overall Highest Displacement		Overall Lowest Displacement	
EX direction	EY direction	EX direction	EY direction
Sylhet zone iv	Sylhet zone iv	Dhaka zone ii	Dhaka zone ii
36.728 mm	42.36 mm	21.117 mm	24.489 mm

The design is OK for all zones

EX= Earthquake in X Direction
EY= Earthquake in Y Direction

4.1.31 Base Shear Reaction of the Building by ETABS 2020

Base shear is an estimate of the maximum expected lateral force on the **base** of the structure due to seismic activity. The highest base reaction is Fz=312.15 and the lowest base reaction value is Fz= 128.45.

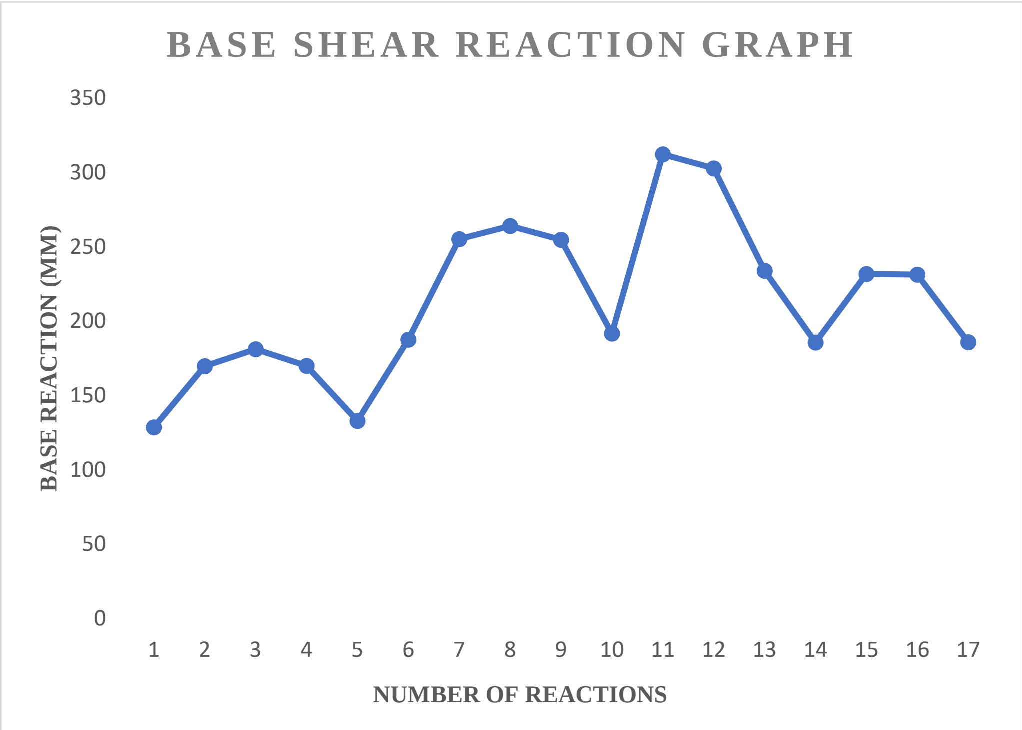


Fig 4.1.31 Base Shear Reaction Graph of Building

The Highest Base Shear Reaction is seen in 11th Number, value=312.15.

The Lowest Base Shear Reaction is seen in 1 Number, value=128.45.

CHAPTER 5

Conclusions and Future Works

5.1.1 Conclusion:

The following conclusions can be made for future research work,

(i) Maximum point displacement is found from this work is EX=26.348, EY=29.833and EX=21.117, EY=24.489and EX=25.802.EY=26.571 and EX=36.728, EY=42.36 for Zone-1, Zone-2, Zone-3, Zone-4 respectively.

(ii) Maximum point drift is found from this work is EX=0.001177, EY=0.001333, EX=0.000931, EY=0.001075, EX=0.001137.EY=0.001149 and EX=0.001149, EY=0.001149 for Zone-1, Zone-2, Zone-3, Zone-4 respectively.

(iii) The Highest Base Shear Reaction is seen in 11^{th} Number, value=312.15
The Lowest Base Shear Reaction is seen in 1 Number, value=128.45

(iv) From the Result it is found that among four Different Zone Maximum Displacement at Zone-IV.

(v) From the Result it is found that among four Different Zone Maximum Drift at Zone-IV.

Proposal: Chittagong Zone III is the second-best area for building ten-story residential structures. This will help to reduce population density in Dhaka Zone II in the future.

5.2.1 Recommendations & Limitations: -

Structural codes (BNBC) should be followed properly while doing analysis on ETABS.

In this research no shear wall was considered. So in further study, shear wall can be considered for better seismic analysis.

3. Similar study can be performed for other types of buildings such as steel frames, ordinary moment resisting frames and masonry structures etc. located in different in places with different site conditions.

4. This study helps to analysis any high-rise building.

5. Shake table Analysis can be performed for experimental seismic analysis.

6. More representative earthquake data should be considered for analyzing the structures and to compare the resulting structural responses.

7. Continuity of study on higher vertical structures in different seismic zones of Bangladesh.

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