

ANALYSIS OF MULTI STOREYED RESIDENTIAL BUILDING USING ETABS SOFTWARE

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The thesis titled “**Analysis of Multi Storeyed Residential Building by Using ETABS Software**” submitted by Sajal Kanti Das , Md. Faisal Ahmed , Abdus Salam have been accepted as satisfactory in partial fulfillment of the requirement for the degree of Bachelor of Science in Civil Engineering on December 2021.

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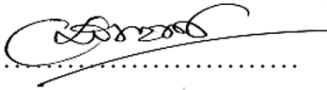
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DECLARATION

The dissertation "**Analysis of Multi Storeyed Residential Buildings Using ETABS Software**" was completed under the supervision of **J. M. Raisul Islam Shohag (Lecturer)**, Department of Civil Engineering, Daffodil International University, Dhaka, Bangladesh, and was accepted in partial fulfillment of the requirement for the Bachelor of Science in Civil Engineering. The capstone contains no elements previously published or written by another individual, to the best of our knowledge and belief, except where due reference is made in the capstone itself..

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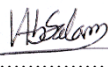
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**Dedicated
To
Almighty ALLAH
& Our Parents**

ABSTRACT

The analysis of a multi-story residential building using ETABS software was explored in this work. And, according to BNBC 2017, we compared four parameters between storeys. The core methodology used here is a sequential presentation of UBC1994, BNBC 2017, and potential places in Bangladesh's study and design of a ten-story skyscraper for earthquake and wind effects. Jessore (zone-1) has been chosen for this purpose. For the analysis and design, ETABS 2017 was used. In Jessore, an upper construction for a ten-story building has been designed (zone-1). After optimization, the sizes of various structural parts are determined. The ETABS 2017 program is used to create the building model for analysis and design. For the purpose of analysis, various parameters such as shear force, bending moment, building storey displacement, and storey drift are considered. In our research, as the number of storeys increases, so does the maximum displacement of the roof, and as the number of storeys increases, so does the number of storeys drift. Maximum shear forces, bending moments, maximum storey displacement, and storey drift were calculated after the structure was analyzed.

Keywords: Analysis, Design, Storey Drift, Storey Displacement

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LIST OF ACRONYMS & ABBREVIATION

ETABS= Extended Three Dimensional Analysis of Building System

DIU=Daffodil International University

ACI = American Concrete Institute

BNBC = Bangladesh National Building Code

DDM = Direct Design Method

PWD = Public Work Department

RCC = Reinforcement Cement Concrete

USD = Ultimate Strength Design

UBC = Uniform Building Code

FF= Floor finish

DL=Dead Load

LL=Live Load

PW= Partition Wall

f'_c = compressive strength of concrete
 E_c = Modules of Elasticity of Concrete
 E_s = Modules of Elasticity of Steel
 M_u = Ultimate Moment
 P = Axial Load of Column
 V = Shear Stress
 A_g = Gross Area of Concrete
 A_{ts} = Area of Tensile Steel
 R_s = Steel Ratio
 h = Slab Thickness
 L_f = Effective Span Length
 b = Width of Beam
 d = Effective Depth of Beam
 U_{LA} = Ultimate Axial Load of Column
 U_{MM} = Maximum Ultimate Moment
 d_E = Equivalent Depth of Beam
 P_{cf} = Pound per Cubic feet
 Ψ = Pound per Square Inch
ASTM = American Standard for Testing Material
 S_{AS} = Allowable Stress of Steel

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CHAPTER-I
INTRODUCTION

1.1 Introduction

The term building in Civil Engineering is used to mean structure having various components like foundation, walls, columns, floors, roofs, stairs lifts etc. The purpose of structural analysis and design is to construct a structure that can sustain all applied loads for the entire life of the structure. ETABS is a piece of engineering software that may be used to analyze and design multi-story structures. The abbreviation for Extended Three-Dimensional (3D) Analysis of Building Systems (ETABS) is Extended Three-Dimensional (3D) Analysis of Building Systems. CAD drawings can be immediately transformed into ETABS models or used as templates for overlaying ETABS objects.

The software generates a report with all of the reinforcing details. The groundbreaking new ETABS is the ultimate comprehensive software package for building structural analysis and design. This analysis mainly deals with the study of a H Shaped plan using ETABS. The maximum shear force, bending moment, maximum storey displacement, and maximum storey drift for the examined examples are compared after the analysis.

1.2 Background of Study

1.2.1. Reinforced concrete and concrete Concrete is a rock-like mass made up of sand, gravel, crushed rock, or other aggregates bound together by a cement-water paste. One or more admixtures are sometimes used to alter the workability, durability, and hardening time of concrete. Concrete, like other rocklike materials, has a high compressive strength but a low tensile strength. Reinforced concrete is made of concrete and steel reinforcement, which gives the tensile strength that the concrete lacks. Steel reinforcement can also withstand compression stresses and is utilized in columns and other applications..

1.2.2. RCC as a construction material When designing a certain structure, the designer may be perplexed by the question of whether to employ reinforced concrete or structural steel. There is no clear solution to this topic because both of these materials offer numerous good properties that can be used successfully in a wide range of buildings. In fact, they're frequently used in the same structures, with fantastic outcomes. In our country, the structural material to be utilized for a certain building is determined by the structure's height and span, the material market, foundation conditions, local building requirements, and architectural considerations. RCC is commonly utilized because its constituent materials are readily available and inexpensive, it can be manufactured in any desired shape, and it requires a lower level of specialized work than steel construction.

1.2.3 Earthquake is a catastrophic event that requires more organized response. Although Bangladesh is particularly prone to earthquakes, the nature and magnitude of these events are still unknown. Complete earthquake monitoring facilities are not accessible in Bangladesh. In most small and moderate-sized buildings, the dynamic effects of earthquake loads are normally studied as an equivalent static load. A comparison research was conducted to determine the fundamental differences between BNBC and BNBC.

1.3 Objective

The objectives of research study may be summarized as follows:

- To analyze G + 9 storeyed residential building (H shape) by using ETABS according to BNBC 2017.
- To compute four parameters like maximum shear force, maximum banding moment, maximum storey displacement and maximum storey drift.
- To compare of these four parameters among storeys according to BNBC 2017.

1.4 Scope of Study

Structure analysis and design has been done by used computer software ETABS. And for design and analysis purpose we used ETABS 2021, BNBC 2020.

CHAPTER -II
LITERATURE REVIEW

P. P. Chandurkar et.al (2013) Shear walls are considered an important earthquake resistant element in this study. Structural walls provide an effective bracing system and have strong lateral load resistance potential. As a result, determining the seismic response of a wall or shear wall is critical. The major goal of this research is to figure out where the shear wall should go in a multi-story building.

Mayuri D. Bhagwat et.al (2014) In this paper, time history analysis and reaction spectrum analysis are used to do dynamic analysis of a G+11 multistory practical RCC building for the Koyna and Bhuj earthquakes, and seismic responses of such buildings are compared analyzed and modeled using ETABS software. Different acceptable criteria have been developed using two time histories (Koyna and Bhuj) (base shear, storey displacement, storey drifts).

Chandrashekar et.al (2015) ETABS software was used to assess and design the multi-story skyscraper. This study used ETABS to analyze a G+5 storey building that was subjected to lateral loading effects from wind and earthquake. They've also examined the likelihood of a fire spreading and the need of using fire-resistant materials that meet the highest feasible performance and reliability criteria. They noted that there are many opportunities for ETABS software, which is very inventive and easy to use for high-rise buildings, reducing the time spent on design.

Geethu S N et.al (2016) STAAD.Pro and ETABS softwares were used to compare analysis and design of multi-story buildings. They provided architectural details for both residential and commercial structures. The design was created using Auto CAD software and adhered to the national building code. When comparing the findings of both software, they found that the ETABS program shows higher values of bending moment and axial force.

Bangladesh is known for being prone to earthquakes. With correct planning and structural design, all buildings must be earthquake resistant. In most cases, new housing in Bangladesh appears to be built to suit social demand, but the effect of earthquakes is not carefully assessed. In Bangladesh, urbanization is fast progressing, but no clear idea exists for quickly applying this knowledge to the design and construction costs of structures in various seismic zones.

Several investigations on seismic for a certain zone had been carried out by various researches. However, only a few studies have been conducted in Bangladesh on seismic action for specific structures due to seismic load in various zones. This research will assist civil engineers in gaining an understanding of seismic zone comparisons for a specific construction in Bangladesh.

CHAPTER -III
METHODOLOGY

3.1 General

To achieve the study's objectives, which include analyzing and designing buildings using ETABS and manual methods that meet basic standards including safety, durability, economy, aesthetic appearance, feasibility, practicability, and acceptability. It has been suggested that the following methods be used.

| Steps | Work Details |
|-------|--|
| 1 | We have used ETABS Software for the purpose of analysis and design of ten stories building. |
| 2 | For Comparison four parameters among stories in Seismic Zone-1 in Bangladesh we selected Jessore (zone-1). |
| 3 | For design and analysis purpose we used ETABS, UBC 1994, BNBC-2017 for seismic zone. |
| 4 | Then wind load & earthquake loads have been calculation on selected beams and columns as per BNBC 2017, UBC 1994 (coefficient, wind speed, seismic zone) for proposed. |
| 5 | Design and detailing of structural elements was drawn in Auto CAD 2016. |
| 6 | Comparison four parameters among stories in according to Jessore (zone-1) of shear force. |
| 7 | Comparison four parameters among stories in according to Jessore (zone-1) of bending moment. |
| 8 | Comparison four parameters among stories in according to Jessore (zone-1) of maximum storey displacement |
| 9 | Comparison four parameters among stories in according to Jessore (zone-1) of maximum storey drift. |

CHAPTER -IV
ETABS MODELING

4.1 Basic information:

Material Properties in ETABS

Compressive Strength of Concrete, $f'_c = 3.5$ ksi

Yield Stress of Steel, $f_y = 60$ ksi

Modulus of Elasticity, $E = 3372$ ksi

Other Information:

Base = 8 ft

Ground Floor Height = 13 ft

Floor Height = 10 ft

Section Properties in ETABS

Grade Beam Size:

GB1 = 15" x 12"

GB2 = 18" x 12"

Floor Beam Size:

FB1 = 18" x 12"

FB2 = 18" x 12"

Column Size:

C1=18" x 24"

C2=24" x 30"

C3=30" x 36"

C4= 24" (circular

Slab Thickness = 5 inch

Brick Wall Thickness = 5 inch

4.2 Guidelines:

Design Load

Dead Load

Floor Finish (FF) = 20 psf

Floor Partition Wall (PW) = 500 psf

Parapet Wall = 150 psf

Live Load

Floor = 40 psf (on floor slab)

Stair = 100 psf

Earthquake Load

Seismic Zone Co-efficient = 0.12 (Jessore) (Zone-1)

Site Co-efficient $F_a = 1.15$

Site Co-efficient $F_y = 1.725$

Response Modification Factor, $R = 6$

Time Period, $T = 1.137$

Long-Period Transition Period = 2 sec

Deflection Amplification, $C_d = 5$

System Overstrength, $\Omega = 2.5$

Occupancy Importance, $I = 1.25$

Wind Load

Wind Speed = 143.584 mph (Jessore)

Wind Exposure = B (Urban Area)

Importance Factor = 1

Topographical Factor, $K_{zt} = 1$

Gust Factor = 0.85

Windward Co-efficient, $C_{pw} = 0.8$

Leeward Co-efficient, $C_{pl} = 0.5$

4.3: Column Layout of a H Shape

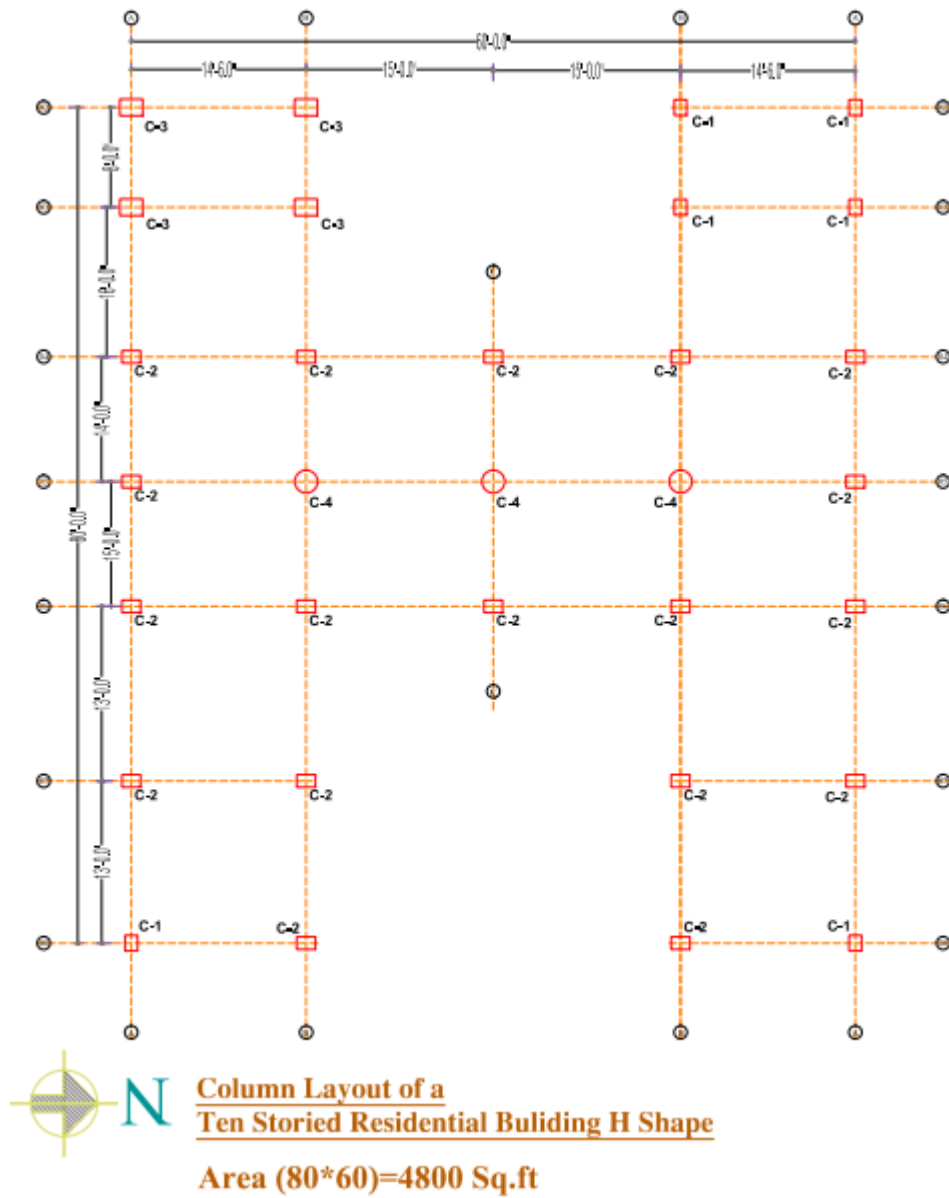
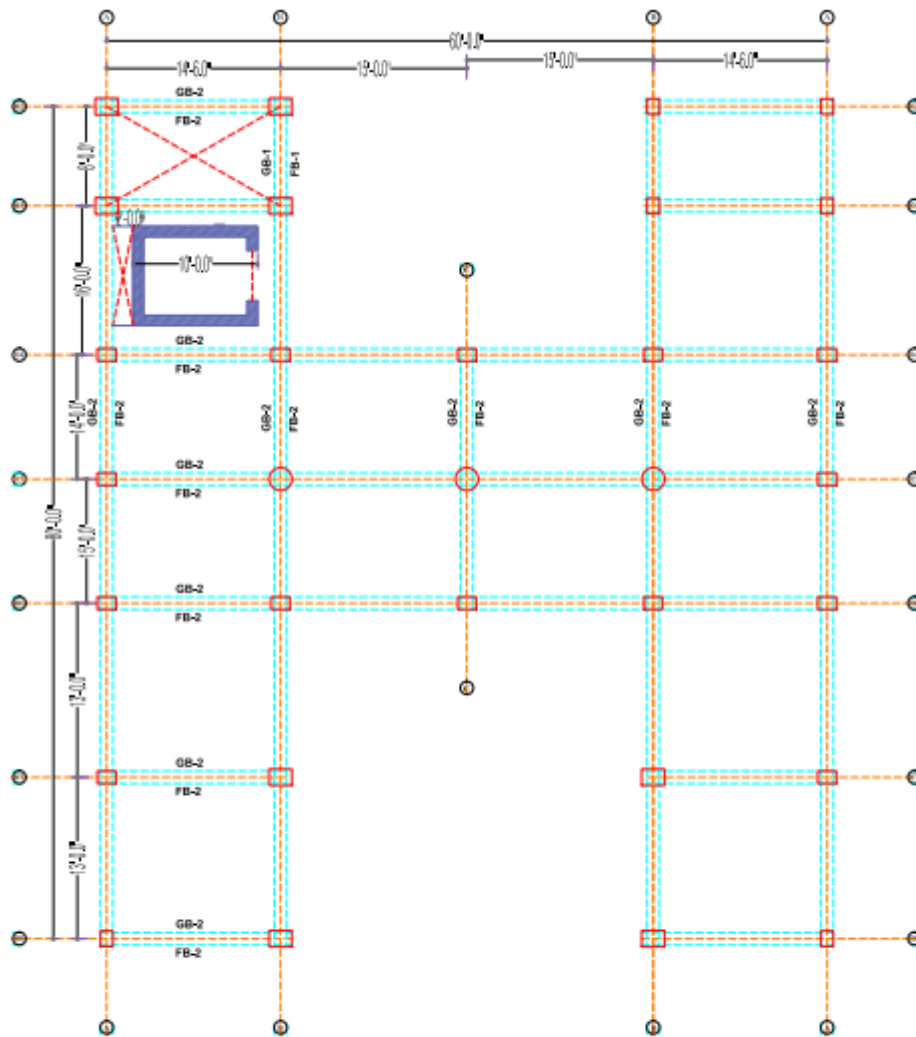


Figure 4.3: Column Layout of a H Shape

4.4: GB & FB Layout of a H Shape




N GB & FB Layout of a Ten Storied Residential Buliding H Shape
Area (80*60)=4800 Sq.ft

Figure 4.4: GB & FB Layout of a H Shape

4.5: Floor Plan with Floor Beam

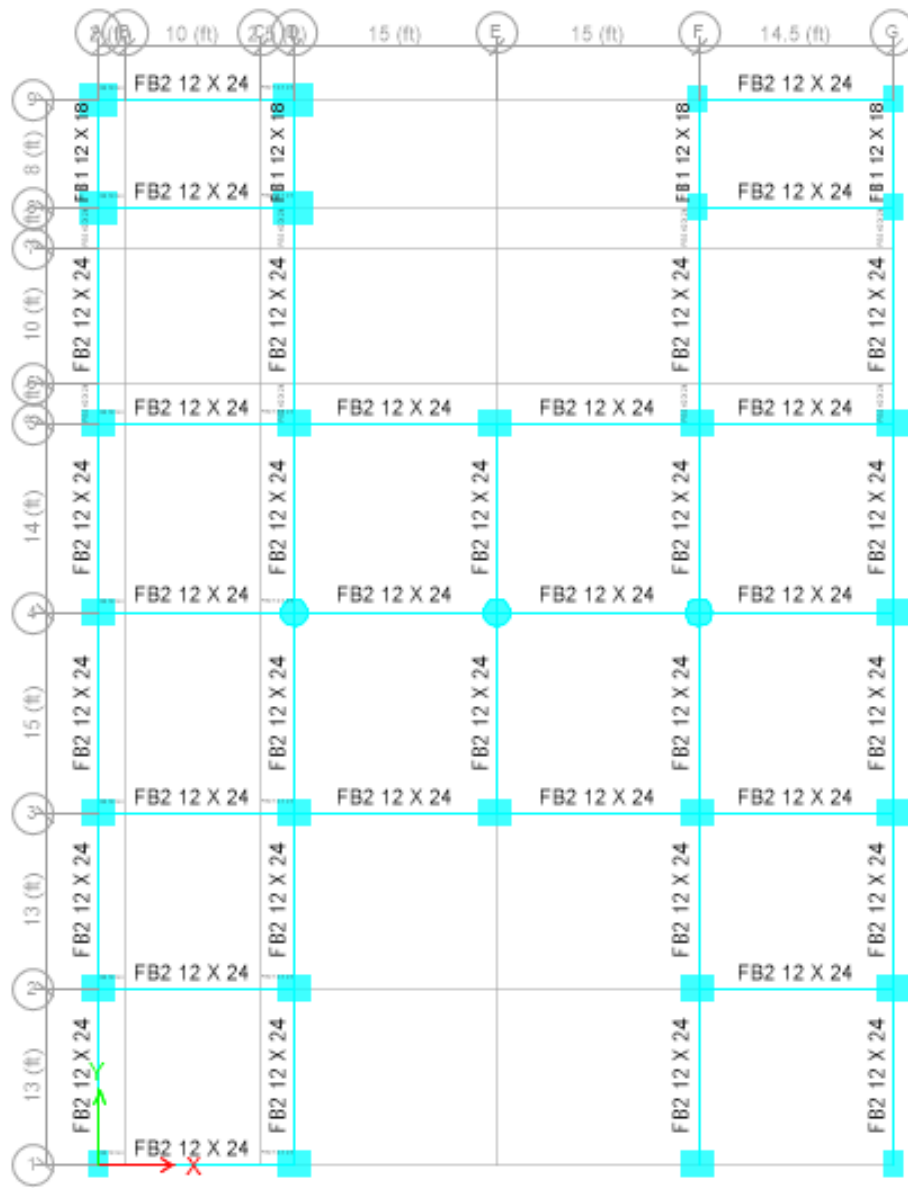


Figure 4.5: Floor Plan with Floor Beam

4.6: H Shape Live Load

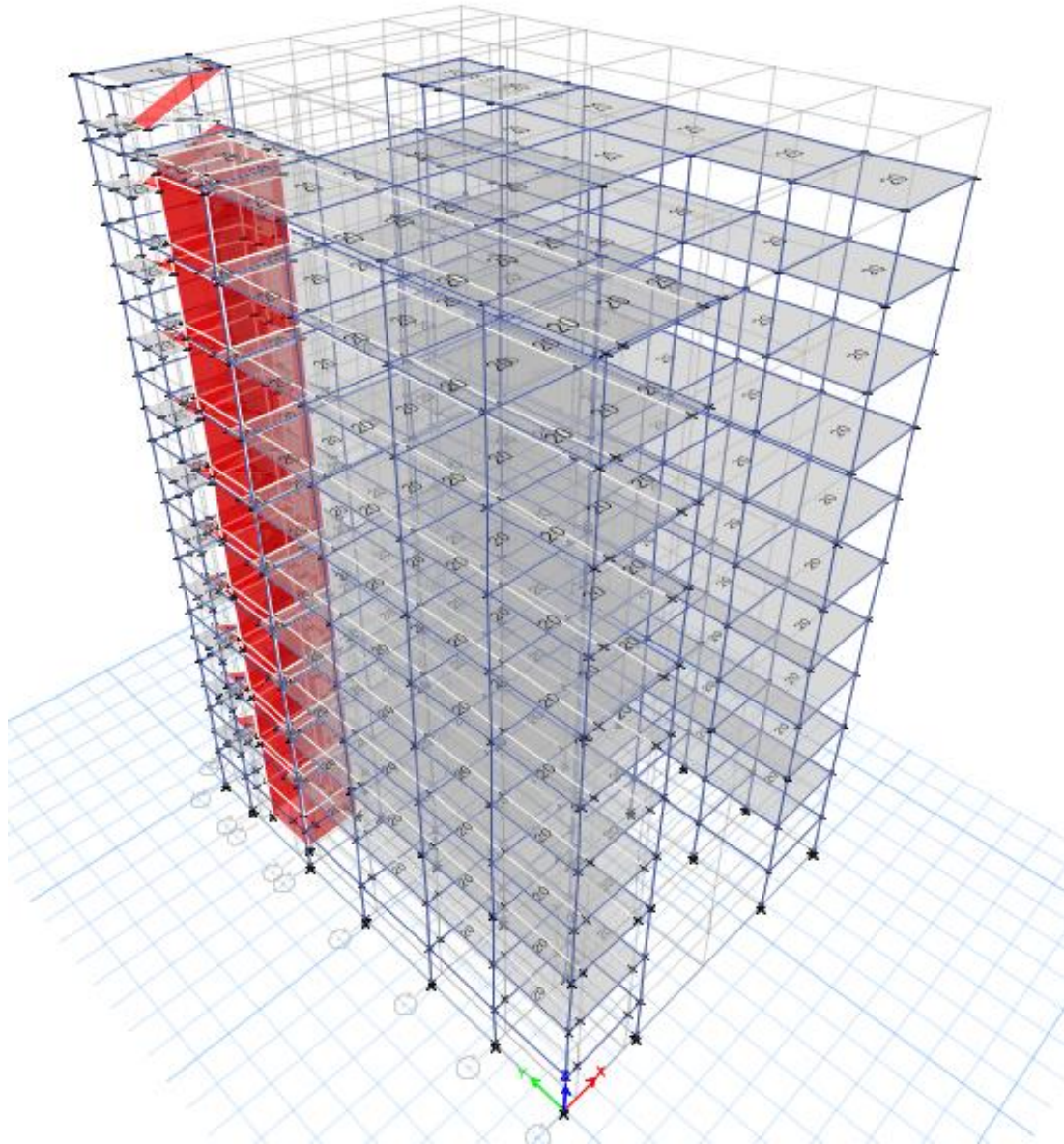


Figure 4.6: H Shape Live Load

4.7: H Shape Roof Live Load

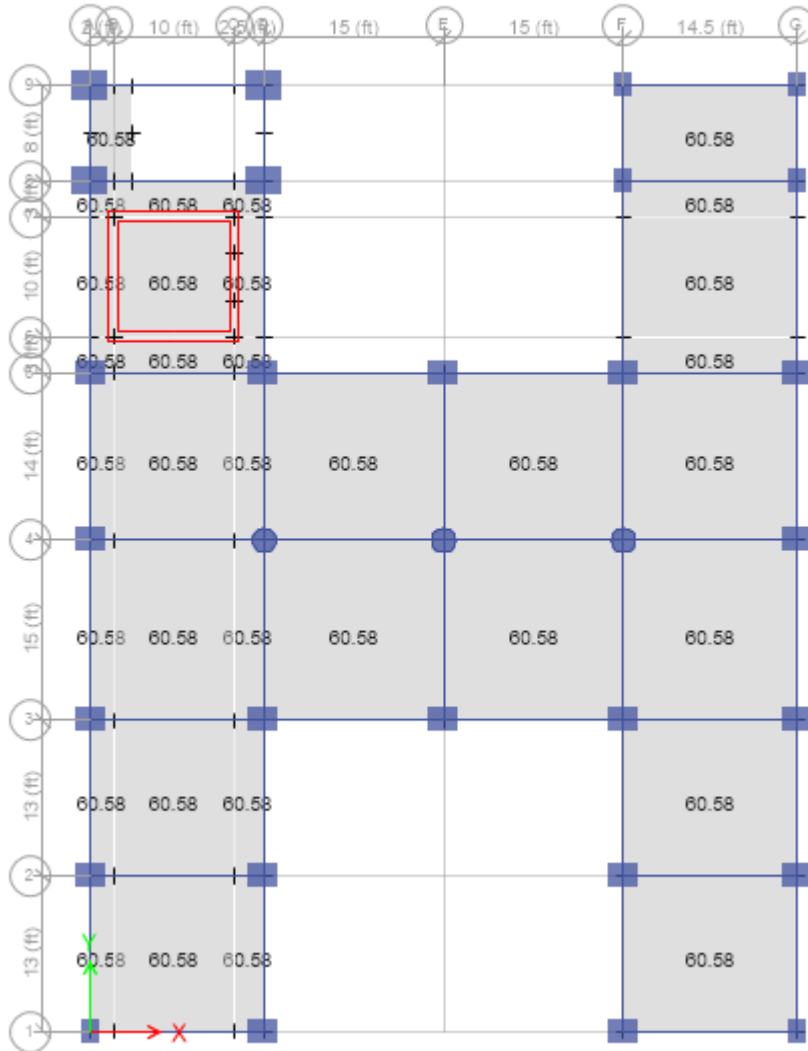


Figure 4.7: H Shape Roof Live Load

4.8: H Shape of Diaphragm

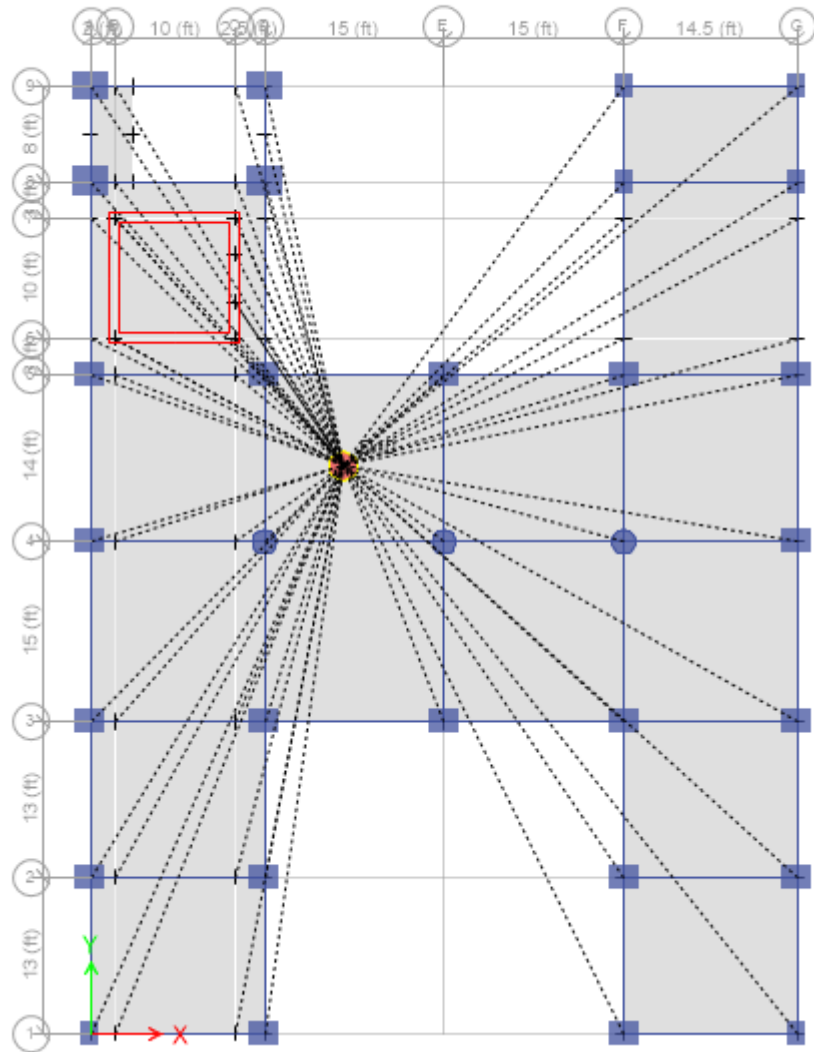


Figure 4.8: H Shape of Diaphragm

4.9: Modeling and design of H shape

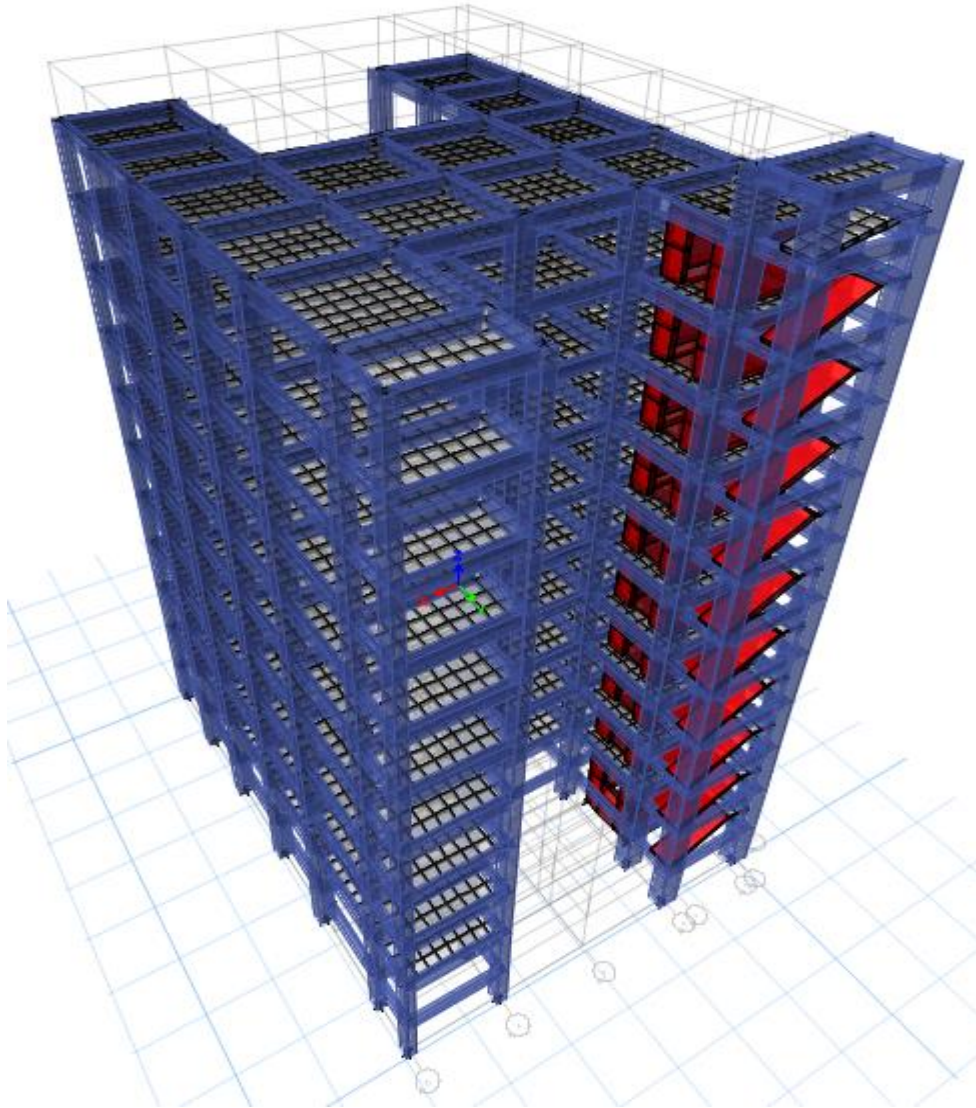


Figure 4.9: 3D View of 10 Story residential building

At first we get Column layout and this dimension put in ETABS .Then we define materials property, Frame section and slab section. Then draw column, beam, and slab in different section.

4.10: Top Deflection in ETABS

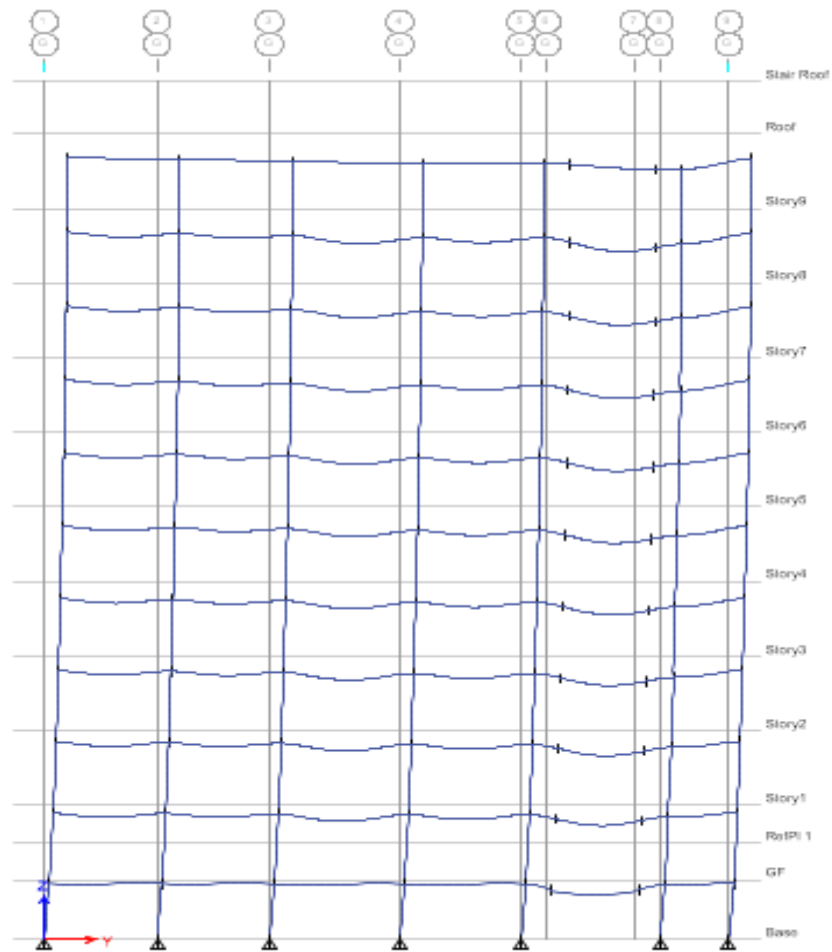


Figure 4.10: Top Deflection in ETABS

We have a wind load limitation $h/500 = 1.65$ inch. Here our maximum given value for X direction is 0.34 inch and Y direction 0.97 inch. So our design criteria is ok.

4.11: Reinforcement area of all columns

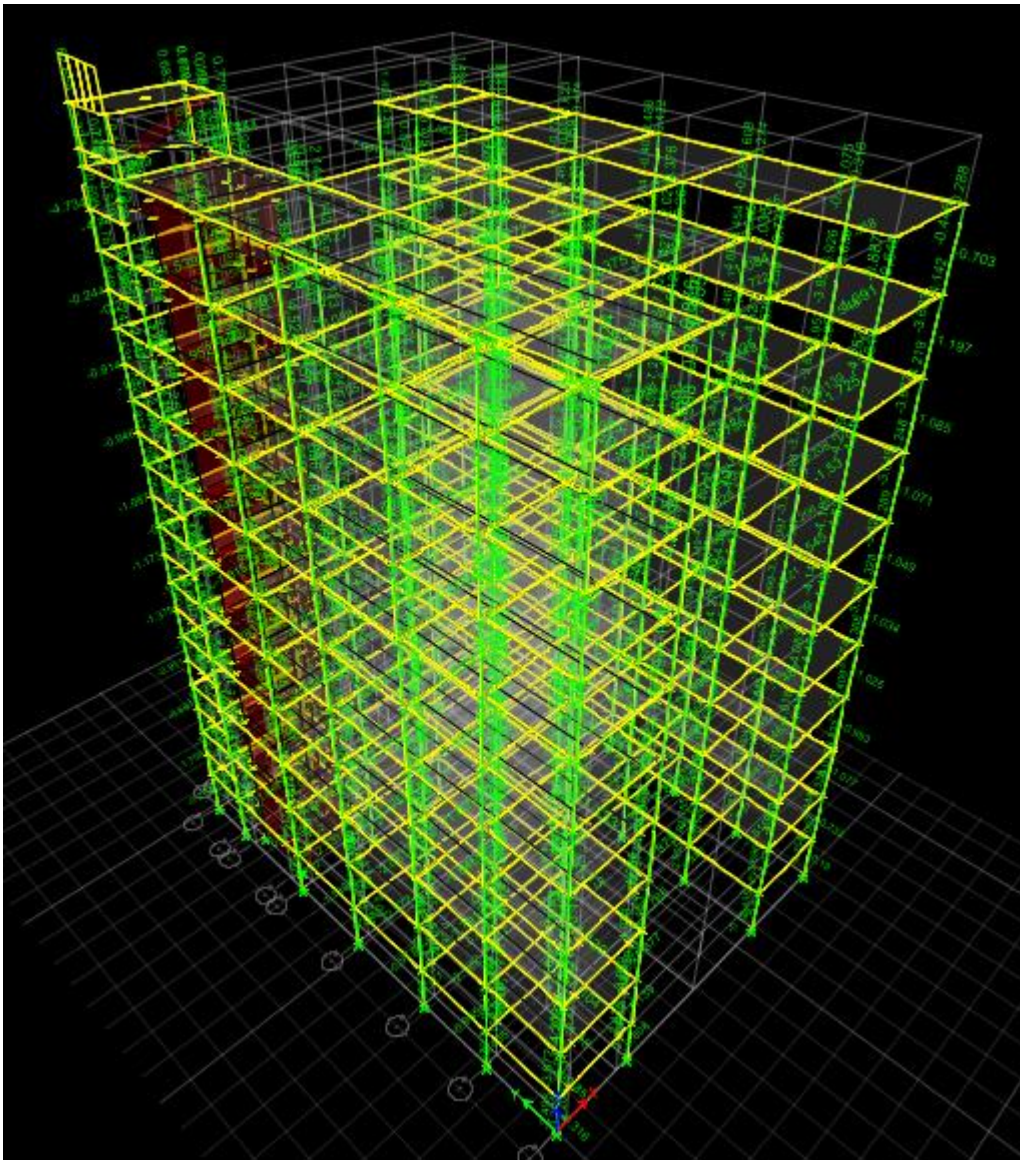


Figure 4.11: Reinforcement area of all columns

After Define static load cases like as FF, PW, WX, WY and EQX, EQY. Then we run analysis and design column reinforcement from ETABS.

4.12: Maximum Shear Force

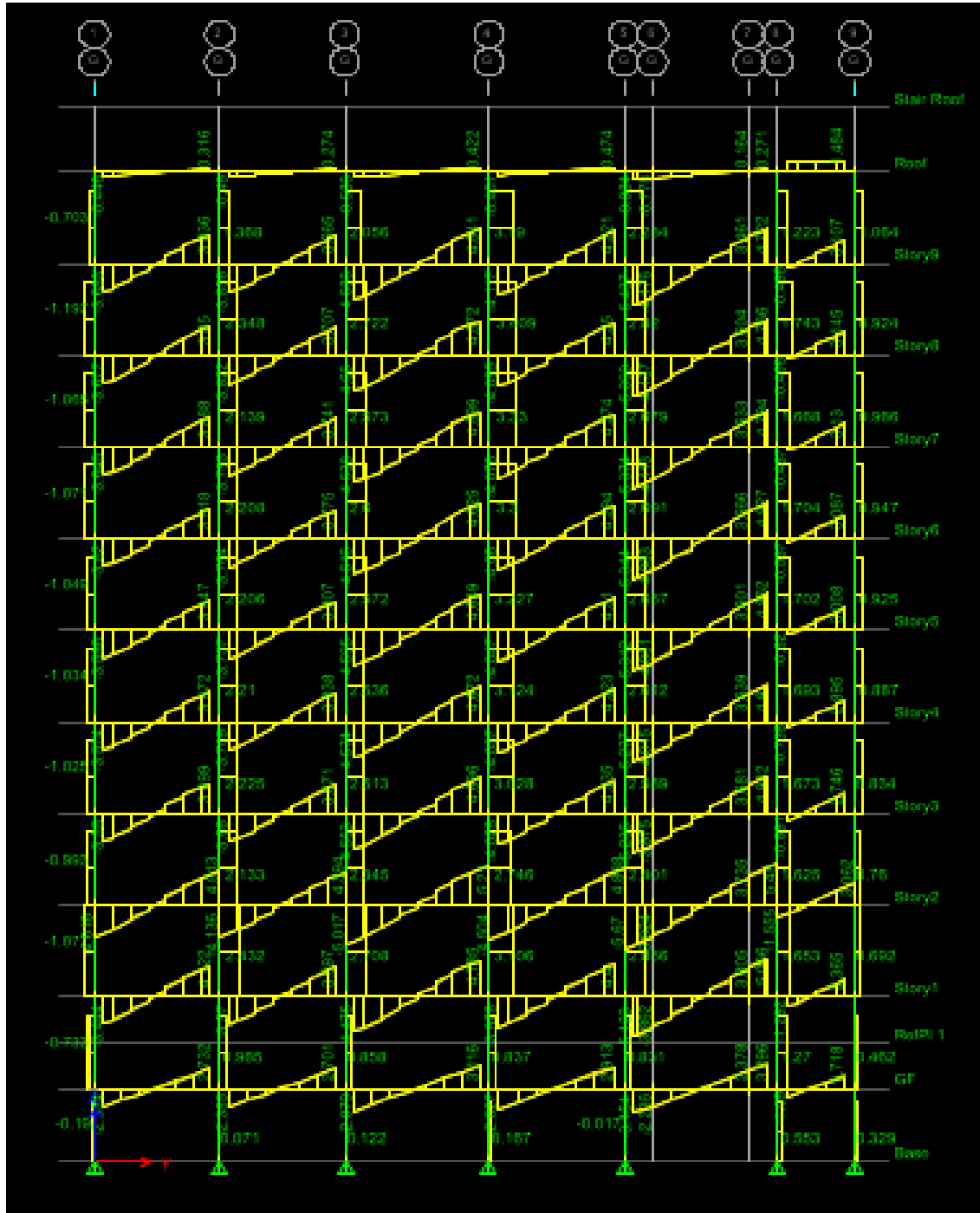


Figure 4.12: Maximum Shear Force

4.13: Maximum Bending Moment

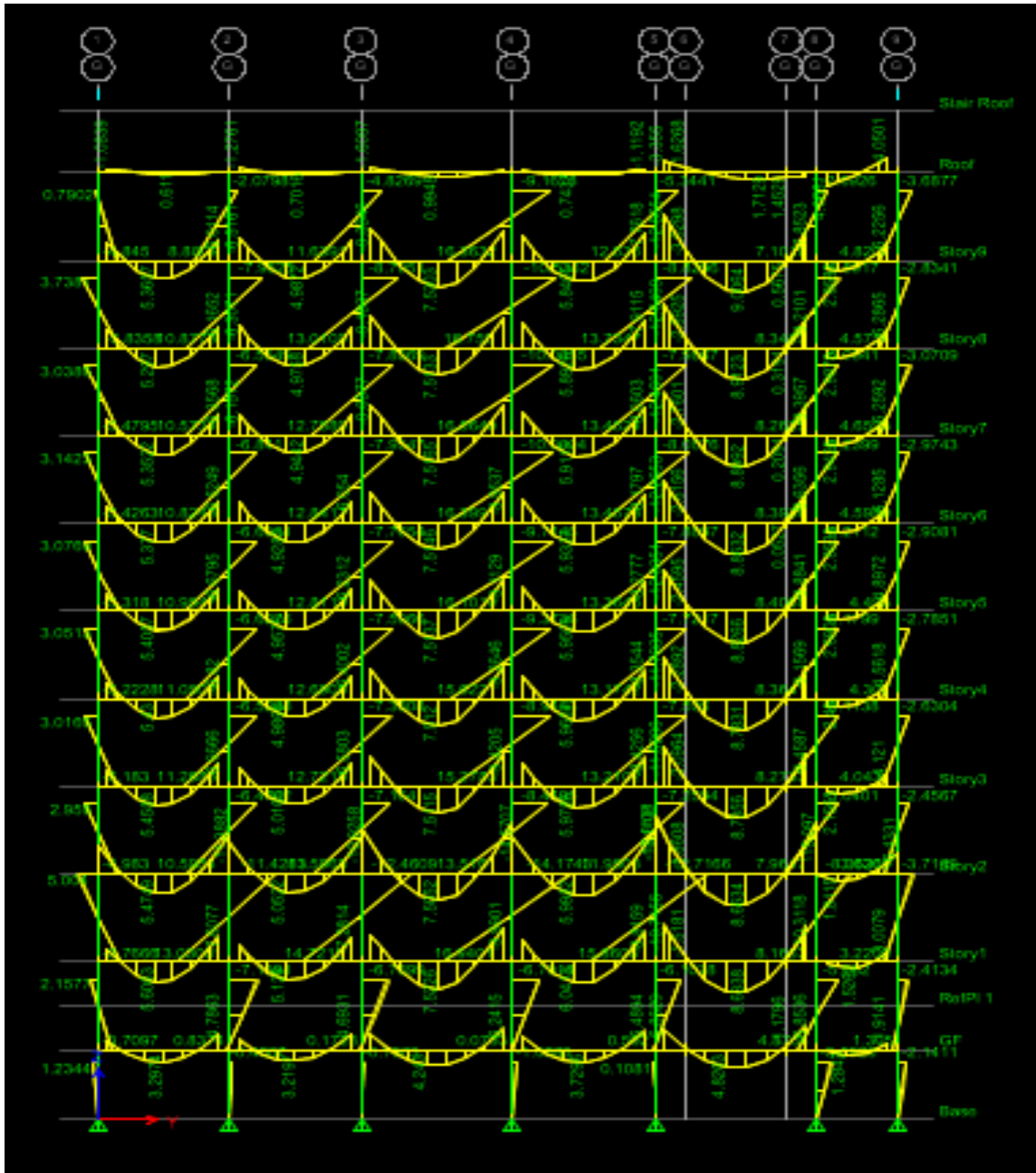


Figure 4.13: Maximum Bending Moment

Same this way. After Define static load cases like as FF, PW, WX, WY and EQX, EQY. Then we run analysis and design beam reinforcement from ETABS.

CHAPTER-V
ANALYSIS OF RESIDENTIAL BUILDING USING ETABS

5.1: Maximum Storey Displacement

Table 5.1: Maximum Storey Displacement

| SL No. | Storey Name | Displacement (in) X Direction | Displacement (in) Y Direction |
|--------|-------------|-------------------------------|-------------------------------|
| 1 | Base | 0 | 0 |
| 2 | GF | 0.0648 | 0.0434 |
| 3 | Storey 01 | 0.1464 | 0.1254 |
| 4 | Storey 02 | 0.248 | 0.224 |
| 5 | Storey 03 | 0.3496 | 0.3294 |
| 6 | Storey 04 | 0.4548 | 0.4259 |
| 7 | Storey 05 | 0.5604 | 0.5434 |
| 8 | Storey 06 | 0.6812 | 0.6422 |
| 9 | Storey 07 | 0.7904 | 0.7532 |
| 10 | Storey 08 | 0.8996 | 0.8287 |
| 11 | Storey 09 | 0.9936 | 0.9346 |
| 12 | Roof | 1.0832 | 1.0143 |
| 13 | Stair Roof | 1.1652 | 1.0432 |

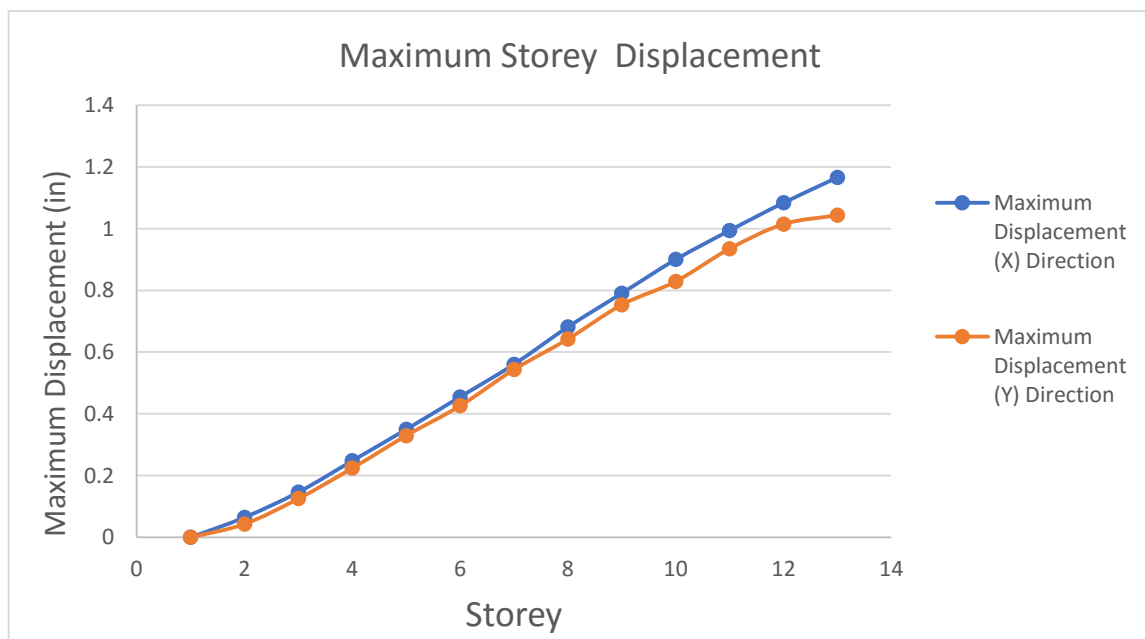


Figure 5.1: Maximum Storey Displacement

5.2: Maximum Storey Drift

Table 5.2: Maximum Storey Drift

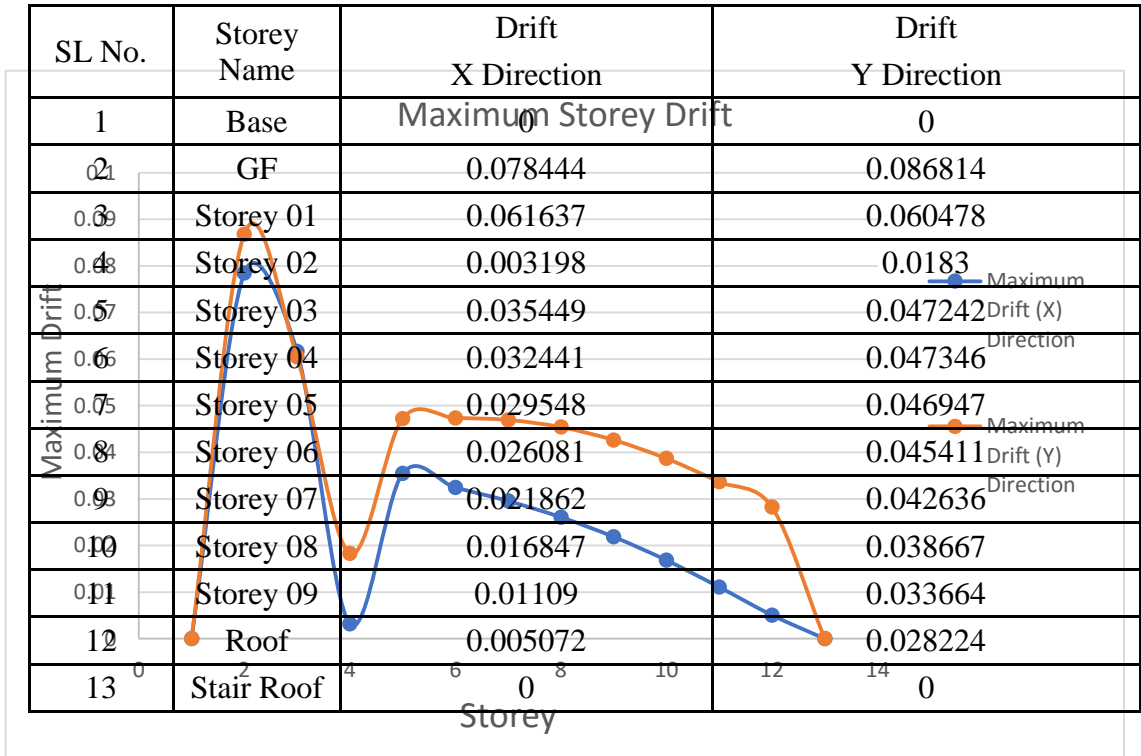


Figure 5.2: Maximum Storey Drift

CHAPTER-XI
CONCLUSION & RECOMMENDATION

6.1: Conclusions:

- It has been observed that maximum shear force was found in 5.066 (kip) for storey 1.
- It has been observed that maximum bending moment was found in 9.0064 (kip-fit) for storey 9.
- It has been observed that maximum storey displacement was found 1.1652 (in) for stair roof in X-direction and 1.0432 (in) for stair roof in Y-direction.
- It has been observed that maximum storey drift was found 0.078444 for GF in X-direction and 0.086814 for GF in Y-direction.

6.2: Recommendations:

- Analysis and design of multi storeyed building may be performed by STAAD Pro software.
- Analysis and design may be performed for four zones according to BNBC 2017.
- Comparison of hand calculations and ETABS analysis may be observed.

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Appendix-I

BNBC for Earth Quake

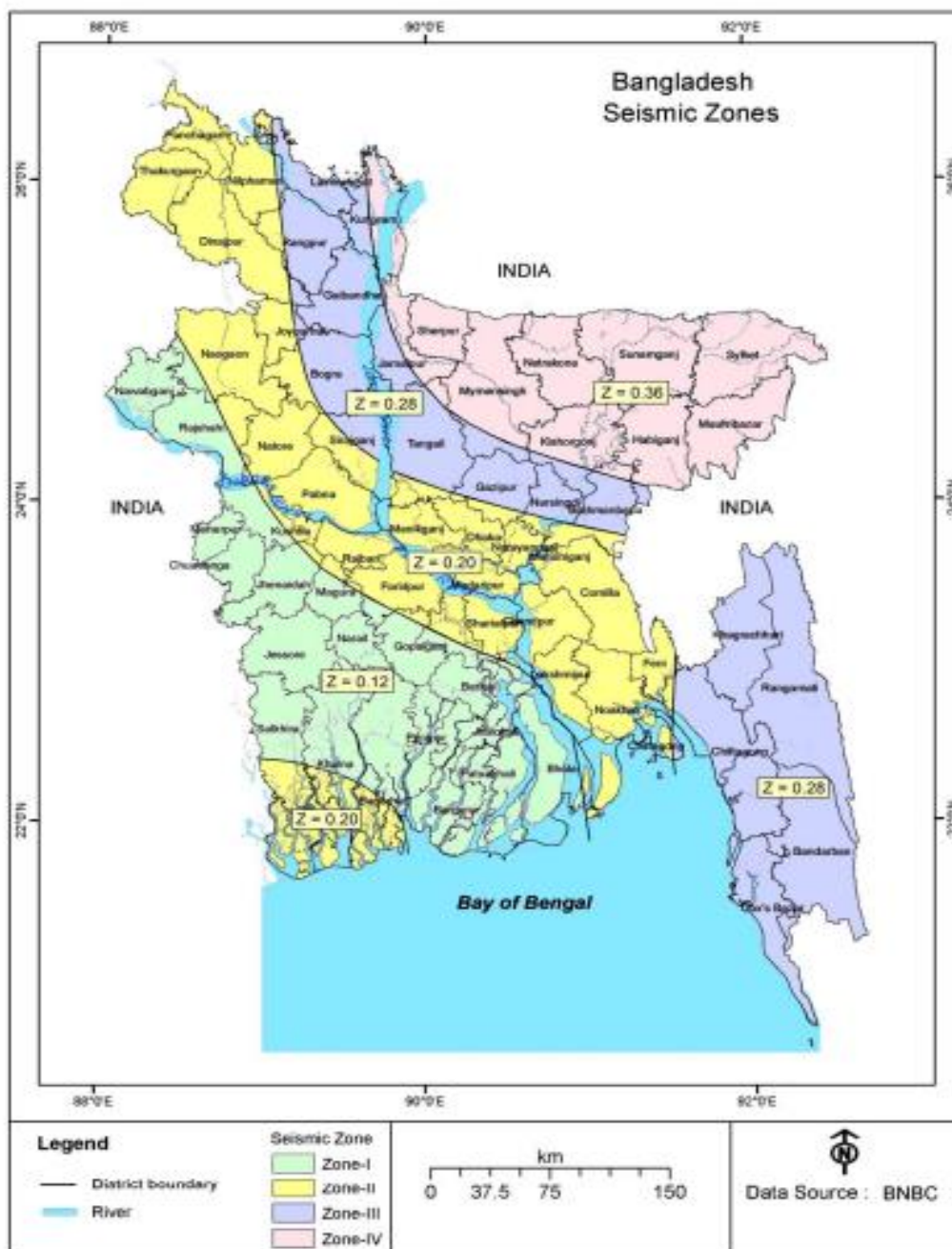


Figure 6.1: Seismic Zone Coefficient, Z

Tabel 6.1: Velocity Pressure Exposure Coefficient K_h and K_z

| Height above ground, z | Exposure (Note 1) | | | |
|------------------------|-------------------|-------|---------|---------|
| | A | | B | C |
| (m) | Case 1 | Case2 | Case1&2 | Case1&2 |
| 0-4.6 | 0.70 | 0.57 | 0.85 | 1.03 |
| 6.1 | 0.70 | 0.62 | 0.90 | 1.08 |
| 7.6 | 0.70 | 0.66 | 0.94 | 1.12 |
| 9.1 | 0.70 | 0.70 | 0.98 | 1.16 |
| 12.2 | 0.76 | 0.76 | 1.04 | 1.22 |
| 15.2 | 0.81 | 0.81 | 1.09 | 1.27 |
| 18 | 0.85 | 0.85 | 1.13 | 1.31 |
| 21.3 | 0.89 | 0.89 | 1.17 | 1.34 |

Tabel 6.2: Wind Directionality Factor, K_d

| Structure Type | Directionality Factor K_d | Structure Type | Directionality Factor K_d |
|----------------------------------|-----------------------------|----------------------------------|-----------------------------|
| Buildings | | Solid Signs | 0.85 |
| Main Wind Force Resisting system | 0.85 | Open Signs and Lattice Framework | 0.85 |
| Components and Cladding | 0.85 | Trussed Towers | |
| Arched Roofs | 0.85 | Triangular, Square, Rectangular | 0.85 |
| Chimneys, Tanks and Similar | | All other cross section | 0.95 |
| Structures | | | |
| Square | 0.90 | | |
| Hexagonal | 0.95 | | |
| Round | 0.95 | | |

Table 6.3: Seismic Zone Coefficient Z for Some Important Towns of Bangladesh.

| Town | Z | Town | Z | Town | Z | Town | Z |
|------|---|------|---|------|---|------|---|
|------|---|------|---|------|---|------|---|

| | | | | | | | |
|-----------------|------|-------------|------|-------------|------|------------|------|
| Bagerhat | 0.12 | Gaibandha | 0.28 | Magura | 0.12 | Patuakhali | 0.12 |
| Bandarban | 0.28 | Gazipur | 0.20 | Manikganj | 0.20 | Pirojpur | 0.12 |
| Barguna | 0.12 | Gopalganj | 0.12 | Maulvibazar | 0.36 | Rajbari | 0.20 |
| Barisal | 0.12 | Habiganj | 0.36 | Meherpur | 0.12 | Rajshahi | 0.12 |
| Bhola | 0.12 | Jaipurhat | 0.20 | Mongla | 0.12 | Rangamati | 0.28 |
| Bogra | 0.28 | Jamalpur | 0.36 | Munshiganj | 0.20 | Rangpur | 0.28 |
| Brahmanbaria | 0.28 | Jessore | 0.12 | Mymensingh | 0.36 | Satkhira | 0.12 |
| Chandpur | 0.20 | Jhalkati | 0.12 | Narail | 0.12 | Shariatpur | 0.20 |
| Chapainababganj | 0.12 | Jhenaidah | 0.12 | Narayanganj | 0.20 | Sherpur | 0.36 |
| Chittagong | 0.28 | Khagrachari | 0.28 | Narsingdi | 0.28 | Sirajgonj | 0.28 |
| Chuadanga | 0.12 | Khulna | 0.12 | Natore | 0.20 | Srimangol | 0.36 |
| Comilla | 0.20 | Kisoreganj | 0.36 | Naogaon | 0.20 | Sunamganj | 0.36 |
| Cox's Bazar | 0.28 | kurigram | 0.36 | Netrakona | 0.36 | sylhet | 0.36 |
| Dhaka | 0.20 | Kustia | 0.20 | Nilphamari | 0.12 | Tangail | 0.28 |
| Dinajpur | 0.20 | Lakshmipur | 0.20 | Noakhali | 0.20 | Thakurgaon | 0.20 |
| Faridpur | 0.20 | Lalmanirhat | 0.28 | Pabna | 0.20 | | |
| Feni | 0.20 | Madaripur | 0.20 | Panchagarh | 0.20 | | |