DESIGN OF A SIX STORIED RESIDENTIAL BUILDING AND COLUMN COMPARISON IN BETWEEN SEISMIC ZONE -1 AND ZONE-3 IN BANGLADESH

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The thesis titled "Design of a Six Storied Residential Building and Column Comparison in Between Seismic Zone -1 and Zone -3 in Bangladesh" submitted by Nipa Akter, Md. Akram Hossain , Jaker Hossain , Salman Miah ,F.M.A Naiyem have been accepted as satisfactory in partial fulfillment of the requirement for the degree of Bachelor of Science in Civil Engineering on July 2021.

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DECLARATION

The dissertation entitled **“Design of a Six Storied residential Building and Column Comparison in Between Seismic Zone -1 and Zone-3 in Bangladesh”** has been performed under the supervision of **Mr. Rayhan Md. Faysal** (Assistant Professor), Department of Civil Engineering, Daffodil International University, Dhaka, Bangladesh and got approved in partial fulfillment of the requirement for the Bachelor of Science in Civil Engineering. To the best of our knowledge and belief, the capstone contains no materials previously published or written by another person except where due reference is made in the capstone itself.

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Dedicated

To

Almighty ALLAH

& Our Parents

ABSTRACT

In this study, we designed a six storied residential building considering later force. And we made column comparison between two seismic zones in Bangladesh. The basic methodology adopted here is the sequential presentation of analysis &design all force of six storied building for earthquake and wind effect by UBC1994, BNBC, ACI, and code 318R-05 code proposed places in Bangladesh. For this purpose Mymensingh (zone -3) and Khulna (zone-1**)** have been selected. Data & Figure are presented wherever felt necessary in reader friendly way. Analysis and design has been performed with ETABS. An upper structure has been designed for a six storied building in Mymensingh (zone-3). After the analysis, we compared the Column Rebar Percentages and Base Shear with a building in Khulna (zone-1) which also resembles identical structure. The result from the comparison shows us that, the Mymensingh (zone-3) needs more 7.40% Column Rebar Percentage and 10.42% Base Shear than the Khulna (zone-1). Mainly it is because of later force variation.

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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

Ec =Modules of Elasticity of Concrete

Es= Modules of Elasticity of Steel

Mu=Ultimate Moment

P = Axial Load of Column

V = Shear Stress

Ag=Gross Area of Concrete

Ats=Area of Tensile Steel

Rs=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

Pcf = Pound per Cubic feet

Psi = Pound per Square Inch

ASTM = American Standard for Testing Material

S_{AS}= Allowable Stress of Steel

LIST OF FIGURE

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CHAPTER-I

INTRODUCTION

1.1- Introduction

The term building in Civil Engineering is used to mean a structure having various components. Structural analysis and design is used to produce a structure capable of resisting all applied loads without failure during its intended life. Structural engineers are facing the challenges of striving for most efficient and economical design with accuracy in solution while ensuring that the final design of a building and the building must be serviceable for its intended function over its design life time. Now a day's various software packages are available in market for analyzing and designing practically all types of structures viz. ETABS, MIDAS, SAP and RAM etc. In this thesis we compare two seismic zones in Bangladesh. Seismic effect on any structure depends on seismic zone coefficient, response reduction factor, soil characteristics, importance of the structure etc. To design an earthquake resistant structure it is mandatory to know the codes. Dynamic effects of earthquake loads are usually analyzed as an equivalent static load in most small and moderate-sized buildings.

1.2- Background of Study

1.2.1. Concrete and Reinforced Concrete is a mixture of sand, gravel, crushed rock, or other aggregates held together in a rock like mass with a paste of cement and water. Sometimes one or more admixtures are added to change certain characteristics of the concrete such as its workability, durability and time of hardening. As with most rocklike substances, concrete has a high compressive strength and a very low tensile strength. Reinforced concrete is a combination of concrete and steel wherein the steel reinforcement provides the tensile strength lacking in the concrete. Steel reinforcing is also capable of resisting compression forces and is used in columns as well as in other situations.

1.2.2. RCC as building materials When a particular type of structure is being considered, the designer may be puzzled by the question, "Should reinforced concrete or structural steel be used?" There is no simple answer to this question, inasmuch as both of these materials have many excellent characteristics that can be utilized successfully for so many types of structures. In fact, they are often used together in the same structures with wonderful results. The selection of the structural material to be used for a particular building depends on the height and span of the structure, the material market, foundation conditions, local building codes, and architectural considerations in our country RCC is mostly used because constituent materials are locally available and low cost, can be produced in any desired shapes and a lower grade of skilled labor is required than steel construction.

Earthquakes a disastrous event that needs to be addressed in amore coordinated way. AlthoughBangladesh is extremely vulnerable to seismic activity, the nature and the level of this activity is yet to bedefined. In Bangladesh, complete earthquake monitoring facilities are not available. The dynamic effects earthquake loads are usually analyzed as an equivalent static load inmost small and moderate-sized Buildings. A comparative study has been made to see the basic difference between BNBC.

1.2.3 Earthquake is a disastrous event that needs to be addressed in a more coordinated way. Although Bangladesh is extremely vulnerable to seismic activity, the nature and the level of this activity is yet to be defined. In Bangladesh, complete earthquake monitoring facilities are not available. The dynamic effects earthquake loads are usually analyzed as an equivalent static load in most small and moderate-sized buildings. A comparative study has been made to see the basic difference between BNBC.

1.3-Objective

The objectives of research study may be summarized as follows: -

- The main objective of this project is to design super structure of six storied residential apartment building for Mymensingh (zone-3).
- To find out the difference of column rebar percentage in between Mymensingh (zone-3) and Khulna (zone-1).
- To find out the difference of the Base Shear in between Mymensingh (zone-3) and Khulna (zone-1)

1.4-Scope of Study

Structure analysis and design has been done bye used computer software ETABS. And for design and analysis purpose we used ACI code, UCB 1994, BNBC-1993.

CHAPTER -II

LITERATURE REVIEW

Varalakshmi V et.al (2014) analyzed a G+5 storey residential building and designed the various components like beam, slab, column and foundation. The loads namely dead load and live load were calculated as per IS 875(Part I & II)-1987 and HYSD bars i.e. Fe .

415 are used as per IS 1986- 1985. They concluded that the safety of the reinforced concrete building depends upon the initial architectural and structural configuration of the total building, the quality of the structural analysis, design and reinforcement detailing of the building frame to achieve stability of elements and their ductile performance.

Chandrashekar et.al (2015) analyzed and designed the multi-storied building by using ETABS software. A G+5 storey building under the lateral loading effect of wind and earthquake was considered for this study and analysis is done by using ETABS. They have also considered the chances of occurrence of spread of fire and the importance of use of fire proof material up to highest possible standards of performance as well as reliability. They suggested that the wide chances of ETABS software which is very innovative and easier for high rise buildings so that time incurred for designing is reduced.

Balaji.U and Selvarasan M.E (2016) worked on analysis and design of multi-storeyed building under static and dynamic loading conditions using ETABS. In this work a G+13 storey residential building was studied for the earth quake loads using ETABS. They assumed that material property to be linear, static and dynamic analyses were performed. The non-linear analysis was carried out by considering severe seismic zones and the behavior was assessed by considering type II soil condition. Different results like displacements, base shear were plotted and studied.

Geethu et.al (2016) made a comparative study on analysis and design of multi storied building by STAAD.Pro and ETABS softwares. They provided the details of both residential and commercial building design. The planning was made in accordance with the national building code and drafted using Auto CAD software. They concluded that while comparing both software results, ETABS software shows higher values of bending moment and axial force.

Bangladesh is recognized as an earthquake prone country. All buildings must be earthquake resistant with proper planning and structural design. New housing in Bangladesh seems to be constructed to meet the social demand, but the effect of earthquake is not properly considered in most of the cases. Urban development has been rapidly progressing in Bangladesh but no definite idea is available for readily applying the knowledge to the design and construction costing of structures in different seismic zones.

Several studies had been carried out on seismic for a particular zone by different researches. But very few studies have been carried out on seismic action for particular structure due to seismic load in different zones in Bangladesh. This study will help the civil engineers to get the idea about seismic zones comparisons for a particular structure in Bangladesh.

CHAPTER -III

METHODOLOGY

3.1-General

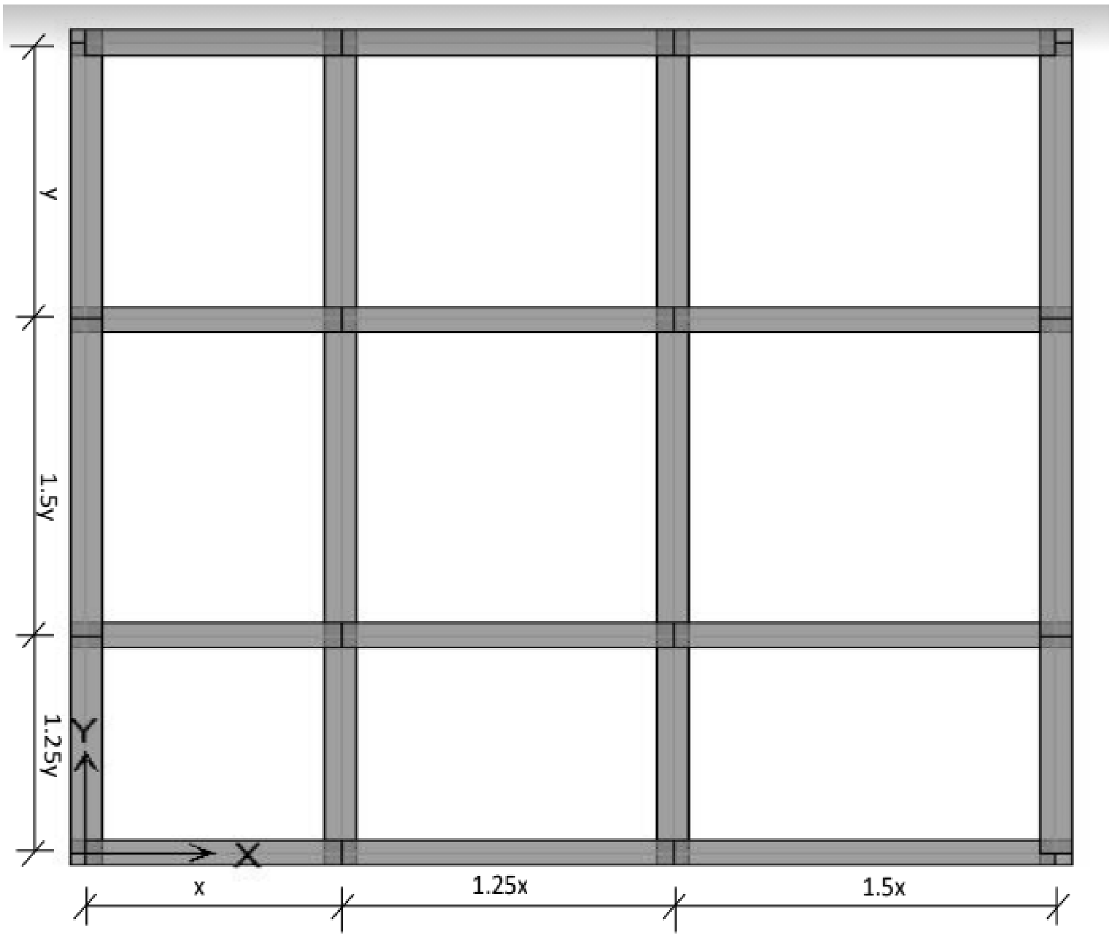
To achieve the objectives of the study that is to analyze and design building using ETABS and by manual method, which meets the basic requirements such as safety, durability, economy, aesthetic appearance, feasibility, practicability and acceptability. It has been proposed to follow the following methodology.

Steps	Work details
1	We have used ETABS Software for the purpose of analysis and design of six stories building
2	For Column Comparison in BetweenSeismic Zone -1 and Zone-3 in Bangladesh we selected Mymensingh (zone-3) and Khulna (zone-1).
3	For design and analysis purpose we used ACI code, UCB 1994, BNBC-1993 for two seismic zone
4	Then Wind load &earthquake loads have been calculation on selected beams and columns as per BNBC, UBC 1993 CODE (coefficient, wind speed, seismic zone) for proposed
5	Design and detailing of structural elements was drawn in Auto CAD 2016
6	Comparison between Mymensingh (zone-3) and Khulna (zone-1) of Column Rebar Percentage
7	Base shear Comparison between Mymensingh (zone-3) and Khulna (zone-1)

CHAPTER -IV

ETABS MODELING

4.1Basic information



x = 2 + group no (in meter unit)

y = group no

Group no=2

- Typical story height = 3.5 m (IMRF Structure, RCC Building)
- Material Properties: fc' = 3.5 ksi, fy = 60 ksi
- Slab thickness = 150 mm (for membrane), 125 mm (for bending)
- Loads: LL = 3 KN/m2, FF = 1.5 KN/m2, PW = 2.5 KN/m2

For Wind Load:

Basic wind speed = 238 Km/hr

Exposure condition =B

For Earthquake Load:

S2 type soil, Zone 2, I = 1

4.2 Guidelines

Frame Section – use SI unit (in mm)

Maximum deflection limit due to wind load = h/500, where h = height from GF to Roof

Column rebar percentage – keep it within 4%

4.3 Modeling and design for Mymensingh

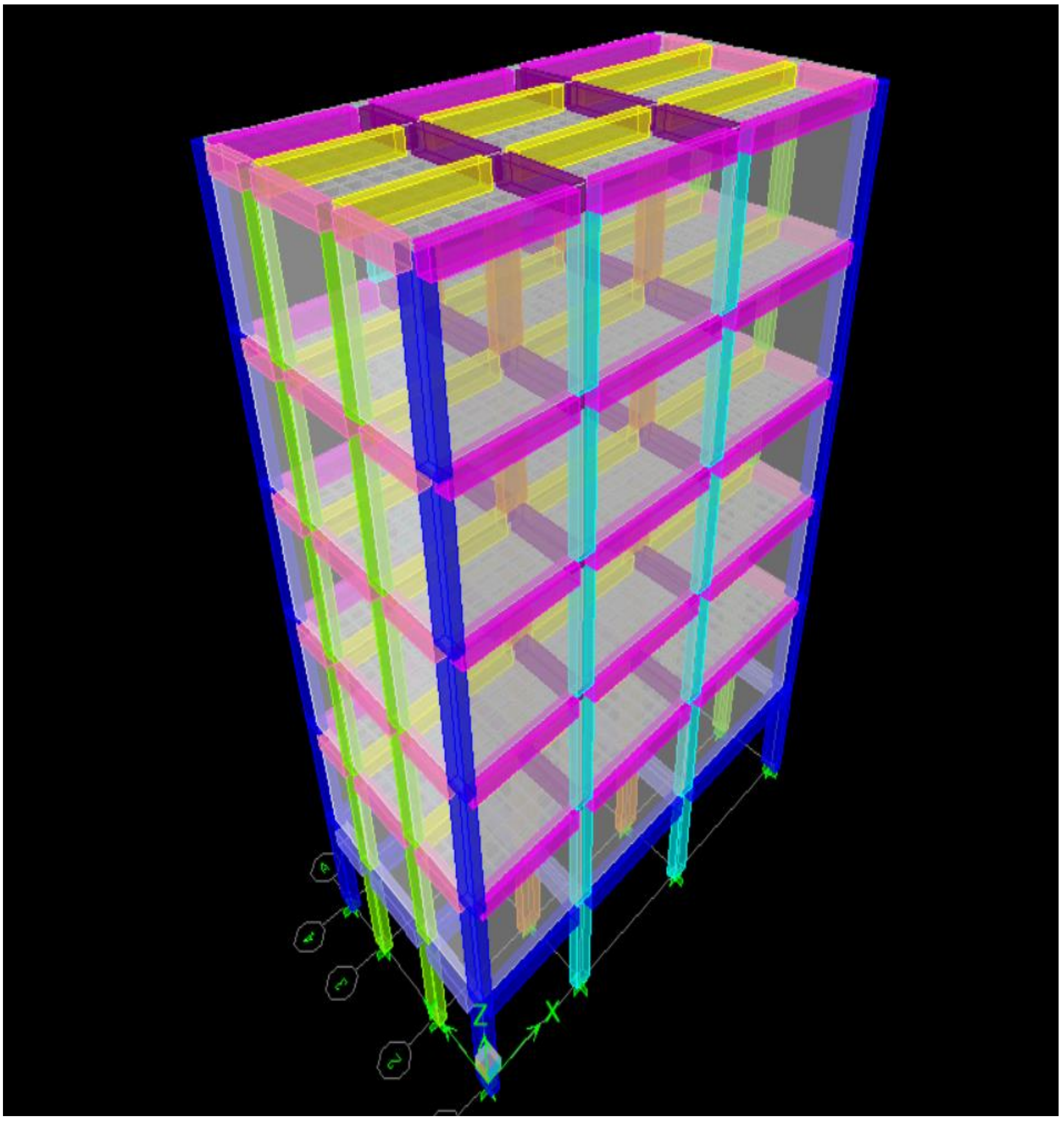


Figure 4.3: 3D View of 6 Story residential building

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

4.4 Deflection view for wind load

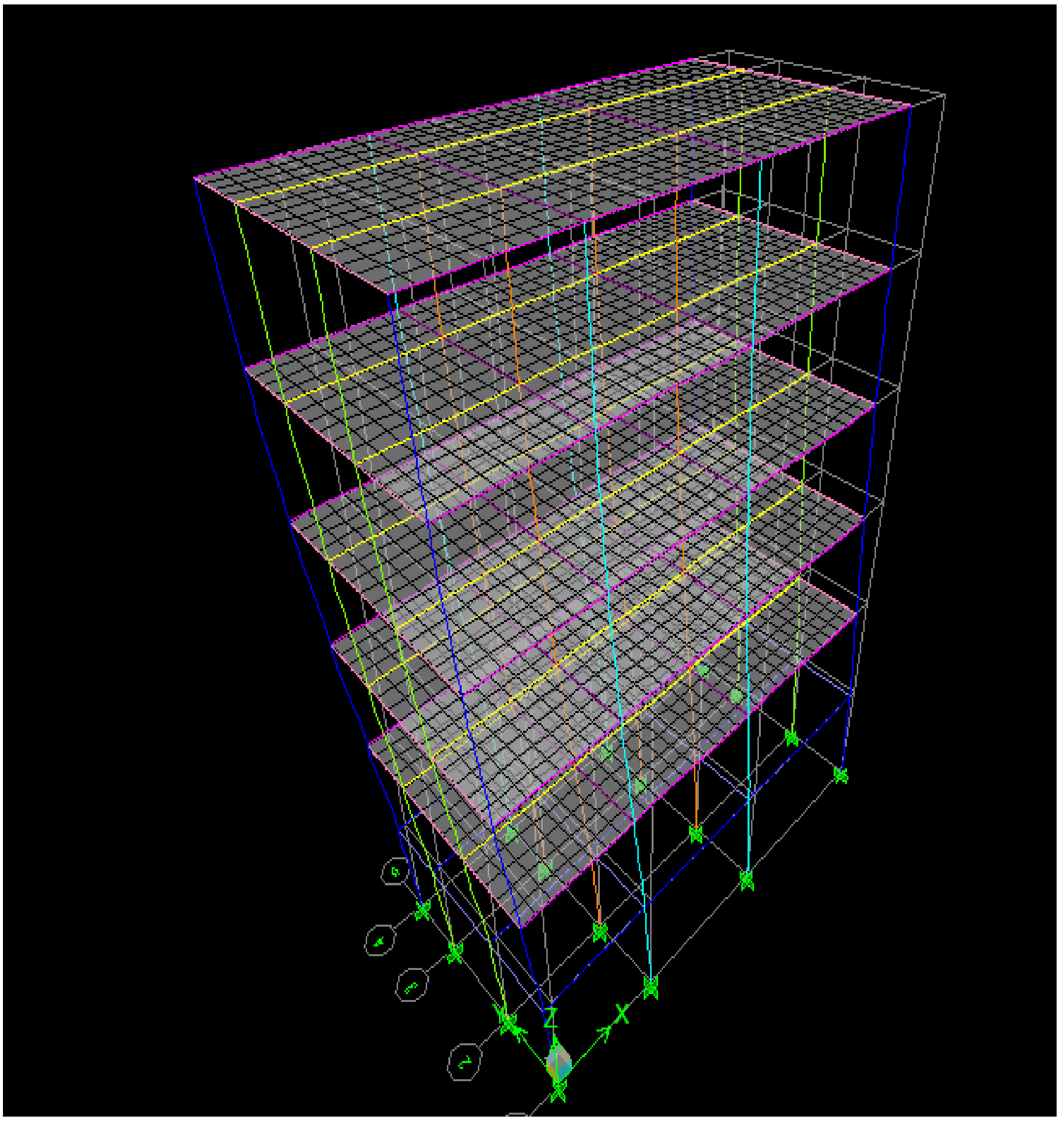


Figure 4.4: Deflection view for wind load

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

4.5: Reinforcement area of all columns

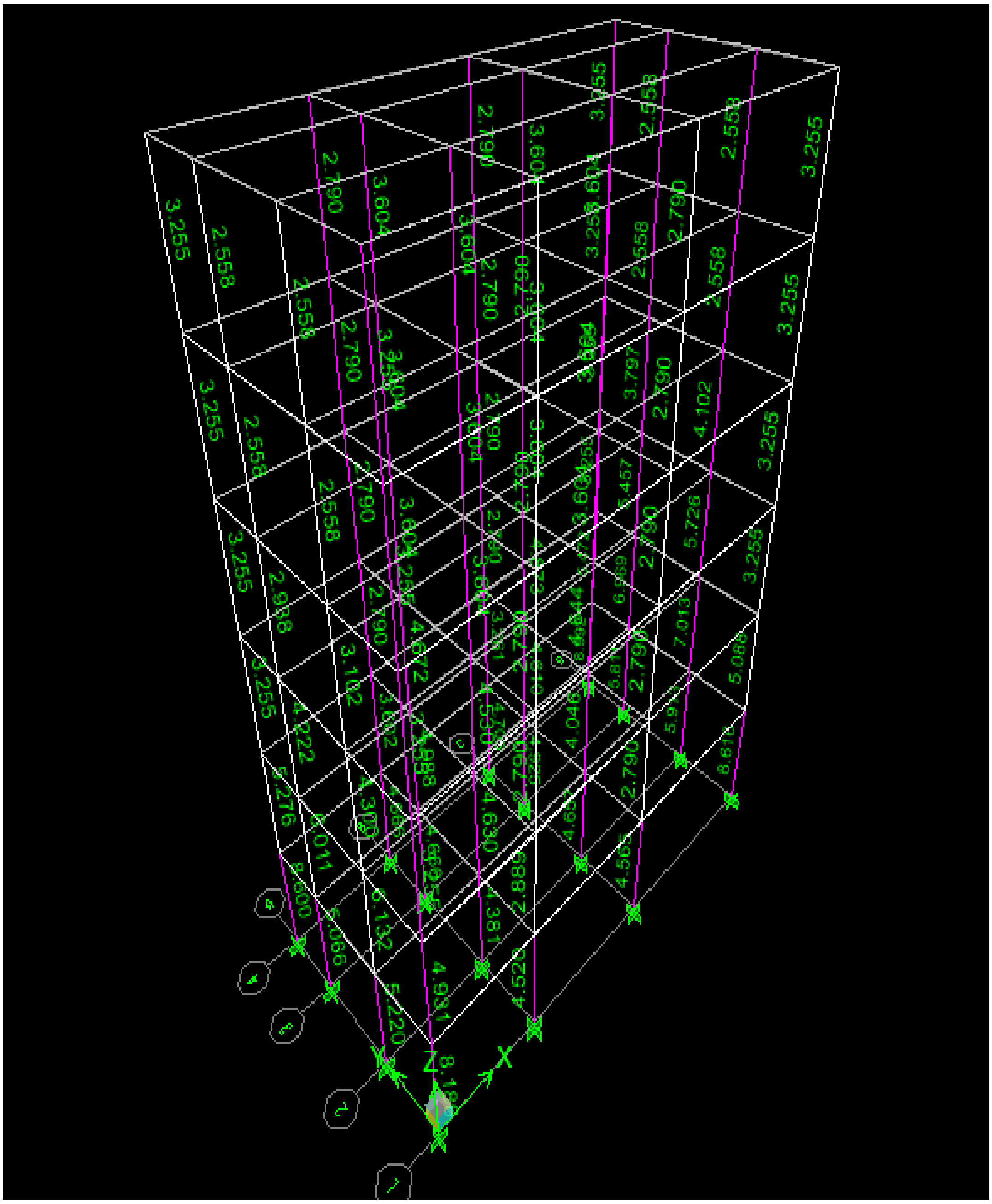


Figure 4.5: Reinforcement area of all columns

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

4.6: Reinforcement area of all beams

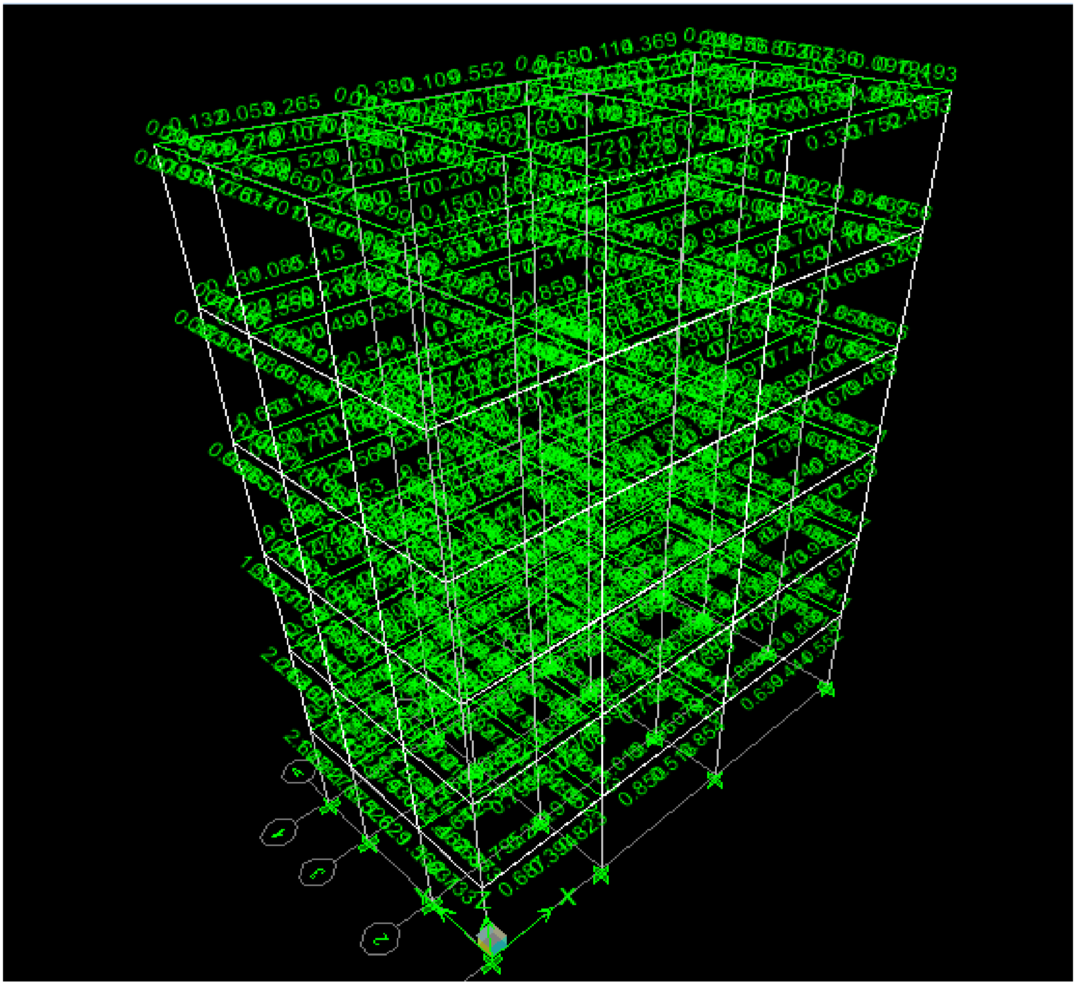


Figure 4.6: Reinforcement area of all beam

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

BEAM DESIGN

MYMENSINGH (ZONE-III)

5.1: Reinforcement Detailing of Grade Beam X-Axis

X-axis GB

Figure 5.1: Reinforcement area of Grade Beam X-Axis

Table 5.1: Reinforcement Detailing of Grade Beam X-Axis

X-axis GB											
Maximum Reinforcement Needed		Bar Selected to be used		Number of Bar Pro.		Maximum Reinforcement Needed		Bar Selected to be used		Number of Bar Pro.	
Negative side (in^2)		N	Area (in^2)	Str.	Ext	Positive side (in^2)		N	Area (in^2)	Str	Ext
Left	1.192	5	.31	2	2	Left	1.192	5	.31	3	1
Middle	0.523	5	.31	2	-	Middle	0.630	5	.31	3	-
Right	1.192	5	.31	2	2	Right	1.192	5	.31	3	1

5.2: Long and Cross Sections of X Axis of GF Beam (18″ X 24″)

GRADE BEAM (X-AXIS)

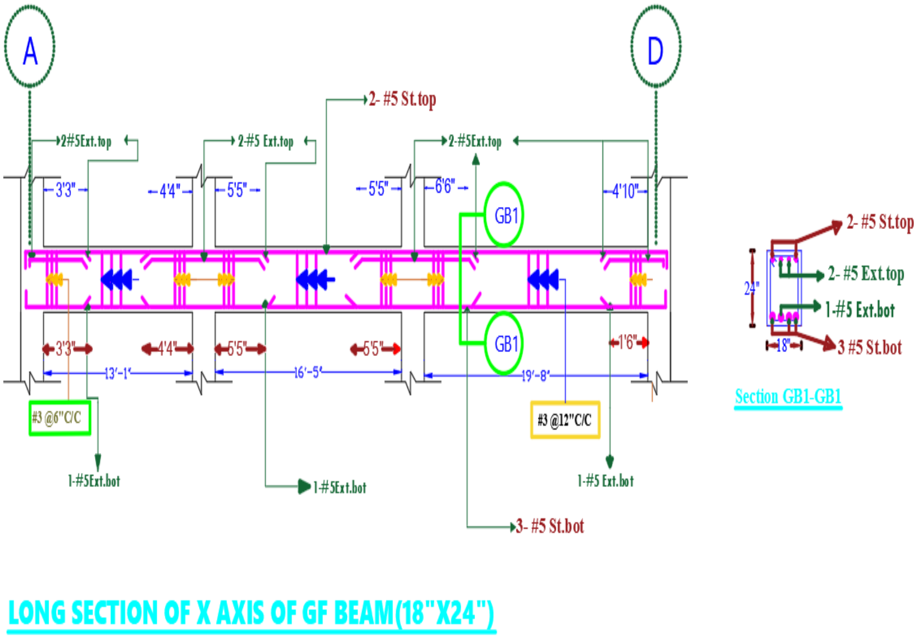


Figure 5.2: Long and Cross Sections of X Axis of GF Beam (18″ X 24″)

For negative side, we get more reinforcement area at left and right corner than the middle that's why we need to provide two extra top at two corners.

For positive side**,** we get more reinforcement area at left and right corner than the middle that's why we need to provide one extra top at two corners.

5.3: Reinforcement Detailing of Grade Beam Y-Axis

Y-axis GB

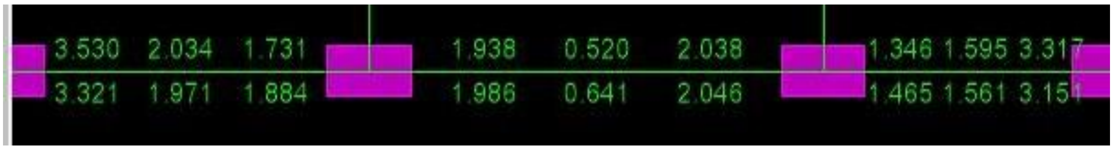


Figure 5.3: Reinforcement area of Grade Beam Y-Axis

Table 5.2: Reinforcement Detailing of Grade Beam Y-Axis

Y-axis GB											
Maximum Reinforcement Needed		Bar Selected to be used		Number of Bar Provided		Maximum Reinforcement Needed		Bar Selected to be used		Number of Bar Provided	
Negative side (in^2)		N	Area (in^2)	Str.	Ext	Positive side (in^2)		N	Area (in^2)	Str.	Ext
Left	3.530	7	.60	4	2	Left	3.321	7	.60	4	2
Middle	2.034	7	.60	4	-	Middle	1.971	7	.60	4	-
Right	3.317	7	.60	4	2	Right	3.151	7	.60	4	2

5.4: Long and Cross Sections of Y Axis of GF Beam (18″ X 24″)

Grade Beam (Y-Axis):

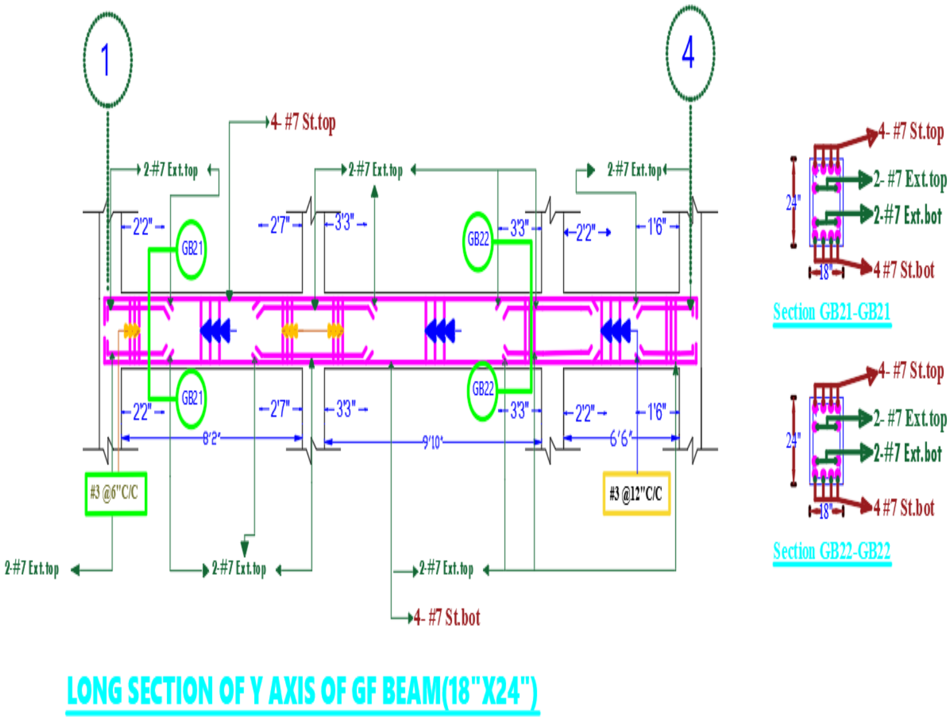


Figure 5.4: Long and Cross Sections of Y Axis of GF Beam (18″ X 24″)

For negative side, we get more reinforcement area at left and right corner than the middle that’s why we need to provide two extra top at two corners.

For positive side, , we get more reinforcement area at left and right corner than the middle that’s why we need to provide two extra top at two corners

5.5: Reinforcement Detailing of 1ST FLOOR (X-Axis)

X-axis 1stF

Figure 5.5: Reinforcement Area of 1STFLOOR (X-Axis)

Table 5.3: Reinforcement Detailing of 1ST FLOOR (X-Axis)

X-axis 1stF											
Maximum Reinforcement Needed		Bar Selected to be used		Number of Bar Provided		Maximum Reinforcement Needed		Bar Selected to be used		Number of Bar Provided	
Negative side (in^2)		N.	Area (in^2)	Str.	Ext	Positive side (in^2)		N.	Area (in^2)	St.	Ext
Left	1.553	5	.31	2	3	Left	0.853	6	.44	2	-
Middle	0.418	5	.31	2	-	Middle	0.903	6	.44	2	1
Right	1.449	5	.31	2	3	Right	0.853	6	.44	2	-

5.6: Long and Cross Sections of X Axis of GF Beam (18″ X 24″)

1ST Floor Beam (X-Axis):

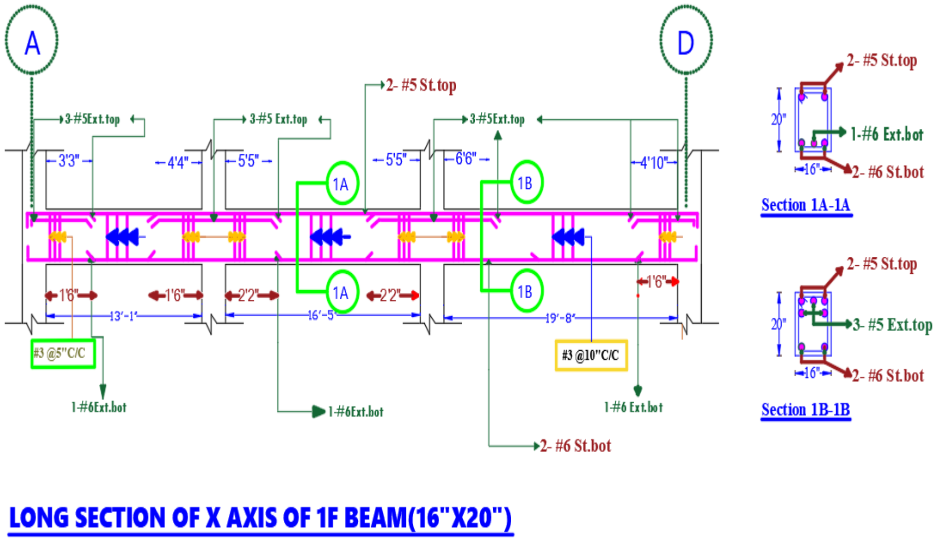


Figure 5.6: Long and Cross Sections of X Axis of GF Beam (18″ X 24″)

For negative side, we get more reinforcement area at left and right corner than the middle that’s why we need to provide two extra top at three corners.

For positive side, we get more reinforcement area at middle than the left and right corners that’s why we need to provide one extra top at middle.

5.7: Reinforcement Detailing of 1ST FLOOR (Y-Axis)

Y-axis 1stF

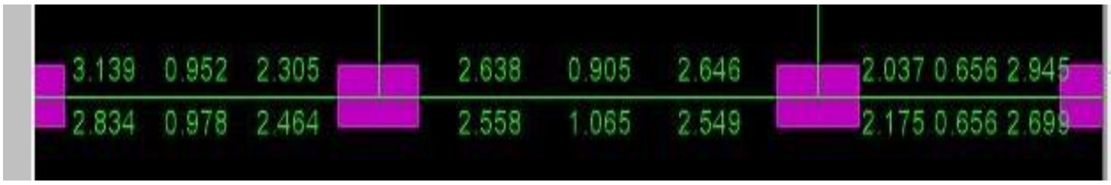


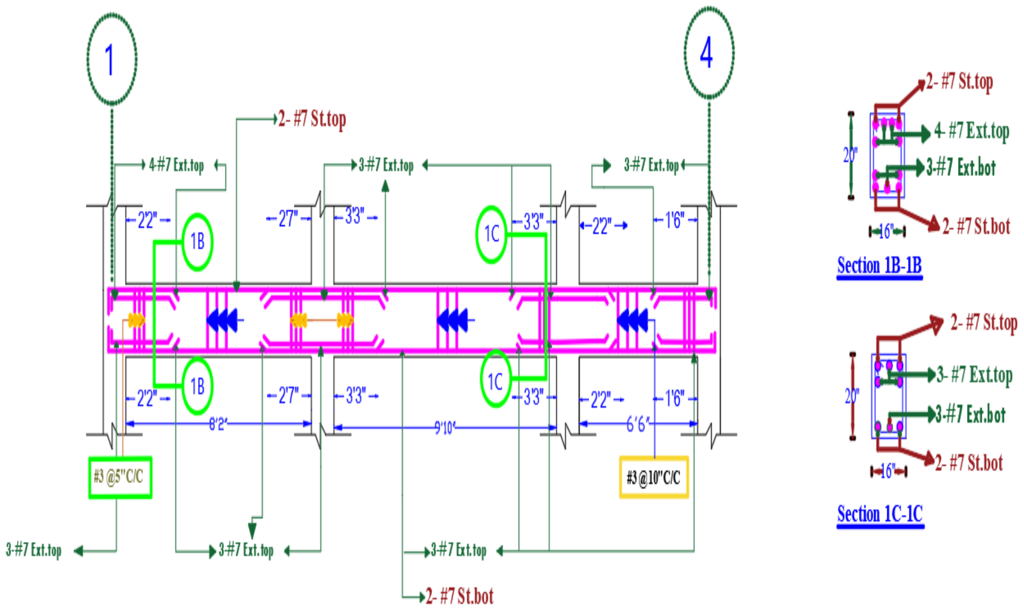
Figure 5.7: Reinforcement Area of 1ST FLOOR (Y-Axis)

Table 5.4: Reinforcement Detailing of 1ST FLOOR (Y-Axis)

Y-axis 1stF											
Maximum Reinforcement Needed		Bar Selected to be used		Number of Bar Provided		Maximum Reinforcement Needed		Bar Selected to be used		Number of Bar Provided	
Negative side (in^2)		No	Area (in^2)	Str.	Ext	Positive side (in^2)		No.	Area (in^2)	Str.	Ext
Left	3.139	7	.60	2	4	Left	2.834	7	.60	2	3
Middle	0.952	7	.60	2	-	Middle	1.065	7	.60	2	-
Right	2.945	7	.60	2	3	Right	2.699	7	.60	2	3

5.8: Long and Cross Sections of Y Axis of 1st Floor Beam (16″ X 20″)

1ST Floor Beam (Y-Axis):



LONG SECTION OF Y AXIS OF 1F BEAM(16"X20")

Figure 5.8: Long and Cross Sectionsof Y Axis of 1st Floor Beam (16″ X 20″)

For negative side, we get more reinforcement area at left and right corner than the middle that’s why we need to providesfour extra tops at left corner and three extra tops and right corner.

For positive side,we get more reinforcement area at left and right corner than the middle that’s why we need to providesthree extra top at two corners.

5.9: Reinforcement Detailing of 2nd FLOOR (X-Axis)

X-axis 2nd Floor:

Figure 5.9: Reinforcement Area of 2ndFLOOR (Y-Axis)

Table 5.5: Reinforcement Detailing of 2nd FLOOR (X-Axis)

Y-axis 2nd F											
Maximum Reinforcement Needed		Bar Selected to be used		Number of Bar Provided		Maximum Reinforcement Needed		Bar Selected to be used		Number of Bar Provided	
Negative side (in^2)		No.	Area (in^2)	Str.	Ext	Positive side (in^2)		No.	Area (in^2)	Str.	Ext
Left	2.547	6	.44	2	4	Left	2.223	6	.44	3	3
Middle	0.801	6	.44	2	-	Middle	0.963	6	.44	3	-
Right	2.322	6	.44	2	4	Right	2.233	6	.44	3	3

5.10: Long and Cross Sections of X Axis of 2ND Floor Beam (16″ X 20″)

2nd Floor Beam (X-Axis):

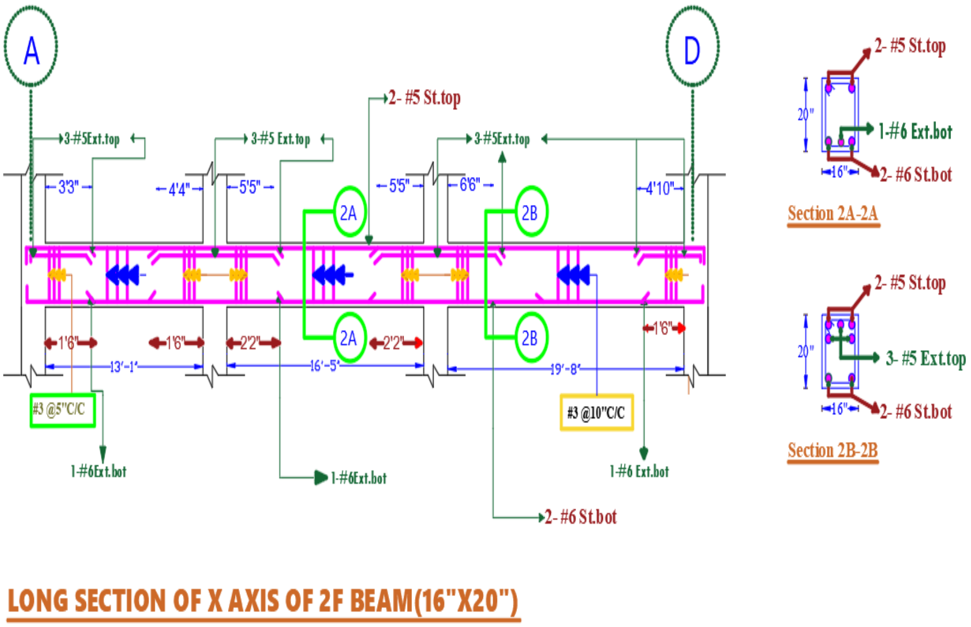


Figure 5.10: Long and Cross Sections of X Axis of 2ND Floor Beam (16″ X 20″)

For negative side, we get more reinforcement area at left and right corner than the middle that’s why we need to provide four extra top at two corners.

For positive side, we get more reinforcement area at left and right corner than the middle that’s why we need to provide three extra top at two corners.

5.11: Reinforcement Detailing of 2nd Floor (Y-Axis)

Y-axis 2nd Floor:

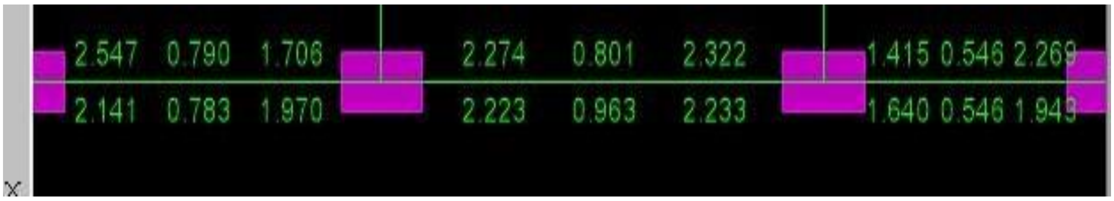


Figure 5.11: Reinforcement Area of 2ndFLOOR (Y-Axis)

Table 5.6: Reinforcement Detailing of 2nd FLOOR (Y-Axis)

Y-axis 2nd F											
Maximum Reinforcement Needed		Bar Selected to be used		Number of Bar Provided		Maximum Reinforcement Needed		Bar Selected to be used		Number of Bar Provided	
Negative side (in^2)		No.	Area (in^2)	Str.	Ext	Positive side (in^2)		No.	Area (in^2)	Str.	Ext
Left	2.547	6	.44	2	4	Left	2.223	6	.44	3	3
Middle	0.801	6	.44	2	-	Middle	0.963	6	.44	3	-
Right	2.322	6	.44	2	4	Right	2.233	6	.44	3	3

5.12: Long and Cross Sections of Y Axis of 2ND Floor Beam (16″ X 20″)

2nd Floor Beam(Y-Axis)

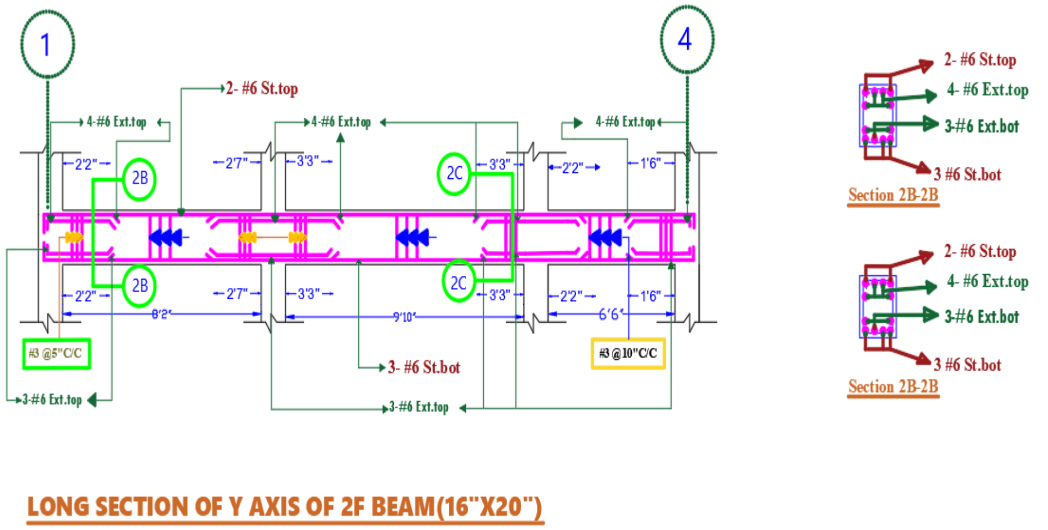


Figure 5.12: Long and Cross Sections of Y Axis of 2ND Floor Beam (16″ X 20″)

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For negative side, we get more reinforcement area at left and right corner than the middle that's why we need to provide four extra top at two corners.

For positive side, , we get more reinforcement area at left and right corner than the middle that's why we need to provide three extra top at two corners.

5.13: Reinforcement Detailing of 3rd FLOOR (X-Axis)

X-axis 3rd Floor

Figure 5.13: Reinforcement Area of 3rd FLOOR (X-Axis)

Table 5.7: Reinforcement Detailing of 3rd Floor (X-Axis)

X-axis 3rd F											
Maximum Reinforcement Needed		Bar Selected to be used		Number of Bar Provided		Maximum Reinforcement Needed		Bar Selected to be used		Number of Bar Provided	
Negative side (in^2)		No.	Area (in^2)	Str.	Ext	Positive side (in^2)		No.	Area (in^2)	Str.	Ext
Left	1.177	5	.31	2	2	Left	0.619	5	.31	2	-
Middle	0.302	5	.31	2	-	Middle	0.980	5	.31	2	1
Right	1.055	5	.31	2	2	Right	0.749	5	.31	2	-

5.14: Long and Cross Sections of x-Axis of 3RD Floor Beam (16″ X 20″)

3rd Floorbeam(x-axis)

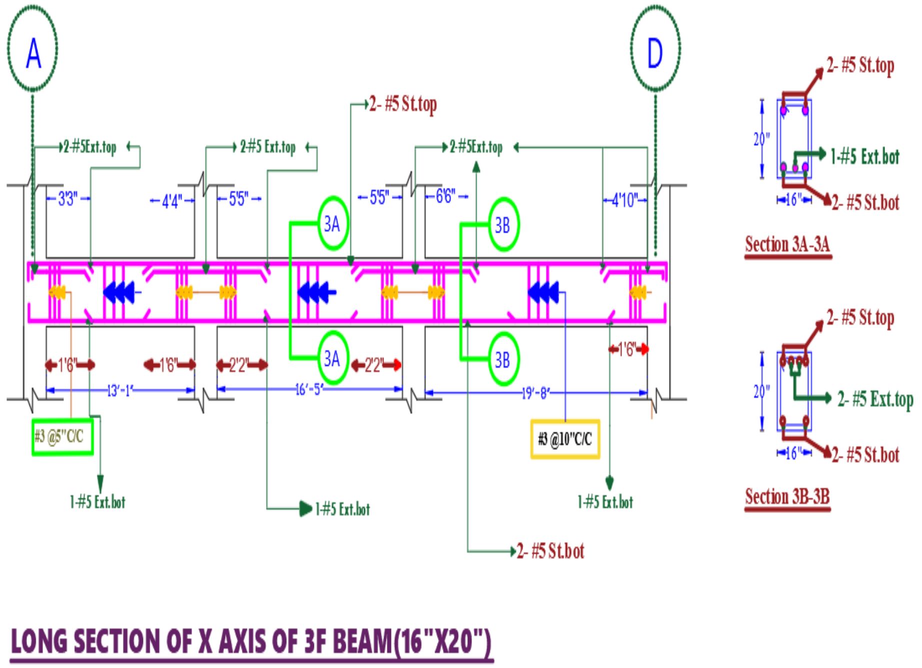


Figure 5.14: Long and Cross Sections of X Axis of 3RD Floor Beam (16″ X 20″)

For negative side, we get more reinforcement area at left and right corner than the middle that's why we need to provide two extra top at two corners.

For positive side, we get more reinforcement area at middle than the left and right corner that's why we need to provide one extra top at middle.

5.15: Reinforcement Detailing of 3rd Floor (Y-Axis)

Y-axis 3rd F

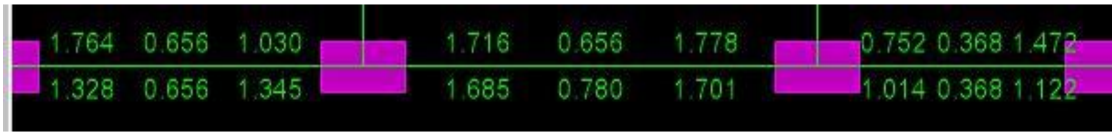


Figure 5.15: Reinforcement Detailing of 3rd FLOOR (Y-Axis)

Table 5.8: Reinforcement Detailing of 3rd FLOOR (Y-Axis)

Y-axis 3rd F											
Maximum Reinforcement Needed		Bar Selected to be used		Number of Bar Provided		Maximum Reinforcement Needed		Bar Selected to be used		Number of Bar Provided	
Negative side (in^2)		No.	Area (in^2)	Str.	Ext	Positive side (in^2)		No.	Area (in^2)	Str.	Ext
Left	1.764	6	.44	2	3	Left	1.658	6	.44	2	2
Middle	0.656	6	.44	2	-	Middle	0.780	6	.44	2	-
Right	1.778	6	.44	2	3	Right	1.701	6	.44	2	2

5.16: Long and Cross Sections of Y Axis of 3rd Floor Beam (16″ X 20″)

<u>3rd Floor beam(y-axis)</u>

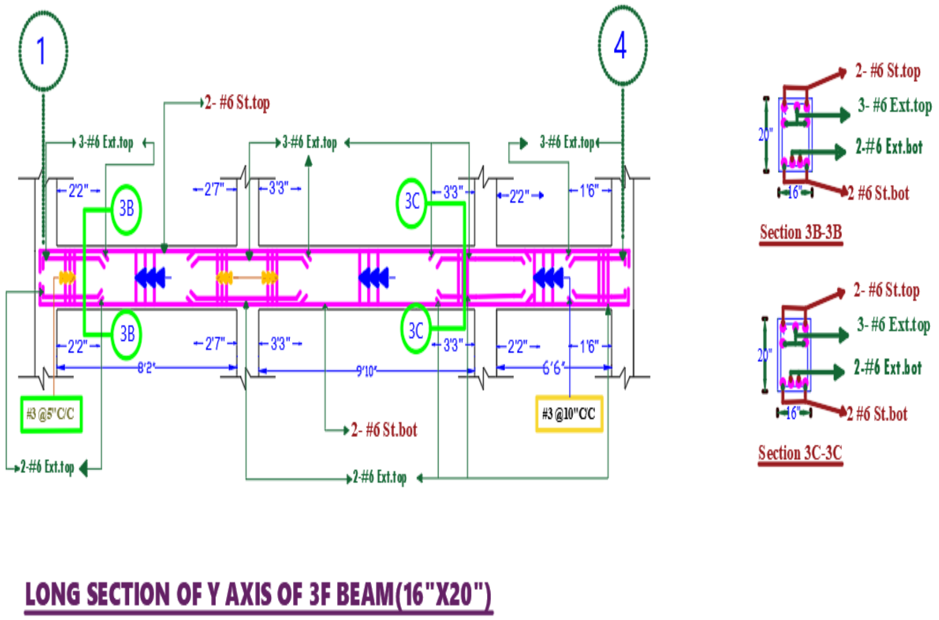


Figure 5.16: Long and Cross Sections of Y Axis of 3rd Floor Beam (16″ X 20″)

For negative side, we get more reinforcement area at left and right corner than the middle that’s why we need to provide three extra top at two corners.

For positive side**,** we get more reinforcement area at left and right corner than the middle that’s why we need to provide two extra top at two corners.

5.17: Reinforcement Detailing of 4th Floor (X-Axis)

X-axis 4th F

Figure 5.17: Reinforcement Detailing of 4th floor (X-Axis)

Table 5.9: Reinforcement Detailing of 4th floor (X-Axis)

X-axis 4th F											
Maximum Reinforcement Needed		Bar Selected to be used		Number of Bar Provided		Maximum Reinforcement Needed		Bar Selected to be used		Number of Bar Provided	
Negative side (in^2)		No.	Area (in^2)	Str.	Ext	Positive side (in^2)		No.	Area (in^2)	Str.	Ext
Left	0.957	5	.31	2	2	Left	0.548	6	.44	2	-
Middle	0.247	5	.31	2	-	Middle	0.970	6	.44	2	1
Right	0.945	5	.31	2	2	Right	0.712	6	.44	2	-

5.18: Long and Cross Sections of X Axis of 4TH Floor Beam (16″ X 20″)

4th Floor beam(x-axis)

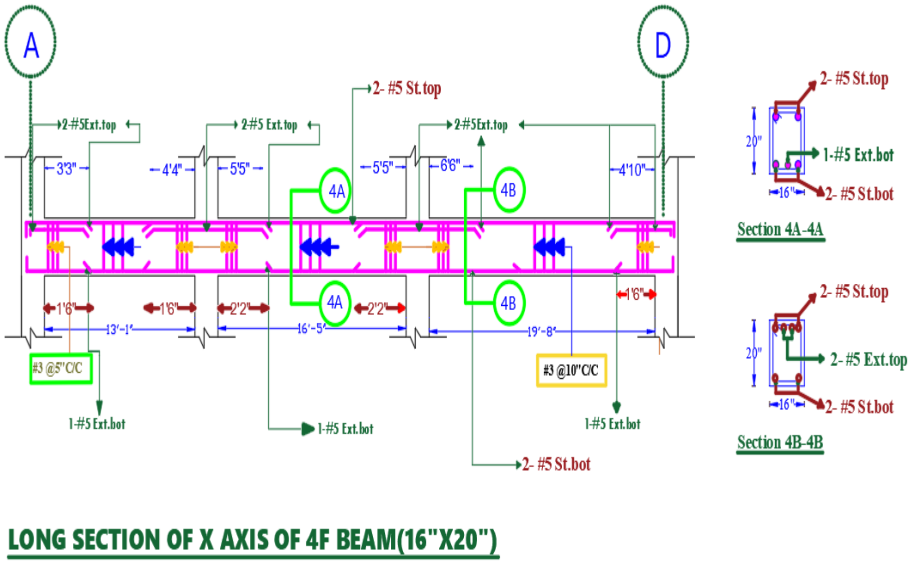


Figure 5.18: Long and Cross Sections of X Axis of 4TH Floor Beam (16″ X 20″)

For negative side, we get more reinforcement area at left and right corner than the middle that’s why we need to provide two extra top at two corners.

For positive side**,** we get more reinforcement area at middle than the left and right corner that’s why we need to provide one extra top at two middle.

5.19: Reinforcement Detailing of 4th FLOOR (Y-Axis)

Y-axis 4^{th} F

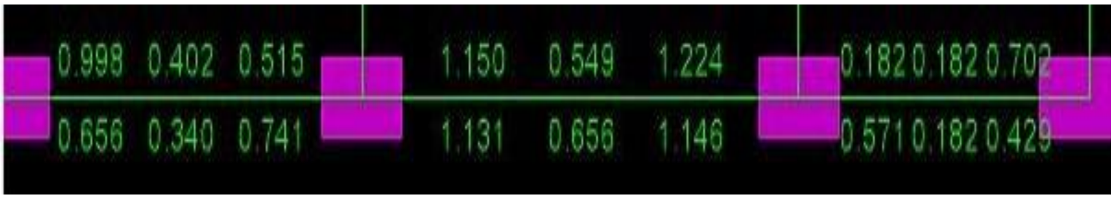


Figure 5.19: Reinforcement Area of 4th FLOOR (Y-Axis)

Table 5.10: Reinforcement Detailing of 4th FLOOR (Y-Axis)

Y-axis 4^{th} F											
Maximum Reinforcement Needed		Bar Selected to be used		Number of Bar Provided		Maximum Reinforcement Needed		Bar Selected to be used		Number of Bar Provided	
Negative side (in^2)		No.	Area (in^2)	Str.	Ext	Positive side (in^2)		No.	Area (in^2)	Str.	Ext
Left	1.150	5	.31	2	2	Left	1.131	5	.31	3	1
Middle	0.549	5	.31	2	-	Middle	0.656	5	.31	3	-
Right	1.224	5	.31	2	2	Right	1.146	5	.31	3	1

5.20: Long and Cross Sections of Y Axis of 4TH Floor Beam (16″ X 20″)

<u>4th Floor beam(y-axis)</u>

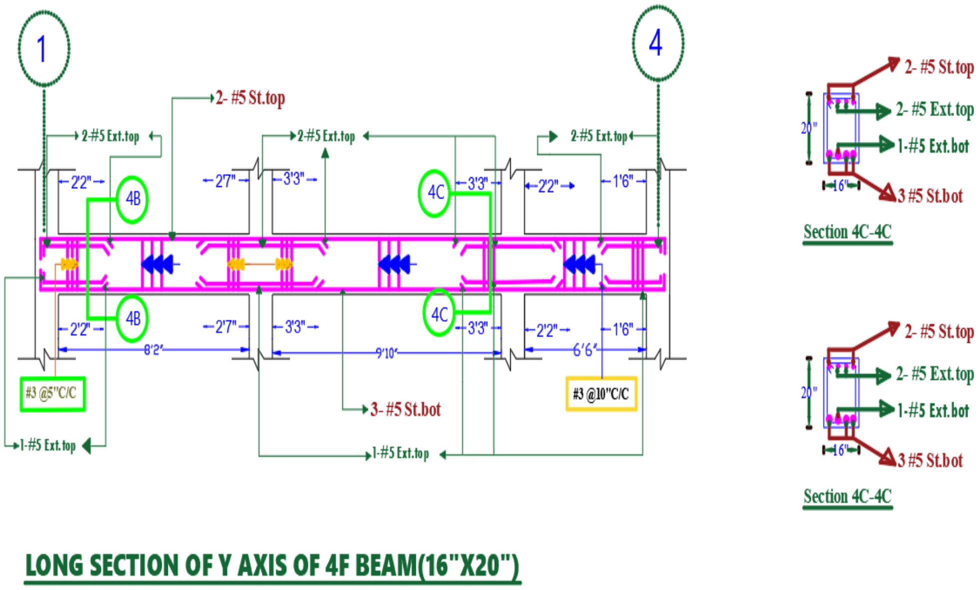


Figure 5.20: Long and Cross Sections of Y Axis of 4TH Floor Beam (16″ X 20″)

For negative side, we get more reinforcement area at left and right corner than the middle that’s why we need to provide two extra top at two corners.

For positive side, , we get more reinforcement area at left and right corner than the middle that’s why we need to provide one extra top at two corners.

5.21: Reinforcement Detailing of Roof (X-Axis)

<u>X-axis RF</u>

Figure 5.21: Reinforcement Area of Roof (X-Axis)

Table 5.11: Reinforcement Detailing of Roof (X-Axis)

X-axis RF											
Maximum Reinforcement Needed		Bar Selected to be used		Number of Bar Provided		Maximum Reinforcement Needed		Bar Selected to be used		Number of Bar Provided	
Negative side (in^2)		No.	Area (in^2)	Str.	Ext	Positive side (in^2)		No.	Area (in^2)	Str.	Ext
Left	0.891	5	.31	2	1	Left	0.551	6	.44	2	-
Middle	0.231	5	.31	2	-	Middle	1.055	6	.44	2	1
Right	0.853	5	.31	2	1	Right	0.853	6	.44	2	-

5.22: Long and Cross Sections of X Axis of 5TH Floor Beam (16″ X 20″)

<u>Roof floor beam(X-Axis)</u>

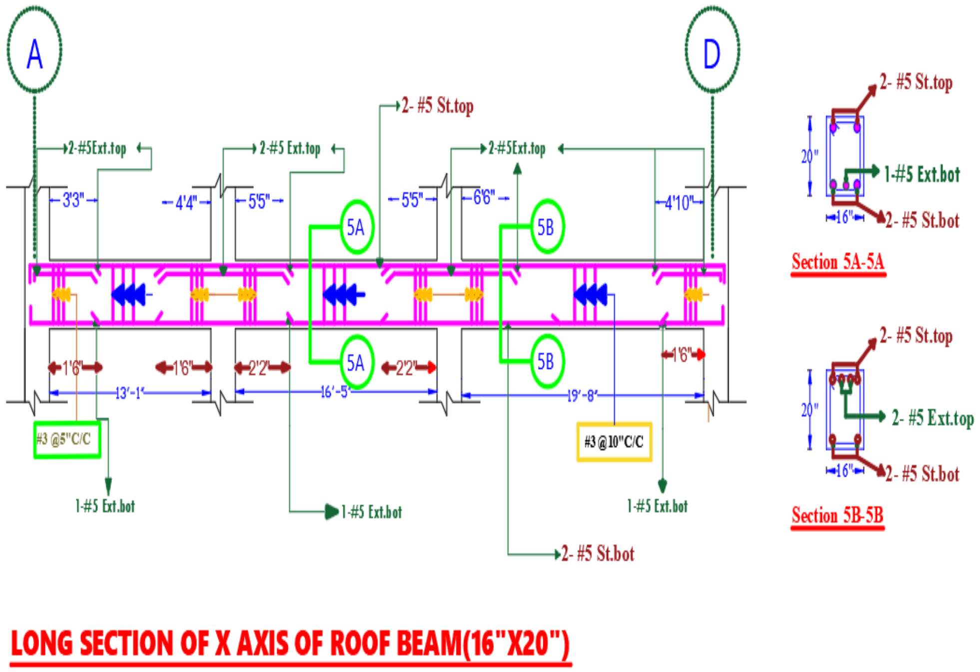


Figure 5.22: Long and Cross Sections of X Axis of 5TH Floor Beam (16″ X 20″)

For negative side, we get more reinforcement area at left and right corner than the middle that's why we need to provide one extra top at two corners.

For positive side**,** we get more reinforcement area at middle than the left and right

That's why we need to provide one extra top at two corners.

5.23: Reinforcement Detailing of Roof (Y-Axis)

Y-axis RF:

Figure 5.23: Reinforcement Area of Roof (Y-Axis)

Table 5.12: Reinforcement Detailing of Roof (Y-Axis)

Y-axis RF											
Maximum Reinforcement Needed		Bar Selected to be used		Number of Bar Provided		Maximum Reinforcement Needed		Bar Selected to be used		Number of Bar Provided	
Negative side (in^2)		No	Area (in^2)	Str.	Ext	Positive side (in^2)		No.	Area (in^2)	Str.	Ext
Left	0.656	5	.31	2	1	Left	0.565	5	.31	2	1
Middle	0.294	5	.31	2	-	Middle	0.586	5	.31	2	-
Right	0.710	5	.31	2	1	Right	0.704	5	.31	2	1

5.24: Long and Cross Sections of Y Axis of 4TH Floor Beam (16″ X 20″)

<u>Roof floor beam (Y-Axis)</u>

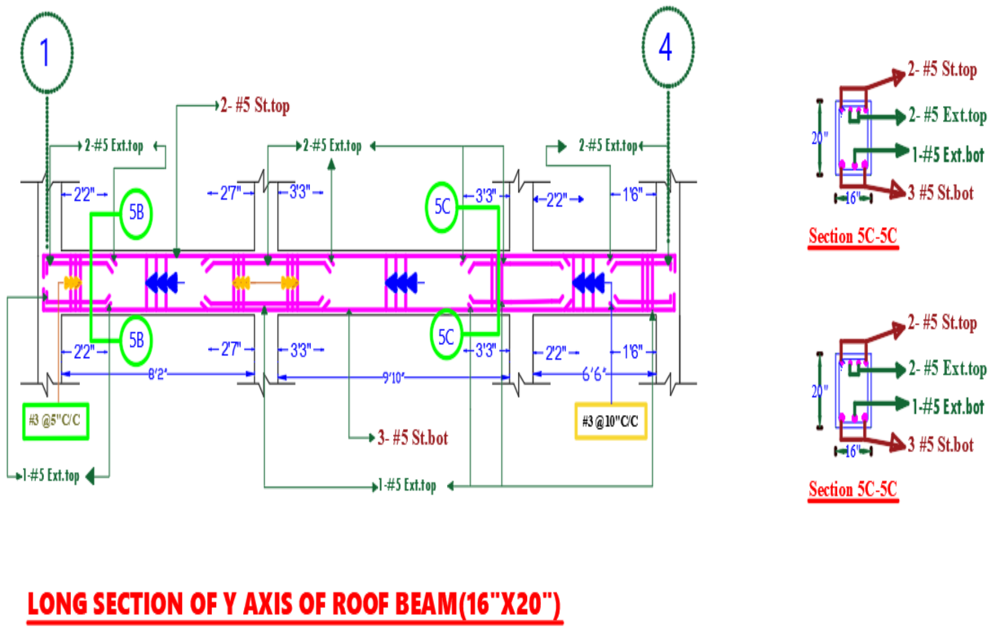


Figure 5.24: Long and Cross Sections of Y Axis of 4TH Floor Beam (16″ X 20″)

For negative side, we get more reinforcement area at left and right corner than the middle that’s why we need to provide one extra top at two corners.

For positive side, we get more reinforcement area at left and right corner than the middle that’s why we need to provide one extra top at two corners.

CHAPTER -VI

COLUMN DESIGN

6.1 Layout of column:

We have use four column and the dimension of this given value after more trial we choose Economical column size.

C1= 12″X28 ″

C2= 12″X24″

C3= 12″X22 ″

C4= 12″X31″

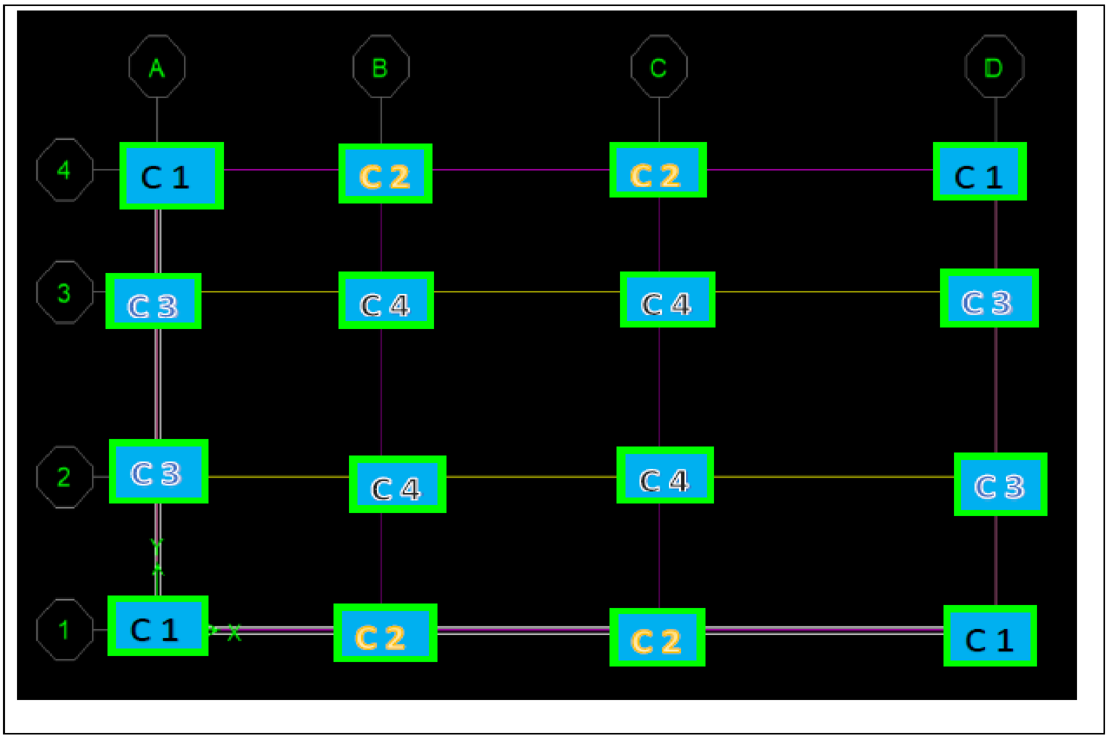


Figure 6.1: Column layout plan

6.2 Details column of C1:

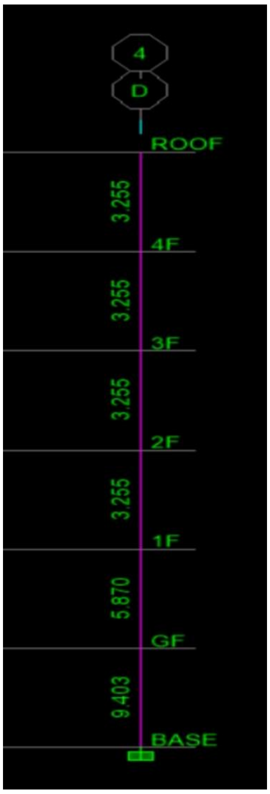


Figure 6.2: Reinforcement Area of C1 column

Steel area (in2)	Using Bar No	Number of bar
9.403	#8 (area=.79 in2)	12
5.870	#8 (area=.79 in2)	8
3.255	#8 (area=.79 in2)	6
3.255	#8 (area=.79 in2)	6
3.255	#8 (area=.79 in2)	6
3.255	#8 (area=.79 in2)	6

Table 6.1: Using bar of C1 column

We maintain reinforcement area within 4% of column cross-section.

6.3 Section details of C1 (base floor):

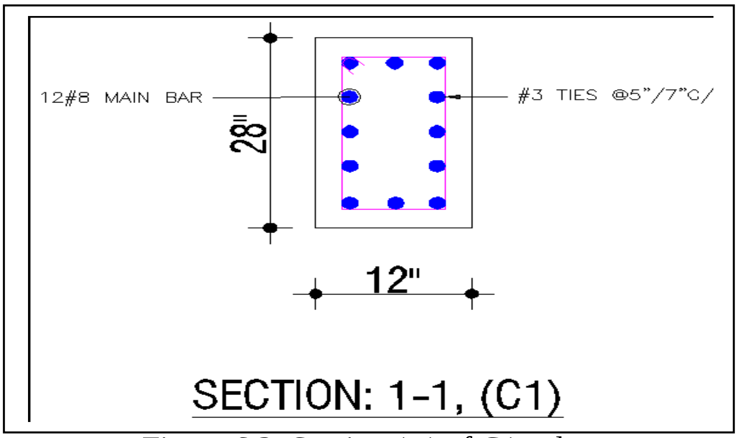


Figure 6.3: Section 1-1 of C1 column

6.3.1: Section details of C1 (GF).

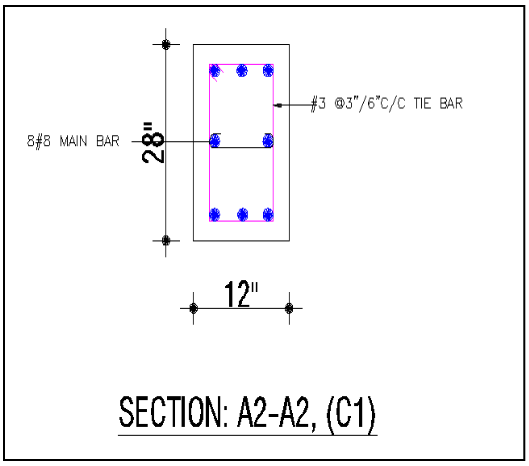


Figure 6.4: Section A2-A2 of C1 column.

6.3.2: Section details of C1: 1st floor to roof.

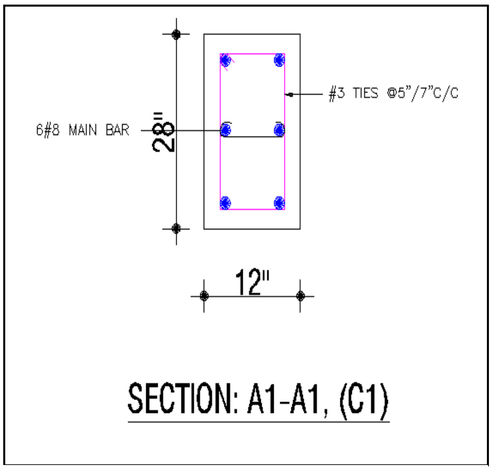


Figure 6.5: Section A1-A1 of C1 column.

Regarding provide the reinforcement for area 9. 403 in^2 we use number 8 bar and therefore we get 12 numbers 8 bar at the lower part of the column. And it reduce to the ground floor and 1st floor to the roof.

For economical practice, we cut off 8 numbers #8 bar at ground floor and rest of the floor 6 number #8 bar will continue 1st floor to the roof.

So, we provide three cross sections area.

6.4 Tie Bar Details for C1 column:

- Highest of

{ 18"
Largest dimension of column
L/6 }

=2'-4"

So=lowest of

{ 4"
Or ¼ of lowest column dimension

Spacingfor corner side of column, So=3"

For middle side of column 2x,So=6"

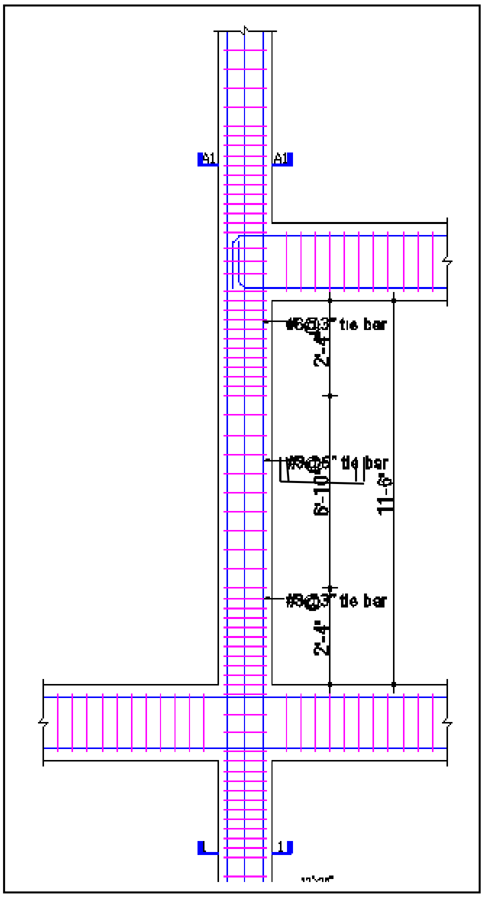


Figure 6.6: Long section of C2column

To prevent the dislocation of main longitudinal bar of column, we should provide tie bar.

For moment resisting frame as per ACI, we provide tie spacing.

6.5 Reinforcements Details column of C2:

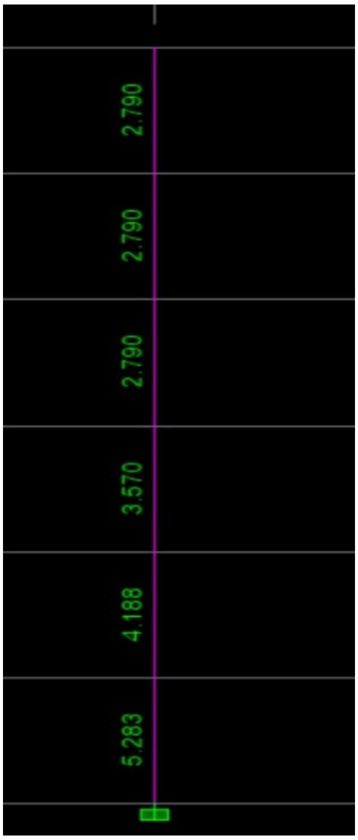


Figure 6.7: Reinforcement Area of C2 column

Steel area (in2)	Using Bar No	Number of bar
5.283	#7 (area=.60 in2)	10
4.188	#7 (area=.60 in2)	8
3.570	#7 (area=.60 in2)	6
2.790	#7 (area=.60 in2)	6
2.790	#7 (area=.60 in2)	6
2.790	#7 (area=.60in2)	6

Table 6.2: Using bar of C2 column

We maintain reinforcement area within 4% of column cross-section.

6.6 Section details of C2 (base floor):

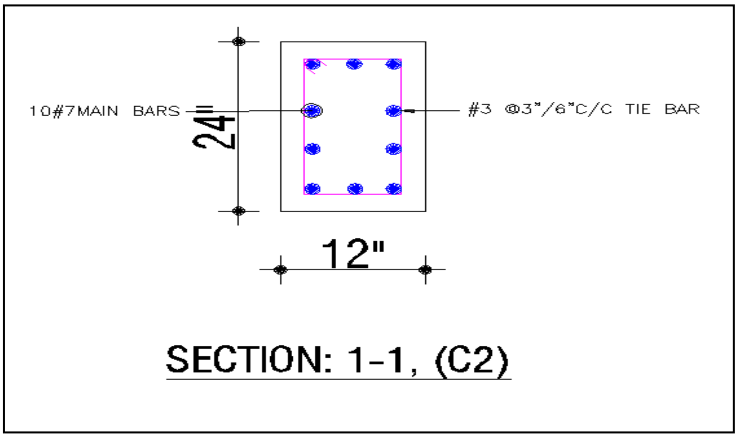


Figure 6.8: Section 1-1 of C2 column

6.6.1: Section details of C2(GF)

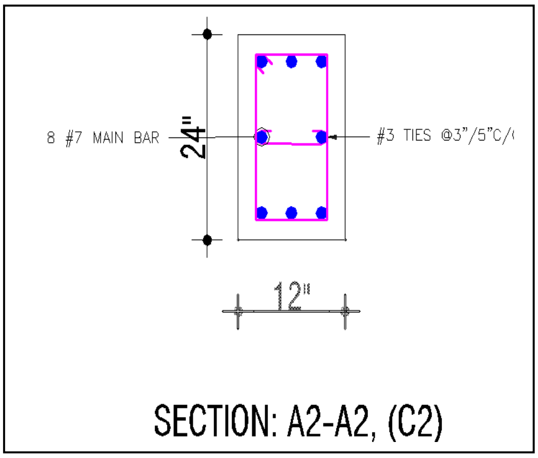


Figure6.9: Section A2-A2 of C2 column

6.6.2: Section details of C2: 1st floor to roof.

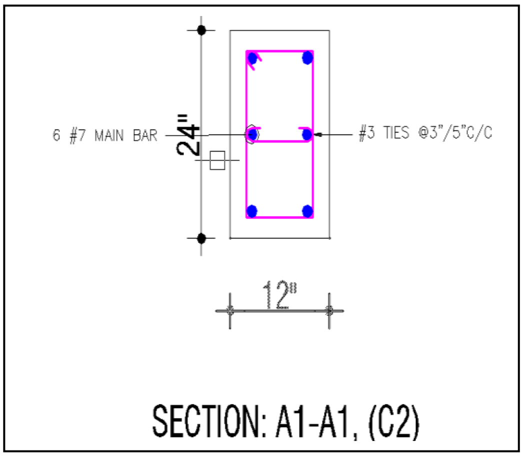


Figure 6.10: Section A1-A1 of C2 column

Regarding provide the reinforcement for area 5.283 in, we use number 7 bar and therefore we get 10 numbers 7 bar-at the lower part of the column. And it reduces to the ground floor and 1st floor to the roof.

For economical practice, we cut off 8 numbers #7 bar at ground floor and rest of the floor 6 number #7 bar will continue 1st floor to the roof.

So, we provide two cross sections area

6.7 Tie Bar Details for C2 column:

- Highest of

{ 18"

Largest dimension of column

L/6 }

=2'-0"

So=lowest of

{ 4''

Or ¼ of lowest column dimension

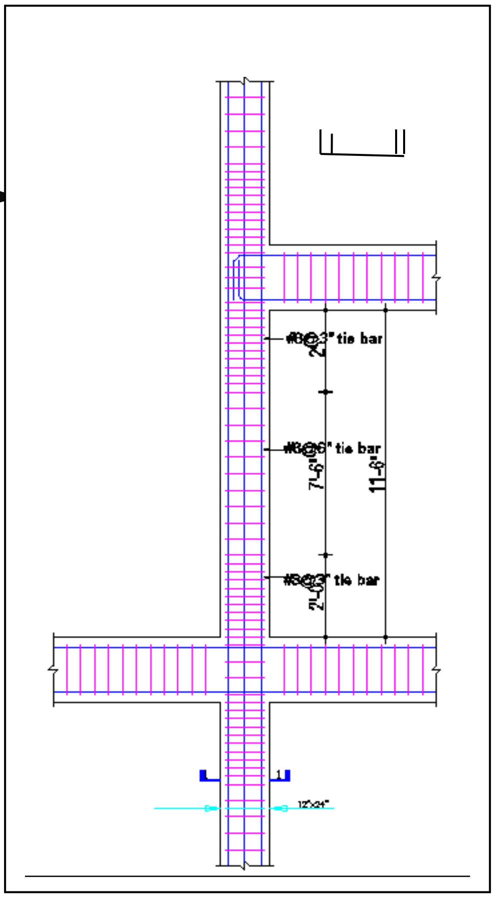


Figure 6.11: Long section of C2

Spacing for corner side of column, So=3"

For middle side of column 2x,So=6"

To prevent the dislocation of main longitudinal bar of column, we should provide tie bar.

For moment resisting frame as per ACI, we provide tie spacing.

6.8 Reinforcements details column of C3

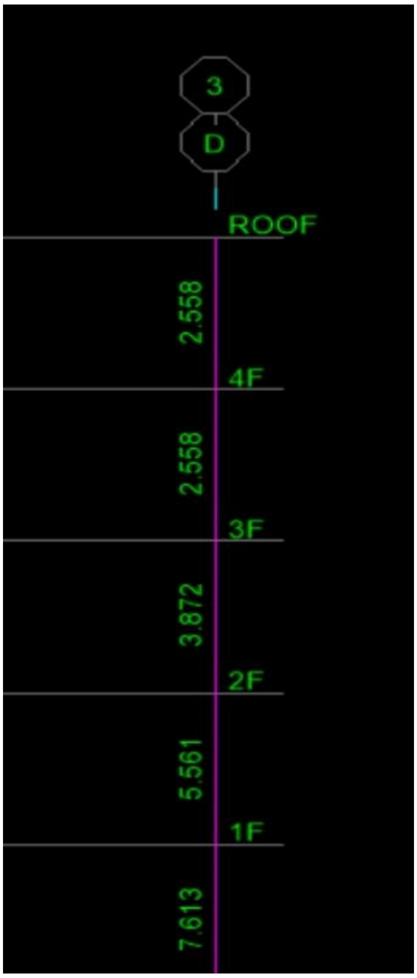


Figure 6.12: Reinforcement Area of C3 column

Steel area (in2)	Using Bar No	Number of bar
6.346	#8 (area=.79 in2)	10
7.613	#8 (area=.79 in2)	10
5.561	#8 (area=.79 in2)	8
3.872	#8 (area=.79 in2)	6
2.558	#8 (area=.79 in2)	6
2.558	#8 (area=.79in2)	6

Table6.3: Using bar of C3 column

We maintain reinforcement area with in 4% of column cross-section.

6.9 Section details of C3 (base floor):

`

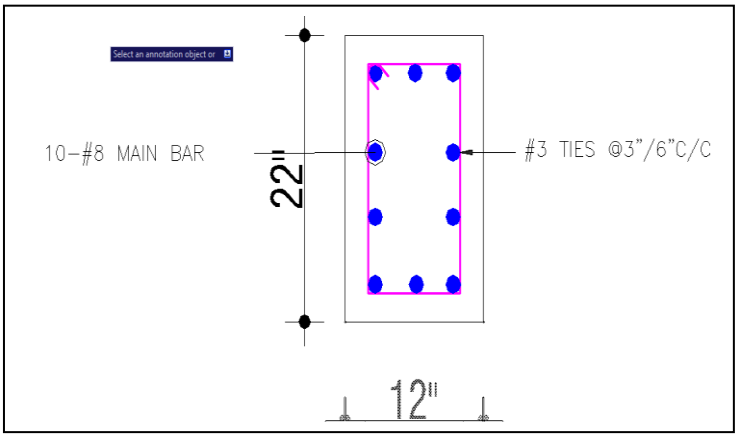


Figure6.13: Section 1-1 of C3 column

6.9.1: Section details of C3 (GF to 1st)

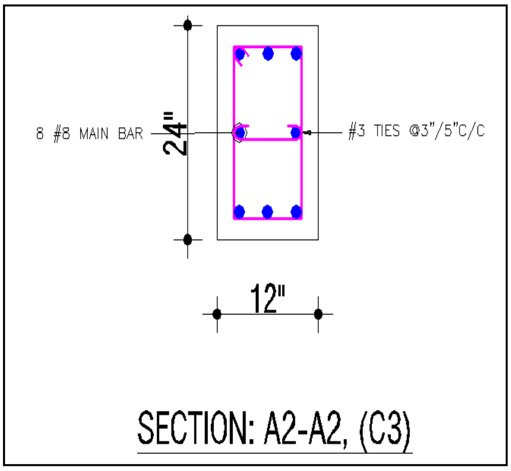


Figure 6.14: Section A2-A2 of C3 column

6.9.2: Section details of C3: 2nd floor to roof.

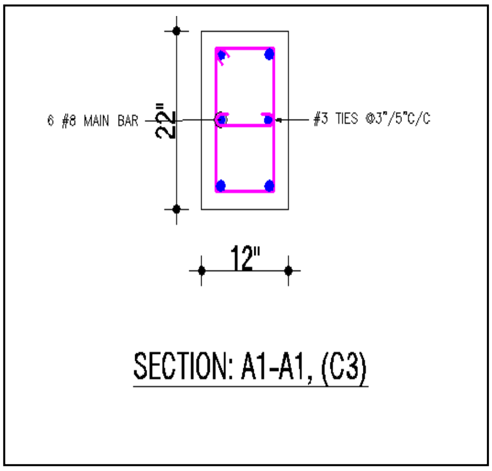


Figure 6.15: Section A-A of C3 column

Regarding provides the reinforcement for area 6.346 in^2, we use number 8 bar and therefore we get 10 numbers 8 bar-at the lower part of the column. And it reduce to the 1st floor and 2nd floor to the roof.

For economical practice, we cut off 8 numbers #8 bar at 1st floor and rest of the floor 6 number #8 bar will continue 2nd floor to the roof.

So, we provide two cross sections area.

6.10 Tie Bar Details for C3 column:

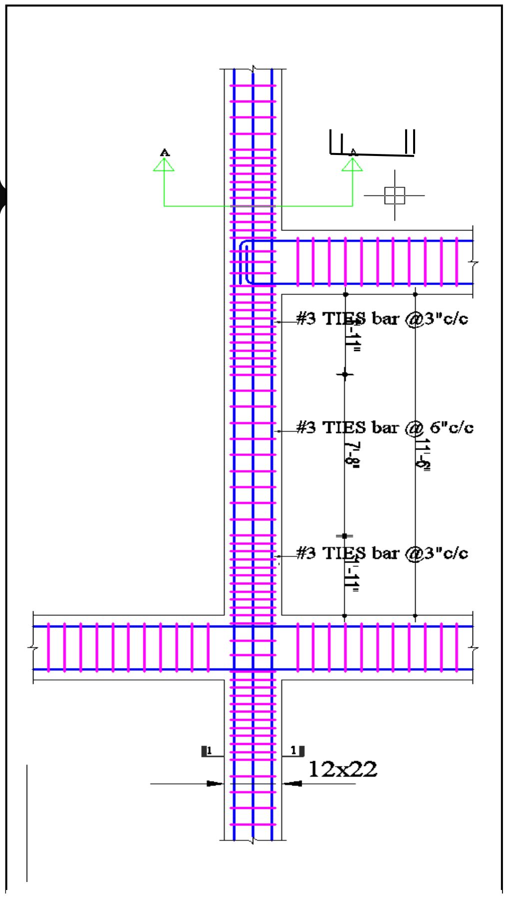
- Highest of

{ 18”
Largest dimension of column
L/6 }

=1’-10”

So=lowest of

{ 4’’
Or ¼ of lowest column dimension



Spacing for corner side of column, So=3”

For middle side of column 2x,So=6

Figure6.16: Long section of C3 column

To prevent the dislocation of main longitudinal bar of column, we should provide tie bar for moment resisting frame as per ACI, we provide tie spacing.

6.11 Reinforcements Details column of C4:

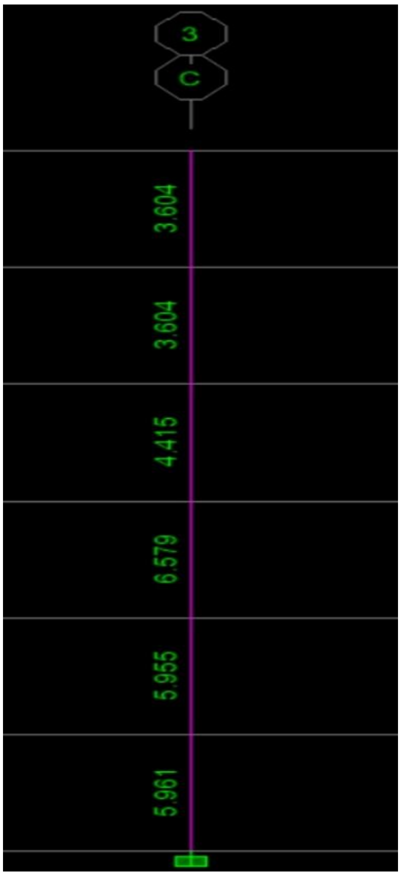


Figure 6.17: Reinforcement Area of C4 column.

Steel area (in2)	Using Bar No	Number of bar
5.961	#8 (area=.79 in2)	10
5.955	#8 (area=.79 in2)	10
6.579	#8 (area=.79 in2)	10
4.415	#8 (area=.79 in2)	6
3.604	#8 (area=.79 in2)	6
3.604	#8(area=.79in2)	6

Table 6.4: Reinforcement Area of C4 column.

We maintain reinforcement area within 4% of column cross-section.

6.12: Section details of C4 (base floor):

`

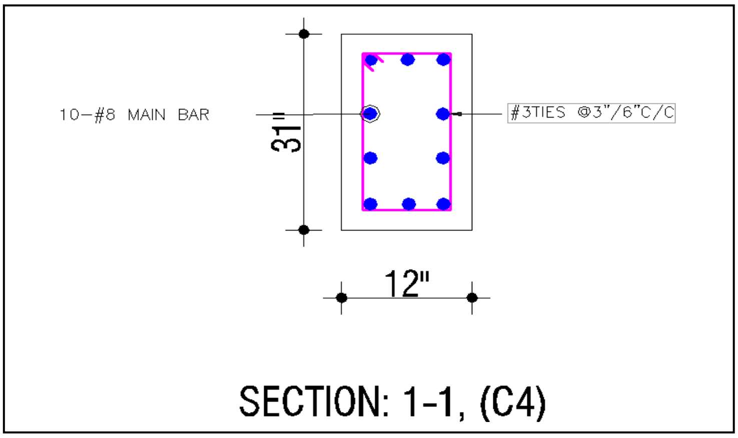


Figure 6.19: Section 1-1 of C4 column

6.12.1: Section details of C4 (GF to 3rd)

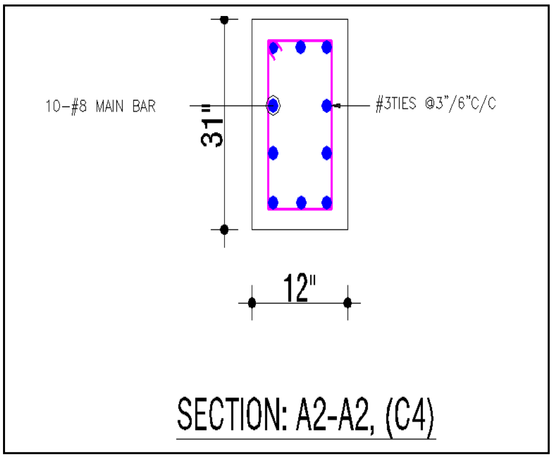


Figure 6.20: Section A2-A2 of C4 column

6.12.2: Section details of C4: 4th floor toroof.

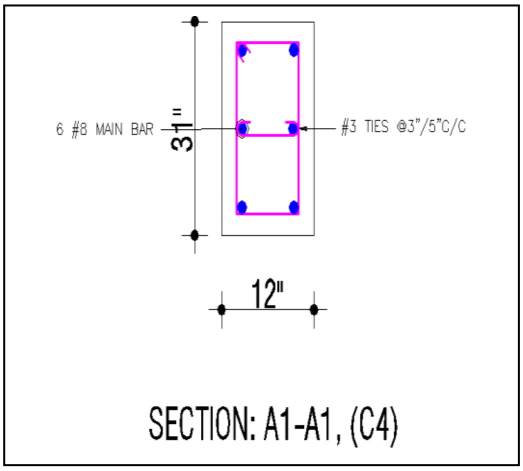


Figure 6.21: Section A1-A1 of C4 of column.

Regarding provides the reinforcement for area 5.961 in^2, we use number 8 bar and therefore we get 10 numbers 8 bar-at the lower part of the column. And it reduce to the ground floor and 4th floor to the roof.

For economical practice, we cut off 10 numbers #8 bar at ground floor and rest of the floor 6 number #8 bar will continue 4th floor to the roof.

So, we provide two cross sections area

6.13 Tie Bar Details for C4 column:

- Highest of

{ 18”

Largest dimension of column

L/6 }

=2’-7”

So=lowest of

{ 4’’

Or ¼ of lowest column dimension

Spacing for corner side of column, so=3”

For middle side of column 2x,So=6”

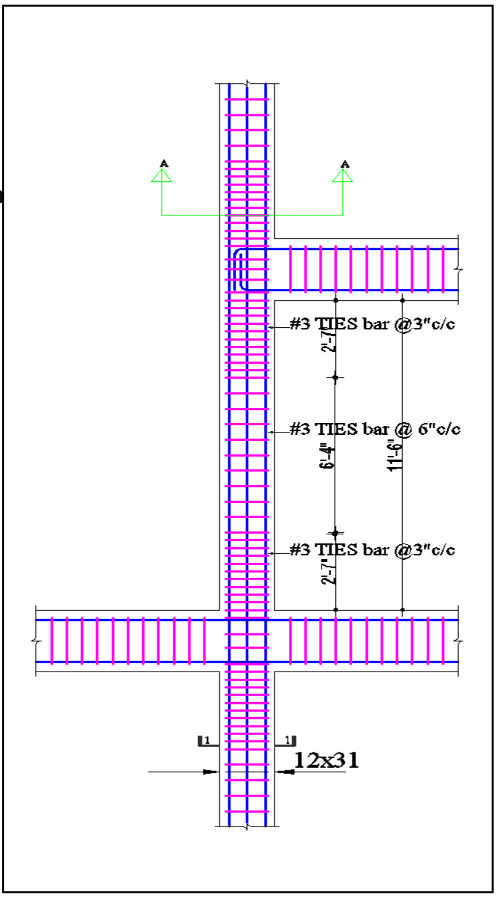


Figure 6.22: Long section of C4 column

To prevent the dislocation of main longitudinal bar of column, we should provide tie bar.

For moment resisting frame as per ACI, we provide tie spacing.

CHAPTER -VII

SLAB DESIGN

7.1 Slab Thickness

Thickness of slab:

Fy=60000	f′c=3500

Thickness=$\frac{longlength(0.8+\frac{fy}{200000})}{36+9\beta}$

Considering the largest panel for slab thickness,

So, β=$\frac{20}{10}$=2

∴ Thickness=$\frac{20*12(0.8+\frac{60000}{200000})}{36+9*2}$

=4.88=5 inches

7.2: Reinforcements design:

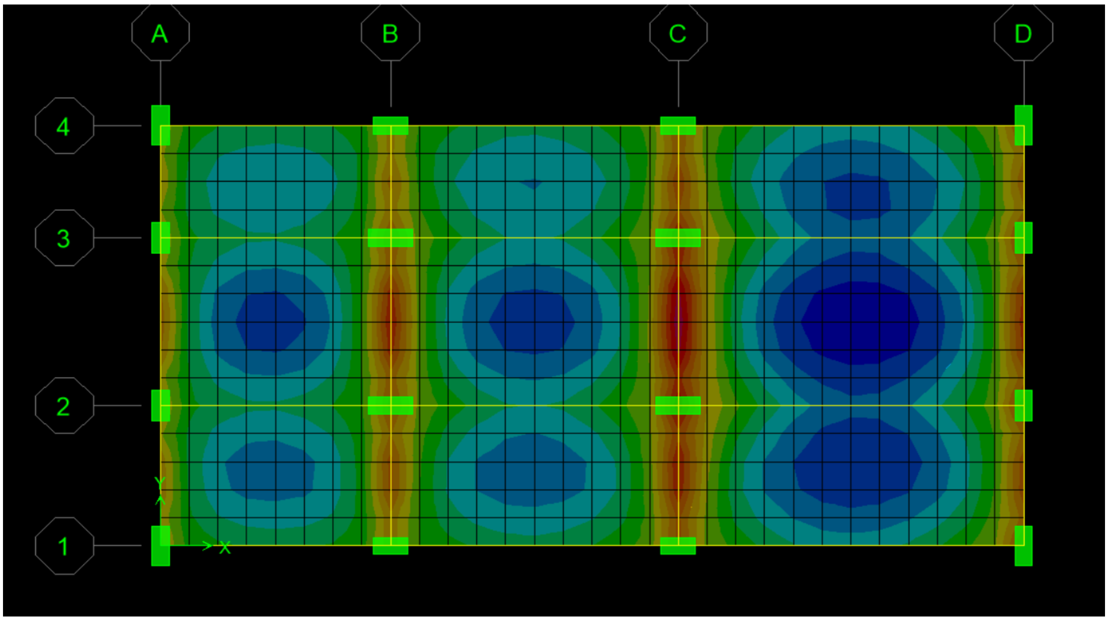


Figure 7.1 : ETABS moment diagram of roof slab

7.3:Reinforcement details of slab

7.3.1 : Maximum moment M-11 for eachfloor

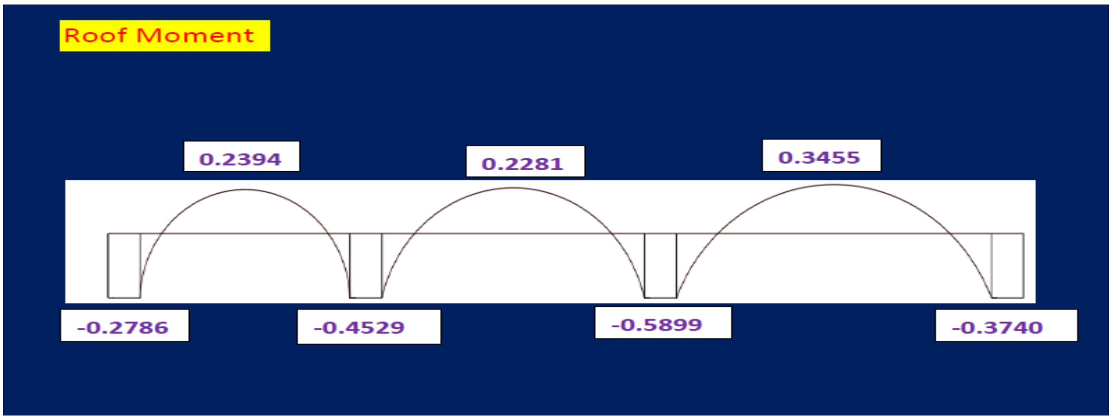


Figure 7.2: Moment diagram of roof slab (X- direction or longer span)

7.3.2 Maximum moment M-22 for eachfloor

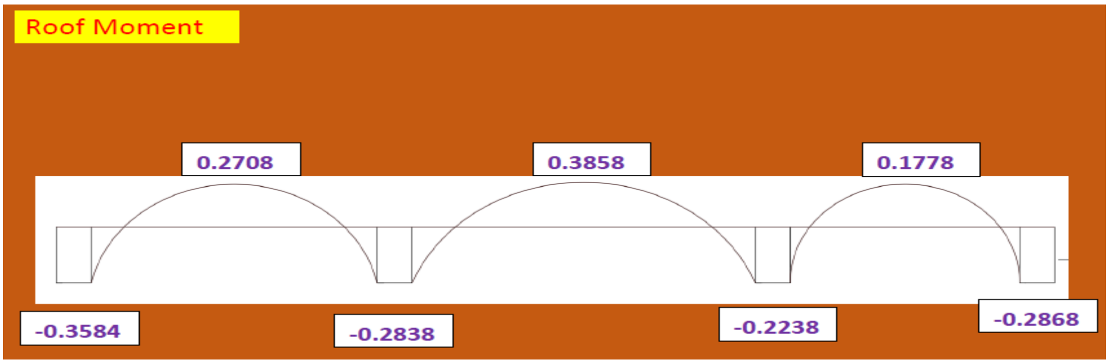


Figure 7.3: Moment diagram of roof slab (Y- direction or shorter span)

According to ETABS output we get moment values for shorter and longer span.

Here we include moment diagram for shorter and longer span

Table 7.1: Reinforment details of slab

location	Moment (k-ft/ft)	As(min) (in2/ft)	As (in2/ft)	Middle strip	Corner strip
Shorter span(M-22)	+m=.3858	=0.0018bt =0.0018*12*5 =0.12 in2/ft	0.02	#5@20″ c/c alt/ckd	#5@30″ c/c alt/ckd
	-m=.3584		0.02	extra top= 0	extra top= 0
Longer span (M-11)	+m=.3455		0.02	#2@20″ c/c alt/ckd	#2@30″ c/c alt/ckd
	-m=.5899		0.03	extra top=0	extra top=0

We identify maximum positive and negative moments for shorter and longer span of slab.

We can see that, our minimum reinforcement is greater than our needed reinforcement.

So, we have designed slab reinforcement as per minimum reinforcement .And there is no extra top needed due to low amount of moment.

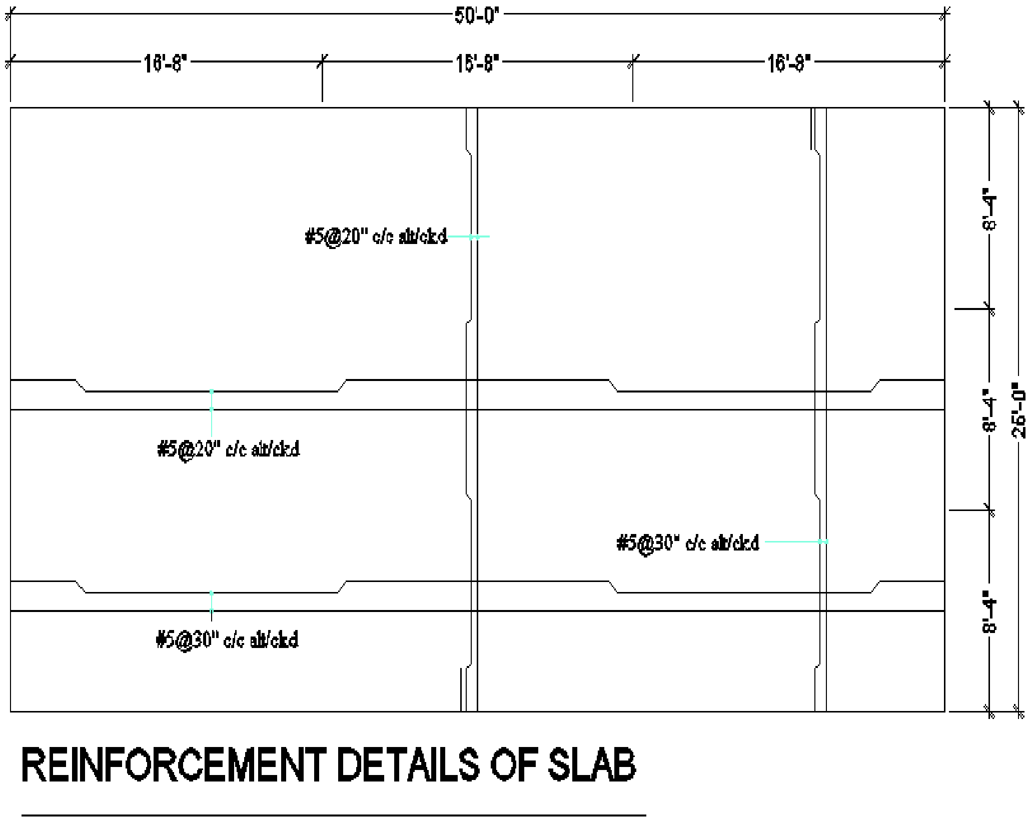


Figure 7.4: Reinforcement details of slab

We have designed slab reinforcement as per minimum reinforcement .And there is no extra top needed for shorter and longer span due to low amount of moment.

CHAPTER-VIII

COMPARISON

8.1: Comparison between Mymensingh (zone-3) and Khulna (zone1) of Column Rebar Percentage:

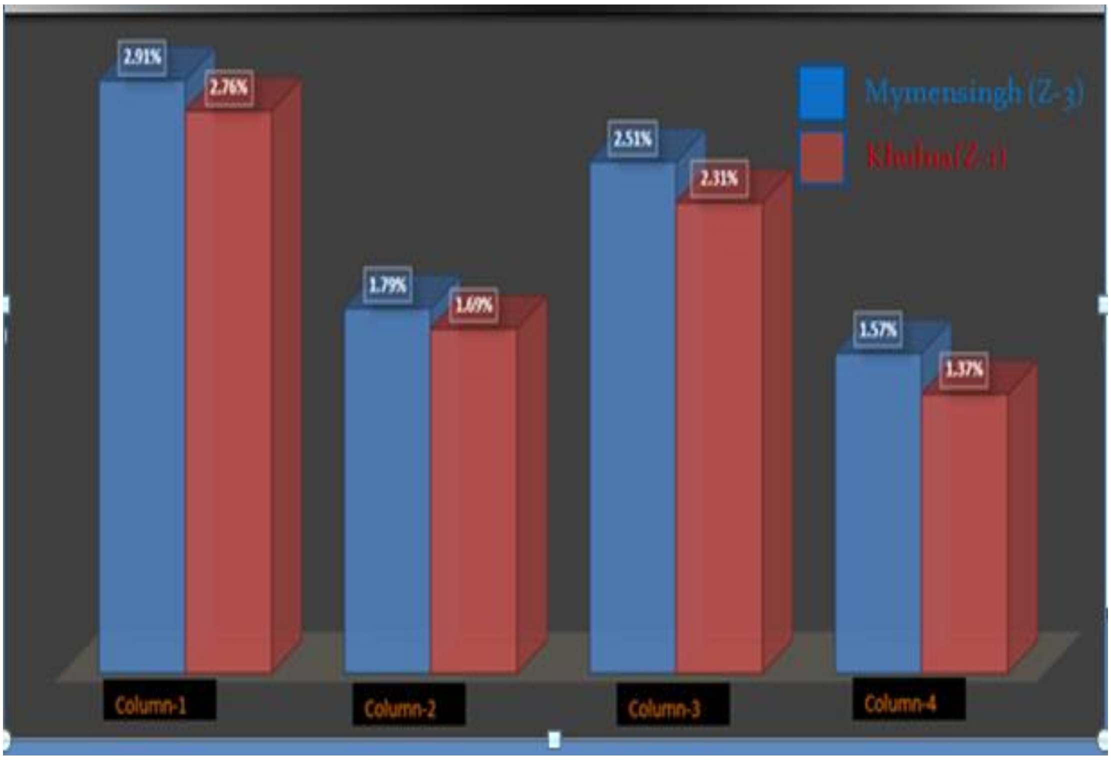


Figure.8.1: Mymensingh and Khulna Rebar Percentage

We already know Mymensingh area column, beam and slab reinforcement value and detailing. Then we compare Mymensingh between Khulna. Here we see Mymensingh rebar percentage is maximum because Mymensingh are zone-3 and this seismic load is higher so we need more number of rebar. For this reason Mymensingh are maximum reinforcement then Khulna and we calculate Mymensingh (zone-3) maximum column reinforcement value and Khulna (zone-1) area maximum column reinforcement. That’s is 7.40% .

8.2: Base Shear Comparison

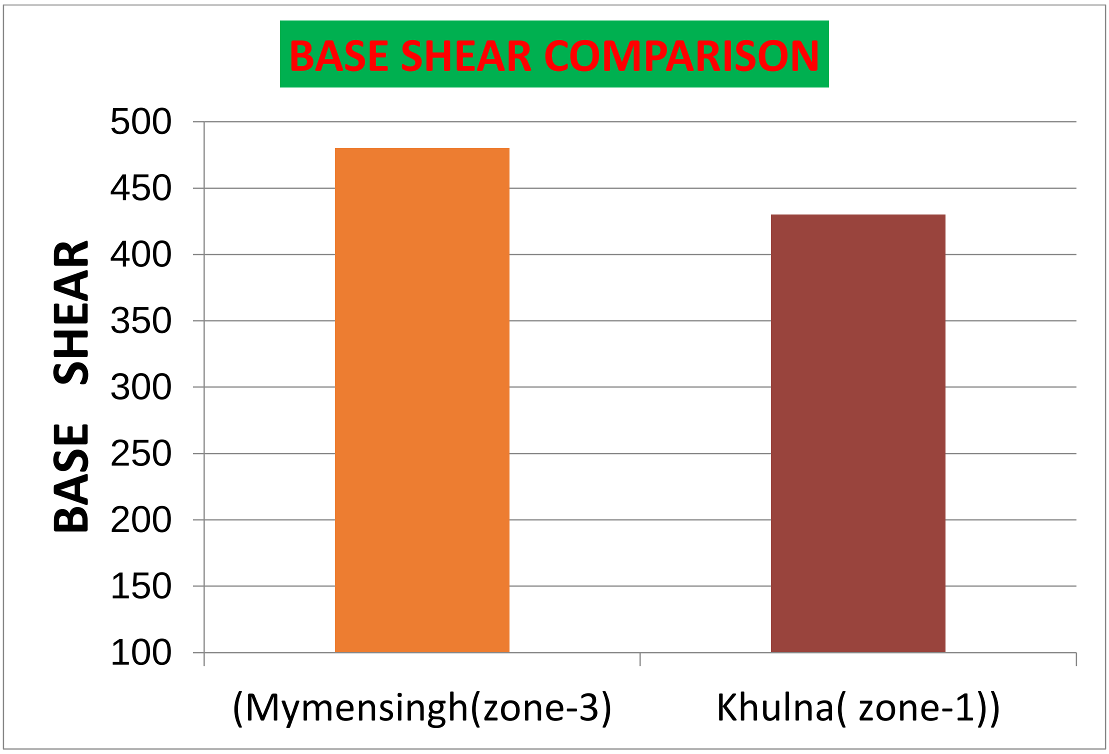


Figure.8.2: Mymensingh and Khulna base share value

Same way we know 5-6 stored building basically base share governs. So we show base share value in two different areas Mymensingh and Khulna. Here Mymensingh base share is high because Mymensingh area earthquake load zone coefficient 0.25 and Khulna zone coefficient 0.15 this is a reason for number of values in base share. Then we calculate maximum base share between

CHAPTER-IX

CONCLUSION& RECOMMENDATION

9.1: Conclusions:

- Using ACI 318, a preliminary design of a Six-story reinforced concrete residential building was completed in Mymensingh(zone-3).

- The Comparison of Column Rebar Percentage in between two zones, we see that Mymensingh (zone-3) needs 7.40% more reinforcement than the Khulna (zone-1)in Bangladesh.

- The Comparison of Base Shear in between two zones.We get 10.42% more Base Shear in Mymensingh (zone-3) than Khulna (Zone-1).

9.2: Recommendations:

- This type of study is done for regular type of structure. Further study can be done for various irregular structures.

- Present study is done for low rise structure. Further study can be done for high rise building structure.

- Present study is done by BNBC -1993. Further studies can be done by update BNBC code.

- Present study is done for two seismic zones. Further study can be done for all seismic zone in Bangladesh

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A: Appendixes

Appendix-I

BNBC for wind load

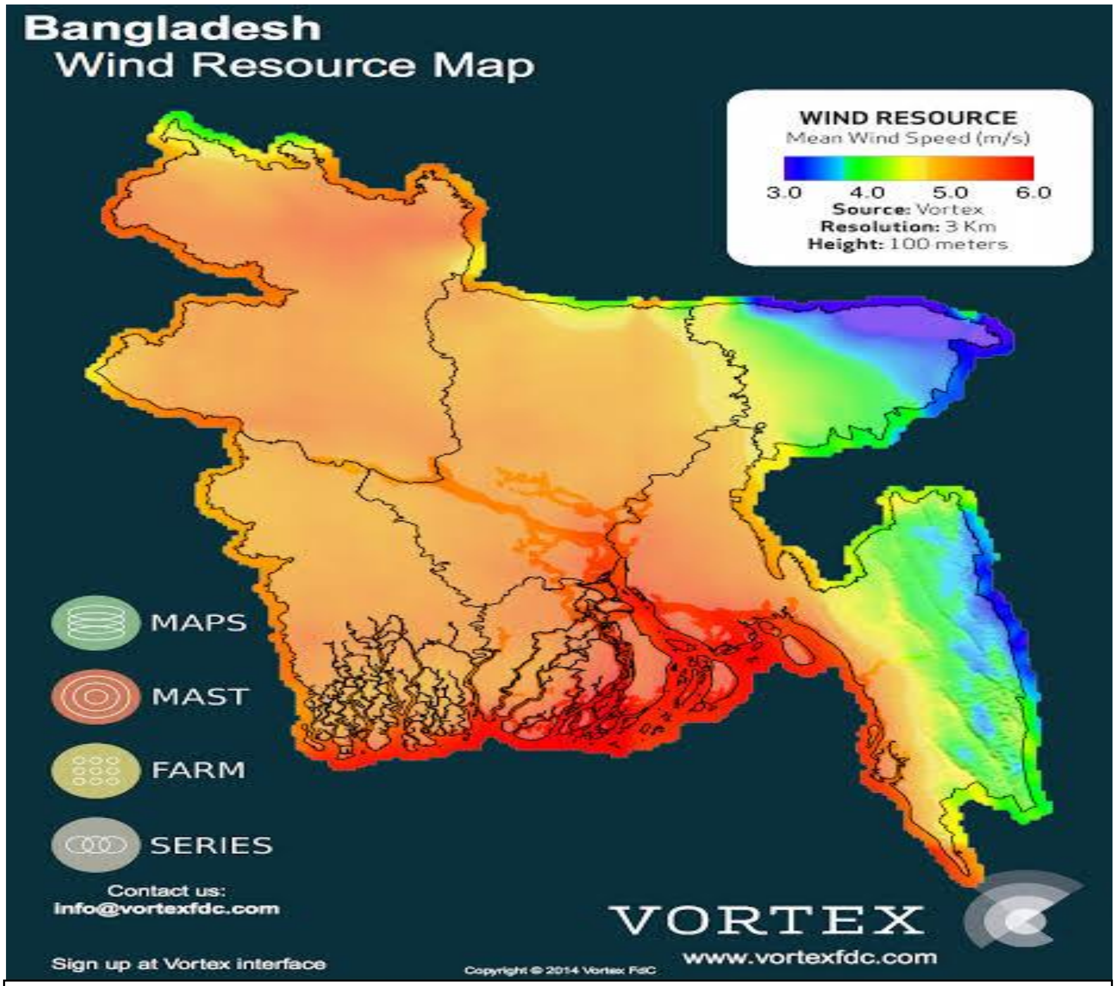

Figure A.1: Bangladesh Wind Resource Map

Table:

Structure Importance Coefficients, *CI* for Wind Loads

Basic Wind Speeds for Selected Locations in Bangladesh

Location	Basic Wind Speed (km/h)	Location	Basic Wind Speed (km/h)

Figure A.2: Structure Importance Coefficients

Angarpota	150	Lalmonirhat	204
Bagerhat	252	Madaripur	220
Bandar ban	200	Magura	208
Barguna	260	Manikganj	185
Barisal	256	Meherpur	185
Bhola	225	Maheshkhali	260
Bogra	198	Moulvibazar	168
Brahman aria	180	Munshiganj	184
Chandpur	160	Mymensingh	217
Chapai Nawabganj	130	Naogaon	175
Chittagong	260	Narail	222
Chuadanga	198	Narayanganj	195
Comilla	196	Narsinghdi	190
Cox's Bazar	260	Natore	198
Dahagram	150	Netrokona	210
Dhaka	210	Nilphamari	140
Dinajpur	130	Noakhali	184
Faridpur	202	Pabna	202
Feni	205	Panchagarh	130
Gaibandha	210	Patuakhali	260
Gazipur	215	Pirojpur	260
Gopalganj	242	Rajbari	188
Habiganj	172	Rajshahi	155
Hatiya	260	Rangamati	180
Ishurdi	225	Rangpur	209
Joypurhat	180	Satkhira	183
Jamalpur	180	Shariatpur	198
Jessore	205	Sherpur	200
Jhalakati	260	Sirajganj	160
Jhenaidah	208	Srimangal	160
Khagrachhari	180	St. Martin's Island	260
Khulna	238	Sunamganj	195
Kutubdia	260	Sylhet	195
Kishoreganj	207	Sandwip	260
Kurigram	210	Tangail	160
Kushtia	215	Teknaf	260
Lakshmipur	162	Thakurgaon	130

Table A.1: Structure Importance Coefficients

Combined Height and Exposure Coefficient, *Cz*

Height above ground level,*z*(metres)	Coefficient, *Cz* (1)		
	Exposure A	Exposure B	Exposure C
0-4.5	0.368	0.801	1.196
6.0	0.415	0.866	1.263
9.0	0.497	0.972	1.370
12.0	0.565	1.055	1.451
15.0	0.624	1.125	1.517
18.0	0.677	1.185	1.573
21.0	0.725	1.238	1.623
24.0	0.769	1.286	1.667
27.0	0.810	1.330	1.706
30.0	0.849	1.371	1.743
35.0	0.909	1.433	1.797
40.0	0.965	1.488	1.846
45.0	1.017	1.539	1.890
50.0	1.065	1.586	1.930
60.0	1.155	1.671	2.002
70.0	1.237	1.746	2.065
80.0	1.313	1.814	2.120
90.0	1.383	1.876	2.171
100.0	1.450	1.934	2.217
110.0	1.513	1.987	2.260
120.0	1.572	2.037	2.299
130.0	1.629	2.084	2.337
140.0	1.684	2.129	2.371
150.0	1.736	2.171	2.404
160.0	1.787	2.212	2.436
170.0	1.835	2.250	2.465
180.0	1.883	2.287	2.494
190.0	1.928	2.323	2.521
200.0	1.973	2.357	2.547
220.0	2.058	2.422	2.596
240.0	2.139	2.483	2.641
260.0	2.217	2.541	2.684
280.0	2.910	2.595	2.724
300.0	2.362	2.647	2.762
Note : (1)	Linear interpolation is acceptable for intermediate values of z.		

Table A.2: Combined Height and Exposure Coefficient, *Cz*

B:Appendix-II

BNBC for Earth Quake

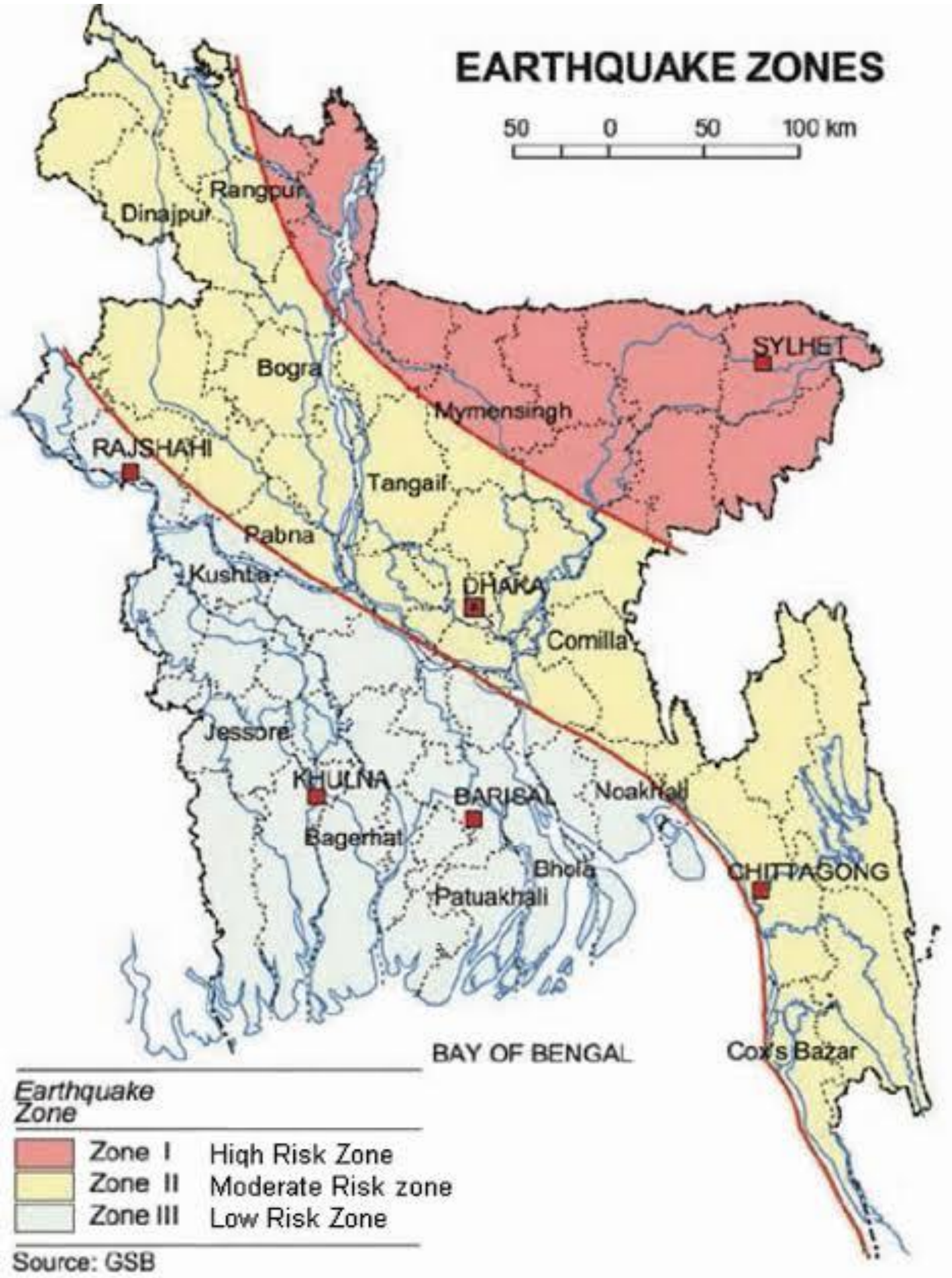

Figure B.1: Seismic Zone Coefficient, Z

Table B.1: Seismic Zone Coefficient	
Seismic Zone	**Zone Coefficient**
1	0.075
2	0.15
3	0.25

Table B.2:Structure Importance Coefficients, *CI* for Wind Loads		
Structure Importance Category (see Table 6.1.1 for Occupancy)		Structure Importance Coefficient, CI
I	Essential facilities	1.25
II	Hazardous facilities	1.25
III	Special occupancy structures	1.00
IV	Standard occupancy structures	1.00
V	Low-risk structures	0.80

B.1: Site coefficient, S for Seismic Lateral Forces

Table B.3:Site Soil Characteristics		
Site Soil Characteristics		
Type	**Description**	**Coefficient**
81	A soil profile with either a) a rock-like material characterized by a shear-wave velocity greater than 762 m/s or by other suitable means of classification, or b) Stiff or dense soil condition where the soil depth is less than 61 meters.	1.00
S2	A soil profile with dense or stiff soil conditions, where the soil depth exceeds 61 meters.	1.20
S3	A soil profile 21 meters or more in depth and containing more than 6 meters of soft to medium stiff clay but not more than 12 meters of soft clay.	1.50
S4	A soil profile containing more than 12 meters of soft clay characterized by a shear wave velocity less than 1. 52 m/s	2.00

Note: (a) The site coefficient shall be established from property substantiated geotechnical data. In locations where the soil properties are not knowing in sufficient details to determine the soil profile type, soil profile S3 shall be used. Soil profile S4 need to be assumed unless the building official determines that soil profile S4 may be present at the site or in the event that soil profile S4 is established by geotechnical data.