# BEAM AND COLUMN DESIGN OF A SIX STORIED RESIDENTIAL BUILDING

**Submitted by**



| | |
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A Thesis Submitted to the Department of Civil Engineering,
Daffodil International University in partial fulfillment of the Requirements for the Degree of **Bachelor of Science in Civil Engineering**


**Under The Supervision of**
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# Department of Civil Engineering

**Daffodil International University**
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# DECLARATION

We hereby declare that, this project has been done by us under the supervision of **Ms. Arifa Akther, Lecturer, Department of Civil Engineering** at Daffodil International University. We further declare that this work has not been submitted for any other purpose (other than publication).

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# ABSTRACT

In this study, we have designed six storied residential buildings considering Beam and column design. This building is designed based on gravity load and lateral loads effect. The weight of a building's floors, ceilings and roofs and to move the load to the framework of a vertical load bearing element for beams support. In order to withstand the combined weight of stacked walls and transfer the support load, often larger and heavier beams called transfer beams are used. Column is a vertical structural member that carries loads mainly in compression. It might transfer loads from a ceiling, floor slab, roof slab, or from a beam, to a floor or foundations. Commonly, columns also carry bending moments about one or both of the cross-section axes. Follow the rules UBC1994, BNBC1993, ACI-318 code proposed places in Dhaka, Bangladesh. Data & Figure are presented wherever felt necessary in reader friendly way. It requires the application work to carry out the analysis and design of components of structure. The deflection is due to the wind being exact 0.35 inches in the X direction and 1.22 inches in the Y direction. Earthquake load check (tensional Irregularity) X direction deflection max = 0.761938inch, deflection min = 0.746922 inch and average 0.77inch.Y direction deflection max = 0.824976 inch, deflection min = 0.741517 inch and average 0.78 inch.

# ACKNOWLEDEMENT

At First, we wish to the Almighty ALLAH who has enabled us to complete the work and lead to the Bachelor of Science in Civil Engineering Degree. Also, we would like to thank our families and friends they give us intensity and individual support and share the idea.

We are grateful to our respected Head, Department of Civil Engineering Professor Dr. Mohammad Hannan Mahmud Khan gave us the opportunity to do the report on "Beam and Column Design for A Six Storied Residential Building" by using the manual calculation USD method and use software ETABS approach.

We would like to express our sincere gratitude and deep gratitude to our esteemed Supervisor Ms. Arifa Akther(Lecturer , DIU) Department of Civil Engineering for her continued supervision, encouragement, contribution of new ideas, and guidance in this work.

We would also like to thanks Mr. Rayhan Md. Faysal (Assistant Professor, DIU), Ms.Mardia Mumtaz (Lecturer, DIU). Without their valuable guidance and sincere cooperation, this study, in particular, would not have been impossible. The work has been completed due to their supervised work and their keen interest.

Thanks to All teachers of civil engineering department who brought us made efficient at work like this during the last four successive years, thanks to all faculty, Department of Civil Engineering, DIU for providing us a lot of support to prepare this Successful report.

# NOTATIONS

Ag=Gross Area of Concrete

$f'_c$= compressive strength of concrete

Ec =Modules of Elasticity of Concrete

$E_s$= Modules of Elasticity of Steel

$M_u$=Ultimate Moment

P = Axial Load of Column

V = Shear Stress

$A_{ts}$=Area of Tensile Steel

Rs=Steel Ratio

h = Height of Building

$L_f$= Effective Span Length

b = Width of Beam

d = Effective Depth of Beam

ULA= Ultimate Axial Load of Column

UMM =Maximum Ultimate Moment

dE= Equivalent Depth of Beam

Pcf = Pound per Cubic feet

Psi = Pound per Square Inch

ASTM = American Standard for Testing Material

SAS= Allowable Stress of Steel

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

ETABS= Extended Three Dimensional Analysis of Building System

# TABLE OF CONTENT

# LIST OF FIGURES

# LIST OF TABLES

# CHAPTER- 1
# INTRODUCTION

## 1.1 Introduction

As you trying to make structural designs with a reality, design engineers need to think various kinds of aspects. Durability & stability is one of the most important cases when you know that building structure is secured and long lasting. Basically there are two main kind of structural elements beam and column that play a vital role in bearing the load capacity from the slab and weight of the building structure. Horizontal structural elements carry a direct load towards the longitudinal side of their beams. The beams support the weight of floor buildings, roofs, ceilings and transfer loads to the frame structure of vertical load bearing elements. The structural engineer is ready to test the work load on the beam. Column is structural components which transmitted on compressive loads. Suppose you pick a big stone, now your hand is bearing load. Then it transfers your arm, shoulder, leg and finally feet. So when you analysis the building, you must be check the anatomy of the structure, how the loads is transmitted from the structure elements to their location.

It is generally accepted that as it was preparing in a special plan aptitude isn't adequate for effective proficient practice. As modern investigates are accessible and always presenting modern plan strategies, the plan programs are changing as often as possible. Understanding these fulfilling improvements, and in arrange to security in imaginative plans, engineers straightforward establishing is required in terms of transformation and fundamental execution to construct houses securely, financially, and productively.

## 1.2 Background of the Study

The improvement of moving forward development procedures has made it conceivable to build a high rise building less costly both in time and cash. The development procedures being broadly utilized in high-rise fortified concrete buildings are:

- Slip-form development strategy
- Prefabricated construction
- Tilt-up development
- Drop-slab development
- Composite development procedure

In Bangladesh, Fortified concrete development is semi-mechanized. Support cutting and authoritative are done physically, concrete blending is by and large done by utilizing blender machine; concrete carrying up to four-storied structure is done physically and over this stature, concrete is gradually carried by skip and raise or bucket and lift. Fabricated sort framework of steel tubes is broadly utilized all over the world. In Bangladesh bamboo or wooden platform are still being utilized. At show slip shapes, flying shapes, etc are being exceptionally effectively utilized for concreting. Wrapping up of strengthened may be put wrap up. Shaped wrap up is utilized in high-rise buildings additionally in moo to medium-rise buildings The display work is concerned with the consider of tall rise building development in Bangladesh. It incorporates the consideration of development strategy being taken after, the state of mechanization in the development industry, and methods and strategies of development in use in Bangladesh. This sort of a consideration is supportive for assessing the state of the tall rise building development industry with its inadequacies and scope of advancement.

## 1.3 Objective

The main purposes of the study are:

- The main objective of this project is to design beam and column for a six storied residential building.

-To know which is code is used for designing a building structure.

- Designing the building considering the loads factor.

- To know the detailing of beam and column bar using ETABS software.

## 1.4 Scope of the study

Utilize ETABS computer program for basic investigation. From the investigation point of view, it is seen that the cost of a private building will be influenced by horizontal strengths and without horizontal drive structural experiment and plan have been completed utilizing computers ETABS computer program. For investigation and plan purposes, ACI code, UCB 1994, BNBC- Used 1993.

## 1.5 Limitations

Investigation of the structure comprises numerous stages and components. For concrete, no impacts from crawl, shrinkage, or temperature impacts have been analyzed. The concrete has moreover been considered uncracked. Moreover, no plan of component cross-sections have been made and the increasing velocities of the building are calculated concurring to BNBC code, thus, no time history investigation is analyzed.

# CHAPTER - 2
# LITERATURE REVIEW

## 2.1 RCC Frame Structure

This combination works very well, as concrete is very strong in compression, easy to produce a site, and inexpensive and steel is very strong in tension. Concrete is very strong in compression, easy to produce at site, and inexpensive and steel is very strong in tension. In an RCC framed structure, the load is transferred from a slab to the beams then to the columns and further to lower columns and finally to the foundation which in turn transfers it to the soil. The walls in such structures are constructed after the frame is ready.

The primary assignment of the structure engineer is of the plan of structure. From the structure architect's the essential goals of this proposition is disperse data on the most recent ideas, strategies, and plan information to underlying specialists locked in the plan of wind and seismic-safe structure. Fundamental to the proposition are ongoing advances in seismic plan, especially those identified with structures in zones of low and moderate seismicity. Wind – and tremor Resistant incorporates the plan parts of steel, cement, and composite structure inside a solitary book. The taller is the structure; it is more basic to pick a proper primary framework.

A significant thought influencing the underlying framework is the capacity of the building. Current places of business call for enormous open spaces that can be partitioned with lightweight dividing to suit the individual occupant's requirements. Subsequently, principle vertical parts are by and large organized, beyond what many would consider possible, around the edge of the arrangement and, inside in-bunch around the lift, mix, and administration lifts. The floor regions between the outside and inside segments, leveling huge segment free region accessible for office arranging leveled. The administrations are disseminated evenly in every story over the parceling and are normally covered in roof spate. The additional profundity needed by this space causes commonplace story tallness in a place of business to be 3000 mm or more.

A significant advance forward in fortified solid tallness rise underlying framework comes with the presentation of shear dividers for opposing level burden. This is the first in a progression of critical improvements in the primary arrangement of solid tall building liberating them and level plate framework. The advancement and refinement of these new frameworks, along with the improvement of higher strength concrete, has permitted the stature of solid structure to reach inside development comes from the wide accessibility of strengthening bars and the constituents of solid, stones, sand, concrete.

## 2.2 Dead Loads

Loads that are imposed on a structure during its lifetime, that is, loads that remain unchanged are called dead loads or stationary loads. For example, the structures own weight.

- This load is calculated through the shape of the structure and the goods.
- Dead load is multiplied by 1.2 to consider the design load of a construction structure as safe.

## 2.3 Live Load

The load that is temporarily pressed on the structure is called live load. It is a temporary load on the structure. it is the moving load. Such as- people, furniture, machinery etc. It is difficult to calculate this load accurately. So these loads are calculated according to the building code. Live load is multiplied by 1.6 to consider the design load of a construction structure as safe.

## 2.4 Floor live load

Floor live loads are fundamental to structural design of buildings. A correct understanding of the intensity of loading is necessary for economic and safe design of structures. In the practical application, the defined design load values are not always the same in design codes. Such loads shall be taken as the minimum of live loads per square foot of pounds. Horizontal rejection to be included in the construction design for the specified occupancies, for uses not mentioned in this section but that are not listed in this section, and loads at least equivalent are considered to be it provides or accommodates comparable loadings. Where it can be measured in Designing floors where the real live load is going to be greater than value. The simulation used the statistical results of existing load surveys as input parameters. Characteristic values of live load for different load effects and possible live load reductions were determined.

## 2.5 Wind Loads

Wind load is the load generated due to storm; wind etc. on the outer surface of the structure. Wherever the wind blows in the structure, the pressure on the foundation decreases on the other hand the pressure increases.

This is a very important design factor, especially for tall buildings, or large surface buildings. Buildings are not meant to withstand daily wind conditions, but rather extreme conditions that can occur every 100 years or more. it is called design wind speeds and are specified in building codes. A building typically requires a wind energy resistance of 150 kg / m2, which can be a very significant force when multiplied by the surface area of the building.

## 2.6 Earthquake Loads

The force caused by an earthquake usually acts vertically downwards or in a twisting direction in the base. Earthquake force is very threatening for Bangladesh. So it should be given more importance.

# CHAPTER – 3
# METHODOLOGY

## 3.1 General

We used ETABS as Design & Analysis software. We maintained the design code as per ACI, BNBC and UBC code for calculation. For analysis, Portal frame method has been used on ETABS. Our required building was selected and its plan & elevation were drawn on ETABS software. All loads (including Wind and Earthquake) have been calculated on all beams & columns. As our proposed buildings locate in Dhaka we used the coefficients and all other variables as per the requirement for Dhaka zone. We have done several comparisons to check all the variations

## 3.2 Work follows Chart

| **Steps** | **Work details** |
|---|---|
| 1 | We have used ETABS Software for the purpose of analysis and design of six stories building Beam and Column. |
| 2 | For design and analysis purpose we used ACI code, UCB 1994, BNBC-1993 seismic zone Dhaka. |
| 3 | Then Wind load and earthquake loads have been calculation on selected beams and columns as per BNBC, UBC 1994 CODE (coefficient, wind speed, seismic zone) for proposed. |
| 4 | Design and detailing of structural elements was drawn in Auto CAD. |
| 5 | Manual Calculation. |

# CHAPTER - 4
# ETABS Modeling & Load Calculation

## 4.1 PLAN OF BUILDING AREA

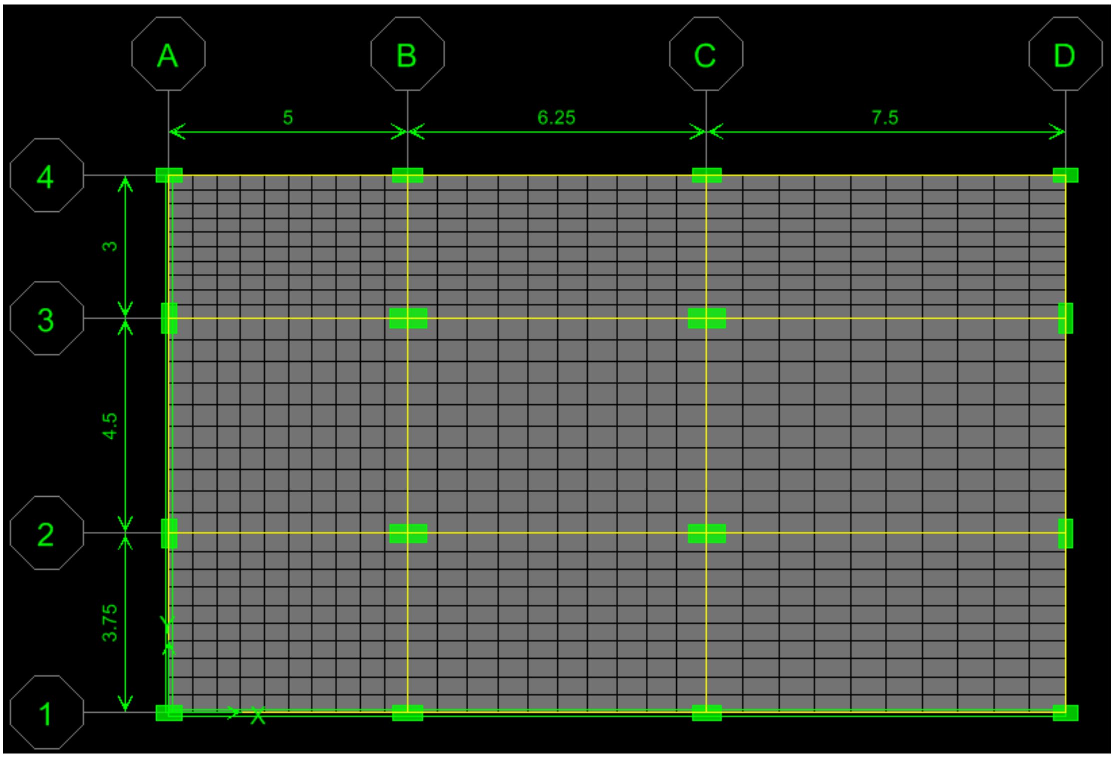



Figure: 4.1 Plan View (Six Storied Building)

Here, X-Direction value:
A-B= 5m
B-C= 6.5m
C-D= 7.5m
Y-Direction value:
1-2= 4m
2-3= 4.5m
3-4= 3m

## 4.2 Guidelines for ETABS modeling

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%

## 4.3Normal Loads

Typical story height= 3.5 m (IMRF Structure, RCC Building)

Material properties $f'_c$ = 3.5 ksi, $f_y$= 60 ksi

Slab thickness = 150 mm (for membrane), 125 mm (for bending)

Loads: LL = 3 KN/$m^2$, FF = 1.5 KN/ $m^2$, PW = 2.5 KN/ $m^2$

For Wind Load (WL):

Basic wind speed = 210 km/hr (Dhaka location)

Exposure condition =A

For Earthquake Load (EQL):

S2 type soil, Zone 2, I = 1

## 4.4Wind loads and Earthquake load Calculation:

*Wind pressure,* $p_z = C_c C_I C_{pe} C_z C_g V^2$

Wind force, F

### Wind load for X Direction

Wind Load Calculation

| | | | | | |
|---|---|---|---|---|---|
| Story | 6 | Meter | | | |
| Floor Height | 3.5 | Meter | | | |
| Length | 19 | Meter | Panel | 3 | Nos |
| Width | 11.5 | Meter | Panel | 3 | Nos |
| Zone | Dhaka | | | | |
| Exposure | Exposure A | | | | |
| Structure | Standard occupancy structures | | | | |
| Direction type | | | | | |
| wind ward wall | YES | | | | |
| Lee ward wall | NO | | | | |
| Side wall | NO | | | | |

| | |
|---|---|
| Cc | 4.72E-05 |
| CI | 1 |
| Cpe | 0.8 |

| | | |
|---|---|---|
| v | 210 | km/hr |

### Wind load for Y Direction

Wind Load Calculation

| | | | | | |
|---|---|---|---|---|---|
| Story | 6 | Meter | | | |
| Floor Height | 3.5 | Meter | | | |
| Length | 11.5 | Meter | Panel | 3 | Nos |
| Width | 19 | Meter | Panel | 3 | Nos |
| Zone | Dhaka | | | | |
| Exposure | Exposure A | | | | |
| Structure | Standard occupancy structures | | | | |
| Direction type | | | | | |
| wind ward wall | YES | | | | |
| Lee ward wall | NO | | | | |
| Side wall | NO | | | | |

| | |
|---|---|
| Cc | 4.72E-05 |
| CI | 1 |
| Cpe | 0.8 |

| | | |
|---|---|---|
| v | 210 | km/hr |

**Wind Load calculation for 6 storied structures:**
The calculation was done using BNBC 1993 (Section 2.4)

| Floors | X direction | | | | | | Y direction | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Height (m) from GL | $C_z$ | $P_{z-x}$ (KN/ $m^2$) | Area $m^2$ | Floor level force (KN) | Floor level force (kip) | $P_{z-y}$ (KN/ $m^2$) | Are a $m^2$ | Floor level force (KN) | Floor level force (kip) |
| 1st | 3.5 | 0.3 68 | 1.32 1 | 40.2 50 | 53.16 9 | 11.95 2 | 1.625 | 66. 500 | 108. 068 | 24.29 4 |
| 2nd | 7 | 0.4 42 | 1.58 7 | 40.2 50 | 63.86 1 | 14.35 6 | 1.952 | 66. 500 | 129. 799 | 29.17 9 |
| 3rd | 10.5 | 0.5 31 | 1.90 6 | 40.2 50 | 76.72 0 | 17.24 7 | 2.345 | 66. 500 | 155. 936 | 35.05 4 |
| 4th | 14 | 0.6 04 | 2.16 8 | 40.2 50 | 87.26 7 | 19.61 8 | 2.667 | 66. 500 | 177. 373 | 39.87 3 |
| Roof | 17.5 | 0.6 68 | 2.39 8 | 20.1 25 | 48.25 7 | 10.84 8 | 2.950 | 33. 250 | 98.0 84 | 22.04 9 |
| | | | Total force along X direction | | | **74.02** | Total force along Y direction | | | **150.5** |

Table 4.2: Winds Loads calculation for six storied structure

## Earthquake load calculations:

The application process was similar to UBC 1994. Used for apply the load on the structure.

| **Earthquake Loads** | | |
|---|---|---|
| **Soil Typ e** | **Zone** | **Importance Factor** |
| **S2** | **Zone 2 Dhaka** | **1** |
| **1.2** | **0.15** | |

Table 4.3: Earthquake Loads

No manual calculation was done. ETABS was used to apply the load on the structure. The application process was similar to BNBC 1993 (Section 2.5)

## 4.5 ETABS 3D MODEL

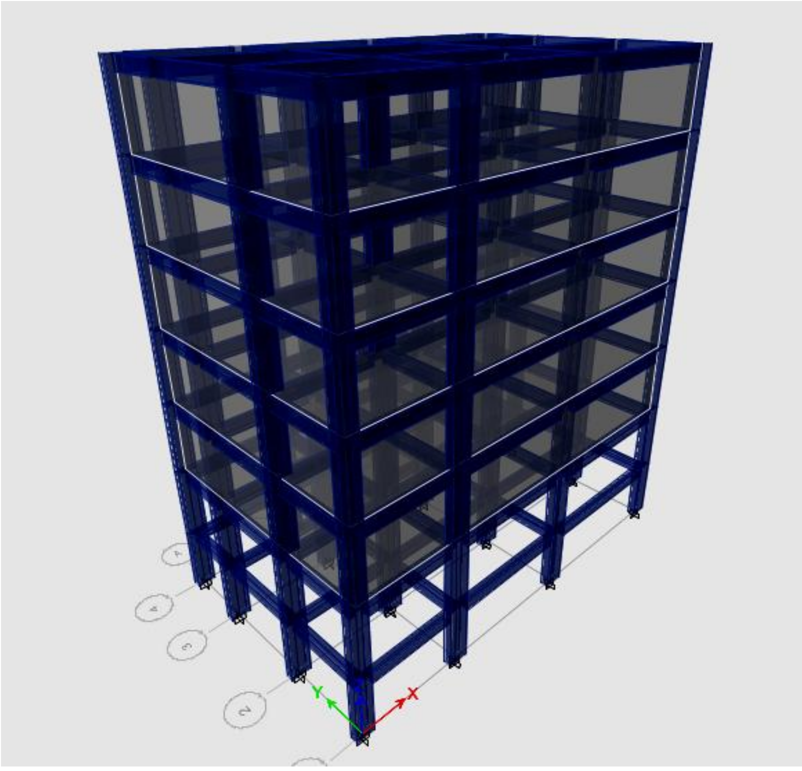



Figure 4.2 3D View of 6 Storied building

First we input plan layout on ETABS. Second input beam, column and slab dimension following BNBC 1993 code. Here shown in this (fig 4.2).

## 4.6 Longitudinal Design and Check Result

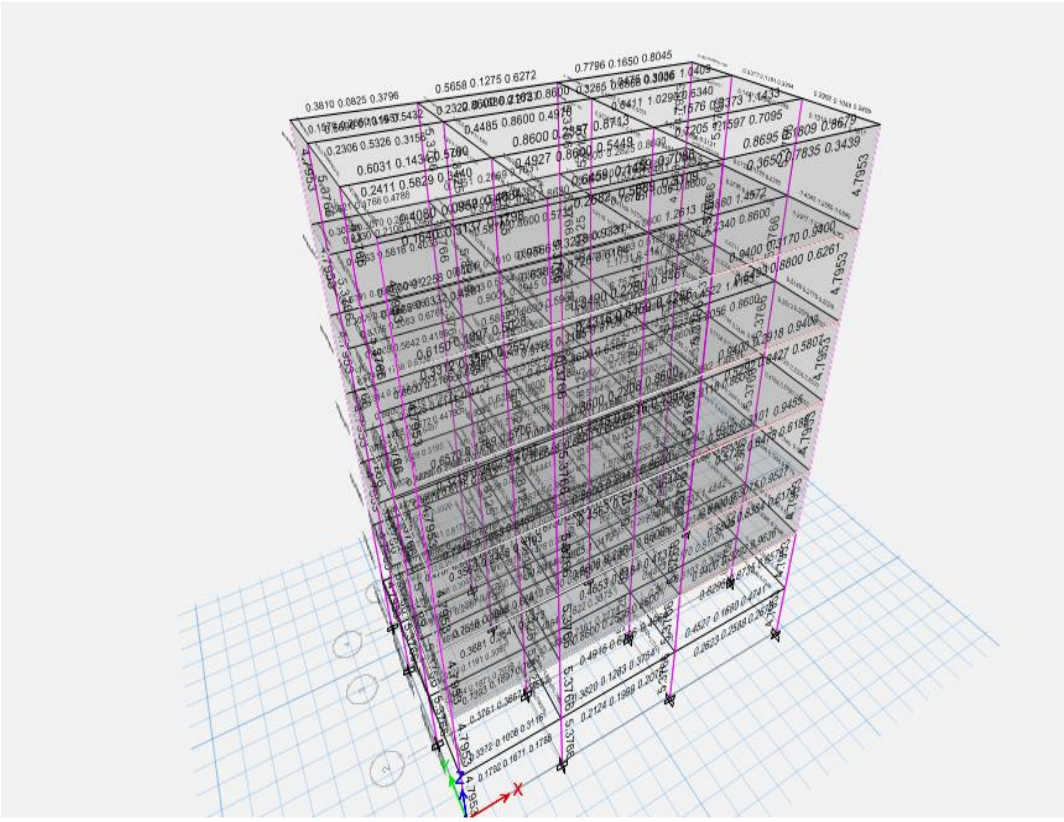


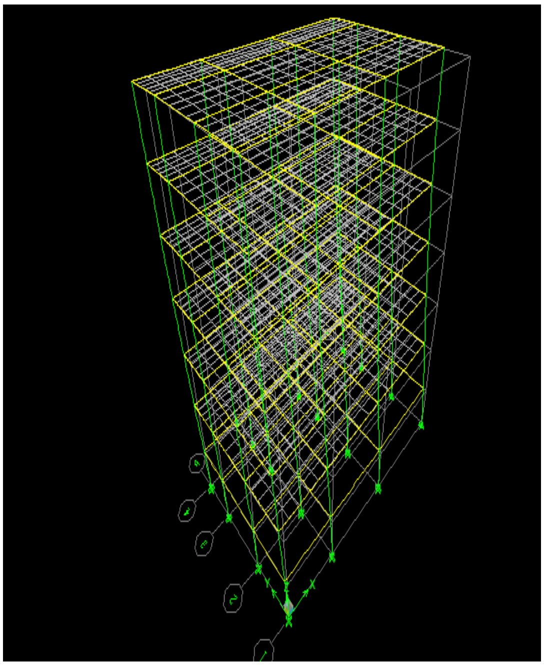
Figure: 4.3 Longitudinal Designs and Check Result

Then we input all loads value according to follow BNBC 1993, ACI 318, UBC 1994 codes. (DL, LL, WL, FF, EQL etc).

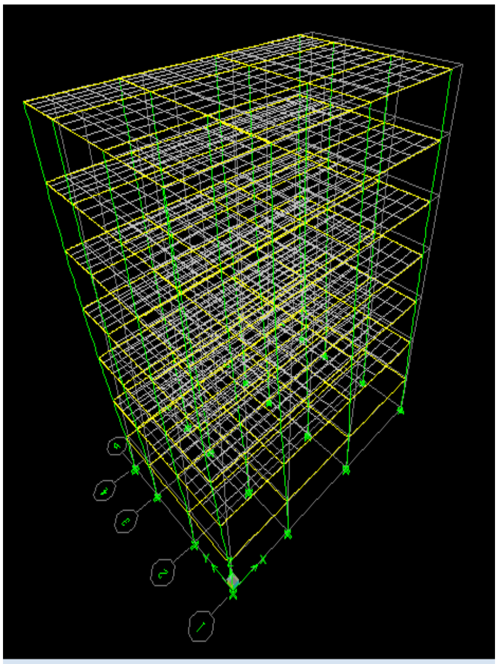
Next run analysis and getting design result. Here shown in figure 4.3 longitudinal design and check result.

## 4.7 Deflection check

## For wind load



Y Direction Deflection

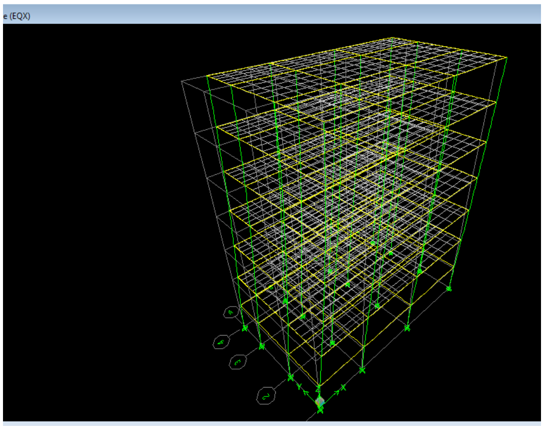


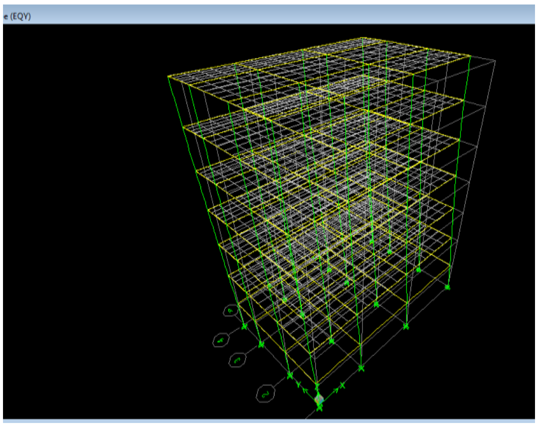
X Direction Deflection

4.4 Figure: Deflection for wind load

**Check, Limitation** for wind load h/500 = 1.378 inch is Acceptable. Here maximum ETABS value for X direction is 0.35 inch and Y direction 1.22 inch. So our design criterion is ok.

## Earthquake load (Deflection Check)





EQL X Direction Deflection EQL Y Direction Deflection

4.5 Figure: Deflection for EQ load

Structure is stable in EQL effect.

## Torsional Irregularity Check diagram

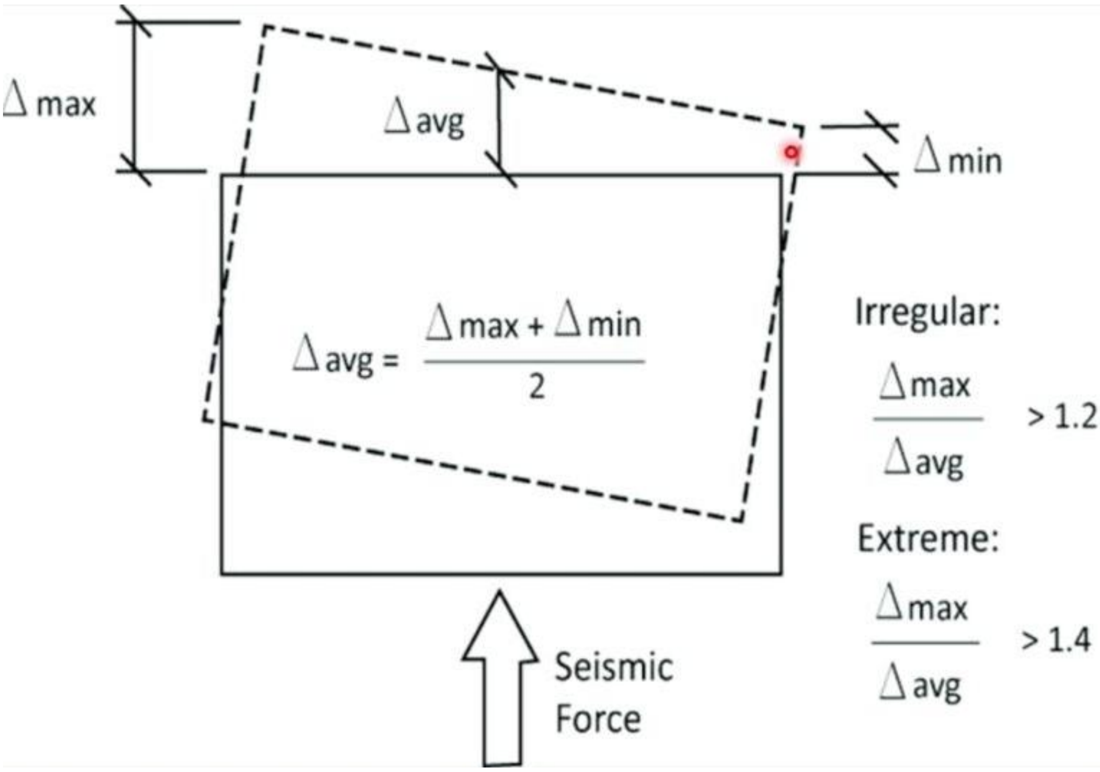



Figure 4.6 Torsional Irregularity Check diagram

From ETABS we get, Earthquake load for X direction:

$\Delta_{Max}$ =

DISPLACEMENTS AND DRIFTS AT POINT OBJECT 3

File

| STORY | DISP-X | DISP-Y | DRIFT-X | DRIFT-Y |
|---|---|---|---|---|
| 5TH | 0.761938 | 0.013368 | 0.000385 | 0.000006 |
| 4TH | 0.708920 | 0.012501 | 0.000611 | 0.000011 |
| 3RD | 0.624761 | 0.011048 | 0.000810 | 0.000014 |
| 2ND | 0.513177 | 0.009175 | 0.000967 | 0.000016 |
| 1ST | 0.379918 | 0.006972 | 0.001078 | 0.000018 |
| GF | 0.231374 | 0.004534 | 0.001121 | 0.000021 |
| PL | 0.076887 | 0.001598 | 0.000651 | 0.000014 |

$\Delta_{Min}$ =

DISPLACEMENTS AND DRIFTS AT POINT OBJECT 4

File

| STORY | DISP-X | DISP-Y | DRIFT-X | DRIFT-Y |
|---|---|---|---|---|
| 5TH | 0.746922 | 0.013472 | 0.000378 | 0.000007 |
| 4TH | 0.694896 | 0.012547 | 0.000599 | 0.000011 |
| 3RD | 0.612349 | 0.011093 | 0.000795 | 0.000014 |
| 2ND | 0.502860 | 0.009207 | 0.000949 | 0.000016 |
| 1ST | 0.372064 | 0.007000 | 0.001058 | 0.000018 |
| GF | 0.226264 | 0.004530 | 0.001098 | 0.000021 |
| PL | 0.074943 | 0.001598 | 0.000635 | 0.000014 |

Select the deflection value for the top floor so,

$\Delta_{Avg} = (\Delta_{Max} + \Delta_{Min})/2 = (0.761938+0.746922)/2 = 0.77$

$\Delta_{Max} / \Delta_{Avg} = 1.03 < 1.2$ so structure is ok.

From ETABS we get, Earthquake load for Y direction:

$\Delta_{Max}$ =

DISPLACEMENTS AND DRIFTS AT POINT OBJECT 4

File

| STORY | DISP-X | DISP-Y | DRIFT-X | DRIFT-Y |
|---|---|---|---|---|
| 5TH | -0.023807 | 0.824976 | 0.000012 | 0.000434 |
| 4TH | -0.022123 | 0.765220 | 0.000019 | 0.000671 |
| 3RD | -0.019437 | 0.672742 | 0.000025 | 0.000864 |
| 2ND | -0.015960 | 0.553648 | 0.000030 | 0.001011 |
| 1ST | -0.011881 | 0.414322 | 0.000033 | 0.001115 |
| GF | -0.007277 | 0.260710 | 0.000035 | 0.001227 |
| PL | -0.002461 | 0.091669 | 0.000021 | 0.000776 |

$\Delta_{Min}$ =

DISPLACEMENTS AND DRIFTS AT POINT OBJECT 1

File

| STORY | DISP-X | DISP-Y | DRIFT-X | DRIFT-Y |
|---|---|---|---|---|
| 5TH | -0.024273 | 0.741517 | 0.000013 | 0.000389 |
| 4TH | -0.022465 | 0.687893 | 0.000020 | 0.000603 |
| 3RD | -0.019717 | 0.604871 | 0.000026 | 0.000776 |
| 2ND | -0.016183 | 0.497951 | 0.000030 | 0.000908 |
| 1ST | -0.012034 | 0.372897 | 0.000033 | 0.001000 |
| GF | -0.007513 | 0.235074 | 0.000036 | 0.001106 |
| PL | -0.002552 | 0.082699 | 0.000022 | 0.000700 |

Select the deflection value for the top floor so,

$\Delta_{Avg} = (\Delta_{Max+} \Delta_{Min})/2 = (0.824976+0.741517)/2 = 0.78$

$\Delta_{Max/} \Delta_{Avg} = 1.05 < 1.2$ so structure is ok.

## 4.8: Reinforcement area of all Beams

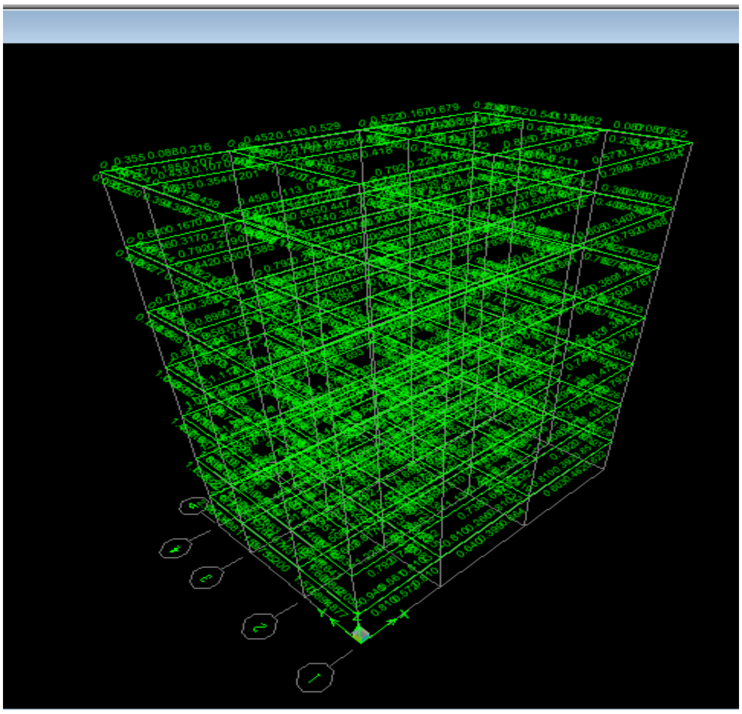


Figure: 4.7: Reinforcement area of all Beams (in inch sq.)

From beams, longitudinal reinforcement area data are used for detailing of reinforcement for beam.

## 4.9: Percent of Reinforcement check for all columns

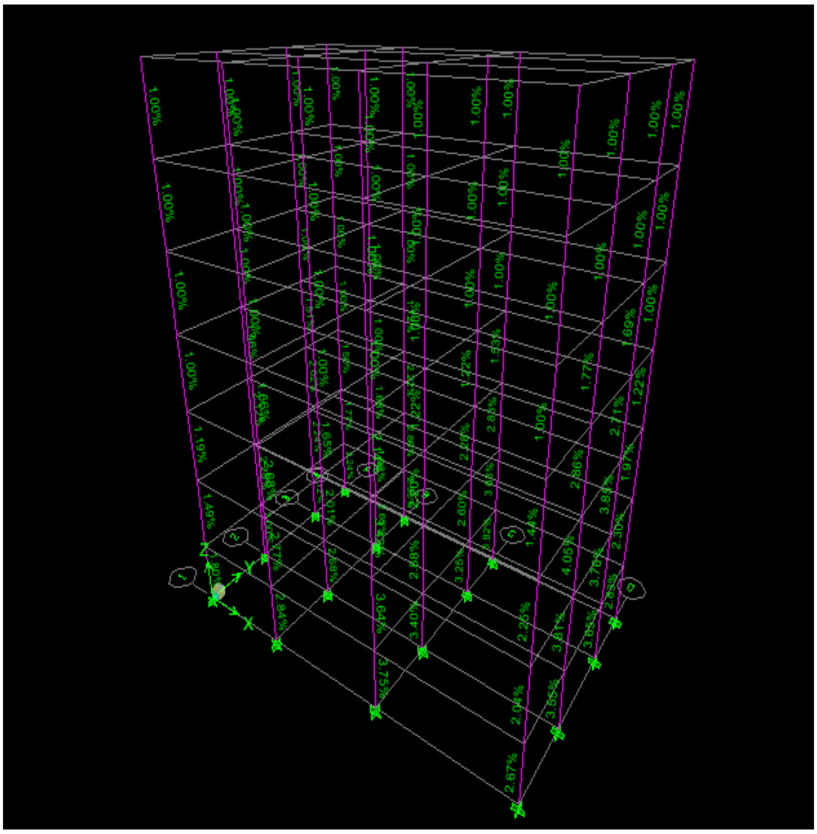


Figure 4.8: Percent of reinforcement of all columns

We find out percent of reinforcement of all columns.

## 4.10: Reinforcement area of all columns

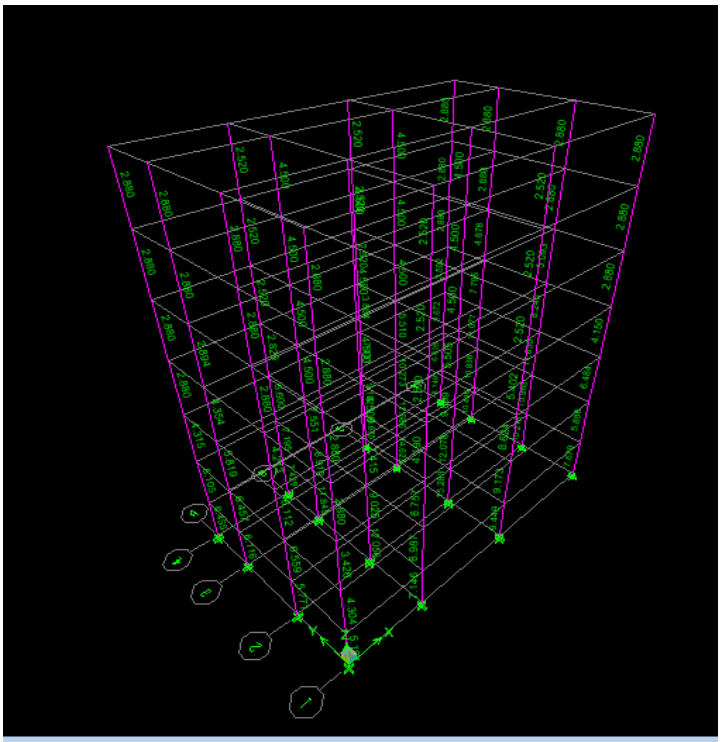


Figure 4.9: reinforcement area of all columns

These are reinforcement area of all columns.

# CHAPTER - 5
# BEAM DESIGN

## 5.1 Ground Floor

### 5.1.1: Reinforcement Detailing of Grade Beam X-Axis

### X-axis GB

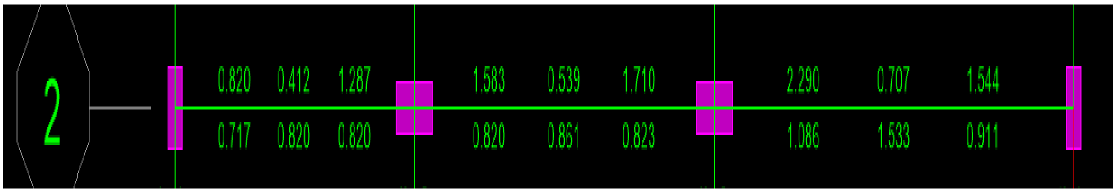



Figure: 5.1 Reinforcement area of Grade Beam X-Axis (in Inch Sq.)

Table 5.1: Reinforcement Detailing of Grade Beam X-Axis

| X-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 ($in^2$) | | No. | Area ($in^2$) | Str. | Ext | Positive side ($in^2$) | | No. | Area ($in^2$) | Str. | Ext |
| Left | 2.29 | 6 | .44 | 2 | 4 | Left | 1.08 | 5 | .31 | 4 | - |
| Middle | 0.70 | 6 | .44 | 2 | - | Middle | 1.53 | 5 | .31 | 4 | 2 |
| Right | 1.54 | 6 | .44 | 2 | 2 | Right | 0.91 | 5 | .31 | 4 | - |

## 5.1.2: Long and Cross Sections of X Axis of GF Beam (15″ X 18″)

## GRAD E BEAM (X-AXIS)

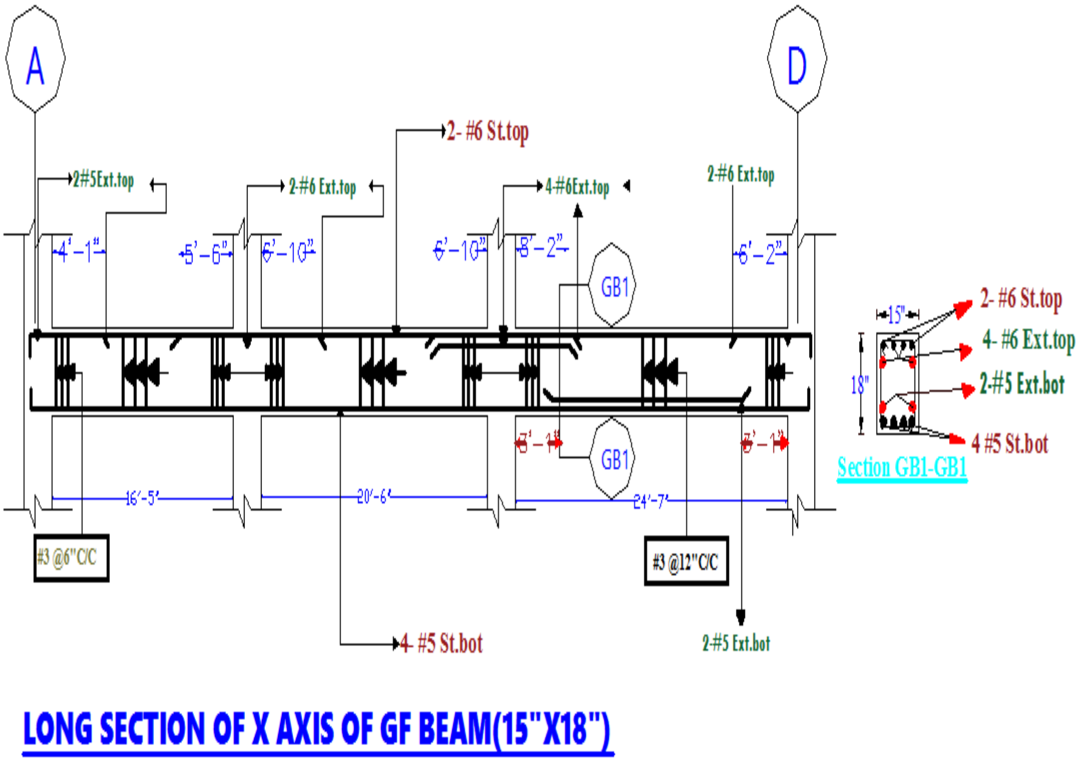



Figure: 5.2 Long and Cross Sections of X Axis of GF Beam (15″ X 18″)

GRADE BEAM (X-AXIS)

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 left and two extra top right corners.

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

## 5.1.3: Reinforcement Detailing of Grade Beam Y-Axis

**Y-axis GB**

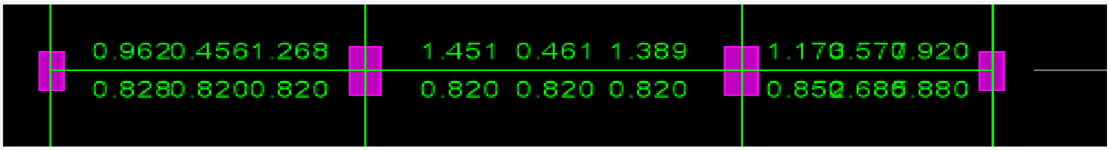



Figure: 5.3 Reinforcement area of Grade Beam Y-Axis (in Inch Sq.)

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 ($in^2$) | | No. | Area ($in^2$) | Str. | Ext | Positive side ($in^2$) | | No. | Area ($in^2$) | Str. | Ext |
| Left | 1.45 | 6 | .44 | 2 | 2 | Left | 0.82 | 5 | .31 | 3 | - |
| Middle | 0.46 | 6 | .44 | 2 | - | Middle | 0.82 | 5 | .31 | 3 | - |
| Right | 1.38 | 6 | .44 | 2 | 2 | Right | 0.82 | 5 | .31 | 3 | - |

## 5.1.4: Long and Cross Sections of Y Axis of GF Beam (15″ X 18″) GRADE BEAM (Y-AXIS):

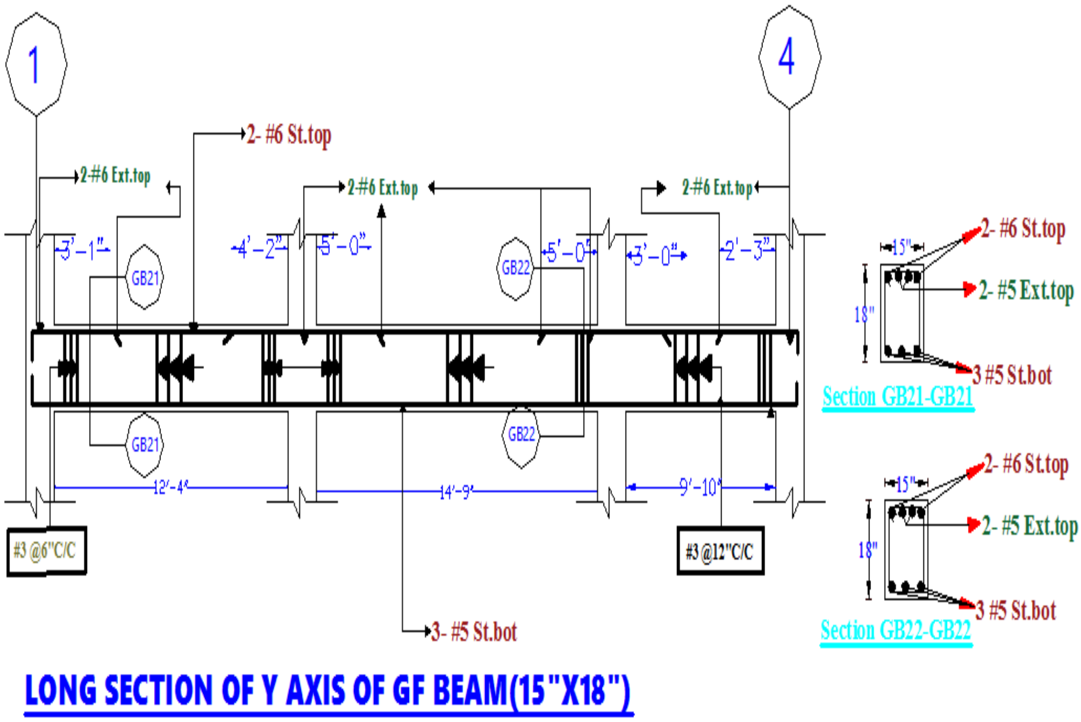



Figure: 5.4 Long and Cross Sections of Y Axis of GF Beam (15″ X 18″)

GRADE BEAM (Y-AXIS)

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 equal reinforcement area at middle, left and right side that's why we need to no extra top at middle, left and right side. Stirrup Design

## 5.2 First Floor

### 5.2.1: Reinforcement Detailing of First Floor Beam X-Axis

**X-axis 1F**

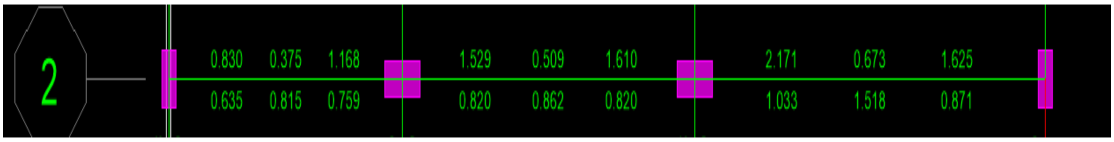



Figure: 5.5 Reinforcement area of First Floor X-Axis (in Inch Sq.)

Table 5.3: Reinforcement Detailing of First Floor X-Axis

| X-axis First Floor | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | 2.171 | 6 & 5 | .44 & .31 | 2 | 3 | Left | 1.033 | 6 & 5 | .44 & .31 | 3 | - |
| Middle | 0.673 | 6 | .44 | 2 | - | Middle | 1.518 | 6 & 5 | .44 & .31 | 3 | 2 |
| Right | 1.625 | 6 & 5 | .44 & .31 | 2 | 3 | Right | 0.871 | 6 & 5 | .44 & .31 | 3 | - |

## 5.2.2: Long and Cross Sections of X Axis of First Floor Beam (12″ X 22″) First Floor (X-AXIS)

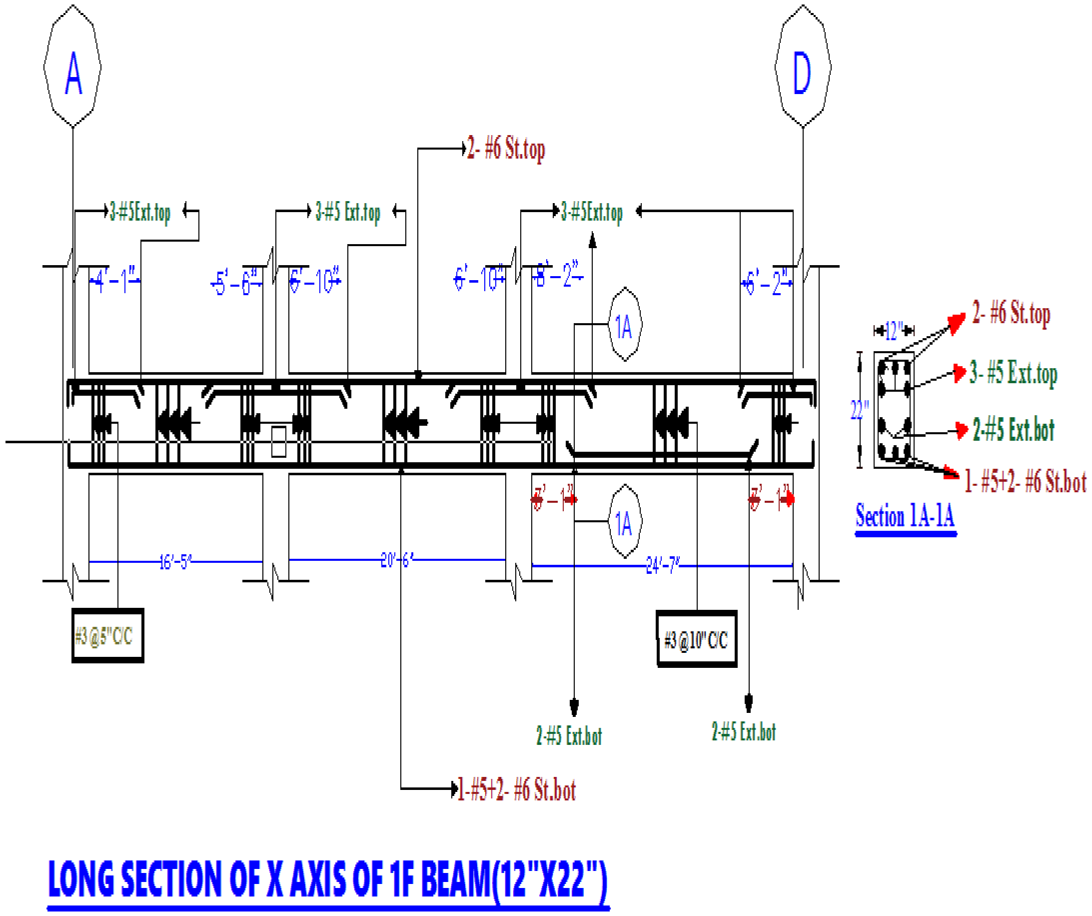



Figure: 5.6 Long and Cross Sections of X Axis of First Floor Beam (12″ X 22″)

First Floor (X-AXIS)

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 middle side then the left and right corner that's why we need to no extra top at left and right side.

## 5.2.3: Reinforcement Detailing of First Floor Beam Y-Axis

### Y-axis 1F


Figure: 5.7 Reinforcement area of First Floor Y-Axis (in Inch Sq.)

Table 5.4: Reinforcement Detailing of First Floor Y-Axis

| Y-axis 1F | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | 1.331 | 5 | .31 | 2 | 2 | Left | 0.82 | 5 | .31 | 3 | - |
| Middle | 0.427 | 5 | .31 | 2 | - | Middle | 0.81 | 5 | .31 | 3 | - |
| Right | 1.303 | 5 | .31 | 2 | 2 | Right | 0.82 | 5 | .31 | 3 | - |

### 5.2.4: Long and Cross Sections of Y Axis of First Floor Beam (12″ X 22″)

### First Floor (Y-AXIS)

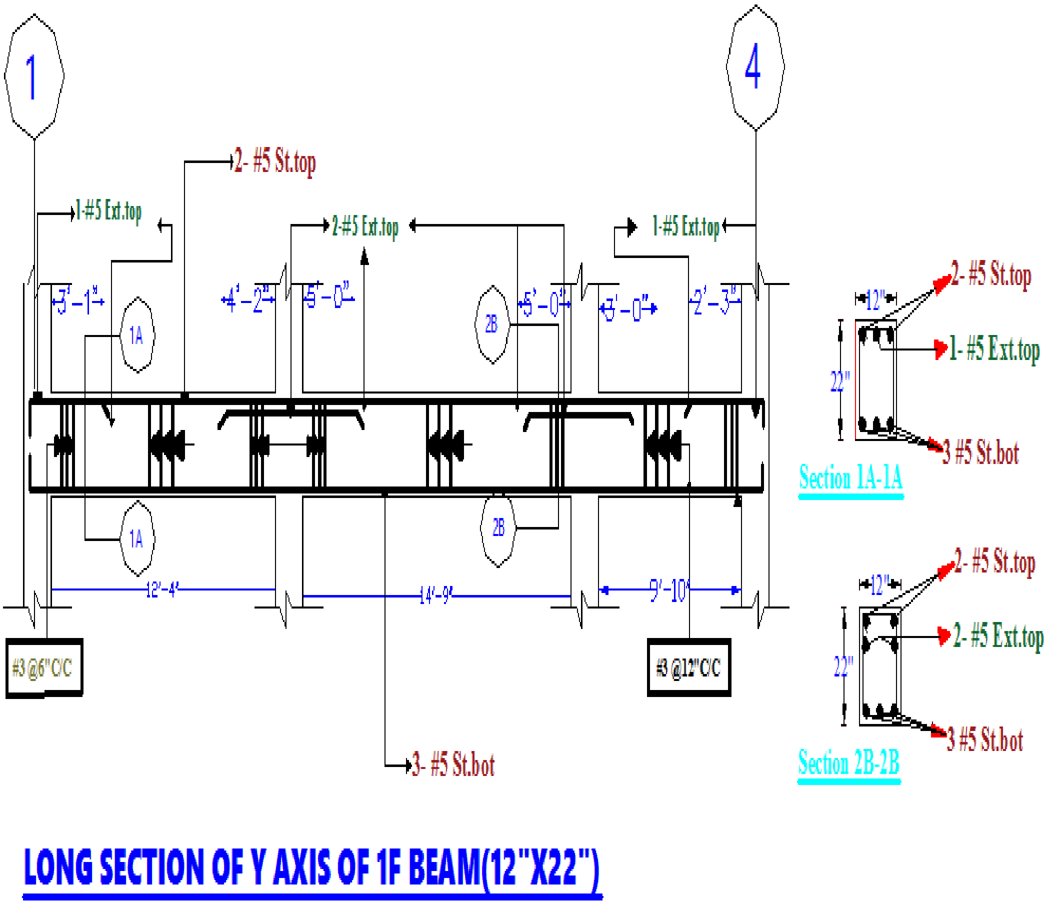



Figure: 5.8 Long and Cross Sections of Y Axis of First Floor Beam (12″ X 22″)

First Floor (Y-AXIS)

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 equal reinforcement area at middle, left and right side that’s why we need to no extra top at middle, left and right side.

## 5.3 Second Floor

### 5.3.1: Reinforcement Detailing of Second Floor Beam X-Axis

### X-axis 2F

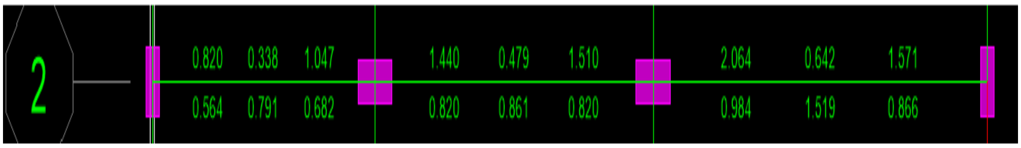



Figure: 5.9 Reinforcement area of Second Floor X-Axis

Table 5.5: Reinforcement Detailing of Second Floor X-Axis

| X-axis 2th Floor | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | 2.06 | 6 & 5 | .44 & .31 | 2 | 3 | Left | 0.98 | 6 & 5 | .44 & .31 | 3 | - |
| middle | 0.64 | 6 | .44 | 2 | - | Middle | 1.51 | 6 & 5 | .44 & .31 | 3 | 2 |
| Right | 1.57 | 6 & 5 | .44 & .31 | 2 | 3 | Right | 0.86 | 6 & 5 | .44 & .31 | 3 | - |

## 5.3.2: Long and Cross Sections of X Axis of Second Floor Beam (12″ X 22″)

### Second Floor Beam X-Axis

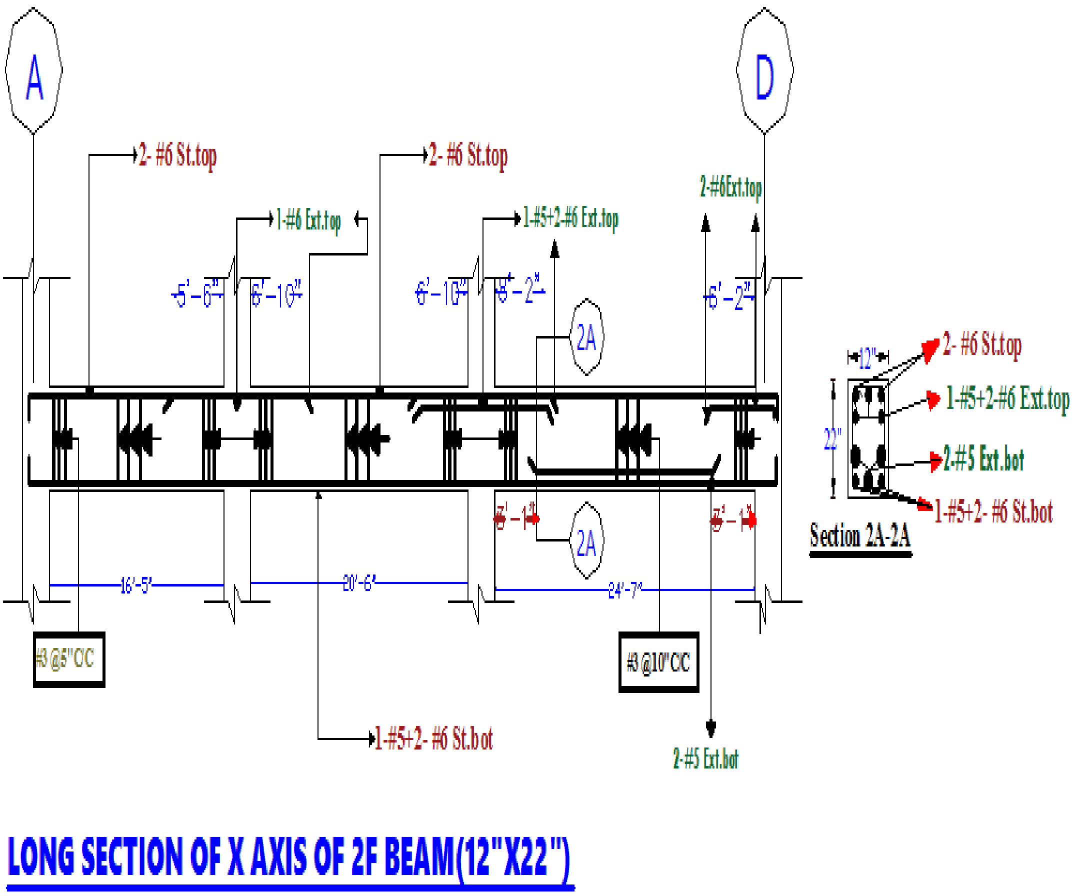



Figure: 5.10: Long and Cross Sections of X Axis of Second Floor Beam (12″ X 22″)

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Second Floor Beam X-Axis

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 less reinforcement area at middle side that’s why we need to no extra top at left and right corner

### 5.3.3: Reinforcement Detailing of Second Floor Beam Y-Axis

#### Y-axis 2F


Figure: 5.11: Reinforcement area of Second Floor Y-Axis (in Inch Sq.)

Table: 5.6 Reinforcement area of Second Floor Y-Axis

| Y-axis 2F | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | 1.17 | 5 | .31 | 2 | 2 | Left | 0.76 | 5 | .31 | 3 | - |
| Middle | 0.37 | 5 | .31 | 2 | - | Middle | 0.74 | 5 | .31 | 3 | - |
| Right | 1.149 | 5 | .31 | 2 | 2 | Right | 0.74 | 5 | .31 | 3 | - |

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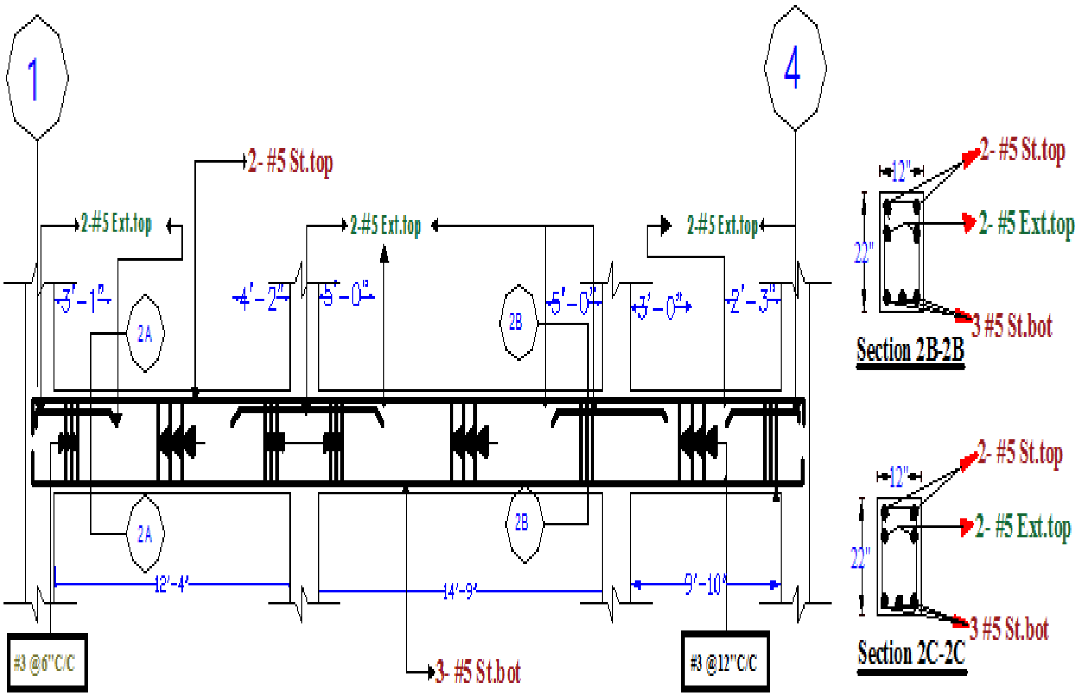
## 5.3.4: Long and Cross Sections of Y Axis of Second Floor Beam (12″ X 22″)

### Second Floor (Y-AXIS)




**LONG SECTION OF Y AXIS OF 2F BEAM(12"X22")**

Figure: 5.12: Long and Cross Sections of Y Axis of Second Floor Beam (12″ X 22″)

Second Floor (Y-AXIS)

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 equal reinforcement area at middle, left and right side that's why we need to no extra top at middle, left and right side

## 5.4 Third Floor

### 5.4.1: Reinforcement Detailing of Third Floor Beam X-Axis

### X-AXIS 3F

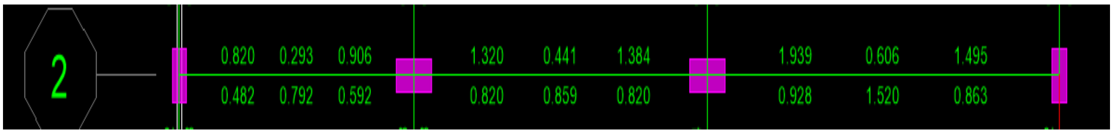



Figure: 5.13: Reinforcement area of Third Floor X-Axis (in Inch Sq.)

Table 5.7: Reinforcement Detailing of Third Floor X-Axis

| X-axis 3F | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | 1.93 | 6 & 5 | .44 & .31 | 2 | 3 | Left | 0.92 | 6 & 5 | .44 & .31 | 3 | - |
| Middle | 0.60 | 6 | .44 | 2 | - | Middle | 1.52 | 6 & 5 | .44 & .31 | 3 | 2 |
| Right | 1.495 | 6 & 5 | .44 & .31 | 2 | 3 | Right | 0.863 | 6 & 5 | .44 & .31 | 3 | - |

## 5.4.2: Long and Cross Sections of X Axis of Third Floor Beam (12″ X 22″)

### Third Floor (X-AXIS)

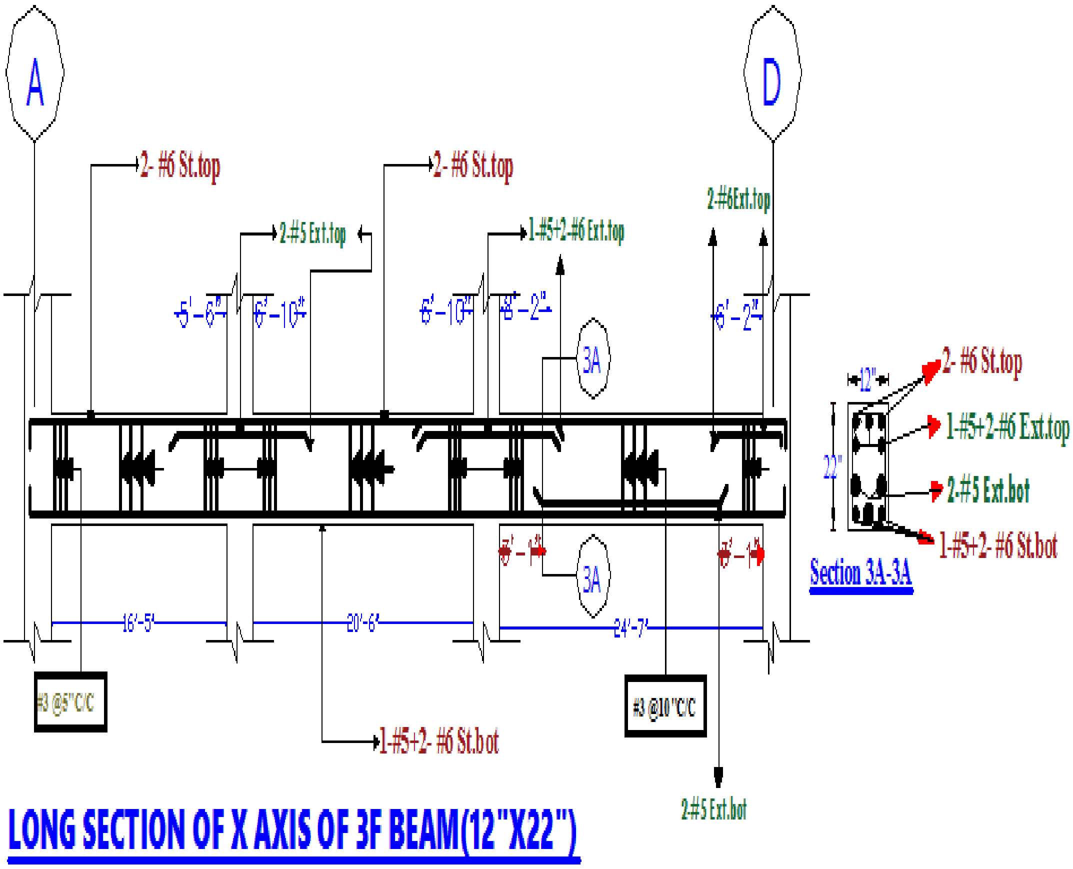



Figure: 5.14: Long and Cross Sections of X Axis of Third Floor Beam (12″ X 22″)

Third Floor (X-AXIS)

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 less reinforcement area at middle side that’s why we need to no extra top at left and right corner.

### 5.4.3: Reinforcement Detailing of Third Floor Beam Y-Axis

**Y-axis 3F**


Figure: 5.15 Reinforcement area of Third Floor Y-Axis (in Inch Sq.)

Table 5.8: Reinforcement Detailing of Third Floor Y-Axis

| Y-axis 3F | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | 0.971 | 5 | .31 | 2 | 2 | Left | 0.634 | 5 | .31 | 3 | - |
| Middle | 0.314 | 5 | .31 | 2 | - | Middle | 0.734 | 5 | .31 | 3 | - |
| Right | 0.961 | 5 | .31 | 2 | 2 | Right | 0.628 | 5 | .31 | 3 | - |

## 5.4.4: Long and Cross Sections of Y Axis of Third Floor Beam (12″ X 22″)

### Third Floor (Y-AXIS)

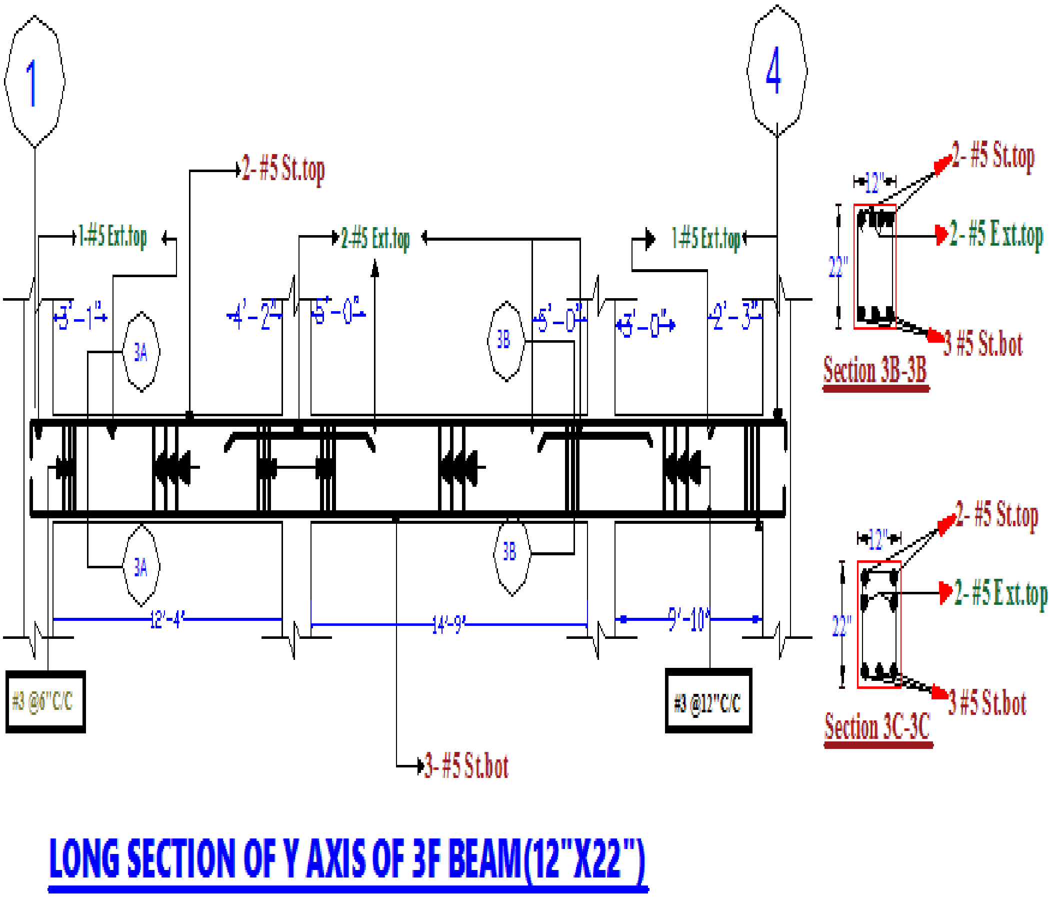



Figure: 5.16: Long and Cross Sections of Y Axis of Third Floor Beam (12″ X 22″)

Third Floor (Y-AXIS)

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 equal reinforcement area at middle, left and right side that’s why we need to no extra top at middle, left and right side.

## 5.5 Forth Floor

### 5.5.1: Reinforcement Detailing of Fourth Floor Beam X-Axis

### X-axis 4F

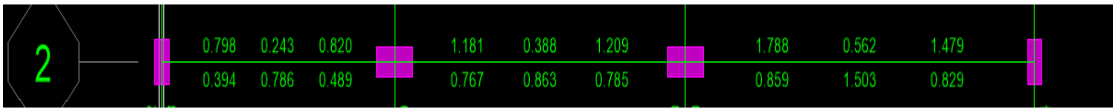



Figure: 5.17 Reinforcement area of Fourth Floor X-Axis

Table 5.9: Reinforcement Detailing of Fourth Floor X-Axis

| X-axis 4F | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | 1.78 | 6 & 5 | .44 & .31 | 2 | 3 | Left | 0.86 | 6 & 5 | .31 | 3 | - |
| Middle | 0.56 | 6 | .44 | 2 | - | Middle | 1.50 | 6 & 5 | .31 | 3 | 2 |
| Right | 1.48 | 6 & 5 | .44 & .31 | 2 | 3 | Right | 0.83 | 6 & 5 | .31 | 3 | - |

### 5.5.2: Long and Cross Sections of X Axis of Fourth Floor Beam (12″ X 22″)

### Fourth Floor (X-AXIS)

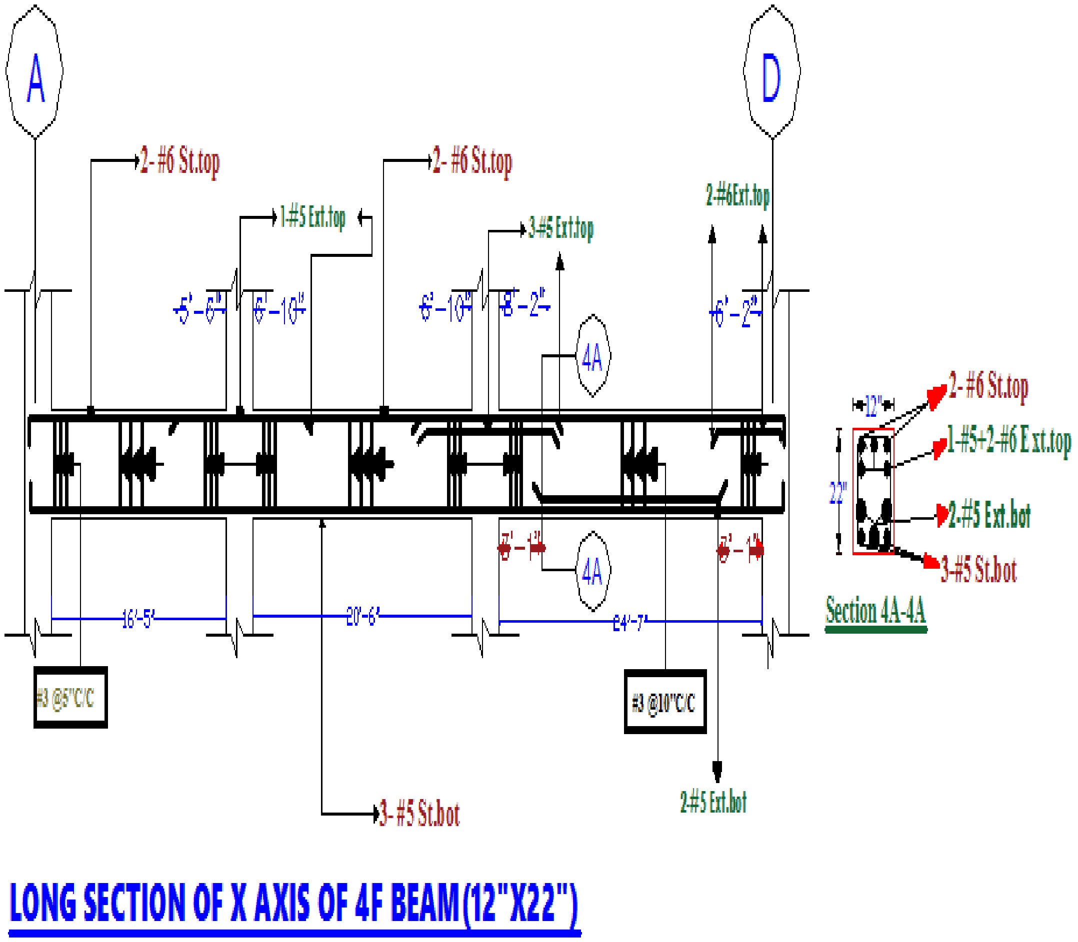



Figure: 5.18: Long and Cross Sections of X Axis of Fourth Floor Beam (12″ X 22″)

Fourth Floor (X-AXIS)

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 less reinforcement area at middle side that’s why we need to no extra top at left and right corner.

### 5.5.3: Reinforcement Detailing of Fourth Floor Beam Y-Axis

**Y-axis 4F**

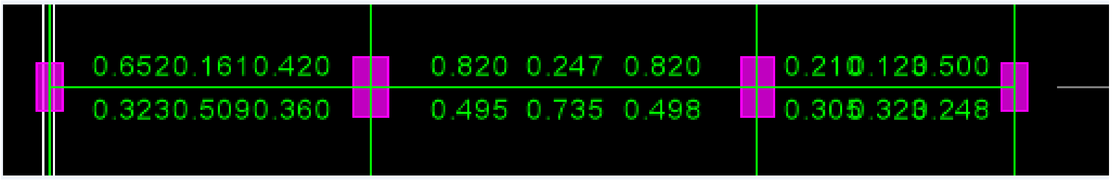



Figure: 5.19 Reinforcement area of Fourth Floor Y-Axis (in Inch Sq.)

Table 5.10: Reinforcement Detailing of Fourth Floor Y-Axis

| Y-axis 4F | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 (in2) | Str. | Ext |
| Left | 0.82 | 5 | .31 | 2 | 1 | Left | 0.49 | 5 | .31 | 2 | - |
| Middle | 0.24 | 5 | .31 | 2 | - | Middle | 0.73 | 5 | .31 | 2 | 1 |
| Right | 0.82 | 5 | .31 | 2 | 1 | Right | 0.49 | 5 | .31 | 2 | - |

### 5.5.4: Long and Cross Sections of Y Axis of Fourth Floor Beam (12″ X 22″)

**Fourth Floor (Y-AXIS)**

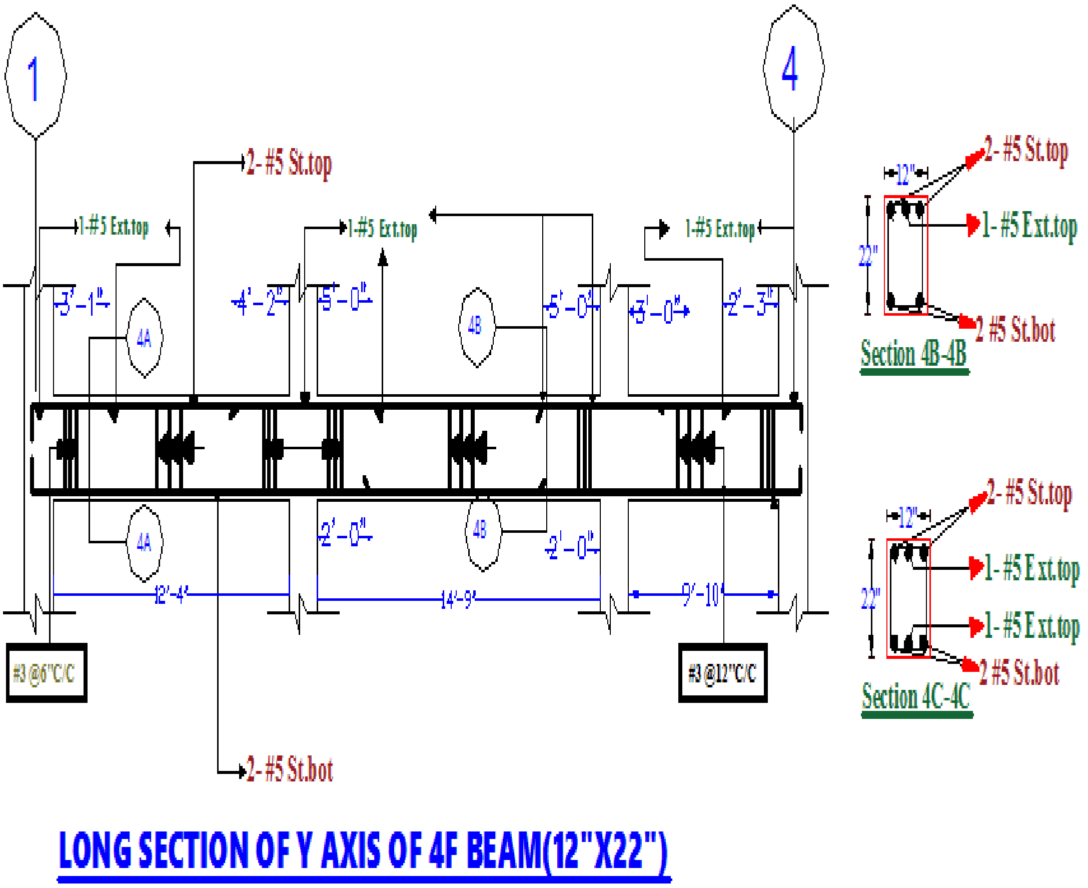



Figure: 5.20 Long and Cross Sections of Y Axis of Fourth Floor Beam (12″ X 22″)

Fourth Floor (Y-AXIS)

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 less reinforcement area at middle side that's why we need to no extra top at left and right corner.

## 5.6 Roof

### 5.6.1: Reinforcement Detailing of Roof Beam X-Axis

### X-axis ROOF

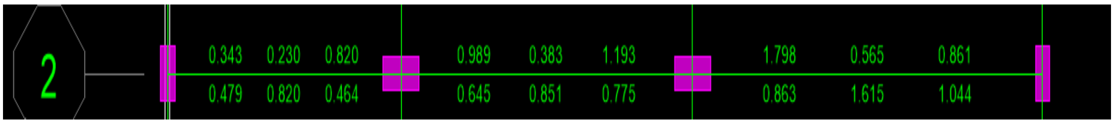



Figure: 5.21 Reinforcement area of Roof X-Axis (in Inch Sq.)

Table 5.11: Reinforcement Detailing of Roof X-Axis

| X-axis Roof | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | 1.79 | 6 & 5 | .44 & .31 | 2 | 3 | Left | 0.86 | 6 & 5 | .31 | 3 | - |
| Middle | 0.56 | 6 | .44 | 2 | - | Middle | 1.61 | 6 & 5 | .31 | 3 | 2 |
| Right | 0.86 | 6 | .44 | 2 | - | Right | 1.04 | 6 & 5 | .31 | 3 | 2 |

## 5.6.2: Long and Cross Sections of X Axis of Roof Beam (12″ X22″)

## Roof (X-AXIS)

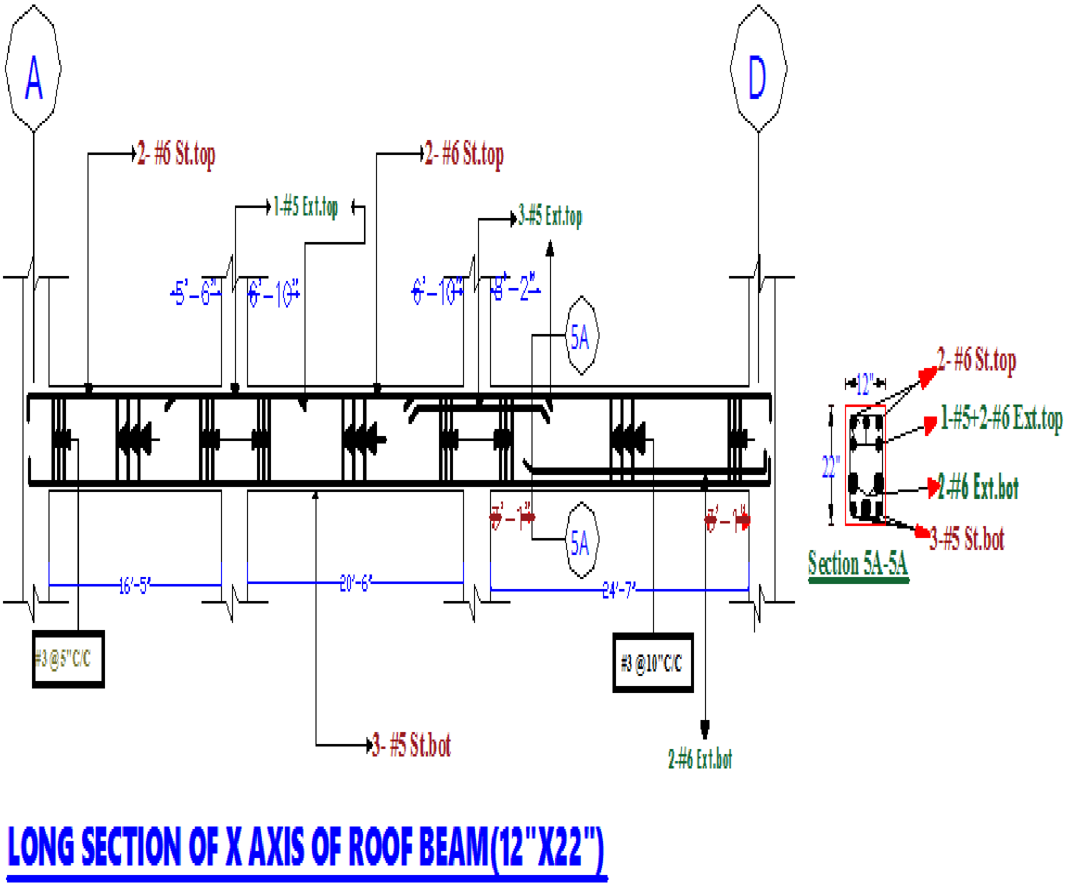



Figure: 5.22 Long and Cross Sections of X Axis of Roof Beam (12″ X22″)

Roof (X-AXIS)

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

For positive side, we get more reinforcement area at middle and right side that's why we need to two extra top at middle and right side.

## 5.6.3: Reinforcement Detailing of Roof Beam Y-Axis

### Y-axis ROOF

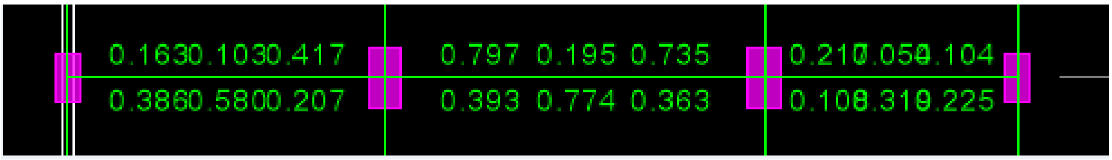



Figure: 5.23 Reinforcement area of Roof Y-Axis (area in inch Sq.)

Table 5.12: Reinforcement Detailing of Roof Y-Axis

| Y-axis ROOF | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | 0.80 | 5 | .31 | 2 | 1 | Left | 0.39 | 5 | .31 | 2 | - |
| Middle | 0.19 | 5 | .31 | 2 | - | Middle | 0.78 | 5 | .31 | 2 | 1 |
| Right | 0.74 | 5 | .31 | 2 | 1 | Right | 0.36 | 5 | .31 | 2 | - |

### 5.6.4: Long and Cross Sections of Y Axis of Roof Beam (12″ X 22″)

### Roof (Y-AXIS)

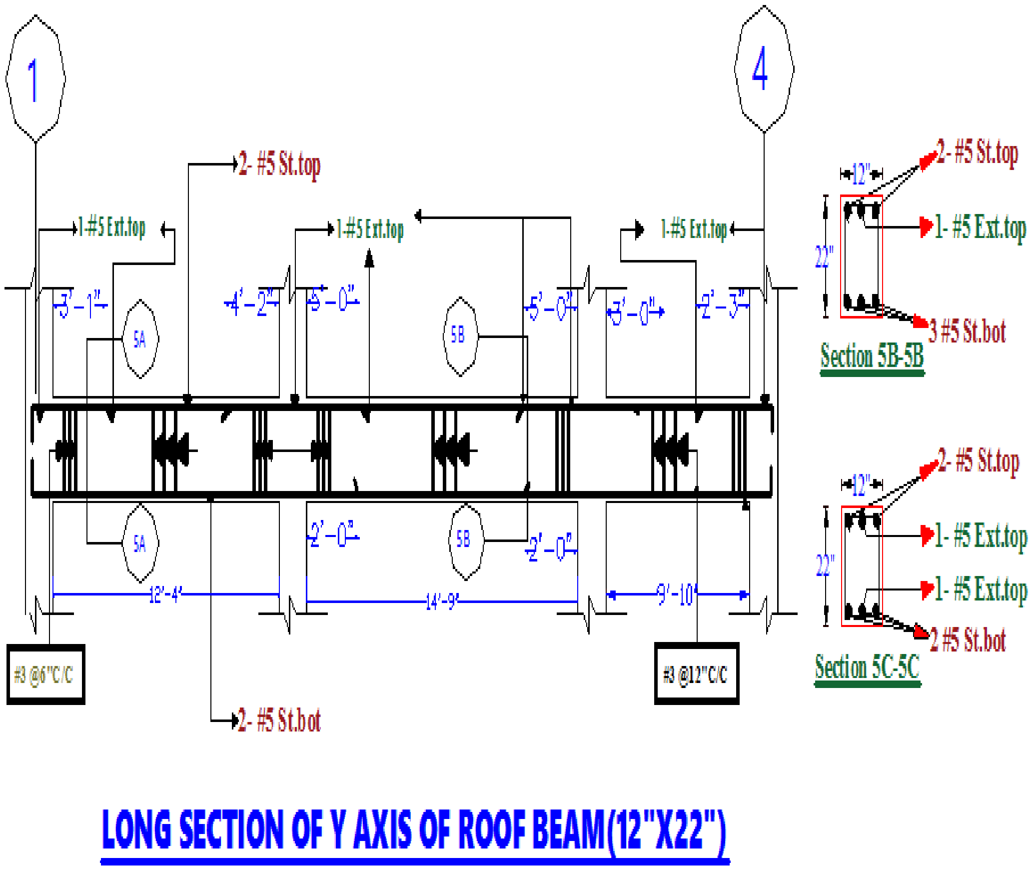



Figure: 5.24 Long and Cross Sections of Y Axis of Roof Beam (12″ X 22″)

Roof (Y-AXIS)

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 less reinforcement area at middle side that's why we need to no extra top at left and right corner.

# CHAPTER – 6
# COLUMN DESIGN

## 6.1 Layout of column:

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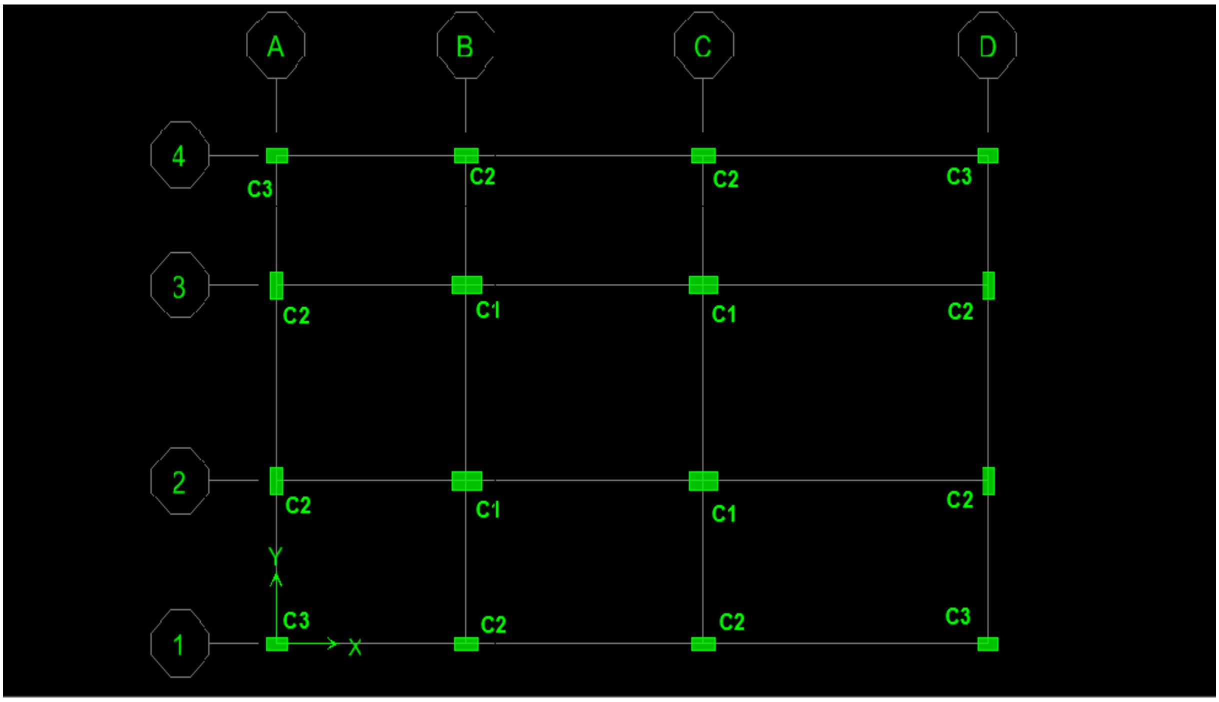


Figure: 6.1: Layout of column

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

**C1= 12"X30"**
**C2= 12"X24"**
**C3= 12"X21"**

## **6.2: Column 1:** Section B Grid-2 Centre Column

Table 6.1: Column 1 bar details

| **Criteria** | **UP to 2nd Floor** | **3rd Floor to Roof** |
|---|---|---|
| Max Bar Area (in2) | 4.5 | 4.5 |
| Bar Number | #6 | #6 |
| Bar Area (in2) | .44 | .44 |
| No of Bar Provided | 12 | 12 |
| Column Cross Section(mm) | 300mm X750mm | 300mm X750mm |
| Area Of Column Section Ag (in2) | 360 (Approximate) | 360 (Approximate) |
| 4% of Ag (in2) | 14.4 | 14.4 |
| Provided total Steel Area Ast (in2) | 5.28 | 5.28 |
| Comments | Ast<14.4 (Ok) | Ast<14.4 (Ok) |

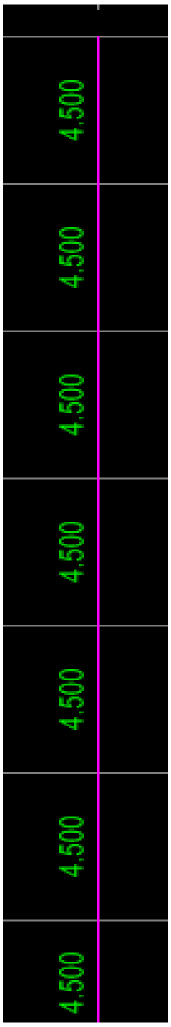


Figure: 6.2 Reinforcement Area of C1 column

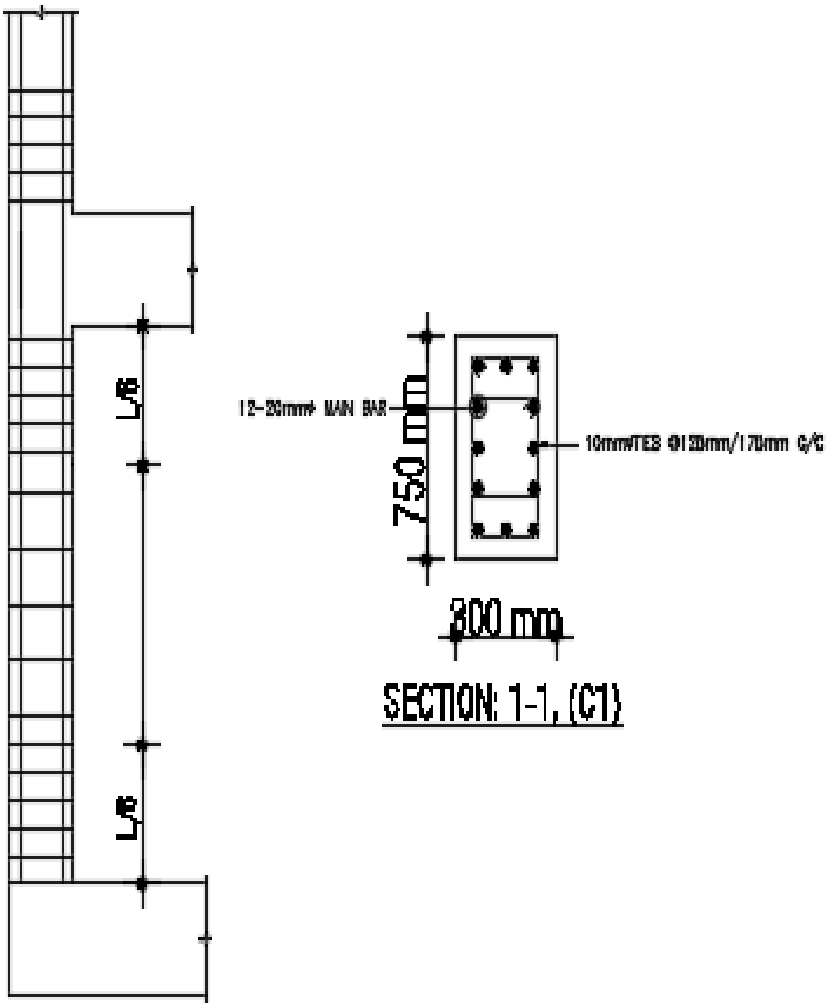


Figure: 6.2.1 Column -1

## 6.3 Tie Bar Details for C1 Column:

Height of
18”

Largest dimension of column

L/6

= 18”

So Lowest of

4”

Or ¼ of lowest column dimension

Spacing for corner side of column, $S_o$=3”

For middle side of column 2x,$S_o$=6”

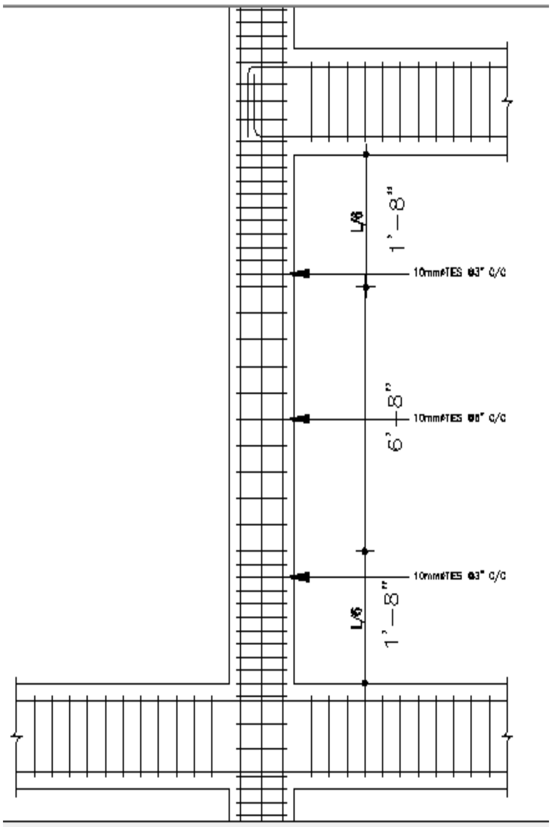


Figure: 6.2.2 Tie Bar Details For C1 Column

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.

## 6.4: Column 2 Section B Grid 4B (CI- Interior Column)

Table 6.2: Column 2 bar details

| **Criteria** | **UP to to $2^{nd}$ floor** | **3rd Floor to Roof** |
|---|---|---|
| Max Bar Area (in2) | 2.88 | 2.88 |
| Bar Number | #5 | #5 |
| Bar Area (in2) | .31 | .31 |
| No of Bar Provided | 10 | 10 |
| Column Cross Section (mm) | 300mm x 600mm | 300mm x 600mm |
| Area Of Column Section Ag ($in^2$) | 288 (approximate) | 288 (approximate) |
| 4% of Ag | 11.52 | 11.52 |
| Provided total Steel Area $A_{st}$ (in2) | 3.1 | 3.1 |
| Comments | $A_{st}<11.52$ (ok) | $A_{st}<11.52$ (ok) |

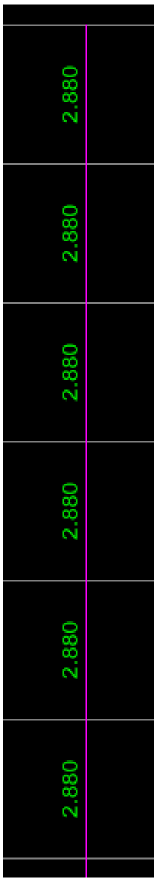


Figure: 6.3 Reinforcement Area of C2 columns (in Inch Sq)

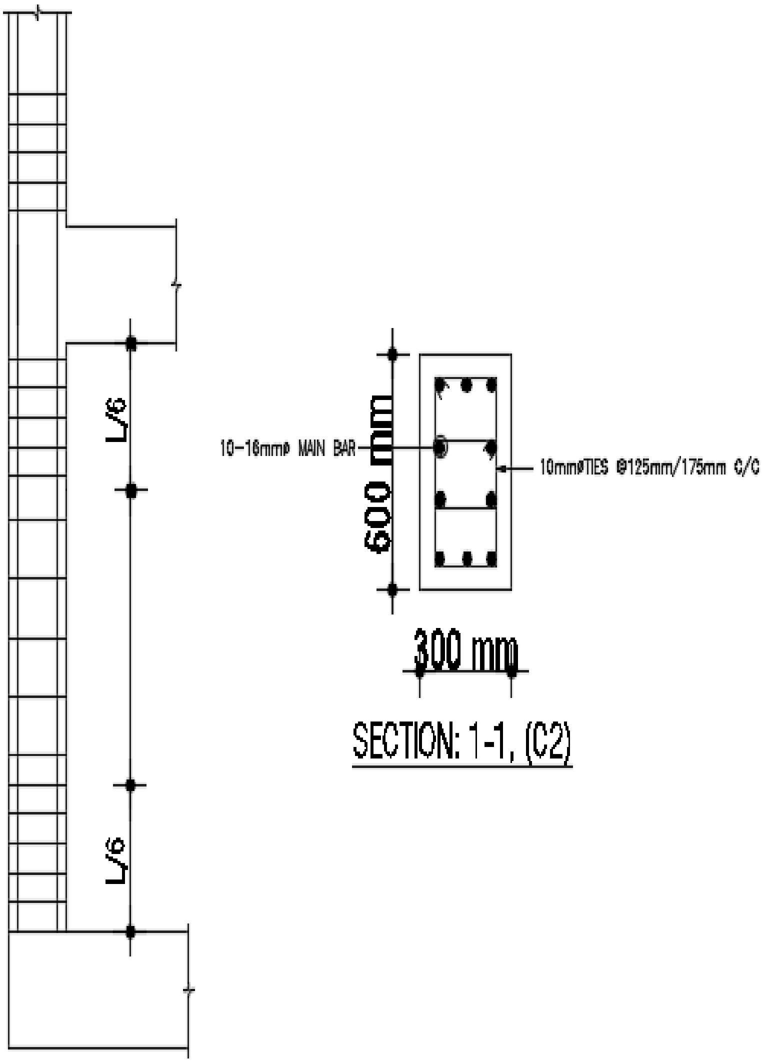


Figure: 6.3.1 Column 2 (CI)

# 6.5 Tie Bar Details for C2 Column:

Height of

18”

Largest dimension of column

L/6

= 18”

So Lowest of

4”

Or ¼ of lowest column dimension

Spacing for corner side of column, $S_o$=3”

For middle side of column 2x, $S_o$=6”

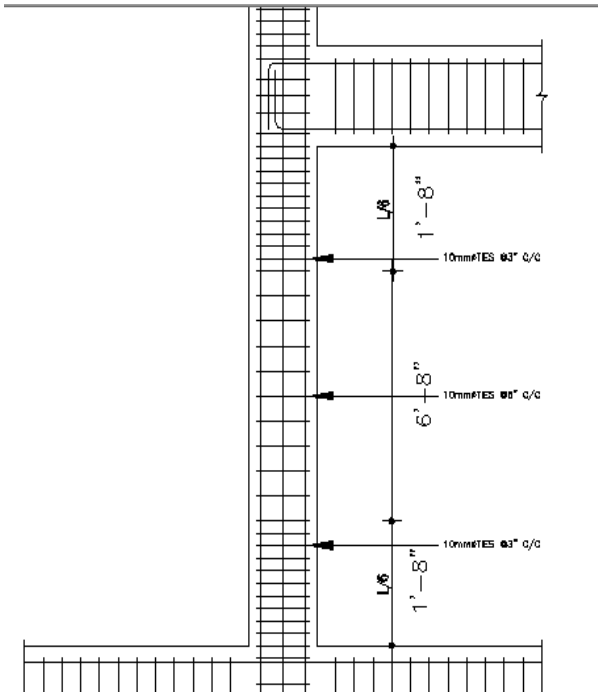


Figure: 6.3.2 Tie Bar Details For C2 Column

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.

## 6.6: Column 3

Section D Grid 4D (CEY- Exterior Column Y-Direction)

Table 6.3: Column 3 bar Details

| **Criteria** | **Up to to 2nd Floor** | **3rd Floor to Roof** |
|---|---|---|
| Max Bar Area (in2) | 8.481 | 6.045 |
| Bar Number | #10 | #10 |
| Bar Area (in2) | 1.27 | 1.27 |
| No of Bar Provided | 8 | 6 |
| Column Cross Section (mm) | 650mm X 600mm | 650mm X 600mm |
| Area Of Column Section Ag (in2) | 605 (approximate) | 605 (approximate) |
| 4% of Ag | 24.2 | 24.2 |
| Provided total Steel Area Ast (in2) | 10.16 | 7.62 |
| Comments | Ast< 24.2 (Ok) | Ast< 24.2 (Ok) |

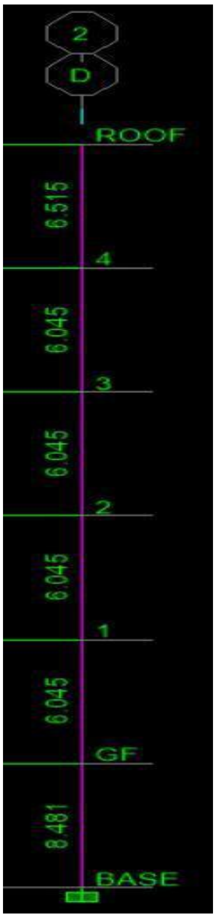


Figure: 6.4 Reinforcement Area of C3 column (in inch Sq.)

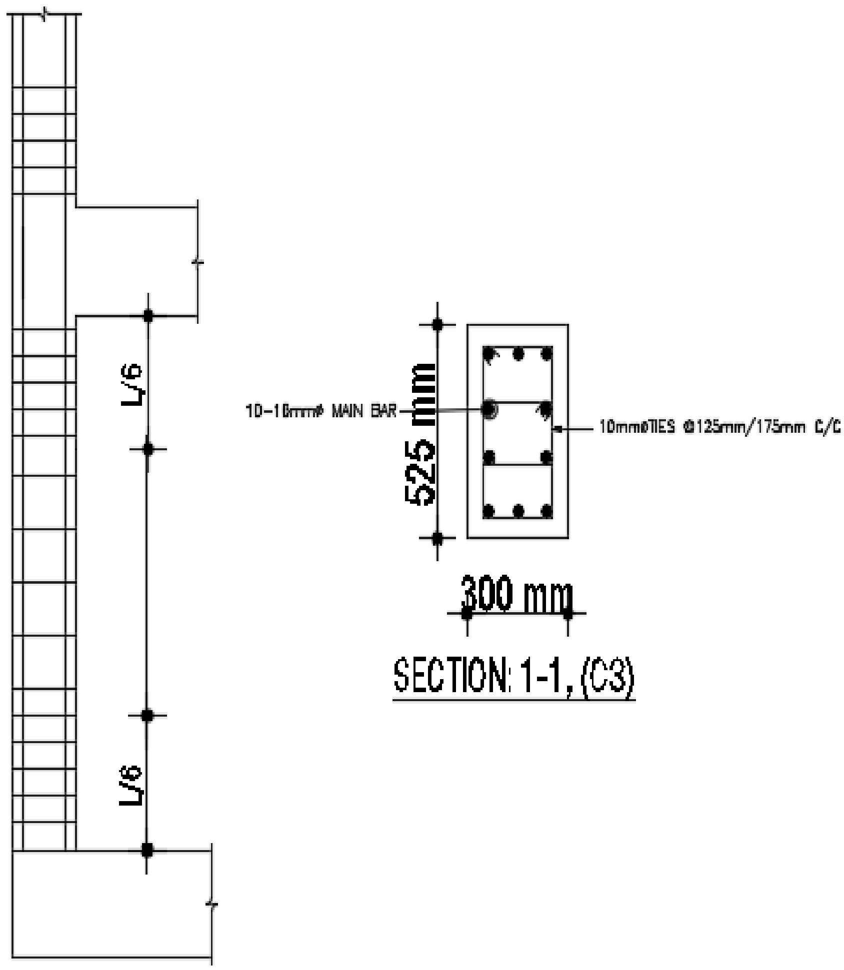


Figure: 6.4.1 Column C3 (CEY)

## 6.7 Tie Bar Details for C3 Column:

Height of

18”

Largest dimension of column

L/6

= 18”

So Lowest of

4”

Or ¼ of lowest column dimension

Spacing for corner side of column, $S_o$=3”

For middle side of column 2x,$S_o$=6”

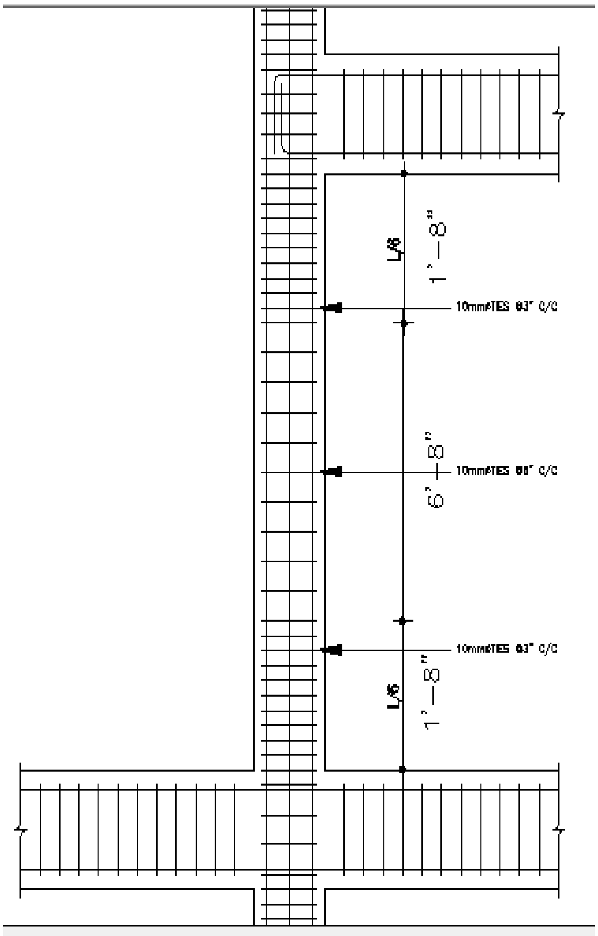


Figure: 6.4.2 Tie Bar Details For C3 Column:

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.

# CHAPTER- 7
# CONCLUSION & RECOMMENDATION

# CONCLUSION

The main work of our thesis is to design beams and columns for a six storied residential building. It requires the application of earlier course work to carry out the analysis and design of components of structure. We have applied dead load, live loads, wind load, earthquake load all load before running the model. Before making design we make some verification on the structure to be ensured that the design will be efficient. The buildings satisfy the design requirements (deflection, period of model etc.).

★ Modeling, Analysis and design used by ETABS software.

★ ETABS used for beam longitudinal reinforcement for detailing and column modular percentage detailing.

★ The deflection due to wind to be exact 0.35 inch in X direction and 1.22 inch in Y direction.

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# RECOMMENDATIONS

★It is recommended that try to use new versions of software and design codes.

★Should be used real life value for better understanding.

★Try to do total estimating cost and it should be encouraged for application in civil engineering project works.

# REFERENCES

1. Nilson, A. H., Darwin, D. and Dolan, C. W. (Third Ed.)2003, Inc. Design of Concrete Structures. Singapore: McGraw-Hill, Inc.

2. Bangladesh National Building Code, Dhaka, 1993

3. Software References:

a. Auto Cad

b. ETABS Software. (Version 9.7.1)

c. MS Excel

d. MS Word

e. Adobe Photoshop

f. ArcGIS (for map making), Data BNBC 1993

# Appendixes

**Appendix 1:**

BNBC for Seismic Load

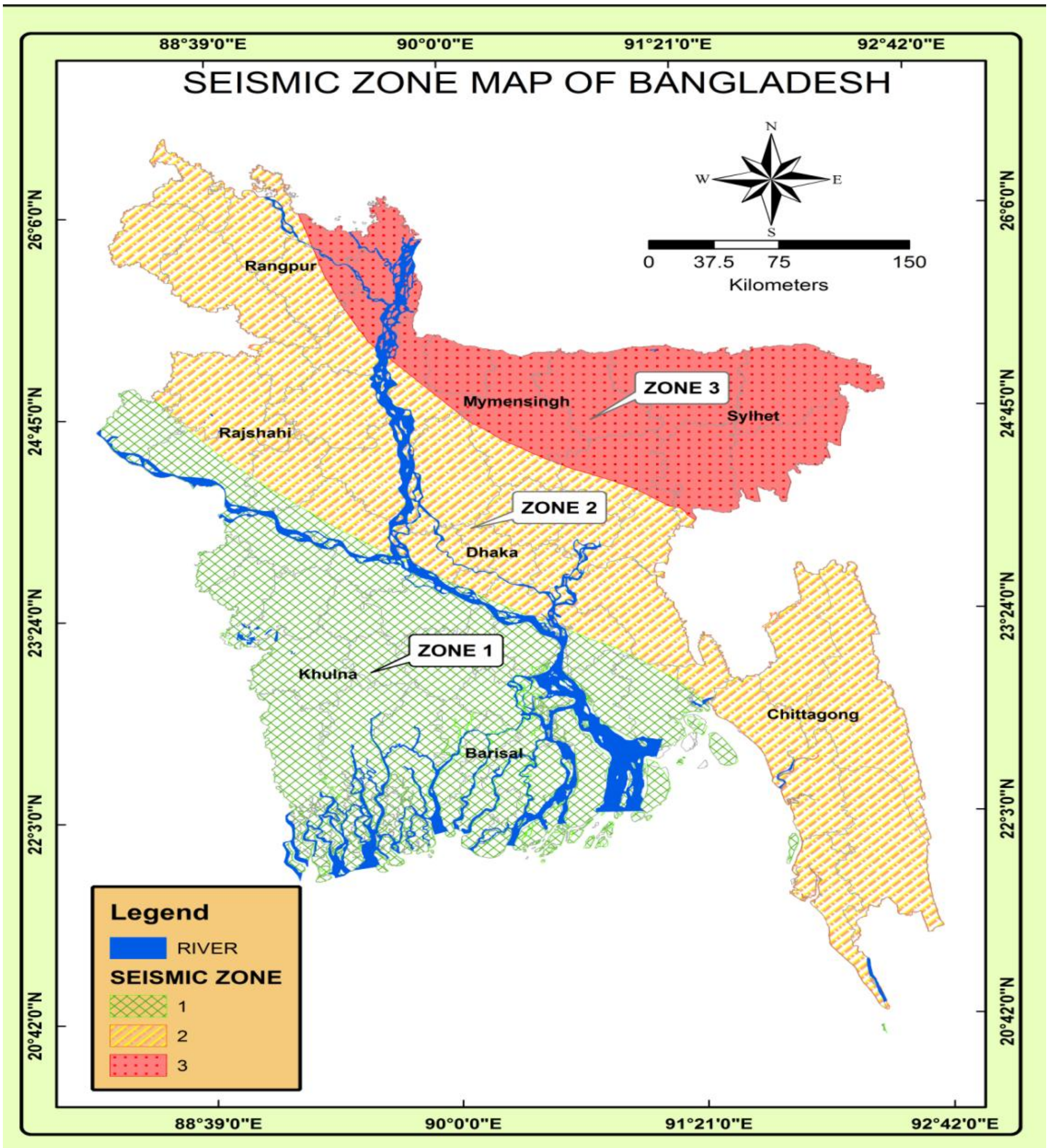


Figure: A.1: Seismic zone map of Bangladesh

Table: A.1: Seismic Zone Coefficient, Z value

| **Seismic Zone** | **Zone Coefficient** |
|---|---|
| 1 | 0.075 |
| 2 | 0.15 |
| 3 | 0.25 |

Table: A.2: Structure Importance Coefficients, $C_I$ for Seismic Loads

| Structure Importance Category (see Table 6.1.1 for Occupancy) | Structure Importance Coefficient, $C_I$ |
|---|---|
| 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 | 1.00 |

## Response modification Coefficient for Structural System, R

Table: A.3: Coefficient for Structural System, R

| | | |
|---|---|---|
| C. Moment Resisting Frame System | 1. Special moment resisting frames (SMRF)<br>a) Steel<br>b) Concrete | <br><br>12<br>12 |
| | 2. Intermediate moment resisting frames (IMRF), Concrete | 8 |
| | 3. Ordinary moment resisting fames<br>a) Steel<br>b) Concrete | <br><br>6<br>5 |

## Site coefficient, S for Seismic Lateral Forces

Table: A.4: Site coefficient, S for Seismic Lateral Forces

| Site Soil Characteristics | | |
|---|---|---|
| Type | Description | Coefficient |
| $S_1$ | A soil profile with either<br>a) A rock-like material characterized by a shear-wave<br>velocity greater than 762 m/s or by other suitable means of<br>classification, or<br>b) Stiff or dense soil condition where the soil depth is<br>less than 61 meters. | 1.00 |
| $S_2$ | A soil profile with dense or stiff soil conditions, where the<br>soil depth exceeds 61 meters. | 1.20 |
| $S_3$ | A soil profile 21 meters or more in depth and containing<br>more than 6 meters of soft to medium stiff clay but not more than 12 meters of soft clay. | 1.50 |
| $S_4$ | A soil profile containing more than 12 meters of soft clay<br>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 do not know 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.

# Appendix 2:

BNBC for wind loads:

**Wind speed map of Bangladesh**

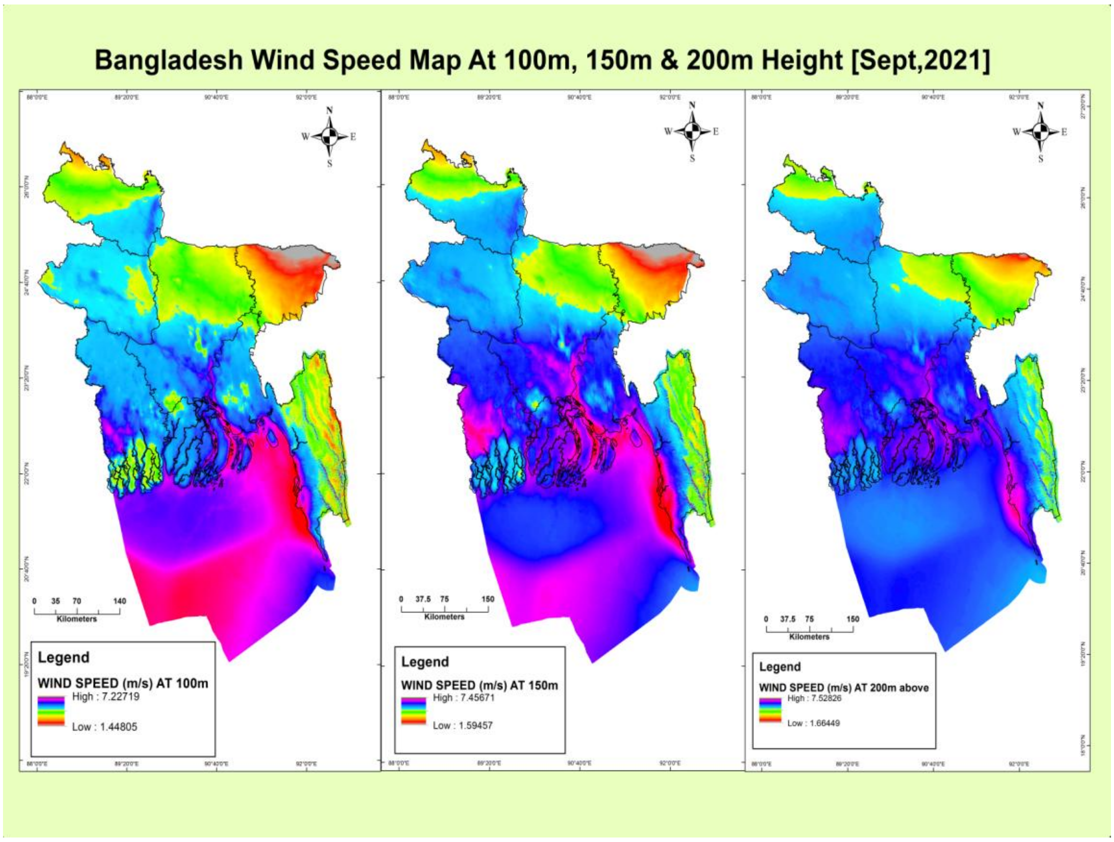


Figure: A.2: Wind speed map of Bangladesh

## Structure Importance Coefficients, $C_I$ for Wind Load

Table A.5: Structure Importance Coefficients, $C_I$

| Location | Baisc Wind Speed (km/h) | Location | Basic Wind Speed (km/h) |
|---|---|---|---|
| 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 |

## Combined Height and Exposure Coefficient, $C_z$

Table A.6: Combined Height and Exposure Coefficient, $\mathbf{C_Z}$

| 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. | | | |