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 for the Degree of

Bachelor of Science in Civil Engineering

Department of Civil Engineering

Daffodil International University

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The thesis titled "**Design of a Six Storied Residential Building"** submitted by **Md. Nafiz Hossain, Tanim Rezion, Md. Al Amin, Md. Ariful Islam Khandoker, Md. Rony Ahmed** have been accepted as satisfactory in partial fulfillment of the requirement for the degree of Bachelor of Science in Civil Engineering on September 2021.

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APPROVAL

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DECLARATION

Declaration the dissertation entitled **"Design of a Six Storied residential Building"** has been performed under the supervision of **Ms. Arifa Akther** (Lecturer), Department of Civil Engineering, Daffodil International University, Dhaka, Bangladesh and 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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ABSTRACT

In this study, we designed a six stories Residential building Considering all Forces. The objective of this study to design and detailing (column, beam, slab). The basic methodology adopted here is the sequential presentation of design all force of six storied building for earthquake and wind effect by UBC1994, BNBC and ACI code 318-99 code proposed places in Bangladesh. Analysis has been performed with ETABS. A residential building with a reinforced concrete frame with six floors was applied to perform its intended purpose while also catering to the needs and comfort of the residents. To accomplish the architectural design, we used AutoCAD tools and ETABS to design and evaluate the building's structure. The structural planning and design process involve not only imagination and intellectual thinking, but also a thorough understanding of structural engineering science, as well as practical knowledge of modern design codes and bye-laws, backed up by ample experience, intuition, and judgment. The goal of standards is to ensure and improve safety while maintaining a careful balance between cost and safety. Using an excel application, the moments in slabs were calculated using method two with approximation to factors and loads in beams with moments and design portion and reinforcement. This program is more effective for analyzing the two-way slab by combining a few factors relating to slab type, beam and column dimensions, and the expected applied load. Finally, we organized the findings into architectural and structural maps for this structure.

LIST OF ACRONYMS & ABBREVIATION

LL = live load

DL = Dead load

PW = partition wall

FF = Floor finish

WL = Wind load

EQL = Earth quake load

Ag= Gross area

Ast= Area of steel

P = Axial Load of Column

V = Shear Stress

h = Slab Thickness

b = Width of Beam

d = Effective Depth of Beam

a = Equivalent Depth of Beam

pcf = Pound per Cubic feet

psi = Pound per Square Inch

ASTM = American Standard for Testing Material

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

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CHAPTER 1: INTRODUCTION

1.1 Introduction:

The structural planning and design process necessitate creativity and conceptual thinking, as well as a thorough understanding of structural engineering science, as well as practical issues such as current design codes, which must be supported by sample experience, intuition, and judgment. The objective of standards is to ensure and improve safety while maintaining a careful balance between cost and safety. The design process begins with the layout of the structure, which is done primarily to meet its functional requirements.
It was underlined that any structure built must efficiently meet the needs for which it was designed and be durable for the duration of its designated life cycle. When failure is imminent, the strength design method concentrates on circumstances at loads larger than service loads. The strength design method was seen to be more conceptually realistic for determining structural safety.

1.2 Background of the Study:

RCC structures are designed and built around the world in accordance with the standards of a building code, which is a legal document that includes regulations for structural safety, fire safety, plumbing, ventilation, and accessibility for the physically challenged. Building regulations outline the design requirements and limits that must be met, rather than providing design techniques. The prescription of minimum live loads for buildings is very important to structural engineers. While the engineer is urged to look into the actual loading conditions and try to come up with realistic figures, the structure must be able to handle the stipulated minimum loads.
Maximum 100-year-interval wind forces vary greatly depending on location; at ground level, they are typically around 100 kilograms per square meter (20 pounds per square foot) in the interior of continents. The Maximum force is higher in coastal places where cyclic storms such as hurricanes and typhoons occur, going upwards of 250 kilograms per meter (50 pounds per square foot). As the influence of ground friction lessens, wind forces increase with building height to a constant or gradient value.
In recent years, Bangladesh has growing trends towards the construction of multi-storied buildings. Almost all of these skyscrapers are beading constructed in Dhaka City. This study is an attempt to compare the effect of lateral force on a residential building. The planning, design and construction of the structure are essentially as old as humankind is, for although nature provides on this planet, an acceptable environment is seldom precisely suitable to their needs, convenience and desires. Early humans could probably find natural caves of hollow trees that would give them partial shelter from the elements, but they would

be adequately situated to meet their needs. The construction of structure came into existence; generally, a concrete structure made of a set of frames consisting of several vertical and horizontal members.

That is why it is known as a frame structure. Generally, there are three types of a frame structure according to the definition of BNBC; any building having a height of less than 2o meter is called a low-rise building. A medium-rise building defined as any building on the floor whose uppermost level does not exceed 70 feet 75 feet is generally not more than eight stories high rise building defined as ay building, the floor whose uppermost levels exceed 70 feet of 75 feet which is generally more than eight stories.

1.3 Objective:

The objectives of the research study are as follows:

I The Objective of this project is to design superstructure of a six storied residential building.
II Detailing of Slab reinforcement details according to moment values from ETABS result.
III Detailing of Beam reinforcement details according to Longitudinal Reinforcing values from ETABS result.
IV Detailing of Column reinforcement details according to Rebar percentage values from ETABS result.

1.4 Scope of Study:

The Design of the structure is done using ETABS software. From the analysis, it is visible clearly that the coasts of a residential building will vary for lateral force and without lateral force. Structure analysis and design have been done using computer software ETABS. For analysis and design purpose, ACI code, UCB 1994, BNBC-1993 has been used.

1.5 Limitations:

The overall Design of the structure could not be done due to a shortage of time. The study consists of a residential building. The substructure part has not been worked on, Only the superstructures part has been worked on. Total Design of the structure was not done (i.e. stair, shear wall, Footing etc.). However, if the structure were chosen based on importance co-efficient, then the variation would be significant. No cost comparison was made.

CHAPTER 2: LITERATURE REVIEW

2.1 RCC Frame Structure

RCC framed structure is a connection of slabs, beams, columns and foundation inter-connected to each other as a unit. The load is transmitted from a slab to a beam, then to the columns, then to the lower columns, and eventually to the foundation, which transfers the load to the soil. Most tall structures use RCC technology.

Because brick has a lower compressive strength than 1:2:4 cement concrete, load-bearing walls for structures with more than four stories become excessively thick. Furthermore, framed constructions are built for such situations.

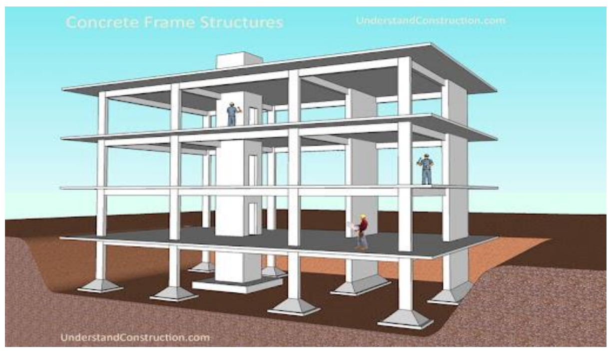


Figure 2. 1: RCC Structure

Structural components in RCC Frame Structure are: Slab, Beam, Plinth Beams, Column, Foundation, and Cantilever.
RCC structures, also known as framed structures, are built of concrete and steel, with the load transferred to the foundation by columns or shear walls resting on concrete piles. Load-bearing structures were commonly constructed before to the 1970s and have limited earthquake resistance.
Normal earthquake effects can also be resisted by providing required further design.

Necessity of RCC Framed Structure:
The steel bars used in cement concrete provide the construction a lot of strength. To improve the bonding or cohesiveness between concrete and steel, the steel bars are usually scraped or corrugated. Steel bars used for RCC work should not have any joints, hence the length of the steel should be increased.

The following are some of the benefits of the RCC Frame Structure: An RCC-framed structure has a floor area that is 10 to 12 percent more than a load-bearing walled building. By adjusting the actual position of the partition walls, you may easily change the interior plan of a room, bathroom, or W.C., giving you greater planning flexibility.

Faster building work saves time and allows for earlier completion. RCC framed buildings can be built anywhere, whether the soil is soft or hard. The cost of maintenance is relatively minimal and can be overlooked.

2.2 Types of Load on Structure

Vertical loads, horizontal loads, and longitudinal loads are the three types of loads that act on structures for buildings and other structures. There are three types of vertical loads: dead load, live load, and impact load. Wind and earthquake loads are examples of horizontal loads.

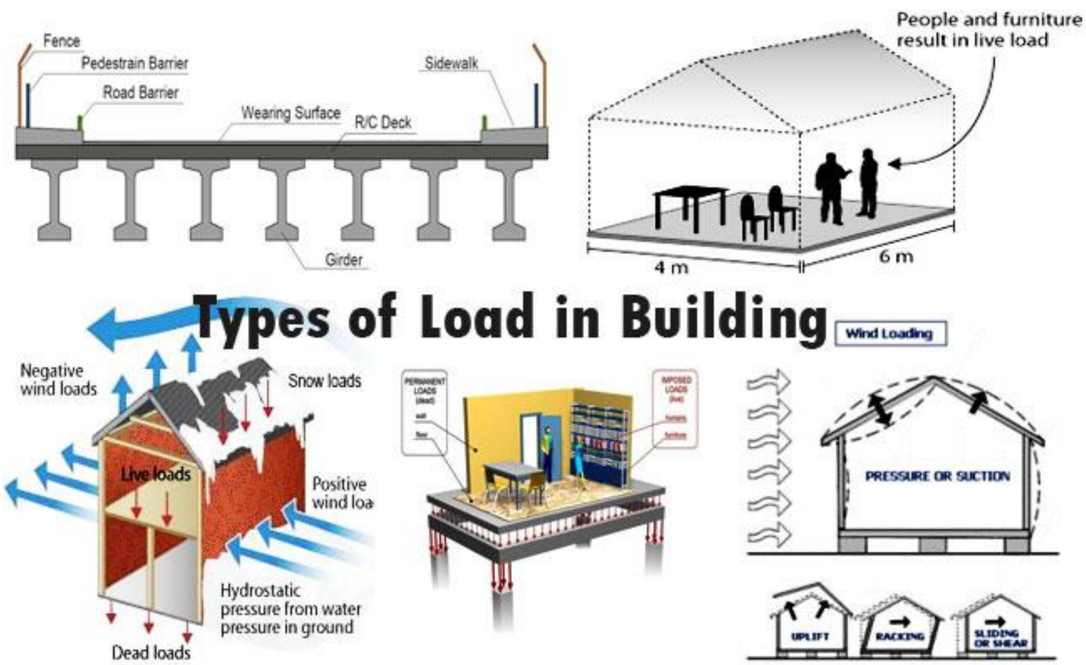


Figure 2. 2: Types of Load on Structure

Permanent or static loads are other terms for dead loads. That is before a structure is put into operation, its dead weight includes its entire weight, which is commonly measured in pounds per square foot.

The most common types of live loads are variable or moving loads. These can include things like impact, momentum, vibration, fluid slosh dynamics, and so on, and they can include a lot of movement.

The application time of an impact load on a material must be less than one-third of the material's natural period of vibration.

Cyclic loads on a structure can lead to fatigue, cumulative damage, or failure. Vibration or recurrent loadings on a structure might produce these loads.

2.2.1 Dead loads

The dead load is made up of loads that are relatively constant throughout time, such as the structure's weight and immovable components like walls, plasterboard, or carpet. The roof has a dead load as well. Permanent or static loads are other terms for dead loads. Building materials are not considered dead loads until they are permanently installed.

An exact dead load for each component can be established by multiplying the volume of each member by the unit weight of the materials from which it is made. The dimensions of a structural member are affected by the loads operating on it. It is simple to calculate the dead loads.

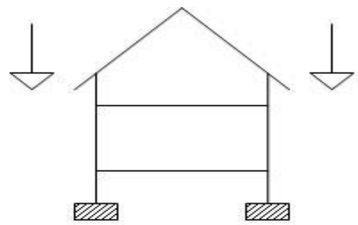


Figure 2. 3: Dead Load

2.2.2 Live Loads

Live loads are movable or moving loads that have not experienced any acceleration or impact. The weights of moveable partitions or furnishings, for example, are supposed to be produced by the building's planned use or occupancy.

The term "live load" refers to all other loads acting on a structure that are not dead loads. They hold all movable weights, including people, furniture, and fixtures, as well as non-structural elements like rain, snow, and ice. The wind pressure, water pressure, and earth's push are all included in Live Load. Because of the widespread use of lighter materials and more energy-efficient construction techniques, wind is recognized as a critical load. The wind load cannot be precisely calculated.

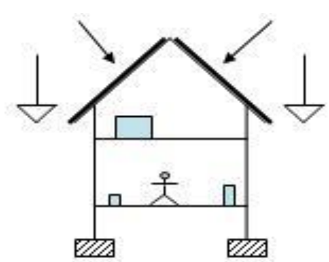


Figure 2. 4: Live Load

Typical living loads include people, the effect of wind on an elevation, furniture, autos, the weight of books in a library, and so on. A live load can be described as a UDL (uniformly distributed load) or as a load acting on a small region (point load).

2.2.3 Floor Live Loads

Live loads, also known as imposed loads, are transient, short-term, or movable loads. Impact, momentum, vibration, fluid slosh dynamics, and material fatigue are all examples of dynamic loads. Live loads, also known as probabilistic loads, are all the variables that occur throughout an object's typical operation cycle, excluding construction and environmental loads.

Workers, equipment, and materials produce live loads on the roof and floor during maintenance, while mobile things such as planters and people produce live loads throughout the structure's life. Vehicles traveling over the bridge deck produce live loads on the bridge.

A live load can be described as a uniformly distributed load (UDL) or as a load operating on a small area (point load). It may be incorporated into the calculation of gravity loads in the future. In the UK and much of Europe, live loads are expressed as kilo Newton's per square meter (KN/m^2), while in the US, the unit is pounds per square foot (psf).

2.2.4 Wind loads

The load put on the exterior of a structure by wind is measured in pounds per square foot. The angle at which the wind strikes the structure will determine this. The structure's appearance (height, width, etc.)

Wind loads are typically determined by the wind velocity and the shape (and surface) of the building, which makes them difficult to anticipate. Any over- or under-pressure effects may be exacerbated by the building's form. Wind overpressures on the windward side (facing the wind) may blow windows in, while under-pressure (suction) on the leeward side (sheltered from the wind) may blow windows out.

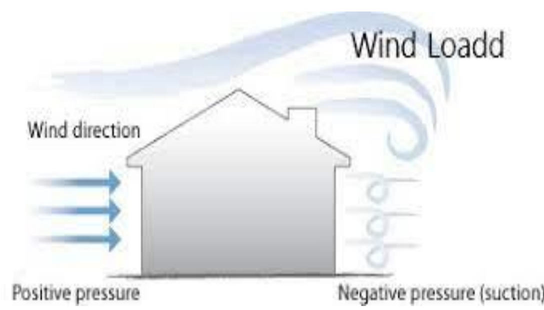


Figure 2. 5: Wind Load

Buildings and other structures and other components and cladding shall always design and constructed to resist wind loads.
This load is dispersed throughout the structure's whole surface area. The size of this load increases as the structure's height increases, implying that taller structures have greater wind resistance than shorter structures.

2.2.5 Earthquake Loads

Earthquakes are rapid releases of energy that occur deep below the earth's crust or upper mantle and are generally triggered by movement along a fault line where tectonic plates collide or volcanic activity.

Seismic waves are created when energy is transmitted from a source of activity and through the earth. These waves force the earth to tremble.

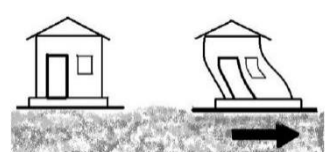


Figure 2. 6: Earthquake effect on Structure

2.3 Other Loads

Engineers must also consider additional factors that could have an impact on a structure, such as:

- Foundation settlement or displacement
- Fire
- Corrosion
- Rain loads
- Load from fluids or floods
- Dust load
- Ponding loads
- Explosion
- Creep or shrinkage
- Impact from vehicles or machinery vibration
- Construction loads
- Temperature changes leading to thermal expansion cause thermal loads

2.4 Load Combinations

When more than one load type acts on a structure, it is called a load combination. In order to ensure the structural safety under various maximum predicted loading situations, building codes often prescribe a number of load combinations as well as load factors (weightings) for each load type.

As example- In the case of a staircase, a dead load factor of 1.2 times the structure's weight and a live load factor of 1.6 times the highest predicted live load can be used. The "necessary strength" of the staircase is calculated by adding these two "factored loads."

The gap between dead load and live load factors, and hence the reason the loads are initially classed as dead or live, is owing to the fact that while a large number of people ascending the staircase at once is reasonable, the structure's permanent load is less likely to alter dramatically.

CHAPTER 3: METHODOLOGY

3.1 General

For design purpose, the calculation has been done as per ACI code, BNBC and UBC code & the portal frame method has used for Design using software ETABS. A Six storied edge supported slab structure building has selected. Its plan and elevation have drawn. Wind load & earthquake loads have calculated on selected beams, columns & Slab as per BNBC, UBC 1994 CODE (coefficient, wind speed, seismic zone) for the proposed building in Dhaka. Necessary comparisons have made to check the variations.

3.2 Work follows Chart

1
- Description of work details and load pattern of Six stories residential building.

2
- Using BNBC code to maintain all coefficient data.

3
- Then use ETABS moment data shorter and longer side to details the slab. Reinforce details, Main rebar, Extra rebar, effective depth check and spacing of rebar check.

4
- Then use longitudinal reinforcement data to details the Beam, Selection of rebar, Spacing of rebar, Drew section and cross section.

5
- The use Rebar percentage to details the column, Selection of rebar, Spacing of rebar, Drew section and cross section.

6
- Drawing of Details using AutoCAD 2016 Software

CHAPTER 4: SLAB DESIGN

4.1 Calculation

4.1.1 Design Data:

Velocity of wind Vb:238 km/hr
Location: Zone 2
Floor to Roof Height: 3.5 m
Dead Load:
Floor Finish (FF): 1.5 KN/m^2
Partition Wall (PW): 2.5 KN/m^2
Self-Weight of Slab: 75 psf
Live Load (LL): 3 KN/m^2
Design Code: ACI, BNBC
Design Method: Intermediate Moment Resisting Frame (IMRF)
Thickness of Slab: 150 mm
=6"
Bending of Slab: 125 mm
=5"
$f_{c'}$= 3.5 Ksi
f_y= 60 Ksi

4.1.2 Slab Information

Table 4. 1: Slab Information

Slab Information						
Slab	**Grid**	L_a	L_b	L_b/L_a	**Type of Slab**	**Type**
S_1	A-B x 3-4	13.12	19.68	1.50	Two-way slab	Two adjacent edges discontinuous
S_2	B-C x 3-4	13.12	26.24	2.00	Two-way slab	One long edge discontinuous
S_3	C-D x 3-4	13.12	29.52	2.25	One-way slab	Two adjacent edges discontinuous
S_4	A-B x 2-3	19.68	19.68	1.00	Two-way slab	One short edge discontinuous
S_5	B-C x 2-3	19.68	26.24	1.33	Two-way slab	Interior panel
S_6	C-D x 2-3	19.68	29.52	1.50	Two-way slab	One short edge discontinuous
S_7	A-B x 1-2	16.4	19.68	1.20	Two-way slab	Two adjacent edges discontinuous
S_8	B-C x 1-2	16.4	26.24	1.60	Two-way slab	One long edge discontinuous
S_9	C-D x 1-2	16.4	29.52	1.80	Two-way slab	Two adjacent edges discontinuous

4.1.3 Moment Selection:

Table 4. 2: Moment Selection

Slab Panel No	B.M for shorter direction			B.M for longer direction		
	Left Support (-ve)	Middle support (+ve)	Right Support (-ve)	Left Support (-ve)	Middle support (+ve)	Right Support (-ve)
1	0.7161	0.3596	0.8698	0.7156	0.4585	1.0418
2	1.0418	0.4492	1.1512	0.7672	0.5336	0.8444
3	1.2601	0.5623	1.053	0.8084	0.5644	0.774
4	1.1026	0.6845	1.3789	1.231	0.6918	1.2881
5	1.649	0.8192	1.815	1.4568	0.9449	1.5252
6	1.9576	0.945	1.6125	1.5114	1.0638	1.5782
7	0.9293	0.5183	1.1408	1.0844	0.6006	0.9647
8	1.3398	0.6105	1.4684	1.2128	0.7701	1.071
9	1.5888	0.7177	1.3238	1.193	0.8378	1.1118

4.1.4 Important Figure:

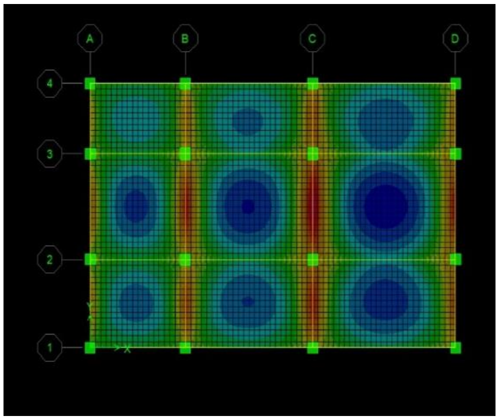


Figure 4. 2: Moment 1-1

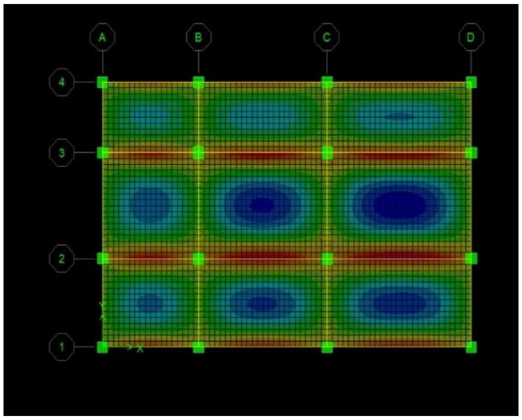
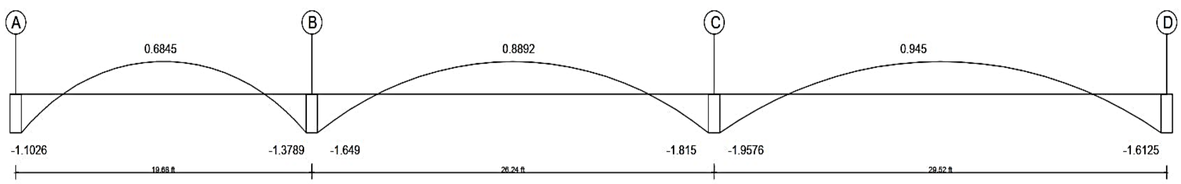


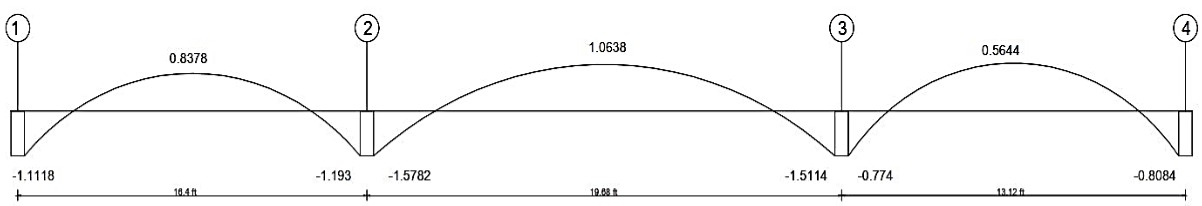
Figure 4. 1: Moment 2-2

Maximum Moment M-11



Plan View-Roof (Slab 4,5,6)

Maximum Moment M-22



Plan View-Roof (Slab 9,6,3)

Figure 4. 3: Bending Moment on Slab

4.1.5 d (Effective depth) Check:

ε_t= 0.004 $f_{c'}$ = 3.5 ksi f_y = 60 ksi
ε_u= 0.003
ρ= $0.85*\beta_1*\frac{fc'}{fy}*\frac{\varepsilon u}{\varepsilon u+\varepsilon t}$

$= 0.85*0.85*\frac{3.5}{60}*\frac{0.003}{0.003+0.004}$

$=0.0181$

b = 12 in
M_{max} = 1.9576

$M_{max}= \phi*\rho* fy *b*d^2*(1-0.59\frac{\rho*fy}{fc'})$

⇨ $1.9576*12 = 0.9*0.0181* 60 *12*d^2*(1-0.59\frac{0.0181*60}{3.5})$

⇨ $d^2 = 2.452$

⇨ d = 1.57 in

$d_{provided}$ = (t-1) = (6-1) = 5"
$d_{required}$ = 1.57"
So, $d_{provided}$> $d_{required}$ (ok)

Maximum Spacing
For two-way Slab maximum Spacing = 2t or 18"
= (2*6) or 18"
= 12

For One-way Slab Maximum Spacing = 3t or 18"
= (3*6) or 18"
= 18"

Calculation Formula:

$A_s = \frac{Mu}{\phi*fy(d-\frac{a}{2})}$

$a = \frac{As*fy}{0.85*fc'*b}$

As_{min} = 0.0018*b*t = 0.0018*12*6 = 0.13

4.2 Reinforcement Table:

Table 4. 3: Reinforcement Table

Slab	Span	Position	Moments (k-ft/ft)	A_s (in^2/ft)	As_{min} (in^2/ft)	$As_{Provided}$ (in^2/ft)	Bar provided	Bar Area (in^2)	Spacing
1	Short	Left Support	0.7161	0.032	0.13 As< As_{min}	0.13	1, #3 extra top	0.11	10 in c/c
		Middle Support	0.3596	0.016		0.13	#3	0.11	10 in c/c
		Right Support	0.8698	0.039		0.13	1, #3 extra top	0.11	10 in c/c
	Long	Left Support	0.7156	0.032		0.13	1, #3 extra top	0.11	10 in c/c
		Middle Support	0.4585	0.021		0.13	#3	0.11	10 in c/c
		Right Support	1.0418	0.047		0.13	1, #3 extra top	0.11	10 in c/c
2	Short	Left Support	1.0418	0.047	0.13 As< As_{min}	0.13	1, #3 extra top	0.11	10 in c/c
		Middle Support	0.4492	0.02		0.13	#3	0.11	10 in c/c
		Right Support	1.1512	0.052		0.13	1, #3 extra top	0.11	10 in c/c
	Long	Left Support	0.7672	0.034		0.13	1, #3 extra top	0.11	10 in c/c
		Middle Support	0.5336	0.024		0.13	#3	0.11	10 in c/c
		Right Support	0.8444	0.038		0.13	1, #3 extra top	0.11	10 in c/c

3	Short	Left Support	1.2601	0.057	0.13 As< As_{min}	0.13	1, #3 extra top	0.11	10 in c/c
		Middle Support	0.5623	0.025		0.13	#3	0.11	10 in c/c
		Right Support	1.053	0.047		0.13	1, #3 extra top	0.11	10 in c/c
	Long	Left Support	0.8084	0.036		0.13	1, #3 extra top	0.11	10 in c/c
		Middle Support	0.5644	0.025		0.13	#3	0.11	10 in c/c
		Right Support	0.774	0.035		0.13	1, #3 extra top	0.11	10 in c/c
4	Short	Left Support	1.1026	0.049	0.13 As< As_{min}	0.13	1, #3 extra top	0.11	10 in c/c
		Middle Support	0.6845	0.031		0.13	#3	0.11	10 in c/c
		Right Support	1.3789	0.062		0.13	1, #3 extra top	0.11	10 in c/c
	Long	Left Support	1.231	0.055		0.13	1, #3 extra top	0.11	10 in c/c
		Middle Support	0.6918	0.031		0.13	#3	0.11	10 in c/c
		Right Support	1.2881	0.058		0.13	1, #3 extra top	0.11	10 in c/c
5	Short	Left Support	1.649	0.074	0.13 As< As_{min}	0.13	1, #3 extra top	0.11	10 in c/c
		Middle Support	0.8192	0.037		0.13	#3	0.11	10 in c/c
		Right Support	1.815	0.082		0.13	1, #3 extra top	0.11	10 in c/c
	Long	Left Support	1.4568	0.066		0.13	1, #3 extra top	0.11	10 in c/c
		Middle Support	0.9449	0.042		0.13	#3	0.11	10 in c/c
		Right Support	1.5252	0.069		0.13	1, #3 extra top	0.11	10 in c/c

6	Short	Left Support	1.9576	0.088	0.13 As< As_{min}	0.13	1, #3 extra top	0.11	10 in c/c
		Middle Support	0.945	0.042		0.13	#3	0.11	10 in c/c
		Right Support	1.6125	0.073		0.13	1, #3 extra top	0.11	10 in c/c
	Long	Left Support	1.5114	0.068		0.13	1, #3 extra top	0.11	10 in c/c
		Middle Support	1.0638	0.048		0.13	#3	0.11	10 in c/c
		Right Support	1.5782	0.071		0.13	1, #3 extra top	0.11	10 in c/c
7	Short	Left Support	0.9293	0.042	0.13 As< As_{min}	0.13	1, #3 extra top	0.11	10 in c/c
		Middle Support	0.5183	0.023		0.13	#3	0.11	10 in c/c
		Right Support	1.1408	0.051		0.13	1, #3 extra top	0.11	10 in c/c
	Long	Left Support	1.0844	0.049		0.13	1, #3 extra top	0.11	10 in c/c
		Middle Support	0.6006	0.029		0.13	#3	0.11	10 in c/c
		Right Support	0.9647	0.043		0.13	1, #3 extra top	0.11	10 in c/c
8	Short	Left Support	1.3398	0.06	0.13 As< As_{min}	0.13	1, #3 extra top	0.11	10 in c/c
		Middle Support	0.6105	0.027		0.13	#3	0.11	10 in c/c
		Right Support	1.4684	0.066		0.13	1, #3 extra top	0.11	10 in c/c
	Long	Left Support	1.2128	0.045		0.13	1, #3 extra top	0.11	10 in c/c
		Middle Support	0.7701	0.034		0.13	#3	0.11	10 in c/c
		Right Support	1.071	0.048		0.13	1, #3 extra top	0.11	10 in c/c

9	Short	Left Support	1.5888	0.072	0.13 As< As_{min}	0.13	1, #3 extra top	0.11	10 in c/c
		Middle Support	0.7177	0.032		0.13	#3	0.11	10 in c/c
		Right Support	1.3238	0.059		0.13	1, #3 extra top	0.11	10 in c/c
	Long	Left Support	1.193	0.054		0.13	1, #3 extra top	0.11	10 in c/c
		Middle Support	0.8378	0.037		0.13	#3	0.11	10 in c/c
		Right Support	1.1118	0.049		0.13	1, #3 extra top	0.11	10 in c/c

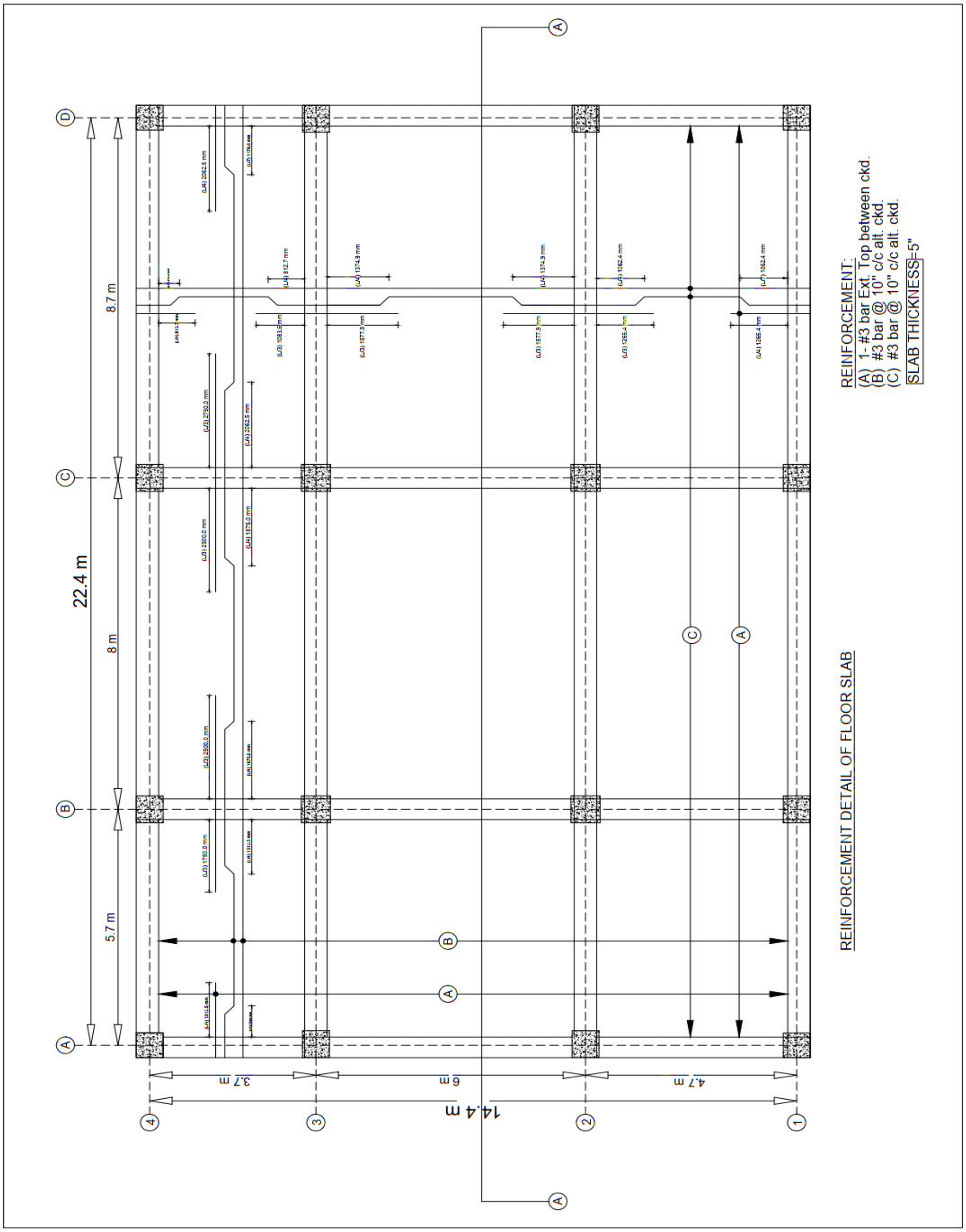


Figure 4. 4: Detailing of reinforcement on Slab

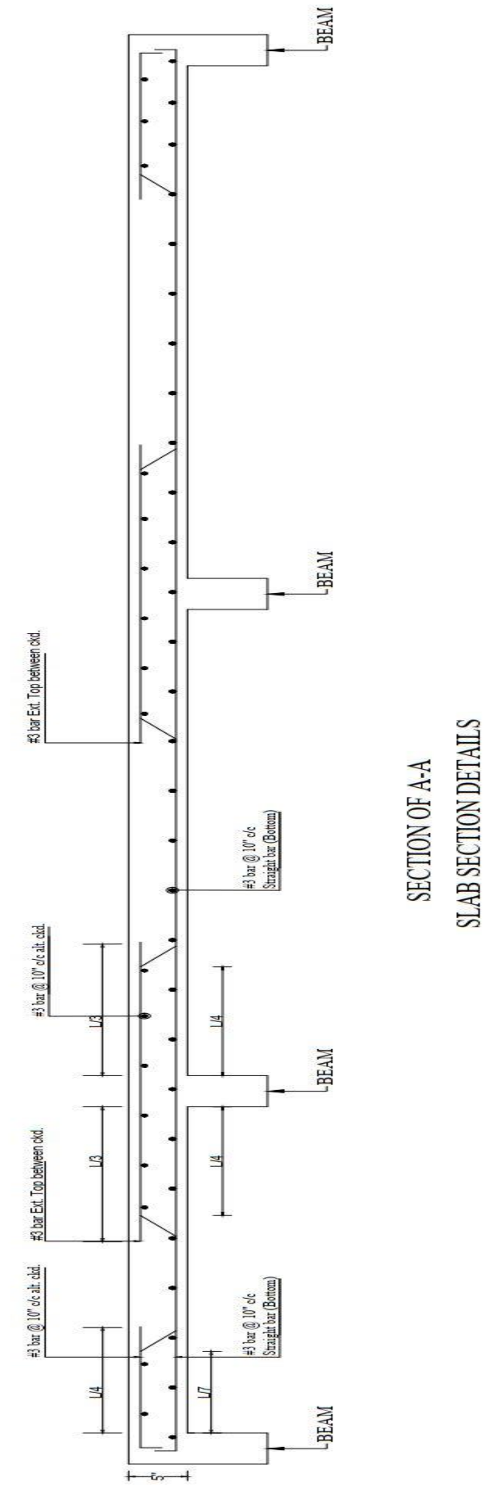


Figure 4. 5: Slab Cross Section

CHAPTER 5: BEAM DESIGN

5.1 Beam Details:

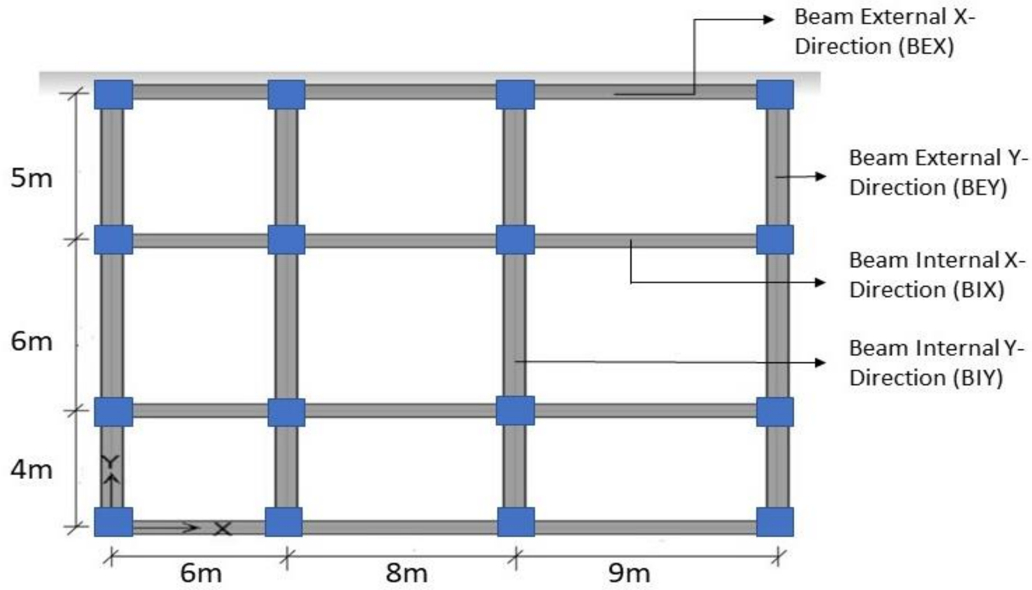


Figure 5. 1: Beam Orientation

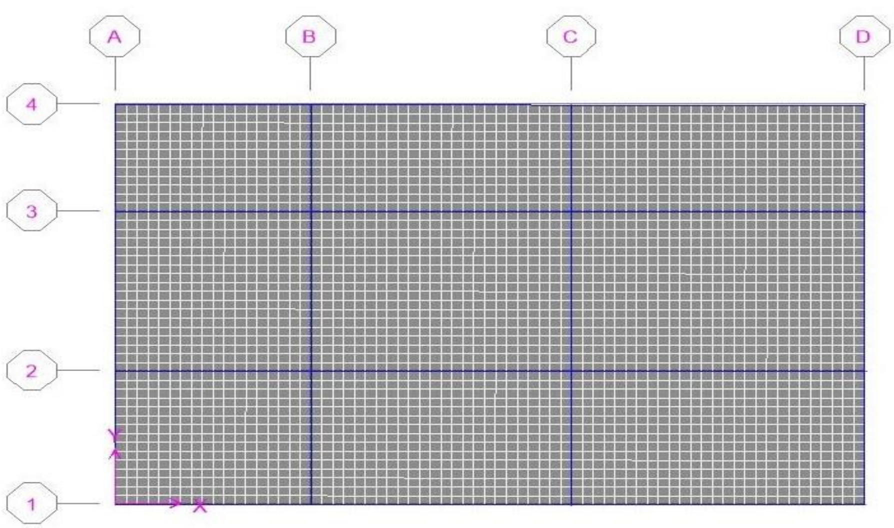


Figure 5. 2: Grid View of Beam

5.1.1 Ground Floor:

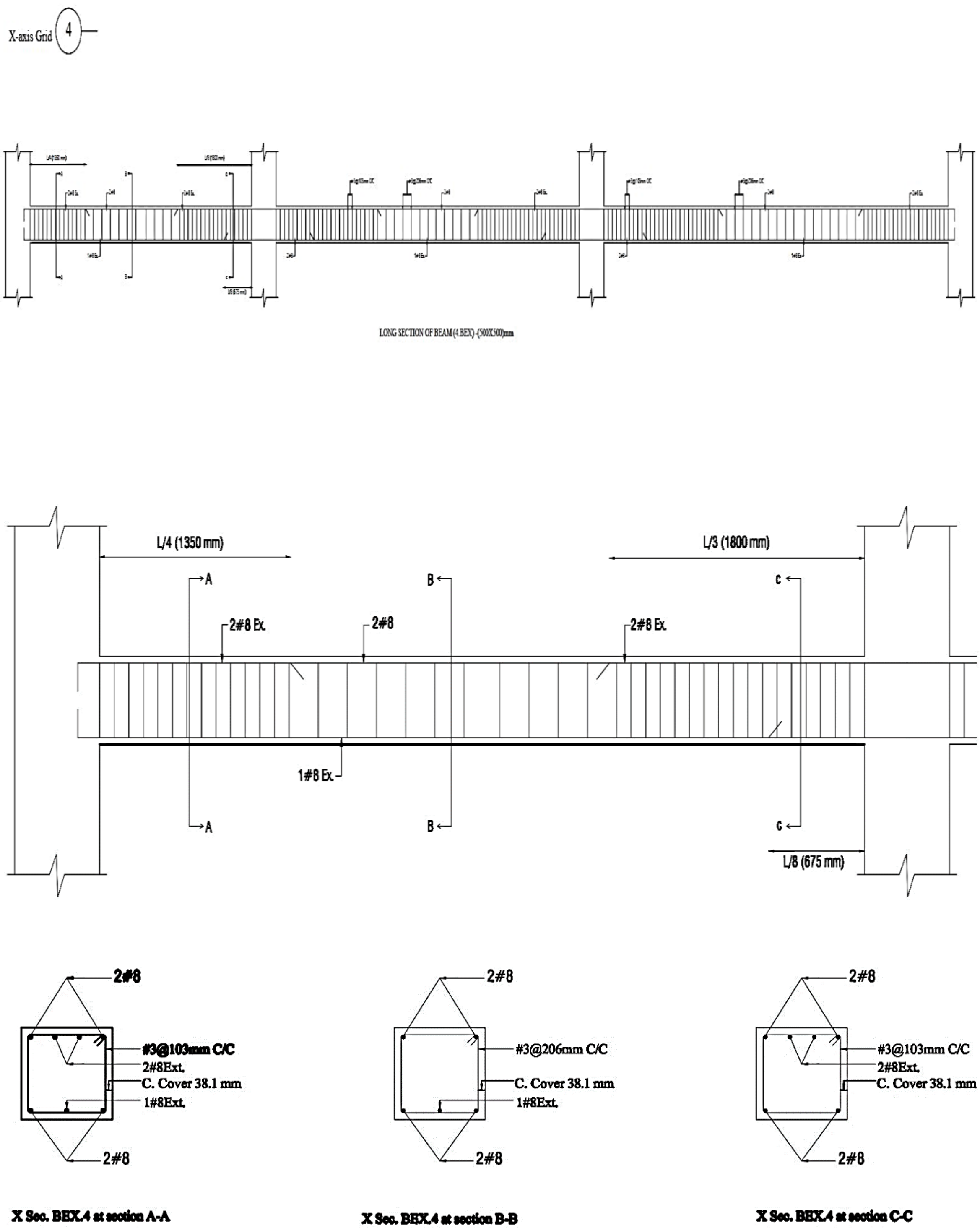
X-Axis Grid **4** Beam Details

Table 5. 1: Ground Floor Beam Bar Calculation (X & Y Directions)

Ground Floor X-Direction (Grid 4)									
Max Reinforcement		**Selected Bar**		**Number of Bar Provided**	**Max Reinforcement**		**Selected Bar**		**Number of Bar Provided**
Positive Side		**No.**	**Area (in^2)**		**Negative Side**		**No.**	**Area (in^2)**	
Left	1.235	8	0.79	2	Left	2.758	8	0.79	4
Middle	1.689	8	0.79	3	Middle	0.856	8	0.79	2
Right	1.125	8	0.79	2	Right	2.659	8	0.79	4

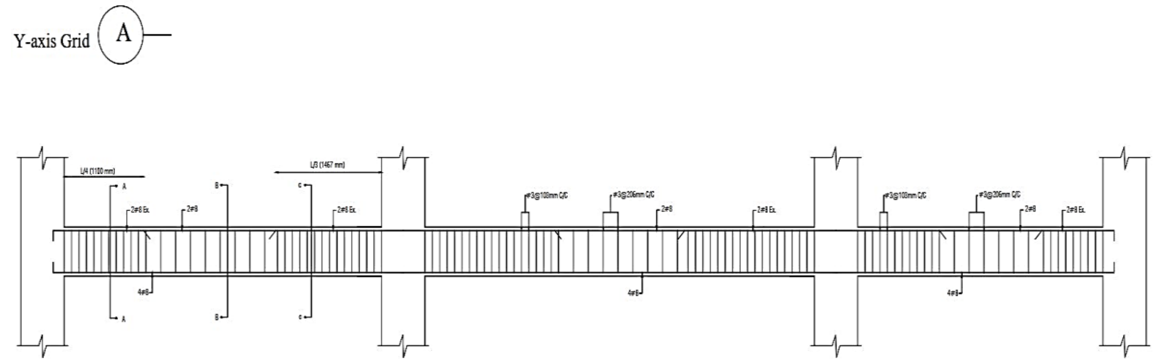
Y-Axis Grid **A** Beam Details

Ground Floor Y-Direction (Grid A)									
Max Reinforcement		**Selected Bar**		**Number of Bar Provided**	**Max Reinforcement**		**Selected Bar**		**Number of Bar Provided**
Positive Side		**No.**	**Area (in^2)**		**Negative Side**		**No.**	**Area (in^2)**	
Left	2.536	8	0.79	4	Left	2.895	8	0.79	4
Middle	1.191	8	0.79	2	Middle	1.013	8	0.79	2
Right	2.733	8	0.79	4	Right	2.994	8	0.79	4

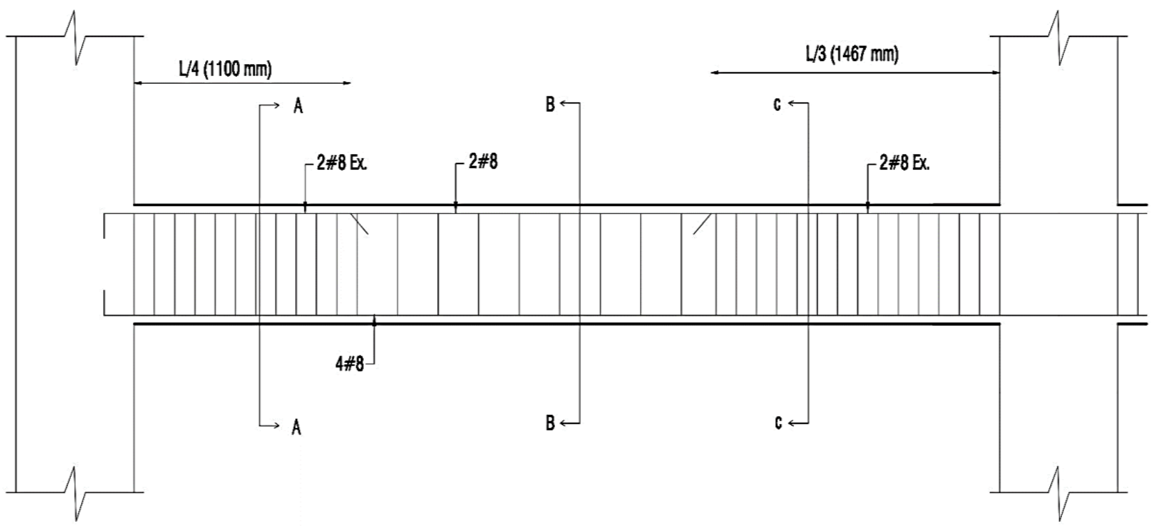


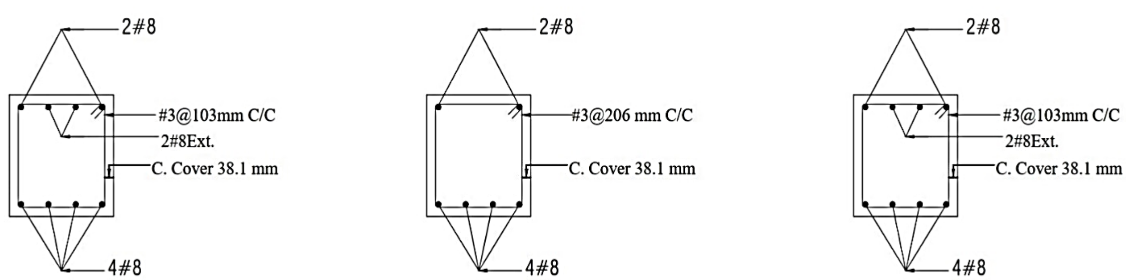
CROSS SECTION OF BEAM (4.BEX) -(500X500)mm

Figure 5. 3: Beam Details Ground Floor X Direction



LONG SECTION OF BEAM (A.BEY) -(500X450)mm





YSec. BEY .Aat section A-A

YSec. BEY.Aat section B-B

Y Sec. BEY.Aat section C-C

CROSS SECTION OF BEAM (A.BEY) -(500X450)mm

Figure 5. 4: Beam Details Ground Floor Y Direction

5.1.2 1st floor:

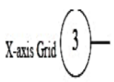
X-Axis Grid **3** Beam Details

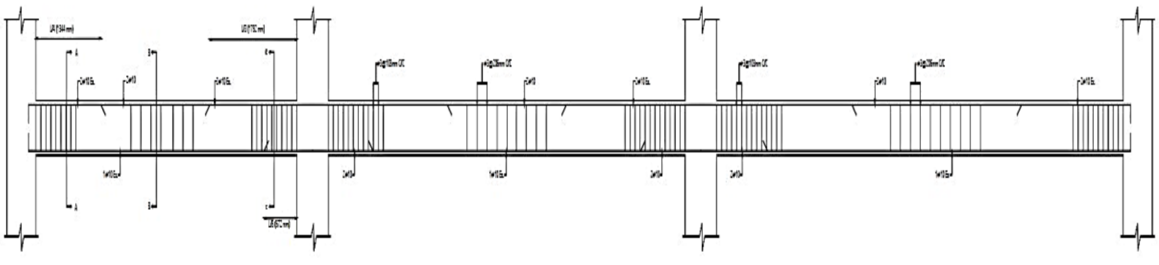
Table 5. 2: 1st Floor Beam Bar Calculation (X & Y Directions)

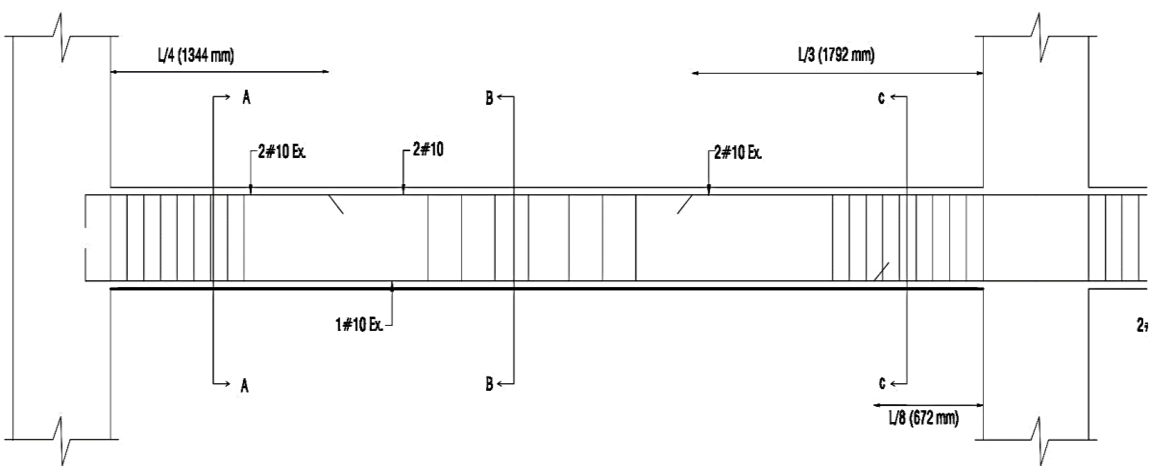
1st Floor X-Direction (Grid 3)									
Max Reinforcement		**Selected Bar**		**Number of Bar Provided**	**Max Reinforcement**		**Selected Bar**		**Number of Bar Provided**
Positive Side		**No.**	**Area (in^2)**		**Negative Side**		**No.**	**Area (in^2)**	
Left	1.600	10	1.27	2	Left	4.730	10	1.27	4
Middle	3.573	10	1.27	3	Middle	1.066	10	1.27	2
Right	1.688	10	1.27	2	Right	4.668	10	1.27	4

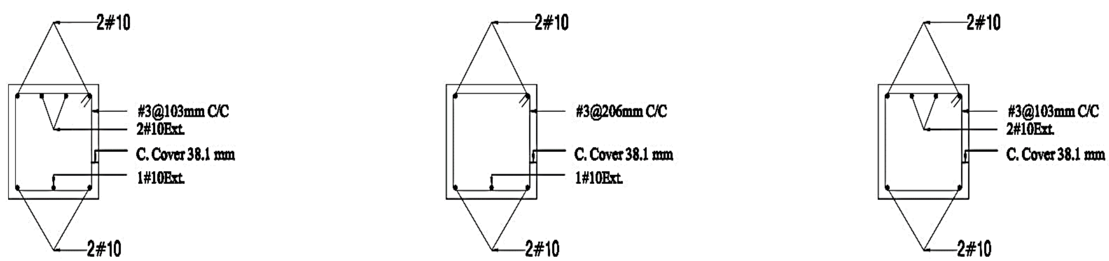
Y-Axis Grid **B** Beam Details

1st Floor Y-Direction (Grid B)									
Max Reinforcement		**Selected Bar**		**Number of Bar Provided**	**Max Reinforcement**		**Selected Bar**		**Number of Bar Provided**
Positive Side		**No.**	**Area (in^2)**		**Negative Side**		**No.**	**Area (in^2)**	
Left	2.915	9	1	3	Left	3.748	9	1	4
Middle	1.501	9	1	2	Middle	1.097	9	1	2
Right	2.904	9	1	3	Right	3.725	9	1	4









X Sec. BIX.3 at section A-A   X Sec. BIX.3 at section B-B   X Sec. BIX.3 at section C-C

CROSS SECTION OF BEAM (3.BIX) -(500X500)mm

Figure 5. 5: Beam Details 1st Floor X-Direction

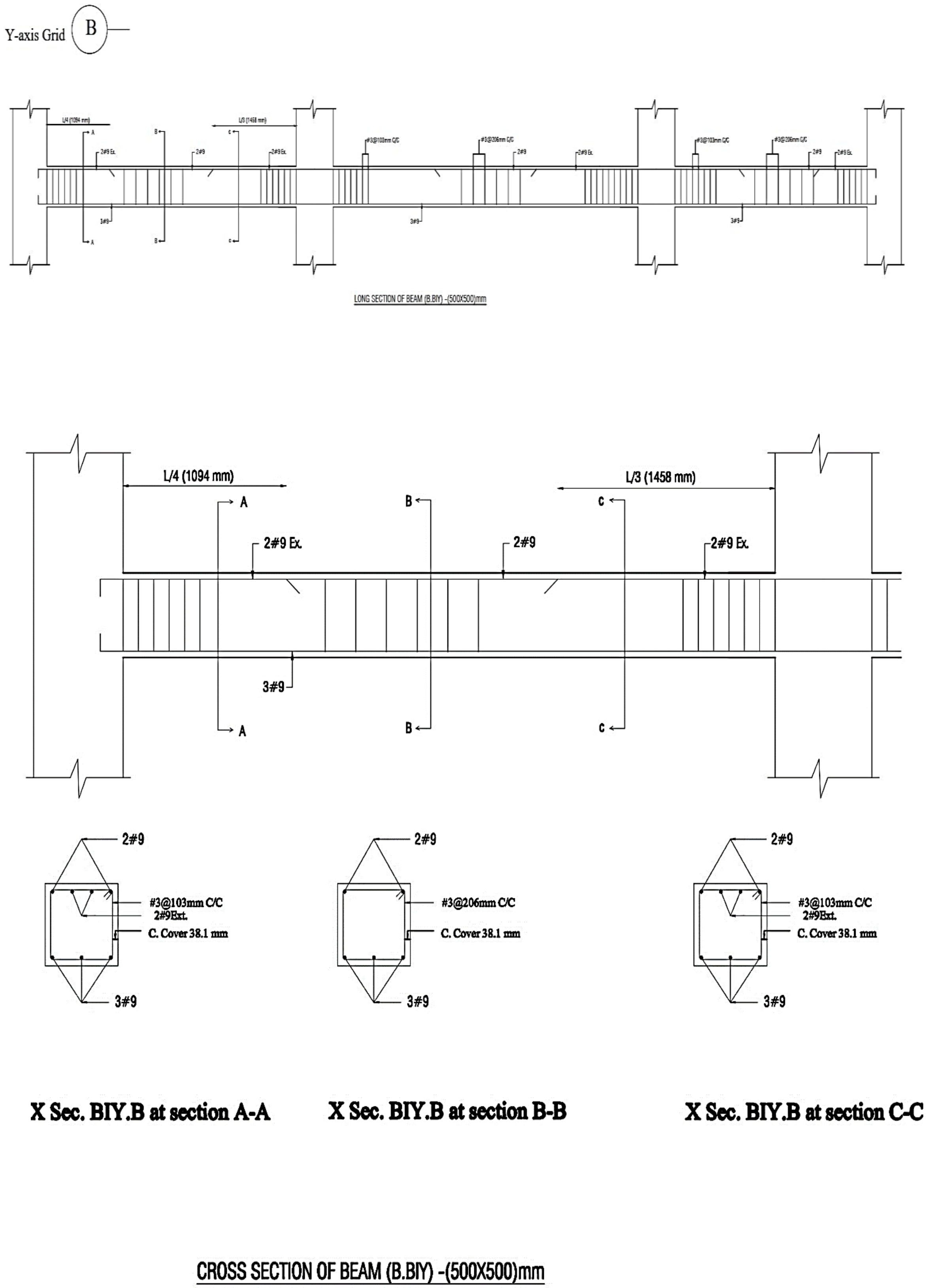


Figure 5. 6: Beam Details 1st Floor Y-Direction

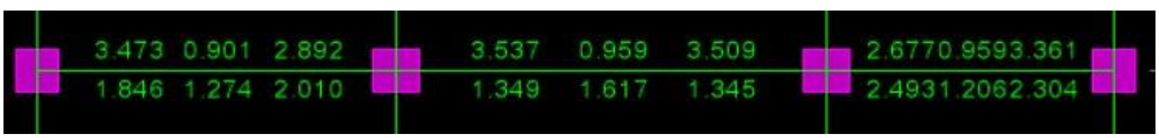
5.1.3 2nd Floor:

X-Axis Grid **2** Beam Details

Table 5. 3: 2nd Floor Beam Bar Calculation (X & Y Directions)

2nd Floor X-Direction (Grid 2)									
Max Reinforcement		**Selected Bar**		**Number of Bar Provided**	**Max Reinforcement**		**Selected Bar**		**Number of Bar Provided**
Positive Side		**No.**	**Area (in^2)**		**Negative Side**		**No.**	**Area (in^2)**	
Left	1.754	9	1	2	Left	4.744	9	1	5
Middle	3.930	9	1	4	Middle	1.066	9	1	2
Right	1.819	9	1	2	Right	4.770	9	1	5

Y-Axis Grid **C** Beam Details



2nd Floor Y-Direction (Grid C)									
Max Reinforcement		**Selected Bar**		**Number of Bar Provided**	**Max Reinforcement**		**Selected Bar**		**Number of Bar Provided**
Positive Side		**No.**	**Area (in^2)**		**Negative Side**		**No.**	**Area (in^2)**	
Left	2.493	9	1	3	Left	3.537	9	1	4
Middle	1.617	9	1	2	Middle	0.959	9	1	2
Right	2.304	9	1	3	Right	3.509	9	1	4

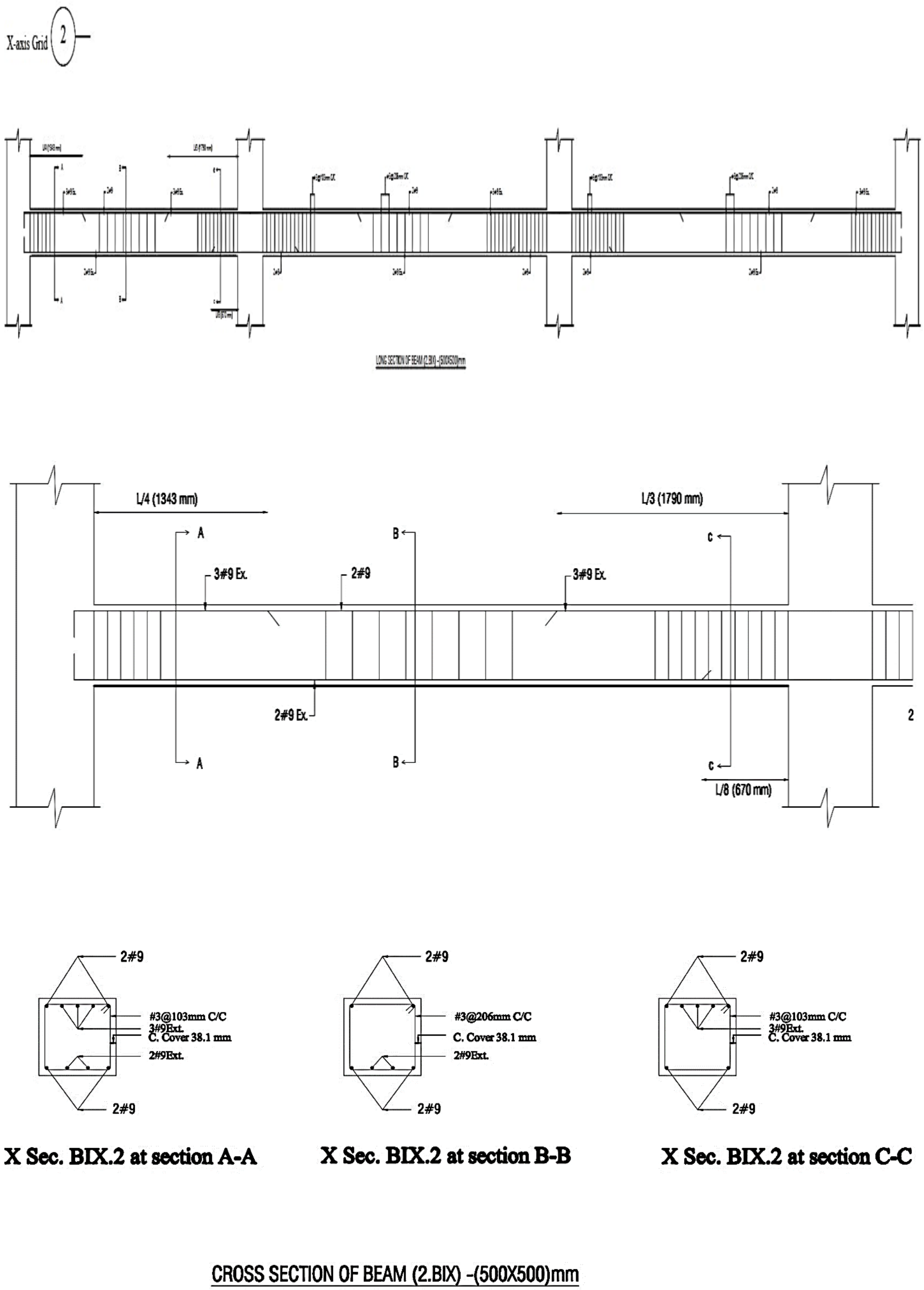
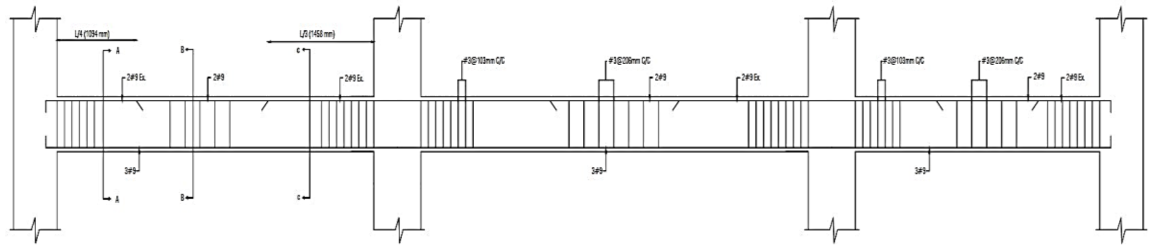
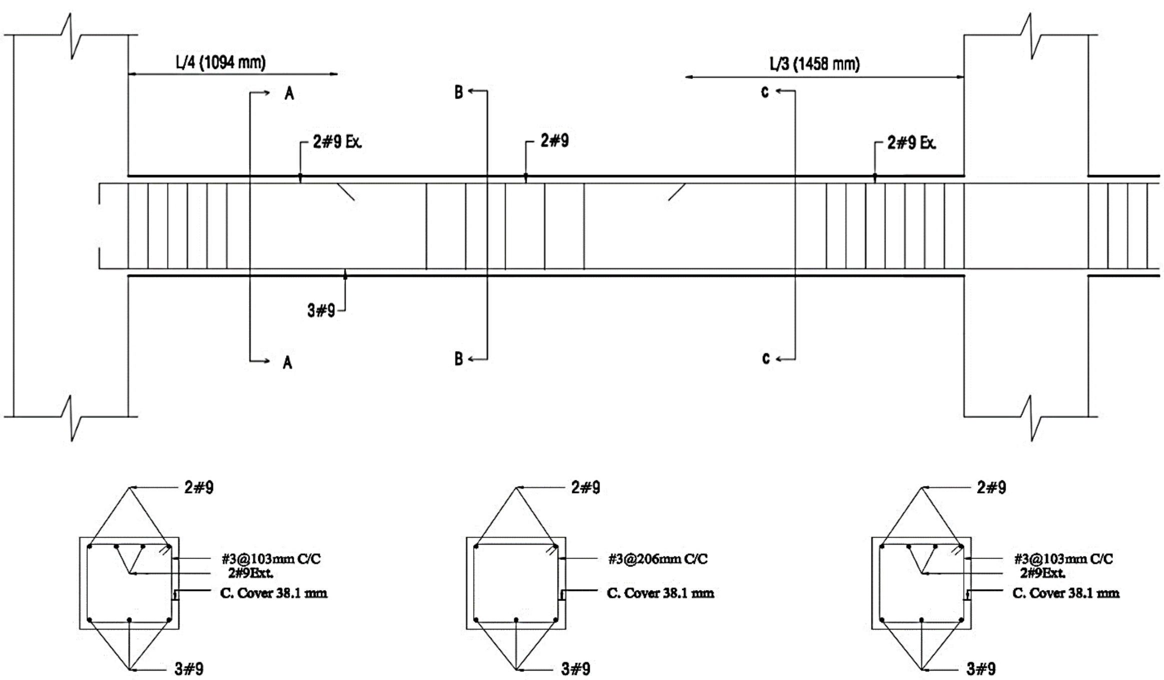


Figure 5. 7: Beam Details 2nd Floor X-Direction

Y-axis Grid C



LONG SECTION OF BEAM (C.BIY) -(500X500)mm



X Sec. BIY.C at section A-A **X Sec. BIY.C at section B-B** **X Sec. BIY.C at section C-C**

CROSS SECTION OF BEAM (C.BIY) -(500X500)mm

Figure 5. 8: Beam Details 2nd Floor Y-Direction

5.1.4 3rd Floor:

X-Axis Grid **1** Beam Details

Table 5. 4: 3rd Floor Beam Bar Calculation (X & Y Directions)

3rd Floor X-Direction (Grid 1)									
Max Reinforcement		**Selected Bar**		**Number of Bar Provided**	**Max Reinforcement**		**Selected Bar**		**Number of Bar Provided**
Positive Side		**No.**	**Area (in^2)**		**Negative Side**		**No.**	**Area (in^2)**	
Left	1.066	7	0.6	2	Left	2.560	7	0.6	5
Middle	1.964	7	0.6	4	Middle	0.649	7	0.6	2
Right	1.066	7	0.6	2	Right	2.613	7	0.6	5

Y-Axis Grid **D** Beam Details

3rd Floor Y-Direction (Grid D)									
Max Reinforcement		**Selected Bar**		**Number of Bar Provided**	**Max Reinforcement**		**Selected Bar**		**Number of Bar Provided**
Positive Side		**No.**	**Area (in^2)**		**Negative Side**		**No.**	**Area (in^2)**	
Left	1.746	7	0.6	3	Left	2.345	7	0.6	4
Middle	0.979	7	0.6	2	Middle	0.935	7	0.6	2
Right	1.658	7	0.6	3	Right	2.273	7	0.6	4

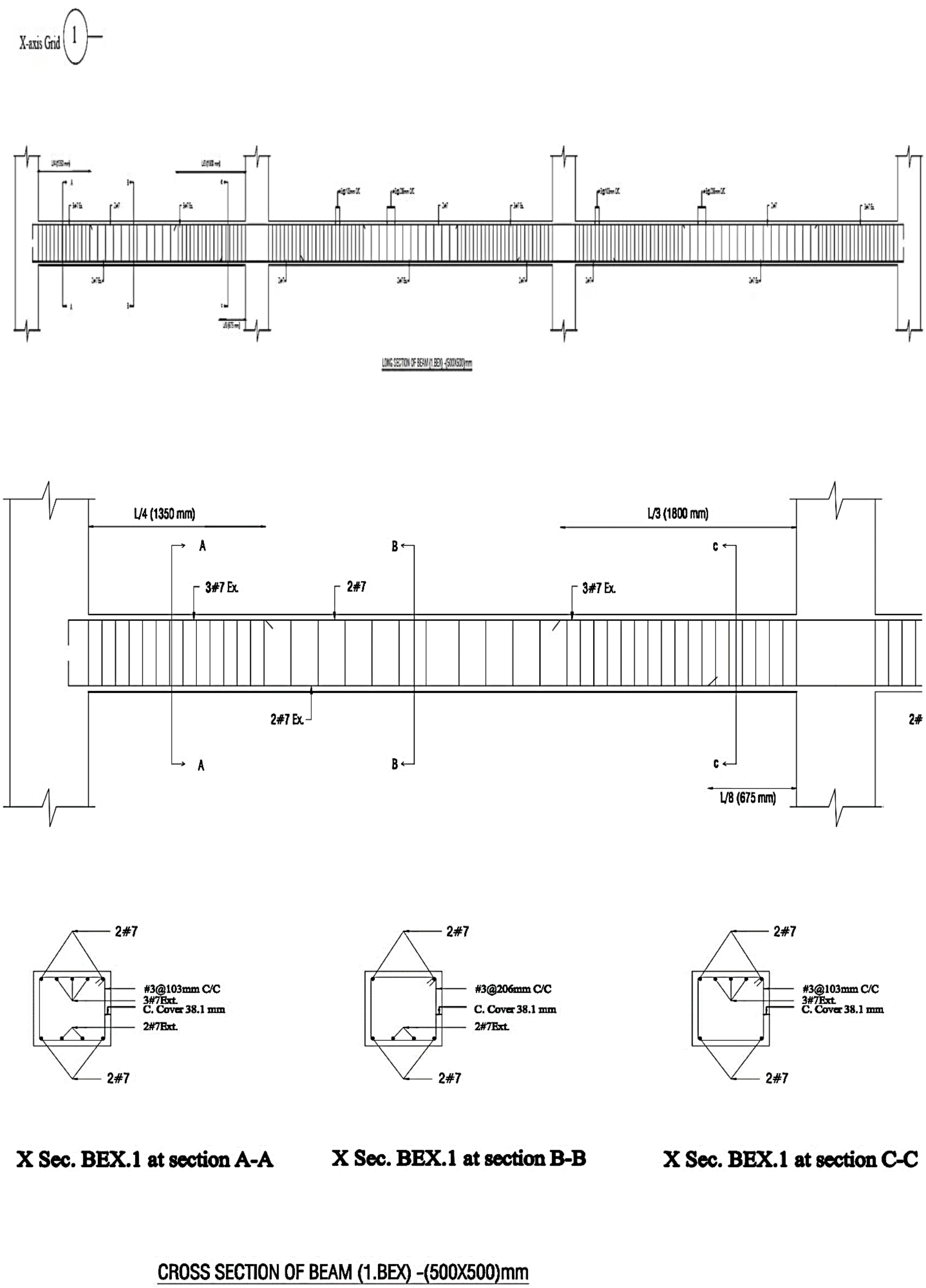
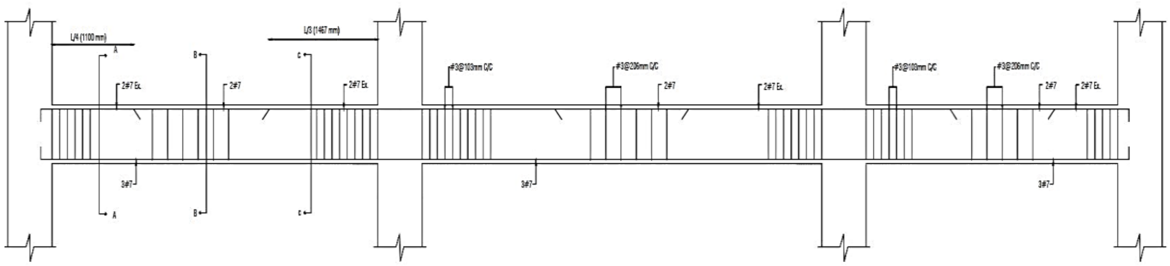
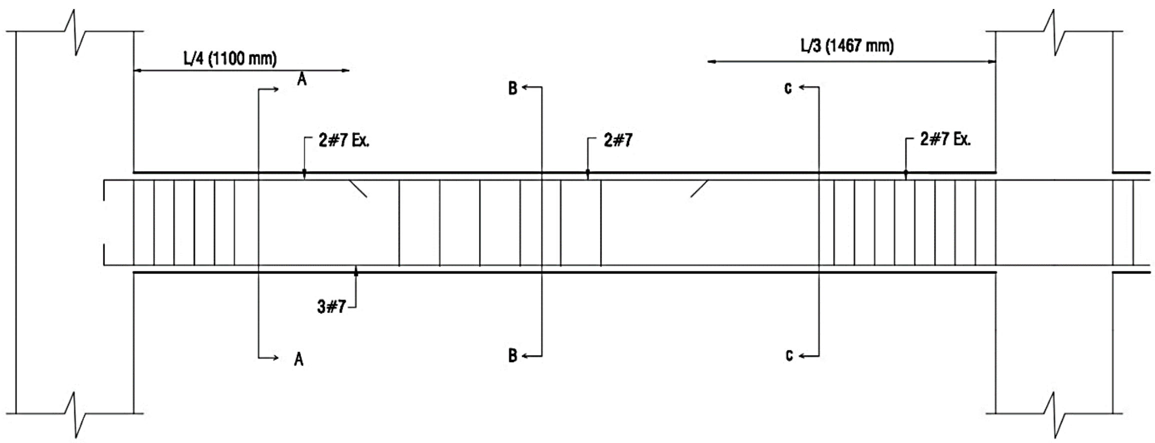


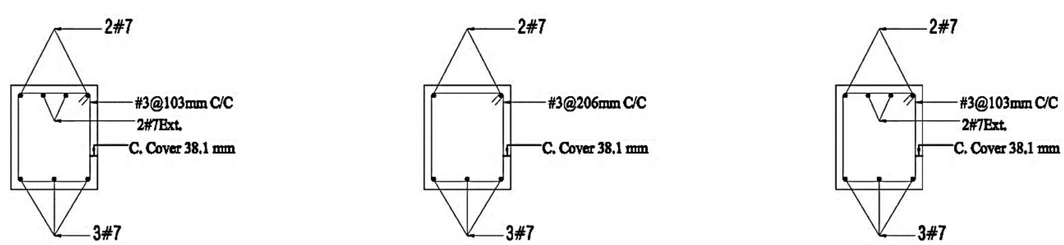
Figure 5. 9: Beam Details 3rd Floor X-Direction

Y-axis Grid D



LONG SECTION OF BEAM (D.BEY) -(500X450)mm





X Sec. BEY.D at section A-A **X Sec. BEY.D at section B-B** **X Sec. BEY.D at section C-C**

CROSS SECTION OF BEAM (D.BEY) -(500X450)mm

Figure 5. 10: Beam Details 3rd Floor Y-Direction

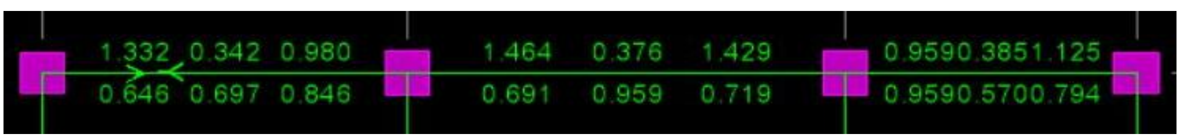
5.1.5 4th Floor:

X-Axis Grid **4** Beam Details

Table 5. 5: 4th Floor Beam Bar Calculation (X & Y Directions)

4th Floor X-Direction (Grid 4)									
Max Reinforcement		**Selected Bar**		**Number of Bar Provided**	**Max Reinforcement**		**Selected Bar**		**Number of Bar Provided**
Positive Side		**No.**	**Area (in^2)**		**Negative Side**		**No.**	**Area (in^2)**	
Left	1.033	7	0.6	2	Left	1.999	7	0.6	4
Middle	1.682	7	0.6	3	Middle	0.535	7	0.6	2
Right	1.009	7	0.6	2	Right	2.121	7	0.6	4

Y-Axis Grid **A** Beam Details



4th Floor Y-Direction (Grid A)									
Max Reinforcement		**Selected Bar**		**Number of Bar Provided**	**Max Reinforcement**		**Selected Bar**		**Number of Bar Provided**
Positive Side		**No.**	**Area (in^2)**		**Negative Side**		**No.**	**Area (in^2)**	
Left	0.959	6	0.44	3	Left	1.464	6	0.44	4
Middle	0.959	6	0.44	3	Middle	0.385	6	0.44	2
Right	0.846	6	0.44	2	Right	1.429	6	0.44	4

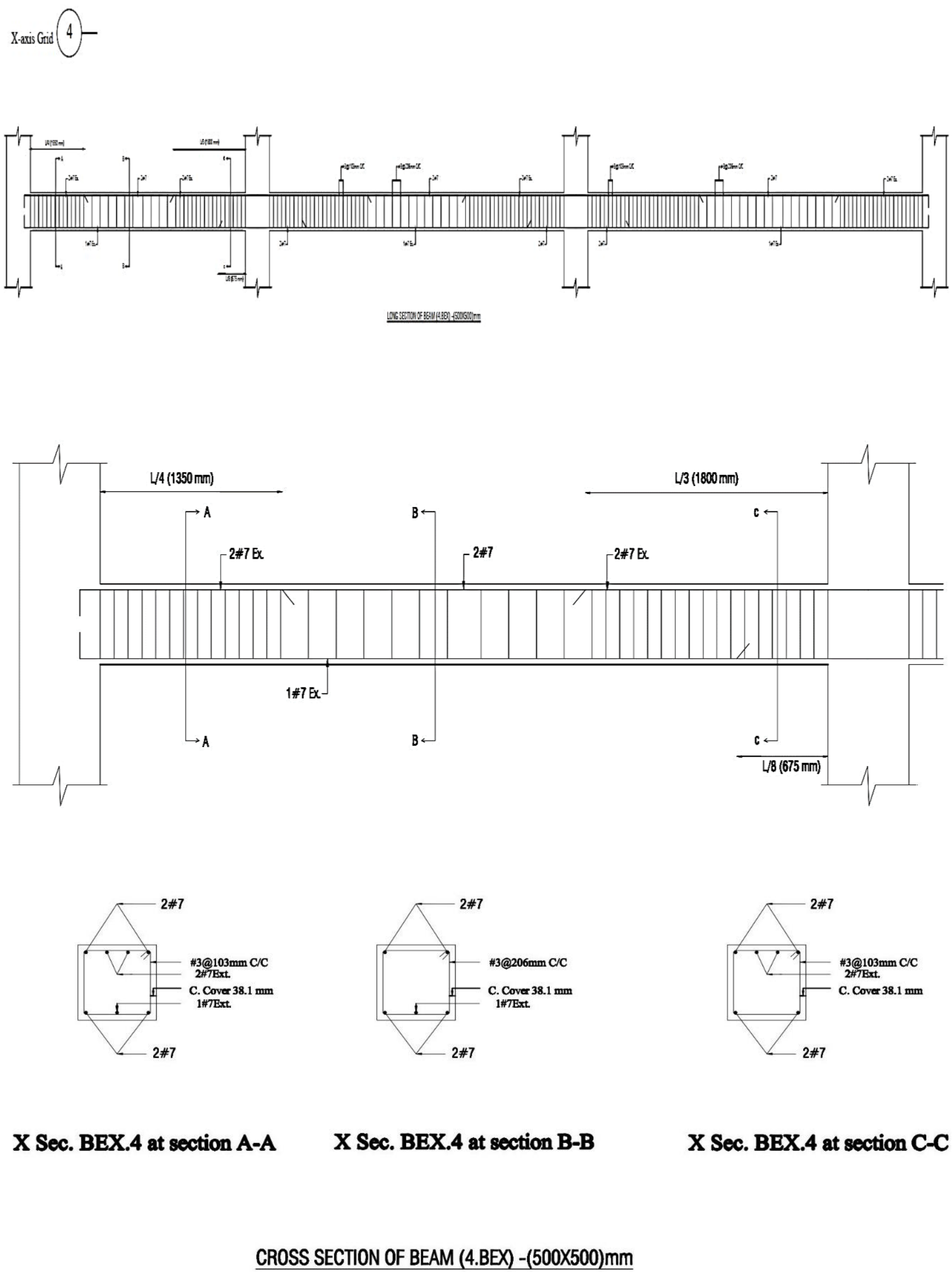


Figure 5. 11: Beam Details 4th Floor X-Direction

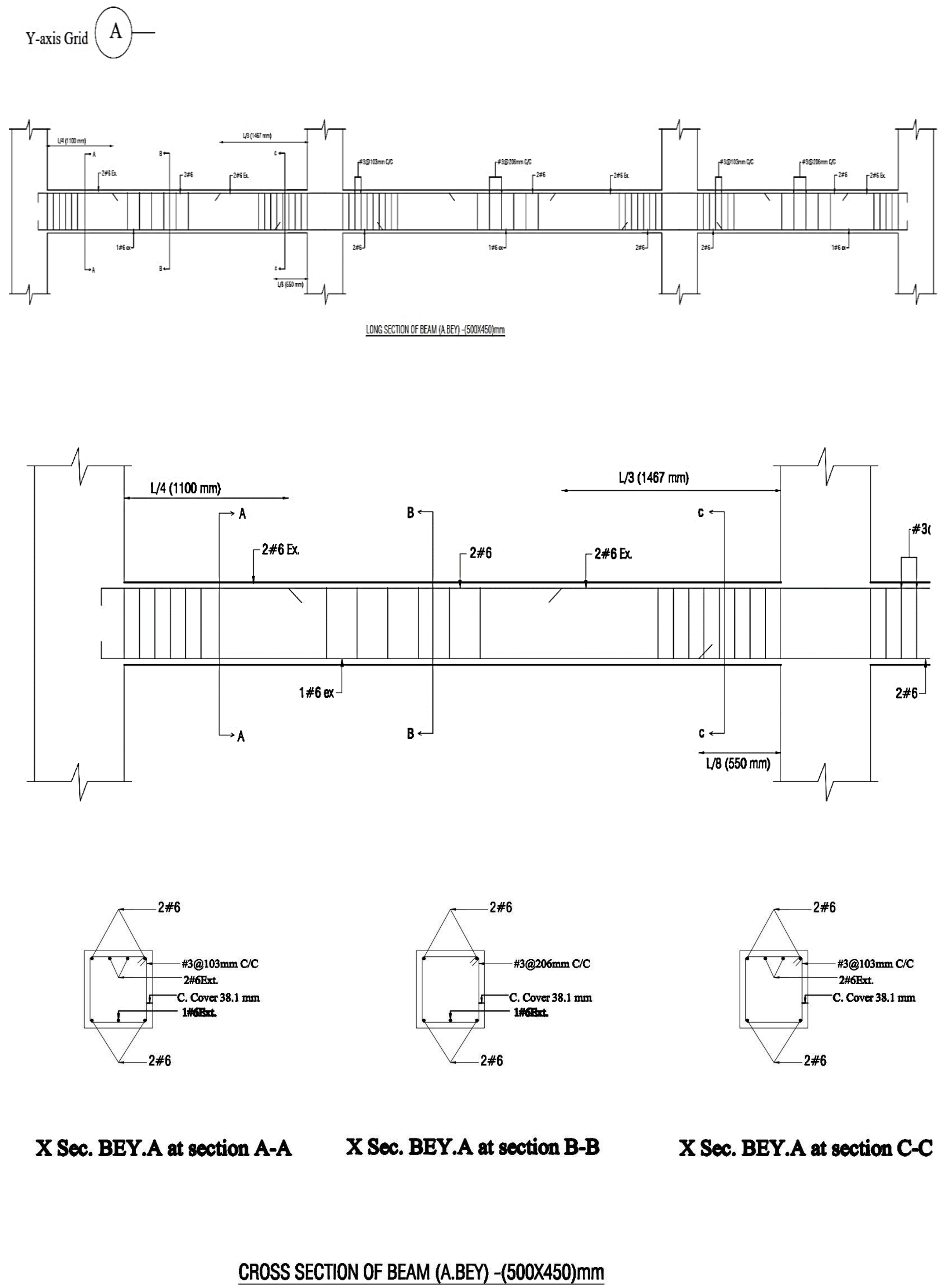


Figure 5. 12: Beam Details 4th Floor Y-Direction

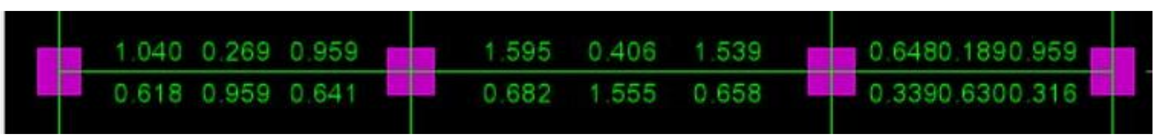
5.1.6 Roof:

X-Axis Grid **3** Beam Details

Table 5. 6: Roof Beam Bar Calculation (X & Y Directions)

ROOF X-Direction (Grid 3)									
Max Reinforcement		**Selected Bar**		**Number of Bar Provided**	**Max Reinforcement**		**Selected Bar**		**Number of Bar Provided**
Positive Side		**No.**	**Area (in^2)**		**Negative Side**		**No.**	**Area (in^2)**	
Left	1.636	10	1.27	2	Left	4.360	10	1.27	4
Middle	3.690	10	1.27	3	Middle	1.028	10	1.27	2
Right	1.855	10	1.27	2	Right	3.788	10	1.27	4

Y-Axis Grid **B** Beam Details



ROOF Y-Direction (Grid B)									
Max Reinforcement		**Selected Bar**		**Number of Bar Provided**	**Max Reinforcement**		**Selected Bar**		**Number of Bar Provided**
Positive Side		**No.**	**Area (in^2)**		**Negative Side**		**No.**	**Area (in^2)**	
Left	0.682	6	0.44	2	Left	1.595	6	0.44	4
Middle	1.555	6	0.44	4	Middle	0.406	6	0.44	2
Right	0.658	6	0.44	2	Right	1.539	6	0.44	4

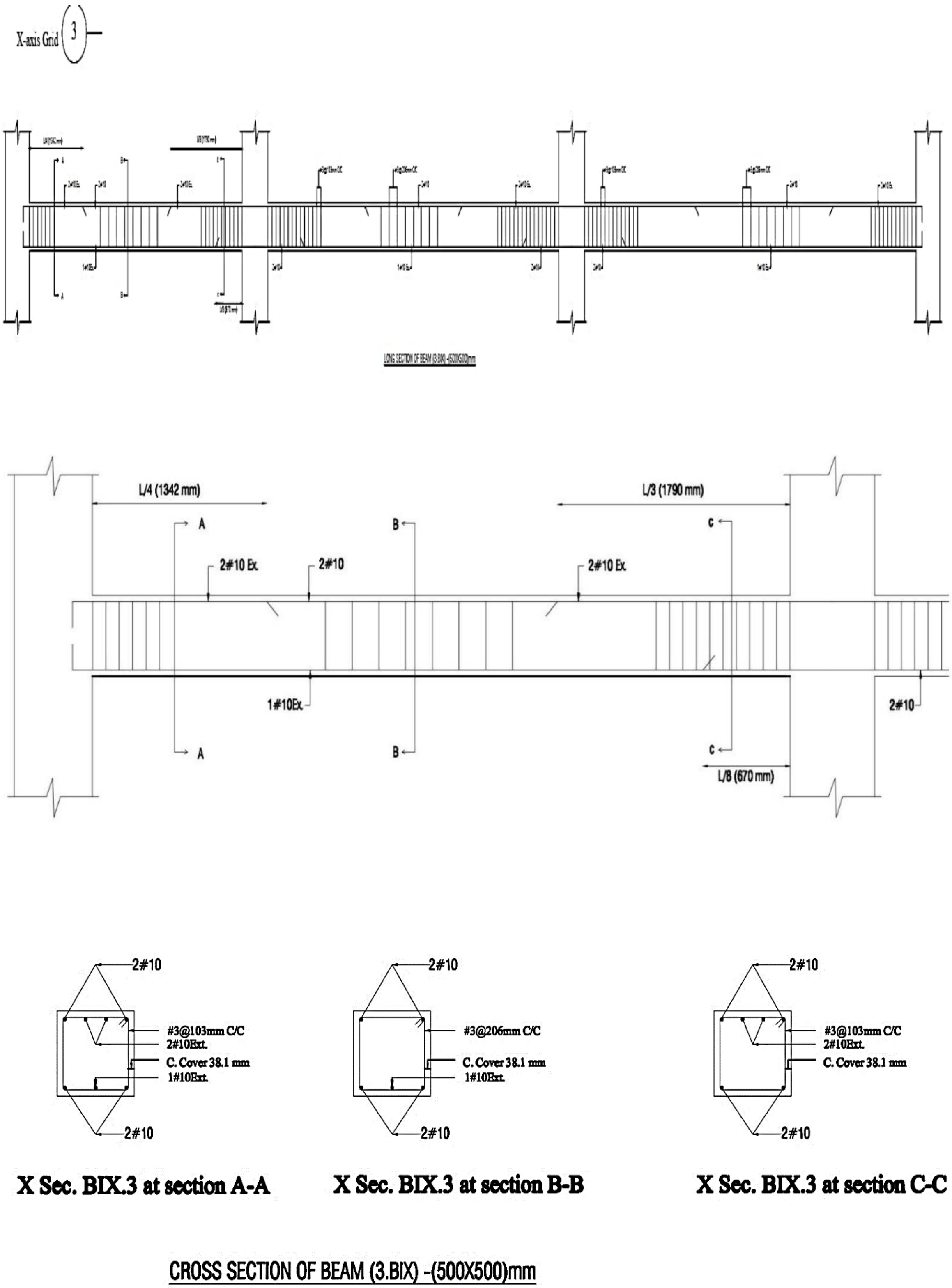


Figure 5. 13: Beam Details Roof X-Direction

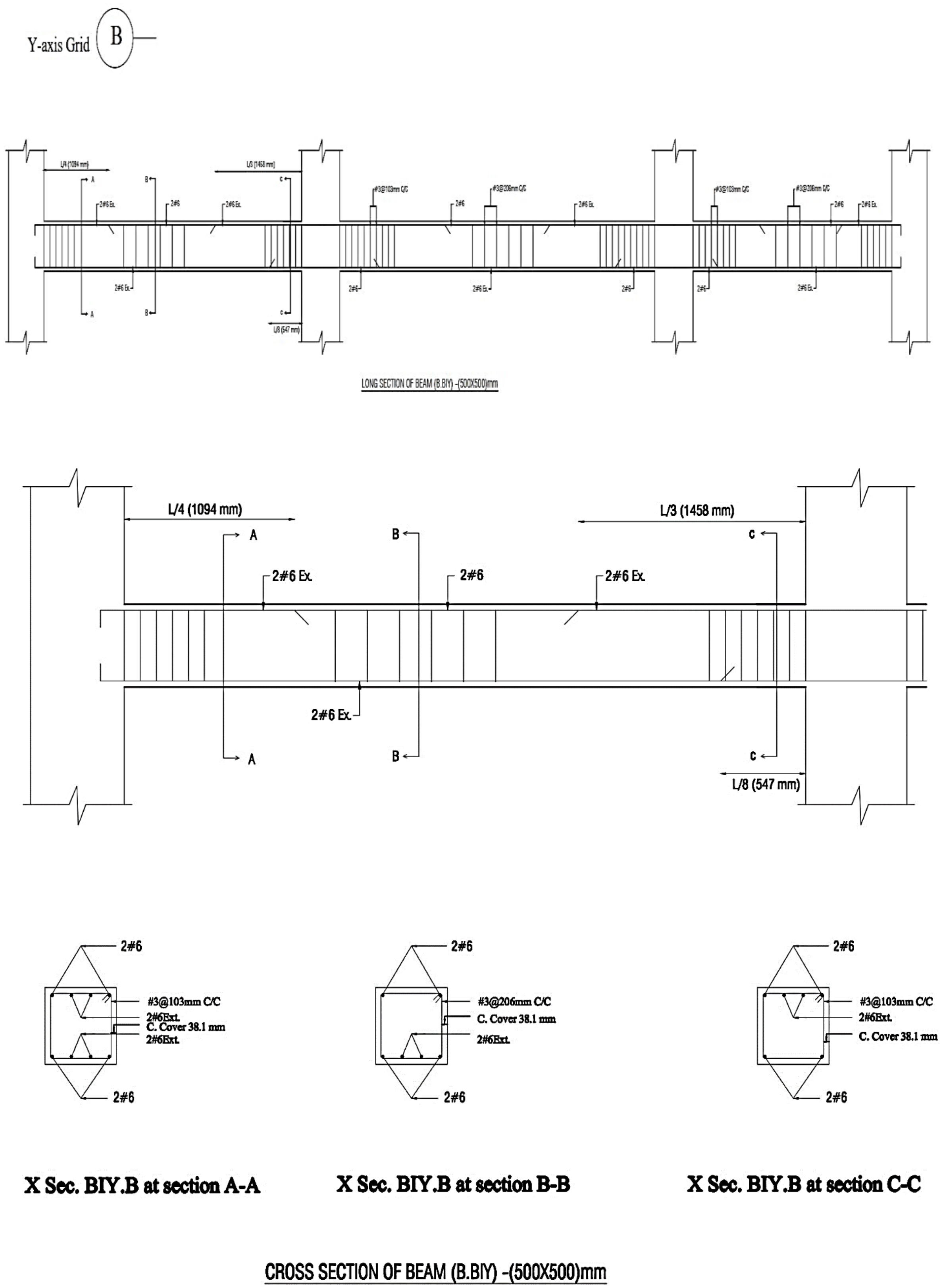
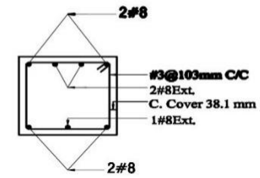
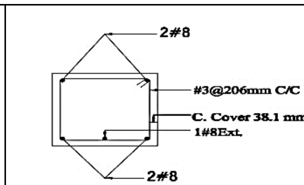
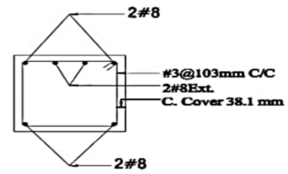
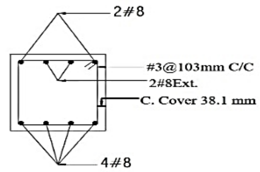
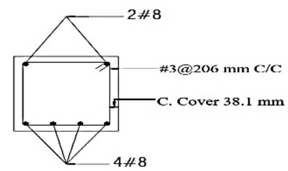
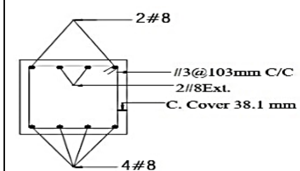
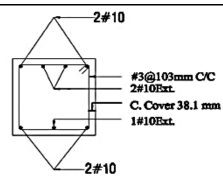
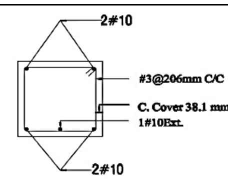
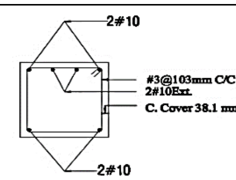
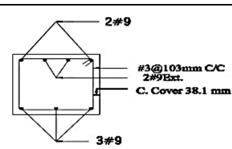
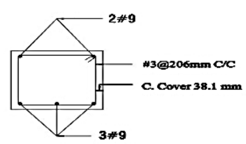
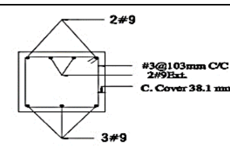
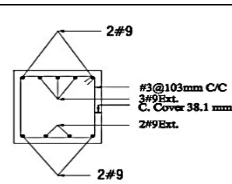
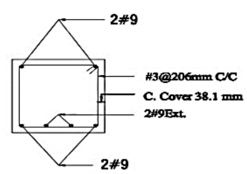
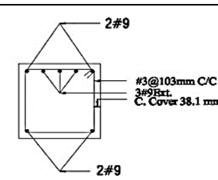
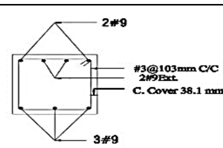
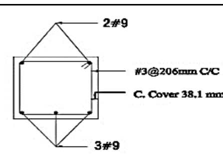
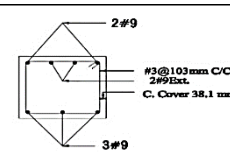
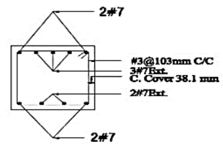
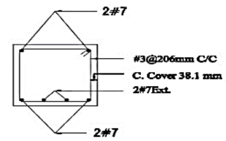
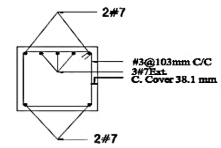
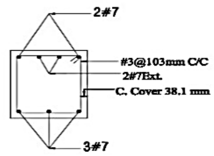
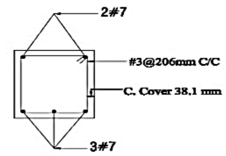
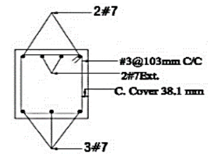
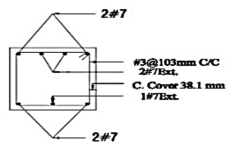
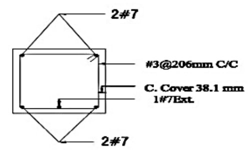
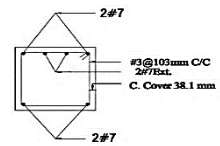
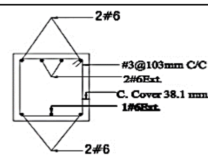
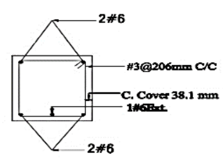
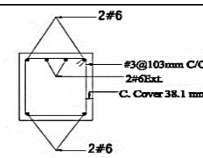
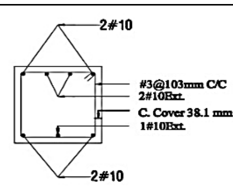
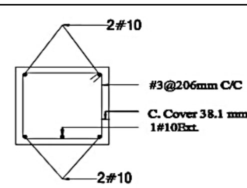
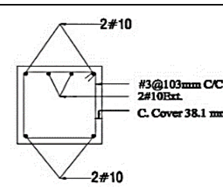
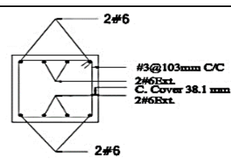
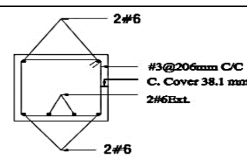
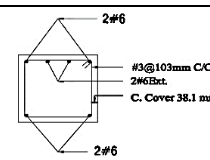


Figure 5. 14: Beam Details Roof Y-Direction

Table 5. 7: Beam Scheduling of Building

BEAM	Grid location	REINFORCEMENT		
GF (BEX)	4	 X Sec. BEX.4 at section A-A	 X Sec. BEX.4 at section B-B	 X Sec. BEX.4 at section C-C
GF (BEY)	A	 YSec. BEY .Aat section A-A	 YSec. BEY.Aat section B-B	 Y Sec. BEY.Aat section C-C
1F (BIX)	3	 X Sec. BIX.3 at section A-A	 X Sec. BIX.3 at section B-B	 X Sec. BIX.3 at section C-C
1F (BIY)	B	 X Sec. BIY.B at section A-A	 X Sec. BIY.B at section B-B	 X Sec. BIY.B at section C-C
2F (BIX)	2	 X Sec. BIX.2 at section A-A	 X Sec. BIX.2 at section B-B	 X Sec. BIX.2 at section C-C
2F (BIY)	C	 X Sec. BIY.C at section A-A	 X Sec. BIY.C at section B-B	 X Sec. BIY.C at section C-C

3F (BEX)	**1**	 X Sec. BEX.1 at section A-A	 X Sec. BEX.1 at section B-B	 X Sec. BEX.1 at section C-C
3F (BEY)	**D**	 X Sec. BEY.D at section A-A	 X Sec. BEY.D at section B-B	 X Sec. BEY.D at section C-C
4F (BEX)	**4**	 X Sec. BEX.4 at section A-A	 X Sec. BEX.4 at section B-B	 X Sec. BEX.4 at section C-C
4F (BEY)	**A**	 X Sec. BEY.A at section A-A	 X Sec. BEY.A at section B-B	 X Sec. BEY.A at section C-C
ROOF (BIX)	**3**	 X Sec. BIX.3 at section A-A	 X Sec. BIX.3 at section B-B	 X Sec. BIX.3 at section C-C
ROOF (BIY)	**B**	 X Sec. BIY.B at section A-A	 X Sec. BIY.B at section B-B	 X Sec. BIY.B at section C-C

CHAPTER 6: COLUMN DESIGN

6.1 Column Design:

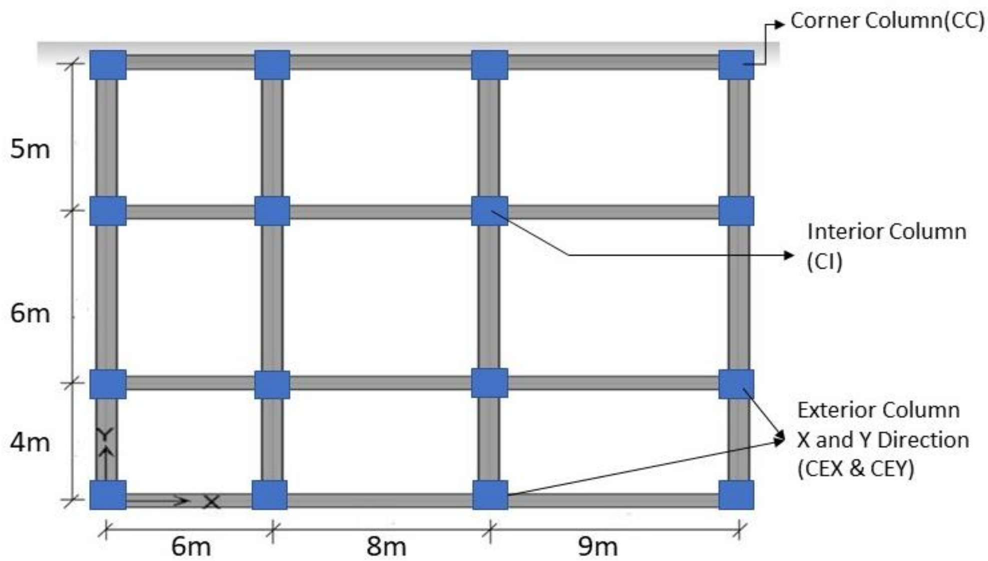


Figure 6. 1: Column Orientation

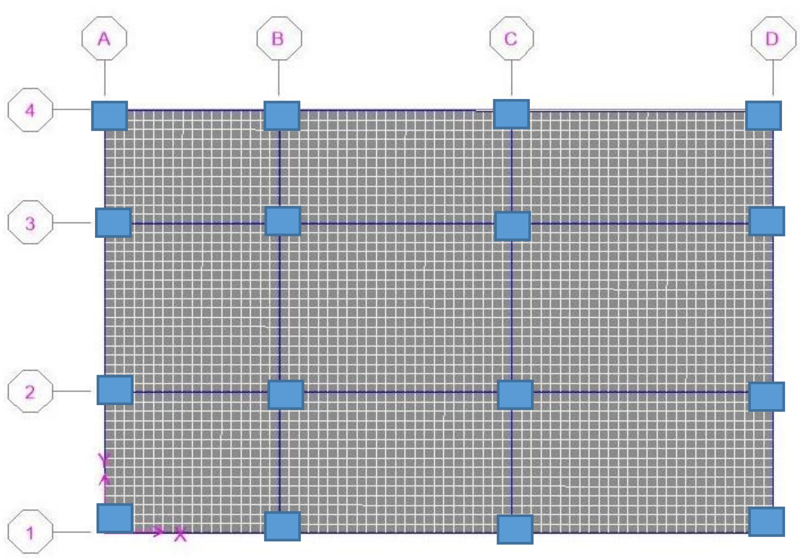


Figure 6. 2: Grid View of Column

6.1.1 Column 1: Section A Grid 1 (CC-Corner Column)

Table 6. 1: Column 1 Bar details

Criteria	UP to 2nd Floor	3rd Floor to Roof
Max Bar Area (in^2)	7.525	5.580
Bar Number	#9	#9
Bar Area (in^2)	1	1
No of Bar Provided	8	6
Column Cross Section (mm)	600mm x 600mm	600mm x 600mm
Area of Column Section A_g (in^2)	576 (Approximate)	576 (approximate)
4% of A_g (in^2)	23.04	23.04
Provided total Steel Area A_{st} (in^2)	8	6
Comments	A_{st}<23.04 (ok)	A_{st}<23.04 (ok)

Corner Column

Ground Floor To 2nd Floor

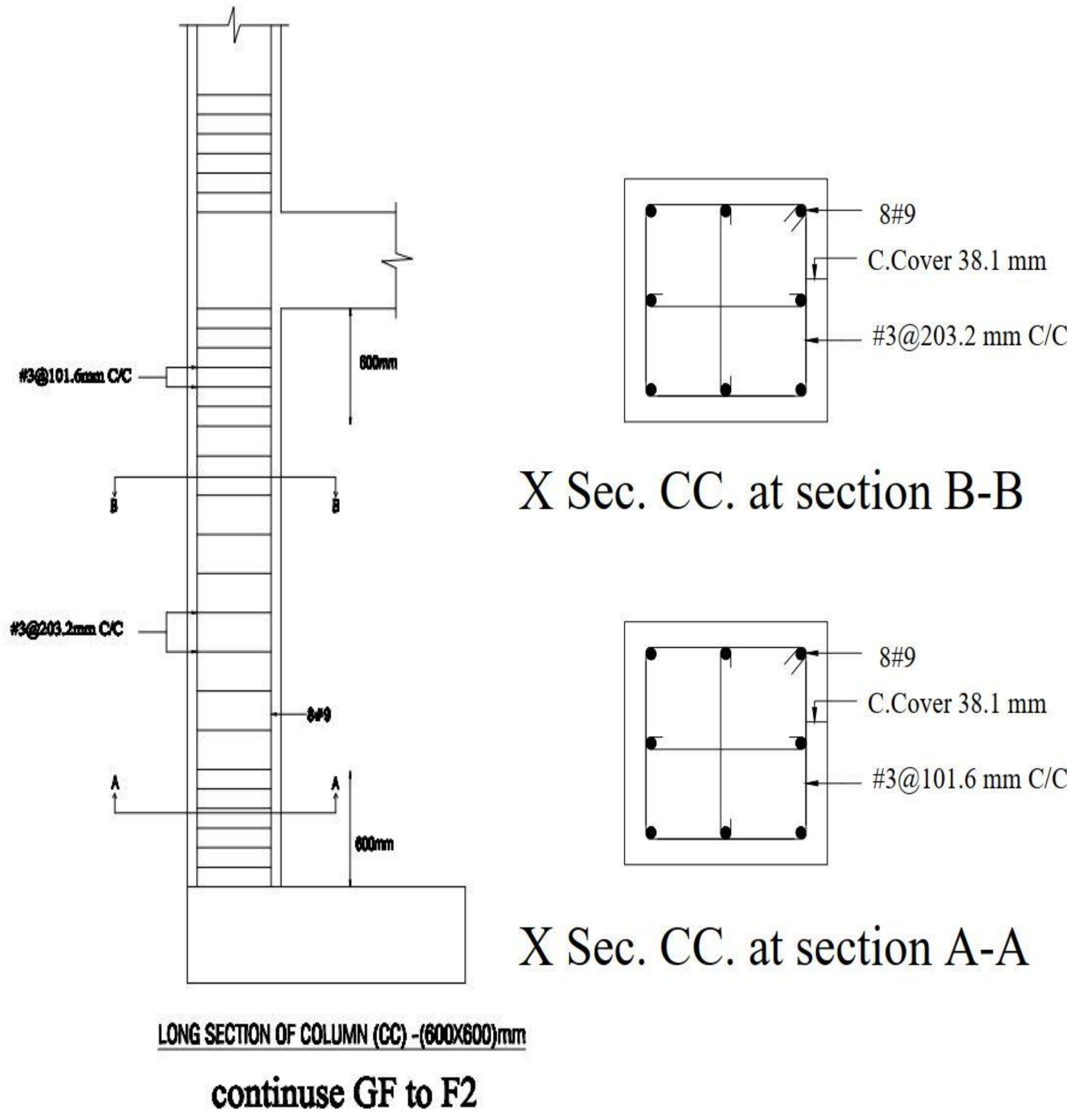


Figure 6. 3: Column details C1, GF to 2nd Floor

3rd Floor to Roof

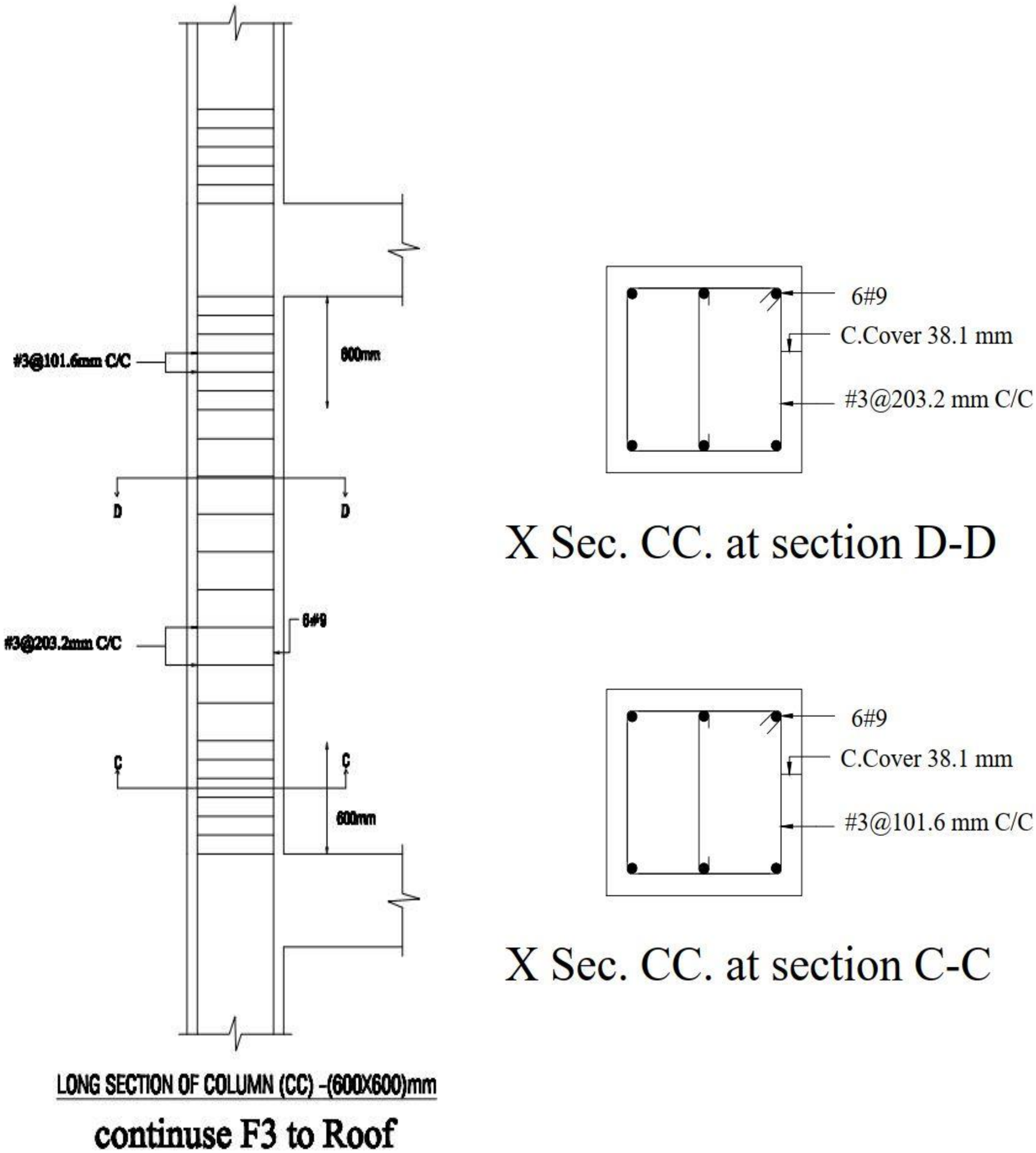


Figure 6. 4: Column details C1,3rd Floor to Roof

6.1.2 Column 2: Section B Grid 3, B (CI- Interior Column)

Table 6. 2: Column 2 Bar Details

Criteria	up to 2nd Floor	3rd Floor to Roof
Max Bar Area (in^2)	7.597	6.549
Bar Number	#10	#10
Bar Area (in^2)	1.27	1.27
No of Bar Provided	6	6
Column Cross Section (mm)	650mm x 600mm	650mm x 600mm
Area of Column Section A_g (in^2)	605 (approximate)	605 (approximate)
4% of A_g	24.2	24.2
Provided total Steel Area A_{st} (in^2)	7.62	7.62
Comments	A_{st}<24.2 (ok)	A_{st}<24.2 (ok)

Interior Column

Ground Floor To 2nd Floor

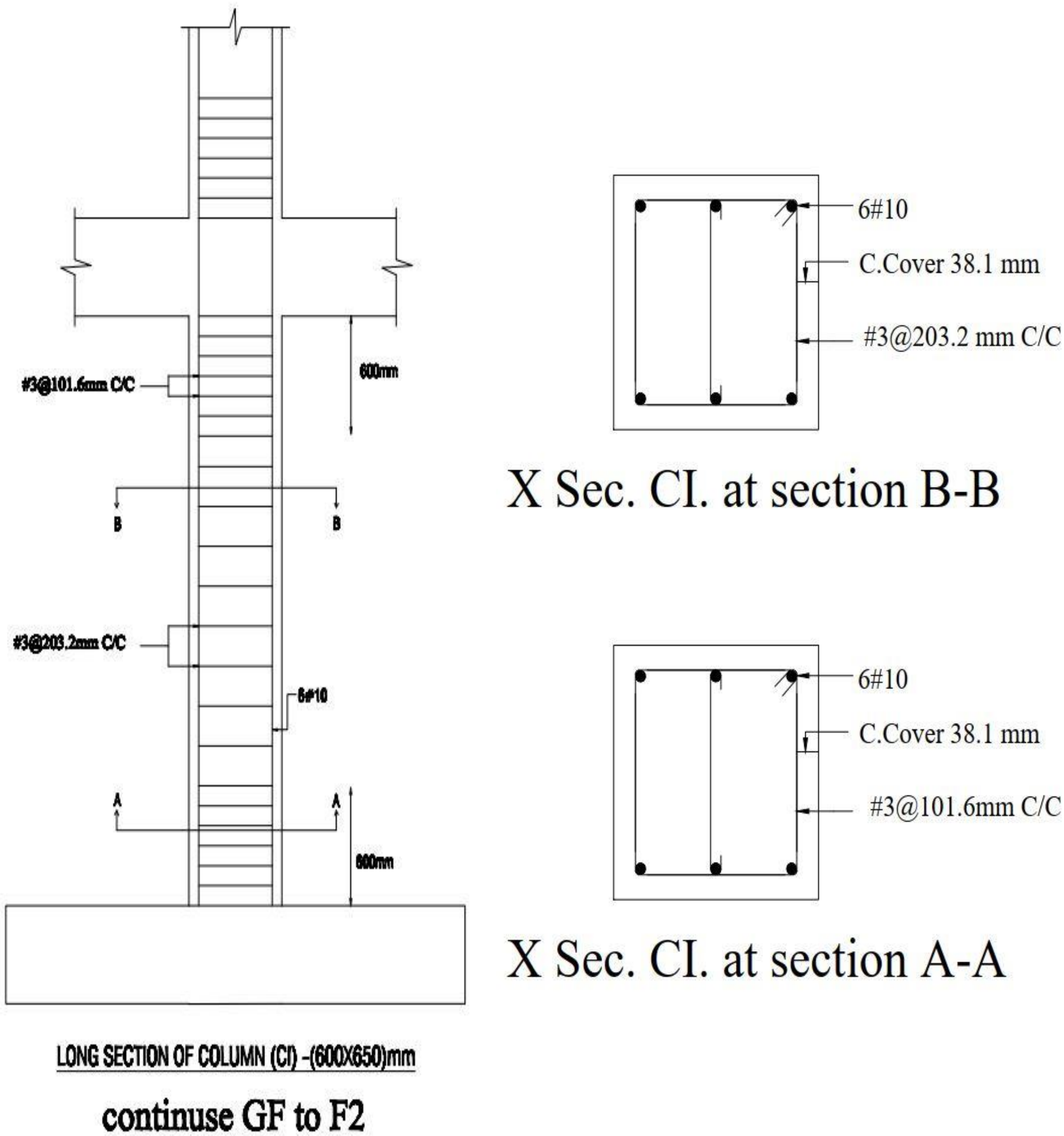


Figure 6. 5: Column details C2, GF to 2nd Floor

3rd Floor to Roof

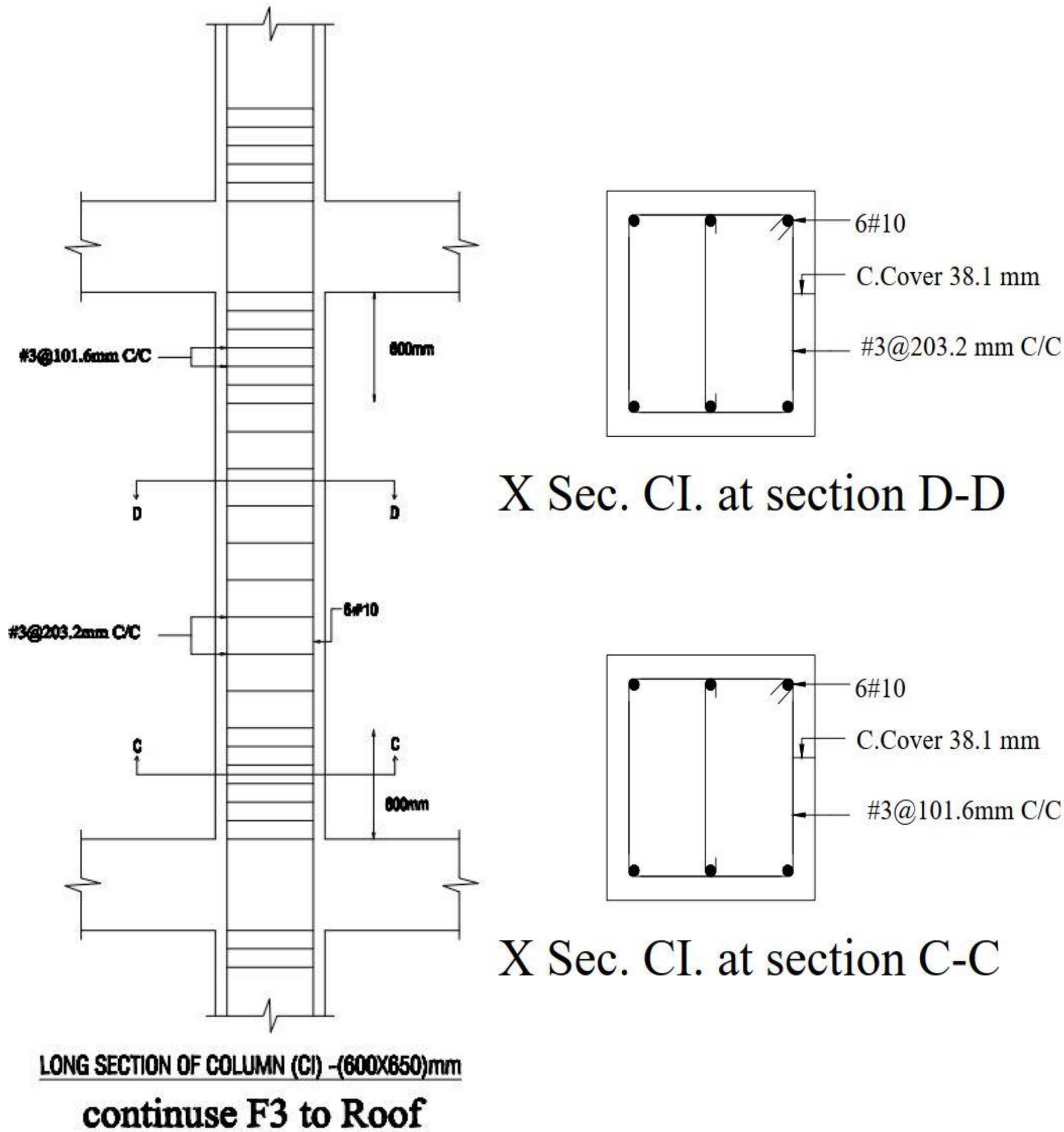


Figure 6. 6: Column details C2, 3rd Floor to Roof

6.1.3 Column 3: Section D Grid 2, D (CEY- Exterior Column Y-Direction)

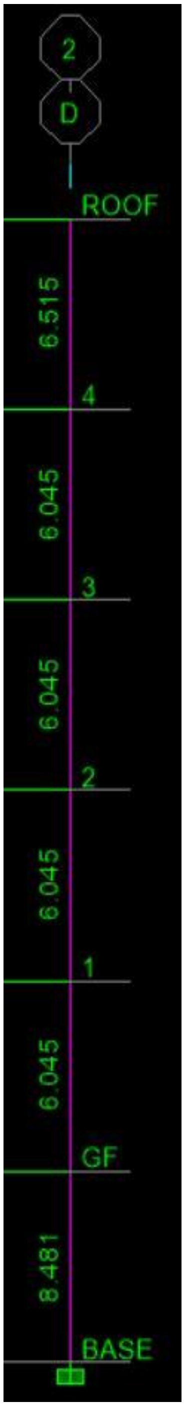


Table 6. 3: Column 3 Bar Details

Criteria	Up to 2nd Floor	3rd Floor to Roof
Max Bar Area (in^2)	8.481	6.045
Bar Number	#10	#10
Bar Area (in^2)	1.27	1.27
No of Bar Provided	8	6
Column Cross Section (mm)	650mm x 600mm	650mm x 600mm
Area of Column Section A_g (in^2)	605 (approximate)	605 (approximate)
4% of A_g	24.2	24.2
Provided total Steel Area A_{st} (in^2)	10.16	7.62
Comments	Ast< 24.2 (ok)	Ast< 24.2 (ok)

Exterior Column

Ground Floor To 2nd Floor

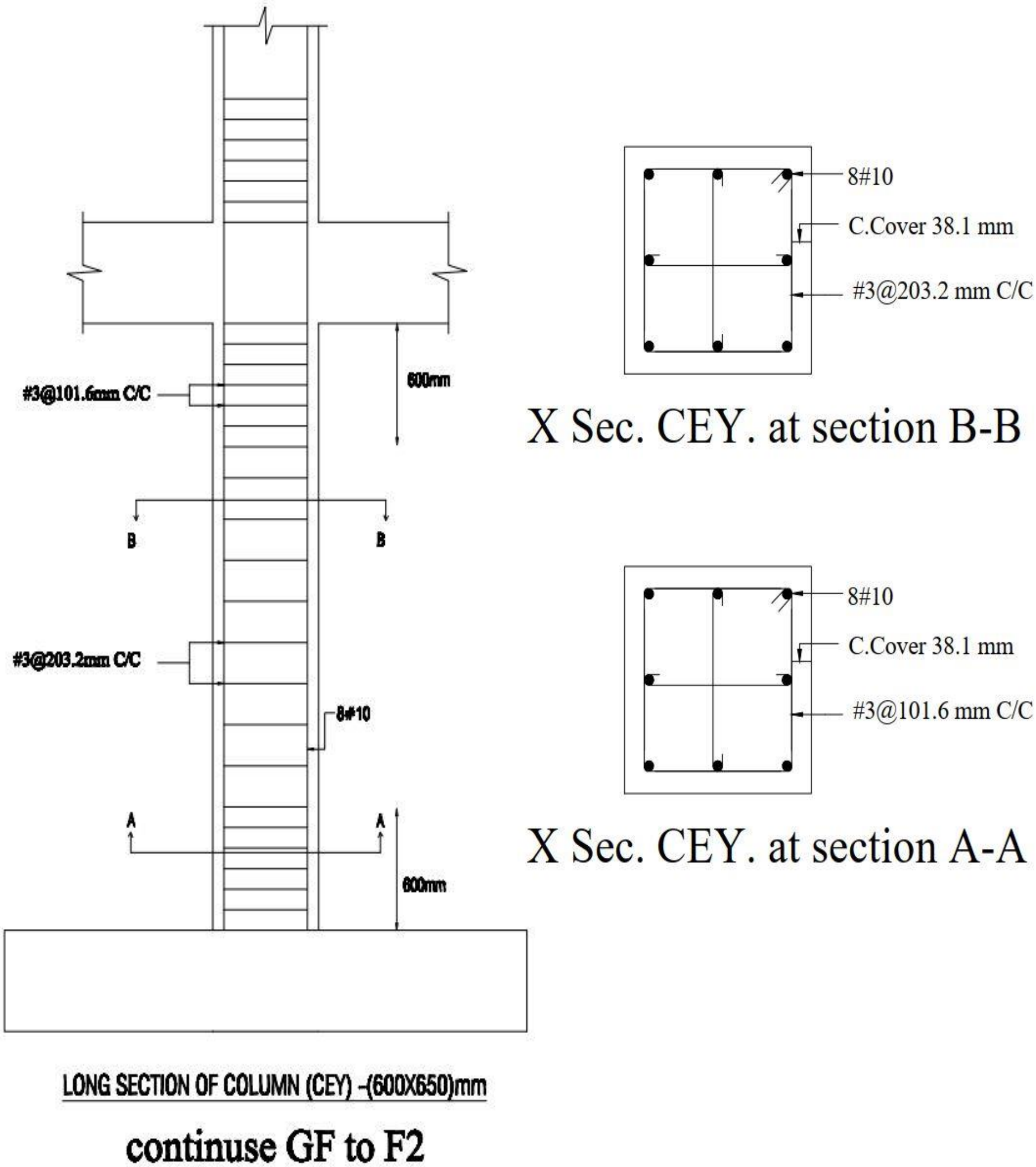


Figure 6. 7: Column details C3, GF to 2nd Floor

3rd Floor to Roof

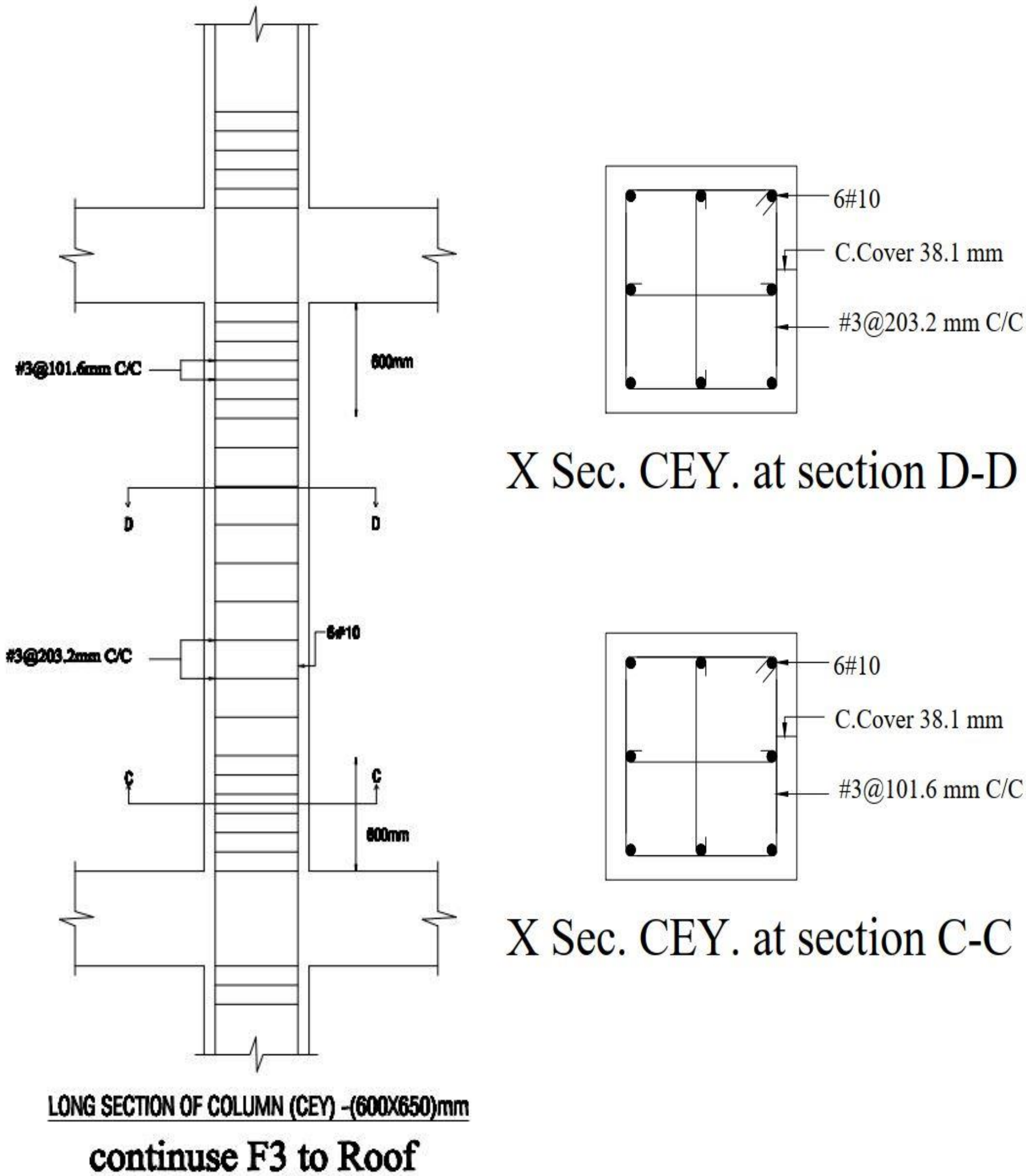
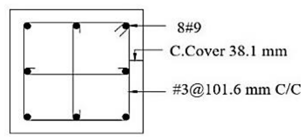
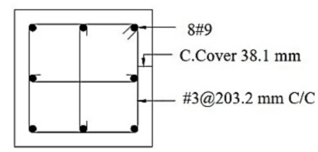
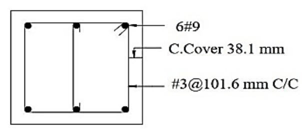
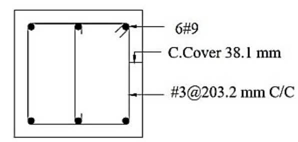
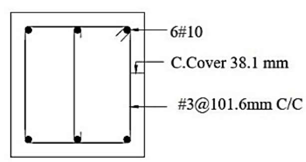
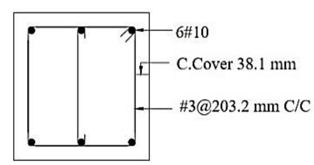
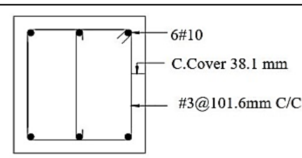
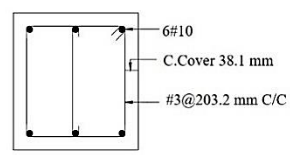
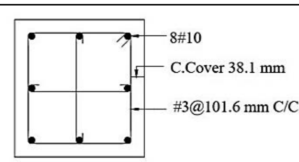
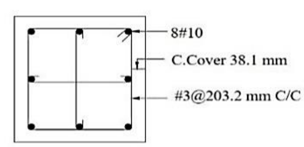
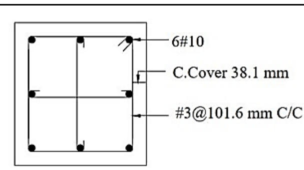
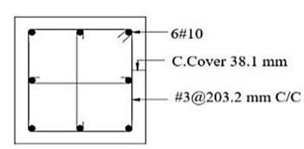


Figure 6. 8: Column details C3, 3rd Floor to Roof

COLUMN SCHEDULE OF BUILDING

Table 6. 4: Column Schedule of Buildings

Column	Grid location	Reinforcement	
C1 **(CC)**	**1, A** **Up to 2nd Floor**	 X Sec. CC. at section A-A	 X Sec. CC. at section B-B
C1 **(CC)**	**1, A** **3rd F to Roof**	 X Sec. CC. at section C-C	 X Sec. CC. at section D-D
C2 **(CI)**	**3, B** **Up to 2nd Floor**	 X Sec. CI. at section A-A	 X Sec. CI. at section B-B
C2 **(CI)**	**3, B** **3rd F to Roof**	 X Sec. CI. at section C-C	 X Sec. CI. at section D-D
C3 **(CEY)**	**2, D** **Up to 2nd Floor**	 X Sec. CEY. at section A-A	 X Sec. CEY. at section B-B
C3 **(CEY)**	**2, D** **3rd F to Roof**	 X Sec. CEY. at section C-C	 X Sec. CEY. at section D-D

CHAPTAR 7: CONCLUSION & RECOMMENDATION

7.1 Conclusions:

In this study, a six-story structure is designed with its (Slabs, Beams, and Columns) utilizing tools such as (AutoCAD, Excel, and ETABS). The dead loads, which are determined by the unit weight of the materials used (concrete, rebar), and the live loads are computed using the code. The initial architectural and structural configuration of the overall structure, the quality of the structural analysis, design, and reinforcement detailing of the building frame to achieve element stability and ductile performance will all affect the safety of reinforced concrete buildings. Additional safety standards of the structure as a whole include proper construction quality and the stability of the infill walls and partitions.

- We have designed a six-story building following BNBC 1993, ACI 318 code and also use (Auto CAD, ETABS) software for beam, column, slab design and detailing.
- For slab design complete hand calculation and check effective depth, rebar spacing. According slab panel moment required reinforcement is less then minimum reinforcement, so we provide minimum reinforcement.
- For reduction of negative moments, we provide steel bars, in most of the cases providing extra top bars.
- This Design of a multistory building for residential purposes is presented.

7.2 Recommendations

- For time constraints we were design only 3 columns. It is recommended that all the columns should be designed. Also, to note is that the rebar percentage for the structure averaging 2.75%, rebar percentage keep within 4% to make the design more economical.
- Cost estimation and Safety management is important to fulfil whole building design.
- In this building, there have no considering Footing and Stair. It is important to design to fulfill a standard Building.
- For time constraints we only designed the one floor slab in this study. It is recommended to design slabs of all the floors.
- Updated software must be used for the design to be more up-to-date and realistic.
- Design multistory building following only BNBC building code 1993 and ACI 318-99. It is recommended that to use Updated code.

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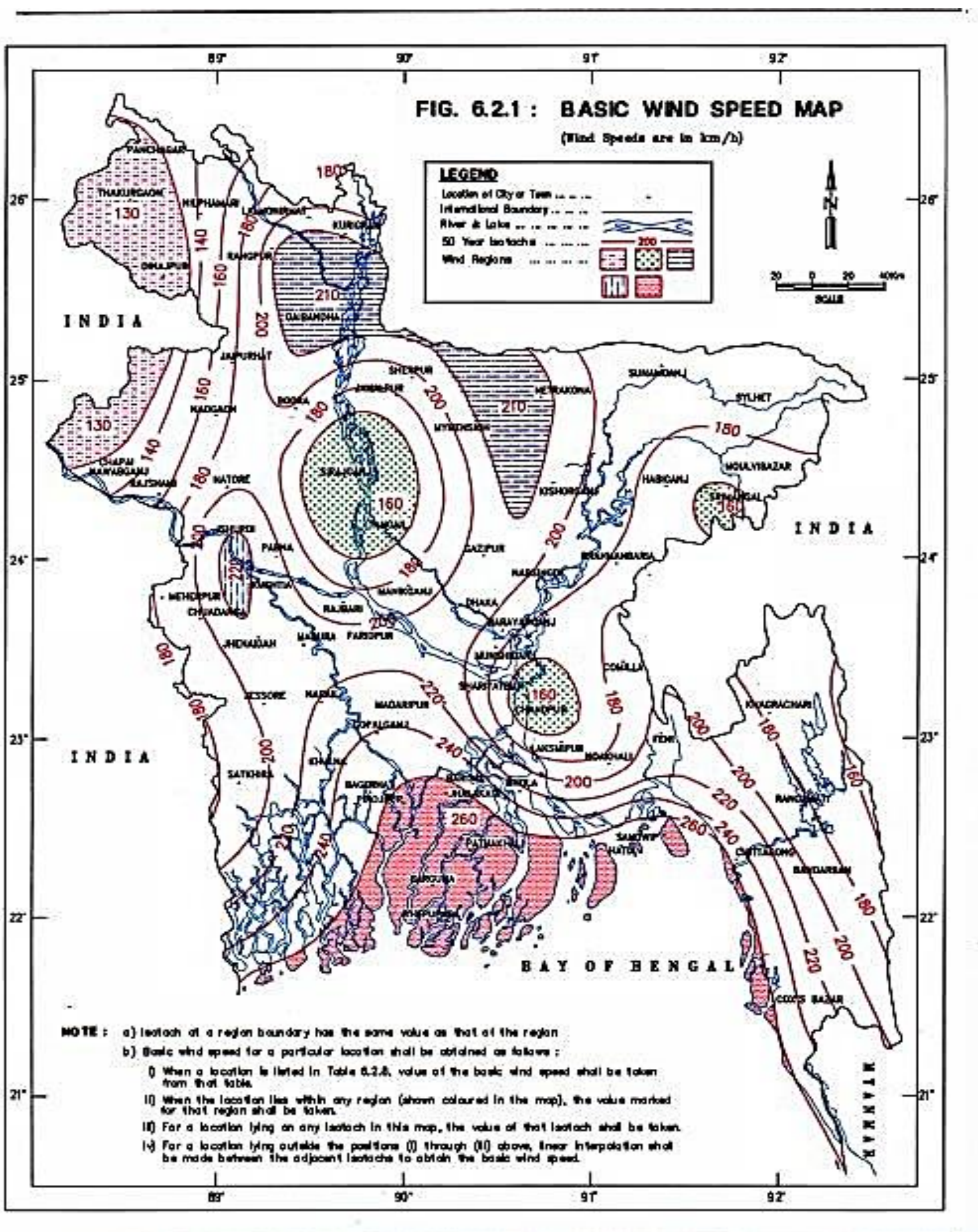
CHAPTER 8: APPENDIXES

Appendix 1:

BNBC for wind loads:

Basic Wind speed map of Bangladesh



Location	Basic Wind Speed (km/h)	Location	Basic Wind Speed (km/h)
Angarpota	150	Lalmonirhat	204
Bagerhat	252	Madaripur	220
Bandarban	200	Magura	208
Barguna	260	Manikganj	185
Barisal	256	Meherpur	185
Bhola	225	Moheshkhali	260
Bogra	198	Moulvibazar	168
Brahmanbaria	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

Sustained Wind Pressure : The sustained wind pressure, q_z on a building surface at any height z above ground shall be calculated from the following relation :

$$q_z = C_c C_I C_z V_b^2$$

where, q_z = sustained wind pressure at height z, kN/m^2

C_I = structure importance coefficient as given in Table 6.2.9

C_c = velocity-to-pressure conversion coefficient = 47.2×10^{-6}

C_z = combined height and exposure coefficient as given in Table 6.2.10

V_b = basic wind speed in km/h obtained from Sec 2.4.5

Table: Structure importance Coefficient,

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	0.80

Table: Combined height and Exposure co-efficient, C_z

Height above ground level, z (metres)	Coefficient, C_z (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.

Design Wind Pressure : The design wind pressure, p_z for a structure or an element of a structure at any height, z above mean ground level shall be determined from the relation :

$$p_z = C_G C_p q_z$$

where, p_z = design wind pressure at height z , kN/m^2

C_G = gust coefficient which shall be G_z , G_h, or $\bar{G}$ as set forth in Sec 2.4.6.6

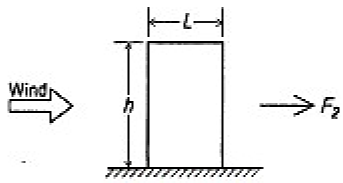
C_p = pressure coefficient for structures or components as set forth Sec 2.4.6.7

q_z = sustained wind pressure obtain from Eq (2.4.1).

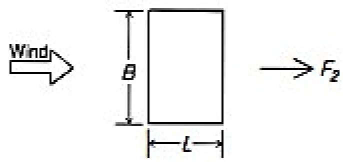
Table: Gust responses factor, G_h and Gz

Height above ground level (metres)	G_h ⁽²⁾ and G_z		
	Exposure A	Exposure B	Exposure C
0-4.5	1.654	1.321	1.154
6.0	1.592	1.294	1.140
9.0	1.511	1.258	1.121
12.0	1.457	1.233	1.107
15.0	1.418	1.215	1.097
18.0	1.388	1.201	1.089
21.0	1.363	1.189	1.082
24.0	1.342	1.178	1.077
27.0	1.324	1.170	1.072
30.0	1.309	1.162	1.067
35.0	1.287	1.151	1.061
40.0	1.268	1.141	1.055
45.0	1.252	1.133	1.051
50.0	1.238	1.126	1.046
60.0	1.215	1.114	1.039
70.0	1.196	1.103	1.033
80.0	1.180	1.095	1.028
90.0	1.166	1.087	1.024
100.0	1.154	1.081	1.020
110.0	1.114	1.075	1.016
120.0	1.134	1.070	1.013
130.0	1.126	1.065	1.010
140.0	1.118	1.061	1.008
150.0	1.111	1.057	1.005
160.0	1.104	1.053	1.003
170.0	1.098	1.049	1.001
180.0	1.092	1.046	1.000
190.0	1.087	1.043	1.000
200.0	1.082	1.040	1.000
220.0	1.073	1.035	1.000
240.0	1.065	1.030	1.000
260.0	1.058	1.026	1.000
280.0	1.051	1.022	1.000
300.0	1.045	1.018	1.000

Note : (1) For main wind-force resisting systems, use building or structure height h for z.
(2) Linear interpolation is acceptable for intermediate values of z.



(b) Elevation



(a) Plan

Rectangular Building

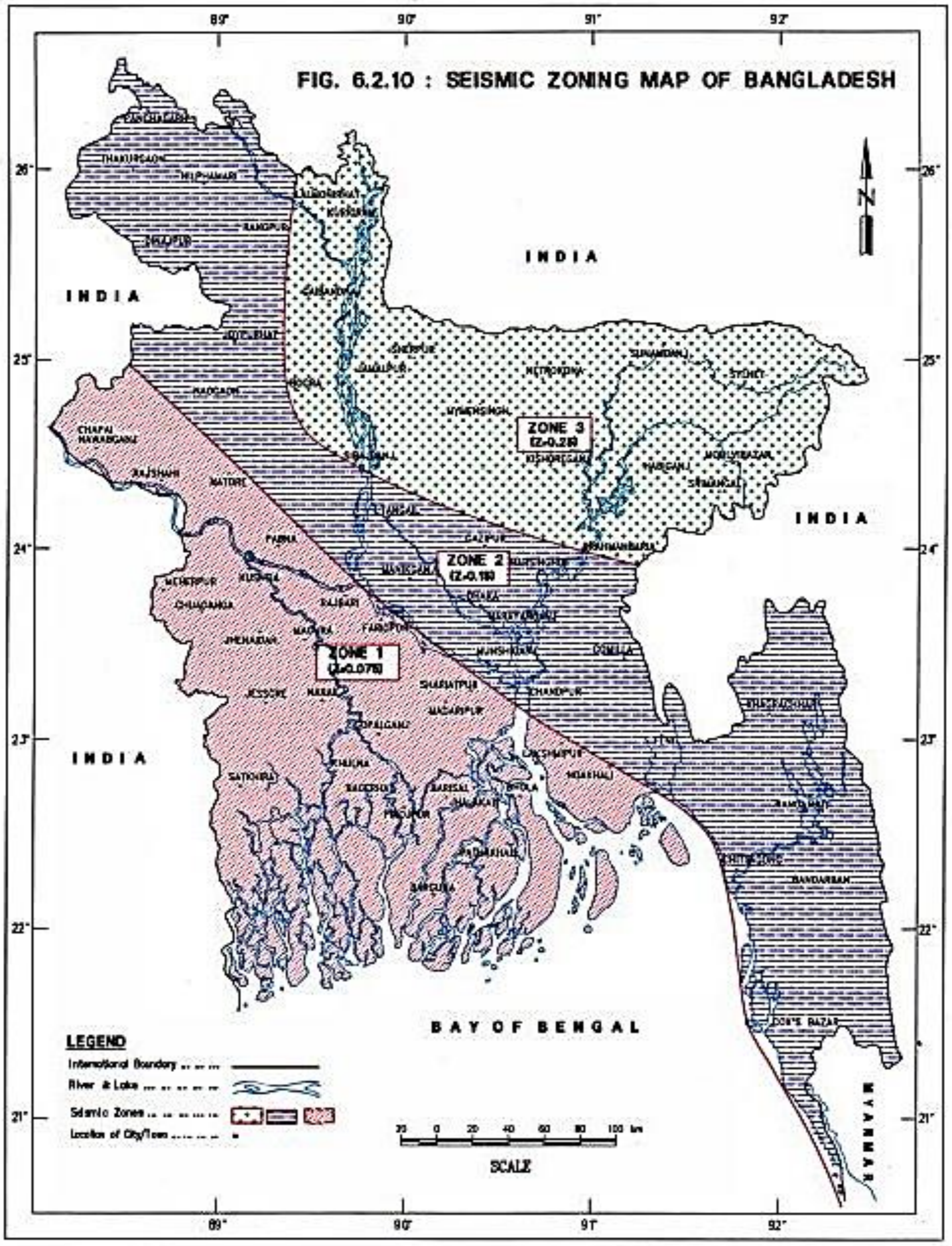
Overall Pressure Coefficients, $\bar{C}_p^{(2)}$ for Rectangular Buildings with Flat Roofs

h/B	L/B					
	0.1	0.5	0.65	1.0	2.0	≥ 3.0
≤5	1.40	1.45	1.55	1.40	1.15	1.10
10.0	1.55	1.85	2.00	1.70	1.30	1.15
20.0	1.80	2.25	2.55	2.00	1.40	1.20
≥40.0	1.95	2.50	2.80	2.20	1.60	1.25

Note:(1) These coefficients are to be used with Method-2 given in Sec 2.4.6.6a(ii). Use $\bar{C}_p = \pm 0.7$ for roof in all cases.
(2) Linear interpolation may be made for intermediate values of $\bar{h}/B$ and L/B.

Appendix 2:

Seismic zoning map of Bangladesh



Seismic Dead Load : Seismic dead load, W, is the total dead load of a building or a structure, including permanent partitions, and applicable portions of other loads listed below :

a) In storage and warehouse occupancies, a minimum of 25 per cent of the floor live load shall be applicable.

b) Where an allowance for partition load is included in the floor design in accordance with Sec 2.3.3.3, all such loads but not less than 0.6 kN/m^2 shall be applicable.

c) Total weight of permanent equipment shall be included.

Design Base Shear : The total design base shear in a given direction shall be determined from the following relation :

$$V = \frac{ZIC}{R} W \qquad (2.5.1)$$

where, Z = Seismic zone coefficient given in Table 6.2.22
I = Structure importance coefficient given in Table 6.2.23
R = Response modification coefficient for structural systems given in Table 6.2.24
W = The total seismic dead load defined in Sec 2.5.5.2
C = Numerical coefficient given by the relation :

Seismic Zone Coefficients, Z

Seismic Zone (see Fig 6.2.10)	Zone Coefficient
1	0.075
2	0.15
3	0.25

Structure Importance Coefficients *I, I′*

Structure Importance Category (see Table 6.1.1 for occupancy)	Structure Importance Coefficient	
	I	I'
I Essential facilities	1.25	1.50
II Hazardous facilities	1.25	1.50
III Special occupancy structures	1.00	1.00
IV Standard occupancy structures	1.00	1.00
V Low-risk Structures	1.00	1.00

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

a) **Method A** : For all buildings the value of T may be approximated by the following formula :

$$T = C_t \, (h_n)^{3/4} \qquad (2.5.3)$$

where, C_t = 0.083 for steel moment resisting frames
= 0.073 for reinforced concrete moment resisting frames, and eccentric braced steel frames
= 0.049 for all other structural systems
h_n = Height in metres above the base to level n.

Response Modification Coefficient for Structural Systems, *R*

c. Moment Resisting Frame System	1. Special moment resisting frames (SMRF) i) Steel ii) Concrete 2. Intermediate moment resisting frames (IMRF), concrete[4] 3. Ordinary moment resisting frames (OMRF) i) Steel ii) Concrete [5]	 12 12 8 6 5

Site Coefficient, S for Seismic Lateral Forces [1]

Site Soil Characteristics		Coefficient, S
Type	Description	
S_1	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 metres	1.0
S_2	A soil profile with dense or stiff soil conditions, where the soil depth exceeds 61 metres	1.2
S_3	A soil profile 21 metres or more in depth and containing more than 6 metres of soft to medium stiff clay but not more than 12 metres of soft clay	1.5
S_4	A soil profile containing more than 12 metres of soft clay characterized by a shear wave velocity less than 152 m/s	2.0

Note : (1) The site coefficient shall be established from properly substantiated geotechnical data. In locations where the soil properties are not known in sufficient detail to determine the soil profile type, soil profile S_3 shall be used. Soil profile S_4 need not be assumed unless the building official determines that soil profile S_4 may be present at the site, or in the event that soil profile S_4 is established by geotechnical data.