ANALYSIS AND DESIGN OF STRUCTURAL COMPONENTS OF A SIX STORIED RCC RESIDENTIAL BUILDING BY USING MANUAL CALCULATION (USD), AND SOFTWARE (ETABS) APPROACH.

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A thesis submitted to the Department of Civil Engineering in partial fulfillment for the degree of Bachelor of Science (B.Sc.) in Civil Engineering



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Section: 23B+D

Fall- 2024

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DECLARATION

We are Mozzamal, Kamrul islam, Abu Jafor Shabbier Ahmed, Md. Kaosar Ahmed, students of B.Sc. in Civil Engineering of Sonargaon an University. Here by solemnly declare that the works presented in this thesis & project has been carried out by us except for the contents where specific references have been made to the work of others and has not previously been submitted to any other University/College/Organization for any academic qualification/certificate/diploma/degree etc. We warrant that the present work does not breach any copyright law. We further undertake to indemnify the University against any loss or damage arising from breach of the foregoing obligations.

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Dedicated

to

"We would like to dedicate this thesis to our family who always support us throughout the period of the work. Also, we dedicate our thesis to our esteemed teachers, who Consistently encourage us and share their valuable knowledge with us."

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The research works" **ANALYSIS AND DESIGN OF STRUCTURAL COMPONENTS OF A SIX STORIED RCC RESIDENTIAL BUILDING BY USING MANUAL CALCULATION(USD),(WSD)ANDSOFTWARE(ETABS) APPROACH.** "has been conducted in partial fulfillment of the requirements for the degree of Bachelor of Science (B.Sc.) in Civil Engineering. This critical works became possible for us due to the unconditional help and cooperation in diverse ways by many people. We express our appreciation and thanks to them for their assistance in preparation of this project and thesis.

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ABSTRACT

The principal objective of this study to conduct structural analysis and design of a Six-storied residential building in Dhaka. In recent era, all of the changes in modern building technology are related to the necessity and comfort of human. The building construction takes the form of complex type of building structure to effectively use the construction materials, reduce construction period and cost and well facilitated building in every corner of the city. These building are equipped with top to bottom residential apartments for new comer city dwellers. But these types of buildings are difficult to arrange to take total advantage of structural, environmental and mechanical system. These need large open space with large loads from mechanical and electrical instruments. The apartments with more intimate spaces need closer column spacing and have fewer vents and wires required for resident's comfort. Thus, the modern design is facing challenges to accommodate all of the desired facilities in one building which requires sufficient knowledge of engineers on space arrangement, planning and formation of structural shape and form of high-rise building. The study is conducted to learn on the facts discussed.

A six-storied residential building was analysis and designed as per ACI and BNBC 2006 codes and specifications where lateral loads were considered. The observation of this study is found several concluding remarks.

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CHAPER 1

INTRODUCTION

1.1 General

A building is an enclosed structure that has walls, floors, a roof, and usually windows. A tall building is a multi-story structure in which most occupants depend on elevators [lifts] to reach their destinations.

Buildings of four floors or higher are associated with high-rise buildings. High-rise building is required for various purposes such as residential, office, market, mixed type etc. Here, the density of population is so higher than the other countries in south Asia and the maximum people depend on agriculture as occupation. The agricultural land is declining day by day for the development work and housing of so many communities in this developing country. Housing problems are being seen across the country, especially in cities. We need to solve this problem. Given the land crisis, there is no alternative to high-rise buildings for housing so many people. More buildings are needed to meet the housing demand in high population density areas. However, many people have a lot of scar and misconceptions about such high-rise buildings. This high-rise building system is an application of science of the present which is very simple, safe and useful. Tall buildings have many advantages that help us to make our lives more dynamic. Construction of 6-storey high or more buildings in Bangladesh, especially in the divisional cities, is very important. It is really very necessary to build high rise buildings because of having many reasons and there as follows.

- Increasing population creates pressure mostly on land which affects building construction.
- High prices of urban land.
- Couldn't afford any kind of misuse of agricultural land.
- High cost of rebuilding the cities.
- Revolutionize the progress and civilization.

In making high-rise buildings, it is important to build them with energy efficiency and sustainability features as well which also include conservative structural design

methodologies that have little regard for delivering added value through structural efficiencies. So in our energy efficient and sustainable buildings, to mitigate the effects of climate change what we are facing now, globally. It is our very much duty to serve the citizens with accommodation facility and to preserve mother nature as well. From the earliest period to the present, building material and labor cost have increased considerably. Material cost cannot be reduced. However, with improvement in design, material consumption can be limited and total construction cost can be reduced by introducing advanced technologies in construction practice. The study of construction
practice therefore, is very important in order to find out the scope of its improvement.

1.2 Background and Motivations

According to the Agenda 2021 of United Nations on 'Sustainable Development' high rise buildings should sustain the nature and contain the energy efficient features. The first seminar on high-rise buildings in Dhaka was organized by Bangladesh Steel Re-rolling Mill (BSRM) in September 2012 where the first initiative was to acknowledge the need to build taller structures in a sustainable manner. After this type of conferences, the rate of awareness to construct sustainable buildings has rapidly grown up. High-rise building construction is majorly influenced from the lack of land usage because those lands should be reserved for agricultural purposes and cultivation. As a result, the horizontal expansion is becoming impossible and this leads to the concept of vertical construction as high-rise buildings. Upon the land data of Dhaka metropolitan area, we can understand the present high-rise buildings construction scenario. In Bangladesh, Research Objectives and Overview' especially in Dhaka, the prices of residential lands are very high. It has been found that the price has increased thirty times or more in the 1980s. The number of vacant land in Dhaka's cities is decreasing due to rising prices. The land and housing development project is helping to address this problem in a variety of ways and tries to constant the high rise buildings more in Bangladesh.

While constructing high rise building Earthquake is the biggest problem. Because Severity of ground shaking at a given location during an earthquake can be minor moderate and strong. Relatively speaking, minor shaking occurs frequently; moderate shaking occasionally and strong shaking rarely. The engineers do not attempt to make earthquake proof buildings that will not get damaged even during the case strong earthquake. Such buildings will be too

robust & also too expensive. Instead the engineering intention is to make buildings earthquake resistant such building resist the effect the ground shaking, although they may get damaged severely but would not collapse during the strong earthquake. Thus safety of people & contents is assured in earthquake resistant's buildings, and thereby a disaster is avoided. This is a major objective of seismic design codes throughout the world.

The conventional approach to earthquake resistant design of buildings depends upon providing the building with strength, stiffness and inelastic deformation capacity which are great enough to great stand a given level to earthquake-generated force. This is generally accomplished through the selection of an appropriate structure configuration and the careful detailing of structural members, such as beams, and columns and the connections between them. Share wall provision is one of the most effective design considerations to reduce the seismic effects.

1.3 Research Objective and Overview

The objectives of the study are as follows:

- To perform a structural analysis of a 6-storied residential RCC building structure according to BNBC 2006provisions
- To make response spectrum dynamic analyze of the 6-storied Dual frame structure using ETABS software
- To design different structural element of high rise building as per BNBC 2006.

1.4 Scope of the study

This study will be useful for the structural engineer to understand the behavior and performance of high-rise structures subjected to various loads and unique challenges, such as gravity, wind, and seismic considerations through the response spectrum analysis according to BNBC 2006 provisions. Also, it will be helpful to provide valuable insights to structural engineers to design safe, efficient, and sustainable earthquake resistant high-rise structures in future.

1.5 Limitation of the study

- Structural detailing, plumbing, electrification, estimation and cost analysis were not covered in this study.
- The dual frame system was analyzed by using ETABS structural analysis software.

1.6 Organization of the thesis

This report is organized in total five chapters. An overview of each remaining chapter is as follows:

Chapter 1: Introduction and Objective. Includes introduction to the problem together with background, objective, scope and limitation of the study and general direction of the research.

Chapter 2: Literature Review. Contains a brief literature review of the studies carried out prior and during this research to undertake this thesis and fulfill the specific objectives. It includes overview of high rise building in Dhaka, brief discussion on the effect of lateral loads, and some important tables and figure of BNBC 2006, related to analysis and design

Chapter 3: Methodology. Discuss is the load calculation of different elements (floor finish, partition wall, beam partition wall, verandah, toilet, water load etc.) figure of modeling. Different load pattern, dynamic analysis, mass ratio, strength check, service ability check, base reaction etc.

Chapter 4: Results and Discussion. Chapter four Contains the analysis and design of a 6 storied building consists of different floor system having regular span many ultimate strength design (USD) method. For space limitations, one set of design example is presented here in detail for component of the building such as slab, beam and column.

Chapter 5: Conclusions and Future Work. Finally, the conclusions and some recommendations for future research elicited from the study and analysis have been accommodated

CHAPER 2
LITERATURE REVIEW

2.1 General

This chapter elaborated a detailed literature review of the study. It presented a brief background of the high-rise building in Dhaka city of Bangladesh, the guidelines and specifications that was required to carry out the analysis of the structure. Discussed here, brief discussion on the effect of lateral loads and some important table and figure from BNBC 2006.

2.2 Background of the High-Rise Building

Dhaka is the capital and largest city of Bangladesh. It is called a beta-global city. After independence, it became the seat of the Government of Bangladesh, many Bangladeshi companies and leading Bangladeshi educational, business, industrial, scientific, medical, research and cultural organizations. Due to these reasons, the population diversity has grown tremendously in Dhaka. Today, it resulted as one of the densely populated cities in the world.

The increasing population creates numerous problems on the sustainable city environment and impedes development as the modern capital city of Dhaka. Moreover, it engenders pressure mostly on lands which affect building construction, land prices, housing problem and the agricultural land mostly. However, in this crisis, the concept of vertical construction of structure i.e., High-rise Buildings bas become the mostly accepted and current time solution especially, for the overpopulated city like Dhaka, Bangladesh. Dhaka city has welcomed and adopted the concept of vertical construction of structure because the horizontal expunction of the structure is almost impossible. In recent times, it has over 800 high rise buildings. Most of them are made with steel and concrete materials. The list of the high rise building in Dhaka based on their height and rank are presented in Table 2.1 to 2.10

Table 2.1: List of constructed high-rise buildings in Dhaka

Rank	Building Name	Height(m)	Floor	Building Occupancy
1.	Bangladesh Bank	115	31	commercial
4.	Sena Kalyan Bhabon	69	20	commercial
2.	The Westin Dhaka	86	26	Hotel
3.	Navana Tower	74.07	23	Mixed Use



Figure 2.1: Bangladesh Bank



Figure 2.2: Sena Kalyan Bhabon



Figure 2.3: The Westin Dhaka



Figure 2.4: Navana Tower

2.3 Effects of Lateral load on High Rise Building

2.3.1 Lateral Earthquake loads

Bangladesh is facing a high risk of moderate to strong earthquakes that may result in widespread catastrophic damage and loss of thousands of lives. The inertia forces can cause shearing of the structure which can concentrate stresses on the weak walls or joints in the structure resulting in failure or perhaps total collapse. Base shear is an estimate of the maximum expected lateral force on the base of the structure due to seismic activity. It is calculated using the seismic zone, soil material, and building code lateral force equations. When a structure is subjected to the lateral forces like wind forces, seismic forces, it will produce the lateral deflection and lateral sway in the structure in one direction. Due to this, an overturning effect is produced in the structure. A high-rise structure is always subjected to high lateral forces.

2.3.2 Lateral Wind loads

Wind loading is the effect of the atmosphere passing by a stationary structure attached to the earth's surface. Wind Loads are controlled by Atmospheric and Aerodynamic effects. It plays an important role in the design of high-rise structure because it exerts pressure on the structure. The actual intensity wind loads pressure depends on a number of factors like angle of incidence of the wind, roughness of surrounding area, effects of architectural features i.e., building's geometry, Shape of the structure etc. Apart from these, maximum design wind load pressure depends on the duration and amplitude of the gusts and the probability of occurrence of an exceptional wind in lifetime of building Fig 2.11 demonstrate the direction wind direction and wind pressure distribution with refer to height of the structure.

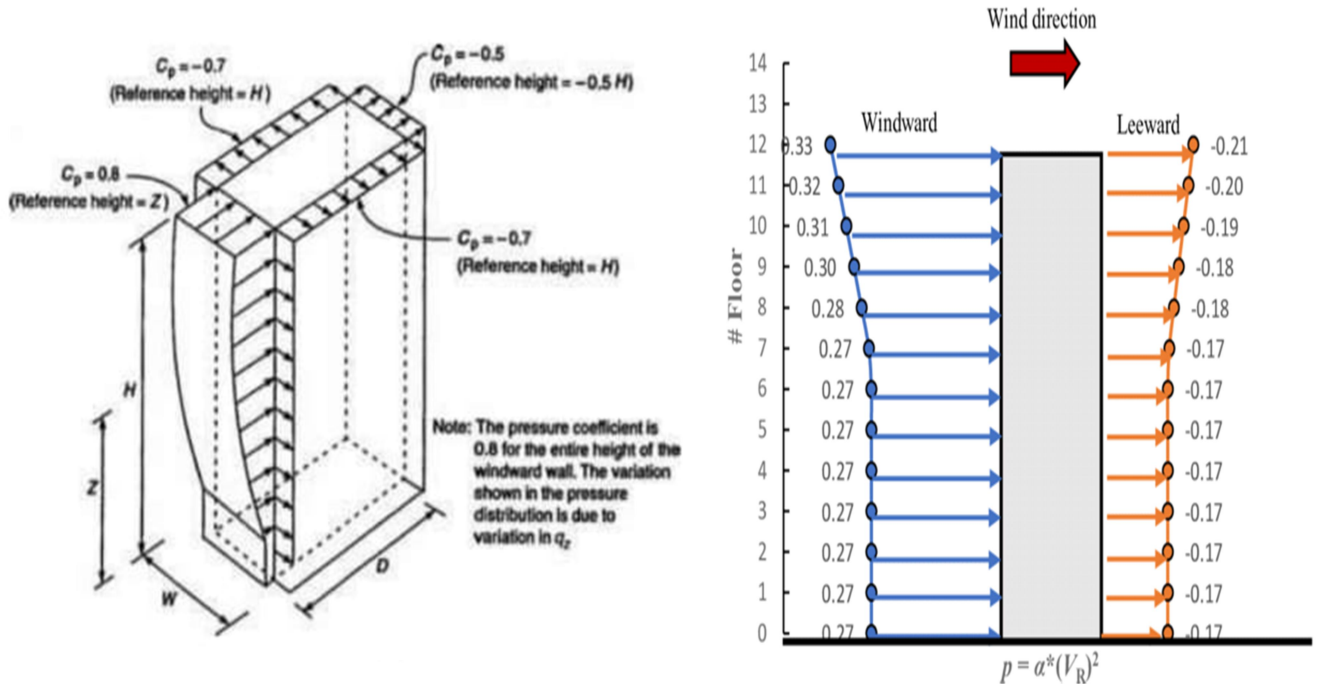


Figure 2.5: Wind directions

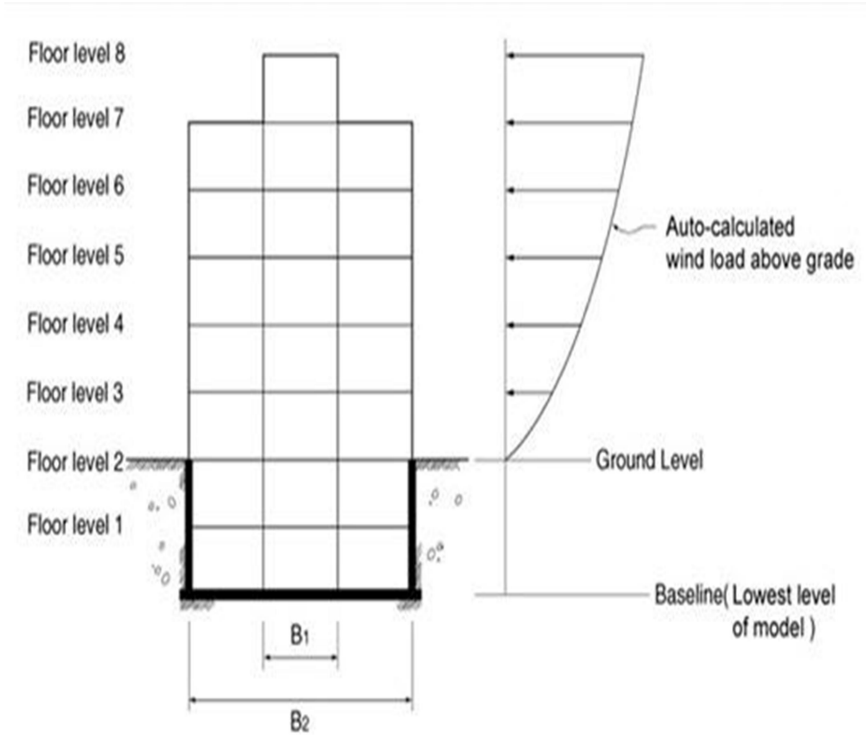


Figure 2.6: Wind directions and variation of wind pressure with respect to height on the Structure.

CHAPER 3
METHODOLOGY

3.1 General

This chapter provides an outline of the methodology, design consideration, and specifications which were followed to complete the study in brief. The non–automatic calculations of earthquake load and Automatic wind loads are shown in detail considering BNBC 2006 code separately. Finally, the BNBC 2006 load combinations were considered for the modeling and analysis of the structure.

3.2 Methodology

Step-I: Selection of a structural system

06 storied high rise structures having edge supported floor system (frame structure) had been considered. The whole structure is a residential building. As standard amenities and modern facilities such as, stairs etc. were provided. Description of the Design data and specifications considered in this Chapter.

Step-II: Modeling & Analysis of the structure

Here we are discuss load calculation of different elements (floor finish, partition wall, beam partition wall, verandah, toilet, water load etc.). Shown Figure of Modeling. Describe different load pattern, dynamic analysis, mass ratio, strength check, service ability check, base reaction.

Step-III: Design of the building

The structure was designed by ultimate strength design (USD) following high-rise design concept. Chapters 4 provide detailed structural design of the different components of the structure.

3.3 Design data and specifications considered in this study

The whole study was carried out based on few considerations and specifications which are summarized in Table 3.1 below

Table 3.1: Summary of the design considerations and specification of the study

Items	Description
Design Code	• American Concrete Institute (ACI) Building design code, 2014. • Bangladesh National Building Code (BNBC 2006)
Loading	• Floor finish for all floors -26 psf • Floor finish for stair -26 psf • Floor finish for water tank-26 psf • Live load for all floors- 42 psf. • Live load for all stair – 102 psf • P.W. load for floors- 42.2 psf • P.W load for toilet- 259 psf • P.W load for veranda -106 psf • Over-head water load- 314 lb • Beam P.W wall load- 0.152 ksf • Earthquake and wind load are considered.
Building Component	• Column type = Tied • Footing type- Deep foundation. • Thickness of all partition walls-5 inch • Thickness of Slab-5 inch
Materials Properties	• Yield strength of reinforcing bars, fy- 72500 psi • Concrete compressive strength, f'c-3500 psi • Normal density concrete having w, 150 pcf • Unit weight of water =62.5 pcf

3.4 Load Calculation

3.4.1 Load case combinations were used according to BNBC 2006 code

1. 1.4DL
2. 1.4DL+1.7LL
3. 1.05DL+ 1.275LL+ 1.275Wx
4. 1,05DL+1.275LL-1.275Wx
5. 1.05DL+ 1.275LL+ 1.275Wy
6. 1.05DL+1.275LL-1.275Wy
7. 1.05DL +1.275 Wx
8. 1.05DL-1.275 Wx
9. 105DL+1.275 Wy
10. 1.05DL-1.275 Wy 11.0.9DL+ 1.3Wx
12. 0.9DL-1.3Wx
13. 0.9DL +1.3Wy
14. 0.9DL-1.3Wy
15. 1.05DL +1.275LL +1.4025Ex
16: 1.05DL+1.275LL-1.4025 Ex
17. 1.05DL+1.275LL +1.4025Ey
18. 1.05DL +1.275LL-1.4025Ey
19. 1.05DL+1.4025Ex
20. 1.05DL-1.4025Ex
21. 1.05DL+ 1.4025Ey
22. 1.05DL-1.4025Ey
23. 0.9DL +1.43 Ex
24. 0.9DL-1.43 Ex
25. 0.9DL+1.43 Ey
26. 0.9DL-1.43 Ey
27.0.81D-1EQx+0.3EQy
28.0.81D-1EQx+1EQy

Where, DL = Dead Load, LL = Live Load, W = Wind Load, E = Earth quake Load

3.4.2 Modeling of structure

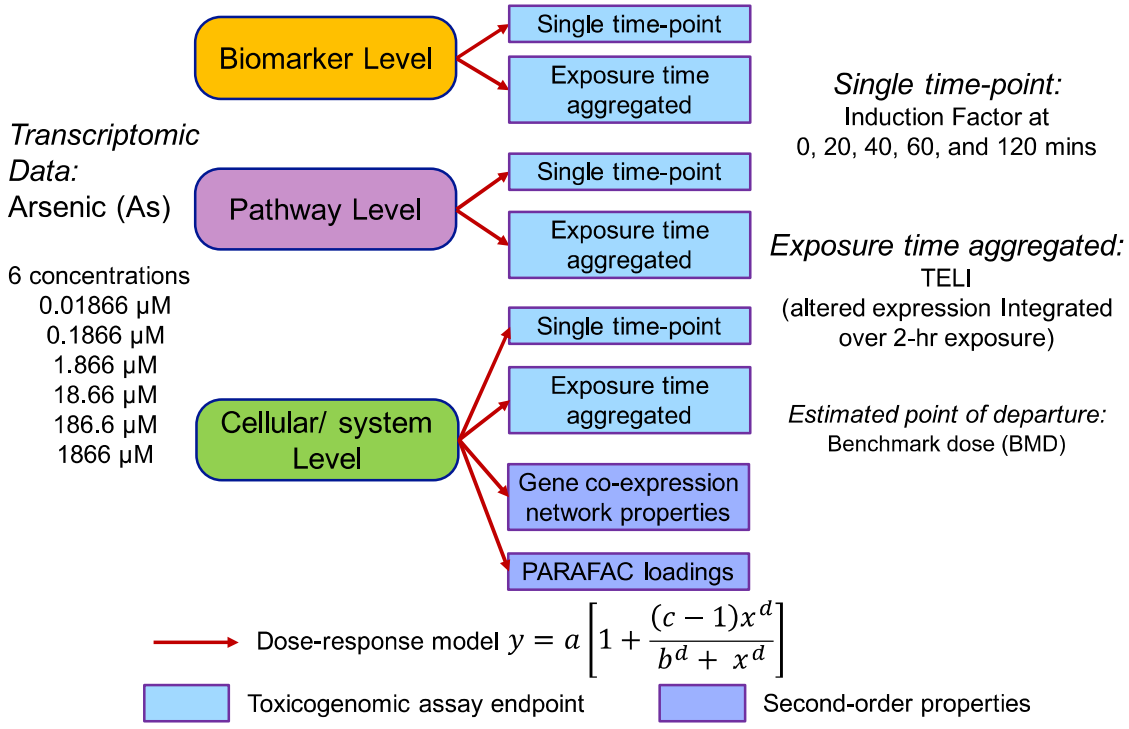


Figure 0-1. Overview of the methodology. Dose-response characteristics of the transcriptomic profiles are quantified at three different biologically relevant molecular levels — biomarker/gene, stress pathway, and cellular/ system level. Dose-response models are generated for static snap-shot or single time-point responses and time-aggregated responses at all three levels. Hill-type model is used to fit the dose-response profiles, from which the benchmark dose is estimated as the point of departure

3.5 Modeling of structure

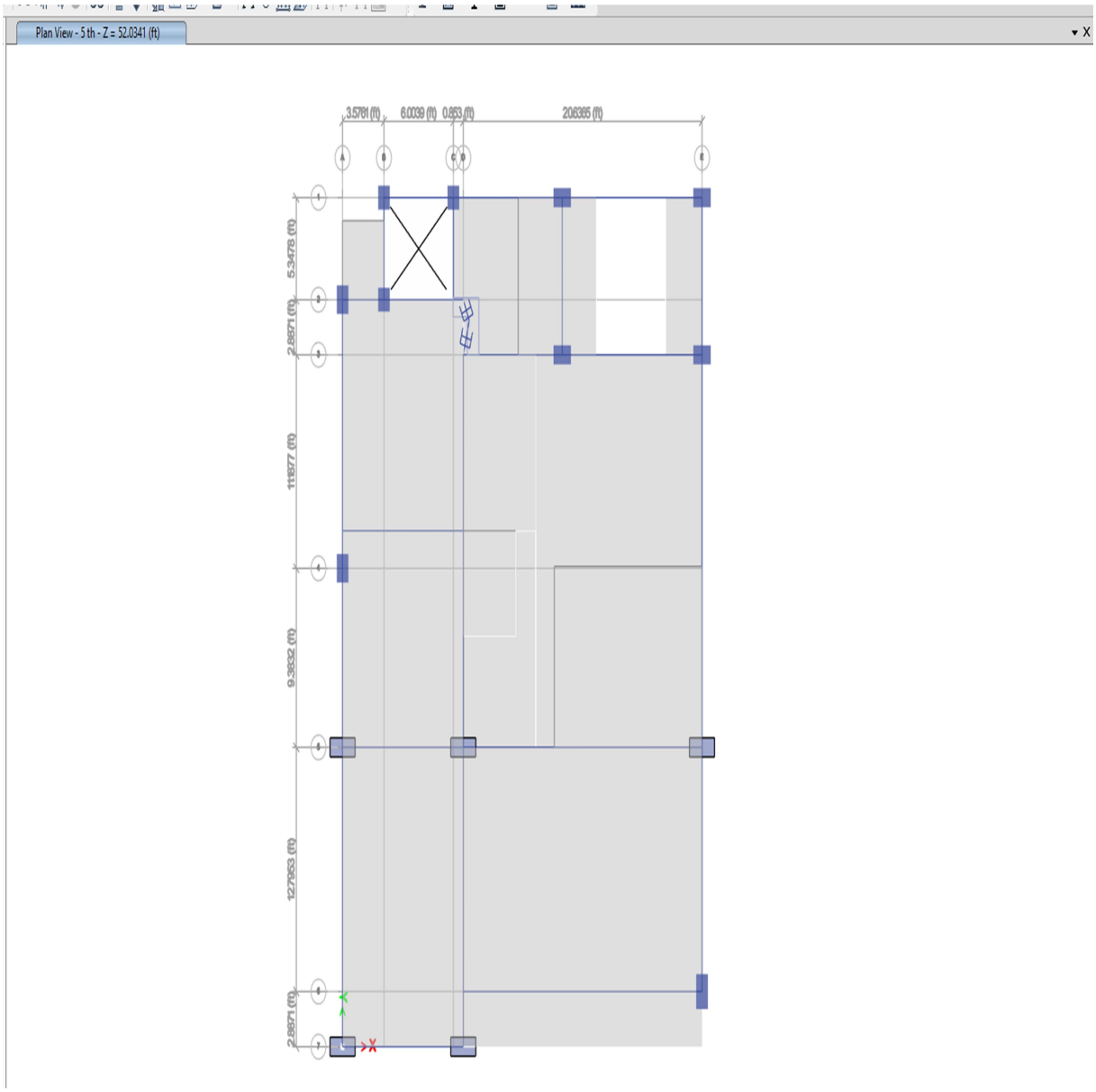


Figure 3.1: 2D Modeling of structure

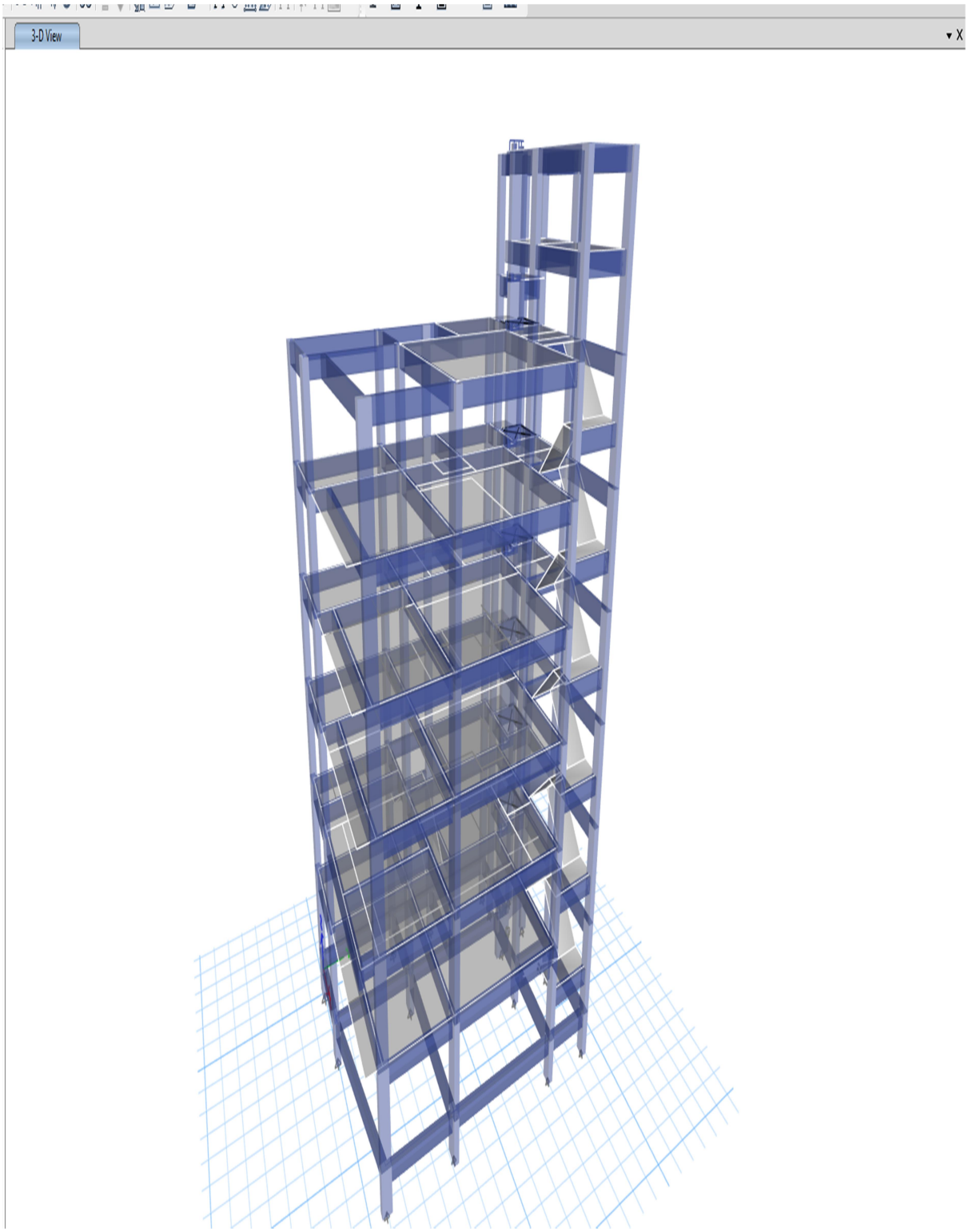


Figure 3.2: 3D Modeling of structure

3.6 Define Load Pattern

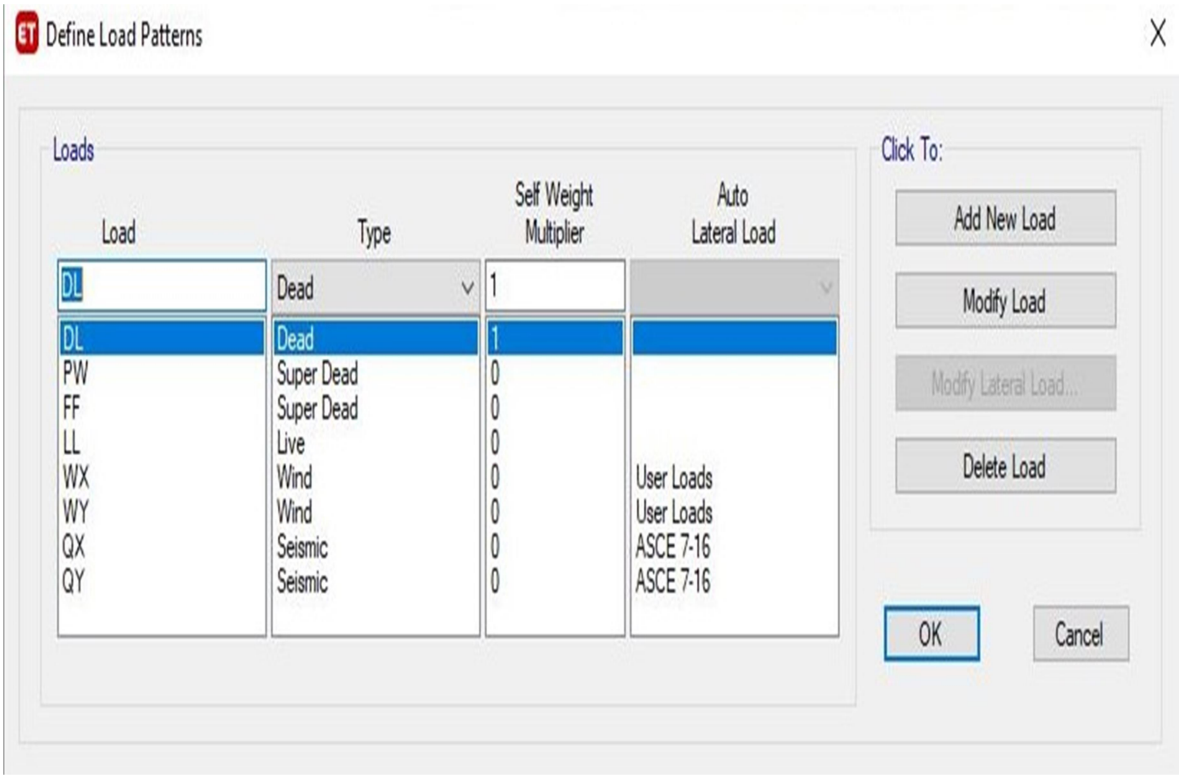


Figure 3.3: Define Load Pattern

3.6.1 Seismic Load Calculation

Seismic engineering looks at the application of earthquake generated agitation to a structure. Damages most often occur where the structure touches the ground or another building. International building code includes the calculation of a seismic load.

Seismic load indicates how much seismic energy (waves of energy that travel through the earth) a structure would need to endure in a specific geographic location.

Seismic loads are calculated by considering the following:

- earthquake parameters at the building site
- the type of materials used to create the structure
- the construction quality of a structure

3.6.2 Seismic Load (Qx):

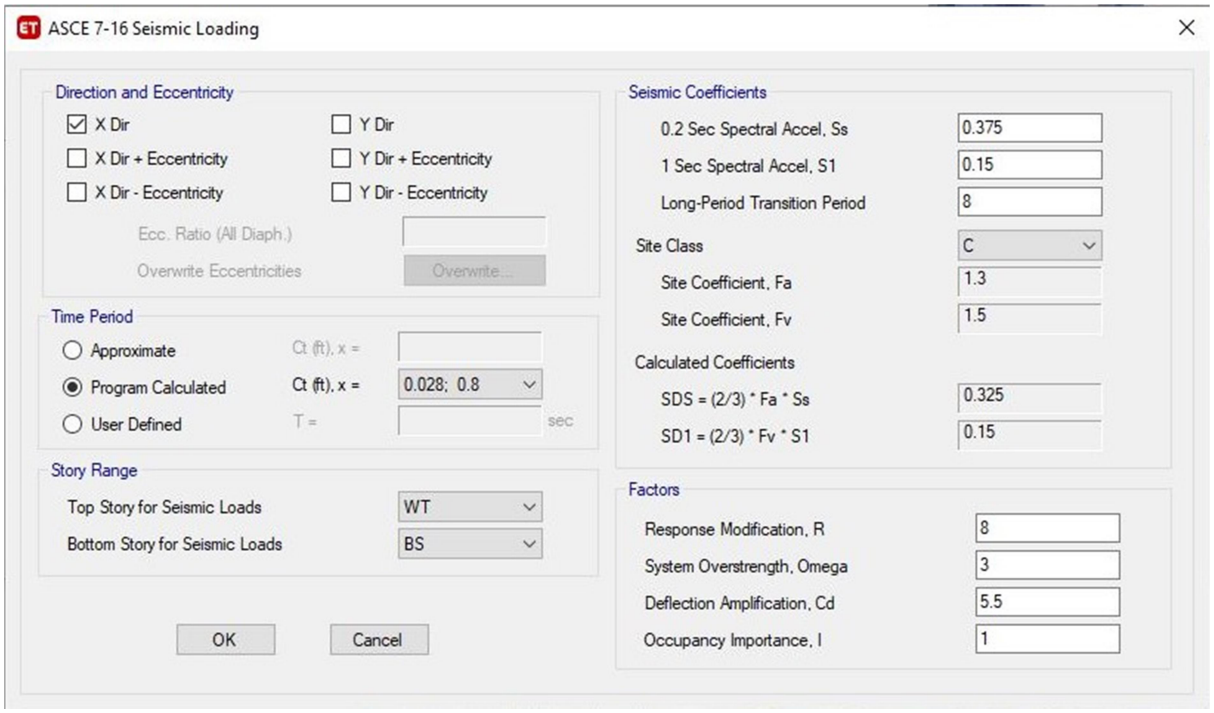


Figure 3.4: Seismic Load (Qx)

3.6.3 Seismic Load (Qy):

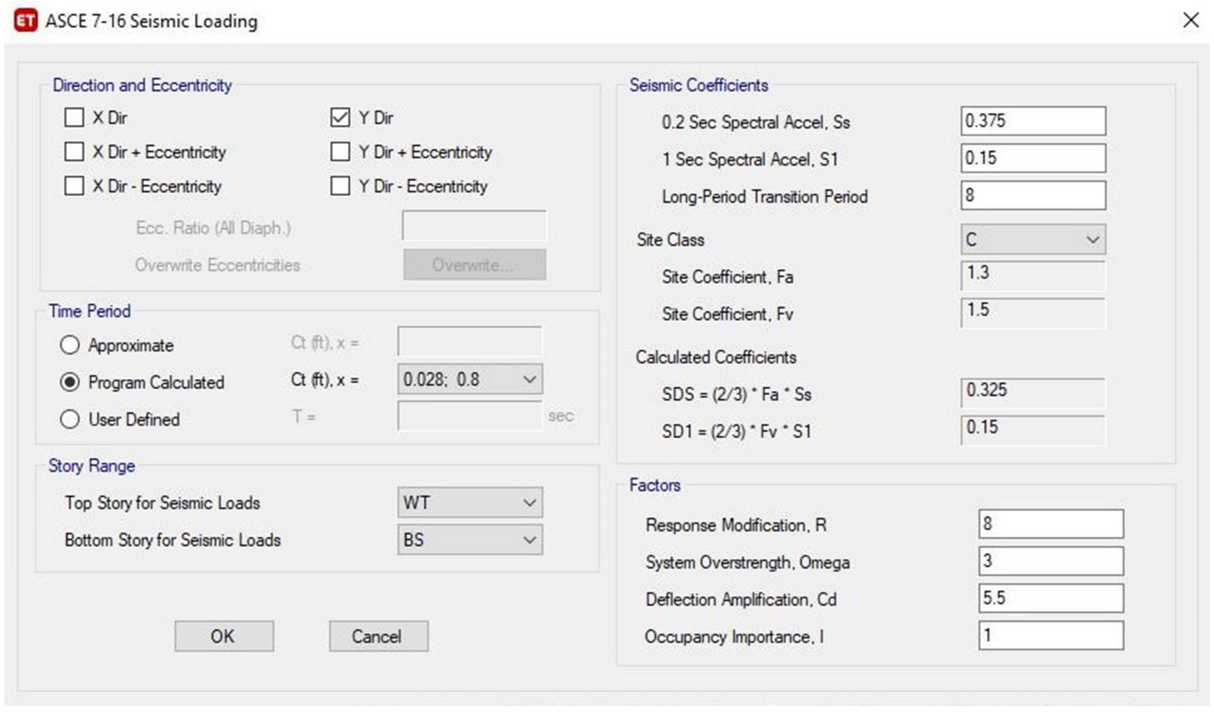


Figure 3.5: Seismic Load (Qy)

3.6.4 Wind Load Calculation

Pressure applied due to the wind on a structure is called wind load. This load gets distributed throughout the surface area of structure.

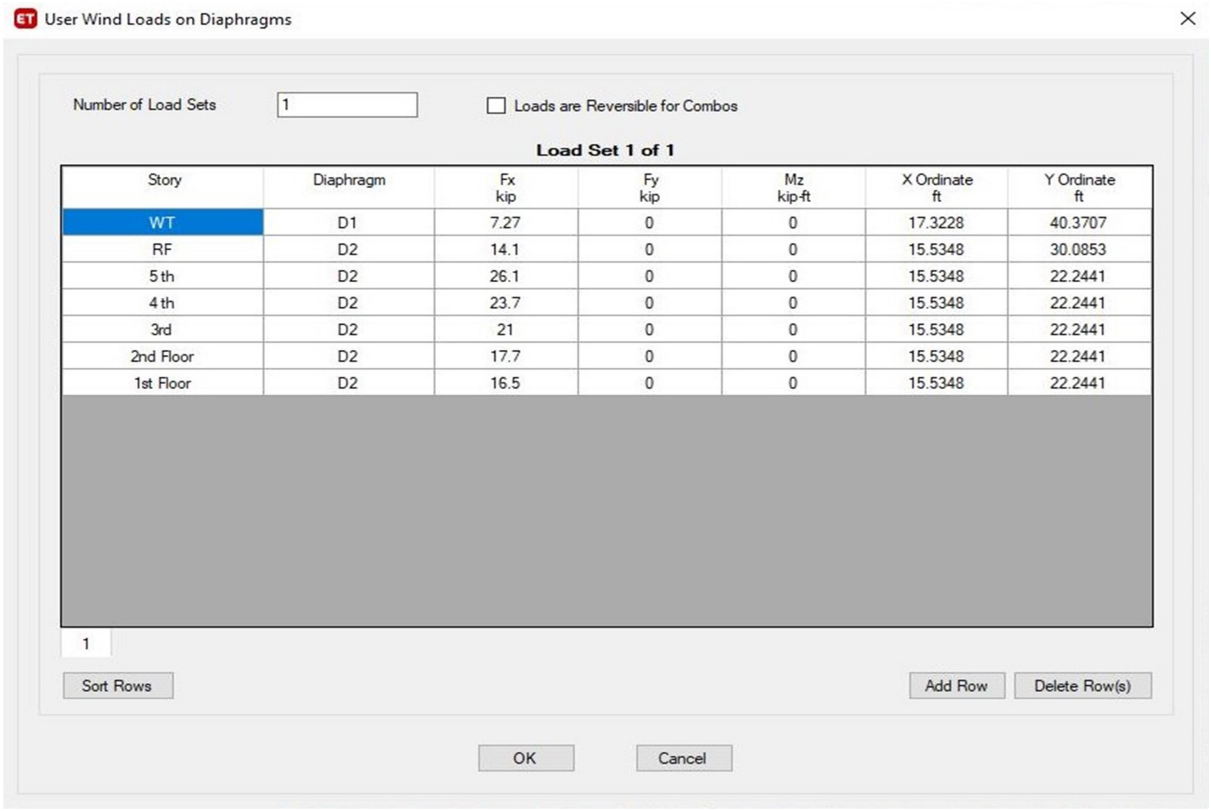
This calculation presents the automatically generated lateral wind loads for load pattern Wx according to ASCE 7-**05**, as calculated by ETABS.

Exposure Parameters

Exposure From = Diaphragms
Exposure Category = B
Wind Direction = 0 degrees
Basic Wind Speed, V [ASCE 6.5.4] V = 146.97 mph
Cp,wind = 0.8
Cp,lee = 0.46

3.6.5 Wind Exposure Width Data Table

Table 3.2 Wind Exposure Width Data



Story	Diaphragm	Fx kip	Fy kip	Mz kip-ft	X Ordinate ft	Y Ordinate ft
WT	D1	7.27	0	0	17.3228	40.3707
RF	D2	14.1	0	0	15.5348	30.0853
5 th	D2	26.1	0	0	15.5348	22.2441
4 th	D2	23.7	0	0	15.5348	22.2441
3rd	D2	21	0	0	15.5348	22.2441
2nd Floor	D2	17.7	0	0	15.5348	22.2441
1st Floor	D2	16.5	0	0	15.5348	22.2441

3.7 DYNAMIC ANALYSIS

One of the most crucial structural analyzes for bridge design is dynamic analysis. Static analysis is a state that does not changes over time because it ignores the effect of time and analyzes the state of equilibrium of forces in an object or system. Therefore, for static analysis problems, the shear force, moment, and deformation inside the member are determined by the size of a given load. Dynamic analysis can be said to be an analysis of the behavior of objects or systems, including changes over time (considering time or frequency).

3.7.1 Load case

Scale factor calculation Scale factor = 386.089
Scaling factor:
U1= Ex/RSx × factor
= 489.87/20804.732 × 386.089 = 9.09
U2 = Ey/RSy × factor
=393.318/19885.66 × 386.089 =7.64

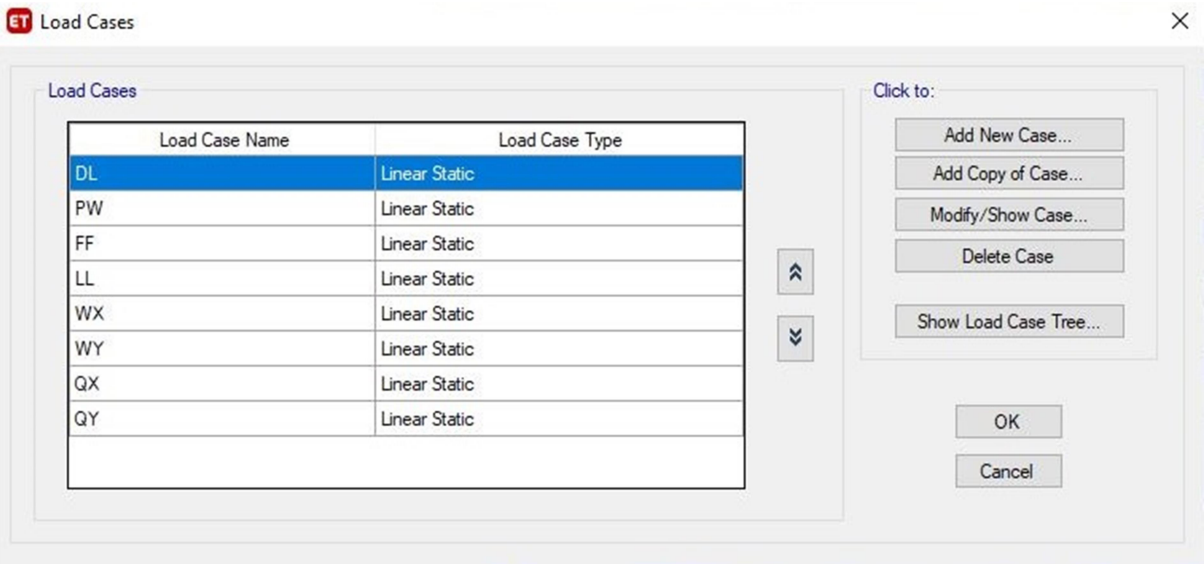


Figure 3.7 Load case

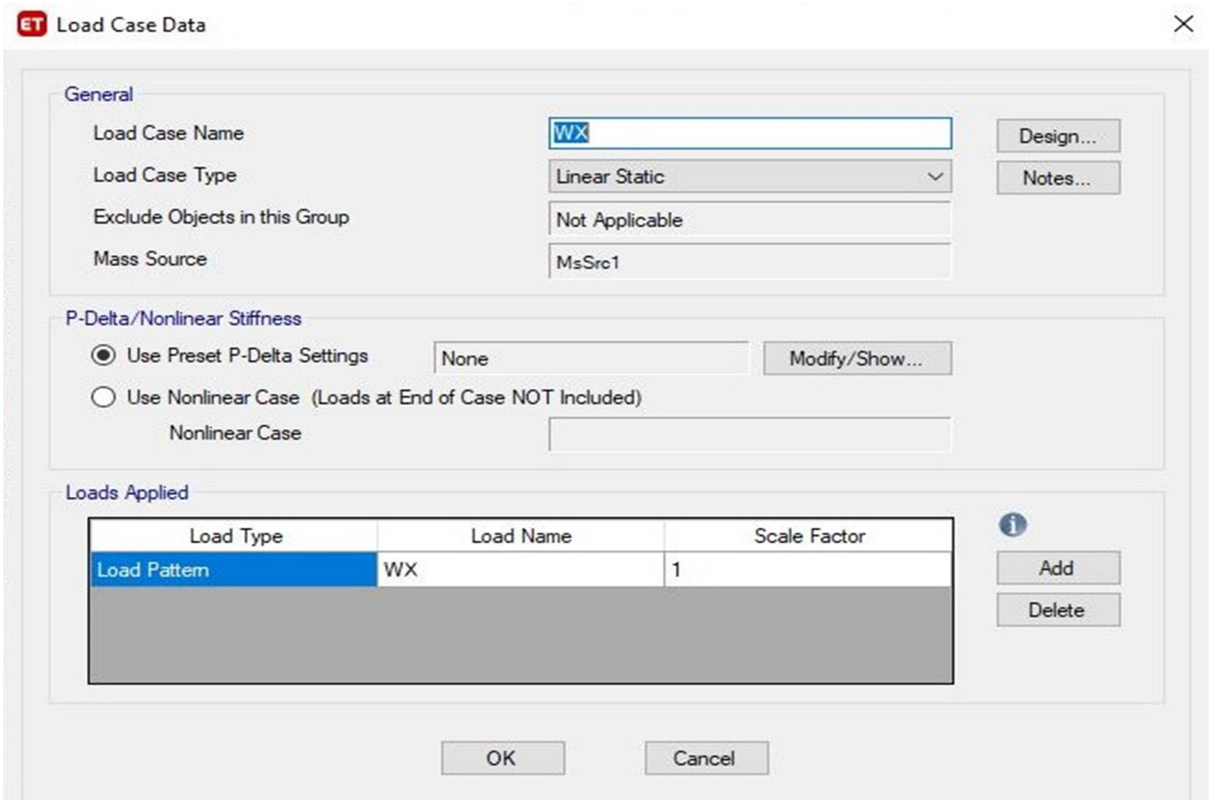


Figure 3.8 Load case

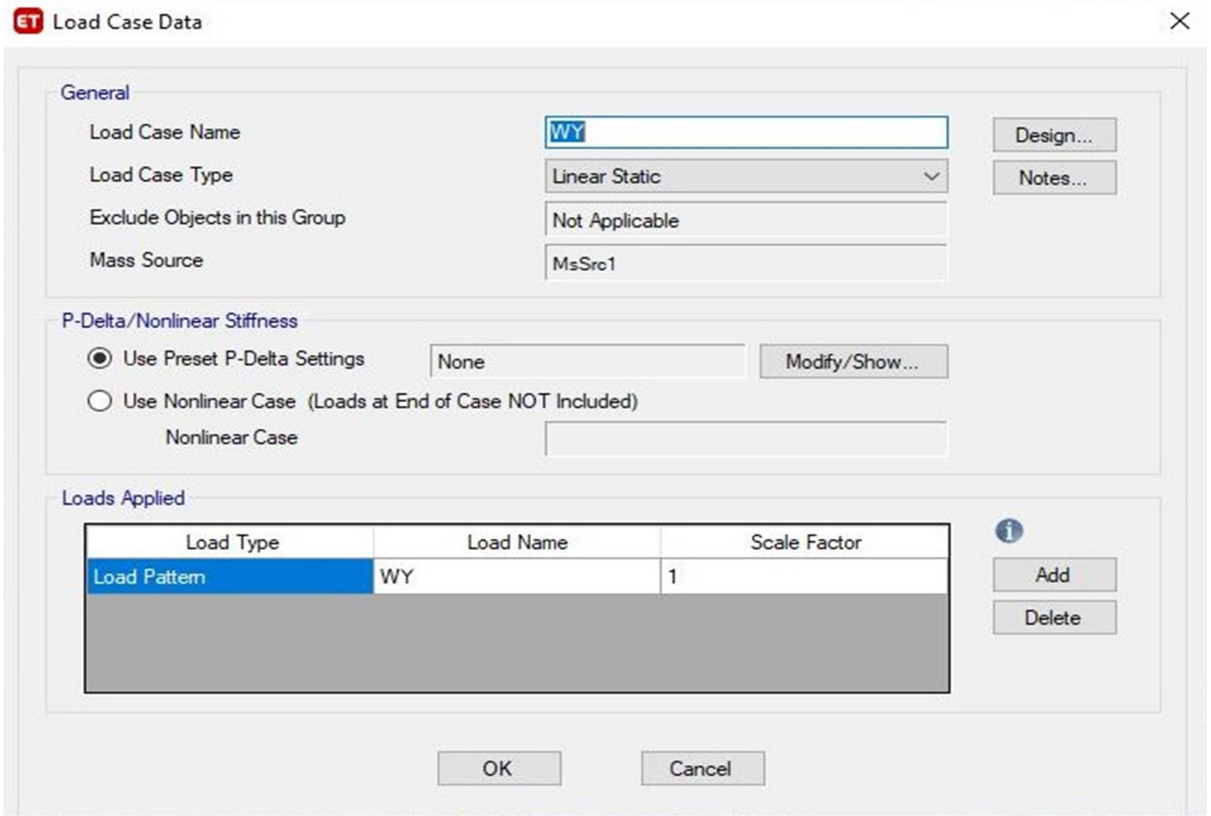


Figure 3.9 Load case

CHAPTER 4
STRUCTURAL ELEMENT DESIGN

4.1 General

In this chapter, the 15 storied building consists of different floor system having regular span is analyzed and designed by ultimate strength design (USD) method. For space limitations, one set of design example is presented here in detail from component of the building such as slab, beam and column. Shown in figures of Elevation view A-A (Shear force 2-2 Diagram), Elevation view A-A (Moment 3-3 Diagram), Elevation view A-A (Axial Force Diagram), Rebar percentage of beam and column.

4.2 Design of building components

Here, Moment is automatic calculation by ETABS, but shown in below one slab, one beam, one column is Non automatic calculation. Detailing provides in APPENDIX, its follows ETABS automatic calculation, steel area and Concrete Gross area.

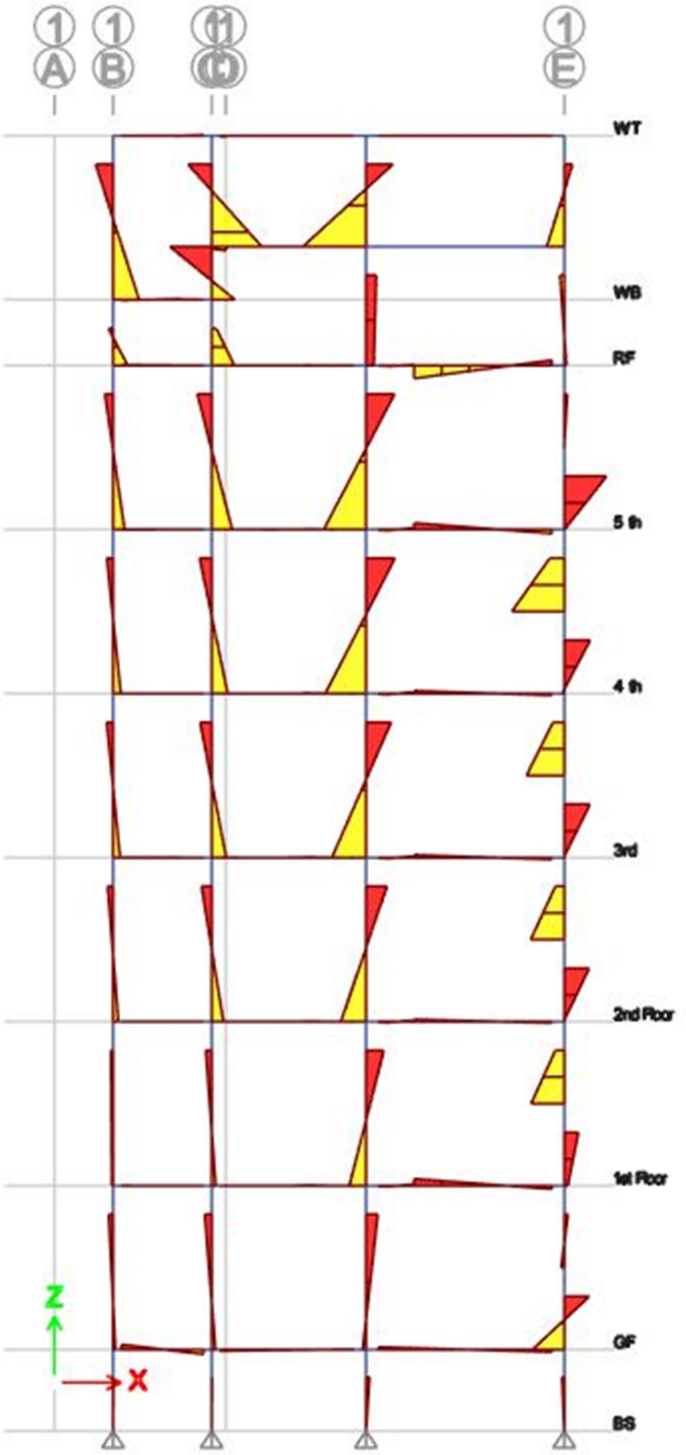


Figure 4.1: Elevation view A-A (Shear force 2-2 Diagram)

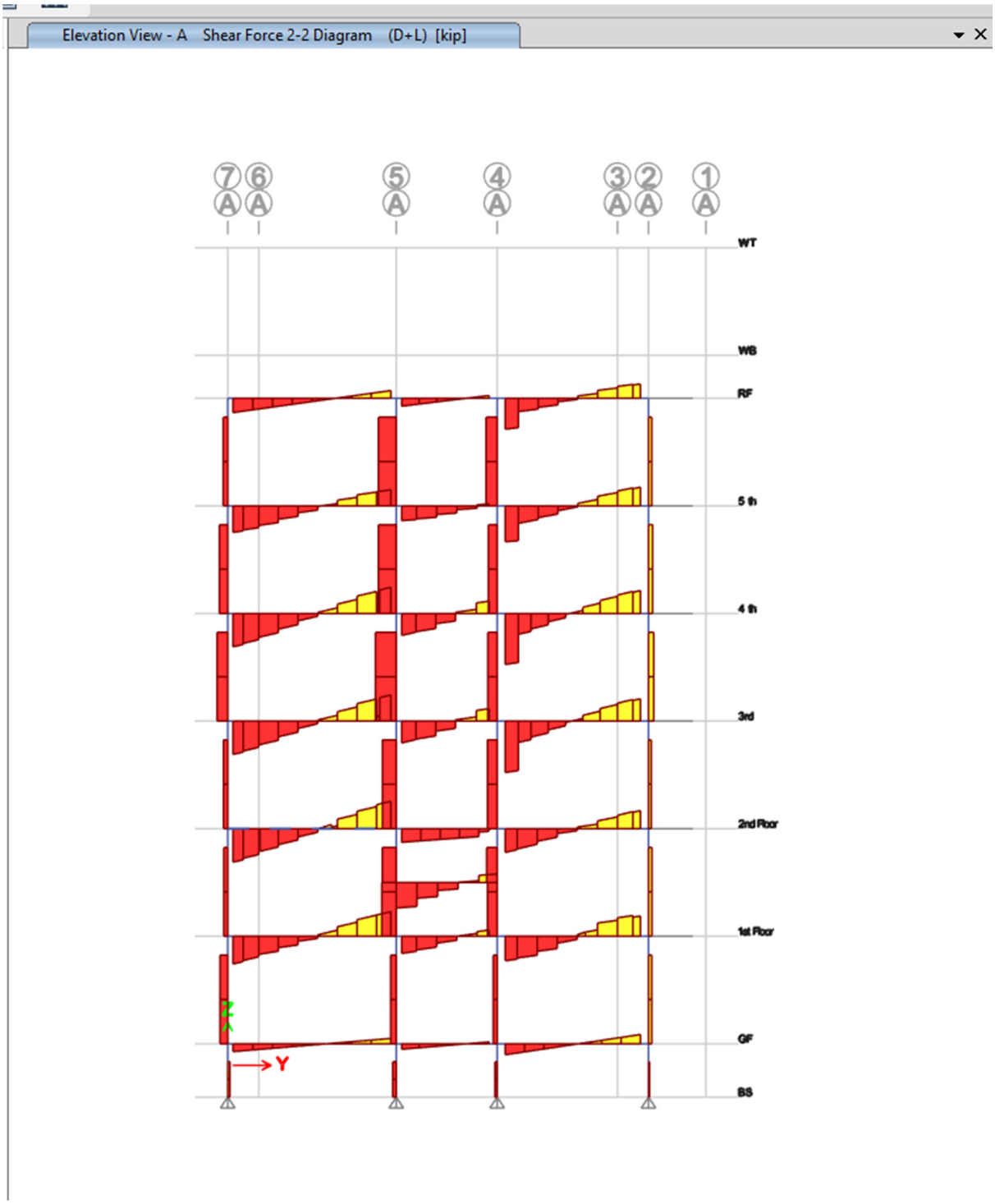


Figure 4.2: Elevation view 1-1 (Moment 3-3 Diagram)

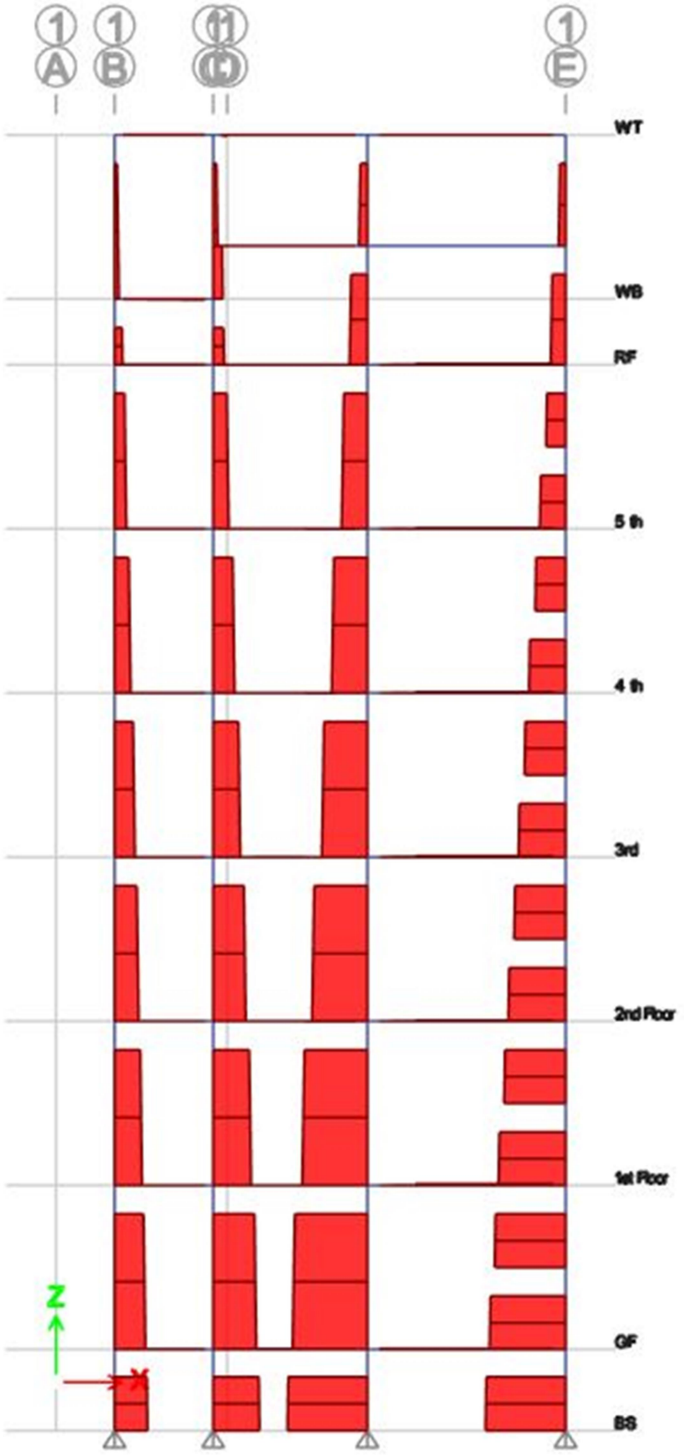


Figure 4.3: Elevation view 1-1 (Axial Force Diagram)

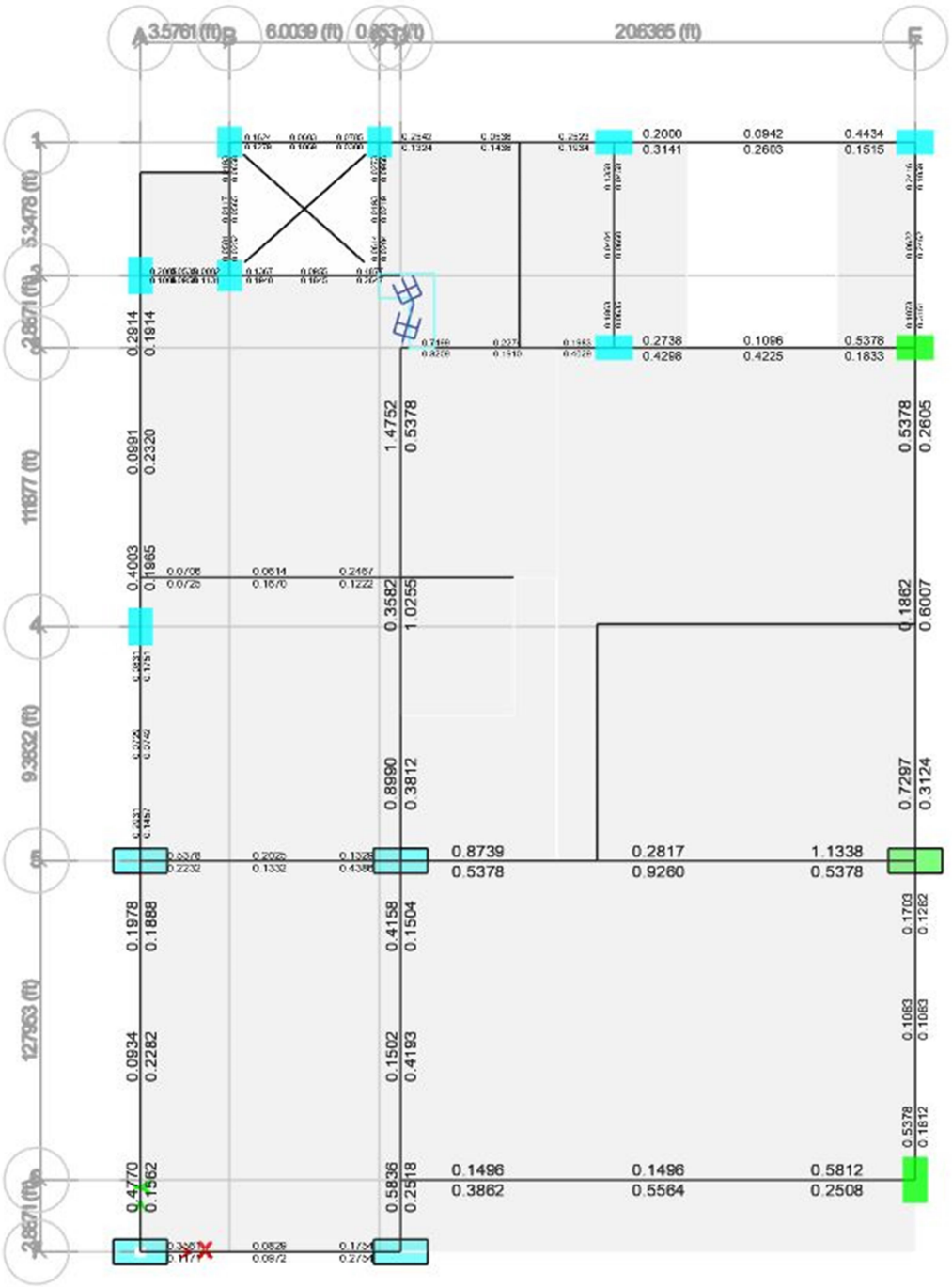


Figure 4.4: Rebar Area of beam

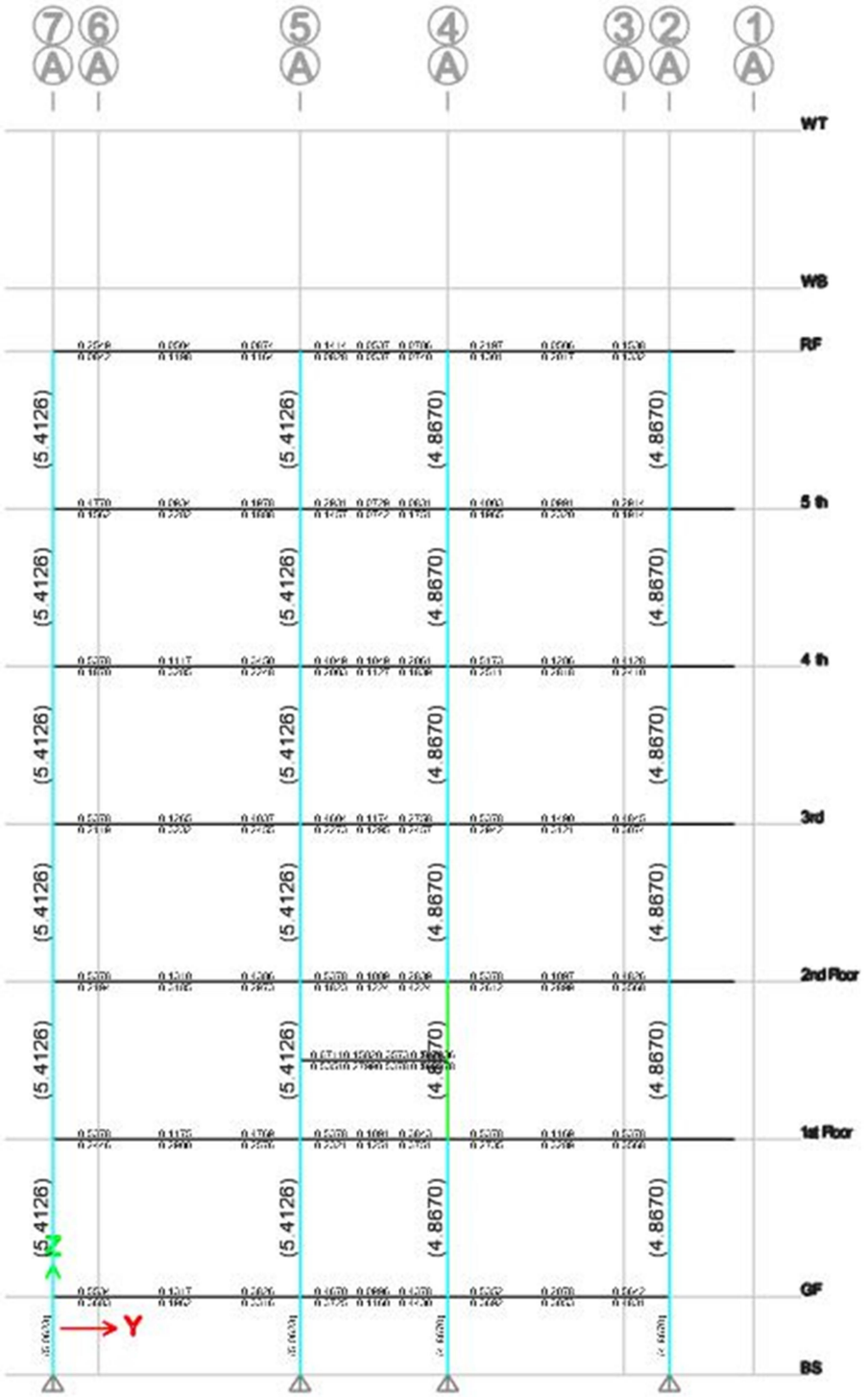
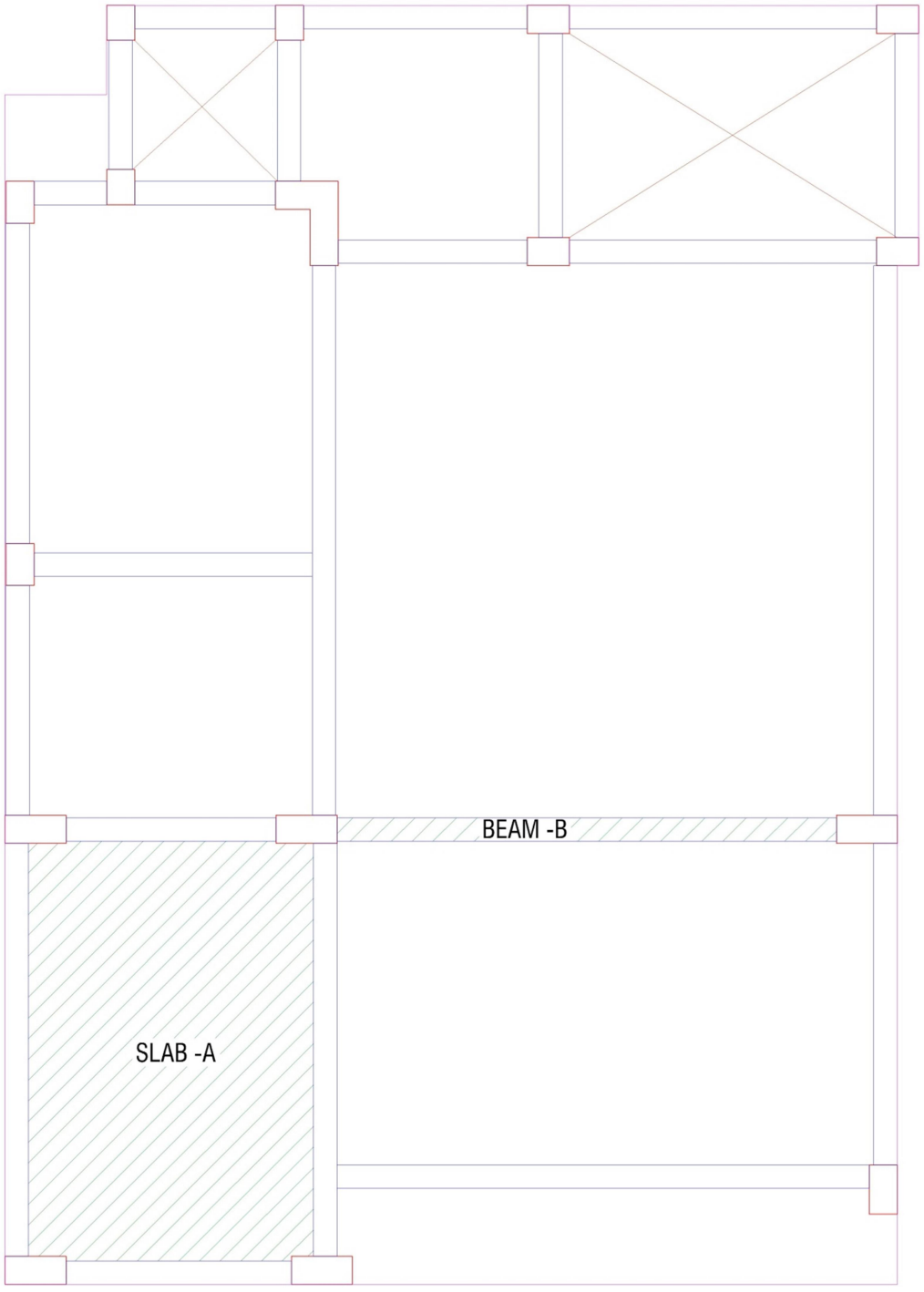


Figure 4.5: Rebar Area of Column



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TYPICAL FLOOR ROOF BEAM LAYOUT PLAN

4.3 DESIGN OF THE EDGE SUPPORTED SLAB BY MCM

A six-storied residential building has edge supported floor system having same panel size of 16.58'x11.75' in each direction. Consider the following design data:
Yield strength of reinforcing bars, fy = 72500 psi
Compressive strength of concrete, f'c =3500 psi
Floor finish, FF = 25 psf
Live load = 40 psf

Design the slab -A Panel.
Solution
Panel size = 16.58'x11.75'
Clear span size (beams are 10" wide) = 14.91' x 9.92'
Panel ratio= La/Lb=14.91/9.92 = 0.67
Panel type = Two-way slab (Case – 4)

Step-1: Slab thickness calculation

Minimum slab thickness, h = $\frac{2(14.91+9.92)x12}{180}$ = 3.31" ≈5.00 > 3.5"

=3.31" ≈5.00 > 3.5"

Effective depth in short direct, ds = 5-1=4
Effective depth in long direction, dl = 5-1.5 = 3.5

Step-2: Load calculation

Self-weight of slab = $\frac{5x150}{12}$ = 62.5psf
Floor finish = 25.0 psf
Live load = 40.0 psf.
Factored load, W = 1.2 DL + 1.6 LL
So, W = 1.2×(62.5+25)+ 1.6×40 = 105 + 64 = 169.00 psf

Step-3: Determination of strip width
Short direction:
Half column strip in short direction =$\frac{l}{4}$ = $\frac{16.58}{4}$ = 4.15'
Full column strip in short direction = 2 x 4.15'= 8.30' = 99.6"
Full middle strip in short direction = 99.6"
Long direction:
Half column strip in long direction = $\frac{l}{4}$ = $\frac{11.75}{4}$ = 2.94'
Full column strip in long direction = 2 x 2.94' = 5.88' = 70.56"
Full middle strip in long direction = 70.56"

Step-4: Moment calculation

A. Short direction

Middle strip moment

-ve moment at interior support:

$M_{a,neg} = Ca \times W \times L^2$

$= 0.081 \times 169 \times 9.92^2$

$= \frac{1347.09 \times 10}{1000}$

= 13.47 k-ft

+vemoment at mid span:

$M_{a,pos} = Ca. \times DL \times L^2 + Ca. \times LL \times L^2$

$= 0.046 \times 105 \times 9.92^2 + 0.057 \times 64 \times 9.92^2$

$= \frac{834.29 \times 10}{1000} = 8.34$ k-ft

-ve moment at exterior support:

$M_{a,neg} = \frac{1}{3} x$ Maximum positive moment

$= \frac{1}{3} \times 8.34 = 2.77$ k-ft

Column strip moment

-vemomentat interior support:

$M_{a,neg} = \frac{2}{3} x M_{aneg} = \frac{2}{3} x 13.47 = 8.98$ k-ft

+ve moment at mid span:

$M_{a,pos} = \frac{2}{3} x 8.34 = 5.56$ k-ft

-ve moment at exterior support:

$M_{a,neg} = \frac{2}{3} x 2.77 = 1.39$ k-ft

B. Long direction

Middle strip moment

-ve moment at interior support:

$M_{b,neg} = Cb \times W \times L^2$

$= 0.019 \times 169 \times 14.91^2$

$= \frac{713.83 \times 8.75}{1000}$

= 6.25 k-ft

+ve moment at mid span:

$M_{b,pos} = Cb. \times DL \times L^2 + Cb. \times LL \times L^2$

$= 0.11 \times 105 \times 14.91^2 + 0.14 \times 64 \times 14.91^2$

$= \frac{4559.54 \times 8.75}{1000}$

= 39.89 k-ft

-ve moment at exterior support:

$M_{a,neg} = \frac{1}{3} x 39.89$

= 13.29 k-ft

Column strip moment

-ve moment at interior support:

M b,neg= $\frac{2}{3}x6.25$

= 4.17 k-ft

+ve moment at mid span:

M b,pos = $\frac{2}{3}x39.89$= 26.60 k-ft

-ve moment at exterior support:

M b,neg = $\frac{2}{3}x13.29$= 8.86 k-ft

Step-5: Check for 'd'

Effective depth will be checked for maximum moment. It is observed that maximum moment occurs at interior support in middle strip in Long direction. So, Mu = 39.89 k-ft = 478.68 k-in

Provided d = 4.0" and middle strip width, b = 70.56"

$$\rho = \rho max = 0.75[0.85 \times 0.85 \times \frac{f'c}{fy} \times \frac{eu}{eu+72500}]$$

$$\rho = \rho max = 0.75[0.85 \times 0.85 \times \frac{3.5}{72.5} \times \frac{87000}{87000+7250}]$$

$$= .0143$$

$$D\ req = \sqrt{\frac{478.68}{.9x.0143x72.5x70.56(1-.59x0.0143x\frac{72.5}{3.5})}}$$

=2.97 inch<4 inch [OK]

Step-6: Steel calculation

Based on moment, reinforcements in both directions are calculated.

Main steel for floor: Sample calculation (short direction): # Interior –ve, column strip moment, Mu = 8.98 k-ft

Column strip width, b = 99.6"

Total depth, h =5.0"

Effective depth, d= 4"

Selected bar is #3 and Ab= 0.11 in^2

Minimum steel requirement for 72.5-grade bar,

Ast = 0.0018x60000 /72500= 0.0015 in^2

Total required reinforcement

$$As\ req = .85x\frac{3.5}{72.5}[1-\sqrt{1-\frac{2x8.98x1}{.85\ \ .9x3.5x99.6x16}}]\ x99.6x4$$

$$= 1.52\ in^2 > .11in^2$$

S max=2h or 18" =10"

Spacing, S = $\frac{b}{n-1}$

$10 = \frac{99.6}{n-1}$

n=11 Nos

Spacing=$\frac{99.6}{11-1}$ = 9.96"

Sample calculation (long direction):

Interior –ve, middle strip moment, Mu = 6.25 k-ft Middle strip width, b= 70.56" Total depth, h =5.0" Effective depth, d = 3.5" Selected bar is #3 and Ab= 0.11 in^2

As req=. $85x\ \frac{3.5}{72.5}[1-\sqrt{1-\frac{2x6.25x12}{.85x.9x3.5x70.56x12.25}}]$ x70.56x3.5

=0.32 in^2>.11in^2

S max=2h or 18" =10"

Spacing, S = $\frac{b}{n-1}$

$10 = \frac{70.56}{n-1}$

n=9 Nos

Spacing=$\frac{70.56}{9-1}$

=8.82"

Table 4.1: Slab-A Design for Short direction

Location		Mu k-ft	Stripwidth*b* (in)	D i n	*As(Min)*	**Asreq=***ρ bd*in^2	Provided As in^2	Use *#3* as mainbar Spacing
Fullcolumnstrip	-veint.	8.98	99.6	4	0.0015	1.52	1.52	9.96"c/c
	-veext.	1.39	99.6	4	0.0015	0.23	0.23	9.96"c/c
	+ve Midspan	5.56	99.6	4	0.0015	0.94	0.94	9.96"c/c
Fullmiddlestrip	-veint.	13.47	99.6	4	0.0015	2.28	2.28	9.96"c/c
	-veext.	2.77	99.6	4	0.0015	0.47	0.47	9.96"c/c
	+ve Midspan	8.34	99.6	4	0.0015	1.41	1.41	9.96"c/c

Table 4.2: Slab-A Design for long direction

Location		Mu k-ft	Strip width *b* (in)	D in	As_{min} in^2	**As req = *ρbd*** in^2	Provided As in^2	Use *#3* as main bar Spacing
Full column strip	-ve int.	4.17	70.56	3.5	0.0015	0.21	0.21	9.5" c/c
	-ve ext.	8.86	70.56	3.5	0.0015	0.45	0.45	9.5" c/c
	+ve Mid span	26.60	70.56	3.5	0.0015	1.36	1.36	9.5" c/c
Full Middle strip	-ve int.	6.25	70.56	3.5	0.0015	0.32	0.32	9.5" c/c
	-ve ext.	13.29	70.56	3.5	0.0015	0.68	0.68	9.5" c/c
	+ve Mid span	39.89	70.56	3.5	0.0015	2.04	2.04	9.5" c/c

4.4 Concrete Beam Design

Beam Label	Section Property	Length	Section Width	Section Depth	Distance to Top Rebar Center
F5	B10X21	17.75ft	10 in	21 in	2.5 in

Table4.6: Geometric Properties (Part2of2)

Distance to Bot. Rebar Center
2.5 in

Concrete Comp. Strength	Concrete Modulus	Longitudinal Rebar Yield	Shear Rebar Yield
3500 lb/in²	3372165.48 lb/in²	72518.86 lb/in²	72518.86 lb/in²

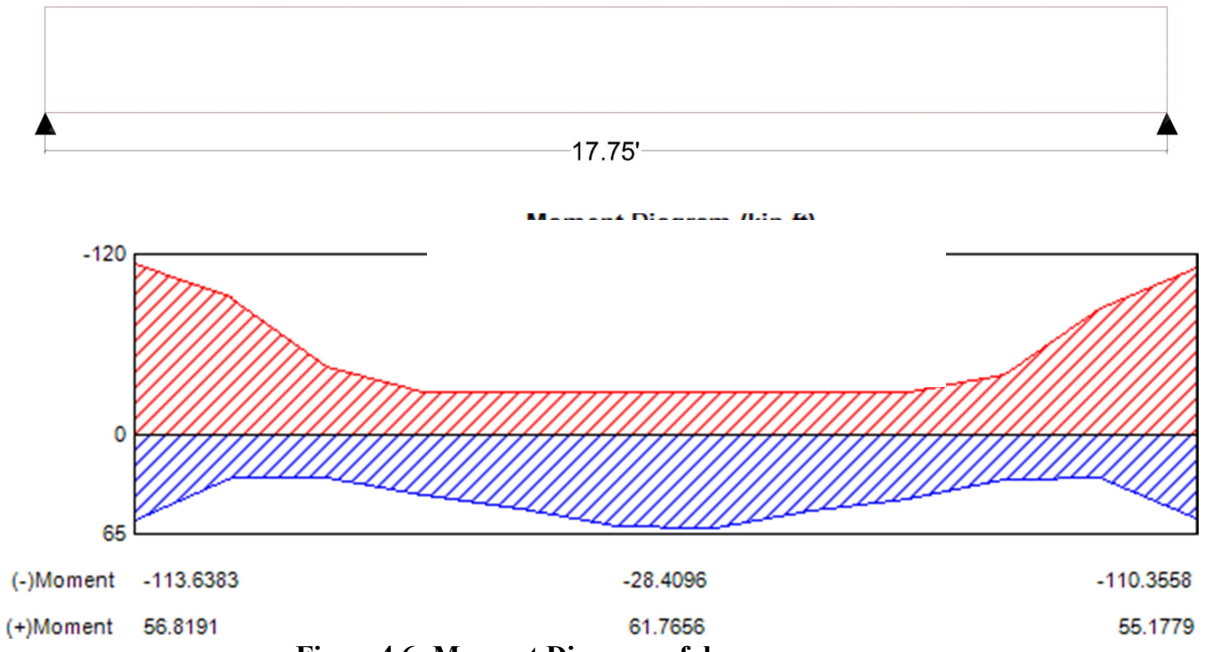


Figure4.6: Moment Diagram of beam

Design of RCC Floor Beams:
Design materials:
fy **= 72,500 psi**
f'c **= 3,500 psi**
Wc **= 150 pcf**
Wbrick **= 120 pcf**
All beams have same dimension 10″ x 21″
Check for seismic requirements as per ACI Code:

a)$\frac{Clear\ Span}{Effective\ Depth}$≥4
Here,
Clear span, ln =213"
Effective depth, d = 21-1.5 = 19.5"
Ln/d=213/19.5=10.92>4 [ok]

b)$\frac{Width}{Dept}$≥ 0.3
h/b= 10/21 =0.47>0.3 ok.

Again, Beam Width ≤ Column width+1.5 x Beam Depth
⇨ 10 ≤ (12+1.5x21 = 43.5) ok.

d) Positive moment capacity at both supports should be ≥ 50% of the negative moment capacity at those supports.
Here,
+ M1 = 56.8191 K-ft + M 2 = 55.1779 K-ft
- M 1 = 113.6383 K-ft - M 2 = 110.3558 K-ft
$\frac{+ME1}{-ME1}$= $\frac{56.8191}{113.6383}$= 0.5 ≤ 0.50 ⇄ok·$\frac{+ME2}{-ME}$= $\frac{55.1779}{110.3558}$ = 0.5 ≤ 0.50 ⇄ok
e) Mid span moment should be ≥ 0.25 times the maximum moment at both supports.
Here,
mid span moment = 61.7656 K-ft
Maximum support moment = 113.6383 K-ft
= $\frac{61.7656}{113.6383}$

f) Material Properties:
$f'c$= 3500 psi > minimum $f'c$= 3000 psi ok.
fy= 72500 psi

Check effective depth:
ρmax = 0.025
$d = \sqrt{\frac{M}{\varphi \times \rho y f y \frac{fy}{f'c}}} = \sqrt{\frac{113.6383}{.9x.025x12x72.5x(1-.59x.025X\frac{72.5}{3.5})}}$
=10.02" >15.5" **ok.**

Longitudinal reinforcement calculation:

1. Top Reinforcement (joint-A):

Negative moment = 113.6383K-ft

Clear span at A to B = 17.75ft

M = ϕ As fy (d – a /2)

Compression zone,

a = $\frac{\mathbf{As \times fy}}{\mathbf{0.85f'c \times bw}}$

$$= \frac{\mathbf{As \times 72.5}}{\mathbf{0.85 \times 3.5 \times 12}}$$

= 2.03 As

Use one layer reinforcement without separator, so the effective depth d = 15.5″

$$As = \frac{\mathbf{113.6383\ x\ 12}}{\mathbf{.90 \times 72.5 \times (19.5 - \frac{2.03}{2})}}$$

= 1.34 in²

Use 3#6 Straight Bar Ap= 3 x .45= 1.35 in^2

Check for ρ

$\rho = \frac{\mathbf{1.35}}{\mathbf{10 \times 19.5}}$ = 0.0068< .0250

$\rho(min) = \frac{\mathbf{200}}{\mathbf{72500}}$ **=.00275 , So** the provided reinforcement is ok

2. Bottom Reinforcement (both joints):

Positive moment = 61.7656 K-ft

Clear span at A to B = 17.75ft

M = ϕ As fy (d – a /2)

Span/4= 4.44' =53"

Compression zone,

$$a = \frac{\mathbf{As \times fy}}{\mathbf{0.85f'c \times b_{eff}}}$$

$$= \frac{\mathbf{As \times 72.5}}{\mathbf{0.85 \times 3.5 \times 53}}$$

= 0.477 As

Use one layer reinforcement without separator, so the effective depth d = 19.5″

$$As = \frac{\mathbf{61.7656\ x\ 12}}{\mathbf{.90 \times 72.5 \times (19.5 - \frac{.477}{2})}}$$

= 0.589 in²

Use 3#5Staright Bar Ap= 3 x .31=0.93 in^2

Check for ρ

$\rho = \frac{\mathbf{.93}}{\mathbf{10 \times 19.5}}$ = 0.0046< .0250

$\rho(min) = \frac{\mathbf{200}}{\mathbf{72500}}$ **=.00275 , So** the provided reinforcement is ok

3. Mid-span Reinforcement:
Positive moment at mid span = 61.7656 K-ft
Use 3 # 5 straight bars, Ap = 3×0.31= 0.93 in^2 and +MU = 61.7656K-f

1. **Splicing Reinforcement**

a) Splice Length For top bars, class A and for bottom bars, class B lap splices will be provided.

Total splice length for top bars = $l_d \geq$ 12"
Total splice length for bottom bars = 1.3 $l_d \geq$ 12"

Here,

For #5 Top Bar

$d_b f_y$= .004 x .875 x72500 =25.37"
Splice length for # 5 (bottom) bars = 1.3 × 25.37 = 32.98" ≈ 33"

For #6 Top Bar

$d_b f_y$= .004 x .44 x72500 =12.76"
Selected l_d= 22"

b) **Splice Location**

* Lap splices of the bars should not be placed within the beam-column joint and within a distance 2h = 2×20 = 40" from both support faces.
* Lap splices of bottom bars should be made immediately beyond the 2h distance. 87 ANALYSIS AND DESIGN OF A 15-STOREY RESIDENTIAL RCC BUILDING STRUCTURE
* Lap splices of top bars should be placed at or near mid span.

c) Confinement of Splices

Total splice length of top & bottom bars should be confined by close hoops with seismic hooks. Spacing, S = d/4 = 19.5/ 4 = 4.875" S = 4"
So, provide # 3 closed hoops with seismic hook @ 4" c/c along the total splice length.

4.5 COLUMN DESIGN

Table 4.8: Column Element Details

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (in)	LLRF	Type
Story 1	**C1**	**42**	**C12X18**	**Envelope**	**0**	**120**	**1**	**Sway Special**

Table 4.9 : Material Properties

E_c(lb/in^2)	f'_c(lb/in^2)	Lt.Wt Factor (Unitless)	f_y(lb/in^2)	f_{ys}(lb/in^2)
3372165.4	**3500**	**1**	**72500**	**72500**

Table 4.10: Axial Force and Biaxial Moment Design for Pu , Mu2 , Mu3

Design Pu kip	Design Mu2 kip-ft	Design Mu3 kip-ft	Minimum M2 kip-ft	Minimum M3 kip-ft	Rebar Area in²	Rebar % %
486.70	49.6623	-51.0354	47.0464	58.5401	3.60	1.67

Story height = 10 ft.
Type of column = Rectangular tied

l) Load calculation:

Design Pu =486.70 kip [From ETABS]
II) Check for column size:
Pu = φrA [0.85 f 'c (1− ρg) + ρgfy]
480.462 = 0.65*0.80* Ag [0.85*3.5(1-0.025) +0.025*72.5]
Ag = 198.59 in^2< Provided Ag = 216 in^2
So column size 12" x 18" has been accepted.

III) Calculation of As

Pu = φr[0.85 f 'c(Ag-Ast) +Astfy] 766.245
486.70= 0.65*0.80[0.85*3.5(216-Ast) +Ast*72.5]
Ast= 3.49 in^2

Check Minimum steel areas:

1. Based on minimum 4Ø16mm bars, steel areas = 4 x 0.31 = 1.24 in^2

2. Based on ρg, minimum steel areas = 1% of Ag = 0.01 x 216 = 2.16 in^2

So here we are using steel area As= 4.21 in^2

So use 4 #20mm bars and 6 #16mm provided steel Ap = 3.60 in^2

IV) Tie bar design:

Use Ø10mm as main tie since main bar size is Ø16mm < Ø32mm.
Spacing of the tie bar:
S = 16 main bar dia = 16*9/8 = 18″
S = 48 tie bar dia = 48*3/8 = 18″
S = least column dimension = 15″ So use Ø10mm@ 15″c/c

4.6 Design of Septic Tank

Design of a septic tank for 100 users provided with water supply at a rate of 140 litres per capita per day –

Quantity of water per person per day = 140 litres.

So, total quantity of water for 100 persons per day = 140 × 100 = 14000litres.

• Assume 80% of water becomes sewage.

So, amount of sewage water is = 14000 x 0.8 = 11200litres /day.

• Assume detention period for 24 hours

So, amount of water in the detention period = 14000× 24/24 = 14000litres

. • Assume, rate of deposition of sludge as 30 litres/capita/ year.

So, for 100 users the amount of sludge is = 100× 30 = 3000litres.

So, Total Capacity of tank required is →

=14000+3000 = 17000 litres. [1 m^3 = 1000 litres]

= 17.00 m³ (V-Volume)

• Assume, liquid depth is 2 m Surface area of the tank (A)=17/2 = 8.5 m²

Now, We are provide two septic tank

So, each septic tank area A = 8.5/2 =4.25m^2

Take, L/B ratio = 3 [L= length of the tank]

So, L = 3B [B= width of the tank]

Now, area A=L × B=4.25

Or, 3B x B = 4.25

Or, B = 1.19 m ≈ 1.2 m

L = 3 × B = 3 × 1.19 =3.57 m ≈ 4.0m

• Assume, free board = 0.3 m So, total depth of tank= 2+0.3=2.3m

Each septic tank size is – 4.0m × 1.2m × 2.3m = (13.5ft × 4 ft×8ft)

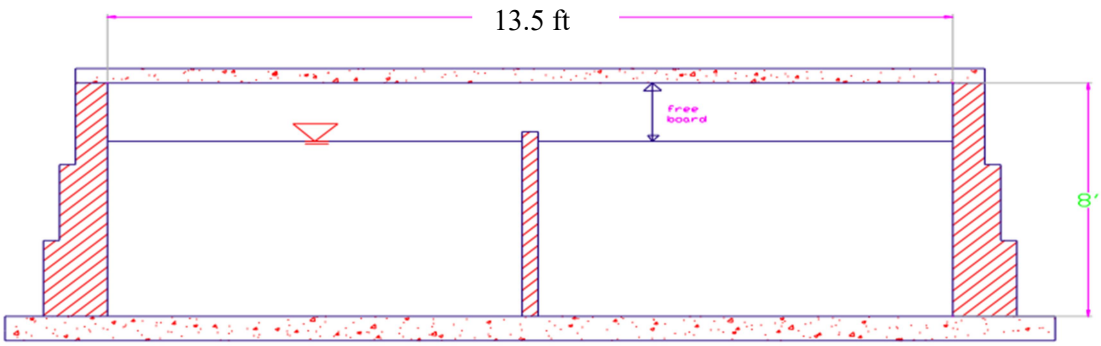


Figure 4.7: Septic tank

4.7 Results and Findings

Comparative Report between ETABS and Manual Calculation

Component	Type	ETABS		Manual Calculation	
		Cross Sectional Area ($in2$)	Reinforcement Area ($in2$)	Cross Sectional Area($in2$)	Reinforcement Area ($in2$)
Floor Beam	FB1	210	0.5,0.37,0.6	180	0.56,0.32,0.55
	FB2	210	0.3,0.19,0.31,	180	0.34,0.14,0.28,
	FB3	210	0.7,0.53,0.71	180	0.76,0.53,0.68
	FB4	210	0.14,0.21,0.36	180	0.16,0.29,0.42
	FB5	210	1.41,1.21,1.67	210	1.93,0.93,1.7
	FB6	210	0.50,0.13,0.45	180	0.51,0.15,0.4
	FB7	210	0.54,0.7,0.83	210	0.59,0.72,0.8
	FB8	210	0.63,0.32,0.39	210	0.7,0.4,0.52
	FB9	210	0.14,0.07,0.11	180	0.2,0.12,0.19
	FB10	210	1.28,1.38,2.01	210	1.48,1.58,2.2
	FB11	210	0.14,0.07,0.11	180	0.19,0.11,0.17
	FB12	210	1.04,0.79,0.80	210	1.24,0.95,0.89
	FB13	210	0.38,0.19,0.31	180	0.45,0.29,0.39

Component	Type	ETABS		Manual Calculation	
		Cross Sectional Area ($in2$)	Reinforcement Area ($in2$)	Cross Sectional Area($in2$)	Reinforcement Area ($in2$)
Column	C1	216	4.8670	216	3.8146
	C2	180	4.1012	180	3.8146
	C3	216	4.8670	216	3.8146
	C4	312	5.4126	312	5.4102
	C5	240	5.1170	240	4.4380
	C6	552	5.9623	552	5.2358

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 General

The purpose of this chapter is to highlight some of the learning techniques and strategies described in previous chapters and to add a few generalizations.

5.2 Conclusion

From the study, it is observed that:

- Preparation of Residential Floor plans for modern types requires comparatively more efforts, attention and considerations according to the need of rentable spaces, owner desires, aesthetics, cost, safety and comfort of the user.
- Proper knowledge on software is essential for analysis of high-rise structure.
- Selection of loadings, materials & their properties should meet the requirement of building codes properly.
- Seismic design requires more detailing works to achieve structural ductility and required strength for structural members.
- The thickness of each panel of the floor slab is varied depending on the size of the panel. However, a unique slab thickness is used for all panels to achieve uniformity in thickness which helps easier distribution of floor reinforcement.

5.3 Recommendations for future work

Based on the scopes and limitations of this study, few recommendations which can be studied further are the followings.

- Foundation design is not covered this Study. Further study may include the design of foundation.
- Cost comparison is an important component for all types of projects. It must be done before finalizing the structure design of a building. It is not considered for the study and recommended for future study.
- This study was conducted based on Edge supported floor system and hence can be extended for flat slab or flat system.
- Sway and deflection effect may be considered in analysis and design

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Appendix A

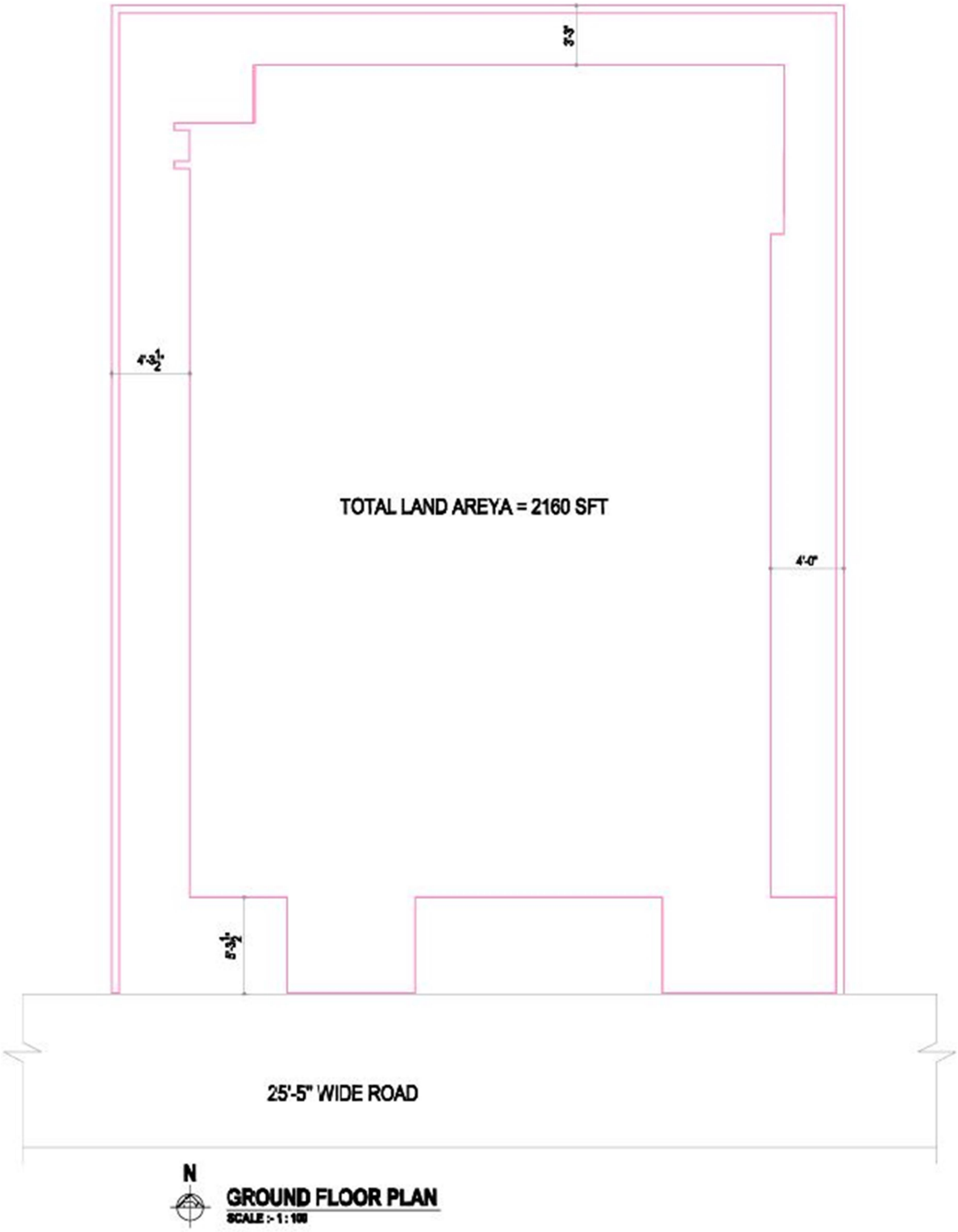


Figure A-1: Plan layout

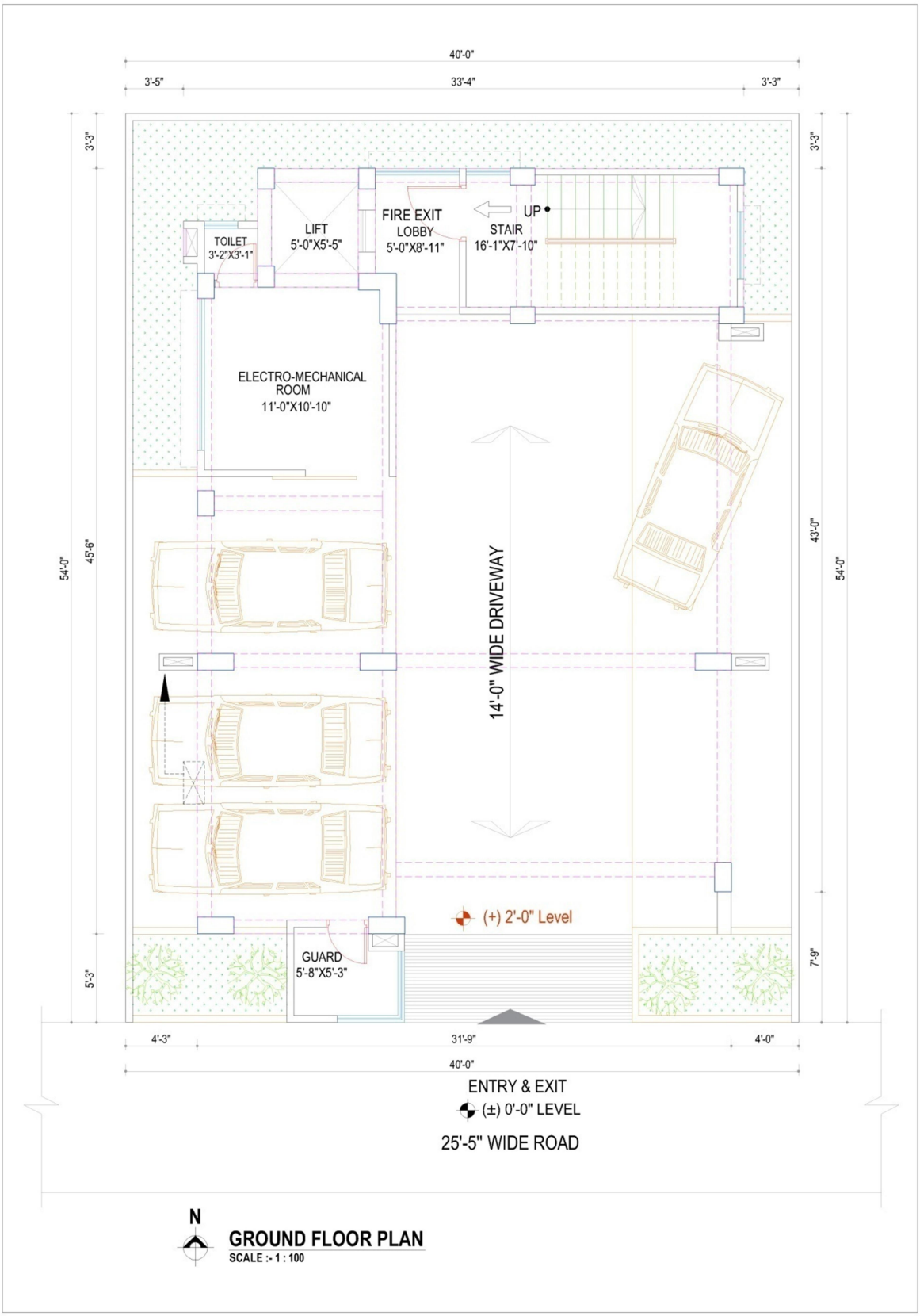


Figure A-2: Ground Floor Plan

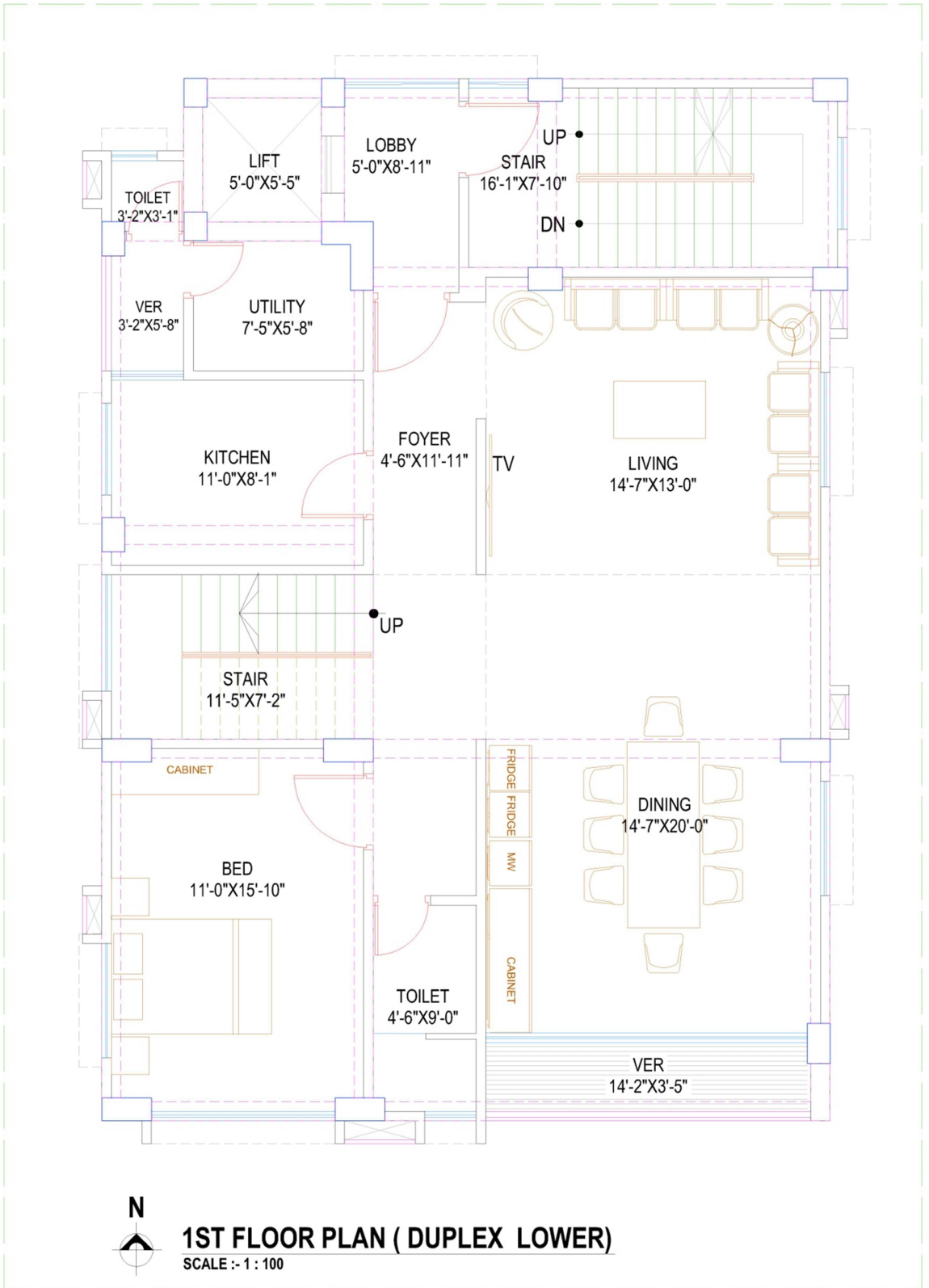


Figure A-3: 1st Floor Plan

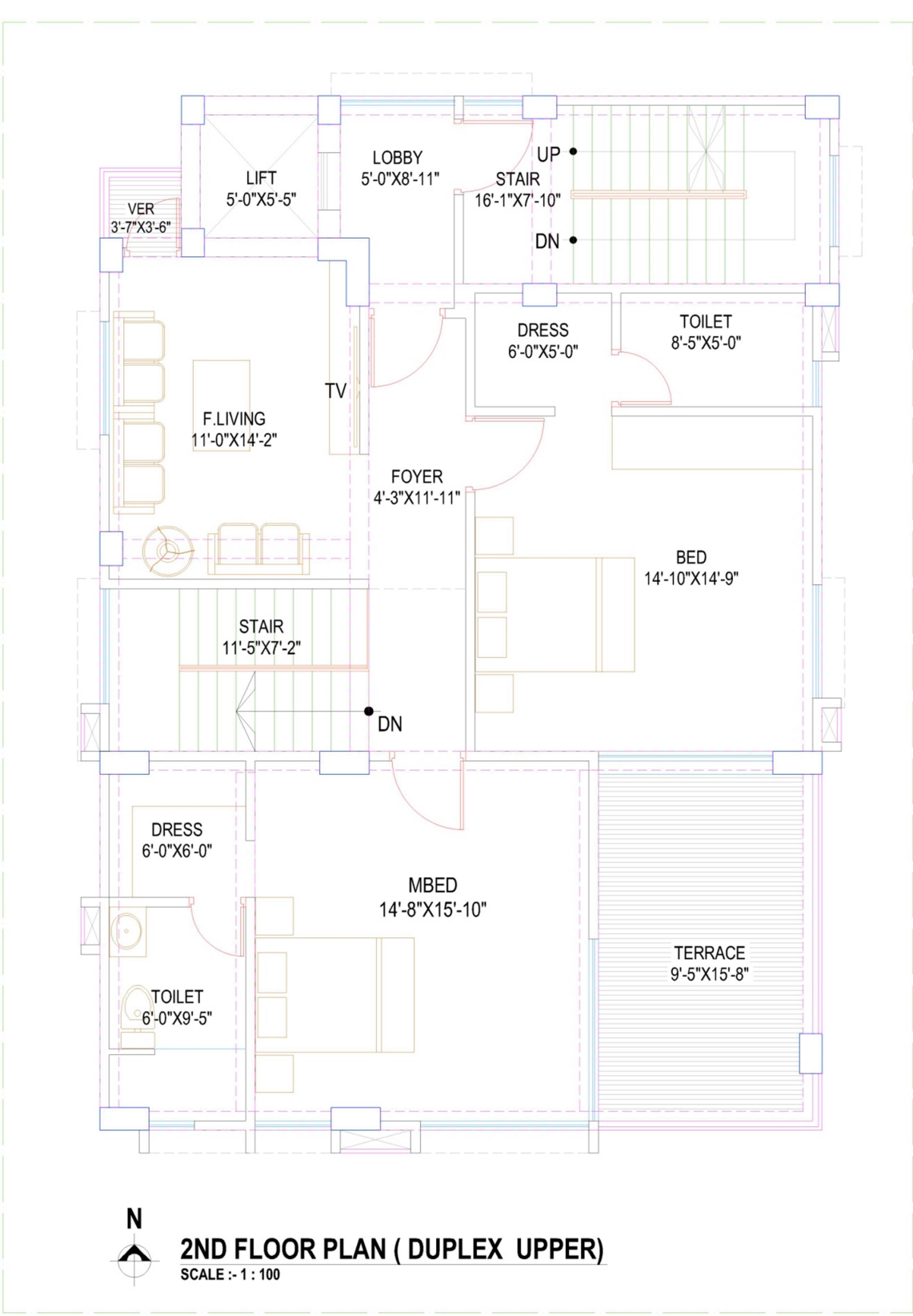


Figure A-4: 2nd Floor Plan

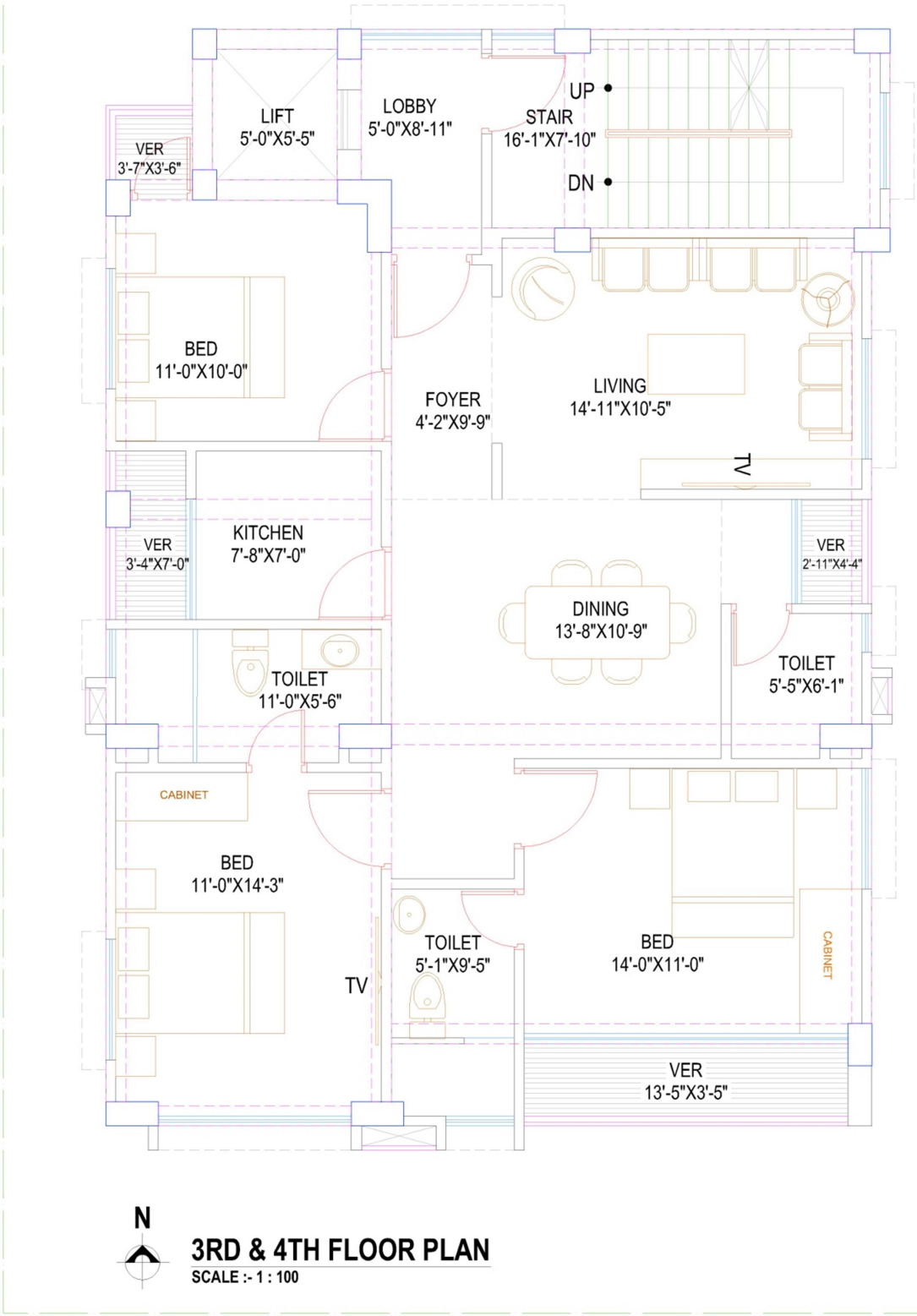


Figure A-5: 3RD & 4TH Floor Plan

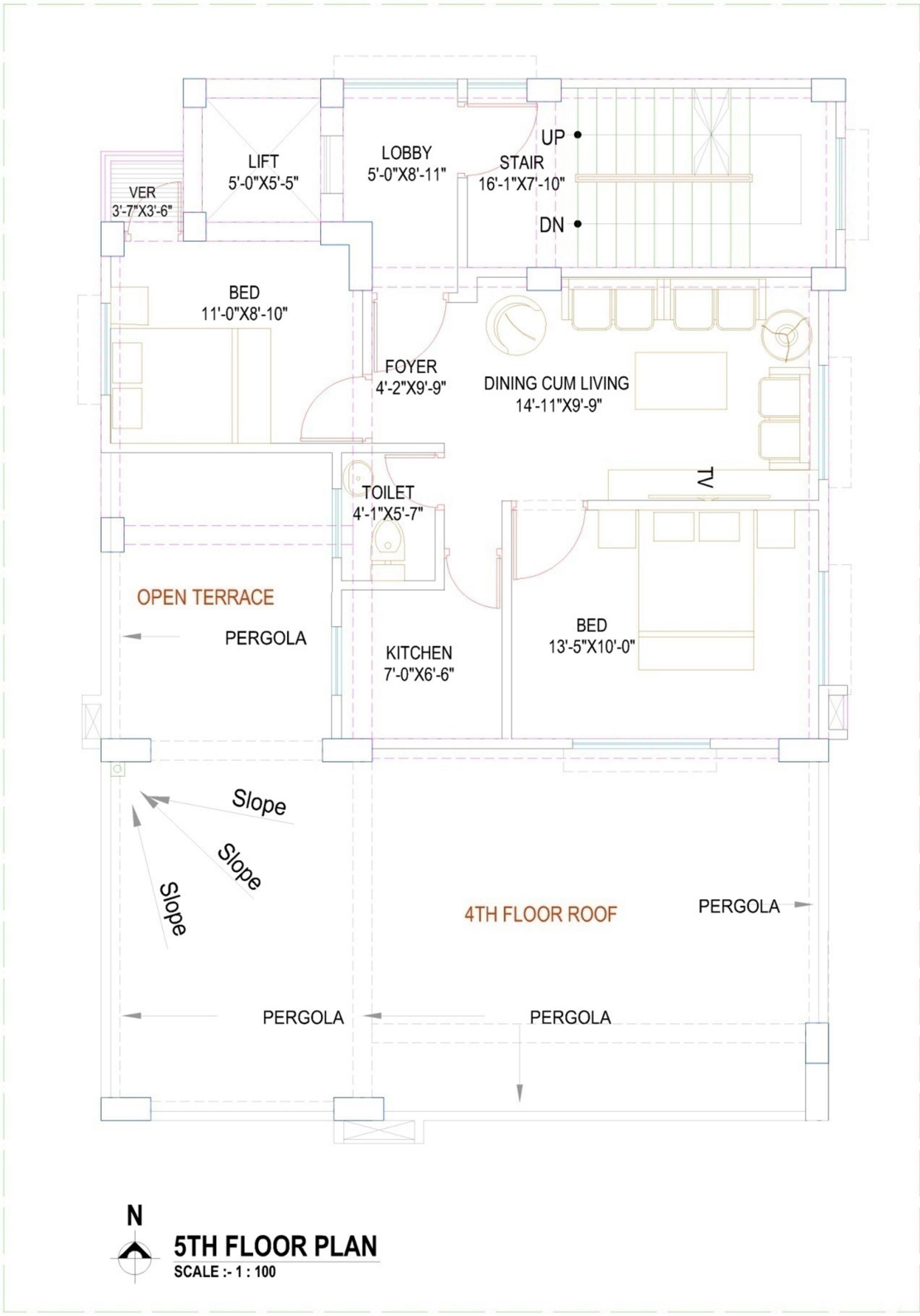


Figure A-6: 5TH Floor Plan

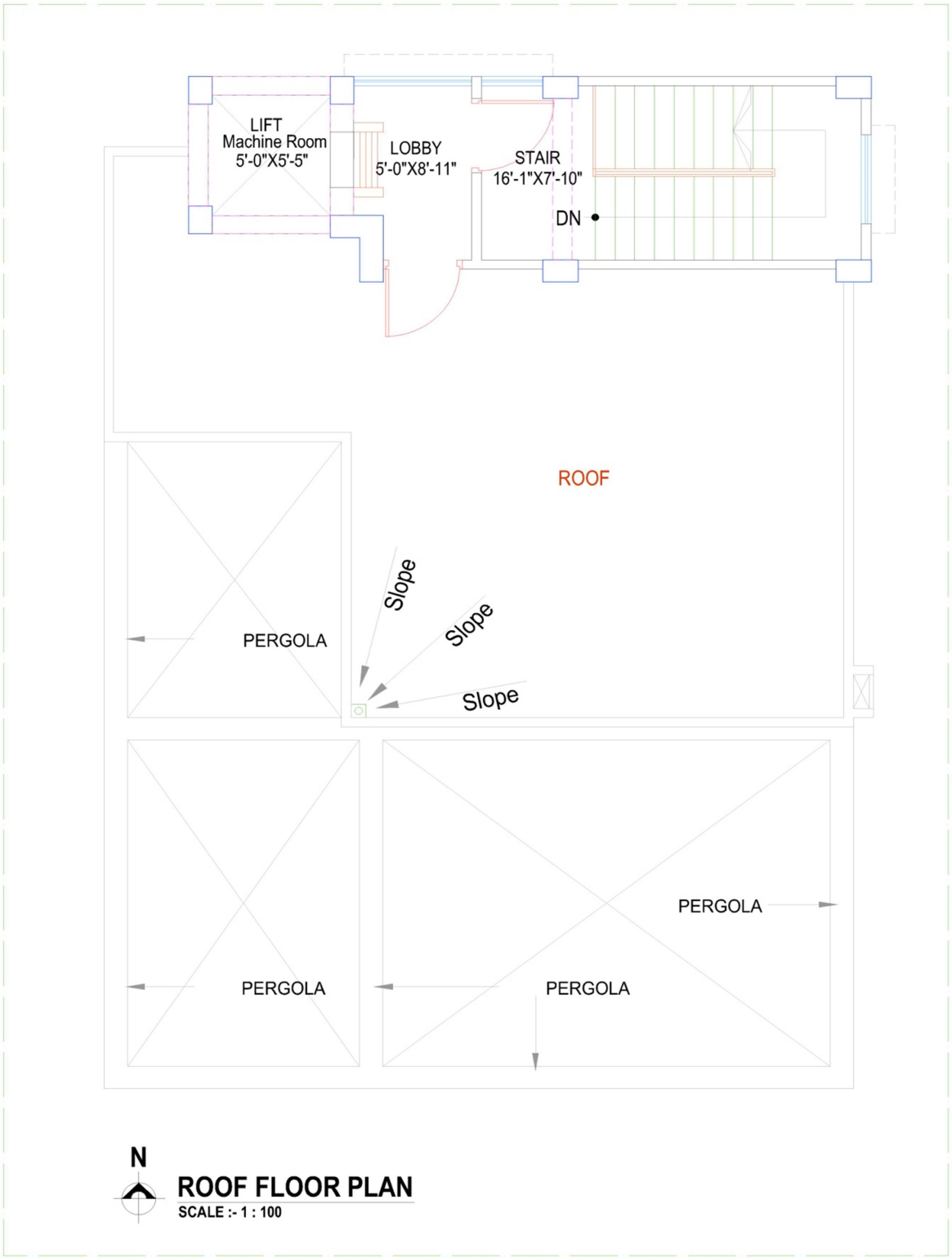


Figure A-7: Roof Floor Plan

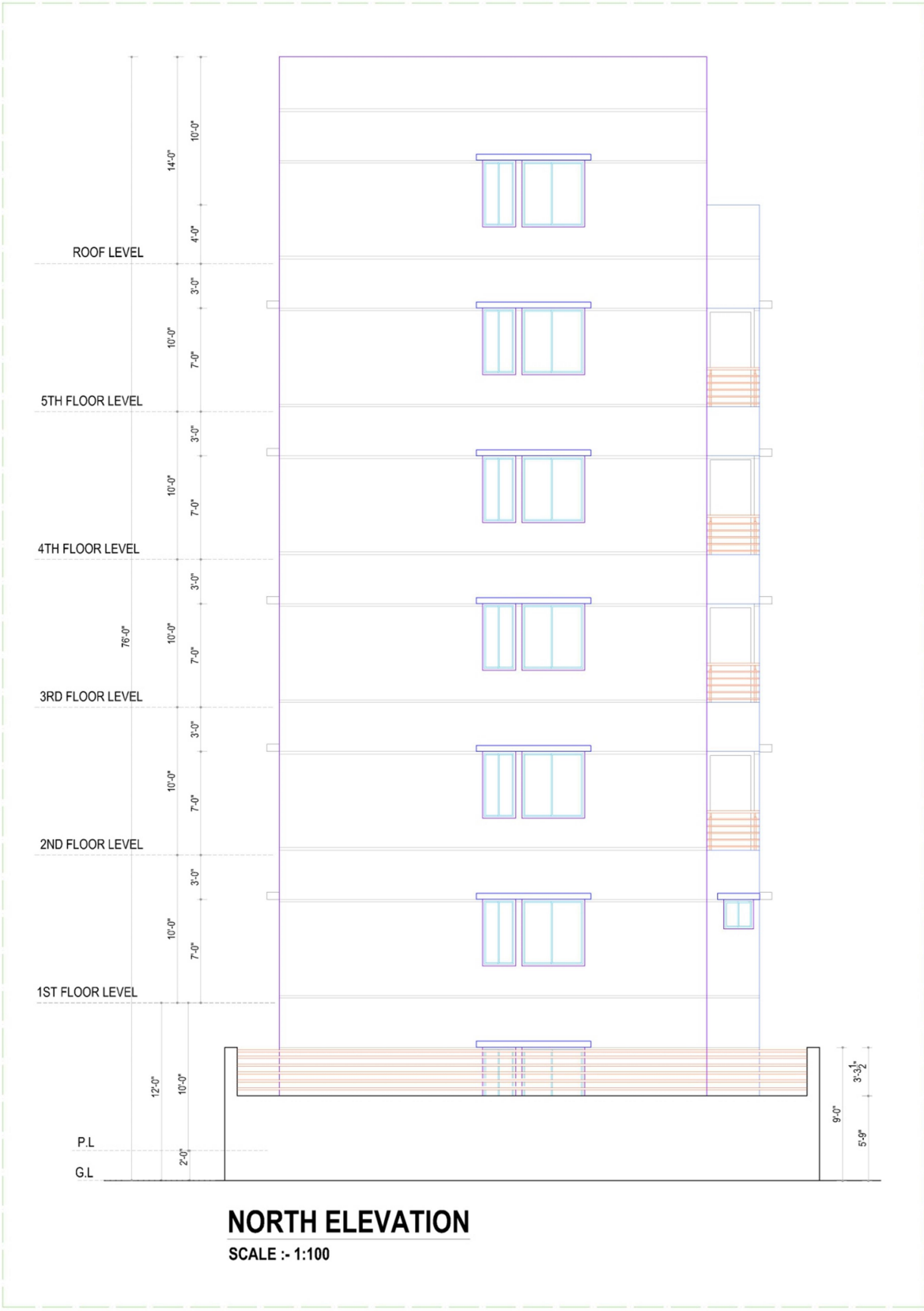


Figure A-8: North Elevation

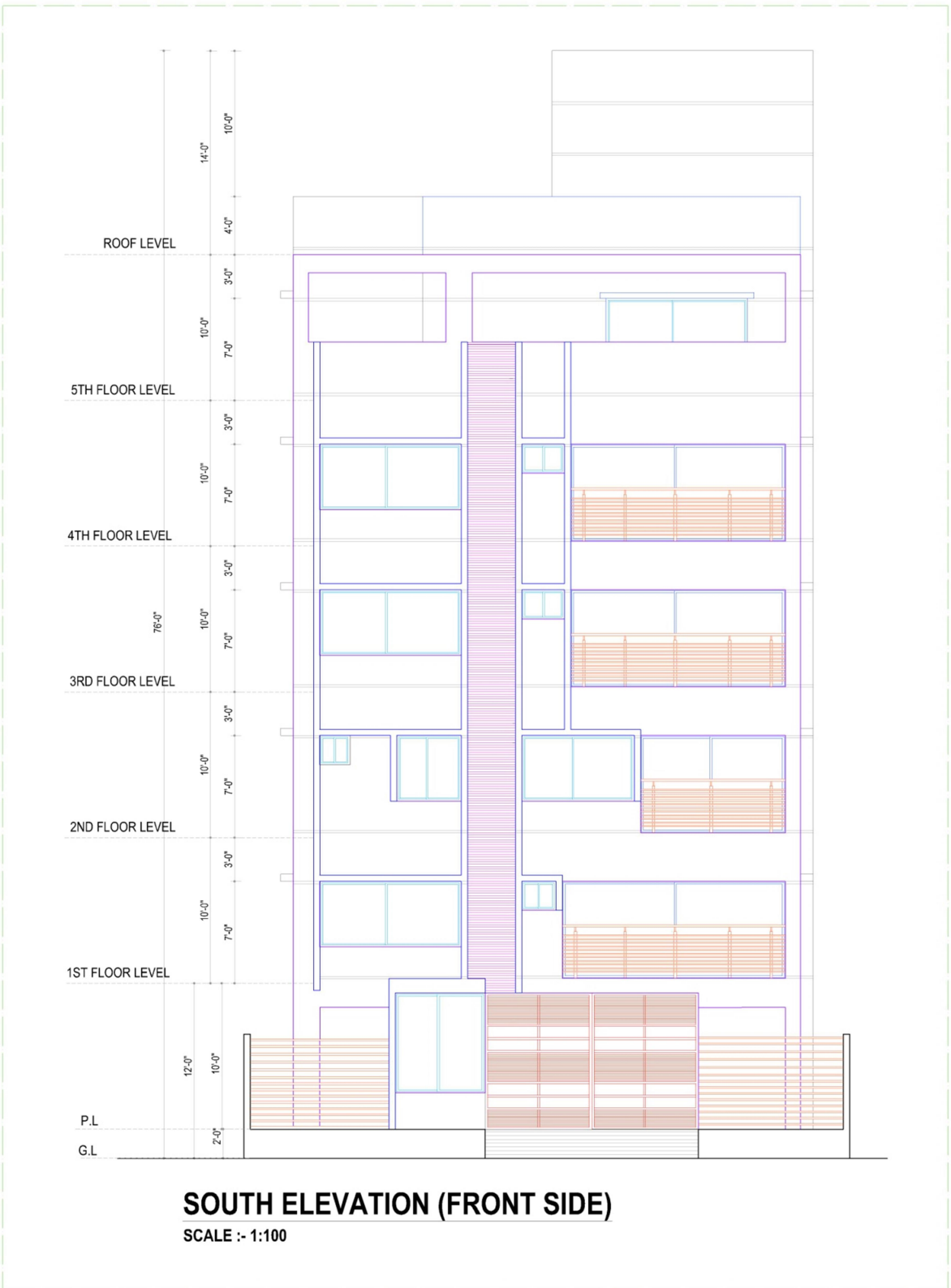


Figure A-9: South Elevation



Figure A-10: East Elevation

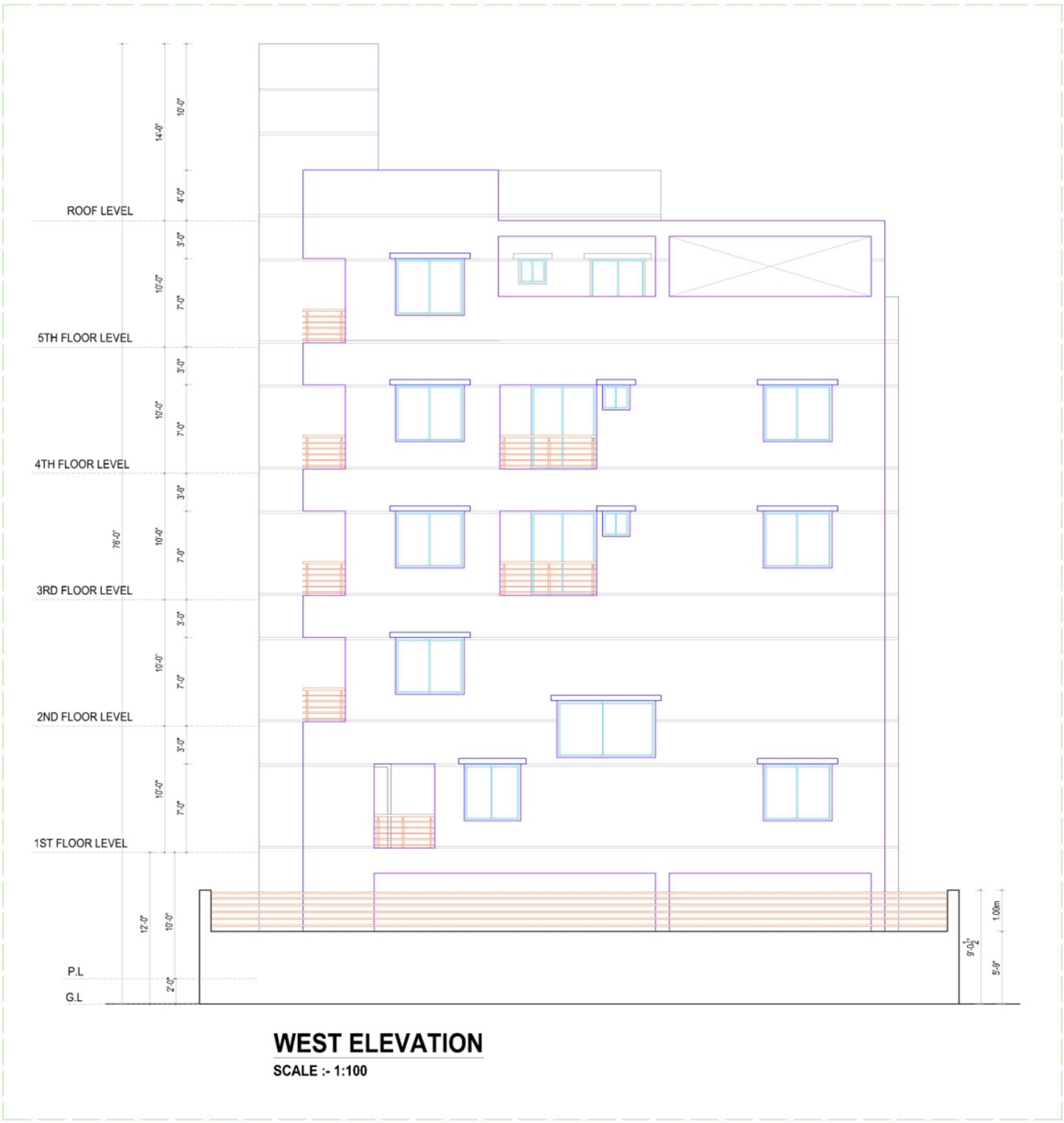
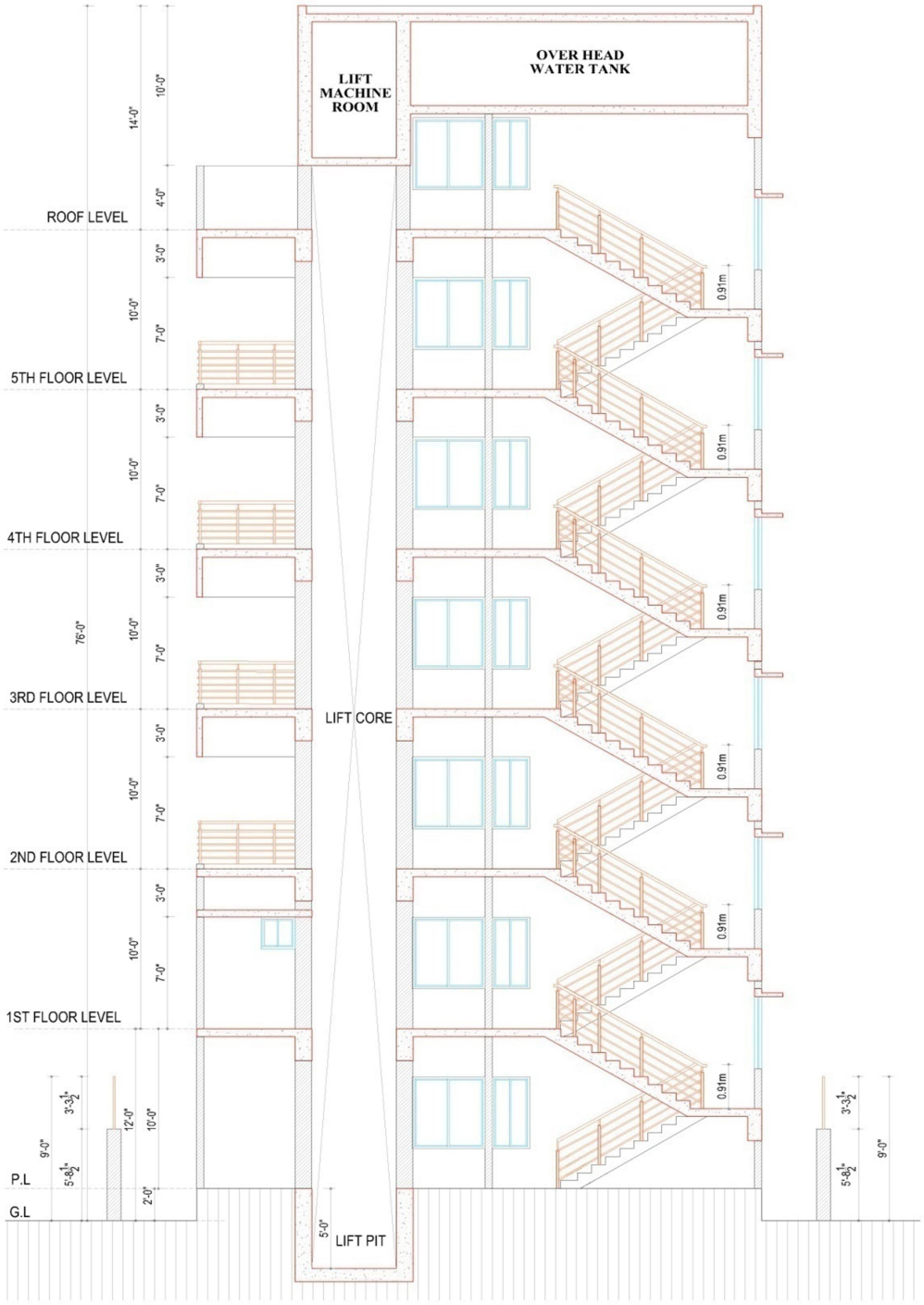


Figure A-11: West Elevation



SECTION:- A-A

SCALE :- 1:100

Figure A-12: Section A-A

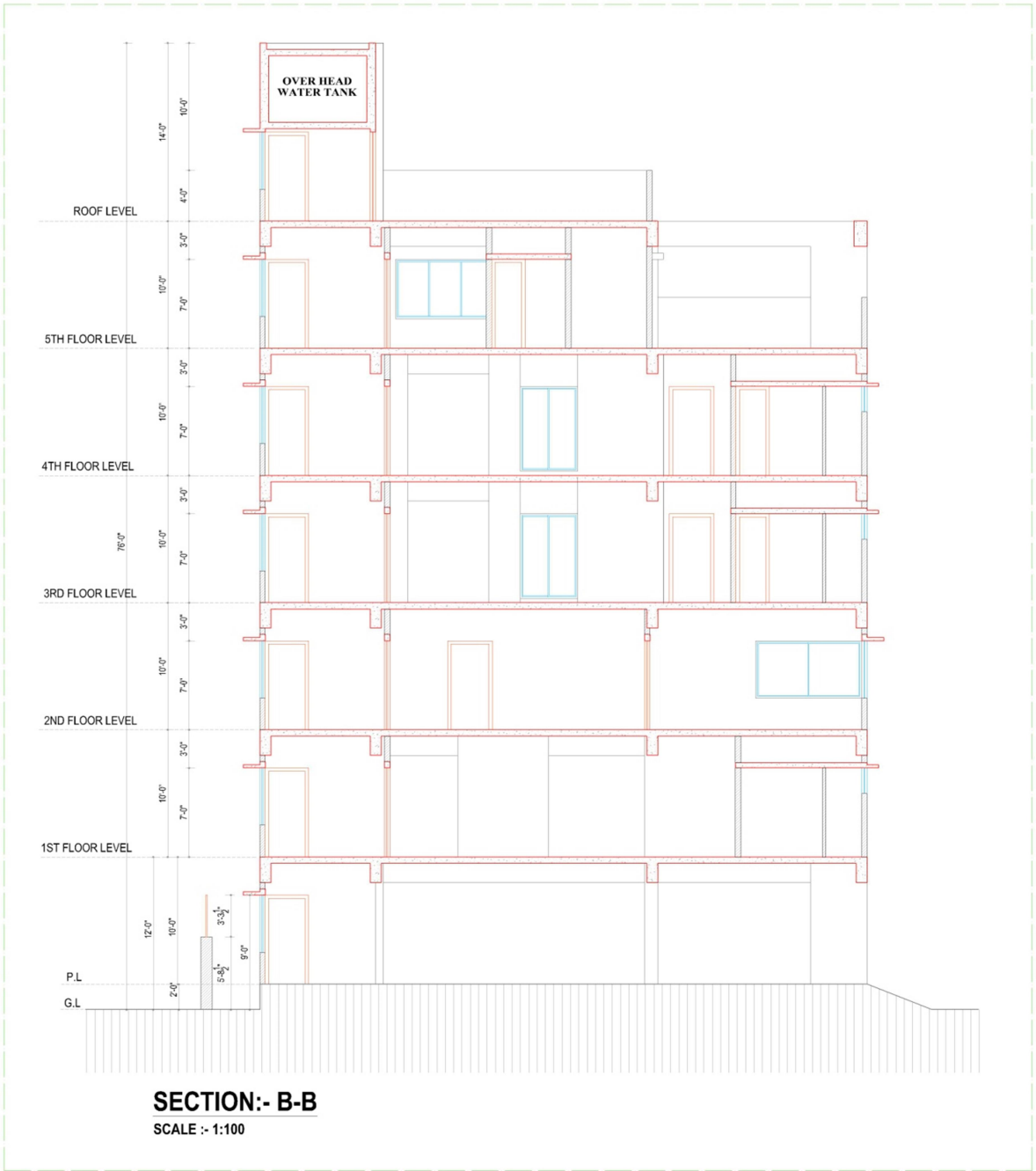


Figure A-13: Section B-B

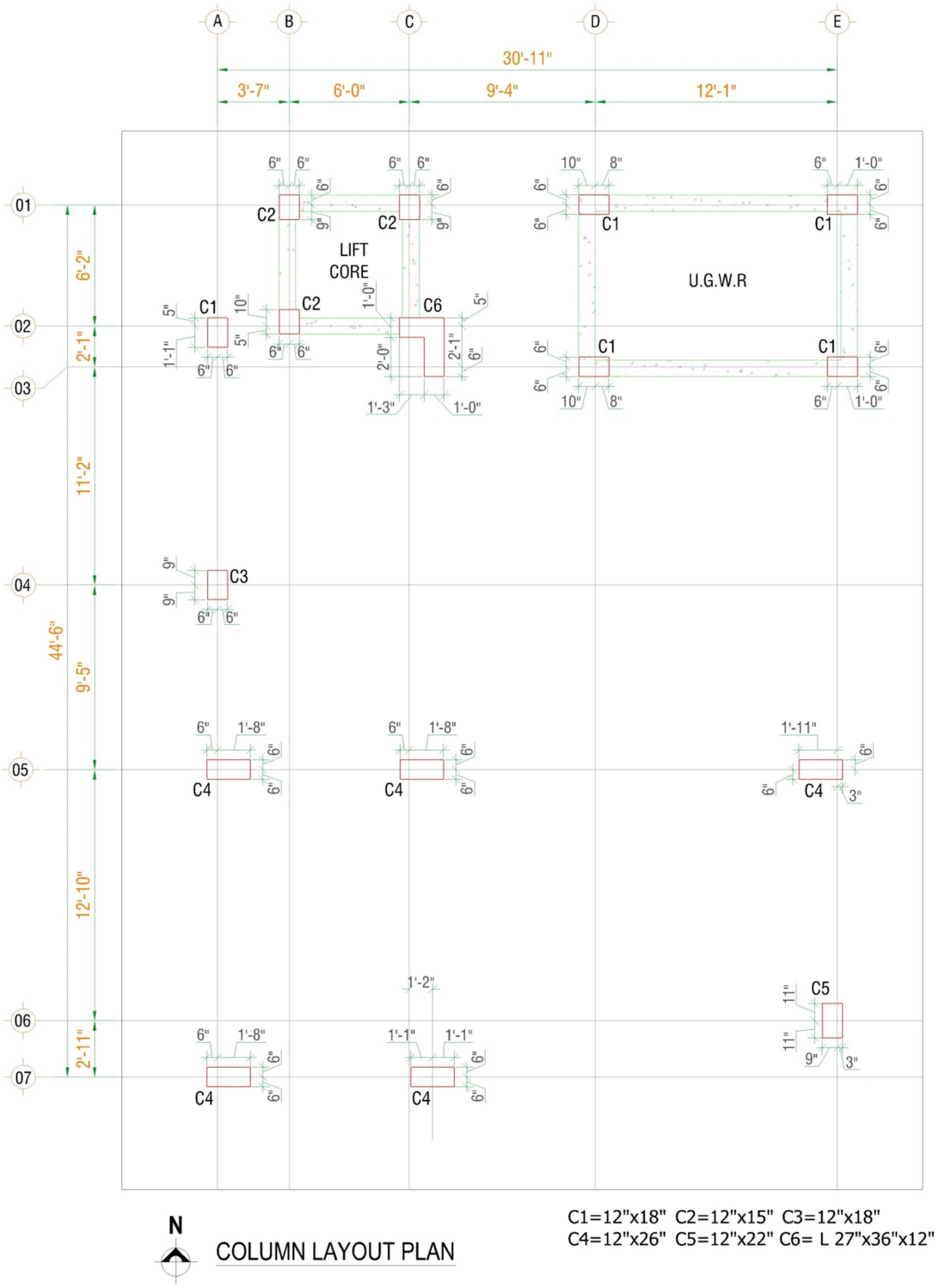


Figure A-14: Column Layout Plan

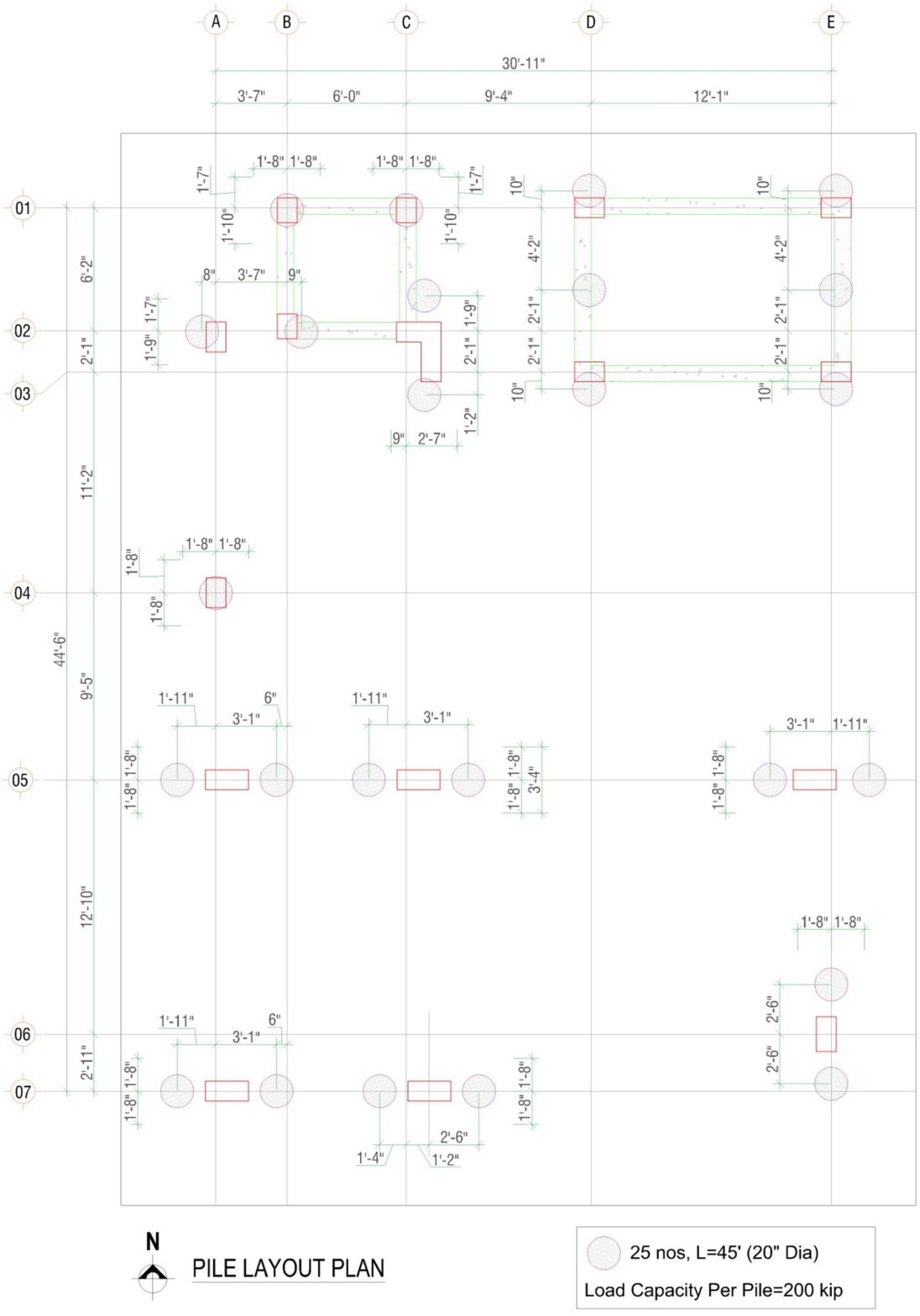


Figure A-15: Pile Layout Plan

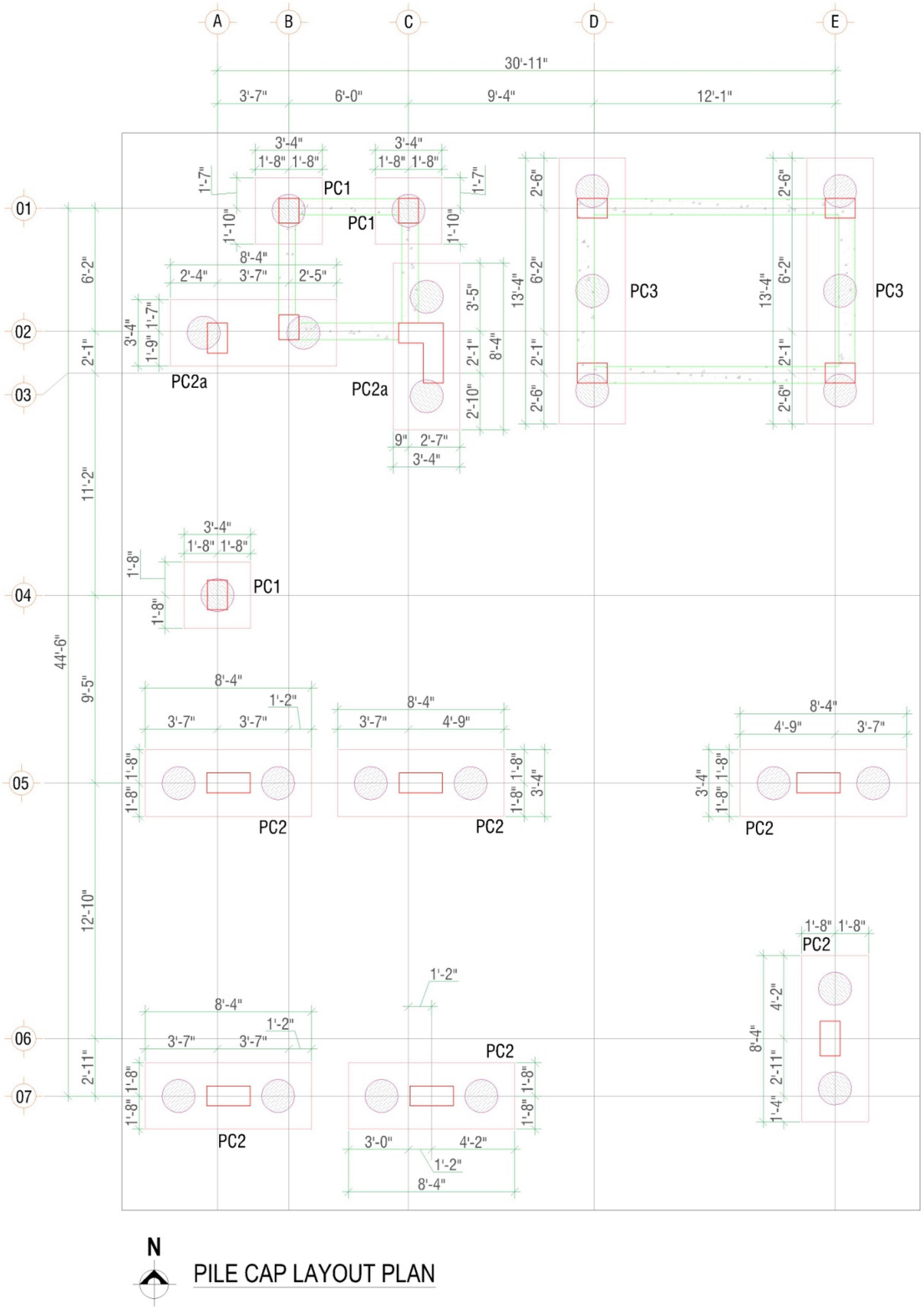


Figure A-16: Pile Cap Layout Plan

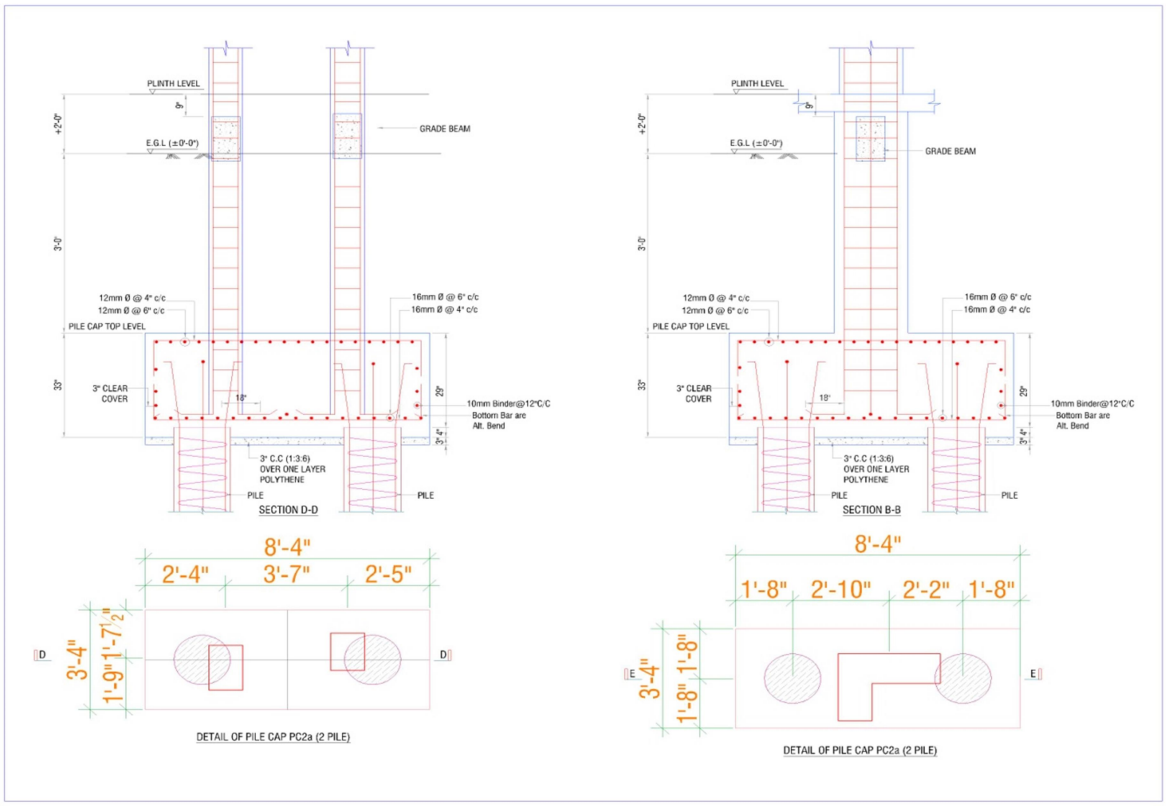


Figure A-17: Pile Cap Reinforcement Details

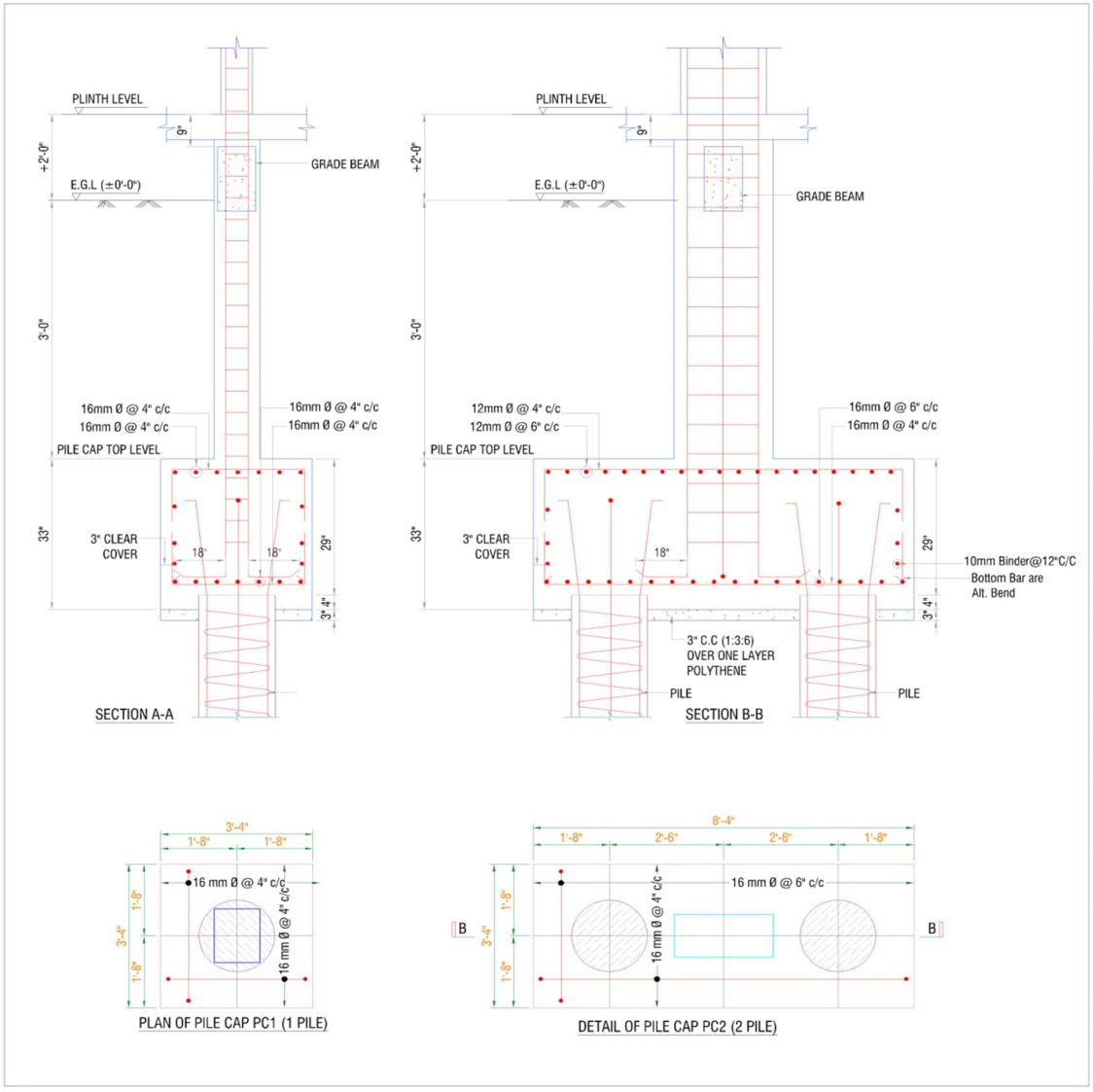


Figure A-18: Pile Cap Reinforcement Details

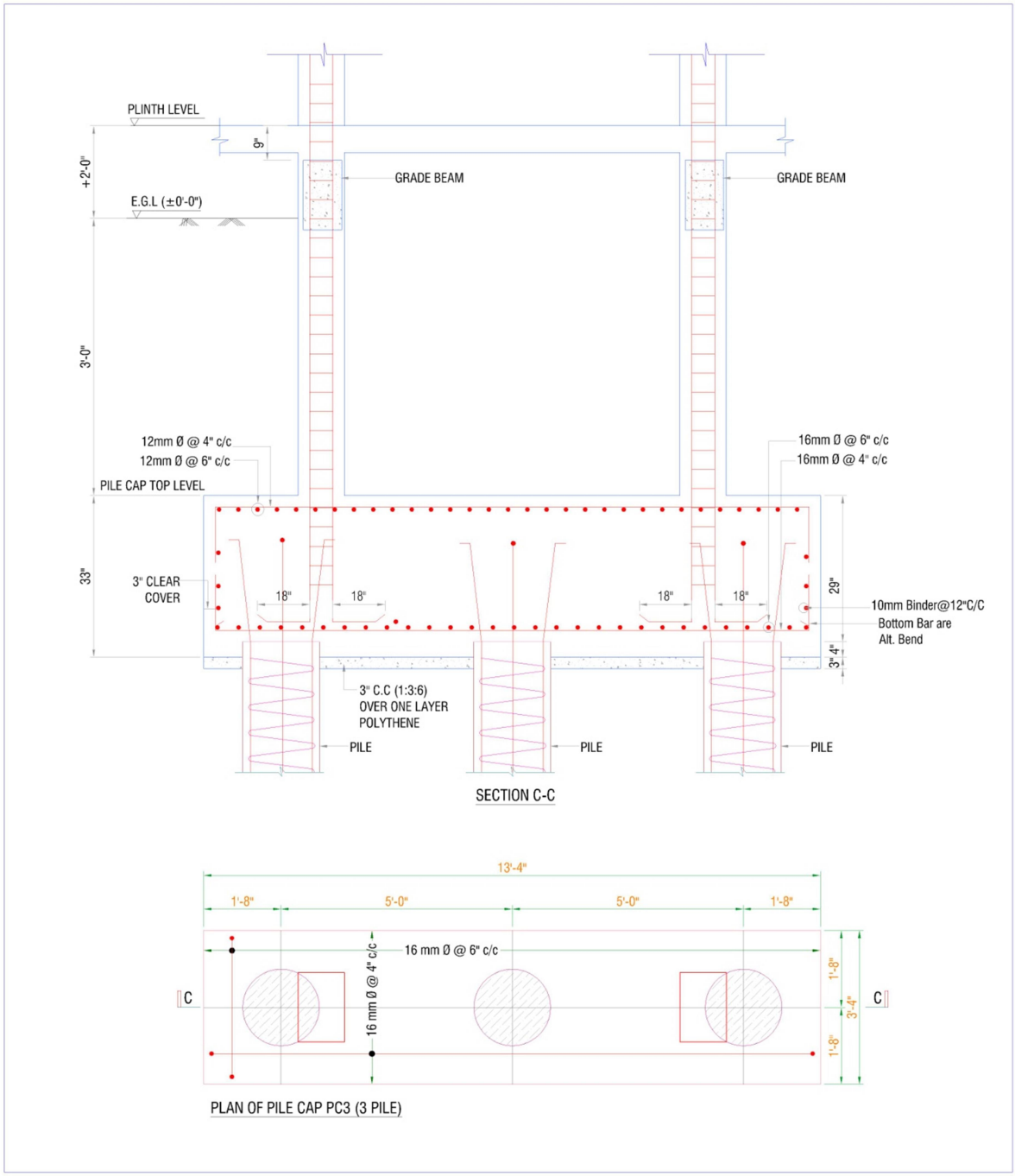


Figure A-19: Pile Cap Reinforcement Details

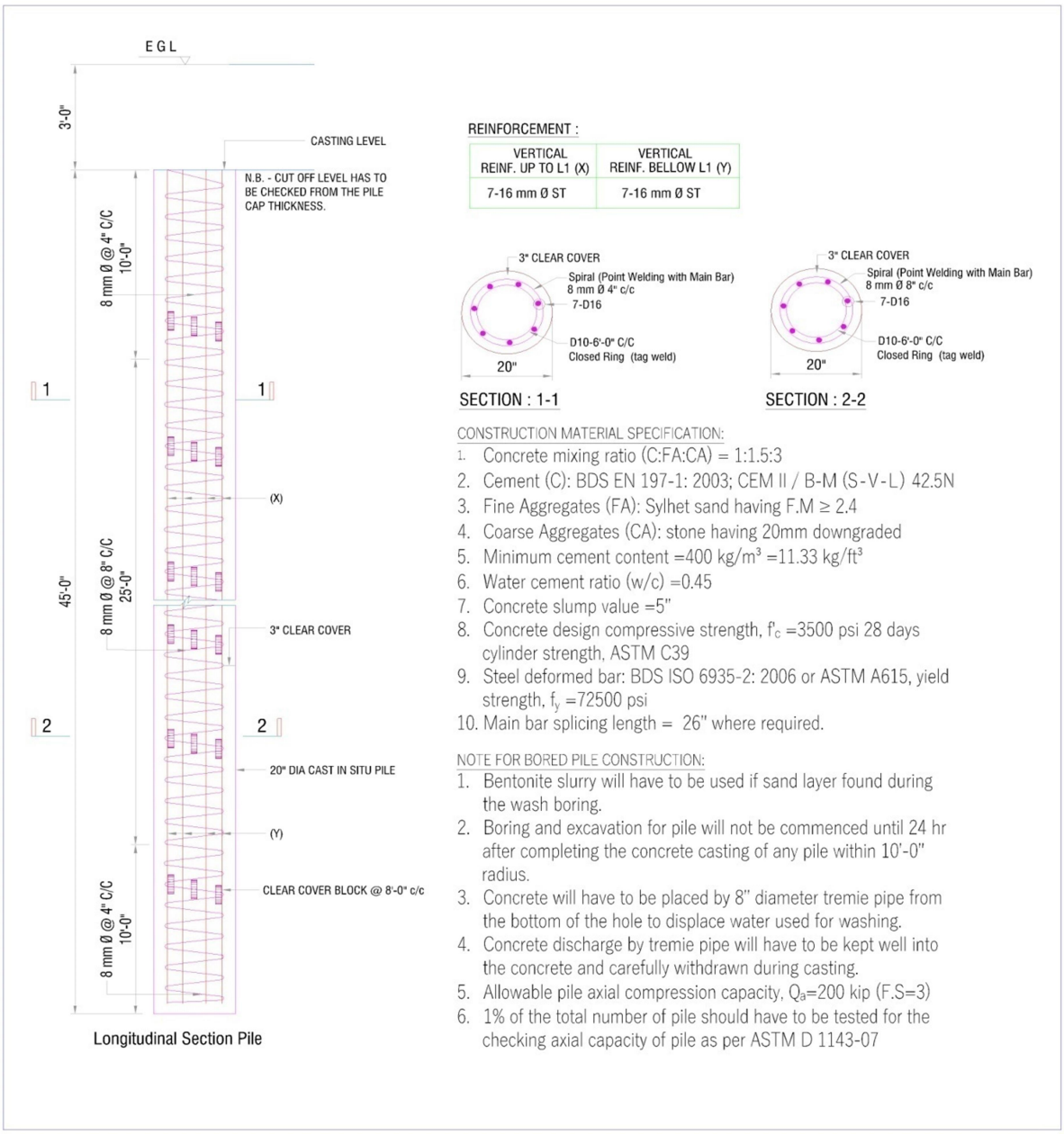


Figure A-20: Long Section OF Pile

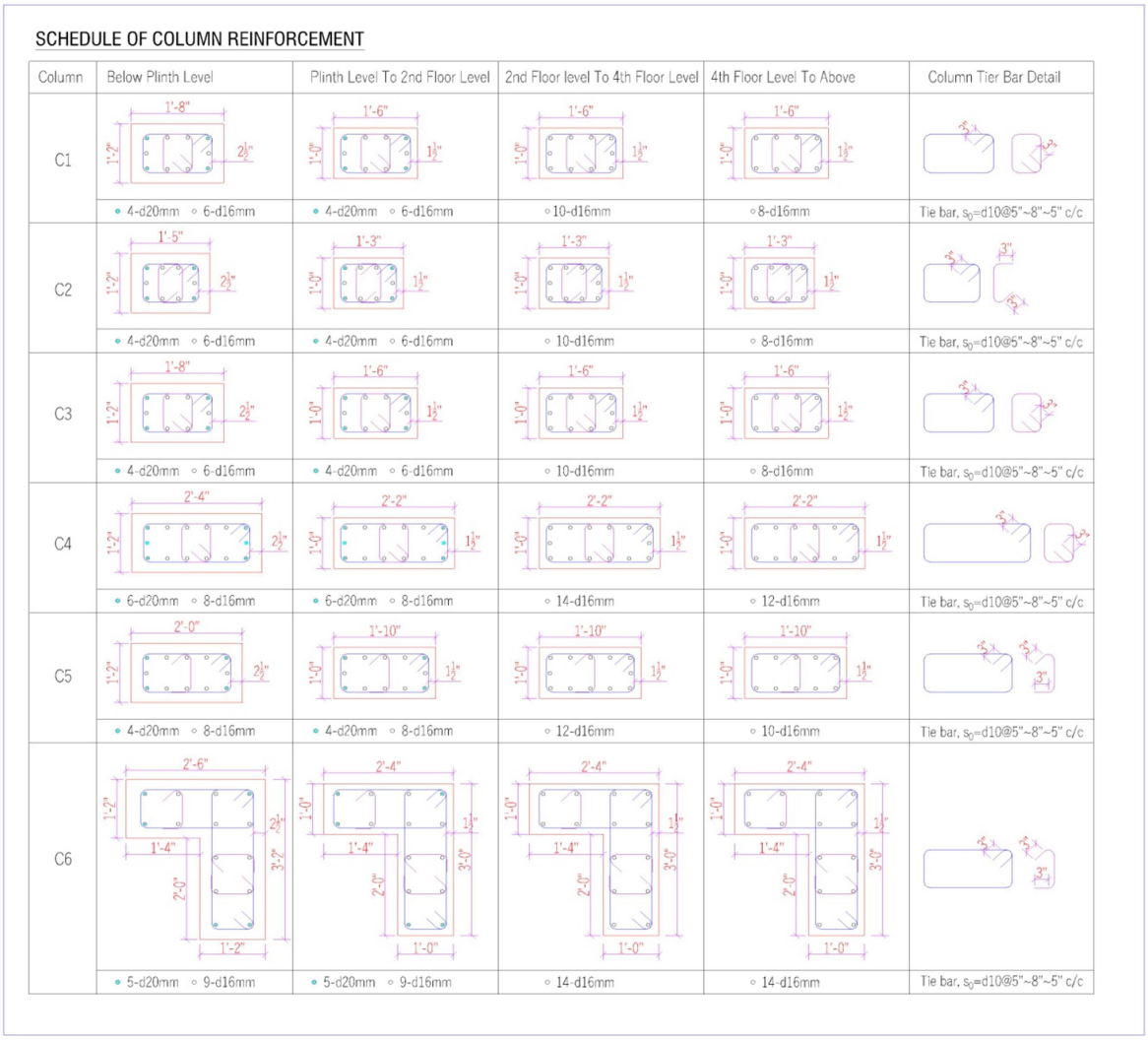


Figure A-21: Column Schedule

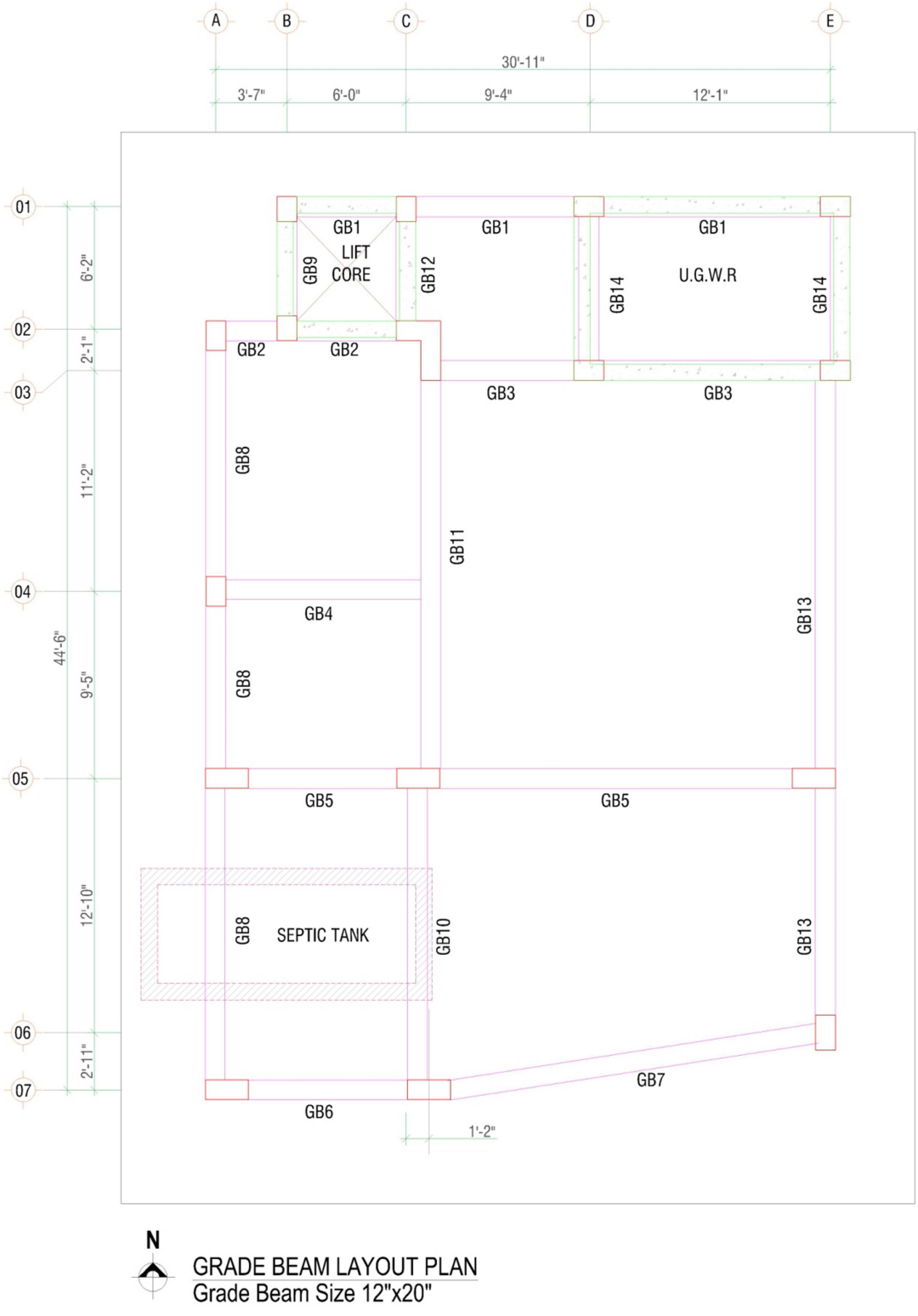


Figure A-22: Grade Beam Layout

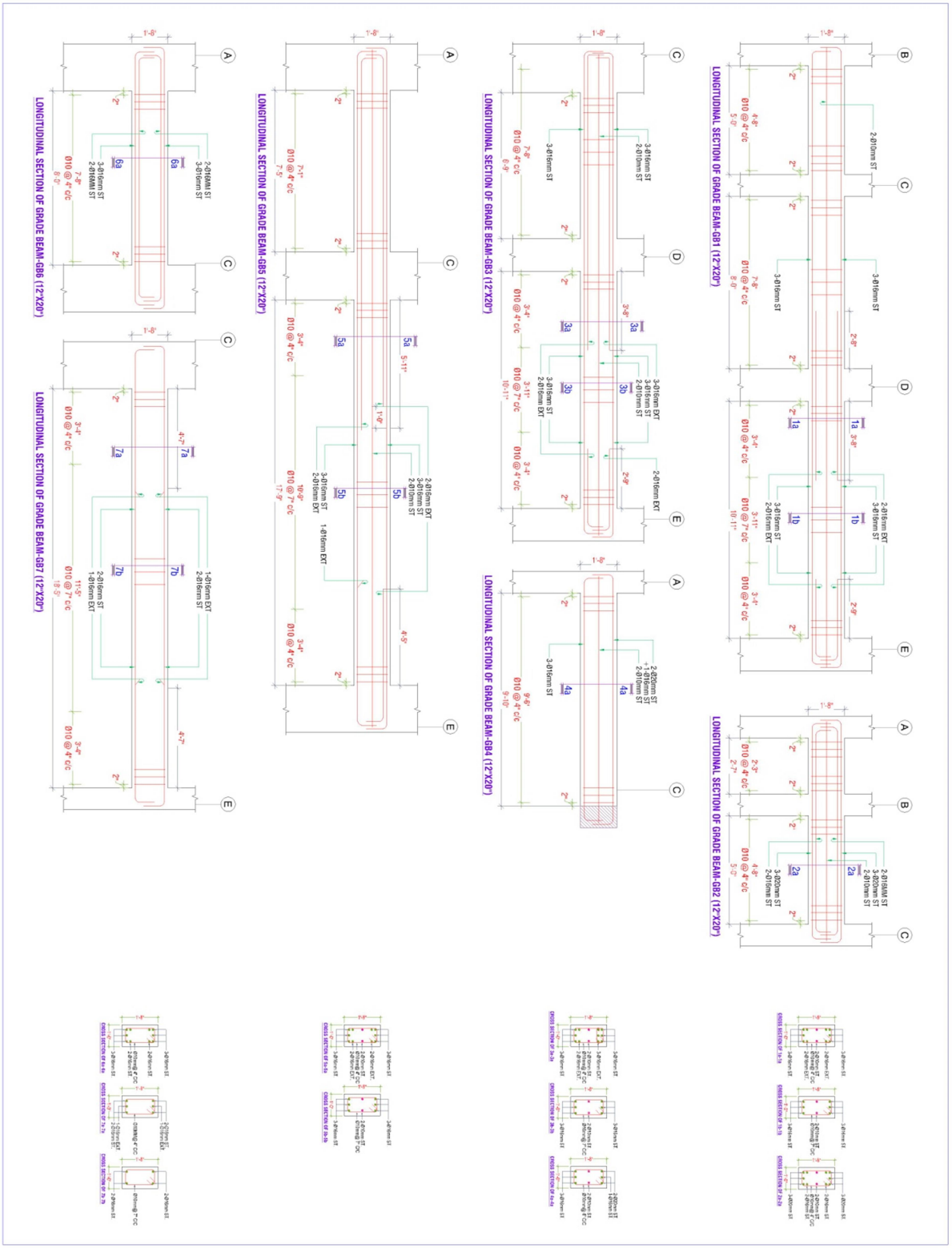


Figure A-23: Long Section of Grade Beam

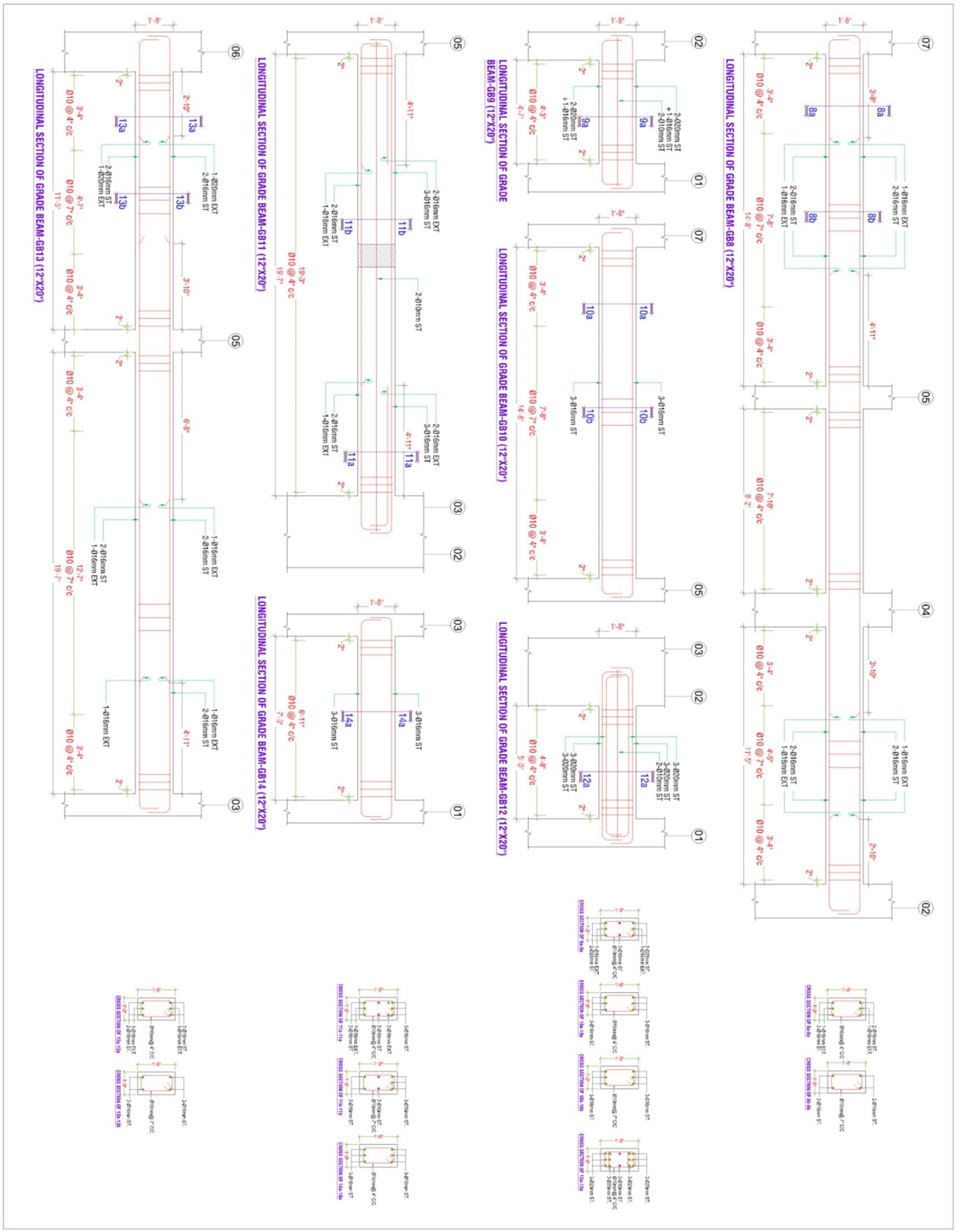


Figure A-24: Long Section of Grade Beam

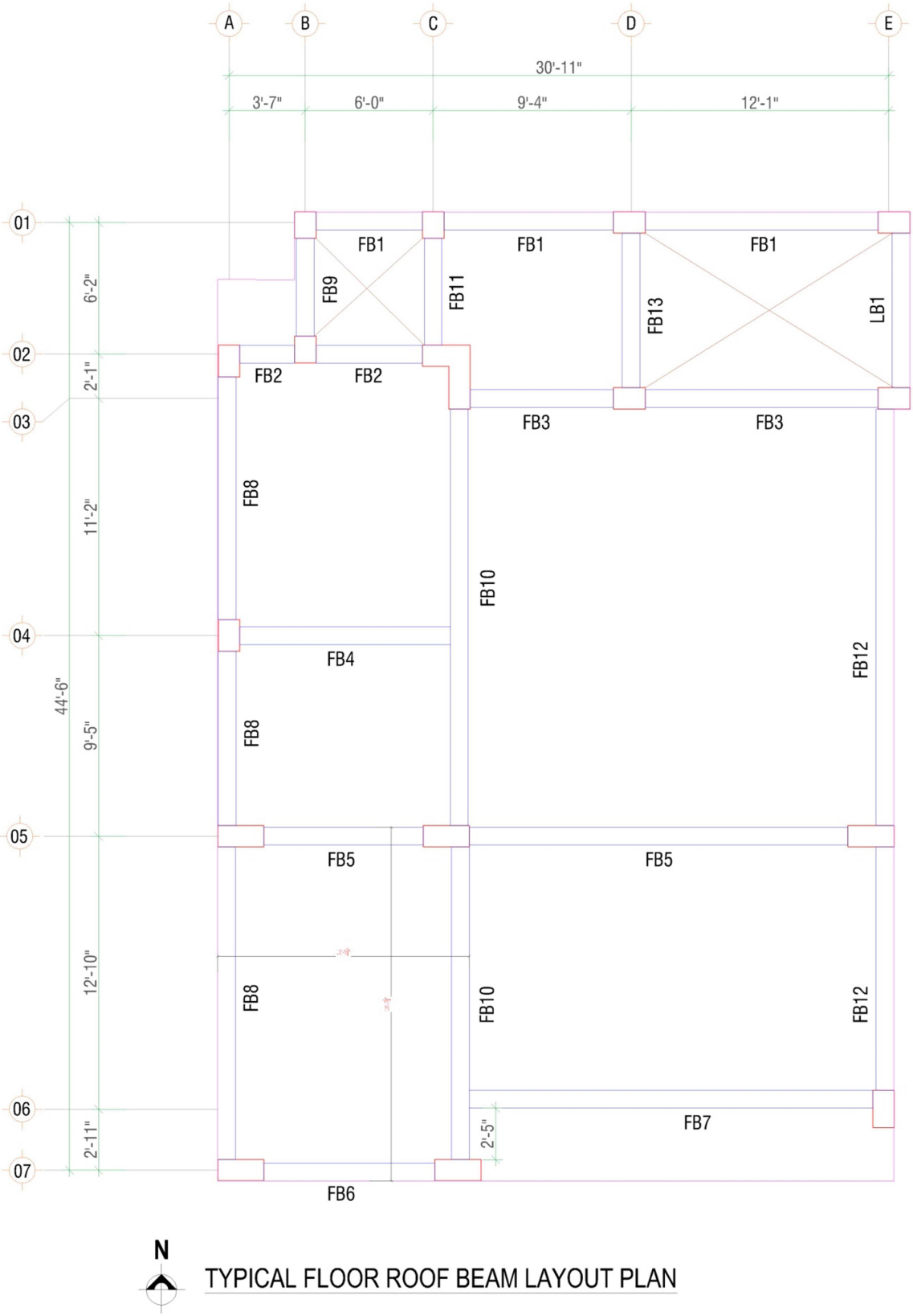


Figure A-25: Typical floor Roof Beam Layout Plan

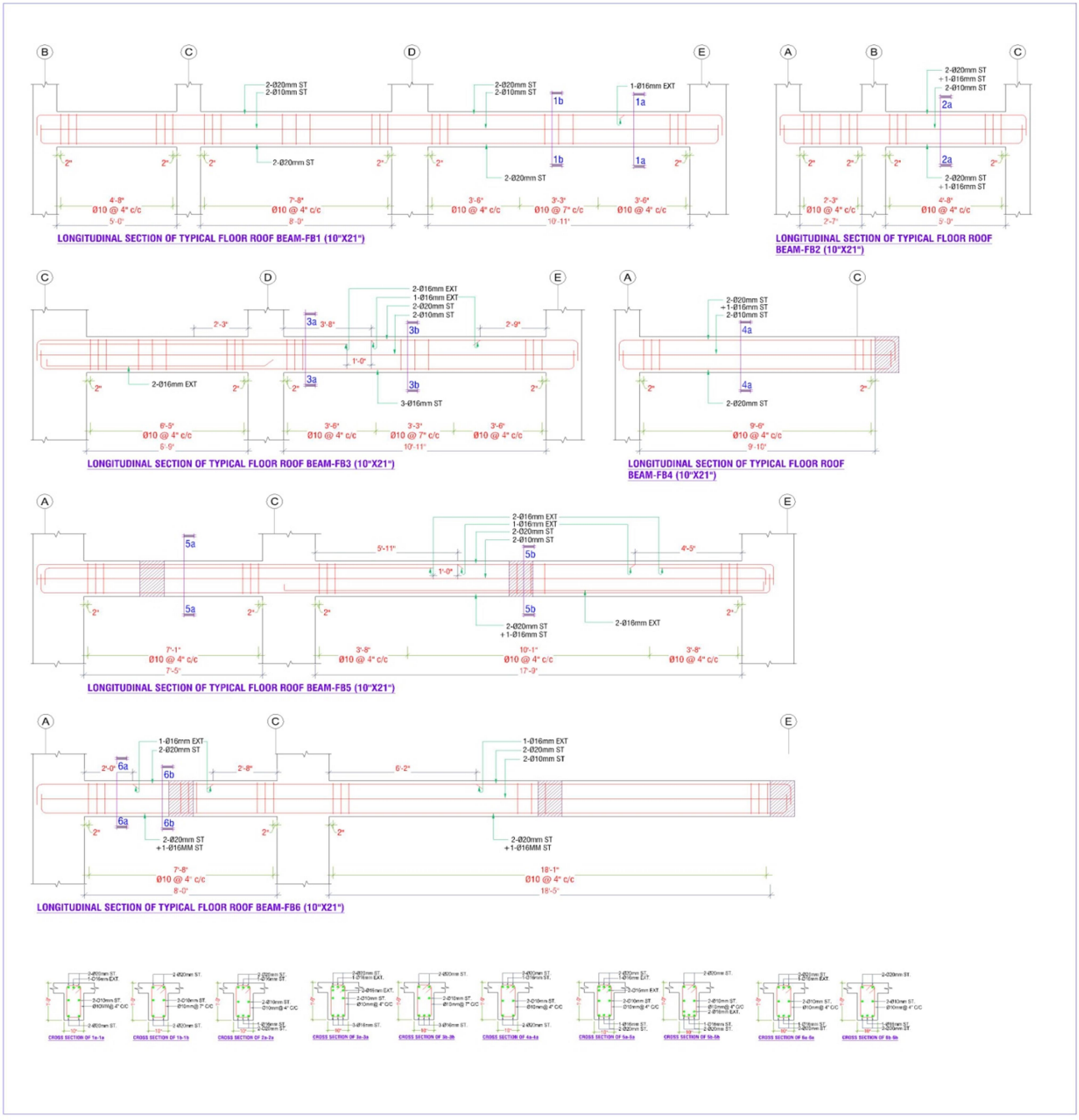


Figure A-26: Long Section of Typical floor Roof Beam

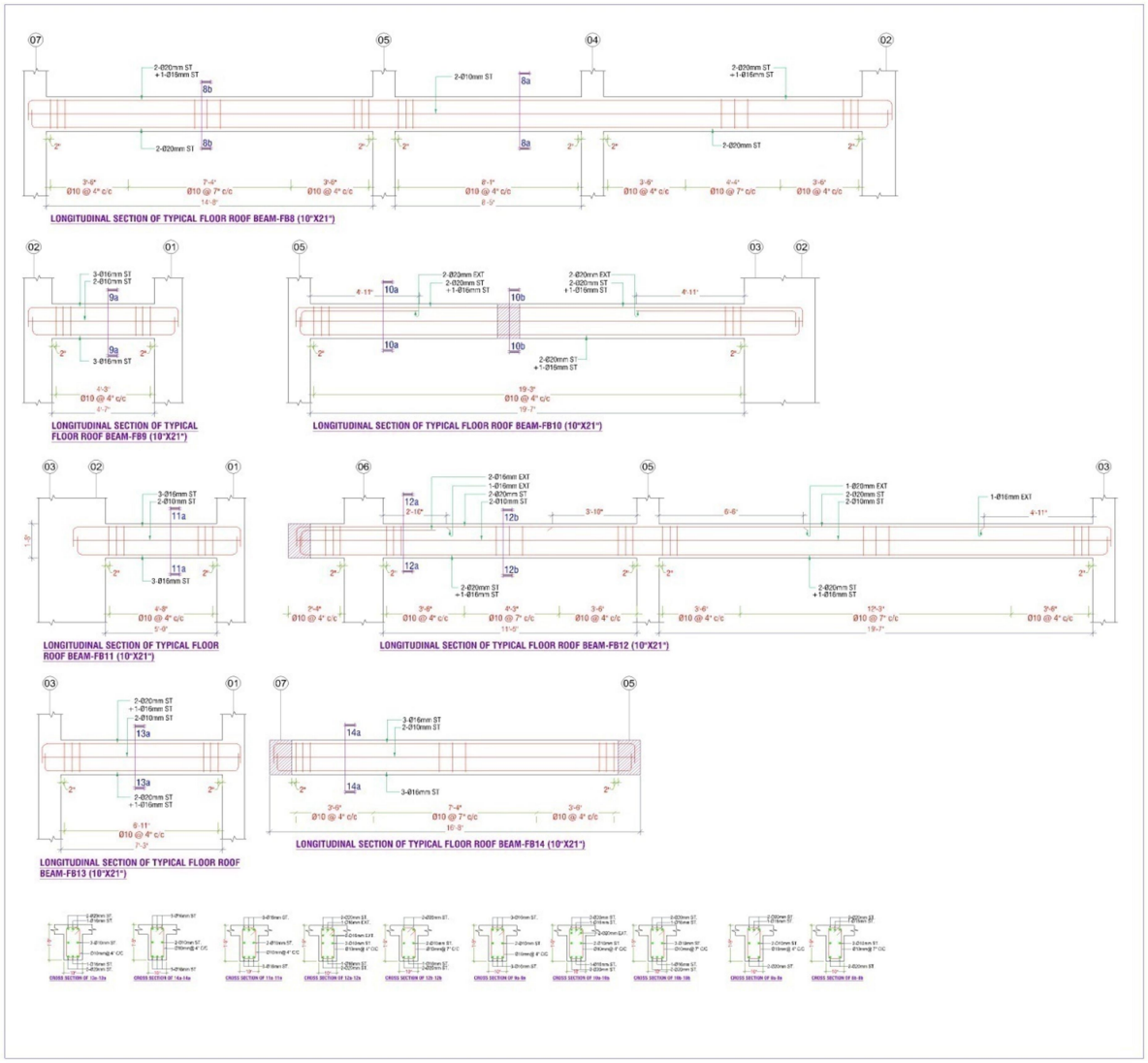


Figure A-27: Long Section of Typical floor Roof Beam

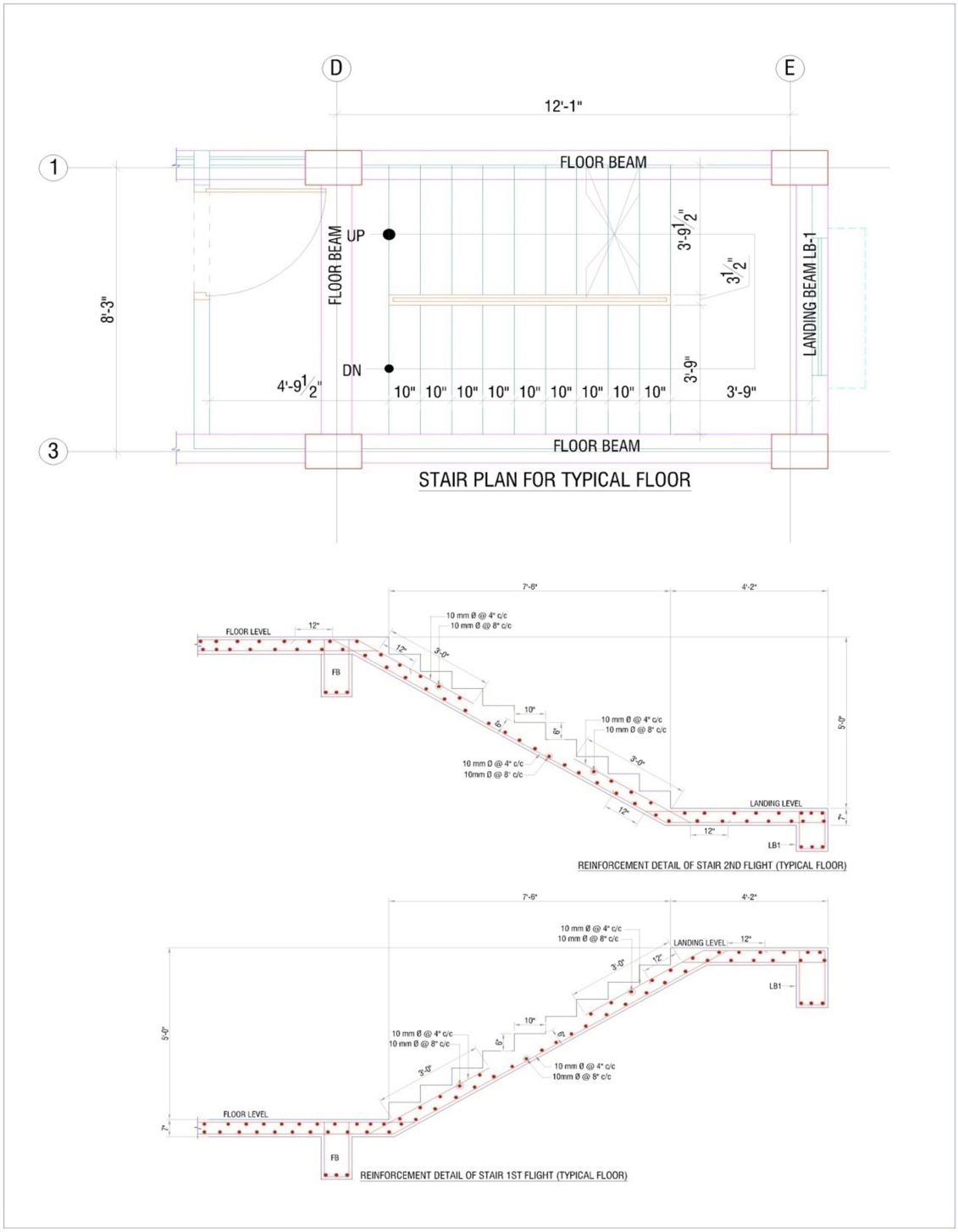


Figure A-28: Reinforcement of stair

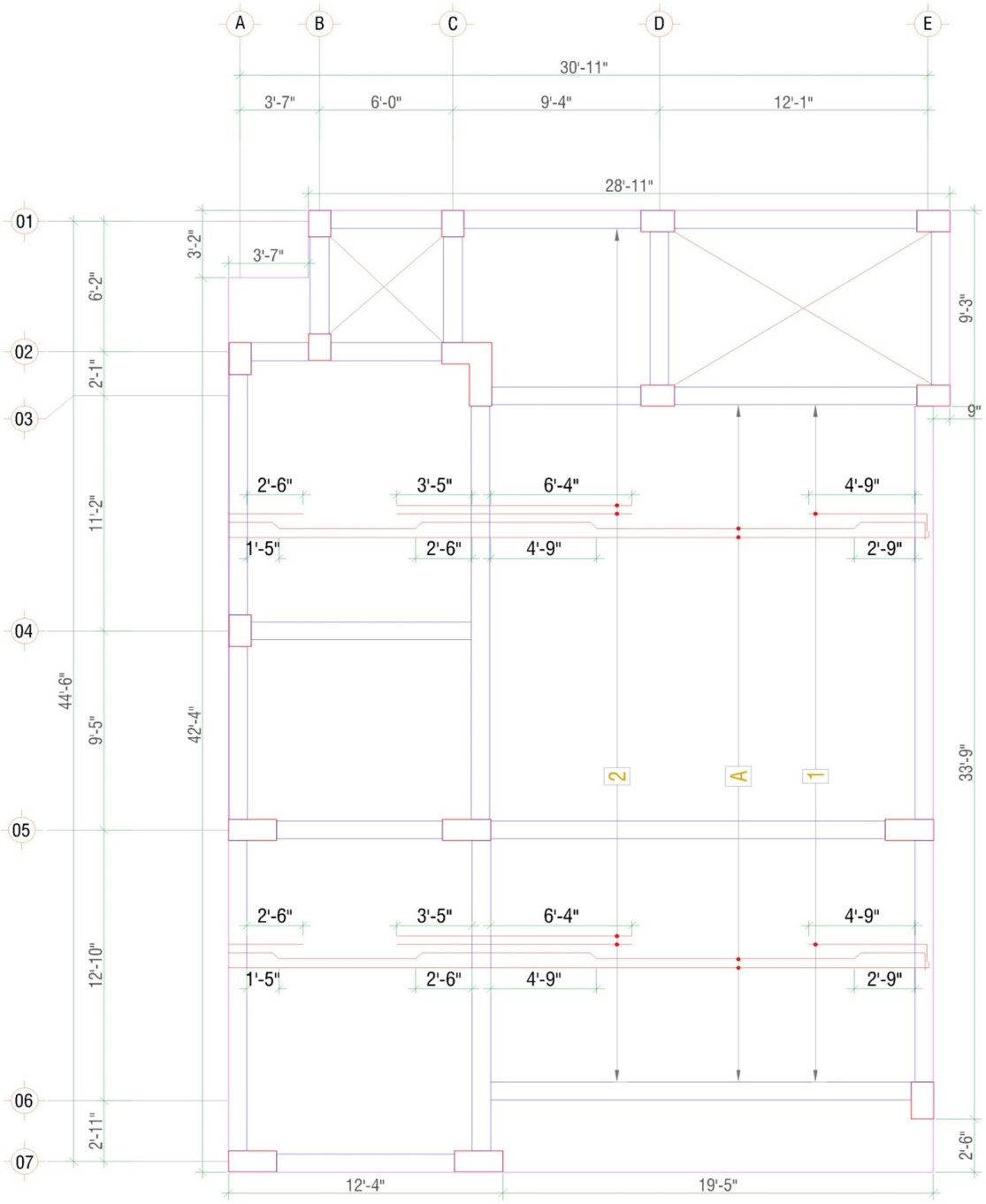


Figure A-29: Typical floor roof slab reinforcement details direction-1

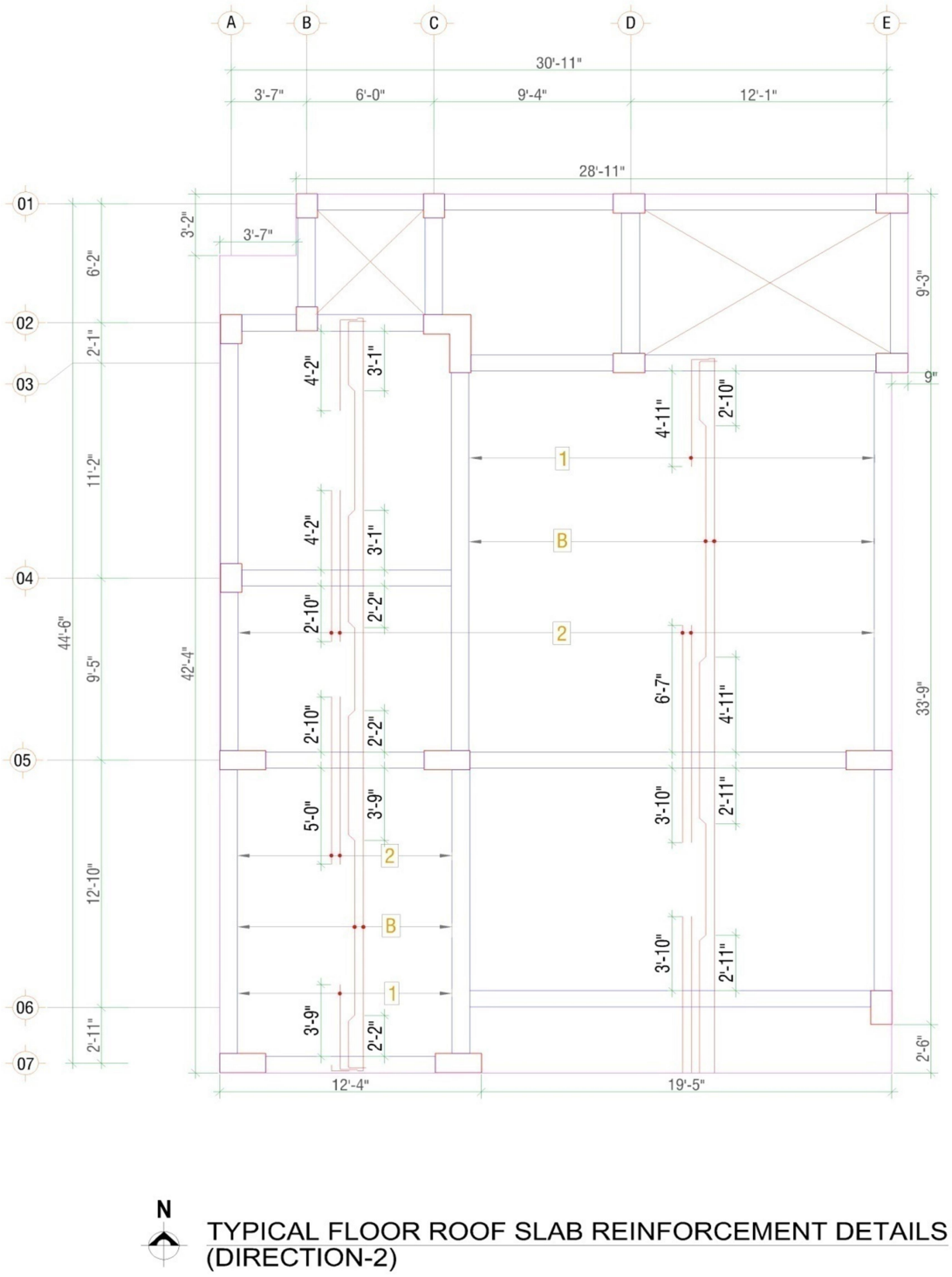


Figure A-30: Typical floor roof slab reinforcement details direction-2

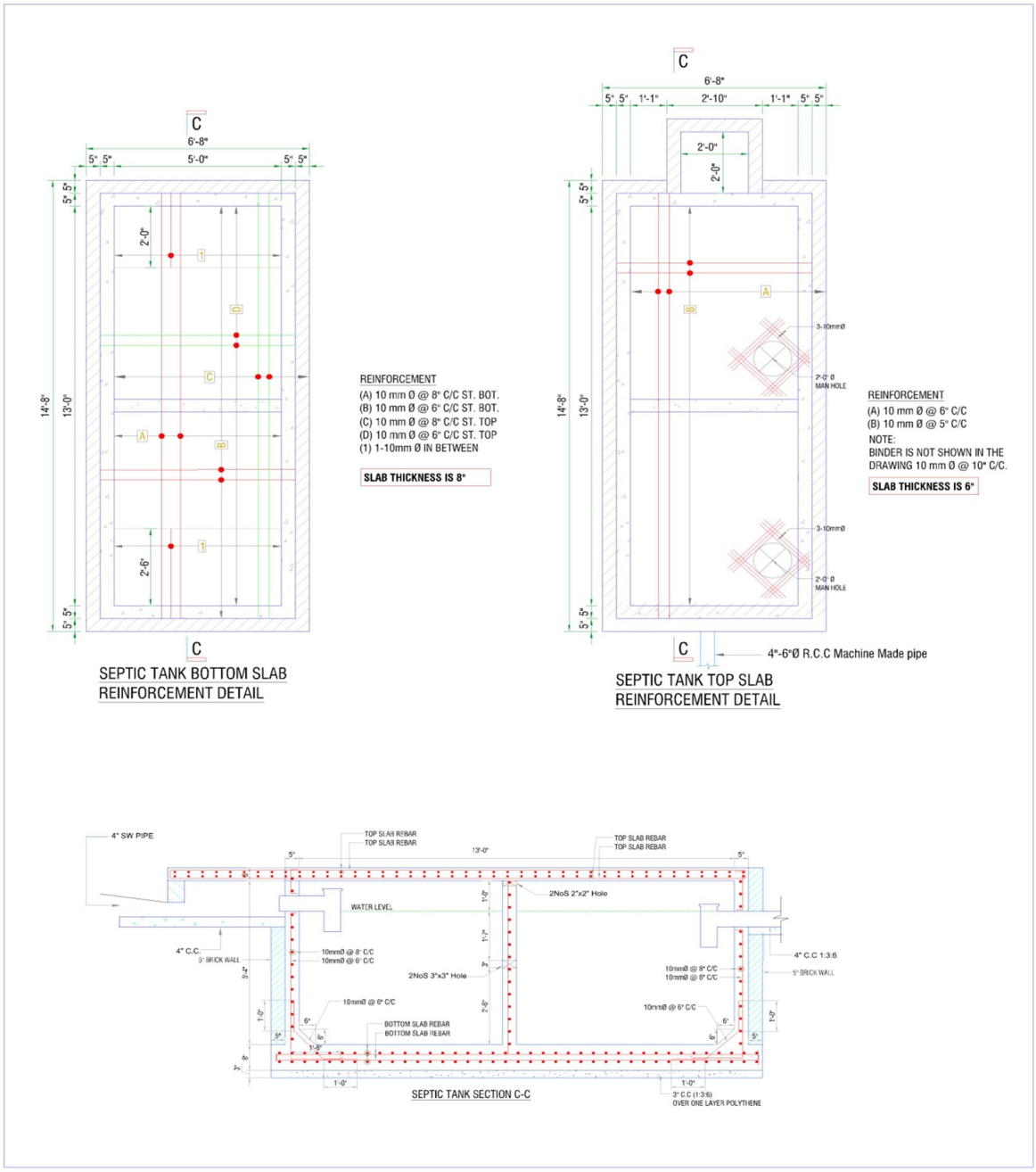


Figure A-31: Septic Tank Section

Analysis & Design Parameters :

Parameters	Values	Reference(s)
Yield Strength, fy	Rebar=72.5 ksi	
Required Concrete 28 days Cylinder Strength f'cr	Pile=3.0 ksi, Pile Cap & Column= 3.5 ksi Grade Beam, Floor Beam, Slab=3.5 ksi	
Frame Type	Intermediate Moment Resisting Frame (IMRF)	From drawing
Response modification factor	8	UBC 94/BNBC-2006
Importance factor	1	UBC 94/BNBC-2006
Seismic zone factor	0.15	UBC 94/BNBC-2006
Soil profile	S3	BNBC-2006
Wind speed	210 km/h	UBC 94/BNBC-2006
Exposure Category	A	BNBC-2006
Dead load	As constructed	BNBC-2006
Live load	General Area=42 psf, Stair=84 psf Kitchen, Veranda, Lobby=63 psf Roof=33 psf	BNBC-2006
Load Combination		BNBC-2006

Figure A-32: Design parameters

Figure A-33: Design Notes-1

15. CONCRETE CLEAR COVER FOR REINFORCING BARS

Member	Location or Condition	Thickness of Cover	Figure
foundation	side	50	
	bottom	75	
column	above ground level	* 50	
	below ground level	* 75	
beam	indoors face : top, side & bottom	** 40	
	outdoors face : top, side & bottom	** 40	
slab and stair	top and bottom	20	
drain wall	exterior and bottom	50	
	interior	25	
water tank	water face	50	
	other face	25	

* from tie
** from stirrups

16. SLAB END REINFORCING DETAILS

a) FREE END OF SLAB INCAPABLE OF EMBEDDING OF STEEL BAR IN BEAM/WALL
b) OTHERS

17. RECOMMENDED END HOOKS

bar hook	Form and Extention	Bend Angle (degree)	Bend Radius (r)	Used Bar	Location
primary reinf.	db, 4db	180°	r = 2db	6 to 25	lap splice end of anchorage
tie/stirrups	db, 6db, 75mm	135°	r = 1.25db	6 to 12	stirrups fastening bar diagonal hoop
primary reinf.	db, 12db	90°	r = 2.5db	6 to 32	bend-up for embedment
slab	db	45°	r = 5db	8 to 20	bend bar in slab

Figure A-34: Design Notes-2

Figure A-35: Design Notes-3

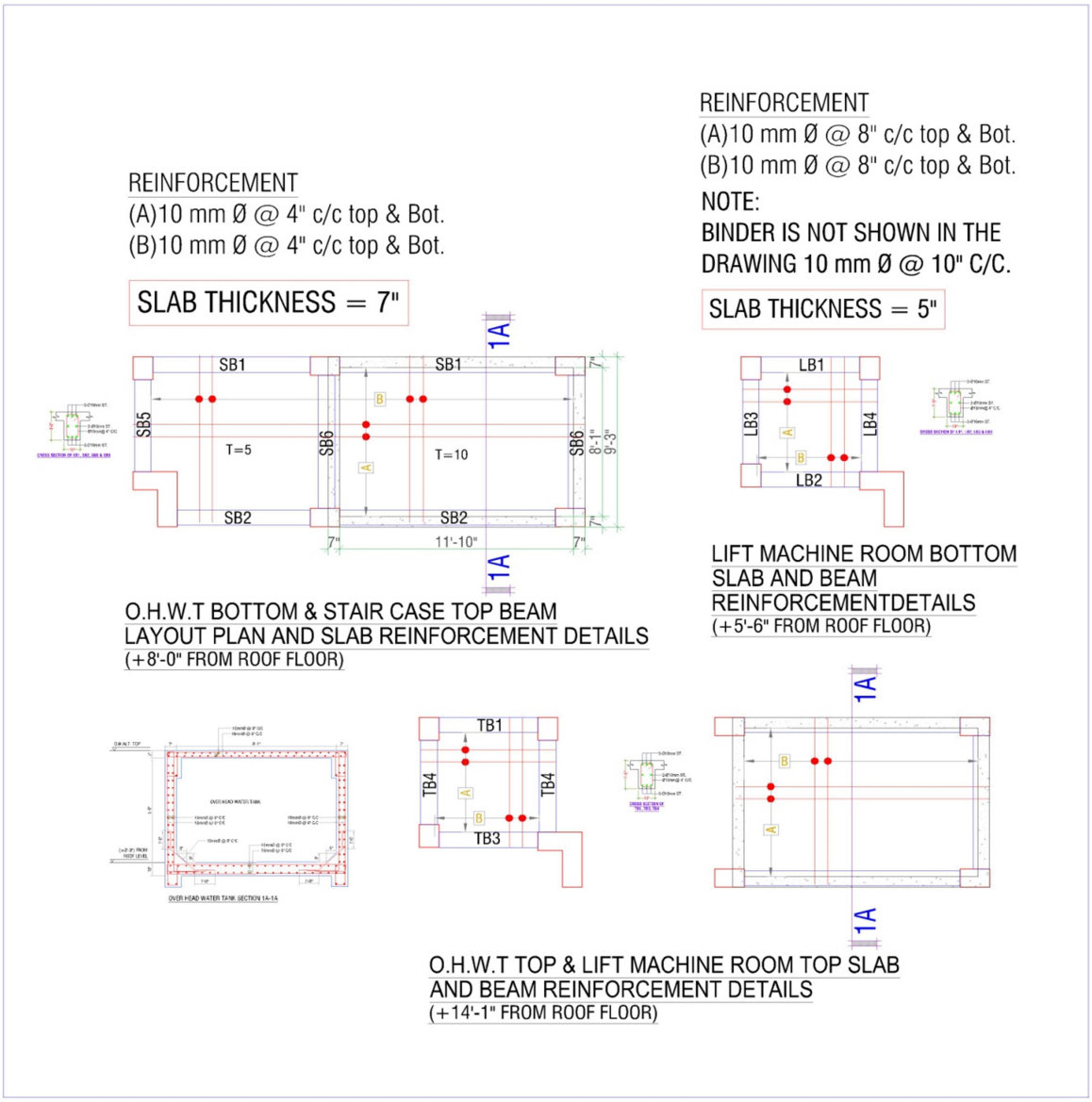


Figure A-36: O.H.W.T Top & Lift Machine Room Top Slab And Beam Reinforcement Details.