

DESIGN OF A TWO-STOREY PRIMARY SCHOOL BUILDING (ZONE 3)

**A Capstone project submitted in partial fulfillment of the Requirements for
the award of a degree of Bachelor of Science in Civil Engineering**

By

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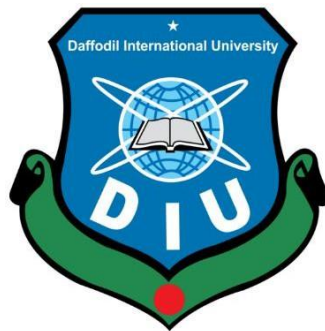
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September 2025

This certifies that the student below finished the "**DESIGN OF A TWO-STOREY PRIMARY SCHOOL BUILDING**" capstone project under my guidance, which was a prerequisite for the Bachelor of Science in Civil Engineering degree. On **September 20, 2025**, the work was successfully presented.

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We would want to express our gratitude to the **Department of Civil Engineering** for giving us this capstone project. Bridging the gap between theory and practice has been made possible by this chance.

Our sincere appreciation is extended to Md. Imran Hasan Bappy, whose steadfast assistance and outstanding direction beyond our expectations. His knowledgeable counsel throughout the report-writing process, together with his guidance, tolerance, and support, inspired us to overcome obstacles and succeed. His confidence in our skills and unwavering encouragement have been crucial to this project's success. We can never enough thank him for his generosity, commitment, and sincere concern during this trip.

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Finally, we would like to express our sincere gratitude to Assistant Professor **Mr. Md. Masud Alom** for his leadership and for highlighting the importance of the Capstone Project to our academic and professional development.

DECLARATION

The study titled "Design of Two-Storeyed Primary School Building with Structural and Environmental Consideration" was carried out under the supervision of Md. Imran Hasan Bappy (Lecturer), Department of Civil Engineering, Daffodil International University, Dhaka, Bangladesh and approved for the partial fulfillment of the requirement for the capstone project part of the Bachelor of Science in Civil Engineering.

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ABSTRACT

The structural design of a two-story primary school building, with a floor space of around 7038 square feet (153 feet by 46 feet) and a total height of 24 feet, is the main emphasis of this capstone project. Nine classrooms, a library, a head office, and a teacher's room are all part of the building. ETABS 2020 was used for structural analysis in accordance with the Bangladesh National Building Code (BNBC 2020). Beams, columns, slabs, and isolated footings are examples of reinforced concrete components that were made with strength, serviceability, and safety in mind. For example, #6 bars (20mm dia) were used to support 12" × 14" columns, and footings like F-41, which were 96" × 72" and 18" deep, were used.

AutoCAD were used to create detailed drawings, while Excel was used to handle the Bill of Quantities (BOQ) and design calculations (such as septic tanks and stairs). The project is projected to 122 days to complete, with a total estimated construction cost of BDT10,000,000. An Intermediate Moment Resisting Frame (IMRF) was the structural system employed, and the live load for classrooms was calculated to be 3 kN/m². With a total volume of 99.3 m³ and a capacity of 320 users, the septic tank was built to handle 30 liters of effluent per person every day. Energy-efficient technologies, pervious pavements, and compliance with ventilation and lighting regulations all contributed to environmental sustainability. This project prepares us for real-world civil engineering difficulties by bridging the gap between academic understanding and actual implementation.

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CHAPTER 1

INTRODUCTION

1.1 Proposed Structure

RCC will build the proposed two-story primary school entirely on separate foundations. The building, which is 24 feet high and around 153 feet by 46 feet on the design, has nine classrooms, a teachers' room, a library, and a head office. The layout plan is shown in Figures 1.1, 1.2, and 1.3. Fig. 1.4 shows an elevation view of the building:

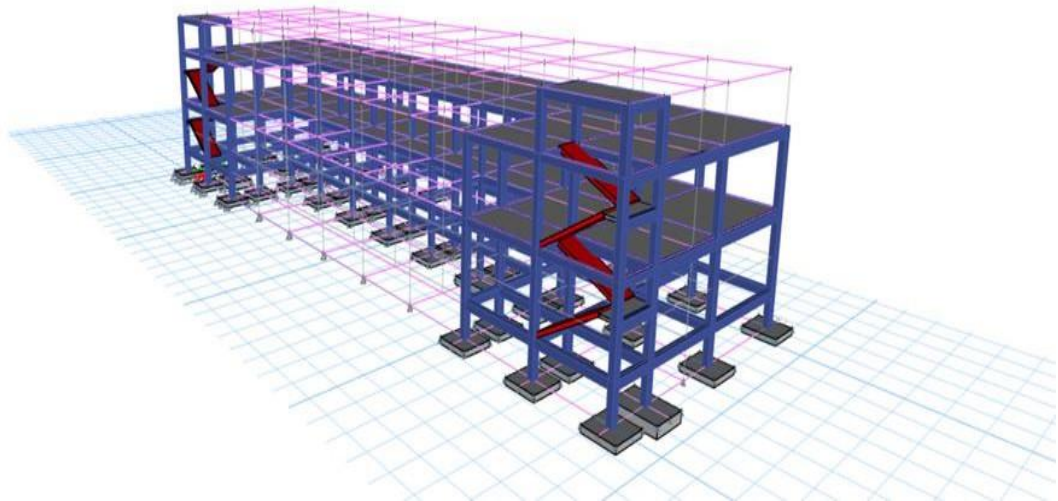


Figure 1.1 : Full Layout Plan

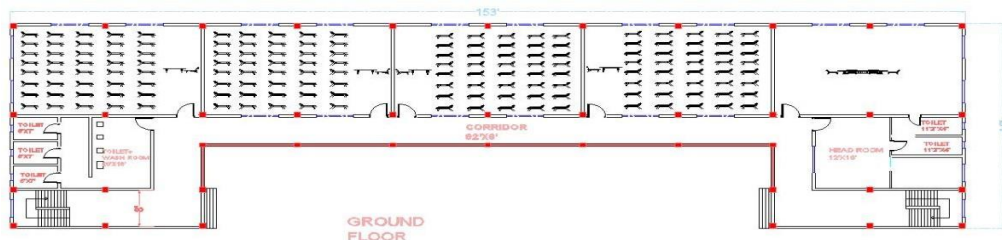


Figure 1.2: Ground floor

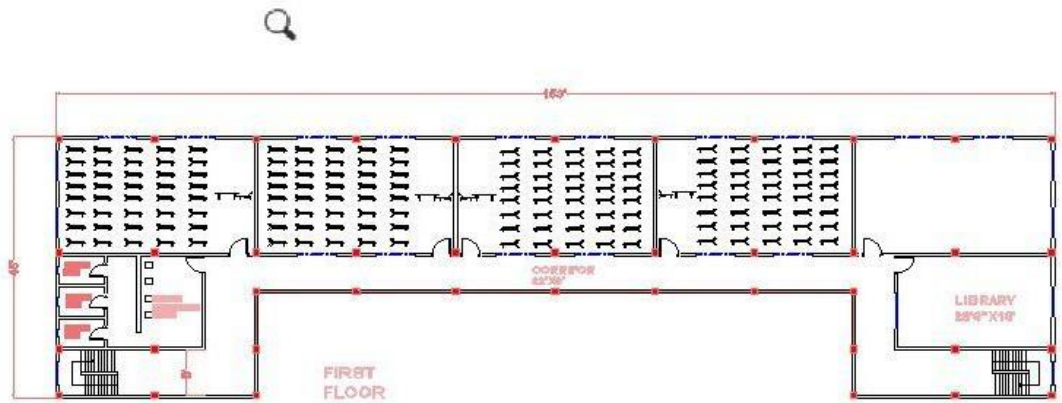


Figure 1.3: First floor

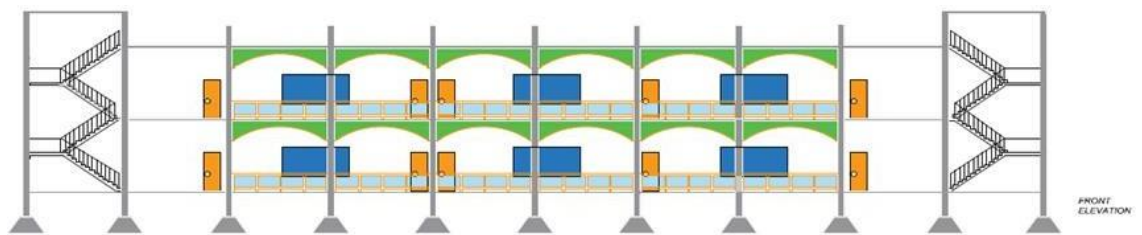


Figure 1.4: Elevation

1.2 Objectives of the Project

1. To use reinforced concrete to construct a two-story primary school building that complies with the Bangladesh National Building Code (BNBC, 2020) and is structurally safe, paying particular attention to Seismic Zone 3.
2. To apply theoretical understanding of civil engineering to practical applications by utilizing AutoCAD to detail all key components, such as slabs, beams, columns, and foundations, and ETABS 2020 for structural analysis.

3. To guarantee sustainability, economic effectiveness, and usefulness by means of appropriate space planning, precise material estimation, and the advocacy of eco-friendly techniques such as energy-efficient design and rainwater collecting.

An Intermediate Moment Resisting Frame (IMRF) structural system is being used in this project to construct a two-story reinforced concrete (RC) educational institution, as shown in Table 1.1. The foundation is built with independent footings to carry the loads, whilst the floor system is made up of edge-supported slabs.

Table 1.1: Basic information of the building

Building Usage Type	Educational building
Structural System	RC Beam-Column frame (Intermediate Moment Resisting)
Floor System	Edge-supported Slab
No. of Stories	2-storey Building
Floor Load	Mentioned in Load Plan
Foundation Type	Isolated Footing

According to the infrastructure plan and planning guideline

A school should maintain a minimum of 50% of its total size as open space. The open space might be utilized for placing things, as well as for a playground. There will be a minimum of five (four) in the classroom, and the restrooms for men and women should be kept apart. The size of the classroom need to be uniform (Education, 2018). For schools with more than 350 children, there is a library, one separate HT room, and at least one teacher room. Classroom size should be 30'ft *20'ft, and staircase size 8'ft*22'6''ft.

CHAPTER 2

DESIGN CODES, STRUCTURAL DESIGN AND REQUIREMENTS

In order to protect life, limb, health, property, and public welfare, it is important to adhere to design codes that set basic standards for the layout, construction, material quality, use and occupancy, placement, and maintenance of all buildings in Bangladesh, within reasonable bounds. To accomplish the same goal, regulations are also in place regarding the installation and usage of specific tools, services, and accessories related to or linked to such buildings. The equations and specifications that would be used in the structural design of this building were sometimes referred to as (BNBC, 2020). Etabs 2020 was also evaluated using (BNBC, 2020).

2.1 Design code

The Bangladesh National Building Code (BNBC, 2020) has been followed in the analysis and design process, and all structural drawings must be examined in combination with pertinent architectural drawings. For specifications or structural requirements not included in the drawings or this design report, refer to (BNBC, 2020).

2.2 Foundation and soil

One suggested foundation type is a footing foundation. It is advised to have a minimum clear cover of 3.0 inches. The foundation's depth must match the sketch. 2.3: characteristics of the material Minimum f_c (crushing strength of a 28-day cylinder) 4000 psi for the foundation and column, with a 1:1:2 mix ratio Slabs and beams at 4000 psi with a 1:1:2 mix ratio

2.3 Lapping Zone of Beam

The minimum lap length required by (BNBC, 2020) depends on the grade of concrete, the diameter of the reinforcement bars, and where they are placed (tension or compression zones). Typically, the lap length is a multiple of the bar diameter (for instance, 40D, where D is the diameter of the bar). The bar's lap length should be 40D for tension and 30D for compression (where D is the bar's diameter).

Note: A tension lap is a column lap.

2.4 Corner reinforcement

Corner reinforcement is required by the Bangladesh National Building Code (BNBC, 2020) in order to strengthen structural corners and sustain concentrations of strain, particularly in seismic zones. To manage shear and torsional loads, BNBC (2020) suggests adding more diagonal bars, closely spaced stirrups, and ties for beams, slabs, and column-beam connections. To avoid slippage under load, bars at corners must have minimum lap lengths and proper anchoring, as shown in Fig. 2.1. In order to assist buildings better tolerate lateral loads and avoid cracking or brittle failure, this reinforcing technique guarantees ductility, energy absorption, and structural integrity at critical areas.

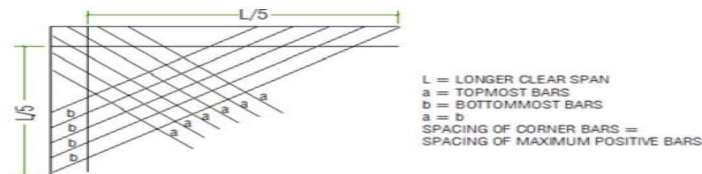


Figure 2.1: Corner reinforcement

2.5 Material strength

Table 2.1: Material Strength

	<i>Concrete, f_c</i>	<i>Unit</i>	<i>Rebar Strength, f</i>
Foundation	4000	psi	60000 psi
Pedestal Column	4000	psi	60000 psi
Grade Beams	4000	psi	60000 psi
Column	4000	psi	60000 psi
Beams and Slabs	4000	psi	60000 psi

2.6 Development length

As per the Bangladesh National Building Code (BNBC 2020), Development Length (L_d) for reinforcement in beams and slabs is the minimum length of reinforcement which must be embedded into concrete to prevent sliding and yield full strength safely. This is calculated as follows; Type of reinforcement, the grade of concrete and spacing $L_d = \frac{\phi f_y}{4\tau_b}$ (where ϕ = bar diameter, f_y is steel compressive strength and τ_b is concrete bond strength) This is on top of the longer development lengths that beams will generally need relative to slabs, due to the higher loads they must take (i.e. compared with structural load slabs), and linear adjustments described in BNBC (2020) for factors like bar type, cover etc. These rules are designed to keep concrete buildings safe and standing strong, so they can specify the right length of anchors for any given load.

2.7 Concrete Clear Cover for Reinforcing Bars

Concrete: There is a minimum amount of space required between the bars and the surface of the concrete to protect them from fire, corrosion and other environmental damage. This is called concrete clear cover. This will cover for the Column, which usually is of 1.5-inch size and very transparent, can be enough durable and protective. Normally this is 1 inch for interior beams, but depending on exposure that may grow. Typically, slabs have a 3/4- to 1-inch-thick transparent cover depending on their exposure and thickness. The cover stabilizes the stair concrete slab and is secured on the edge Figure 2-3 and results can be seen in Table 2.2. Reinforcement does not corrode, there is no attacking of the structure by moisture and chemicals, resistance to fire enhances; in sum all characteristics of a durable lasting construction are provided.

Table 2.2: Concrete Clear cover

<i>Member</i>	<i>Location or Combination</i>	<i>Thickness of Cover</i>
Column	Not in contact with the ground or water	1.5"
	In contact with the ground or water	2.5"
Beam	Indoors face: Top, Side & Bottom	1.5"
	Outdoors' face: Top, Side, & Bottom	1.5"
Slab	Bottom	1"
	Top	$\frac{3}{4}$ "

Summary

To ensure safety and adherence to construction, material, and service requirements, the building design conforms with BNBC 2020. ETABS 2020 was used for structural analysis and design in accordance with BNBC 2020 norms.

CHAPTER 3

STRUCTURAL ANALYSIS AND OUTPUT

Introduction

In this project the beams, columns, footings, slabs and stairs are modelled in ETABS which is a G+1 building. I defined the appropriate span lengths along with stress conditions for beam design so that ETABS will determine required reinforcement for both shear and bending. I monitored the cracks and deflections of the beams to guarantee serviceability. The columns were considered as vertical frame members, and the interaction equations given by design codes to apply axial loads and moments for determining the reinforcement, were used. Before building the footing, I computed the forces this mass applies on the system based on the assumed reaction and did a structural evaluation of the foundation system using estimated loads and soil properties. Then I modeled it and design the reinforcement that will provide enough stiffness & strength using ETABS to check the load capacity. I checked that my actual slab thickness, applied loads and deflection and moment capacities from results were designed to a safety and serviceability standard. To check that the stairs followed all regulations, I ended up designing them by assuming a series of slabs and beams. The detailed analysis done in ETABS allows full-proof integrated approach towards structural design revealing complete safety and robustness of elements present within structure of the building. After structural designing of G+1 building in ETABS, detailing was done using AutoCAD. This Phase mainly focuses on making sure that the design can be visualized and represented properly. After that, an auto cad drawing is made for beams, columns, and slabs of footings and stair cases in which everything should be drawn accurately along with the measurements like material takeoffs & RC structural drawings. This technique allowed me to understand in a more precise way how different elements work together structurally speaking, such as the connection between the beams and columns or the supporting slab. I also made a few quick labels and symbols for the designs. To ensure that the drawings can be built effectively, we marry well-organized ETABS analysis with detailed AutoCAD drawings to make sure that plans were not only working structurally but also could be understood by those who had to build it.

3.1 Load consideration

Dead load, live load, and floor finish load are the three categories into which the loads are divided in ETABS while designing a model for a primary school building in compliance with (BNBC, 2020) regulations. The entire weight of the building's permanent structural elements, including floors, walls, beams, and columns, as well as its fixed installations, including ceilings and partitions, is known as the dead load. The weight of the materials—such as concrete, brick, or steel—determines this load. The building's inhabitants, furniture, and mobile items are all taken into account by Live Load. Primary schools should assign a live load of around 2 to 4 kN/m² in classrooms due to normal use and occupancy. Increase the Live Load to 4 to 5 kN/m² in order to handle increased foot activity in crowded places like assembly rooms and hallways. Finally, the weight of the flooring elements, such as carpet or tiles, is known as the floor finish load, and it is typically set between 1 and 1.5 kN/m². These loads should then be coupled in ETABS in compliance with the load combination guidelines (BNBC, 2020) in order to accurately estimate the building's structural performance under various conditions.

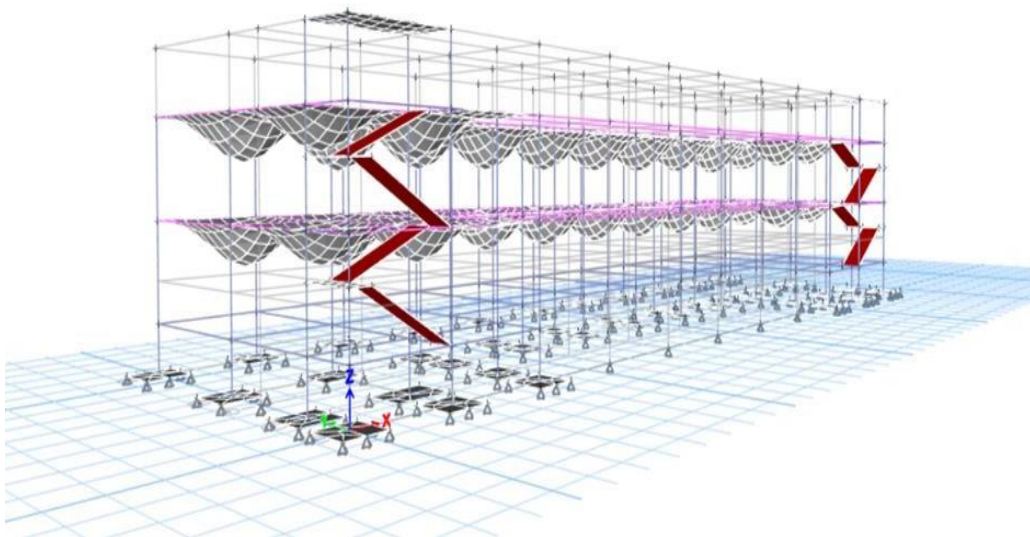


Figure 3.1: Load Combinations

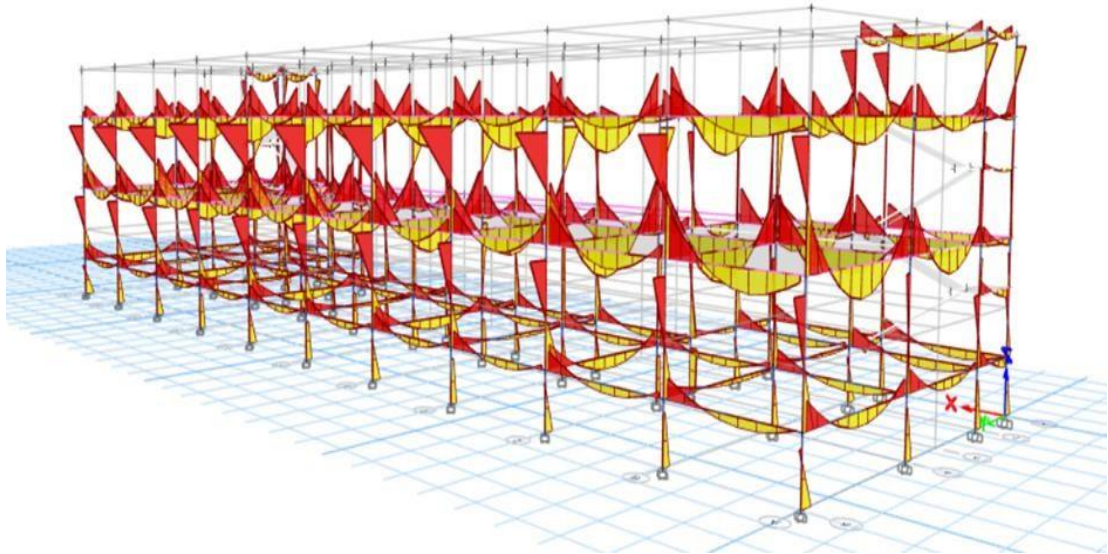


Figure 3.2: Flexural Load combination

3.2 Design of Slab and detailing

In this way, many important aspects are there while you design slabs in ETABS so that the resultant slabs will be structurally sound and also code compliant. The Slab Analysis program considers the following factors: slab geometry, material data of flat plate, load types (dead, live and environmental loads) as well as working conditions. By means of the finite element analysis, it checks out the stresses, deflections and reinforcement required through the slabs. Additionally, ETABS analyses the performance of slab subjected to different types of load distributions (live and dead), load combinations and support conditions (read simply supported, fixed or continuous). It also includes safety features and regional design requirements to ensure compliance with local standards for the specific location

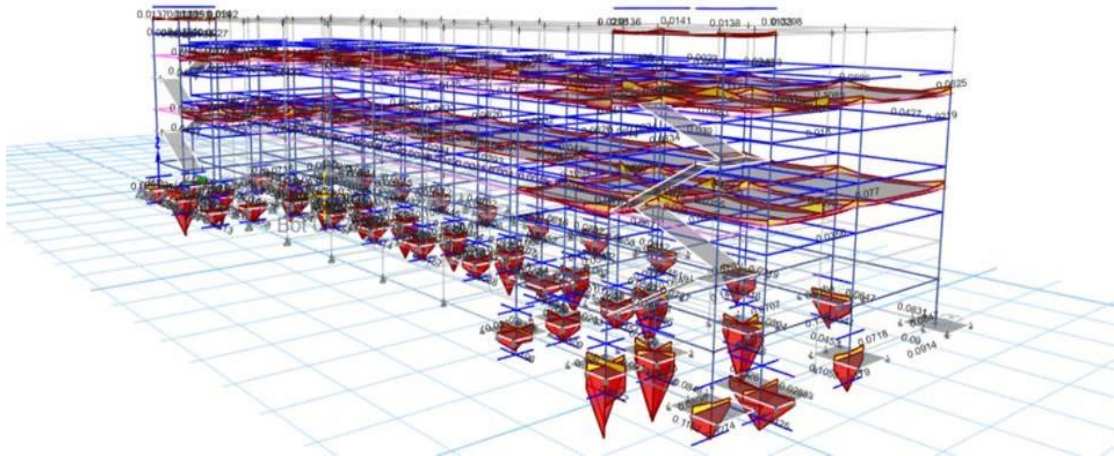


Figure 3.4: Flexural Stress

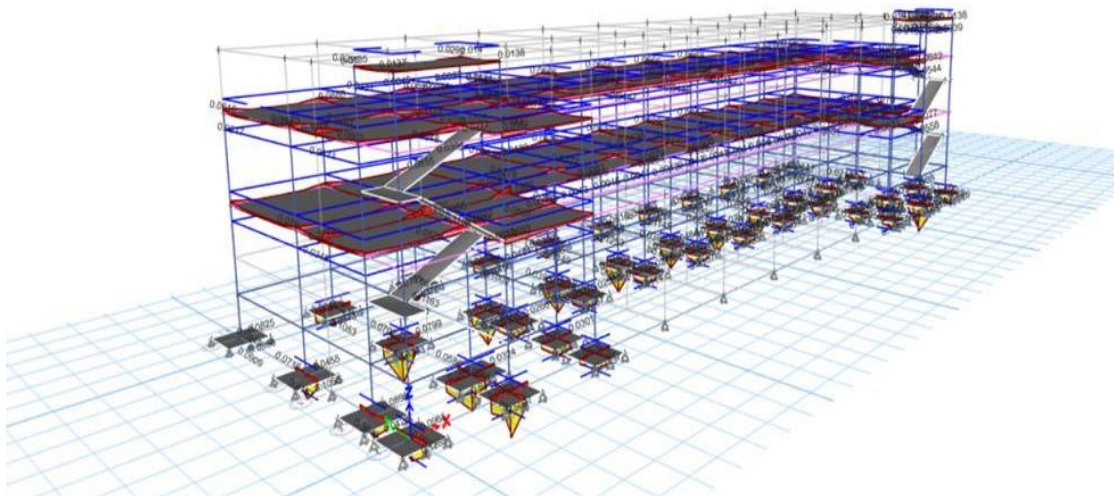


Figure 3.5: Flexural Stress (Slab)

3.3 Design of Beam and Detailing

The G+1 building's ETABS beam design method involves determining the beam's dimensions and outlining the loading conditions, including dead and live loads, in compliance with the relevant standards. Once the model was configured, we examined the beams for bending moments and shear forces using ETABS, as seen in Fig. 3. The program ensured that the beams met structural safety standards by automatically

determining the reinforcing required for both positive and negative moments. After reviewing the analytical results, it was confirmed that the reinforcement scheme satisfied the basic code requirements, successfully resisted the applied loads, and that the calculated deflections were within permissible boundaries for serviceability. Taking everything into account.

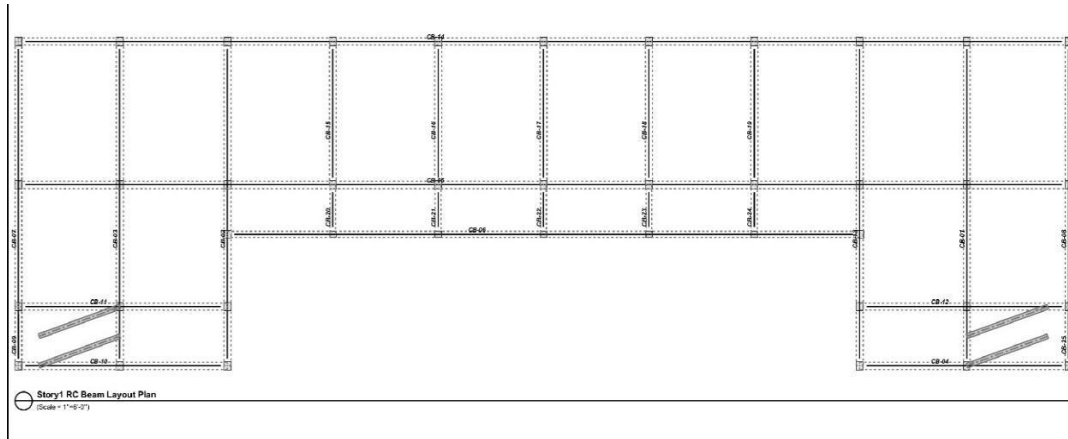


Figure 3.6: Beam Layout Plan

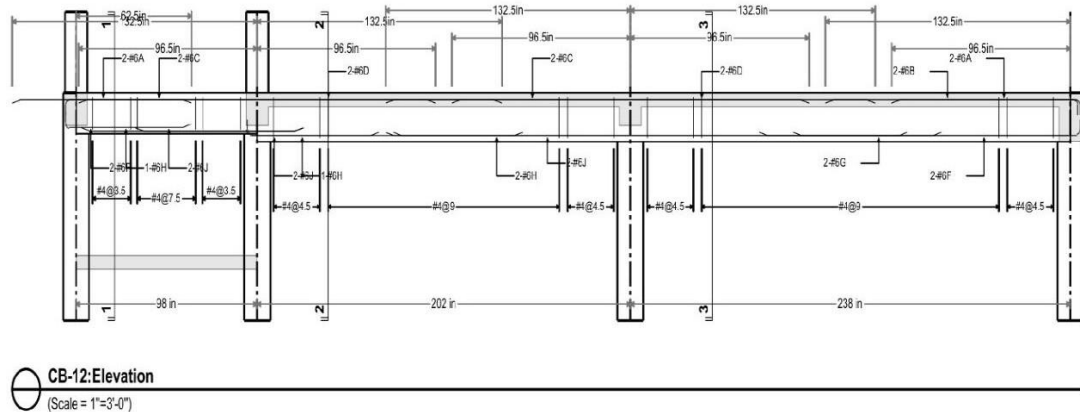


Figure 3.7: CB-12 Beam Elevation

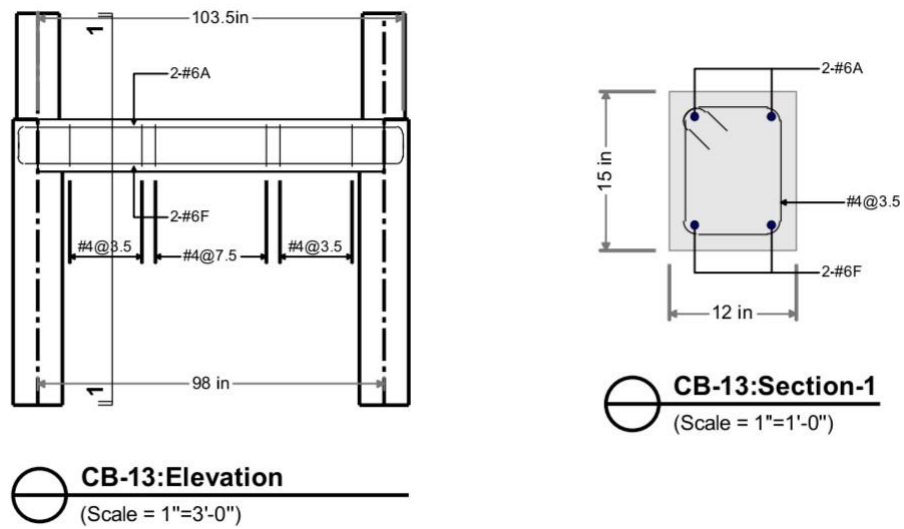


Figure 3.8: CB 13 Beam Elevation

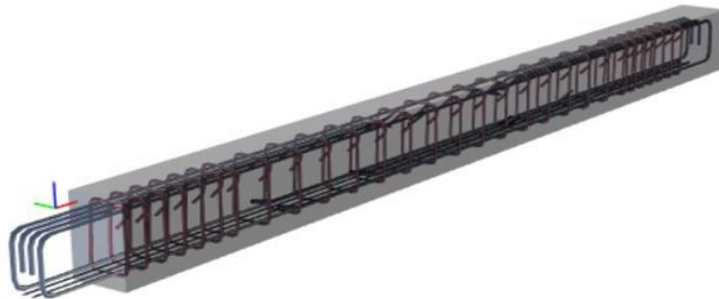


Figure 3.9: 3D Dimension Beam Rebar Profile

3.4 Lap Location

- The middle third zone of the span should not have a bottom bar lap for the beam.
- The middle third zone of the span may include a lap bar for the beam top. Figures 3.10 and 3.9.
- A maximum of 50% of the bars must be spliced together.

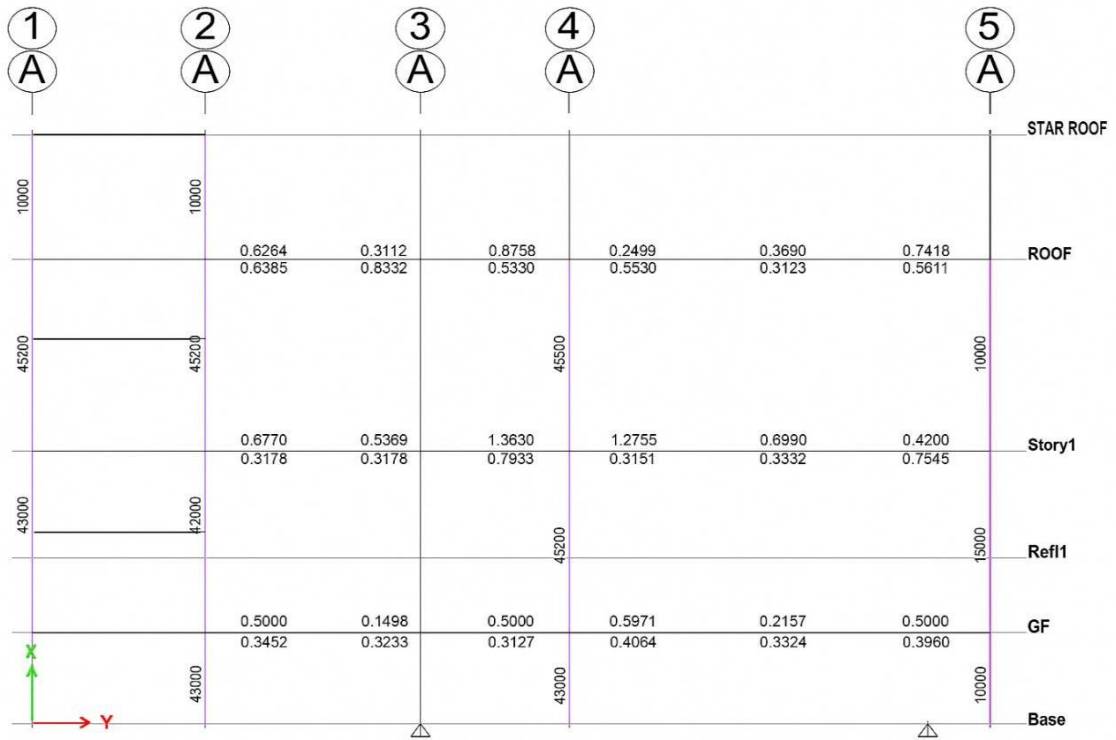


Figure 3.10: Elevation 1 (A) Reinforcement

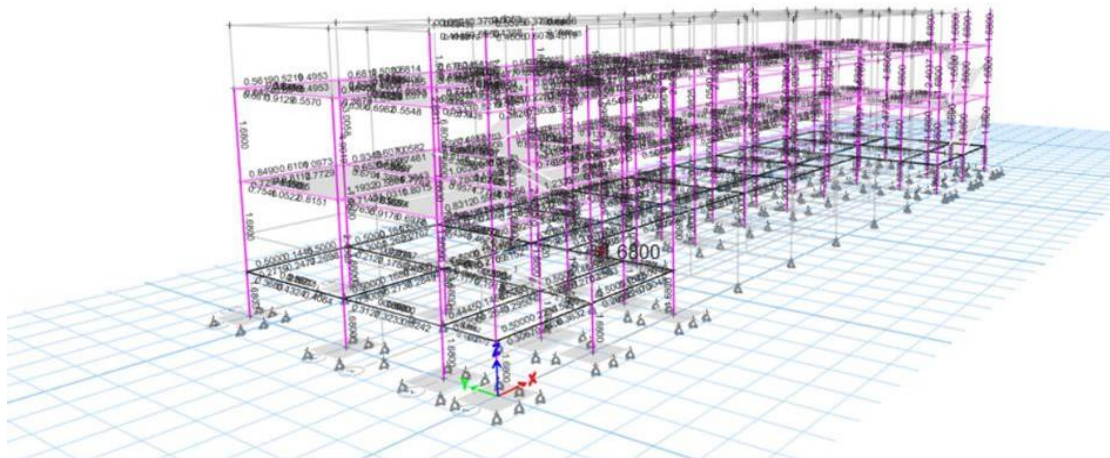


Figure 3.11: 3D Dimensional All Floor Slab Beams Reinforcement

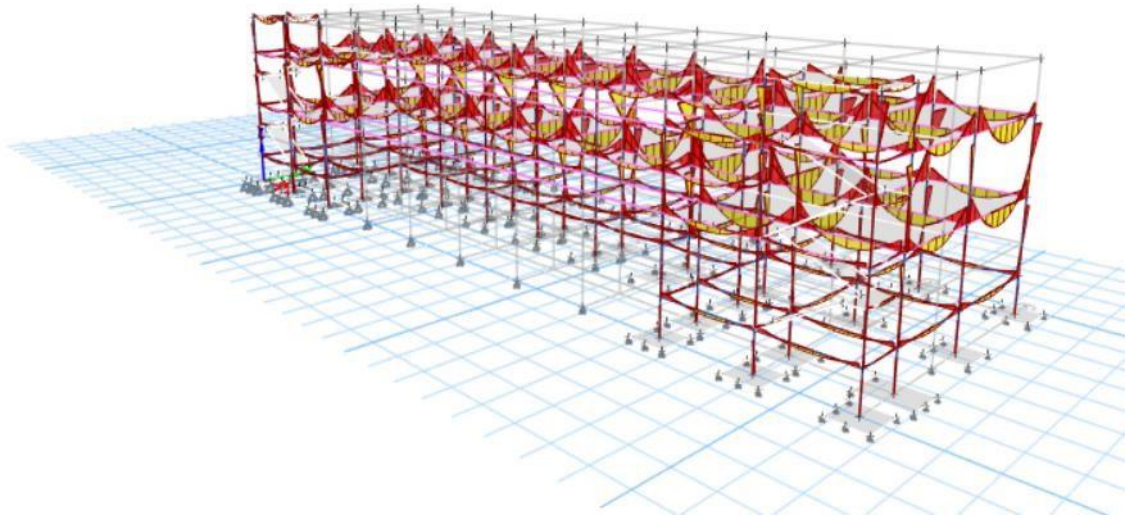


Figure 3.12: Bending Moment Diagram (Dead load Kip-ft)

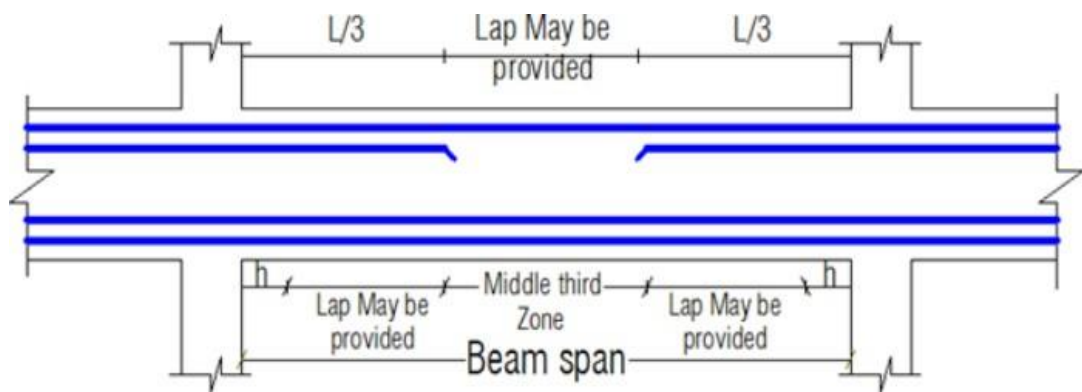


Figure 3.13: Lap position

Beam of Roof

Table 3.1: Beam details

Beam No	Dimension	Bottom Rebar	Top Rebar	Stirrups
B1	(12''X12'')	3# 20mm dia	4# 20mm dia	12mm @ 4.5c/c
B2	(10''X14'')	2# 20mm Dia	2# 20mm Dia	12mm @ 4.5c/c
B3	(12''x18'')	3# 20mm Dia	4# 20mm Dia	12mm@ 4.5c/c
B4	(12''x20'')	3# 20mm Dia	3# 20 mm Dia	12mm@ 4.5c/c
GB1	(12''X15'')	2# 20mm Dia	2# 20 mm Dia	12mm @3.5''c/c
GB2	(10''X15'')	2# 20mmDia	2# 20mm Dia	12mm @ 3.5c/c
SB	(12''X15'')	3# 20mm Dia	4# 20mm Dia	12mm @ 4.5c/c

3.5 Design of Column and detailing

When developing columns for a structural model, ETABS considers many crucial factors. In order to determine the columns' strength and stability, it begins with evaluating the axial loads and moments that are influencing them. ETABS looks at loads such as dead loads and active loads to see how they impact column performance. Additionally, the software takes into account the column's stiffness and buckling capacity, cross-sectional area, reinforcing details, and all of these factors impact the column's resistance to compression. and bending. ETABS employs pertinent design rules and considers the implications of slenderness to ensure that the column meets safety and performance standards. By integrating all of these elements, ETABS assists structural engineers in creating building columns that are both effective and compliant with codes. ETABS. By giving precise details on column sizes, reinforcing

configurations, and bar sizes, these detailed drawings guarantee that the design meets structural requirements and permits flawless execution throughout construction.

Figure 3.15: Column Design (10"x12")

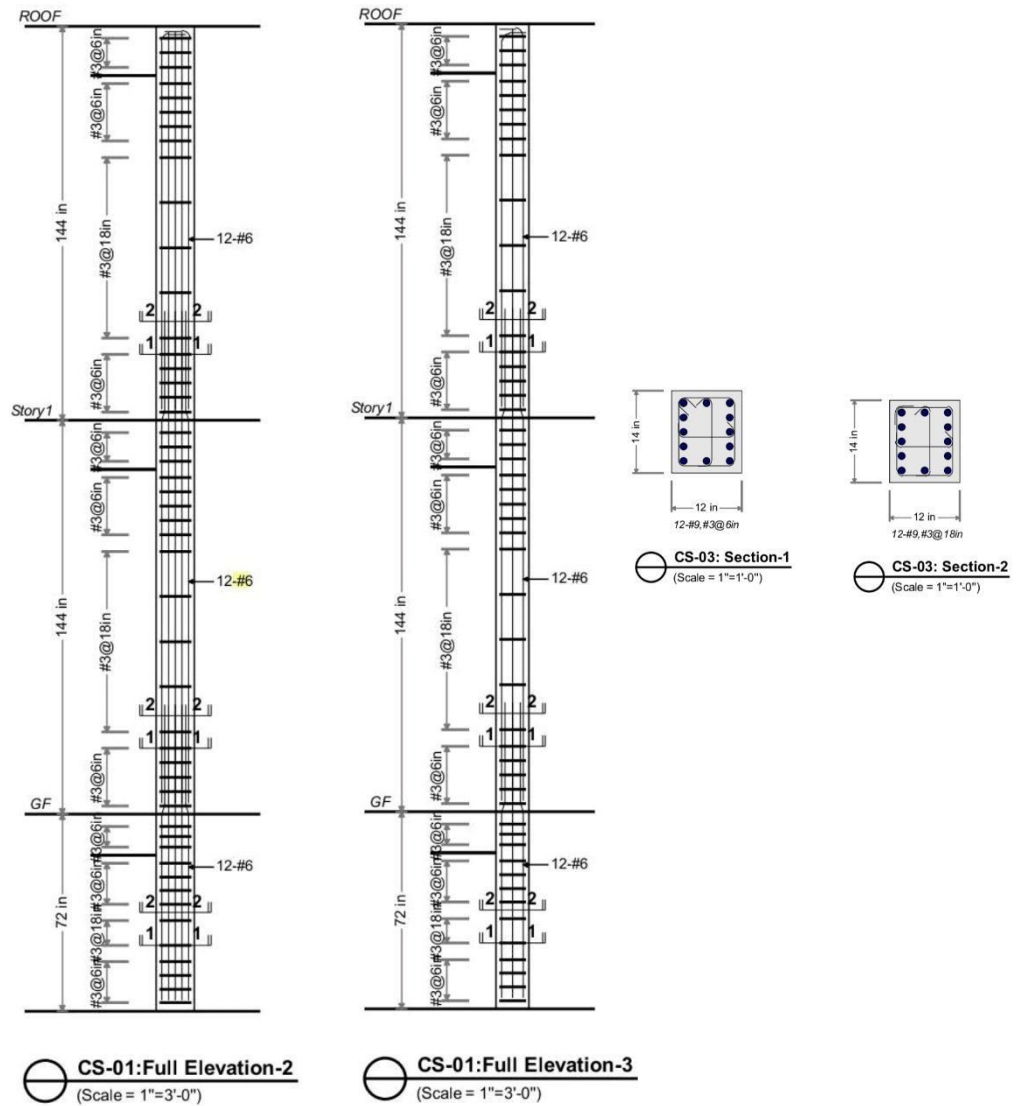


Figure 3.16: Column Design (12"x14")

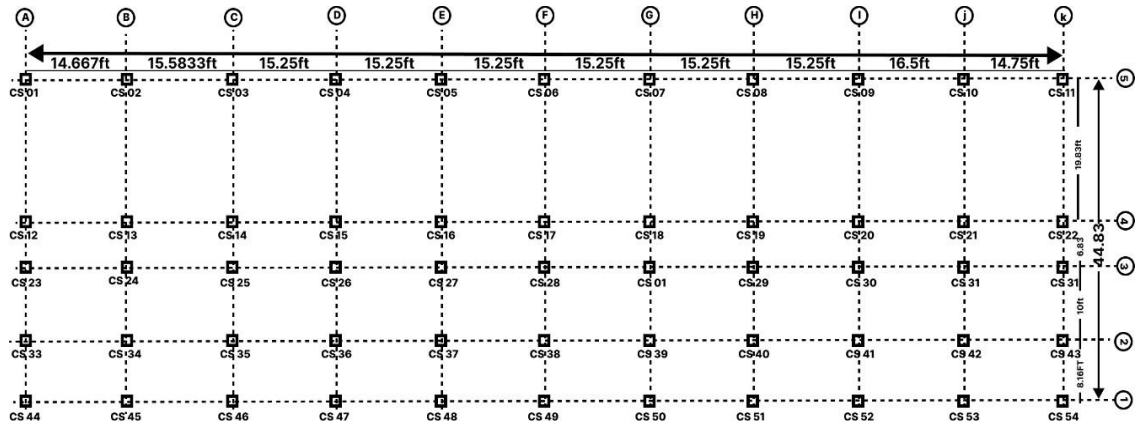


Figure 3.17: Column Layout Plan

	CS-01					CS-35					CS-40							
	COLUMN SIZE	SECTION	REINFORCING	TIES ZONE-A	TIES ZONE-B	TIES ZONE-C	COLUMN SIZE	SECTION	REINFORCING	TIES ZONE-A	TIES ZONE-B	TIES ZONE-C	COLUMN SIZE	SECTION	REINFORCING	TIES ZONE-A	TIES ZONE-B	TIES ZONE-C
STAIR ROOF																		
ROOF																		
Story1	12 inx14 in	A	10-#6	#306in	#3018in	#306in	10 inx12 in	B	8-#6	#306in	#3018in	#306in	12 inx14 in	A		#306in	#3018in	#306in
GF			10-#6						8-#6									
Base																		

Figure 3.18: All Column Rebar Table chart

Columns from Basement to Ground Floor

Table 3.2: Details of Ground to Roof Column

Column No.	Size of Column	Main Reinforcement	Lateral Ties
1	12"x14"	20mm Dia	10mm @ 6" C/C
2	12"x14"	20mm Dia	10mm @ 6" C/C
3	12"x14"	20mm Dia	10mm @ 6" C/C
4	12"x14"	20mm Dia	10mm @ 6" C/C
5	12"x14"	20mm Dia	10mm @ 6" C/C
6	12"x14"	20mm Dia	10mm @ 6" C/C
7	12"x14"	20mm Dia	10mm @ 6" C/C
8	12"x14"	20mm Dia	10mm @ 6" C/C
9	12"x14"	20mm Dia	10mm 6" C/C
10	12"x14"	20mm Dia	10mm @ 6" C/C
11	12"x14"	20mm Dia	10mm @ 6" C/C
12	12"x14"	20mm Dia	10mm @ 6" C/C
13	12"x14"	20mm Dia	10mm @ 6" C/C
14	12"x14"	20mm Dia	10mm @ 6" C/C
15	12"x14"	20mm Dia	10mm @ 6" C/C
16	12"x14"	20mm Dia	10mm @ 6" C/C
17	12"x14"	20mm Dia	10mm @ 6" C/C
18	12"x14"	20mm Dia	10mm 6" C/C

19	12"x14"	20mm Dia	10mm @ 5.5"/6" C/C
20	12"x14"	20mm Dia	10mm @ 6" C/C
21	12"x14"	20mm Dia	10mm @ 6" C/C
22	12"x14"	20mm Dia	10mm @ 6" C/C
23	12"x14"	20mm Dia	10mm @ 6" C/C
24	12"x14"	20mm Dia	10mm @ 6" C/C
25	10"x12"	20mm Dia	10mm @ 6" C/C
26	10"x12"	20mm Dia	10mm @ 6" C/C
27	12"x14"	20mm Dia	10mm @ 6" C/C
28	12"x14"	20mm Dia	10mm @ 6" C/C
29	10"x12"	20mm Dia	10mm @ 6" C/C
30	10"x12"	20mm Dia	10mm @ 6" C/C
31	10"x12"	20mm Dia	10mm @ 6" C/C
32	10"x12"	20mm Dia	10mm @ 6" C/C
33	10"x12"	20mm Dia	10mm @ 6" C/C
34	10"x12"	20mm Dia	10mm @ 6" C/C
35	10"x12"	20mm Dia	10mm @ 6" C/C
36	10"x12"	20mm Dia	10mm @ 6" C/C
37	12"x14"	20mm Dia	10mm @ 6" C/C
38	12"x14"	20mm Dia	10mm @ 6" C/C
39	10"x12"	20mm Dia	10mm @ 6" C/C

40	12"x14"	20mm Dia	10mm @ 6" C/C
41	12"x14"	20mm Dia	10mm @ 6" C/C

3.6 Design of Foundation and detailing

The design of isolated footings in ETABS takes into account several factors to ensure the structural stability and conforms to the design requirements. Soil carrying capacity has a major impact on the size of the footing and need for its reinforcement. ETABS additionally calculates the footing load from columns (dead, live and other applied) to provide proper support in accordance with soil restrictions. It also takes into account the shear stresses and moments at the foundation, especially regarding the necessary for punching and bending shear. The first step is to determine the footing depth, and reinforcement required for resisting bending pressures which will keep the settlement within permissible limits. Taking into account criteria such as concrete strength, footing form and size – quite a few details to be specific – our design is tailored and dimensioned accordingly on the interval specified according to regional building code making it an optimized one.

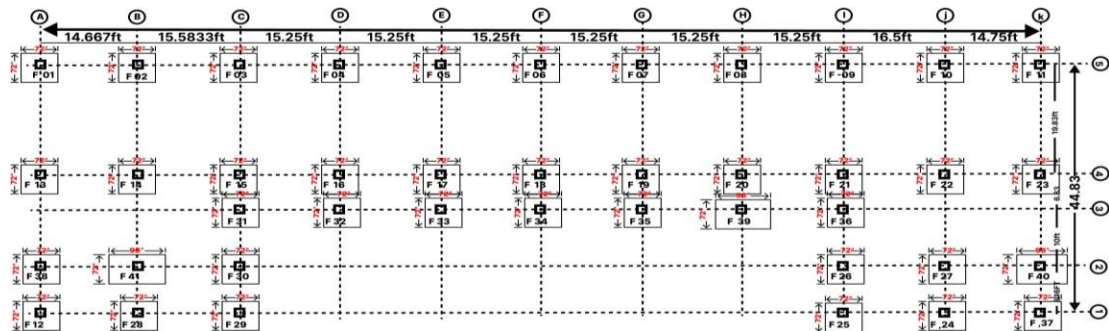


Figure 3.18: Footing Size & Position

Table: Footing Schedule

Item	Diameter	Thickness	Length	Width	Reinforcement
F- 01	#6	12"	72"	72"	16mm @ 3in c/c
F- 02	#6	18"	96"	72"	20 mm @ 3 in c/c

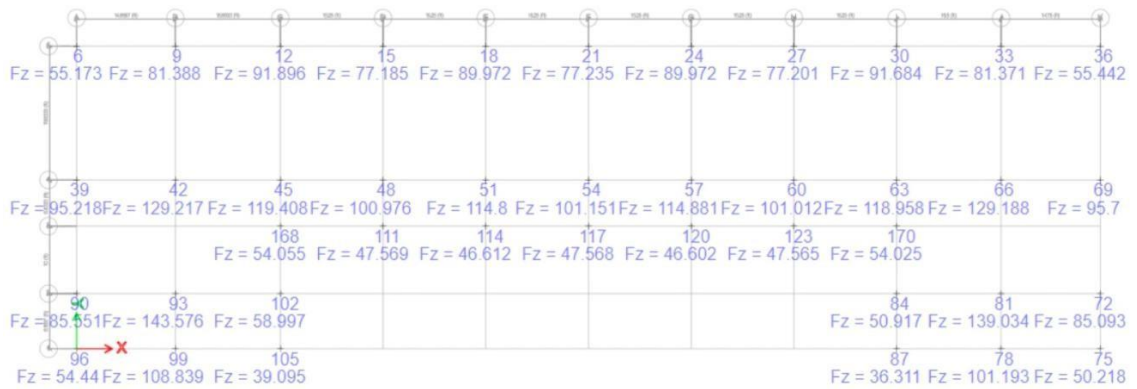


Figure 3.19: Footing load

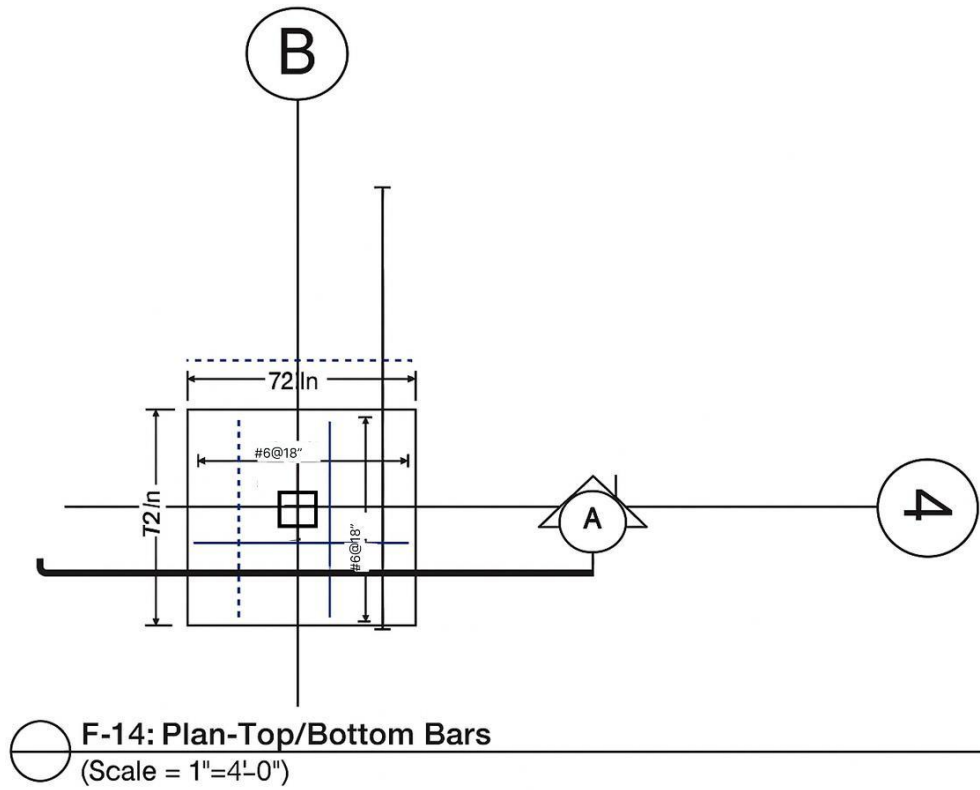


Figure 3.20 Footing F-14 Plan -Top/ Bottom Bars (72"X72"), Height 12"

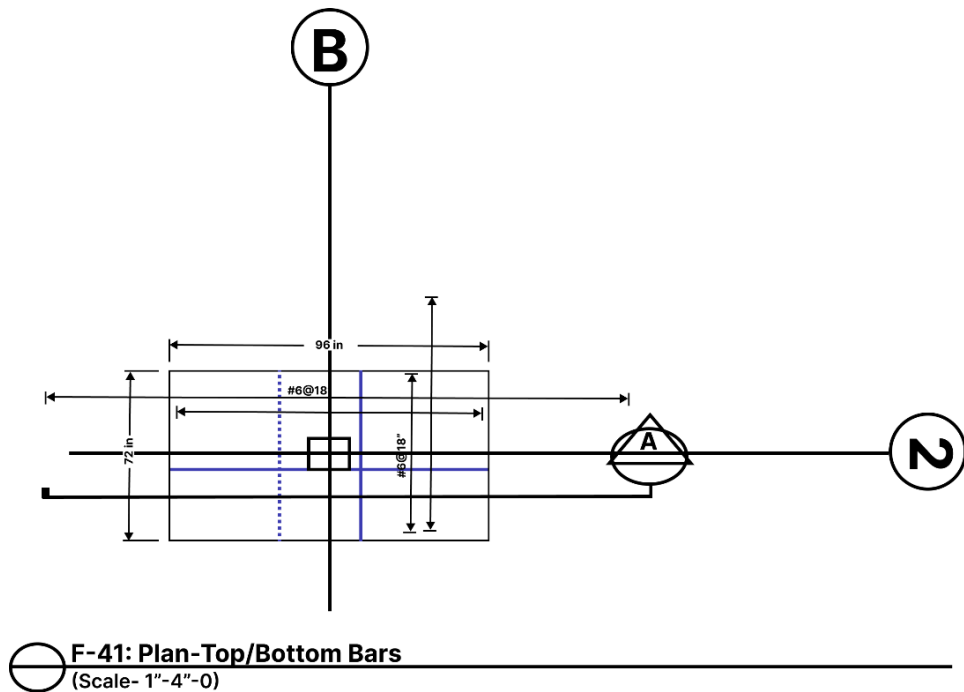


Figure 3.21 Footing F- 41 Plan -top/bottom Bars (96"x72"), Height 18"

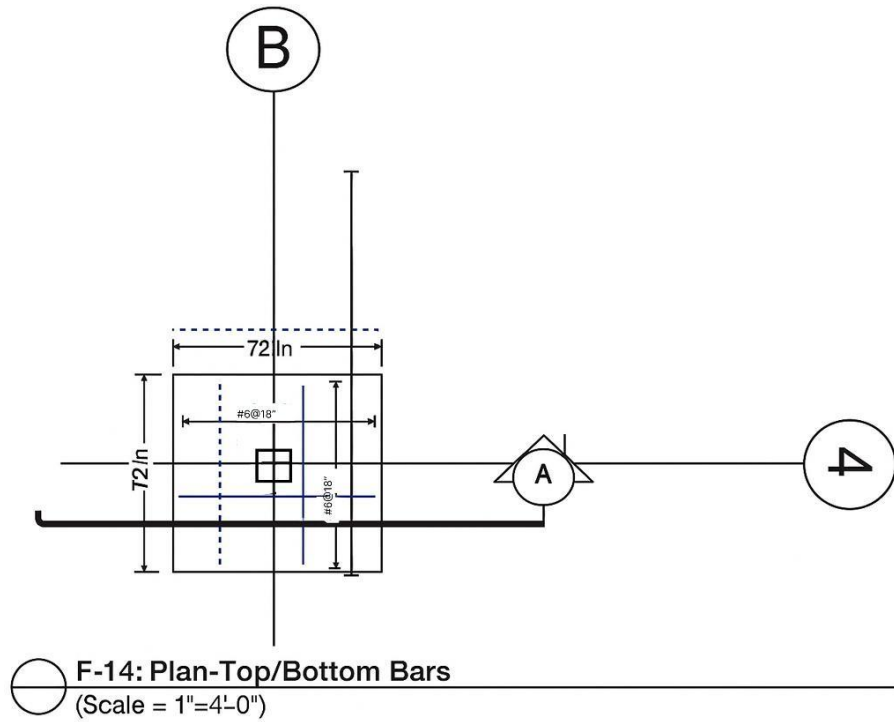


Figure 3.22: F-30 Footing 4.1 Plan-bottom Bars

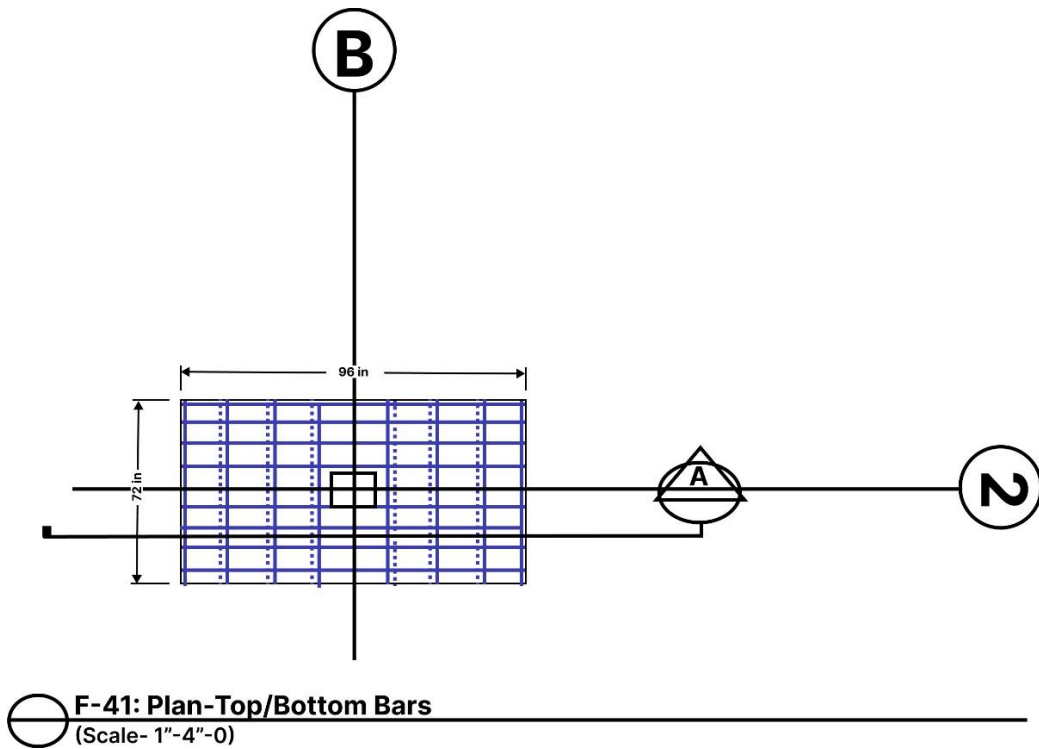


Figure 3.23: F-41 Plan all bars Top/bottom Bars

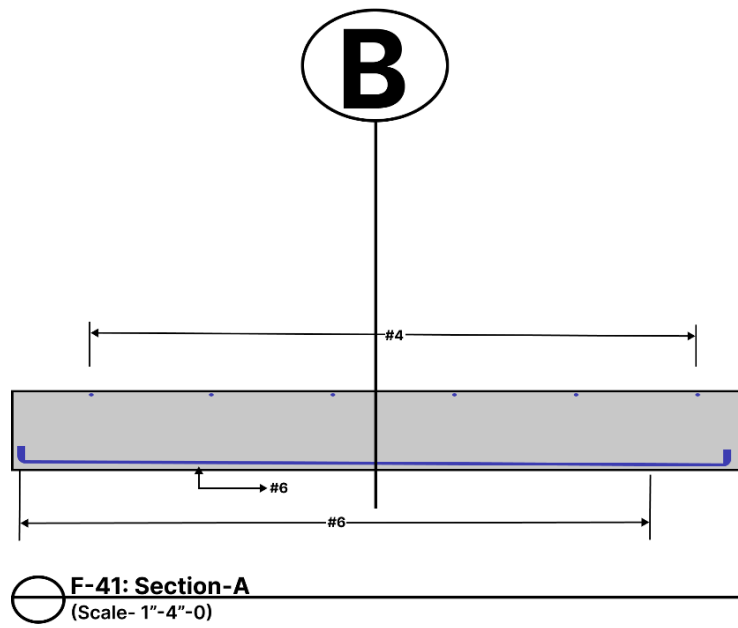


Figure 3.24: F-41 Section A

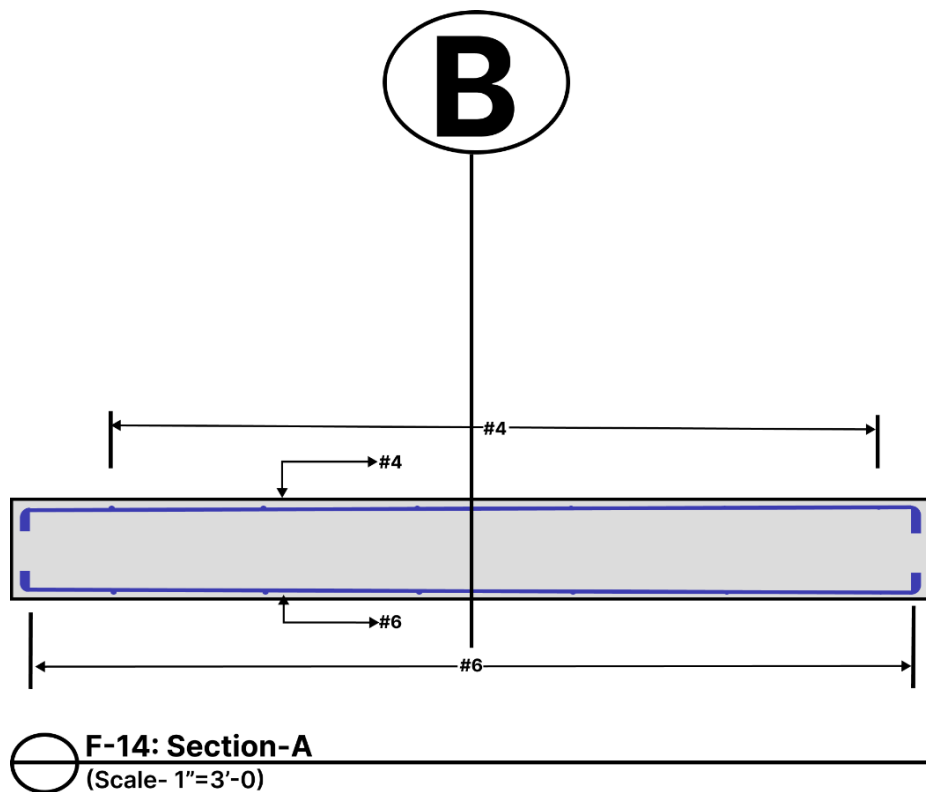


Figure 3.25: 14 Section A

3.6 Design of Staircase and detailing

When constructing a staircase in ETABS, certain structural and load considerations are essential to guaranteeing both safety and usefulness. ETABS will analyze the staircase's geometry, considering the rise, run, and overall slope, in order to meet architectural criteria. In order to account for their structural features, it considers the materials' strength and stiffness, such as concrete or steel. Load calculations must consider both live loads (such as the weight of persons and objects being moved up stairs) and dead loads (such as the structure's self-weight) in order to adhere to architectural regulations. The program also evaluates boundary constraints and support types, such as whether the staircase is cantilevered, supported at both ends, or resting on intermediate landings.

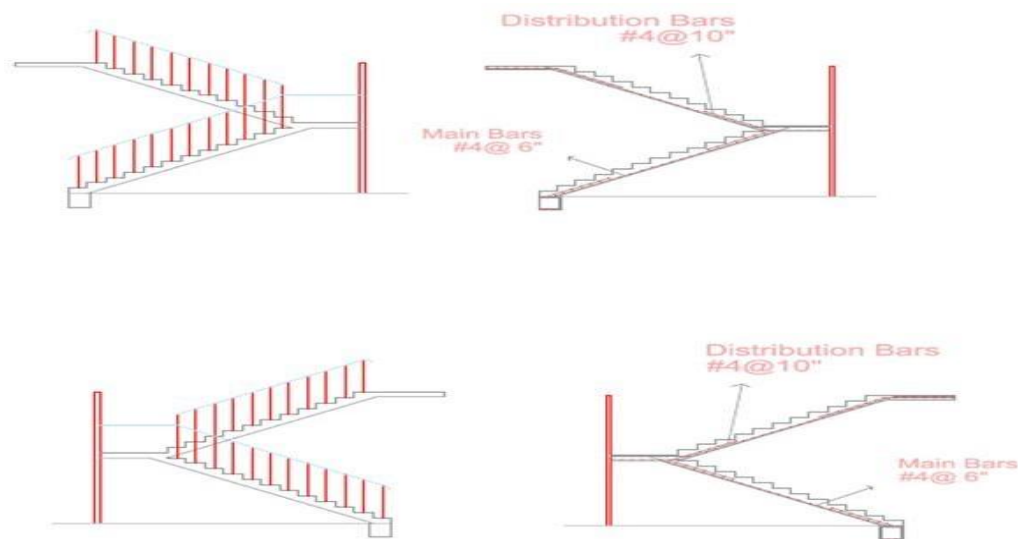


Figure 3.26: Stair & Technical Rebar Bindings

Name of the Rebars	Types of Rebar
Main Bar	#4@6”C/C
Distribution Bar	#4@10”C/C

3.7 School Gate

Top-notch entrance structure The design gives a thought-provoking and practical accommodation with an entrance that works both in security purposes, as well as aesthetics. A guardhouse was at the center of the model, included were walls that kept structural integrity and openings for doors and windows enabling safety personnel to be supplied with required shelter & work space. A guardhouse with large gate columns that look as if they could eventually support a heavy horizontal beam form a frame for some kind of sliding or swinging gate system.

Contemporary Its appearance will maintain a modern architectural style including the enclosure walls that incorporated sealed vertical holes or slots by each side of the gate to allow air passage and visibility. With the addition of red-and-white checkered tiles to accentuate the pavement below, it becomes an attractive pedestrian path that makes visitors and students safer.

The entry opens to a two-lane road with yellow dashed lines clearly marking the bidirectional traffic system. Curved pavement corners for the entrance are created to improve accessibility and traffic flow. Overall, this gate design does not only secure access but also embodies institutional character and operational capacity of the learning center. It strikes a good balance between a modern look and functionality & security.

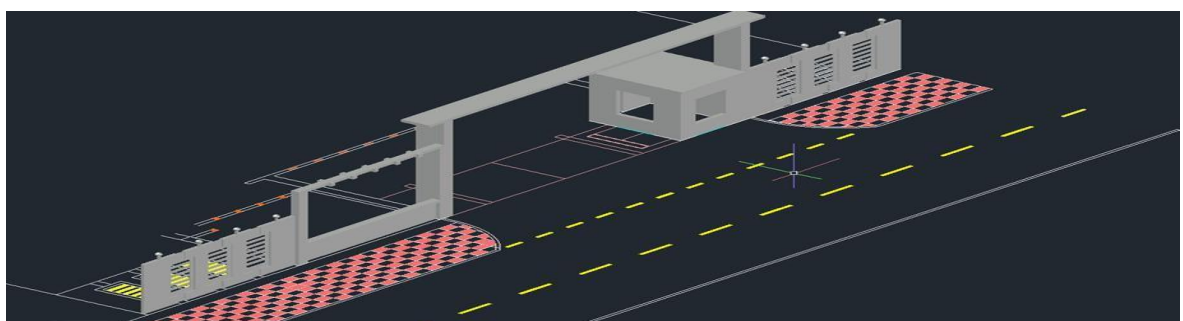


Figure 3.27: School Gate

Summary

ETABS were used for the design of footings, slabs, columns, beams and stairs i.e. structure elements of G+1 building project in this work. Through detailed analytical studies, and meeting the design requirement, every element has been modelled,

analyzed and enhanced to ensure its performance is safe It and serviceable in case of electrical malfunction. AutoCAD proceeded to then translate those into well-drawn designs, complete with all dimensions and labels, as well as reinforcement levels. This approach integrated checking the stability of the structure and its compliance with the code, making sure that all aspects are secure for a practical execution.

CHAPTER 4

COST ESTIMATION AND PROJECT SCHEDULE CHART

Introduction

Construction Bill of Quantities (BOQ) in construction and particularly valid for G+1 project, where it lists all the materials and resources needed to complete each structural element. BOQ details out the concrete handy along with its reinforcement requirements for each of the principal structural component i.e. slabs, beams, columns, isolated footings & stairs. This distinction keeps the integrity first by providing transparent budgets and material guarantee that suit on fairy tale asset. This table covers all the needs for concrete, reinforcing and required, well as a summary of slab beam column footing staircase Everything is examined in the BOQ:

4.1 Column

Table 4.1: All RC Columns – Rebar Weight Summary

Sr. No.	Size	Area (in ²)	Length (ft)	Weight (Ton)
1	#3	0.11	12435.41	2.33
2	#6	0.44	10352	12.6

Table 4.2: All RC Columns – BOQ Summary

Sr. No.	Item	Quantity	Unit
1	Longitudinal Bars	12.6	Ton
2	Ties and Stirrups	2.33	Ton
3	Total Rebars	14.96	Ton
4	Total column Length	1294	Ft
5	Total column Volume	1459.67	Cu ft
6	Weight/ Volume	97.57	lb /cu ft

4.2 Beam

Table 4.3: Stair Roof: RC Beams – Rebar Weight Summary

Sr. No.	Size	Area (in²)	Length (ft)	Weight (Ton)
1	#4	0.20	753.67	0.26
2	#6	0.44	731.49	0.55

Table 4.4: Stair Roof: RC Beams – BOQ Summary

Sr. No.	Item	Quantity	Unit
1	Longitudinal Bars	12.6	Ton
2	Ties and Stirrups	2.33	Ton
3	Total Rebars	14.96	Ton
4	Total Beams Length	1294	Ft
5	Total Beams Volume	1459.67	Cu ft
6	Weight/ Volume	97.57	lb /cu ft

Table 4.5: Story 1: RC Beams – Rebar Weight Summary

Sr. No.	Size	Area (in²)	Length (ft)	Weight (Ton)
1	#4	0.20	7618.28	2.59
2	#6	0.44	7924.88	5.93

Table 4.6: RC Beams – BOQ Summary

Sr. No.	Item	Quantity	Unit
1	Longitudinal Bars	5.93	Ton
2	Ties and Stirrups	2.59	Ton
3	Total Rebars	8.52	Ton
4	Total Beam Length	890.61	Ft
5	Total Beams Volume	1033.58	Cu ft
6	Weight/ Volume	16.5	lb /cu ft

Table 4.7: GF: RC Beams – Rebar Weight Summary

Sr. No.	Size	Area (in ²)	Length (ft)	Weight (Ton)
1	#4	0.20	7589.14	2.56
2	#6	0.44	7283.22	5.45

Table 4.8 :GF: RC Beams – BOQ Summary

Sr. No.	Item	Quantity	Unit
1	Longitudinal Bars	5.45	Ton
2	Ties and Stirrups	2.58	Ton
3	Total Rebars	8.03	Ton
4	Total Beam Length	918.83	Ft
5	Total Beams Volume	1121.18	Cu ft
6	Weight/ Volume	1433	lb /cu ft

Table 4.9 : ALL Floor: RC Beams – Rebar Weight Summary

Sr. No.	Size	Area (in ²)	Length (ft)	Weight (Ton)
1	#4	0.20	24010.26	8.17
2	#6	0.44	23972.88	17.95

Table 4.10: ALL Floor: RC Beams – BOQ Summary

Sr. No.	Item	Quantity	Unit
1	Longitudinal Bars	17.95	Ton
2	Ties and Stirrups	8.17	Ton
3	Total Rebars	26.12	Ton
4	Total Beam Length	2838.11	Ft
5	Total Beams Volume	3268.06	Cu ft
6	Weight/ Volume	15.98	lb /cu ft

4.3 Slab/Mate/Footing**Table 4.11 : Stair Roof: Slab – Rebar Weight Summary**

Sr. No.	Size	Area (in²)	Length (ft)	Weight (Ton)
1	#4	0.20	736.5	0.25

Table 4.12: Stair Roof: Slab – BOQ Summary

Sr. No.	Item	Quantity	Unit
1	Total weight of Rebar W	0.25	Ton
2	Total Area A	240.24	Sq. ft
3	Total Volume V	100.1	Cu. ft
4	Average Thickness V/A	5	in
5	Weight over Volume W/A	2.09	lb/ sq ft

Table 4.13: Story 1: Slab – Rebar Weight Summary

Sr. No.	Size	Area (in²)	Length (ft)	Weight (Ton)
1	#4	0.20	13591.48	4.62
2	#5	0.31	274.55	0.14

Table 4.14: Story 1: Slab – BOQ Summary

Sr. No.	Item	Quantity	Unit
1	Total weight of Rebar W	4.77	Ton
2	Total Area A	4961.16	Sq. ft
3	Total Volume V	2067.16	Cu. ft
4	Average Thickness V/A	5	in
5	Weight over Volume W/A	1.92	lb/ sq ft
6	Weight Over Volume W/v	4.61	lb /cu ft

Table 4.15: Roof: Slab – Rebar Weight Summary

Sr. No.	Size	Area (in²)	Length (ft)	Weight (Ton)
1	#4	0.20	13591.48	4.62
2	#5	0.31	168.33	0.09

Table 4.16 : Roof: Slab – BOQ Summary

Sr. No.	Item	Quantity	Unit
1	Total weight of Rebar W	4.7	Ton
2	Total Area A	4961.18	Sq. ft
3	Total Volume V	2067.16	Cu. ft
4	Average Thickness V/A	5	in
5	Weight over Volume W/A	1.9	lb/ sq ft
6	Weight Over Volume W/v	4.55	lb /cu ft

Table 4.17 : All Floor Slab/Mate/Footing– Rebar Weight Summary

Sr. No.	Size	Area (in²)	Length (ft)	Weight (Ton)
1	#4	0.20	28174.9	9.59
2	#5	0.31	509.84	0.27
3	#6	0.44	375.05	0.28

Table 4.18: All Floor Slab/Mate/Footing: – BOQ Summary

Sr. No.	Item	Quantity	Unit
1	Total weight of Rebar W	12.96	Ton
2	Total Area A	11674.6	Sq. ft
3	Total Volume V	5834.42	Cu. ft
4	Average Thickness V/A	6	in
5	Weight over Volume W/A	2.22	Lb./sq. ft
6	Weight Over Volume W/v	4.45	Lb. /cu ft

4.4 Total Rebar Required**Table 4.19: Total Rebar**

Sr	Item (description)	Quantity	Unit
1	Reinforcement — Columns (longitudinal + ties)	14.96	Ton
2	Reinforcement — Beams (ALL FLOORS)	26.12	Ton
3	Reinforcement — Slabs / Mat / Footings (ALL FLOORS)	12.96	Ton
4	Reinforcement — Subtotal (sum of items 1–3)	54.04	Ton
5	Reinforcement — Project summary (alternate value shown in file)	43.51	Ton

6	Bricks (total number)	69,728	Nos
7	Cement — Slab/ Mat / Combined Footing	1,027	Bags
8	Cement — Columns	257	Bags
9	Cement — Beams	576	Bags
10	Cement — Total (bags)	1,860	Bags
11	Sand — Columns	643	Cu ft
12	Sand — Slab / Mat / Combined Footing	2,568	Cu ft
13	Sand — Beams	1,438	Cu ft
14	Sand — Total	4,649	Cu ft
15	Aggregate — Slab	5,135	Cu ft
16	Aggregate — Columns	1,285	Cu ft
17	Aggregate — Beams	2,876	Cu ft
18	Aggregate — Total	9,296	Cu ft
Sr	Item (description)	Quantity	Unit
1	Reinforcement — Columns(longitudinal + ties)	14.96	Ton

2	Reinforcement Beams (ALL FLOORS)	26.12	Ton
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4.5 Cost of table (BDT)

Table 4.20: Cost of table

Sr	Item	Quantity	Unit Price (BDT)	Item Cost (BDT)
1	Rebar (option A)	54.04	100,000 / ton	5,404,000
	Rebar (option B)	43.51	100,000 / ton	4,351,000
2	Bricks	69,728	10 / piece	697,280
3	Cement (all)	1,860	700 / bag	1,302,000
4	Sand (total)	4,649	35 / cu ft	162,715
5	Aggregate (total)	9,296	45 / cu ft	418,320

4.6 Septic Tank Cost

Table 4.21: Total Septic tank cost

Item	Unit	Qty	Rate (BDT)	Amount (BDT)
1. Excavation (soil)	m ³	110	300	33,000
2. Plain Cement Concrete (PCC) (100 mm thick)	m ³	10	8,000	80,000
3. Brick Masonry (1st class bricks, 1:5 mix)	Nos	10129	11,000	111,419
4. Plaster (in/out walls)	m ²	300	250	75,000
5. Reinforced Concrete Slab (Top Cover)	m ³	5	15,000	75,000
6. Reinforcement Steel	kg	800	100	80,000
7. Manhole Cover (RCC)	pcs	4	4,000	16,000
8. Inlet/Outlet Pipework	LS	—	—	15,000
Total				485,419

Total Overhead tank cost

Table 4.22: Total Overhead Tank Cost

Component	Estimated Cost (BDT)
Steel	30,610
Concrete (3×Steel)	91,830
Labor (25% materials)	$(30,610 + 91,830) \times 0.25 = 30,110$
Miscellaneous (15%)	$(30,610 + 91,830) \times 0.15 = 18,670$
Total Estimate	171,220 BDT (approx.)

4.7 Summary of BOQ

Table 4.23 : Grand Total Estimated Cost

Sr	Item	Amount (BDT)
1	Estimation of slab, foundation, and footing	1,799,875
2	Estimation of Column	450,450
3	Estimation of the floor beam	1,008,450
4	Estimation of Rebar	3,676,595
5	Estimation of stairs	160,000
6	Estimation of labor	400,000
7	Estimation of brick masonry, wall plaster, Floor Tiles, plastic, and painting	2,098,904
8	Estimation of a septic+ Overhead tank	656,639
	Grand Total	10,250,913

Grand Total Estimated Cost: BDT 10,250,913

4.9 Project Schedule Chart

Because it provides a straightforward, visual timeline of all the major tasks associated with the project — a Gantt chart is an essential management tool for construction projects such as a G+1 school building. It helps engineers, construction teams and project managers to plan, supervise and coordinate all work related activities of a project. The Gantt chart outlines the time and sequence of structural work (eg, excavation, footing, column casting and slab construction) so that each action is in line with progress towards overall project goals and deadlines. This method reduces delays and utilizes resources in an efficient manner that improves the workflow, maintains organizations within budget and keeps projects on set deadlines.

Table 4.19: Project Schedule

Sl. No.	Activity	Duration	Start Date	End Date	Remarks
1	Site Preparation	7 days	Day 1	Day 7	Clearing, fencing, and layout
2	Excavation & Earthwork	5 days	Day 8	Day 12	For footing/foundation
3	Foundation Work	10 days	Day 13	Day 22	PCC, footing, column starter
4	Ground Floor Slab & Beams	12 days	Day 23	Day 34	Rebar, formwork, casting
5	Brick Work (Ground Floor)	10 days	Day 35	Day 44	Partition & external walls
6	First Floor Slab & Beams	12 days	Day 45	Day 56	Same as the ground floor
7	Brick Work (First Floor)	10 days	Day 57	Day 66	Masonry walls
8	Roof Casting (Top Slab)	7 days	Day 67	Day 73	Rebar, formwork, casting
9	Plastering (All Floors)	15 days	Day 74	Day 88	Internal and external
10	Doors & Windows Installation	7 days	Day 89	Day 95	After plaster

11	Electrical & Plumbing Works	10 days	Day 96	Day 105	Wiring, pipes
12	Floor Finishing (Tiling, etc.)	7 days	Day 106	Day 112	Tiles, skirting
13	Painting	7 days	Day 113	Day 119	Internal & external walls
14	Final Cleaning & Handover	3 days	Day 120	Day 122	Site cleanup

Total Estimated Duration: ~122 Days (Approximately 4 months)

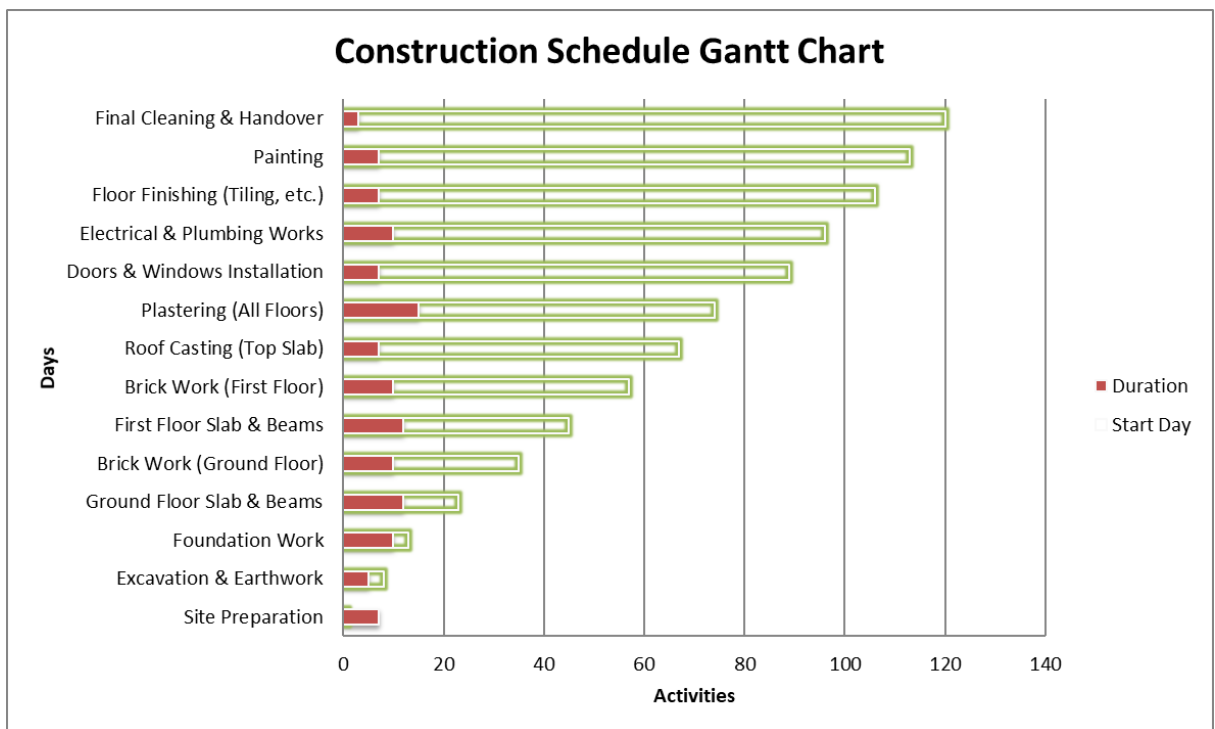


Figure 4.1: Construction Schedule Gantt chart

Summary

The construction project is expected to cost around BDT10,000,000 in total, which includes all of the important architectural and structural elements. This covers structural components including floor beams and staircases as well as foundational

work like the slab, footing, and columns. Reinforcement (rebar) has received a substantial investment, accounting for more than one-third of the whole budget. A significant amount of the overall cost also goes into finishing touches like painting, floor tiles, wall plastering, brick masonry, and plastic fittings. Additionally, labor costs and necessary utilities like a septic tank have been included in.

The project is fairly time-bound, with a projected construction length of 122 days, or approximately 4 months. This estimate guarantees thorough scheduling and budgeting, providing a solid basis for the effective management and execution of the building process.

CHAPTER 5

DESIGN AND CONSIDERATION OF SEPTIC TANK AND OVERHEAD TANK

Introduction

Water supply and sanitation are fundamental components of any building's infrastructure, directly influencing public health, hygiene, and overall quality of life. In regions where centralized sewerage and water supply systems are limited or unavailable, the design and construction of independent facilities such as septic tanks and overhead tanks become essential.

A septic tank is an underground, watertight structure designed to treat and dispose of domestic wastewater through sedimentation, anaerobic digestion, and infiltration into the surrounding soil. Proper sizing, material selection, and placement are critical to ensuring efficient waste treatment, environmental safety, and long-term durability.

An overhead water tank serves as a storage system positioned at an elevated level to provide a consistent water supply to a building through gravity flow. The design must account for factors such as water demand, structural stability, material selection, and maintenance accessibility to ensure reliable performance and safety.

This capstone project focuses on the design principles, structural considerations, and capacity calculations required for septic tanks and overhead tanks, particularly in the context of small-to-medium scale buildings. Emphasis is placed on compliance with local building codes, environmental regulations, and cost-effectiveness, while ensuring that the solutions are sustainable, durable, and suitable for varying site conditions.

By integrating engineering knowledge, practical design standards, and safety guidelines, this work aims to provide a comprehensive reference for students, engineers, and practitioners engaged in the planning and construction of water supply and sanitation systems.

5.1 Components of a Septic tank

Together, the several essential parts of a septic tank purify domestic wastewater. Wastewater from homes is sent into the tank via an entry line, where the liquids and solids start to separate. Lighter substances, such as fats and oils, float to the top of the tank to produce a scum layer, while heavier substances sink to the bottom to form a

sludge layer. Between them is the effluent layer, which holds water that has been partially treated. To help manage the flow and avoid obstacles, baffles and tees are placed close to the input and outflow pipes. This ensures that wastewater flows easily from the tank into the drain field for additional treatment. Additionally, the tank has access ports, often called risers, that enable routine sludge and scum pumping, maintenance, and inspections.

5.2 Design Considerations of a Septic Tank

The Bangladesh National Building Code (BNBC, 2020) provides detailed design criteria for septic tanks to ensure the safe and efficient treatment of wastewater and the quantity of users, daily water use per concessions and retention time of sewage will be of importance in design a septic tank for 320 users, where 40 students will attend each classroom requiring an area of approximately 16 square feet per student. Here is an explained and step-by-step process of how you can calculate the septic tank size and its details: The size of the tank should be big enough so that at least one to two days' wastewater may be stored, resulting in separation of particles naturally because those particles break down within this duration based on the water used by your family members. Construct tanks from materials resistant to leaks such as concrete, fiberglass or plastic to safeguard the groundwater. Baffles or walls are also added within tanks to create two compartments which help in cleaning. To control the flow, use fittings at the inlet and outlet pipes which should be positioned correctly for the wastewater to flow out properly (the outlet pipe should be turned slightly downward). Ventilation must be allowed to let out gasses, keep odors under control and really get that bacterial activity going. These risers also provides access for a regular pumping and inspection by contractors, who will seal the riser to prevent contamination (BNBC 2020). This is the drain field, a place where the wastewater from the septic system exits the tank, and the soil in which it was buried should have enough suddenness- conduction to water. It must also be located a safe distance from wells, buildings or water sources. The septic tank should be positioned far enough away from structures and water sources so it doesn't freeze. To maintain it from there, the state suggests pumping out sediments

every two to five years — as needed based on volume of use — and empties more often to keep the tank functioning properly and protect public health.

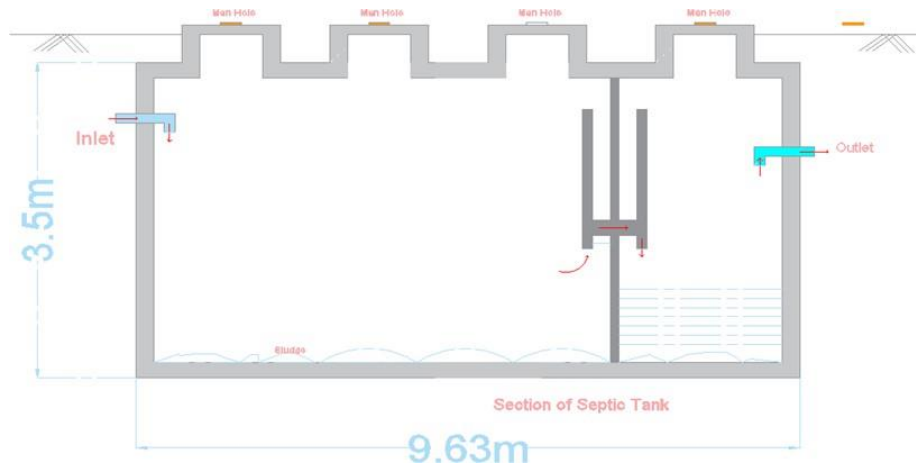


Figure 5.1: Section view of a Septic tank

5.3 Components of an Overhead Tank

An overhead tank is a vital structure for storing and distributing water at an elevated level, ensuring adequate pressure and uninterrupted supply to a building. It consists of several key components, each serving a specific function.

The tank body is the main container where water is stored. It is usually constructed from reinforced cement concrete (RCC), steel, or high-density polyethylene (HDPE) to ensure strength and durability. The roof or cover slab protects stored water from dust, debris, and contaminants while reducing evaporation.

The inlet pipe allows water to enter the tank from the pump or municipal supply, often equipped with a float valve to prevent overflow. The outlet pipe delivers water to the distribution network using gravity flow. To avoid flooding, an **overflow pipe** is installed near the top of the tank. A vent pipe ensures proper air circulation, preventing vacuum formation or excessive pressure.

A drain pipe is located at the lowest point of the tank for complete emptying during cleaning or maintenance. For accessibility, a ladder and access hatch are provided to facilitate inspection and repairs. The supporting structure—made of RCC columns,

steel frames, or masonry towers—elevates the tank to generate the required water pressure. This structure must be strong enough to withstand the combined weight of the water and the tank itself.

Proper integration and maintenance of all these components ensure that the overhead tank functions efficiently, providing a safe, reliable, and consistent water supply for domestic, commercial, or institutional use.

5.4 Design Considerations of a overhead Tank

Designing an overhead tank requires careful planning to ensure structural safety, durability, and efficient water storage. The following factors are generally considered: Capacity Requirement – Determined based on daily water consumption, peak demand, and reserve storage needs. This depends on the type of building (residential, commercial, institutional) and the number of users.

Material Selection – Common materials include reinforced cement concrete (RCC), steel, and high-density polyethylene (HDPE). Selection depends on budget, durability, and environmental conditions.

Shape and Design Type – Tanks can be circular, rectangular, or spherical. Circular tanks are more economical and efficient in stress distribution, while rectangular tanks may be easier to construct.

Structural Stability – The supporting structure must be designed to withstand the full water load, self-weight of the tank, wind load, seismic forces, and possible dynamic effects.

Height of the Tank – Determined to provide adequate water pressure through gravity flow to all outlets in the building.

Inlet, Outlet, and Overflow Provisions – Properly designed piping ensures smooth inflow and outflow, with an overflow pipe to prevent water spillage.

Ventilation and Access – A vent pipe ensures air circulation, while ladders and hatches allow safe inspection and maintenance.

Leakage Prevention – Proper waterproofing and construction practices are essential to avoid seepage and contamination.

Maintenance Accessibility – The design should allow for easy cleaning, repairs, and safety measures during maintenance.

The overhead tank is currently designed to serve 160 students, but the total number of students is 320, so the existing tank capacity meets only half of the actual water demand.

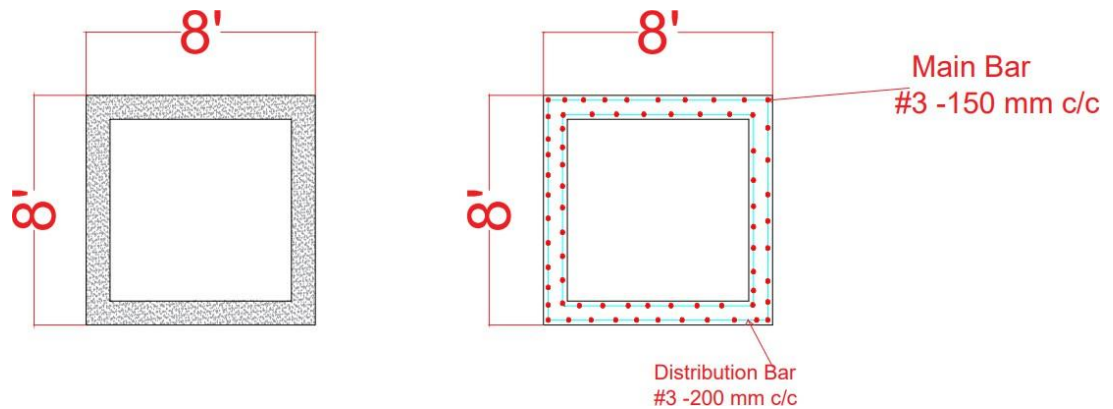


Figure 5.2: Overhead Tank Design

Summary

This project focuses on the design and key considerations involved in constructing septic tanks and overhead water tanks, which are essential components of water supply and sanitation systems in buildings. A septic tank is an underground wastewater treatment unit that collects and partially treats domestic sewage through sedimentation and anaerobic digestion. Proper design includes calculating the tank volume based on wastewater flow, ensuring effective settling, providing baffles to control flow, and allowing for easy maintenance. Environmental safety and durability are important factors in material selection and construction.

An overhead tank is an elevated water storage structure designed to provide consistent water pressure through gravity. Its design requires calculating capacity based on daily water demand, selecting appropriate materials, ensuring structural stability to support the tank and water load, and incorporating features like inlet/outlet pipes, overflow, ventilation, and access for maintenance. The supporting structure must withstand various loads including seismic and wind forces.

The integration of these tanks in a building's infrastructure ensures efficient water management, sanitation, and user convenience. This study emphasizes compliance with relevant codes and standards, sustainability, and cost-effectiveness to provide practical and safe solutions for water supply and wastewater treatment in residential, commercial, and institutional buildings.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

- The thorough structural design of a two-story reinforced concrete (RC) primary school building located in Bangladesh's Seismic Zone 3 was the focus of this capstone project. The design was completed using AutoCAD for detailing and ETABS 2020 for structural analysis in accordance with the Bangladesh National Building Code (BNBC, 2020). The project placed a strong emphasis on real-world application that was in line with academic understanding, guaranteeing sustainability, cost effectiveness, and structural safety.
- The project's concrete met the BNBC's minimum criteria for public-use buildings with a typical compressive strength of 4000 psi, or around 27.58 MPa. In accordance with BNBC Section 6.2, deformed bars having a yield strength of 60,000 psi (about 413.7 MPa) were utilized for reinforcement. Beam sections were strengthened with bars of 20 mm in diameter and were developed in a range of sizes, from 12 inches by 12 inches to 12 inches by 20 inches. One common arrangement, for example, had 12mm stirrups spaced 4.5 inches center-to-center, with three 20mm bars at the bottom and four 20mm bars at the top.
- Typically measuring 10 inches by 12 inches or 12 inches by 14 inches, the columns were strengthened by six 20mm main bars and fastened with lateral ties of 10mm diameter at 5.5 to 6 inches apart. For a 20mm bar, the lap length was determined to be 40 times the bar diameter in tension zones and 30 times in compression, or 800 and 600 mm, respectively. Assuming a bond strength of 1.2 MPa, the development length for 20mm bars was similarly determined using the BNBC formula, yielding an estimated length of 679mm.
- Additionally, the concrete transparent cover was made to offer sufficient defense against environmental deterioration, fire, and corrosion. Depending on exposure, a 1.5-inch cover was applied to columns, a 1-inch cover to beams, and a 0.75- to 1-inch cover to slabs. With an average thickness of 5 inches, the slab satisfied all serviceability and deflection requirements. Assuming a soil

bearing capability of 25 tons per square meter, separate footings for the foundation system were planned with dimensions varying from 72 inches by 72 inches to 96 inches by 72 inches.

- The classroom live load was calculated to be 3 kN/m², which is within the typical BNBC range of 2 to 4 kN/m² for learning environments. A thorough Bill of Quantities was also used in the project's cost estimating phase. The construction was reported to have cost ₱9,716,274 in total, rounded to ₱10,000,000. An estimated 43.5 tons of reinforcing were needed for all structural parts. According to the projected building timeline, the project will take 122 working days, or around four months, to complete.
- All things considered, this capstone project effectively combined academic understanding with practical structural procedures. It showed proper member size, correct material estimations, code-compliant analysis, and efficient cost control. The project's results significantly advance the objective of providing a secure, useful, and profitable learning environment.

6.2 Recommendations

- Several suggestions are made to improve construction quality, safety, sustainability, and long-term performance in light of the thorough design and study of this two-story primary school structure. These recommendations are meant to direct the implementation of this project as well as related future developments and are in line with both national standards and international best practices.
- Before building starts, it is advised that the soil's carrying capability be confirmed on-site using field tests like the Plate Load Test or the Standard Penetration Test (SPT). Actual field conditions may differ from the 25 tons per square meter soil carrying capability estimated in the structural design. If the tested values differ much, footing dimensions or reinforcement may need to be adjusted. Preventing tilting, differential movement, or foundation settlement requires precise geotechnical data.
- Regular material testing during the building process is crucial to maintaining the highest standards of construction quality. To keep concrete workable within the desired range of 75 to 125 mm, slump tests should be conducted on a regular

basis. To make sure the concrete reaches the intended compressive strength of 4000 psi, cylinder or cube compression tests should be performed at 7 and 28 days. Similar to this, reinforcing bars must undergo tensile and bend tests to ensure they fulfill the required yield strength of 60,000 psi. Mechanical vibrators should be required throughout the casting process in order to remove voids and guarantee that the steel and concrete are properly bonded.

- All reinforcement must be positioned precisely in accordance with the design drawings for structural safety, particularly in crucial locations such as seismic corners, beam-column connections, and lapping zones. Development lengths should adhere to the BNBC formula, which is based on bar diameter, yield strength, and concrete bond stress. The lap length should be kept at 40 times the bar diameter in tension zones and 30 times in compression zones. Strict adherence to minimum clear covers—1.5 inches for columns, 1 inch for beams, and 0.75 to 1 inch for slabs—is also necessary to shield reinforcement from harsh environmental exposure, fire, and corrosion.
- Using high-performance concrete (HPC) with the right admixtures is advised for cost control. This will drastically save future maintenance, especially in humid settings, although it may slightly raise the original cost. Additionally, to improve overall budget effectiveness, aggregates and sand should be purchased from local quarries wherever feasible. This will save transportation expenses by around 8 to 12 percent.
- Future educational building designs should incorporate sustainability as well. Water consumption may be greatly decreased by installing rainwater collecting systems, and solar panels can provide renewable energy for ventilation or lighting in classrooms. In order to minimize the need for artificial cooling, the building should be designed to optimize cross ventilation and natural illumination. The environmental effect can be further reduced by using recycled building materials, such as fly ash in cement or crushed concrete as aggregate.
- The last step is to put in place a proper post-construction maintenance plan. This should involve routinely checking for cracks, especially in slabs and beams, to make sure they stay under permitted width limits, which are normally less than 0.3 mm for flexural parts. The roof slab should be inspected annually for waterproofing problems, especially prior to the monsoon season, and the septic

tank should be cleaned every two to three years. Building life may be significantly increased and unforeseen repair expenses can be decreased by keeping a digital record of every structural and service maintenance.

- Following these suggestions will guarantee the project's longevity and safety while also encouraging cost-effectiveness and environmental responsibility in accordance with contemporary civil engineering standards.

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APPENDIX

DESIGN OF SEPTIC TANK

Design of a septic tank to serve a primary school of 320 persons who produce 30 lpcd of wastewater, and the tank is to be dislodged every two years.

Solution:

$$P = 320 \text{ persons}$$

$$N = 5 \text{ years}$$

$$C = 0.04 \text{ m}^3/\text{person}/\text{yr.}$$

$$T = 25 \text{ }^\circ\text{C}$$

$$q = 30 \text{ lpcd.}$$

Volume calculation (m^3)

Sedimentation Zone V_h

$$\begin{aligned} T_h &= 1.5 - 0.3 \log(Pq) \\ &= 1.5 - 0.3 \log(320 \times 30) \\ &= 1.5 - 0.3 \log(9600) \\ &= 1.5 - 0.3 \times 3.982 \\ &= 1.5 - 1.1946 \\ &= 0.3054 \text{ days} \end{aligned}$$

The volume required by the Sedimentation Zone:

$$\begin{aligned} V_h &= 10^{-3} (Pq) \times T_h \\ &= 10^{-3} \times (320 \times 30) \times 0.3054 \\ &= 2.932 \text{ m}^3 \end{aligned}$$

Sludge Digestion Zone V_d

Assuming a design temperature of 25°C

$$T_d = 30 (1.035)^{(T-25)} = 42.3 \text{ days} \quad T = 35$$

$$\begin{aligned} V_d &= 0.5 \times 10^{-3} \times P \times T_d \\ &= 0.5 \times 10^{-3} \times 320 \times 42.3 = 6.768 \text{ m}^3 \end{aligned}$$

Sludge Zone Vsl

$$V_{sl} = C \times P \times N \quad C = \text{Sludge accumulation constant (0.04 m}^3\text{/person/year)}$$

$$= 0.04 \times 320 \times 5$$

$$= 64 \text{ m}^3$$

Scum Zone (Sc)

$$V_{sc} = 0.4 \times V_{sl}$$

$$= 0.4 \times 64$$

$$= 25.6 \text{ m}^3$$

$$\text{Total Volume } V = V_h + V_d + V_s + V_{sc}$$

$$V = 2.932 + 6.768 + 64 + 25.6 = 99.3 \text{ m}^3$$

Depth Calculation

$$\text{Cross – sectional area } A = 23.4 \text{ m}^2$$

The maximum depth of sludge:

$$d_{sl} = V_{sl} / A = 64 / 23.4 = 2.735 \text{ m}$$

The maximum submerged scum

$$d_{ss} = 0.4 \times V_{sl} / A = 0.4 \times 64 / 23.4 = 1.094 \text{ m}$$

Sludge clear depth = 0.3 m is adopted

$$\text{Total clear space} = 0.3 + 0.075 = 0.375 \text{ m}$$

Depth of the digestion zone

$$d_d = V_d / A = 6.768 / 23.4 = 0.289 \text{ m} < 0.375$$

Depth required for sedimentation

$$d_h = V_h / A = 2.932 / 23.4 = 0.125 \text{ m}$$

Since $d_h < 0.375 \text{ m}$,

$d_h = 0.375 \text{ m}$ is adopted

Total effective depth

$$= d_{sl} + d_{ss} + d_d + d_h$$

$$= 2.735 + 1.094 + 0.289 + 0.375$$

$$= 4.493 \text{ m}$$

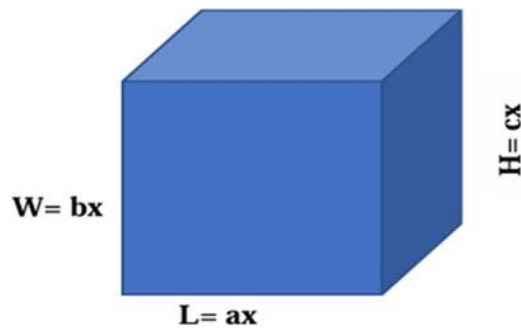
The suitable overall internal dimension of the septic tank can be chosen as:

$$9.63 \text{ m} \times 3 \text{ m} \times 3.5 \text{ m}$$

$$V = L * W * H$$

$$X = \sqrt[3]{V/abc}$$

$$A = abx^2$$



DESIGN OF A DOG-LEGGED STAIRCASE SUPPORTED LONGITUDINALLY

Floor to floor height 3.66 m

Riser (R)= 150 mm

Tread (T)= 250 mm

First landing width (L1)= 1000 mm

Second landing width (L2)= 1000 mm

Number of risers in all flights (N)= 12

Width of stair= 1000 mm

Imposed load= 3 KN/m²

Floor finishes= 1.25 KN/m²

Beam width (B)= 304.8 mm

Unit wt. of concrete (γ)= 25 KN/m³

Grade of steel (f_y)= 500 N/mm²

Grade of concrete (f_{ck})= 20 N/mm²

Step 1: Calculation of effective span

Effective span (L_{eff})

$$\begin{aligned} &= \{(N-1)*T\}+L_1+L_2+(B/2)+(B/2) \\ &= \{(12-1)*250\}+1000+1000+304.8 \\ &= 5054.8 \text{ mm} \end{aligned}$$

Step2: Calculation of effective depth

clear cover (c)= 15 mm

Adopt the diameter of the bar (ϕ)= 12 mm

(assuming constant 30-40)

Effective depth (d)= ($L_{eff}/30$) = 168.493 mm

$$\begin{aligned} \text{Overall Depth (D)} &= d+(\phi/2)+c = 168.493+(12/2)+15 \\ &= 189.493 \text{ mm} \approx 190 \text{ mm} \end{aligned}$$

Provided eff. depth= 169 mm

Step 3: Calculation of load

(i) Load on going on the projected plan area

Live load = 3 kN/m

$$= 3 \text{ kN/m}$$

Floor finish = 1.25 kN/m

$$= 1.25 \text{ kN/m}$$

wt. of waist slab = $\frac{\text{Upsilon} \cdot D \cdot \sqrt{R^2 + T^2}}{T}$

$$= 5.5394 \text{ kN/m}$$

wt. of steps = $\text{Upsilon} \cdot 0.5 \cdot R$

$$= 1.875 \text{ kN/m}$$

Total load $l = 11.66 \text{ kN/m}$

Factored load = $1.5 \cdot 11.66$

$$= 17.497 \text{ kN/m}$$

Live load = 3 kN/m

(i) Load on landing

Floor finish = 1.25 kN/m

$$= 3 \text{ kN/m}$$

self wt. of slab $J = \text{Upsilon} \cdot D \cdot 1$

$$= 1.25 \text{ kN/m}$$

$$= 4.75 \text{ kN/m}$$

Total Load = 9KN / m

Factored load = $1.5 \times 9 = 13.5\text{KN / m}$

Step 4: Calculation of maximum bending moment and maximum shear force

Taking the moment of all forces about point B

$$R_a \times 5.0548 = (13.5 \times 1.1524 \times (1.1524/2 + 2.75 + 1.1524)) + (17.5 \times 2.75 \times (2.75/2 + 1.1524)) + \{13.5 \times 1.1524 \times 1.1524/2\}$$

$$R_a \times 5.0548 = 200.247 \quad R_a = 39.62\text{KN}$$

$$R_a + R_b = (13.5 \times 1.1524) + (17.5 \times 2.75) + (13.5 \times 1.1524)$$

$$39.62 + R_b = 79.23 \quad R_b = 39.62\text{KN}$$

$$V_{\max} = (13.5 \times (1.1524 + 1.1524)) + (17.5 \times 2.75) = 39.62 \text{ KN}$$

$$M_{\max} = [13.5 \times 1.1524 \times \{(1.1524/2) + (2.75/2)\}] - [17.5 \times (2.75/2) \times (2.75/2 \times 2)] + [39.62 \times \{1.1524 + (2.75/2)\}]$$
$$= 53.23 \text{ KN-m}$$

Step 5: Check for depth against bending moment

$$M_{\max} = 0.133 \times f_{ck} \times b \times d_{\text{req}}^2 \quad 53.23 \times 10^6 = 0.133 \times 20 \times 1000 \times d_{\text{req}}^2$$
$$d_{\text{req}} = 141.46 \text{ mm}$$

($d_{\text{req}} > d_{\text{prov}}$).

Hence OK

Step 6: Designing the reinforcement

$$53.23 \times 10^6 = 0.87 \times 500 \times A_{\text{st}} \times 169 \times [1 - \{(500 \times A_{\text{st}}) / (20 \times 1000 \times 169)\}]$$

$$A_{\text{st}} = 824.642 \text{ mm}^2$$

(A_{st})_{min.} = 0.12% of bD

$$= (0.12/100) \times 1000 \times 190 = 228 \text{ mm}^2$$

$$\text{Spacing} = [1000 / (824.64 / (3.142 \times 12^2 / 4))] = 137.147 \text{ mm} \approx 150 \text{ mm}$$

Provide 12mm dia. bar @ 150mm c/c

$$(A_{\text{st}})_{\text{prov.}} = [1000 / 150 \times (3.142 \times 12^2 / 4)] = 753.982 \text{ mm}^2 \quad \% \text{ of steel prov.} = 0.45\%$$

Step 7: Check for shear force

For M20 concrete

$$\text{Shear strength } (T_c) = 0.280 \text{ N/mm}^2$$

IS 456:2000, Table-19

$$\tau_{\text{max}} = (39.62 \times 10^3) / (1000 \times 169) = 0.234 \text{ N/mm}^2 \text{ OK}$$

Step 8: Check for deflection

$$(L_{eff}/d)_{prov.} = 5054.8/169 = 29.91$$

Basic values

$$\text{Basic value: } (\alpha) = 20$$

$$\text{Modification factor } (\beta) = 1$$

$$\text{For Tension Reinforcement } (\gamma) = 1.5$$

$$\text{For Compression Reinforcement } (\delta) = 1$$

$$\text{Reduction factor for flanged beam } (\lambda) = 1$$

For calculating the factor γ

$$\text{Steel Stress of service load } (t_s) = 0.58f_y$$

$$= 0.58 * 500 * [(A_{st,reg.}) / (A_{st,provided})] = 317.177$$

$$(A_s/bd) \% = [753.982 / (1000 * 169)] * 100 = 0.446$$

$$(\gamma) = 1.5$$

$$\text{Now, } \alpha * \beta * \gamma * \delta * \lambda = 20 * 1 * 1.5 * 1 * 1 = 30$$

$$(I / (d)) \leq \alpha * \beta * \chi * \delta * \lambda \text{ OK}$$

Step 9: Development length

$$L_d = \frac{\sigma_{s,eq}}{4 * \sigma_{s,eq} * 0.87}$$

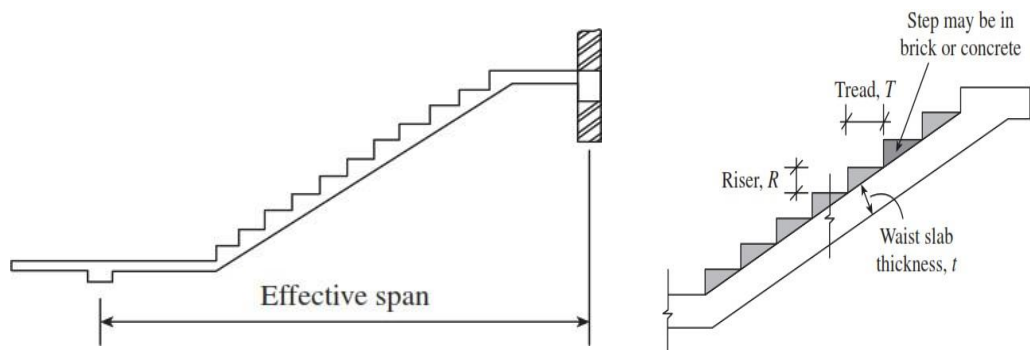
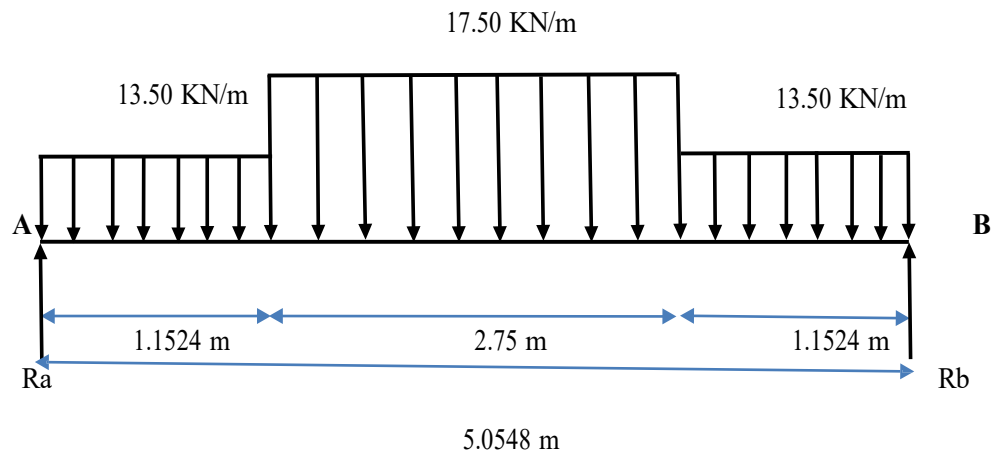
$$= (12 * 0.87 * 500) / (4 * 1.2 * 1.6) = 679.688 \text{ mm}$$

Step 10: Distribution bar reinforcement detailing

$$\text{Spacing} = 1000 \sqrt{228} / (3.142 / 4 * 12^2)$$

$$= 496.041 \text{ mm} \leq 450 \text{ mm} \leq 845 \text{ mm} \text{ Spacing provided} = 250 \text{ mm}$$

Provide a distribution bar of 12mm diameter. @ 250mm c/c



BILL OF QUANTITY (BOQ)

Item	Particular	Quantity	Unit	Rate (BDT)	Per	Amount (BDT)
1	Cement	1,860.0	Bag	500.00	Bag	930,000.00
2	Sand	4,649.0	cu ft	35.00	cu ft	162,715.00
3	Aggregate (River Shingle etc.)	9,296.0	cu ft	45.00	cu ft	509,320.00
4	Brick	69,724.0	No	10.00	No	697,240.00
5	Broken Brick	4.39	Sud	48.61	Sud	213.57

6	Concrete Screen Block	130.0	No	0.89	No	115.70
7	X-met	2,238.4	RFT	3.00	RFT	6,715.20
8	Teak	0.24	Ton	110,000.00	Ton	26,400.00
9	Pyinkado	2.04	Ton	90,000.00	Ton	183,600.00
10	Jungle Wood	2.82	Ton	50,000.00	Ton	141,000.00
11	5 Plywood	32.35	Sheet	700.00	Sheet	22,645.00
12	Nail	33.33	Viss	100.00	Viss	3,333.00
13	Roofing Screw	1,273.46	No	2.00	No	2,546.92
14	(5"x2") U MS	213.35	RFT	35.00	RFT	7,466.75
15	(4"x2") U MS	524.76	RFT	34.00	RFT	17,841.84
16	(3"x2") Lip Channel GI	1,325.84	RFT	20.00	RFT	26,516.80
17	(2"x2") L MS	238.25	RFT	15.00	RFT	3,573.75
18	16mm ø MS Rod	3.85	Ton	100,000.00	Ton	415,610.00
19	12mm ø MS Rod	0.24	Ton	100,000.00	Ton	24,000.00
20	8mm ø MS Rod	0.75	Ton	100,000.00	Ton	75,000.00
21	6mm ø MS Rod	0.03	Ton	100,000.00	Ton	3,000.00
22	Binding Wire	27.03	Viss	70.00	Viss	1,892.10
23	4 angle Color Roofing Sheet (0.4mm)	218.10	RFT	1,800.00	RFT	392,580.00
24	0.4mm thk Plain Ridge Colour	138.43	RFT	1,400.00	RFT	193,802.00
25	UPVC Window	429.00	SFT	1,500.00	SFT	643,500.00
26	3mm thk Glass	22.50	SFT	1,000	SFT	22,500.00
27	Plastic Paint	76.35	Gal	250.00	Gal	19,087.50
28	Readymixed Paint	2.66	Gal	700.00	Gal	1,862.00
29	Putty	57.79	Gal	250.00	Gal	14,447.50
30	Roller	21.25	No	30.00	No	637.50
31	Sand Paper	453.28	No	10.00	No	4,532.80
32	Putty Trowel	21.25	No	30.00	No	637.50

33	2'x2' Cement Board	596.64	No	35.00	No	20,882.40
34	6" Tower Bolt	6.00	No	35.00	No	210.00
35	6" Sliding Bolt	3.00	No	35.00	No	105.00
36	5" Hinge	24.00	No	35.00	No	840.00
37	6" Handle	12.00	No	30.00	No	360.00
38	1.5" Wood Screw	182.33	Doz	10.00	Doz	1,823.30
39	Door Chock wet Bracket	18.00	No	10.00	No	180.00
40	5"x5" PVC Gutter	196.35	RFT	60.00	RFT	11,781.00
41	MS Gutter Bracket	93.50	No	40.00	No	3,740.00
42	ø 3" PVC Pipe (13.5)	67.00	RFT	30.00	RFT	2,010.00
	Materials subtotal					9,279,716.60
	Labour					403,0110.00
	GRAND TOTAL (BDT)					10,250,913.00

OVERHEAD TANK CALCULATION

Roof top water reservoir (Overhead water reservoir)

Assumptions and considerations

$F'c = 3 \text{ ksi}$

$F_y = 4 \text{ ksi}$

Total Floor 1

Units 1

Per Unit Member 160

Water consumption for big multi-family apartment/flat in city corporation area, considering full facility = 200 liters per capita per day (Part VIII, Table 8.5.1 (a),

BNBC 2020: Page 4815

= 200 lpcd

b) Water Reservoir size Calculation

Total 160 Persons

Total Water Consuming = 32000 Litter for full day

$$= 32 \text{ m}^3$$

$$= 1129.202 \text{ ft}^3$$

Inner length & width of Reservoir are,

Length 12 ft

width = 14 ft

so, Height of the Reservoir **6.72** **7.72**

Height = 8 ft, 8 ft

L = 4 ft B = 4 ft

c) Vertical Reinforcement of wall

Let wall Thickness = 6 m

Effective Depth = 5 m

$$\rho = \rho_{0.005} = 0.85 f_y \times \epsilon_u$$

$$\epsilon_u = 0.005$$

$$= 0.2032$$

$$M_u = \phi \times \rho \times 0.005 \times f_y \times b \times d^2 \times (1 - 0.59 \times \rho \times 0.005 \times f_y / f_c)$$

$$Mu = \sqrt{\frac{M_{d,reg} M_{u,max}}{\phi \rho F_y b (1 - 0.59 \rho \frac{f_y}{f_c})}}$$

D = 1.92 < provided 5 (Ok)

Asmin = 0.13 in²/ft pi = 3.1416

USE As = 5 cross

$$As = \frac{Mu}{\phi f_y (d - \frac{a}{2})} = 0.24 \text{ in}^2/\text{ft}$$

$$a = \frac{Mu}{0.85 f_c b} = 0.034 \text{ in}^2/\text{ft}$$

Bar No	Cross Sectional area in ²	Bar mm
3	0.11	10
4	0.20	13
5	0.31	16
6	0.44	19
7	0.60	22
8	0.79	25
9	0.99	29
10	1.23	32
11	1.48	36
14	2.41	43
18	3.98	57

Large As = 0.24, Spacing = 15.5

Use # 16 mm @ 15 c/c

d) Horizontal reinforcement of wall

Force = $\gamma * h * (14.52 + 14.52)$

e) Design of Bottom slab

Table 3: Minimum thickness of non-prestressed one-way slabs

Element	Simply Supported	One end continuous	Both ends continuous	Cantilever
One way solid slabs	1/20	1/24	1/28	1/10

Here, l is the clear span

$$\text{Multiplying factor} = 0.4 + \frac{f_y}{100} \quad f_y \text{ in ksi}$$

If,

Thickness < 6 inch then upper rounding to nearest 0.2

Thickness > 6 inch then upper rounding to nearest 0.50

Thickness 8.4 in

Self-weight of slab = 105 psf

Floor finish = 15 psf

WB = 68.19 psf Total load, w = 0.693 ksf

WA = 36.81 psf

As min = 0.18 in²/ft

$$A_s = \frac{M_u}{\phi f_y (d - \frac{a}{2})} = 0.24 \text{ in}^2/\text{ft}$$

$$a = \frac{M_u}{0.85 f_c b} = 0.649 \text{ in}^2/\text{ft}$$

Bar No	Cross Sectional area	Bar mm
3	0.11	10
4	0.20	13
5	0.31	16
6	0.44	19
7	0.60	22
8	0.79	25
9	0.99	29
10	1.23	32
11	1.48	36

14	2.41	43
18	3.98	57

Spacing= 2.04 in

Use# 3 mm @ 2 in c/c

Top slab supported on all four tank walls (two-way slab)

Top slab supported on all four tank walls (two-way slab)

Clear span of slab: 11 ft (wall-to-wall clear)

L= 12

Concrete strength: 3000 psi (fc')

W= 14

Steel yield strength: 60,000 psi (fy)

Slab is exposed to pedestrian live load: 40 psf

Cover: 1 inch

Assume: 6 inch thick slab initially

unit weight of concrete 150 psf

Durability class per BNBC: water tank, exposure moderate

Top slab is cast in place and monolithic with walls

load calculation:

live load 40 psf

dead load 75 psf

Total service load: 115 psf

Step 2: Slab Thickness Check BNBC (or ACI) minimum thickness for two-way slabs:

$L_{short} / 36 = 0.3055556 \times 3.66666667$ in

(Use 1.4DL + 1.7LL as per BNBC load combinations)

=173 psf

Step 4: Design Moments (two-way slab)

Use simplified coefficients from BNBC (similar to ACI Table 9.5(c)):

For a square slab with four edges continuous:

Positive $\alpha_w u L^2$ $\alpha = 0.041$

$M = 2298.132$ ft-lb/ft = 27577.584 in-lb/ft

Step 5: Steel Area

$d = 4.5 < \text{provided}, 3.666667$ not ok

$A_{smin} = 0.08 \text{ in}^2/\text{ft}$ $\pi = 3.1416$

Spacing : 11.5 c/c

Step: 6 Shrinkage/ Temperature Steel

BNBC recommends minimum 0.0012

Bar No	Cross Sectional area	Bar mm
5	0.31	16
6	0.44	19
7	0.60	22
8	0.79	25
9	0.99	29
10	1.23	32
11	1.48	36

Spacing: 25.1 in c/c

Use # 10 mm @ 12 c/c.

Use # 10 mm @ 25 c/c.

Self-assessment of COs with Knowledge Profile, Complex Engineering Problem Solving and Complex Engineering Activities

COs	Description	Criteria	Justification
CO1 (K6, P1, A1)	Application of modern engineering tools	Applied tools for design, drawings, etc.	Used CAD for design and ETABS for structural analysis, ensuring precision.
CO2 (K7)	Work on a Team	Attendance	Collaborated effectively through regular meetings and task integration. Name: Sovik Hasan Mithu ID: 213-47-484 Name: Firoz Mahmud ID: 213-47-482
CO3 (K7, P2, A2)	Alternative analysis presented	Economic, environmental, social, ethical aspects, health and safety considered	Conducted alternative analysis, balancing cost, sustainability, and ethics.
CO4 (K7)	Societal and environmental benefit evaluation	Environmental, social and ethical obligation considered	Incorporated eco-friendly materials and energy-efficient designs. i.e., Fly Ash Concrete, Recycled Steel.
CO5 (K7)	Professional and ethical responsibility	Punctuality based on presentations in the specified weeks	Maintained punctuality, adhered to deadlines, and upheld professionalism.
CO6 (P5, A3)	Lifelong learning	Demonstrate the ability to learn new skills (based on the statement in accordance with the lifelong learning in Final report)	Demonstrated the ability to learn new skills, i.e., advanced skills in ETABS, Building Information Modeling (BIM) , and project management like Microsoft Project .
CO7 (A1)	Effective project management – time, financial	Prepared Tender Document	Due to time limitations, incomplete.
		Prepared BOQ	ensuring accurate financial and material planning for the project.
		Show Financial Assessment	Due to time limitations, incomplete
		Show time management skill	Used a Gantt chart to manage project timelines and ensure timely completion

COs	Description	Criteria	Justification
CO8 (K7)	Communication	Drawing	Created precise technical drawings in A3 paper for clear demonstration of detailing.
		Presentation	Presented the visibility of the project by showcasing its innovative design and functionality.
		Report	<ul style="list-style-type: none"> i Design of Slab and detailing. ii Design of Beam and detailing. iii Design of Column and detailing. iv Design of Footing and detailing. v Design of Stairs and detailing, vi Design of Septic tank vii Design of Overhead Tank

* K: Knowledge Profile, P: Complex Engineering Problem Solving and A: Complex Engineering Activities