DESIGN OF A TWO-STORY PRIMARY SCHOOL BUILDING IN SAVAR, DHAKA

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A Capstone Project Submitted in Partial Fulfilment of The Requirements for The Award of a Degree of Bachelor of Science in Civil Engineering

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This is to certify that the student named below, has completed the Capstone Project titled **"Design of a Two-Story Primary School Building in Savar, Dhaka"** under my supervision. This project was conducted as part of the academic requirements for the Bachelor of Science degree in Civil Engineering. The final presentation of the project was successfully held on November 15/2025.

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DECLARATION

We here by declared, this dissertation entitled "Design of a Two-Story Primary School Building with Structural and Environmental Considerations," was carried out under the supervision of **Md. Masud Alom,** Assistant Professor, Department of Civil Engineering, Daffodil International University, Dhaka, Bangladesh. The work has been approved as a partial requirement for the completion of the Capstone Project component of the Bachelor of Science in Civil Engineering program.

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DEDICATION

This capstone project is wholeheartedly dedicated to my beloved parents, whose unwavering love, sacrifices, and encouragement have been my greatest source of strength and inspiration. Their constant guidance, patience, and belief in my abilities have motivated me to overcome every challenge throughout this journey. Without their prayers and support, this achievement would not have been possible. They have taught me the values of hard work, perseverance, and integrity, which continue to guide me in all aspects of life. This work stands as a humble token of my deepest gratitude and love for both of you.

ACKNOWLEGEMENT

First and foremost, we express our heartfelt gratitude to **Almighty Allah,** whose blessings and guidance have enabled us to successfully complete both the practicum and this Capstone Project report. We are deeply thankful to our families for their unwavering support, encouragement, and love, which served as a continuous source of motivation throughout this journey.

We also extend our sincere appreciation to the Department of Civil Engineering for granting us the opportunity to undertake this Capstone Project. This invaluable experience has bridged the gap between academic learning and practical application, greatly enriching our understanding.

Our deepest thanks go to Md. Masud Alom for his exceptional mentorship and continuous guidance, which went far beyond our expectations. His thoughtful suggestions, patience, and motivation greatly influenced the quality of our work and helped us overcome various challenges. His belief in our abilities and sincere dedication played a vital role in the successful completion of this project.

We are also sincerely thankful to **Dr. Mohammad Hannan Mahmud Khan,** Associate Professor and Head of the Department of Civil Engineering, for offering us the opportunity to engage in this project and conduct the necessary fieldwork for our report.

Lastly, we would like to express our appreciation to **Md. Masud Alom,** Assistant Professor, for his valuable guidance and for highlighting the importance of the Capstone Project in shaping both our academic journey and professional development.

ABSTRACT

The primary focus of this capstone project is the structural design of a two-story primary school building, total students 400 numbers, whose floor space measures about 6166 square feet (124 feet by 64 feet) and a general height of 24 feet. The building has nine classrooms, a library, a head office as well a teacher room. Structural analysis was done in ETABS 2020 as per Bangladesh National Building Code (BNBC 2020). Examples of reinforced concrete components are beams, columns, slabs, combined and isolated footings which were designed with regard to strength, serviceability and safety. As an example, 12" × 12" columns were supported using 4 bars 6 c/c, and 15 × 24" were supported using 4 bars 6 c/c. The project has four types of beams & also were employed, respectively have two types of footing, The detailed drawings were made in AutoCAD and the Bill of Quantities (BOQ) was managed and calculations related to design (septic tanks and stairs) were made in Excel. The estimated project construction cost was BDT 10,186,757 approximate. The structural system used was the Intermediate Moment Resisting Frame (IMRF) and the calculated weight that was going to be live in classrooms was 3kN/m^2. The septic tank is composed of a total of

62.43 m3 and maximum capacity of 400 users, that is designed to receive 30 liters of effluent per capita daily. Environmentally sustainable technologies, paving that is pervious, meeting of ventilation and lighting standards all helped in environmental sustainability. The project makes us ready to face real world challenges of civil engineering by closing the gap that exists between theory and practice.

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CHAPTER 1

INTRODUCTION

1.1 General

The type of construction planned in the proposed project is a Two-Story primary school building. built all in reinforced cement concrete (RCC) and isolated footing. foundations. The building is about 120 feet in length, and 64 feet in breadth, with a total height of 32 feet. It has eight classrooms, a teacher's room, computer rooms and washroom. The general layout of the building is illustrated in Figure 1.1 and Figure 1.2, while an isometric view is presented in Figure.

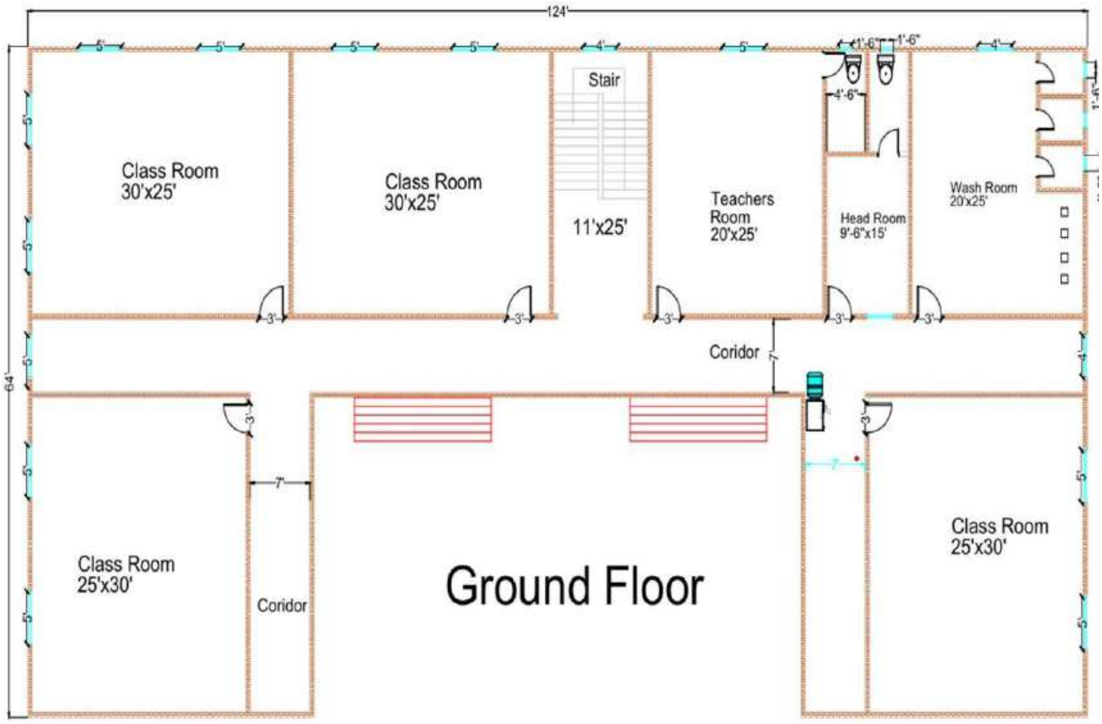

Figure 1.1: Ground Floor Plan

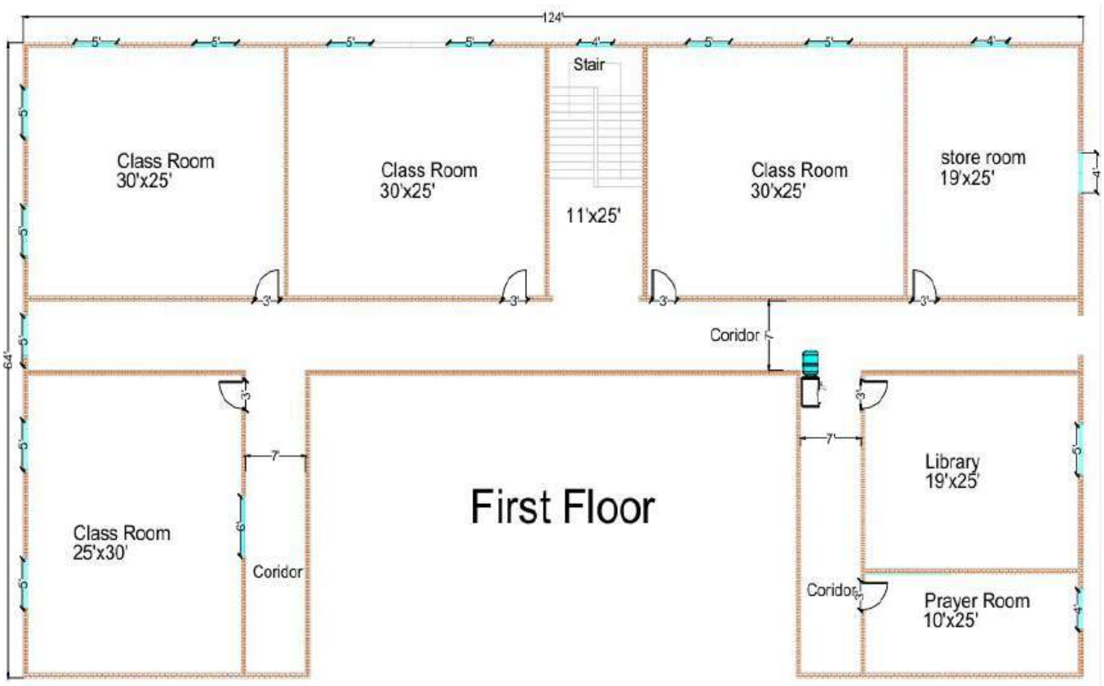

Figure 1.2: First Floor Plan

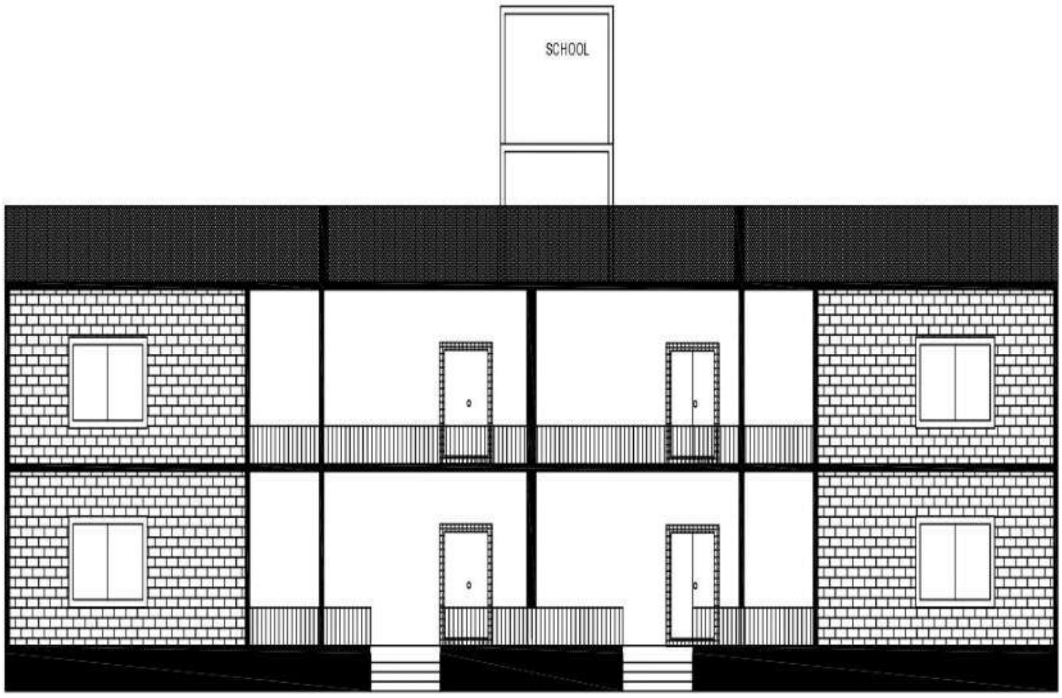

Figure 1.3: Elevation of School Building

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 2.

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.

1.3 Basic Information

In the given project, an Intermediate Moment Resisting Frame (IMRF) structural system has-been has been used to construct a two-story reinforced concrete (RC) educational. Table 1.1 describes the building as follows. The building employs an integration of isolated. Footings and combined footings so that they may be in a position to support the applied loads effectively. The floor system comprises of edge supported slabs. Structural integrity should be emphasized along with.
functionality, the design will provide the building to support the required floor loads safely. And observing all the relevant regulations of gravity and lateral loads.

Table 1.1: Basic Information of The Building

Building Usage Type	Educational building (two-story)
Structural System	RC Beam-Column frame (Intermediate Moment Resisting)
Floor System	Edge-supported Slab
No. of Stories	2-storey Building
Floor Load	Mentioned Load in chapter 3
Foundation Type	Isolated footing & Combined footing

1.3.1 Infrastructure plan and planning guideline

As per the infrastructure plan and planning guideline. Based on the general school planning requirements (Education, 2018), some of the spatial and functional requirements should be satisfied in order to create a well-organized and student-friendly one. environment. At least half of the total area of the school is advised to stay open. to allow a playground, assembling area, or outdoor games. For a primary school building such as the one proposed in this project-which has a size of around 124 ft. and ascending 64 ft, the plan comprises 8 classrooms, each of the same size (30 ft × 25 ft) in accordance with the principle that classroom dimensions must be similar. Separate male and female has been applied to the design as well. washroom blocks to ensure privacy and hygiene. 5) Corner bars should have to prevent slipperiness. Fig. 2.1 illustrates the need to have minimum lap lengths and adequate anchoring. In order to assist this, the better lateral loads are tolerated by buildings, and they do not crack or fail in a brittle manner. reinforcing technique ensures ductility, energy-absorption and structural integrity. at critical areas.

CHAPTER 2

DESIGN CODES, STRUCTURAL DESIGN AND REQUIREMENTS

2.1 Introduction

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).

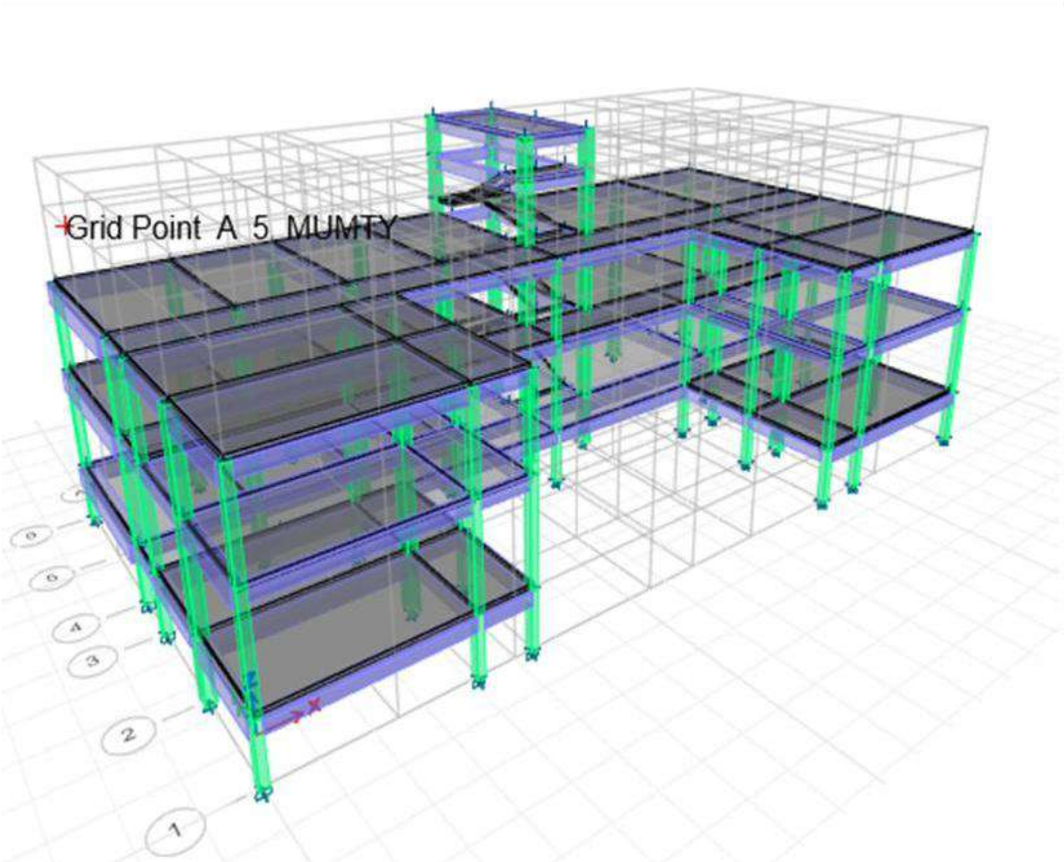

Figure 2.1 Structural Elevation

2.2 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).

2.3 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

2.4 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).

2.5 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. Corner bars should have to prevent slipperiness. Fig. 2.1 illustrates the need to have minimum lap lengths and adequate anchoring. In order to assist this, the better lateral loads are tolerated by buildings, and they do not crack or fail in a brittle manner. reinforcing technique ensures ductility, energy-absorption and structural integrity. at critical areas

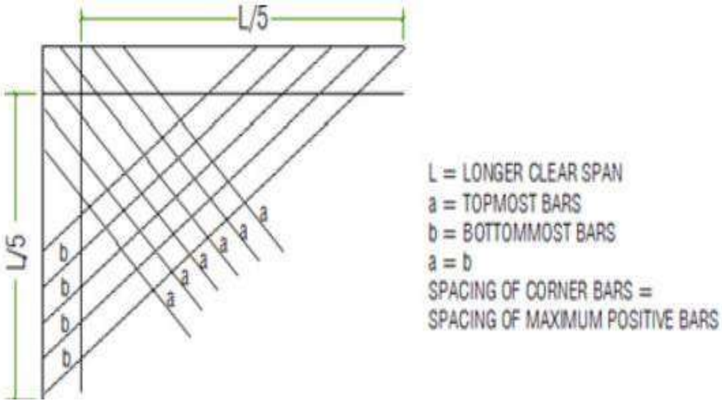

Figure 2.2: Corner Reinforcement

2.6 Material Strength

According to the project specifications, the compressive strength of concrete (f c) of all at all locations. structural elements- such as the foundation, pedestal columns, grade beams, Columns, beams, and slabs- will be not less than 5000 psi. Additionally, the yield strength (fy) of the reinforcement steel adopted in the entire structure is stated to be as. 60,000 psi (60 ksi). These material characteristics as summarized in Table 2.1 guarantee consistency in the performance of structures and rigorous conformity to the normal design practices. and safety requirements

Table 2.1: Material Strength

Name	Concrete, f'c	Unit	Rebar Strength, fy
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

2.7 Development Length

The Bangladesh National Building Code (BNBC, 2020) states that the length of development (Ld) is the shortest embedment which is necessary to reinforce the reinforcing bars in. concrete so that there will be sufficient bond strength and to avoid slippage, it is necessary to have concrete. reinforcement to bring up its tensile capacity to the full. It is determined by the following formula:

Ld = (ϕ × fy) / (4 × τb)

and where ϕ is the reinforcement bar diameter, fy is the steel yield strength and τb is the reinforcement bar tensile stress. is the stress of the bond between the reinforcement and the concrete. The value of τb varies depending on a number of factors, such as concrete strength, bar surface condition (plain or abnormal, and position of the bars (top or bottom reinforcement). Generally, the development length of beams takes a longer time compared to the slabs because of the high. shear and bending forces they have to undergo. The BNBC (2020) also incorporates modification factors to consider various conditions like type of bar, top reinforcement placement, and confinement conditions. These provisions ensure that structural integrity is maintained by providing adequate anchorage under various loading scenarios, ultimately contributing to the safety and durability of reinforced concrete structures.

2.8 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: Concreate Clear cover

Member	Location Or Condition	Thickness Of Cover
Footing	Side	3"
	Bottom	3"
Column	Above Ground Level	1½"
	Below Ground Level	3"
Beam	Indoors Face: Top, Side & Bottom	1½"
	Outdoors Face: Top, Side & Bottom	1½"
Slab And Stair	Top And Bottom	¾"
Wall (Above 10" Except Basement Wall)	Exterior	2"
	Interior	¾"
Water Tank	Water Face	2"
	Other Face	2"

2.9 Design Considerations of a Septic Tank

According to the Bangladesh National Building Code (BNBC, 2020), several key recommendations guide the safe and efficient design of septic tanks for wastewater management. When designing a septic tank for 200 users—assuming each classroom accommodates 40 students with a floor area of 16 sq ft per student—the main design factors include the number of users, average daily water consumption, and the required wastewater retention period. The capacity of the tank should be based on the household's daily water usage, ensuring it can retain wastewater for at least one to two days to allow solids to settle and undergo decomposition. of heavy, waterproof materials like concrete reinforced, fiberglass, or plastic to stem the leakage and safeguard groundwater defilement. To improve treatment efficiency, tanks can be subdivided into two compartments with the help of baffles or partition. walls. The inlet and outlet pipes must be aligned well to allow ease of wastewater. flow and the outlet pipe is placed a little lower to ensure proper discharge. Adequate it should be ventilated so as to release gases, odor and improve bacterial. activity. The presence of sealed access openings or risers is also stated in BNBC (2020). to maintain, inspect, and remove sludge, with a reduction in the possibility of contamination. The soakaway layout or drain field should be designed with regard to the absorption ability of soil. and be placed in a safe position with regard to wells, buildings and water sources. The septic tank must be set in deep enough a position to avoid freezing and assure structural. stability. Routine maintenance such as sludge removal of two to five years is critical to ensure efficiency, increase the lifecycle of the system and provide protection to the citizens. health.

2.10 Design Considerations of Overhead Water Tank

Water tanks overhead (or rooftop) overhead water tanks contain large dead loads. live loads and own structure loads of the stored water. These loads must be properly considered in the design of the structure as per BNBC 2020, Volume II, Chapter 2, Section 2.7, that stipulates applicable load combination requirements. Tanks should not only be designed to provide the support in the stationary position but also to provide the load to accommodate combined loading conditions, such as the dead, live, wind and seismic conditions, especially at school buildings. situated in places that are prone to natural calamities. Minimum Septic Tank Requirements (as per BNBC Part 8 -Sanitary Drainage):

Minimum liquid capacity: 2,000 liters (2 m^3)

• Minimum width: 3 ft

•Minimum liquid depth: 3 ft

•Length: At least twice the width.

2.11 Summary

Structural design of the project is done in line with the. Bangladesh national building code (BNBC), 2020, which provides coordination with architectural plans. The system of foundation was a footing-type based on soil. conditions, a durable cover of 3 inches of concrete. All structural Compressive strength of concrete is of 4000 psi and is used to design components. reinforcement steel of yield strength of 60,000 psi. Sufficient reinforcement at corners. has been presented to guarantee the integrity of the structure. Reinforcement length of development. bars has been calculated in accordance with standard of BNBC to attain complete tensile strength and prevent bond failure.

CHAPTER 3

STRUCTURAL ANALYSIS & DESIGN

3.1 Introduction

In this chapter, the structural analysis and products are shown of a Two-Story. reinforced concrete (RCC) school building that is included in the Capstone Project. The facility is planned to be used as a major learning center, which will include. classrooms, administration areas and utilities. Structurally, the building measures about 120 feet by 64 feet, and its overall height is 32 feet, and is to be designed. with an Intermediate Moment Resisting Frame (IMRF) system that will assure both gravities. and lateral load resistance as stipulated in BNBC 2020. The standard engineering practices have been used to analyze the structural system. programs to calculate internal forces, moments, deflections and reinforcement. requirements. Footings (isolated and combined), columns, grade, etc. beams, slabs and stairs were simulated and tested under load. loads, such as dead loads, live loads, wind loads and seismic loads. All materials and design assumptions are in line with the requirements provided in the. Bangladesh National Building Code (BNBC, 2020). The aim of this analysis is to provide structural security, serviceability of the building. and code compliance and fulfilling the functional requirements of a contemporary educational. facility. Member design is based on the outputs contained in this chapter. detailing, and construction.

3.2 Load consideration

ETABS Classification of loads (As per BNBC 2020), When modelling a ETABS primary school building, loads are in compliance with BNBC (2020), divided into three key components dead load, live load, and floor finish load.

Live Load consists of the weight of occupants, furniture, and other transportable objects. In the case of classrooms in primary schools, a live load of about 2 to4 kN/m^2 is. typically used. Nevertheless, in places where traffic is heavier like corridors and assembly areas, the live load must be enhanced to approximately 4 to 5 kN/m^2.

Dead Load is the weight of all the structural components and fixed. Building installations, including floors, beams, columns, walls, partitions, and others ceilings. This estimated with regards to the density of building materials such as concrete, brick, or steel.

Finish Load includes the weight of the finishing material (tiles or carpet) used. And is normally estimated at 1 to 1.5 kN/m^2. Such loads should be then combined in ETABS appropriately using the BNBC (2020). load combination rules in a manner that will help to determine the structural behavior of the building. under conditions different loads.

Load Combinations

DL = Dead + SDL

1) Service capability check
S1 = DL + Live (L)
S2 = DL + 0.5L
S3 = DL + 0.5L + 0.7Wx
S4 = DL + 0.5L - 0.7Wx
S5 = DL + 0.5L + 0.7Wy
S6 = DL + 0.5L - 0.7Wy

2) Strength Check & Concrete Frame Design

S1 = 1.4DL
S2 = 1.2DL + 1.6L + 0.5Lr
S3a = 1.2DL + 1.6Lr + L
S3b = 1.2DL + 1.6Lr + 0.8Wx
S3c = 1.2DL + 1.6Lr - 0.8Wx
S3d = 1.2DL + 1.6Lr + 0.8Wy
S3e = 1.2DL + 1.6Lr - 0.8Wy
S4a = 1.2DL + 1.6Wy + L + 0.5Lr
S4b = 1.2DL - 1.6Wx + L + 0.5Lr
S4c = 1.2DL + 1.6Wy + L + 0.5Lr
S4d = 1.2DL - 1.6Wy + L + 0.5Lr
S5a = 1.2DL + EQx + L
S5b = 1.2DL - EQx + L
S5c = 1.2DL + EQy + L
S5d = 1.2DL - EQy + L
S6a = 0.9DL + 1.6Wx
S6b = 0.9DL - 1.6Wx
S6c = 0.9DL + 1.6Wy
S6d = 0.9DL - 1.6Wy

According to BNBC code 2020 for Strength Check & Concrete Frame Designs 24 formula but it is a two storied building that's why we consider only dead load and live load.

3.4 Serviceability Check

Sway Limit= $\frac{1}{500} * Building\ hieght$

$=\frac{1}{500}$*24*12=0.58 in

In table 3.1 shown serviceability load combination, maximum positive - negative displacement and Sway limit. Fig 3.1 shown deflection due to load.

Table 3.1: Serviceability Check

Serviceability load combination	Displacement(in)	Sway Limit(in)	Serviceability Check
S1	Max=+0.11 Min=-0.085	0.58	OK
S2	Max=+0.11 Min=-0.08		OK
S3	Max=+0.11 Min=-0.07		OK
S4	Max=+0.11 Min=-0.07		OK
S5	Max=+0.04 Min=-0.09		OK
S6	Max=+0.075 Min=-0.25		OK
S7	Max=+0.07 Min=-0.3		OK
S8	Max=0.19 Min=0.77		OK

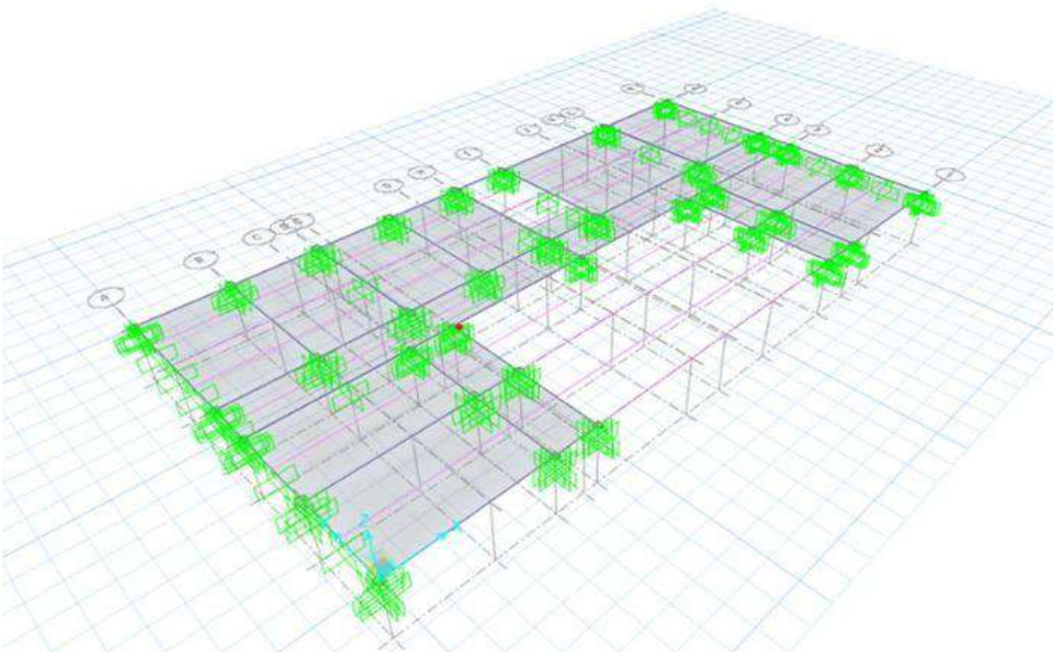

Figure 3.1: Load Combination

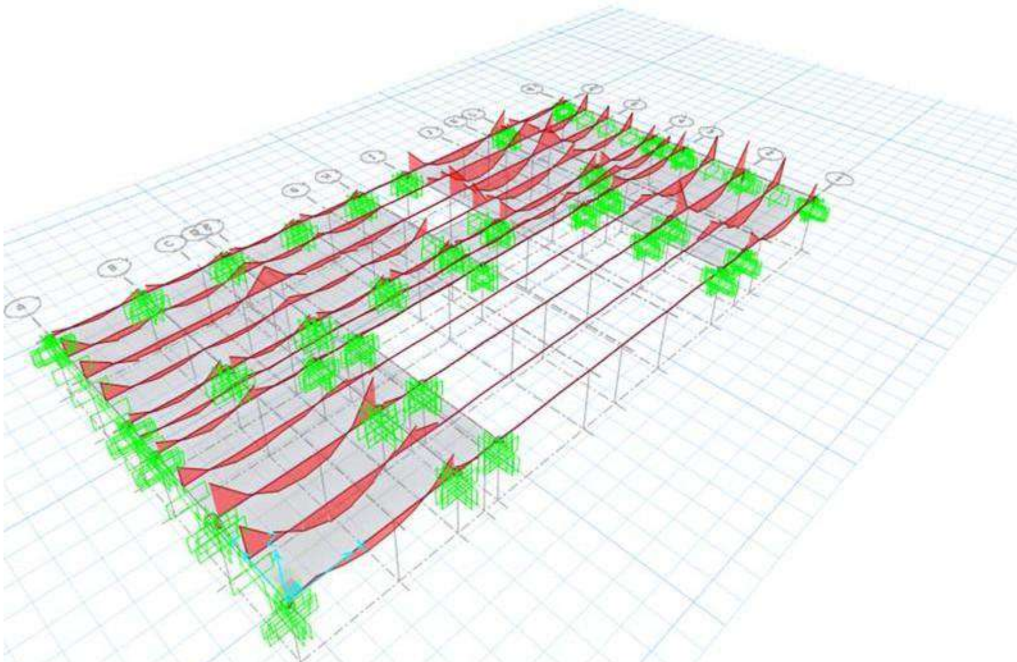

Figure 3.2: Flexural Load Combination

3.3 Design of Slab and Detailing

The slab was prepared with the SAP2000 in accordance with the requirements of the

BNBC 2020. ACI 318-19, concrete strength fc1 = 4000 psi, and reinforcement steel fy = 60000. A two-way, one-way slab system was taken based on the dimensions of psi. A Loads were applied under BNBC, such as dead load, live load, floor finish, and suitable load. combinations (e.g., **1.4D, 1.2D+1.6L).** The modelling was done using the etabs shell elements, and analysis was undertaken. calculate deflection, shear, and bending moments. Adequate reinforcement was given depending on moment capacity and minimum code requirements given. on moment capacity and minimum codes requirements.

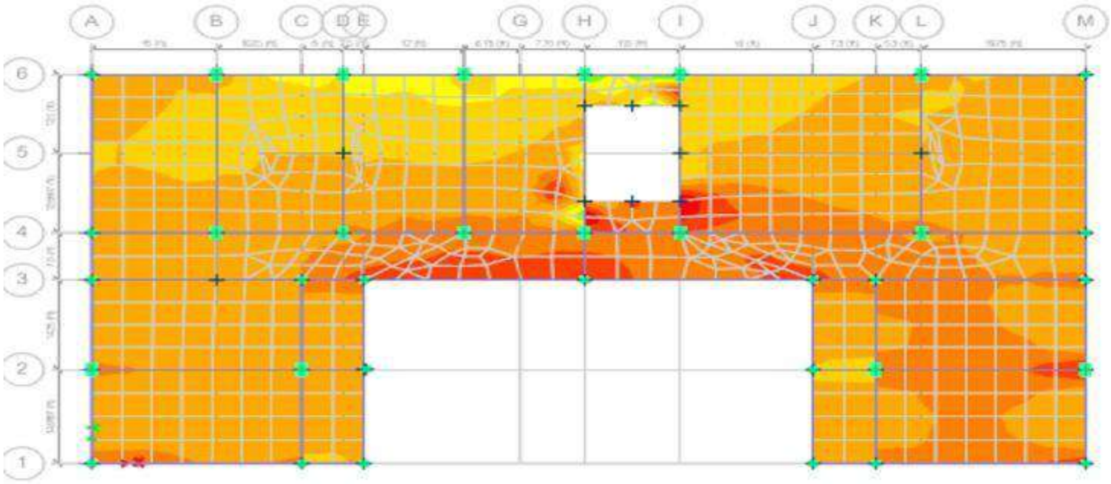

Figure 3.4: Flexural Stress

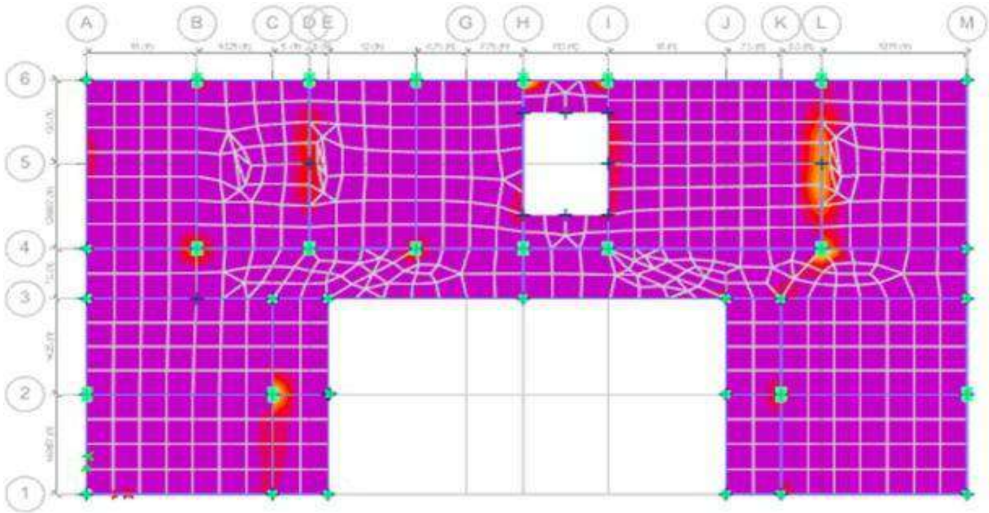

Figure 3.5: Flexural Stress (Slab)

3.4 Design of Beam and Detailing

The ETABS beam design approach of G+1 building entails the calculation of the beam. dimensions and describing the loading conditions, dead and live loads, in. conformity to the applicable standards. After the model was set up, we analyzed the beams to get the bending moments and shear forces of ETABS as in Fig. 3.6 The program to make sure that the beams were structurally safe by default. calculating the reinforcing needed on the positive and the negative moments. Having analyzed the results of the analysis, it was ensured that the reinforcement scheme met the minimum code provisions, and was able to withstand the imposed loads, and that calculated deflections were acceptable to service. Taking everything into account.

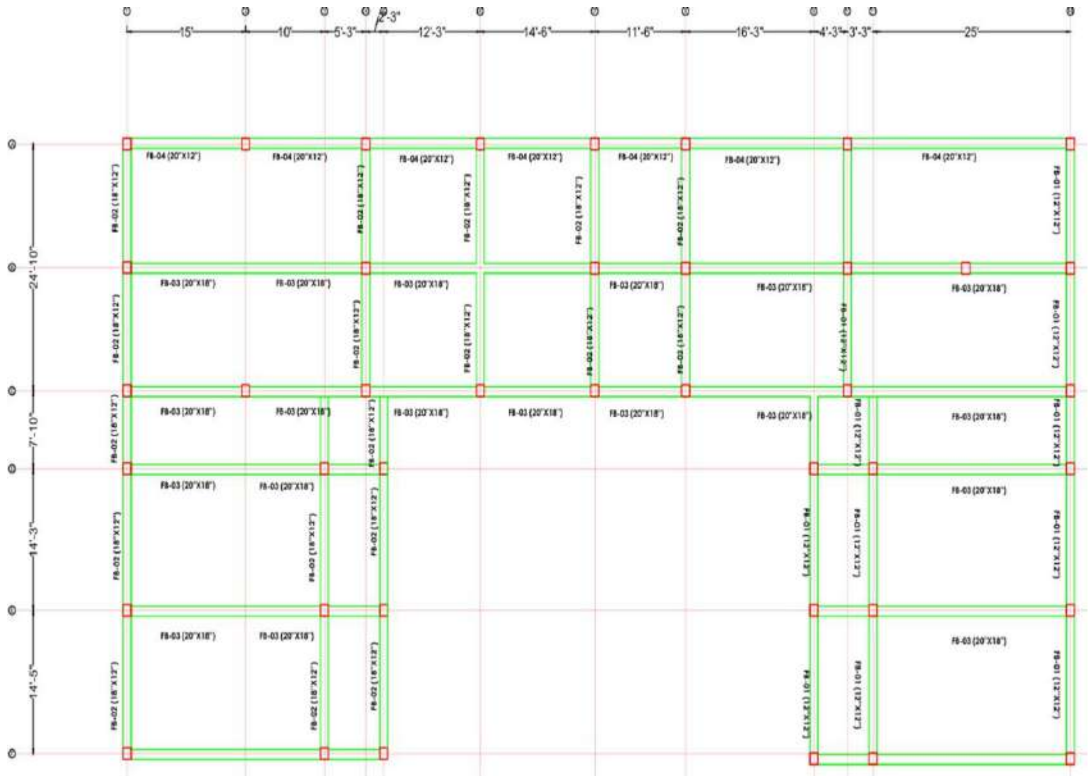

Figure 3.6: Beam Layout Plan

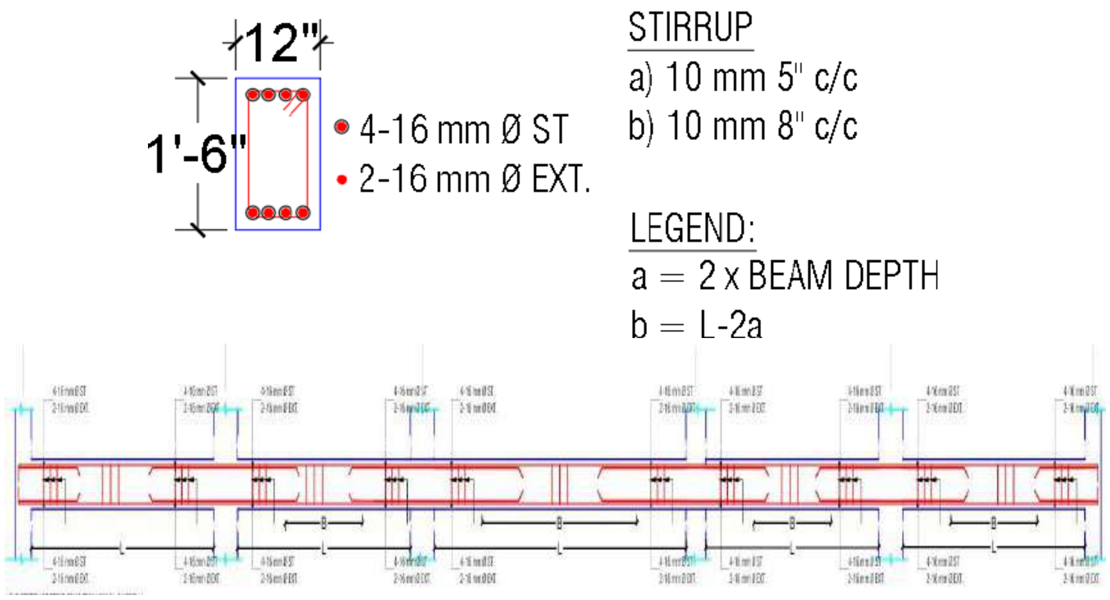

Figure 3.7: Beam Elevation

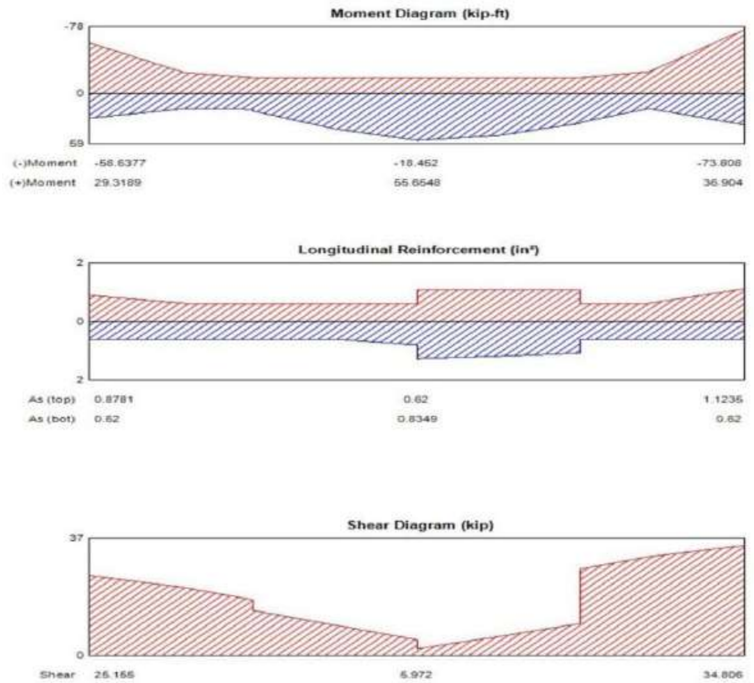

Figure 3.8: Moment Diagram, Shear Diagram Detailing of Beam

Figure 3.9: 3D Dimension Beam Rebar Profile

3.5 Lap Location

1) The span middle third zone lacks bottom bar lap on the span.

beam.

2) Middle third zone of the span could have the beam top fitted with a lap bar.

Figures 3.10 and 3.9.

3) 50% of the bar should be spliced as much as possible.

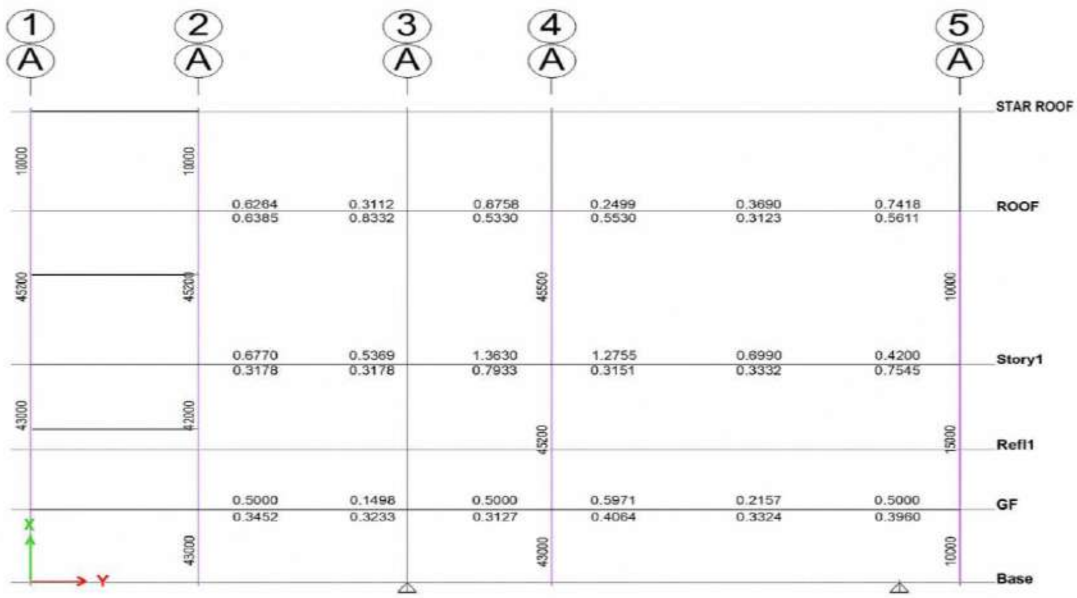

Figure 3.10: Elevation Reinforcement

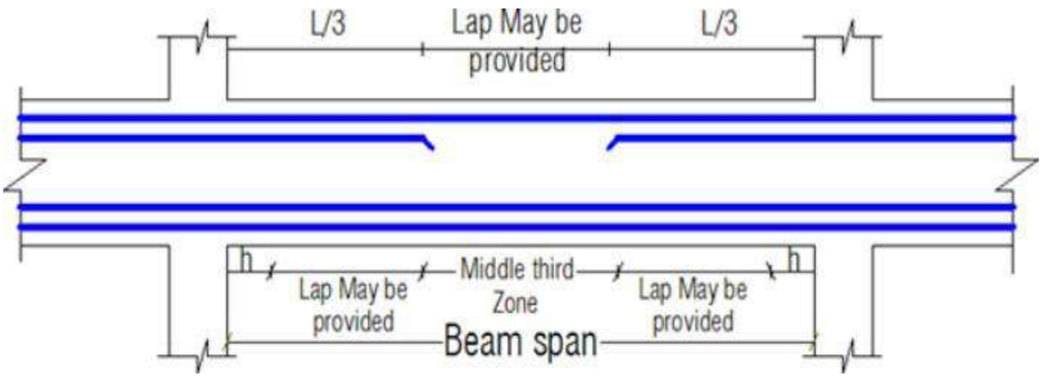

Figure 3.11: Lap Position

Table 3.2: Beam Details

Beam size (in)	Bottom Rebar	Top Rebar	Stirrups
B-1=12*12	4 # 16 mm Dia	4 # 16mm Dia	10mm @ 8in c/c
B-2=18*12	4 # 20 mm Dia	2 # 20 mm Dia	10mm @ 6in c/c
B-3=20*18	4 # 20 mm Dia	4 # 20 mm Dia	10mm @ 6in c/c
B-4=20*12	2 #16 mm Dia	2 #16 mm Dia	10mm @ 6in c/c

3.6 Design of Column and Detailing

In ETABS incorporates several important factors into the design process in the structural design. columns. It starts with the calculation of the axial loads and bending moments on the. I would include columns since they are essential in determining their strength and stability. The program examines the various types of loads such as dead loads, and live loads to learn more about them. effect on column performance. The program also bears in mind the column cross-sectional dimensions, the reinforcement. The aspects that directly influence the resistance of its ability are; detailing, stiffness, and buckling capacity. crushing and compression forces. Effects of slenderness are taken into consideration to make sure the design complies with performance and safety standards as per BNBC 2020 standards. ETABS is used to generate efficient column designs by combining these parameters. physically sound, and code-compliant. Detailed drawings are produced, and these are specifying. dimensions, reinforcement patterns and bar dimensions so that they are correctly implemented. during construction.

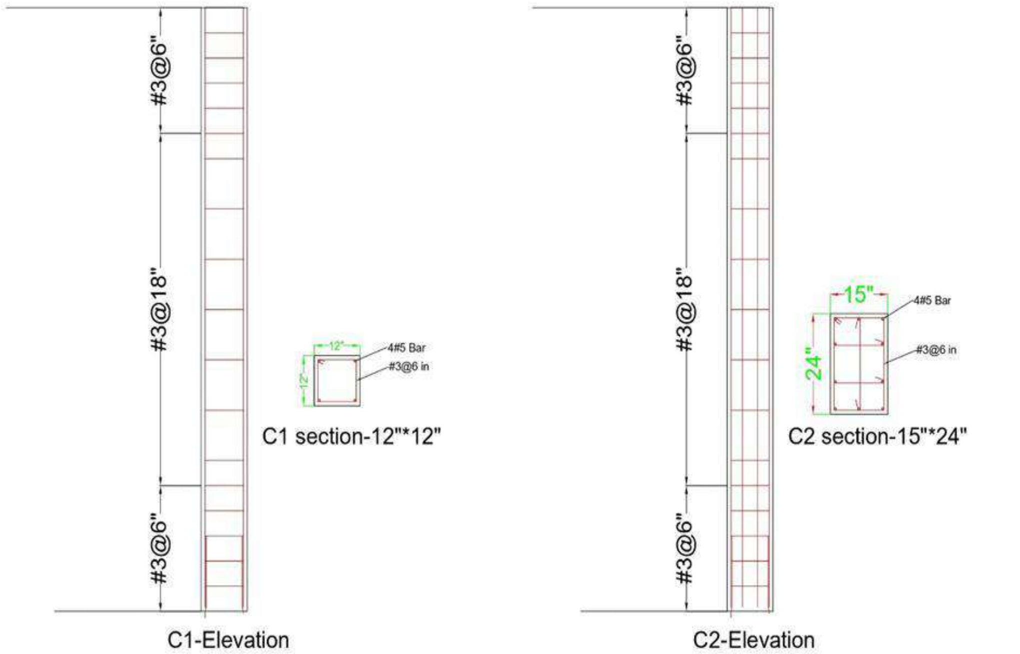

Figure 3.12: Column Design

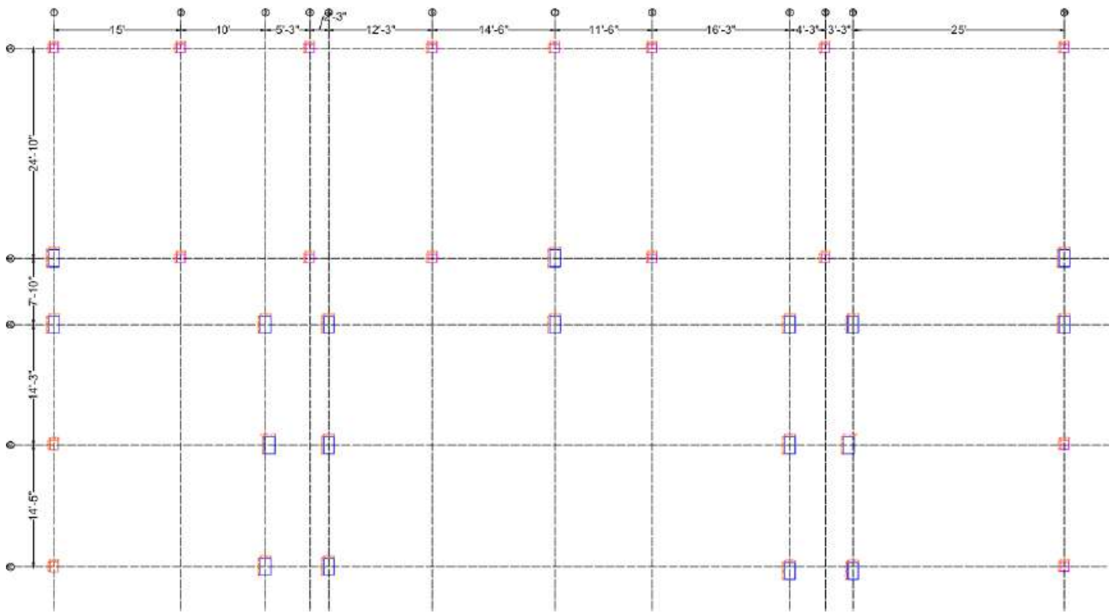

Figure 3.13: Column Layout Plan

Table 3.3: Details of Ground to Roof Column

COLUMN SIZE	REINFORCEMENT
C1-12×12	4#16 mm, 10 mm @6in
C2-15×24	10#20 mm,10 mm @6in

3.7 Design of Foundation and Detailing

The square, rectangular and combined footings of ETABS are designed in such a way that they are square, rectangular and combined. consideration of different structural and geotechnical parameters to make it stable. observance of pertinent design codes. It starts with the determination of the soil. bearing capacity, which has a direct influence on the dimensions and reinforcement requirements. of the footings. In case of square and rectangular isolated footings, ETABS computes transferred loads. between columns- these are dead forces, live forces and other forces that are exerted- spreads them over the footing area to ensure that the soil pressures are within acceptable limits. Bending moments, one-way shear and punching shear are checked to guarantee the analysis. the foundation has the capacity to support the loads being applied on it, without structural failure. Footing depth is chosen to oppose shear stresses as well as manage settlement within. allowable limits. Combined footing is applied in case there are two or more columns in close proximity, or when. isolated footings cannot be used due to soil conditions or constraints of the boundaries. ETABS designs the footings arranging loads of supporting columns in such a manner that the loads are distributed. resultant load is carried through centroid of footing area, so as to have a uniform soil. pressure. Bending and shear checks are carried on in both directions and reinforcement is enforced to meet the calculated needs. Details of concrete grade, type of reinforcement and where the construction is to be placed are finalized accordingly. with the respective design codes, which provide sufficient cover and permanence. Detailing consists of defining the main reinforcement bars, the distribution reinforcement, the spacing, etc. lengths of anchorage, as shown in Fig. 3.14 and in Table 3.15.

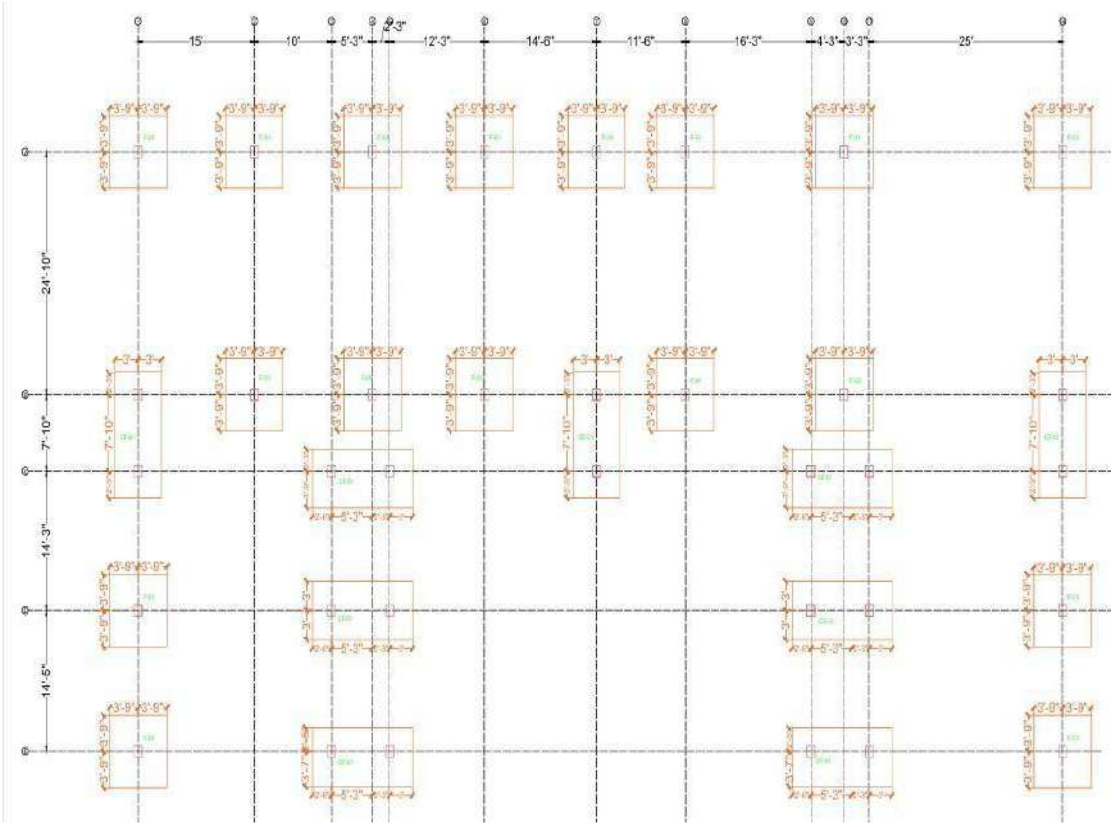

Figure 3.14: Footing Size & Position

Table 3.4: Footing Schedule

FOOTING NO	Thickness	Width	Length	Long Direction Reinforcement	Short Direction Reinforcement
F-01	10in	7’5”	7’5”	20mm @ 4 in c/c	20mm @ 4 in c/c
CF-01	15in	6’	13’	20mm @ 5 in c/c	10mm @ 10 in c/c

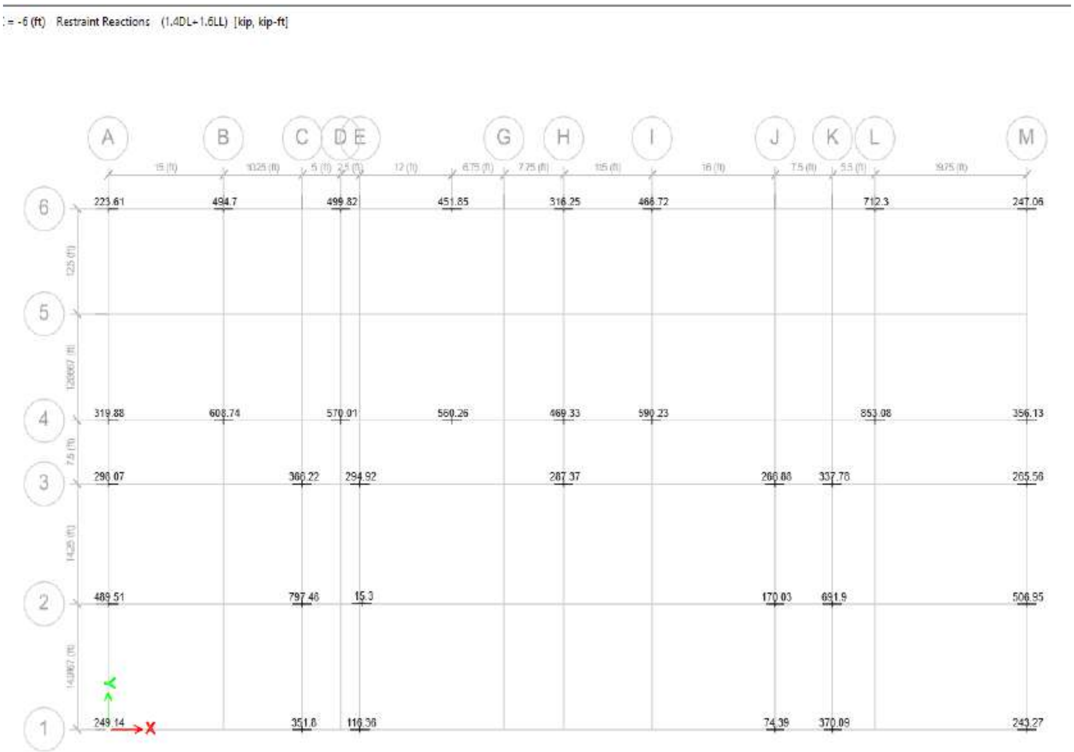

Figure 3.15: Footing Load

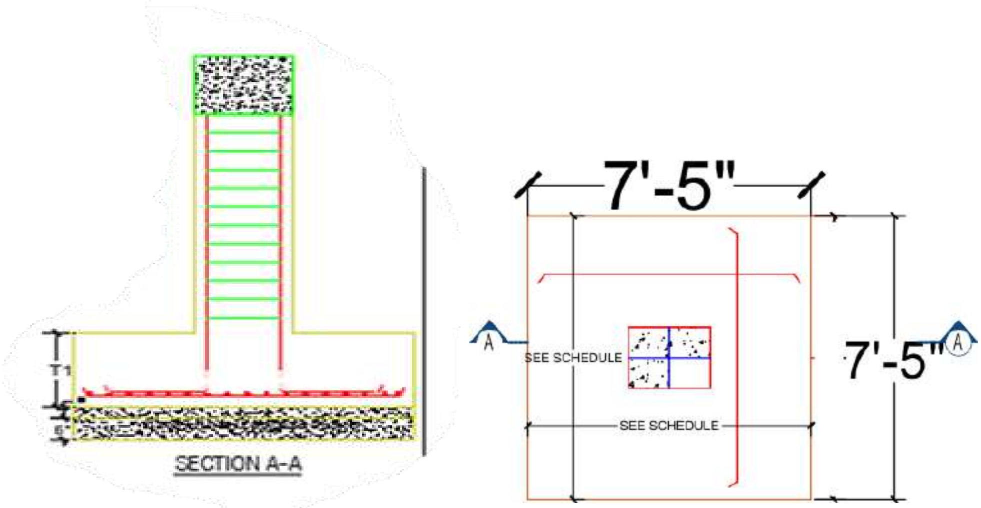

Figure 3.16: Typical Footing F-1Pan -Top/ Bottom Bars

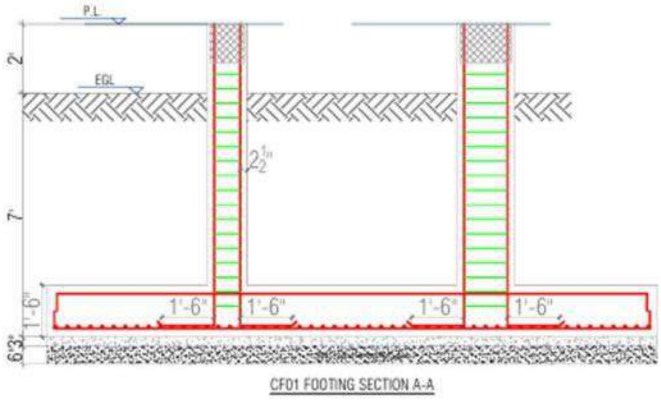

Figure 3.17: Typical CF-01 Footing (6'x13'), Thickness 15"

3.8 Design of Staircase and Detailing

In ETABS, there are a few important structural and load considerations in the staircase design. provide safety and functionality. This starts with an examination of the staircase. geometry--considering the rise, run and general slope--to conform to the architectural requirements. The physical characteristics e.g., the strength and stiffness. of concrete or steel are thought to be sufficient to support the structure. Load considerations are both dead loads (self-weight of staircase, and structural) and live loads. according to as per components) and live loads (weight of occupants and moving loads on the steps). BNBC 2020 provisions. The structural configuration- either the presence or absence of the, will depend on whether the structural configuration is in the presence or absence of the. staircase cantilevered, at both extremities, or on intermediate landings-- ETABS examines the boundary conditions and the supports. This ensures that the staircase can withstand the available loads as well as serviceable. code compliance.

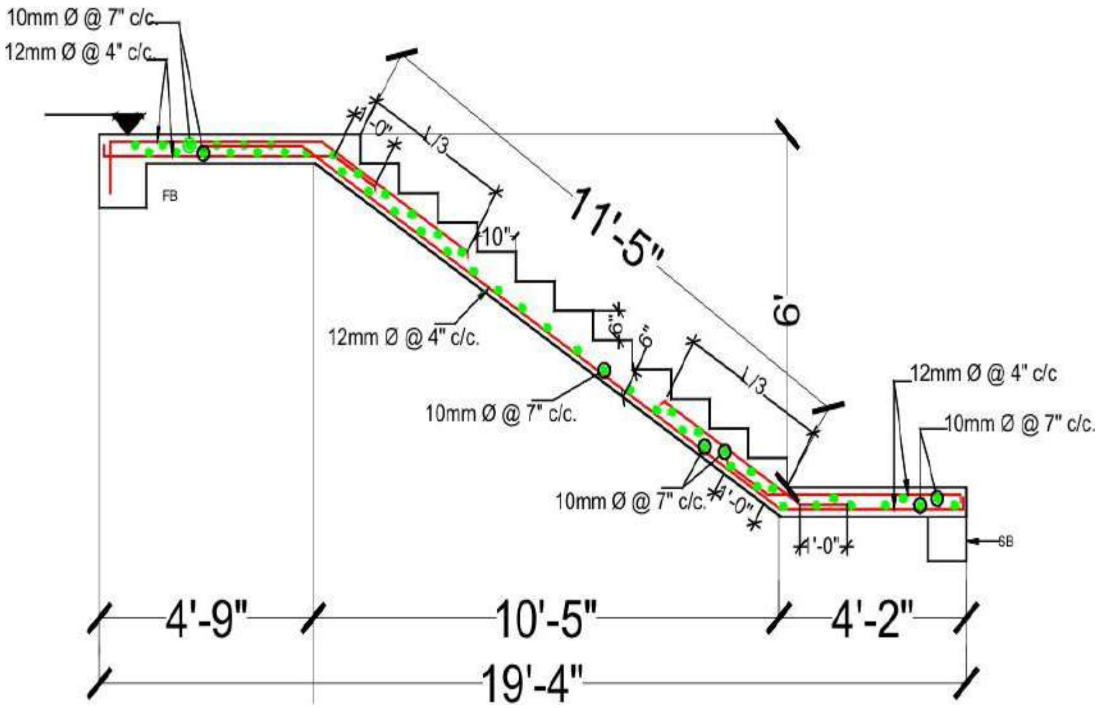

Figure 3.18: Stair & Technical Rebar Bindings

Table 3.5: Stair Schedule

Name of the Rebars	Types of Rebar
Main Bar	12 mm@ 4”C/C
Distribution Bar	10 mm @ 7”C/C

3.9 Summary

ETABS was also used in the design of structural components of a G+1 in this project. construction, the foundations, slabs, pillars, beams and ladders. Each element was constructed with care, formulated and optimized with complex analytical research to fulfill. design standards and provide safety and serviceability, even in case of electrical. faults. The completed structural data were then incorporated into the AutoCAD to generate. accurate, detailed, and exact drawings and labeling, and reinforcement specifications. This combined construction made the structure steady, code compliance, and preparation to safe and viable implementation.

CHAPTER 4

DESIGN OF SEPTIC TANK & OVERHEAD TANK

4.1 Introduction

Water storage and water sanitation are important in provision of steady water. - supply and their hygiene in residential and institutional buildings. An overhead water tank is a raised construction that is used to store and distribute water using. gravity, which secures a good and continuous supply. Its design requires careful taking into account the aspects of water demand, structural stability, material choice, and so on. and service to guarantee safety, longevity, and cost efficiency. Similarly, a septic tank is a subsurface treatment of wastewater treatment system that is often utilized in regions that lack. centralized drainage pipes. It works in solid-liquid separation and separating organic waste by letting anaerobic bacteria break it down prior to the partially treated. effluent is released to a drain field where it is further purified. This is a project that combines the design features of overhead and septic tank, with the focus on the structural requirements, capacity estimation, material durability, and environmental safety. It places emphasis on the need to follow local construction regulations, hygiene, and sustainability measures to defend human health and groundwater quality. The necessity of a routine check and inspection also comes out in the study. servicing so as to guarantee long-term functionality and efficiency. By combining theoretical designed this way through practical design techniques, this work is engineering knowledge. complete information guide to students, engineers and professionals working in the. organizing, creation, and execution of dependable water provision and wastewater. management systems applicable to small to medium sized construction.

4.2 Components of A Septic Tank

A septic tank consists of several important components which treat home wastewater. The house wastewater is channeled to the tank through an inlet pipe and the liquids are directed to the tank. and solids start to separate. Light substances like fats and oils come to the surface of. the tank towards the formation of a scum layer, with the more substantial contents getting laid down to the bottom in order to compose a sludge layer. The effluent layer consists of water which is partially treated. them. To make sure that the effluent enters the drain field to undergo further treatment, baffles and tees are installed near the input and the outflow pipes to ensure that the effluent flows freely into the drain field. aid the circulation and prevent congestions. Also, the tank has access ports. which are called risers, and that allow scum and sludge pumping on a regular basis, care, and inspections.

From the analysis gets,

The 200 number of student septic tank was developed based on Bangladesh National Building Code (BNBC). Total 2 number of tanks provided. The main design parameters will be population of 200, sludge build-up rate of 0.04 m^3 /client/annual, a cleaning cycle of 5 years and temperature of 25 C. The total volume of the tank was computed at 62.43 m^3, which included sedimentation (2.2 m^3), digestion (4.23 m^3), sludge (40 m^3), and scum (16 m^3) areas with 30 l per capita per day flow. The overall effective depth was 3.025m and the ultimate internal dimensions was 7.5mx2.75m x 3. 025m.

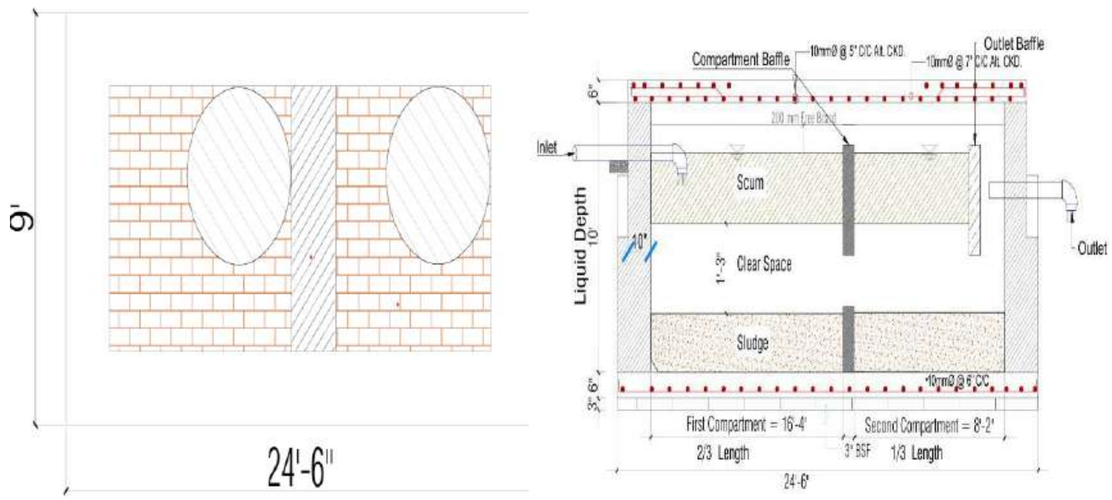

Figure 4.1: Section View of a Septic Tank

4.3 Components of an Overhead Tank

An overhead tank is another important feature of supplying and storing water in a high level so that the pressure is enough and the supply is not disrupted to any building. It is divided into a number of major elements that perform a particular role. The tank body is the primary storage of water. It is normally made of reinforced cement concrete (RCC), steel or high-density polyethylene (HDPE) so that it is strong and durable. The cover slab or roof keeps the stored water out of the dust, debris and contaminants as well as minimizing evaporation. Water is added to the tank by the inlet pipe which may also have a float valve to ensure that the tank does not fill up. The outlet pipe conveys the water to the distribution system with the help of a gravitational flow. An overflow pipe is built to prevent flooding next to the top of the tank. Vent pipe This is a pipe designed to allow the proper circulation of air to avoid vacuum developing or excessive pressure. The tank has a drain pipe at its lowest point to empty completely whenever cleaning or conducting some maintenance. To create the needed water pressure, the supporting structure, consisting of the RCC columns, iron frames, or masonry towers, raises the tank. This construction should be firm enough to support the weight of the water and the weight of the tank. The effective integration of all these elements, together with their maintenance, will guarantee that the overhead tank is efficient delivering a safe, reliable and consistent water supply to the domestic, commercial or institutional use.

From the analysis gets,

An overhead water reservoir layout to be used in a septic system with 200 students was done based on the Bangladesh National Building Code (BNBC 2020). The overall daily water consumption was determined as 40 m^3 (40,000 liters). The concrete strength was set at f′c =3 ksi which was the structural design parameter and the steel yield strength was 4 ksi f′y =4 ksi. Total 2 number of tanks provided. The overall effective depth was 3.025m and the ultimate internal dimensions was 14’ x 12’x 6.721’.

Vertical and horizontal wall reinforcements were calculated by use of 13 mm bars at 15-inch c/c spacing with bottom slab being calculated as one-way slab of 9-inch thickness with 4 bars at 3-inch c/c spacing.

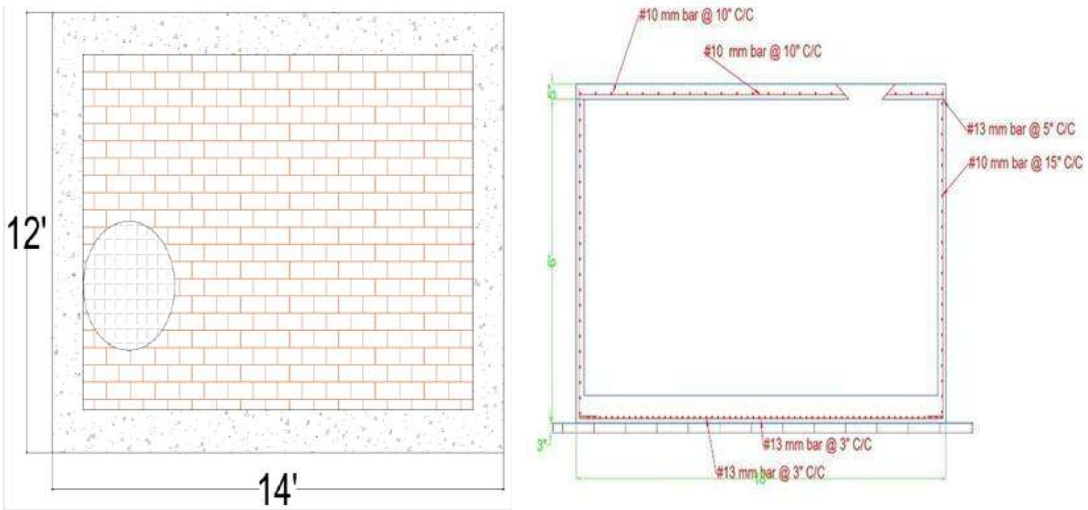

Figure 4.2: Section View of Overhead Tank

4.4 Summary

The project is dedicated to design and construction works on septic tanks and overhead water tanks, which are the necessary part of building water supply and sanitation systems. The septic tank is a wastewater treatment facility in the form of underground tank, which separates the solid and liquid materials using anaerobic action. The inlet and outlet pipes, baffles, sludge and scum layer, and ventilation are the main components that make the operation effective and easy to maintain. The design is based on Bangladesh National Building Code (BNBC, 2020) which includes such aspects as daily water consumption, storage period, long-lasting materials, and secure location without contact to buildings and water sources. Also, a well-formulated drain field that is constructed on soil absorption augments safety on the environment. The overhead water tank on the other hand offers quality water distribution through gravity. The design entails the determination of the storage capacity based on the demand, structural stability to water, wind and seismic loads, and added characteristics such as overflow, access openings and ventilation. The two systems are sustainable, hygienic as well as durable. The combination of them enables the management of water effectively, economically, and in connection with the applicable standards, with sustainable, safe, and pragmatic solutions to residential, commercial, and institutional buildings.

CHAPTER 5

COST ESTIMATION

5.1 Introduction

Construction Bill of Quantities (BOQ) in construction and especially applicable to G +1. project, in which it enumerates all the materials and resources in completing each structural. element. BOQ gives the description of the concrete handy as well as its reinforcement needs. on each of the major structural component i.e., slabs, beams, columns, isolated. footings & stairs. This difference preserves the integrity in the first place by offering transparency. budgets and material ensure that suit on fairy tale asset. This table covers all the concrete, reinforcing and required needs and a summary of slab beam column. footing staircase All this is reviewed in the BOQ:

5.2 Site Cleaning Work

Table 5.1: Site Cleaning Work Summary

Item	Number	Measurement L ×B × H	Contents	Unit	Total of Each	Total cost (TAKA
Site Cleaning work	1	120’ * 64’	7680.0	SF	7680	460,800

5.3 Foundation

Footing works cost is divided into two major activities, which start with. the excavation on the earth to form the pits of the different two footing types, and the biggest one is 13’ × 6’ × 15” . This first stage, which the elimination. of 20,200 CFT of soil, is the greatest expense incurred on the foundations, with a total cost of 1282632 Taka. The next stage is the Reinforced. M30 grade reinforcement Cement Concrete (RCC) work. concrete footings. The overall price of the provision and repair of the 11,567 kg of high-strength. rebar needed to be made of steel to offer tensile strength is 1110432 Taka, which translates to a unit. rate of 96 Taka per KG.

Table 5.2: Estimation of Footing

Item	Number	Measurement L ×B × H	Reinforcement	Brick	Total cost (TAKA)
F-01	17	7’5”× 7’5” × 10”	11567 KG	12300	1282632
CF-2	9	13’ × 6’ × 15”			

Table 5.3: C.C. Under Footing (1:3:4 Concrete)

Item	Area	Sand	Cement	C/A	Total cost (TAKA)
Dry Volume	1262.4 SF	1050 cft	280 bags	1387 cft	374400

5.4 Column

The column work cost is subdivided into two major categories of material, representing the makeup of these crucial vertical structures intended to transmit loads. to the foundations. The reinforcement steel is the most important element of cost, and its value is. a total weight of 90,286 kilogram of high strength rebar- both main and main. longitudinal bars and transverse ties to the 15x 24 inch and 12x 12-inch columns-demanding a supply and repair cost of 772,319 Taka. The second category discusses the concrete materials used in the M30 grade mix, in which the overall cost of the sand, cement, and coarse aggregate is 103,060 Taka.

Table 5.5: Total Quantity of RCC Work (Column)

Item	Measurement L ×W (IN)	Contents	Unit	Total of Each	Total cost (TAKA)
Reinforcement C1	15 × 24	3359.6	KG	9286 KG	772319
Reinforcement C2	12× 12	4906.3	KG		
Tie C1	15 × 24	434.2	KG		
Tie C2	12× 12	386.0	KG		

Table 5.6: Total Quantity of Dry Volume

Item	Sand	Cement	C/A	Total cost (TAKA)
Dry Volume	260 cft	102 bags	380 cft	103060

5.5 Beam

The cost of the financial outlay on the beams is distributed in two important components. The installation and purchase of reinforcement steel, 10455 kilograms in total, incurred. a cost of 836,400 Taka. At the same time, the concrete materials such as the raw materials are included. sand, cement, and coarse aggregate, had an investment of 666,647 Taka.

Table 5.7: Total Quantity of RCC Work (Beam)

Item	Measurement L × W (in)	`Detail	Bar & spacing	Contents	Unit	Total of Each	Total cost (TAKA)
Beam	12 × 12	Extra Top	2#5	88.5	KG	10455 KG	836,400
Beam	12× 20	Extra Top	2#5	4747	KG		
Beam	24 × 30	Extra Top	2#5	392	KG		

Table 5.8: Total Quantity of Dry Volume

Item	Sand	Cement	C/A	Total cost (TAKA)
Dry Volume	478 cft	192 bags	956 cft	666,647

5.6 Slab

The price of the 6,012 square foot slab is bundled up on the entire Reinforced. Finishing work and Cement Concrete (RCC). The construction of the is covered as well. M30 concrete slab that takes 530 bags of cement, 1330 CFT of sand and 2,646 CFT of coarse aggregate, mixed in total of 6,701 kilograms of reinforcement steel. Moreover, the final painting work is also included in the cost. estimated on 21 gallons of paint. The entire combined expense of all these materials, and slab activities sum up to 977, 286 Taka.

Table 5.9: Total Quantity of RCC & Volume Work (Slab)

Area	Cement	Sand	C/A	Total Reinforcement	Painting	Total cost (TAKA)
6012 SF	530 Bag	1330 cft	2646 cft	6701 kg	21 gallons	977286

Table 5.10: Total Quantity of 5” Thick Brick Wall & 0.75” Thick Plastering in 1:3 Cement Mortar

Wall Volume	Per Brick Volume	Total Brick	Total Cement	Total Sand	Total C/A	Total Cost
3408 cft	0.0553 cft	122800 nos	282 bags	1034 cft	380 cft	16,96,611 taka

5.7 Deductions

The section takes into consideration the openings and the structural elements related with the. building's walls. The deductions will include the expenses of a total of 32 windows, 12 standards. doors, 2 main doors, and lintels and sills of the reinforced concrete, necessary above and. below these openings. The total price of all these, and this supply. and installations, will be a sum total of 375,155 Taka.

Table 5.11: Total Quantity of Window, Doors, Lintel & Sills

Item	Number	Measurement L × W (FT)	Contents	Unit	Total of Each	Total cost (TAKA)
Window	32	6 × 6	7000	TK	224000	375155
Doors	12	7 × 4	10000	TK	120000	
Lintel & Sills	21	200 × 6	55	TK	1155	
Main Door	2	7× 6	15000	TK	30000	

5.8 Septic Tank Cost

Table 5.12: Total Septic tank cost

Item	**Unit**	Contents	Unit **(TK)**	**Amount (TK)**
1. Excavation (soil)	m³	110	300	33,000
2. Plain Cement Concrete (PCC) (100 mm thick)	m³	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)	m²	300	250	75,000
5. Reinforced Concrete Slab (Top Cover)	m³	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

5.9 Overhead Tank Cost

Table 5.13: Total Overhead Tank Cost

Component	**Estimated Cost (BDT)**
Steel	30,610
Concrete (3×Steel)	91,830
Labor (25% materials)	30,110
Miscellaneous (15%)	18,670
Total Estimate	171,220 BDT

5.10 Summary

Name of Project: School Building

Name of Work: 120'x64' R.C.C School (2 Story)

Report Type: Details of Measurement

Table 5.14: Summary Of BOQ

Estimation	**Estimated (Taka)**
Costing of slab and footing	32,00,988
Costing of column	15,13202
Costing of the beam	19,08,858
Costing of stairs	74,547
Costing of labor	650,000
Costing of brick masonry, wall plaster, Floor Tiles, plastic, and painting	19,97,684
Costing Of Septic Tank & Overhead Tank	841,478
Grand Total	**10,186,757**

Grand Total Estimated Cost: Approximately 10,186,757 Taka

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Through this capstone project, the independence of civil engineering concepts can be sufficiently illustrated in regards to the overall design of a two-story primary school building. The project ended up as a structurally sound, code-compliant, and functional design that was able to satisfy the specific requirements of a learning center.

The structural system is a model that is developed as an Intermediate Moment Resisting Frame (IMRF) through ETABS software and is successfully capable of bearing gravity and lateral forces as per the Bangladesh National Building Code (BNBC 2020). The entire critical elements such as isolated and combined footings, columns, beams, slabs, a staircase and many more were carefully analyzed and designed in regards of safety, serviceability, and durability. AutoCAD and Revit were used, which made the construction drawing detailed and clear enough to ensure clarity in case of construction.

An elaborate Bill of Quantities (BOQ) was worked out and the total estimated project cost was 10,186,757 taka (about Ten Million, One Hundred Eighty Six Thousand, Seven Hundred Fifty Seven). The realistic construction timeline of the project is presented in the form of a Gantt chart, which allows managing the project effectively and distributing resources.

The project in addition to the basic construction included the necessary ancillary designs in order to have a complete facility. This will feature a septic tank system, which is sustainable in terms of wastewater management and a plumbing system, which can sustain the daily water needs of 330 occupants. The project is therefore a holistic approach to engineering, where structural integrity, functionality, cost-effectiveness, and environmental factors are put into consideration.

6.2 Recommendation

In accordance with the findings and the design process, the following recommendations are offered towards the successful implementation and possible improvement of the project:

Geotechnical Investigation: Before construction is done, a site-specific investigation on soil must be done to validate the estimated soil bearing capacity and define any adjustment that will have to be done on the design of the foundation.

Quality Control: It should be provided with strict quality assurance and control of all the materials to be used on-site, and in particular the mixing of concrete, the pouring of the concrete and the placement of the reinforcements to ensure that the structure built reflects the design. Construction Supervision: Construction is to be supervised by qualified structural engineers to counter any unplanned site obstacles and make sure that the design requirements and BNBC 2020 standards are met.

6.2.1 Future Enhancement:

Integration of Sustainability: Future versions of the design may further embrace the concept of sustainability, which could be through inclusion of rainwater harvesting systems, installations of solar panels at the roof, installation of energy efficient lights, and fixtures to minimize the long-term cost of running the building and the environmental impact of the building.

Material Optimization: The design would be reconsidered to consider the option of using other building materials that are environmentally friendly like recycled aggregates in concrete or fly ash without affecting the structural performance.

Expansion Planning: The structural layout may take into account the possible future plan of the structure to expand horizontally (e.g., third floor) with extra load margins being taken into account in the column layout and foundation early-on.

6.2.2 Project Management:

Gradual Implementation: In case of budget limit, the project may be undertaken in stages with the most important being the completion of the block of core classrooms.

Digital Twin and BIM: Building Information Modeling (BIM) is strongly suggested to be used during the process of design and construction in the future. This would enhance coordination, detection of clashes and management of facilities even after the construction has been completed.

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APPENDIX

DESIGN OF SEPTIC TANK

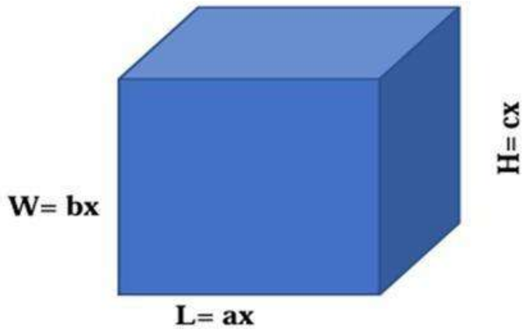
Design of a septic tank to serve a primary school of 200 persons who produce 30 lpcd of wastewater, and the tank is to be dislodged every two years.

Solution:

$$V = L * W * H$$

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

$$A = abx^2$$



Designing a septic tank for 200 students according to the Bangladesh National Building Code (BNBC) involves several key steps:

P = 200 persons

N = 5 years

C= 0.04 m3/person/yr.

T= 25 °C

q = 30 lpcd.

Volume calculation (m^3)

Sedimentation Zone Vh

Th = 1.5 - 0.3 log (Pq)

= 1.5 - 0.3 log (200 × 30)

= 1.5 - 0.3 log (6000)

$= 1.5 - 0.3 \times 3.778$

$= 1.5 - 1.1334$

= 0.3666 days

The volume required by the Sedimentation Zone:

$Vh = 10^{-3} (Pq) \times Th$

$= 10^{-3} \times (200 \times 30) \times 0.3666$

$= 2.1996\ m^3$

Sludge Digestion Zone Vd

Assuming a design temperature of 25°C

$Td = 30\ (1.035)^{(35-T)} = 42.3$ days T = 25°

$Vd = 0.5 \times 10^{-3} \times P \times Td$

$= 0.5 \times 10^{-3} \times 200 \times 42.3 = 4.23\ m^3$)

Sludge Zone Vsl

$Vsl = C \times P \times N$

$= 0.04 \times 200 \times 5$

$= 40\ m^3$

Scum Zone (Sc)

$Vsc = 0.4 \times Vs$

$= 0.4 \times 40$

$= 16\ m^3$

Total Volume V = Vh + Vd + Vs + Vsc

V = 2.1996 + 4.23+ 40 + 16 = **62.43 m³**

Depth Calculation

Cross-sectional area $A = 22.7\ m^2$

The maximum depth of sludge:

dsl = Vsl / A = 40 / 22.7 = 1.76 m

The maximum submerged scum

dss = 0.4 × Vsl / A = 0.4 × 40 / 22.7 = 0.704 m**.**

Sludge clear depth = 0.3 m is adopted

Total clear space = 0.3 + 0.075 = 0.375 m

Depth of the digestion zone

dd = Vd / A = 4.23 / 22.7 = 0.186 m< 0.375

Depth required for sedimentation

dh = Vh / A = 2.1996 / 22.7 = 0.097 m

Since dh < 0.375 m,

dh = 0.375 m is adopted

Total effective depth

= dsl + dss + dd + dh

= 1.76 + .704+ 0.186 + 0.375

= 3.025 m

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

7.5 m × 2.75 m × 3.025 m

OVERHEAD TANK CALCULATION

Roof top water reservoir (Overhead water reservoir)

Assumptions and considerations

F’c= 3ksi

Fy= 60 ksi

Total Floor 1

Units 1

Par Unit Member 200

Water consumption for big multi-family apartment/flat in city corporation area, considering full facility = 40 liters per capita per day (Part VIII, Table 8.5.1 (a), BNBC 2020: Page 4815

=40 lpcd

b) Water Reservoir size Calculation

Total 400 Persons

Total Water Consuming = 9000 Litter for full day

= 9 m^3

Inner length & width of Reservoir are,

Length 12 ft

width = 14 ft

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

c) Vertical Reinforcement of wall

Let wall Thickness = 4 inch

Effective Depth = 3 inch

ρ = $p_{0.005}$= 0.85 fy×∈ u

∈ u + 0.005

=0.0181

Mu = ϕ×ρ0.005×fy×b×d2× (1−0.59×ρ0.005×fy fc)

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

D= 1.92 < provided 3 (Ok)

As, min= 0.09 in^2/ft pi= 3.1416

USE As= 5 in^2/ft

As=$\frac{Mu}{\emptyset f_y(d-\frac{a}{2})}$ = 0.45 in^2/ft

a=$\frac{Mu}{0.85 f_c b}$ = 0.697 in^2/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 = 0.70, Spacing = 5in

Use # 13 mm@ 15” c/c

d) Horizontal reinforcement of wall

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

= 5437.5 lb/ft

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	l/20	l/24	l/28	l/10

Here, l is the clear span

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

If,

Thickness <6 inch then upper rounding to nearest 0.2

Thickness > 6 inch then upper rounding to nearest 0.50

Thickness 9 in

Self-weight of slab= 112.5 psf

Floor finish = 25 psf

WB= 56.25 psf Total load, w= 0.693 ksf

WA= 56.25 psf

As min = 0.19 in^2/ft

As= $\frac{Mu}{\emptyset f_y(d-\frac{a}{2})}$ = 1.096 in^2/ft

a= $\frac{Mu}{0.85 f_c b}$ = 0.745 in^2/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= 3.16 in

Use# 4 mm @ 3 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: 14 ft (wall-to-wall clear) L= 15

Concrete strength: 3000 psi (fc′) W= 15

Steel yield strength: 60,000 psi (fy)

Slab is exposed to pedestrian live load 40 psf

Cover: 1 inch

Assume: 5 thick slab initially

unit weight of concreted 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 62.5 psf

Total service load: 102.5 psf

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

L Short /36 0.388 4.666666667 in

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

=155.5 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 =αwu L2 α=0.041

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

Step 5: Steel Area

d = 3.5 < provided, 4.666667 ok

Asmin= 0.10 in2/ft pi= 3.1416

Spacing: 8.5 in 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 @ 9 c/c.

Use # 10 mm @ 20 c/c.

DESIGN OF A DOG-LEGGED STAIRCASE SUPPORTED LONGITUDINALLY

Rise = 6 in West Slab = 6 in
Tread = 10 in No of tread = 12 nos
stair width = 4.9 ft
H = 144” = 12 ft

θ= 32.0 deg Fc = 3ksi
fy = 60ksi
Floor to floor height 3.66 m

Impose load= 3 KN/m²

Floor finishes= 1.25 KN/m²

Beam width (B)= 304.8 mm

Unit wt. of concrete (ϒ)= 25 KN/m³

Grade of steel (fy)= 500 N/mm²

Grade of concrete (fck)= 20 N/mm²

Step 1: Calculation of effective span

Effective span (Leff)

= {(N-1)*T}+L1+L2+(B/2)+(B/2)

= {(12-1)*250}+1000+1000+304.8

= 5054.8 mm

Step2: Calculation of effective depth

clear cover (c)= 15 mm

Adopt the diameter of the bar (0)= 12 mm

(assuming constant 30-40)

Effective depth (d)= (Leff/30) = 168.493 mm

Overall Depth (D)= d+(0/2)+c = 168.493+(12/2)+15

= 189.493 mm ≈190 mm

Provided eff. depth= 169 mm

Step 3: Calculation of load

(i) Load on going on the projected plan area

Live load = 3 ^ * 1

= 3KN / m

Floor finish = 1.25 ^ * 1

= 1.25KN / m

wt. of waist slab =\ Upsilon^ * D^ * V(R ^ 2 + T ^ 2) \ /T

= 5.5394KN / m

wt. of steps = Upsilon ^ * 0.5^ * R

= 1.875KN / m

Total load l = 11.66KN / m

Factored load = 1.5 ^ * 11.66

=17.497KN / m

Live load = 3 ^ * 1

(i) Load on landing

Floor finish = 1.25 ^ * 1

= 3KN / m

self wt. of slab J = Upsilon^ * D^ * 1

= 1.25KN / m

= 4.75KN / m

Total Load = 9KN / m

Factored load = 1.5 ^ * 9 = 13.5KN / m

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

Taking the moment of all forces about point B

Ra.^ * 5.0548=\ \ (13.5^ * 1.1524^ * (1.1524/2 + 2.75 + 1.1524) \ pm\ 17.5^ * 2.75^ * (2.75/2+1.1524)\ +{13.5*1.1524*1.1524/2)}]

Ra*5.0548= 200.247 Ra = 39.62KN

Ra+Rb (13.5*1.1524)+(17.5*2.75)+(13.5*1.1524)

39.62 + Rb = 79.23 Rb = 39.62KN

Vmax= =\ 13.5^ * (1.1524 + 1.1524) \ +(17.5^ * 2.75))/2 = 39.62 KN

Mmax= =[13.5^ * 1.1524^ * \{(1.1524/2) + (2.75/2)\}]-[17.5^ * (2.75/2)^ * (2.75/2^ * 2)]+[39.62^ * \{1.1524 + (2.75/2)\}]

= 53.23 KN-m

Step 5: Check for depth against bending moment

Mmax=0.133*fck*b*dreq^2 53.23*10^6=0.133*20*1000*dreq^2 dreq

= 141.46 mm

(dregdprov).

Hence OK

Step 6: Designing the reinforcement

53.23*10^6= 0.87*500*Ast*169*[1-{(500*Ast)/(20*1000*169)}]

Ast= 824.642 mm²

(Ast)min.= 0.12% of bD

= (0.12/100)*1000*190 = 228 mm²

Spacing= [1000/824.64/(3.142*12^2)/4}] = 95.598 mm ≈100 mm

Provide 12mm dia. bar @ 100mm c/c

(Ast)prov.= [1000/150/(3.142*12^2)/4}] = 753.982 mm² % of steel prov. = 0.45%

Step 7: Check for shear force

For M20 concrete

Shear strength (Tc)= 0.280 N/mm²

IS 456:2000, Table-19

Глаах= (39.62*10^3)/(1000*169) = 0.234 N/mm² OK

Step 8: Check for deflection

(Leff/d)prov.= 5054.8/169 = 29.91

Basic values

Basic value: (α) = 20

Modification factor (β) = 1

For Tension Reinforcement (y) = 1.5

For Compression Reinforcement (8) = 1

Reduction factor for flanged beam (λ) = 1

For calculating the factor y

Steel Stress of service load (ts)= 0.58fy

= 0.58*500* [(Ast.reg.)/(Ast.provided)] = 317.177

(As/bd) %= [753.982/(1000*169)]*100*0.446

(γ) = 1.5

Now, alpha*beta*y*delta*lambda =20^ * 1^ * 1.5^ * 1^ * 1 = 30

(I / (d)) <= alpha*beta*chi*delta*lambda OK

Step 9: Development length

Ld. =\ ^ * sigma equip underline *0.87*

=(12 ^ * 0.87^ * 500)/(4^ * 1.2^ * 1.6)) = 679.688mm

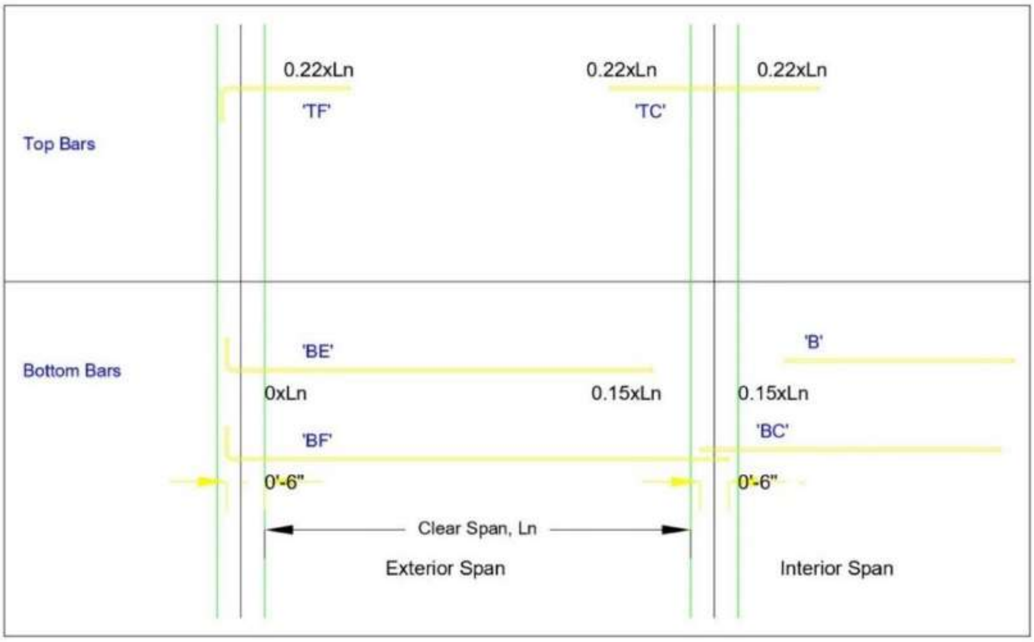
Step 10: Distribution bar reinforcement detailing

Spacing =1000/\ 228/(3.142/4^ * 12 ^ 2)\

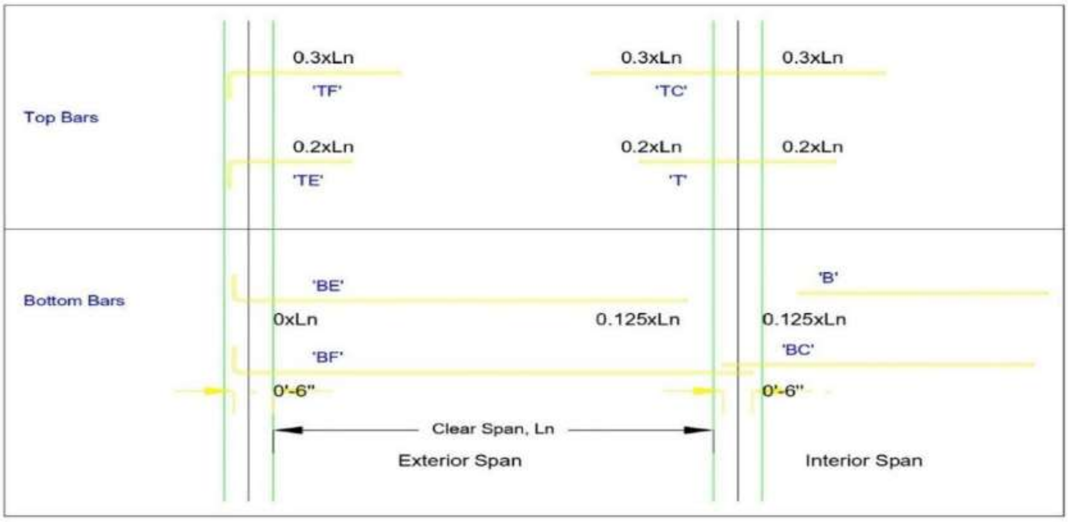
= 496.041mm <= 450mm <= 845mm Spacing provided = 177 mm

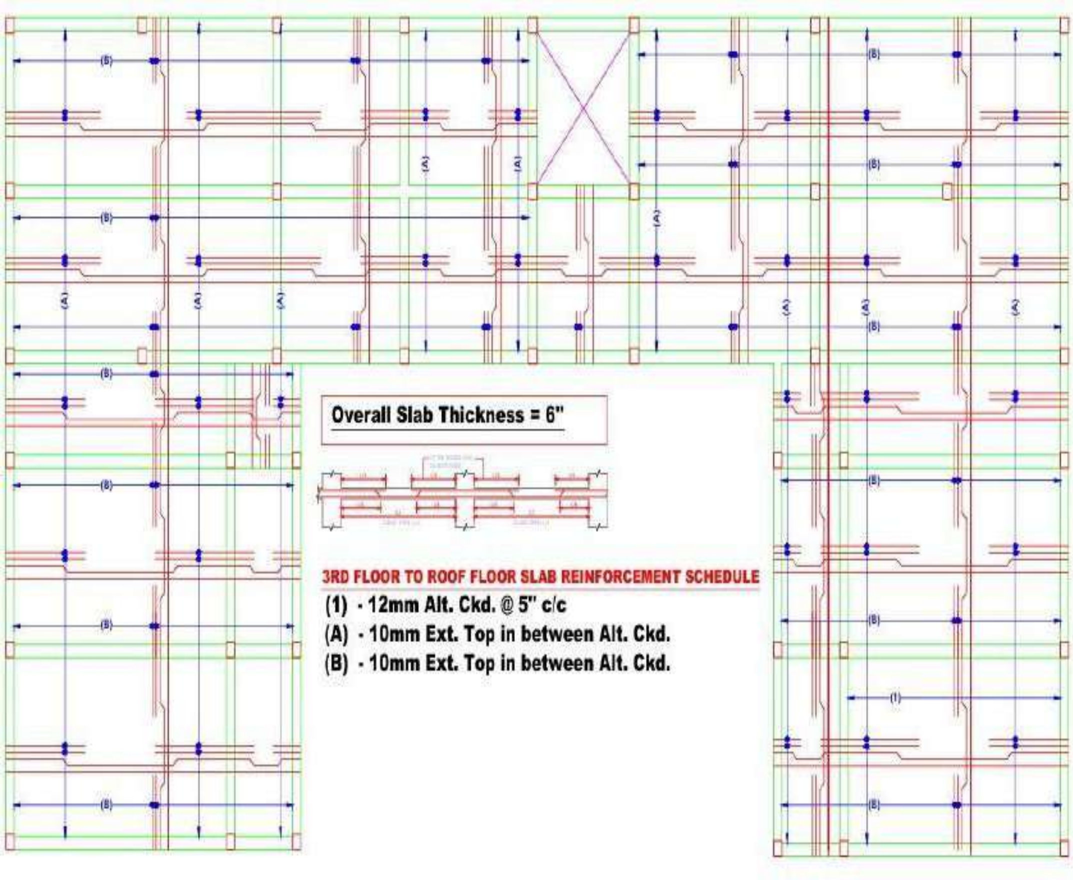
Provide a distribution bar of 10mm diameter. @ 177mm c/c

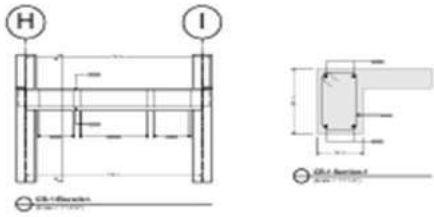
Slab Rebars: Middle Strip



Slab Rebars: Column Strip



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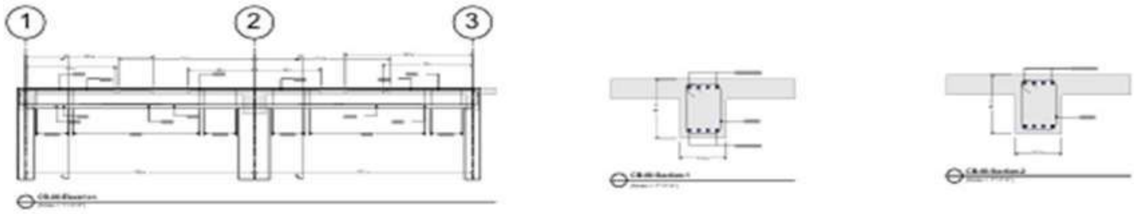
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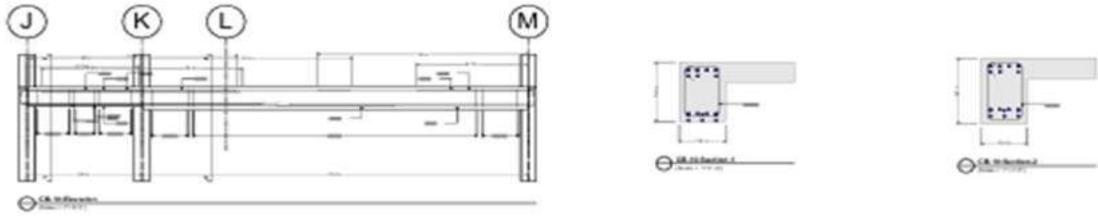
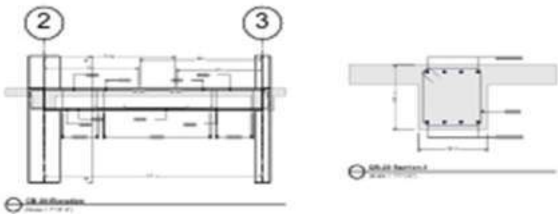
2
3


J
K
L
M


2
3

Square (F-01,) Footing Calculation

FOOTING DESIGEN

fy =	60		KSI		
Axail Load =	700	kips	700000 lbs		F2
Allowable Soil Capacity=	3.5	ksf	3500 psf		
Footing Area= P/q allow	200.0		ft2		
fc' =	3		KSI		
Squair Footing				Effective depth	
Thickness of Footing =	15		in	11.5	K
				COLUMN SIZE	
B =	14.1	ft	15.0 ft	L	24
L =	14.1	ft	15.0 ft	B	24

Square Footing

with of footing b = $\frac{LOAD}{qe}$ 200.00 ft

200 ft^2

LENGTH = 14.1 ft

CHECK SOIL PRESSURE $q_u = q/b$

3.11 K OK since OK ksf

3111.11111

vu =	667138.9 lbs	ASASUME FOOTING DEPTH	
vc =	219.1 psi		
	31.5 ksf		
now ,	453.5	15	in
	453514.3		
Check shear	3		
Let's place the column in the center:	7 ft	bo=	13 ft
so shear critical section:	6.04166667 ft	Acritical=	10.5625 sq.ft
One-way shear demand:	140 k		
Allowable one way sher chack =	$2 \times \gamma\sqrt{fc'}$	vu =	667138.8889 | 453514.3 | depth not ok
	109.544512		

Requaired d = $\frac{vu}{Q\,(2\,\sqrt{Fc'})b}$

142.00 in

☑ 4. PUNCHING SHEAR

Critical perimeter at d/2d/2d/2 from column face:

assume d = 15

bo= 108 in

Uu = 432.098765 psi

ACI punching capacity

Moment Calculation	M=ql2/8	l=	[redacted]
	76.2222222 ft-k/ft		
in inch-lb:	914666.7 in-lb		
design moment	1097.6 k-in		

Area of the steel

$$As = \frac{Mu}{Q\ fy\ (d - \frac{a}{2})}$$

1.96 in^2/ft

As min = 0.31 in^2/ft

Spacing $S = \frac{b\ as}{AS}$

Using bar no 6 0.44

2.70 in

6 @ 4" in c/c

Reinforcement Detailing

6 @ 4" in c/c

Fl =	L =	[redacted] ft
	B =	[redacted]
	T =	[redacted] in
	R-L =	# 6 @ 4" in c/c
	R-S =	# 6 @ 4" in c/c

Combined (Cf-01) Footing Calculation

Combined Footing Design Calculation (BNBC + ACI Based)

☑ Input:

P_C1	600	← Load on Column C1 (kip)
P_C2 =	300	← Load on Column C2 (kip)
s =	7.5	← Center to center spacing between columns (ft)
f'c =	4000	← Concrete compressive strength (psi)
fy =	60000	← Steel yield strength (psi)
q_allow =	3.5	← Allowable soil pressure (ksf)
b =	8	← Footing width (ft) (Assumed)

☑ 1. Total Load on Footing:

P_total = P_C1 + P_C2

900 kip

☑ 2. Required Area of Footing:

A_req = P_total / q_allow

257.1428571 ft²

☑ 3. Footing Length:

L = A_req / b

32.14 ft

☑ 4. Load Centroid Location:

x̄ = (P_C2 × s) / (P_C1 + P_C2)

2.50 ft ← From Column C1

☑ 5. Soil Pressure under Footing:

q = P_total / (L × b)

3.5 ksf

3500 psf

24.31 24.31 psi

☑ 6. Max Bending Moment between Columns (Simplified):

M_max = (q × s²) / 8

24.609375 kip-ft

295.3125 kip-in

☑ 7. Effective Depth (d):

d = √[(M × 12 × 1000) / (ϕ × b_in × 0.9 × fy)]

0.7

0.8 ft RE

9.9 in

→ Use d = 9.9

→ Total depth D = 10 in

✔ 8. Required Steel Area (As):

As = M / (ϕ × d × fy)

6.614378278 in²

Use # bar 4 0.196

Number of bars = 33.687 nos

Spacing = 11.8

→ Provide #4 @ 6" c/c

Bar No	cross-section area in2	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	1.0	29
10	1.27	32
11	1.56	36
14	2.25	43
18	4.00	57

✔ 9. Transverse Reinforcement (Temperature Steel):

As_temp = 1.7 in²

Use # bar 3 0.11

Bars = 15.5 bars

Spacing = 24.8

→ Provide #3 @ 12" c/c (minimum spacing followed)

✔ 10. One-Way Shear Check:

Vu = q × b × d_ft

23.15032397 kip

ϕVc = ϕ × 2 × √f'c × b_in × d_in

90359.28287 kips

90.35928287 23.15 SAFE

✔ Final Reinforcement Summary:

Item	Value	
Main Steel	→ Provide #4 @ 6" c/c	
Transverse Steel	→ Provide #3 @ 12" c/c (minimum spacing followed)	X =
Footing Size		2.50
L =	32.14285714	CI
B =	[redacted]	
Depth (Effective / Total)	[redacted]	
Soil Pressure	[redacted]	
Max Moment	295.3125	
Shear Capacity	SAFE	

List of Deliverables

No.	Deliverable	Timeline	Format	Date of Submission
Level-4 / Term-1				
1	Project Proposal	Week 1–3	Write-up	Not applicable
2	Detailed planning, methodology, data/survey requirements, stakeholder identification, identification of external expert requirements,	Week 4–5	Write-up, Presentation	18/06/2025
3	Data/Survey Summary	Week 6–9	Write-up	20/06/2025
4	Preliminary Analysis and Design	Week 10–12	Write-up	28/06/2025
5	Analysis of Alternatives and preliminary cost estimation	Week 13	Write-up, Presentation	12/07/2025
Level-4 / Term-2				
6	Analysis scheme for detailed design	Week 1–2	Write-up	02/8/2025
7	Analysis output	Week 3–4	Write-up	05/8/2025
8	Detailed Design Report	Week 5–9	Write-up, Drawings, Presentation	15/8/2025
9	Final BOQ and Cost Estimation	Week 10–11	Write-up, Presentation	20/8/2025

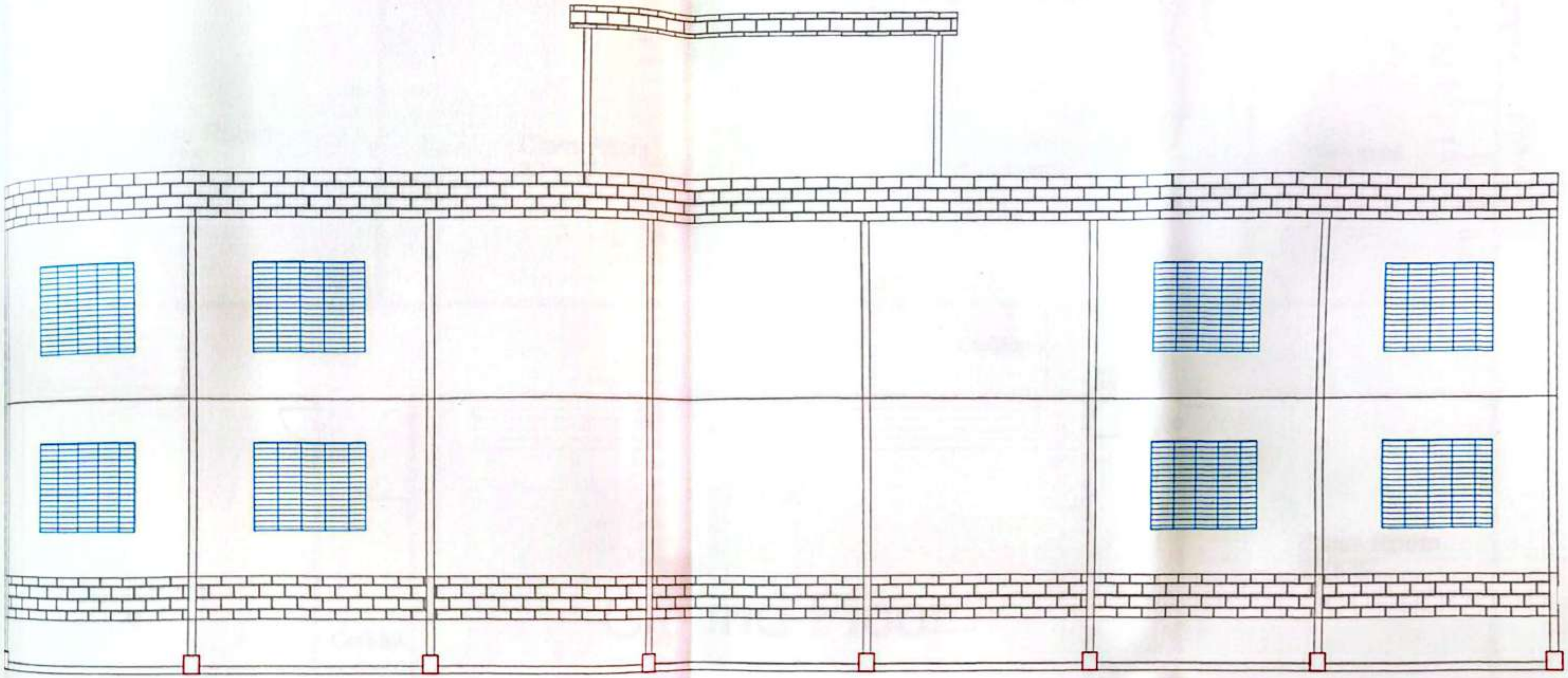
10	Final Report (Including Ethical Aspects, Lifelong Learning)	Week 14	Write-up, Drawings	08/9/2025
11	Final Presentation	Week 15	Presentation	Presented to the supervisor twice a week; Final presentation to the examiner board on 15/11/2025

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

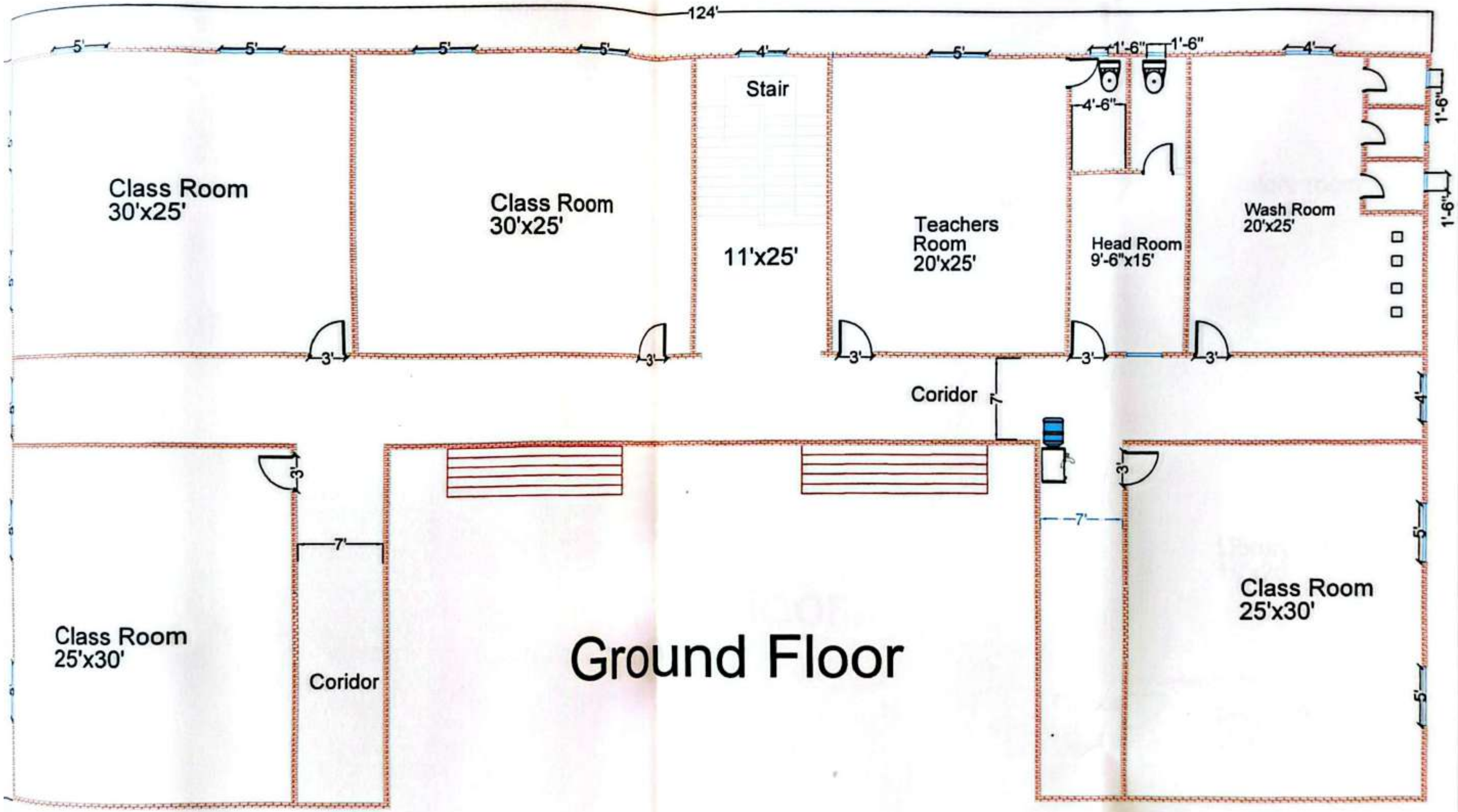
COs	Description	Criteria	Justification
CO1 (K6, P1, A1)	Application of modern engineering tools	Applied tools for design, drawings, etc.	Used AutoCAD for drawing and ETABS for structural analysis, ensuring precision.
CO2 (K7)	Work on a Team	Attendance	Collaborated effectively through regular meetings and task integration. **Name: K. M. Saifur Rahman** ID: 213-47-463 **Name: Avijit Baidya** ID: 213-47-470 **Name: Md. Rafikul Islam Razib** ID:213-47-471
CO3 (K7, P2, A2)	Alternative analysis presented	Economic and safety considered	Conducted alternative analysis, balancing cost, sustainability, and ethics.
CO4 (K7)	Societal	Ethical obligation considered	Incorporated eco-friendly materials
CO5 (K7)	Professional and ethical responsibility	Punctuality based on presentations in the	Maintained punctuality, adhered to deadlines, and upheld professionalism.

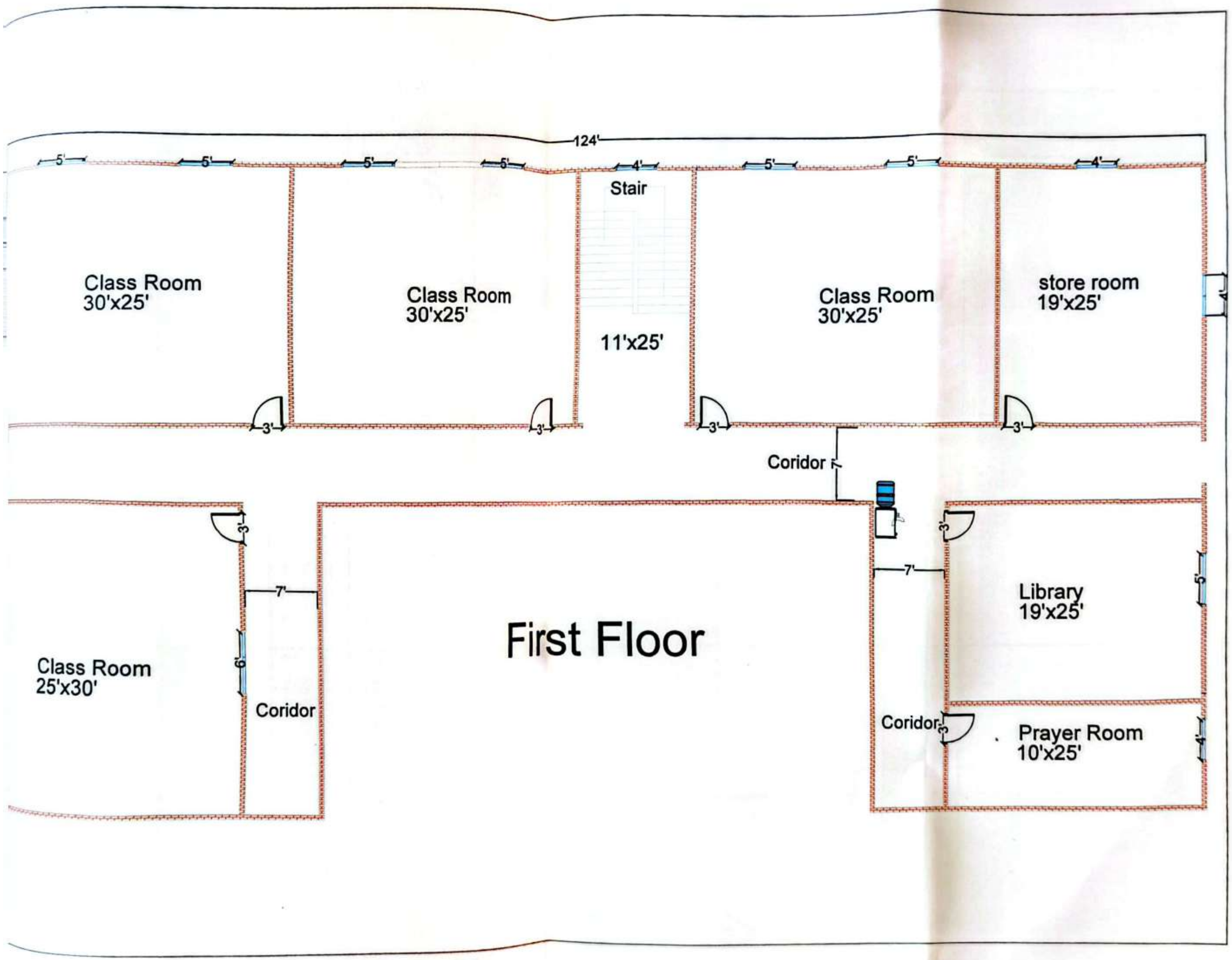
		specified weeks	
CO6 (P5, A3)	Lifelong learning	Demonstrate the ability to learn new skills (based on the statement in accordance with the lifelong learning in Final report)	Demonstrated the ability to learn new skills, **i.e.,** advanced skills in ETABS & AutoCAD
CO7 (A1)	Effective project management – 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
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	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.

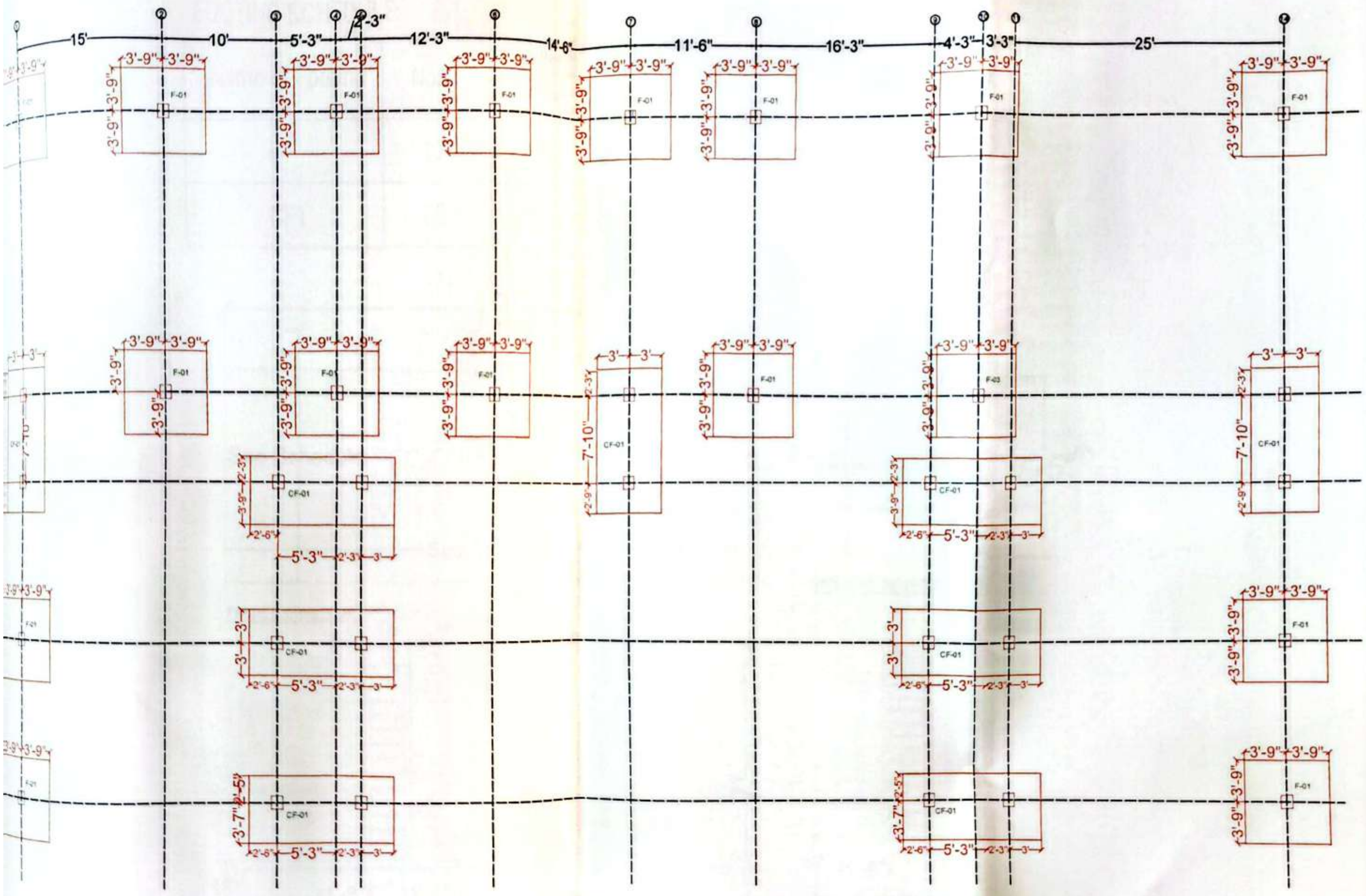


FRONT ELEVETION


124'
5'
5'
5'
5'
4'
5'
1'-6"
1'-6"
4'
Stair
11'x25'
4'-6"
1'-6"
1'-6"
Class Room
30'x25'
Class Room
30'x25'
Teachers
Room
20'x25'
Head Room
9'-6"x15'
Wash Room
20'x25'
3'
3'
3'
3'
3'
Coridor
7'
4'
3'
3'
7'
7'
5'
5'
Class Room
25'x30'
Coridor
Ground Floor
Class Room
25'x30'



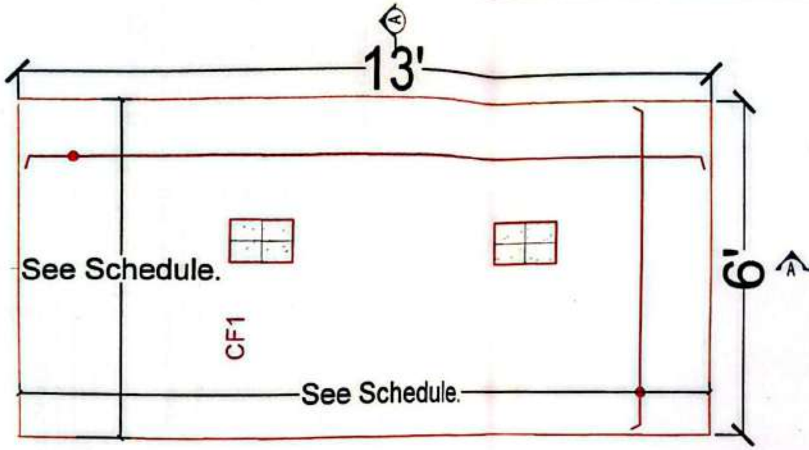
124'
5'
5'
5'
5'
4'
5'
5'
4'
Stair
Class Room
30'x25'
Class Room
30'x25'
11'x25'
Class Room
30'x25'
store room
19'x25'
4'
3'
3'
3'
3'
Coridor
7'
3'
3'
7'
7'
Library
19'x25'
5'
Class Room
25'x30'
6'
Coridor
First Floor
Coridor
3'
Prayer Room
10'x25'
4'



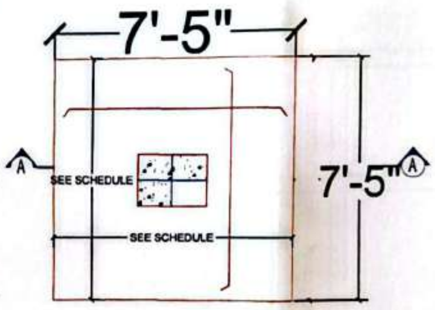
FOOTING LAYOUT

FOOTING SCHEDULE:

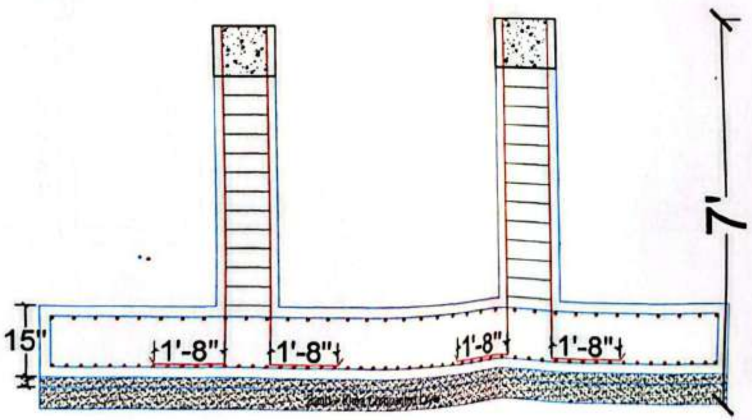
Name of Footing	Nos	Footing Size		Thickness	Steel
		L	S	T1	
F1	17	7'-5"	7'-5"	18"	20 mm Ø 5" c/c (b/w)
CF1	09	13'-0"	6'-0"	18"	20 mm Ø 5" c/c (b/w)



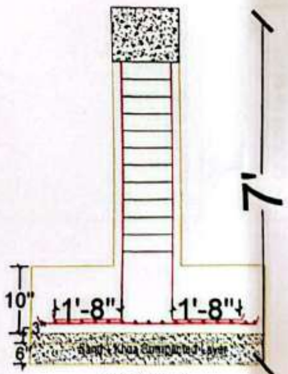
TYPICAL FOOTING DETAIL



TYPICAL FOOTING DETAIL



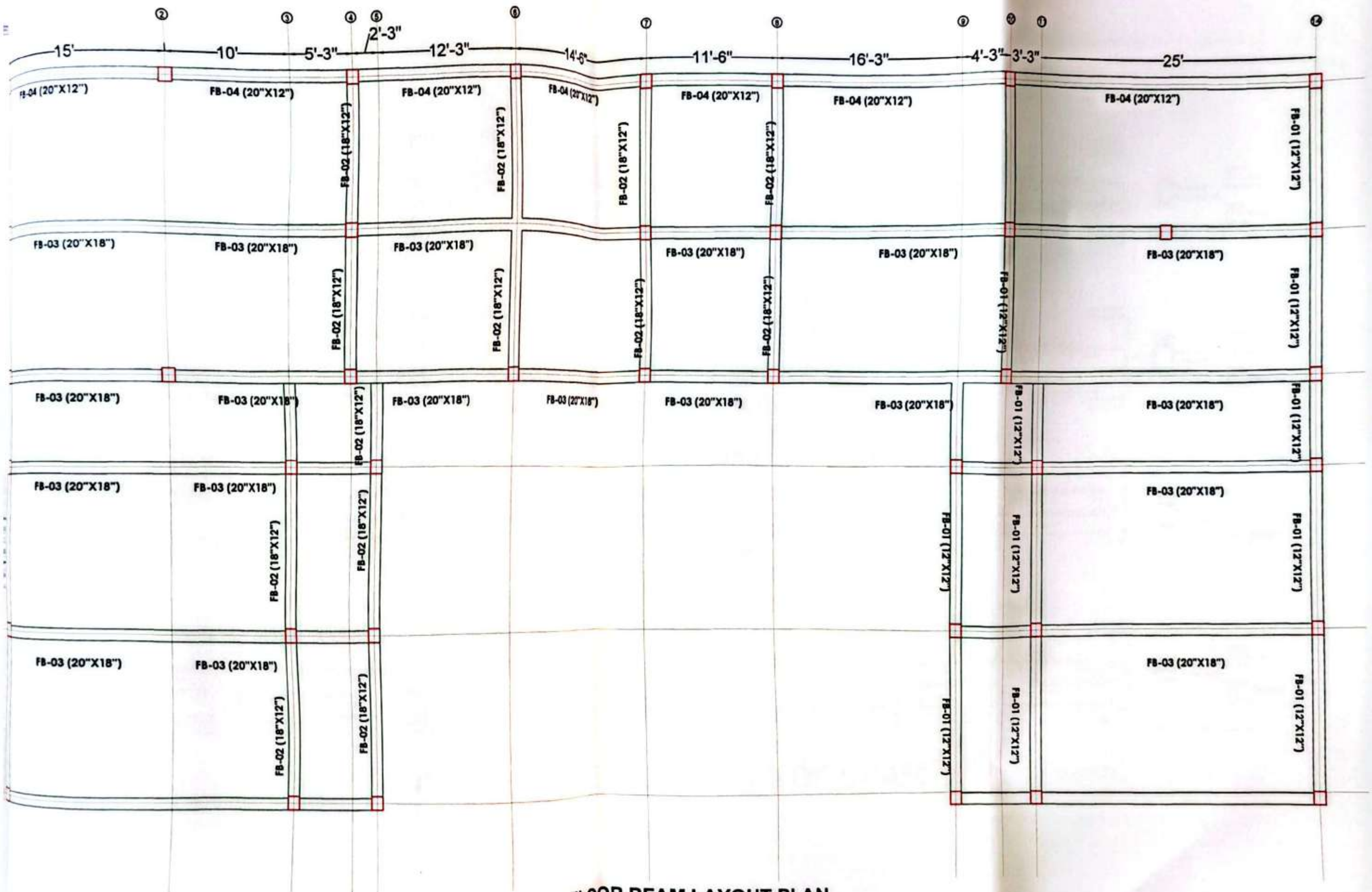
SECTION A-A



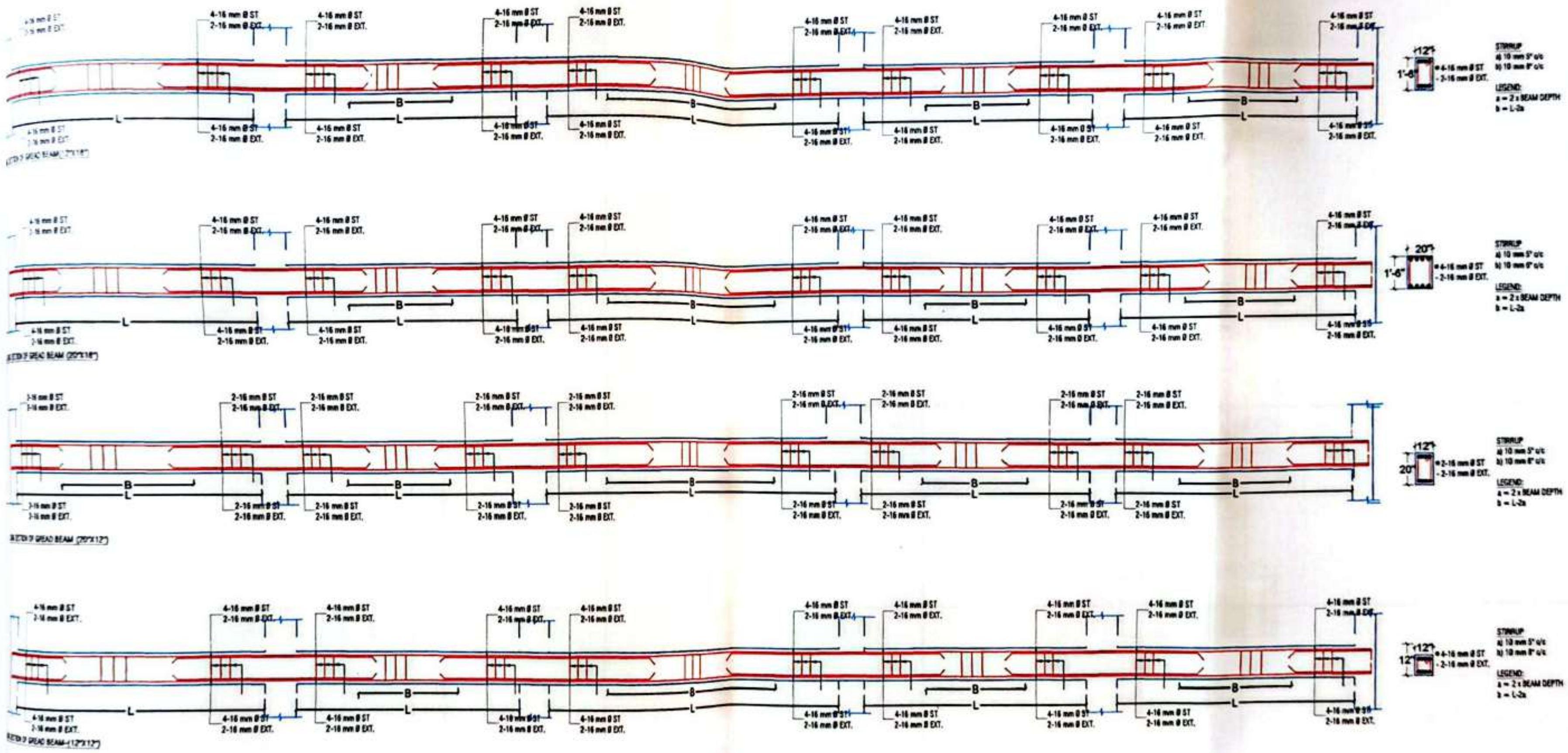
SECTION A-A

FOOTING SCHEDULE

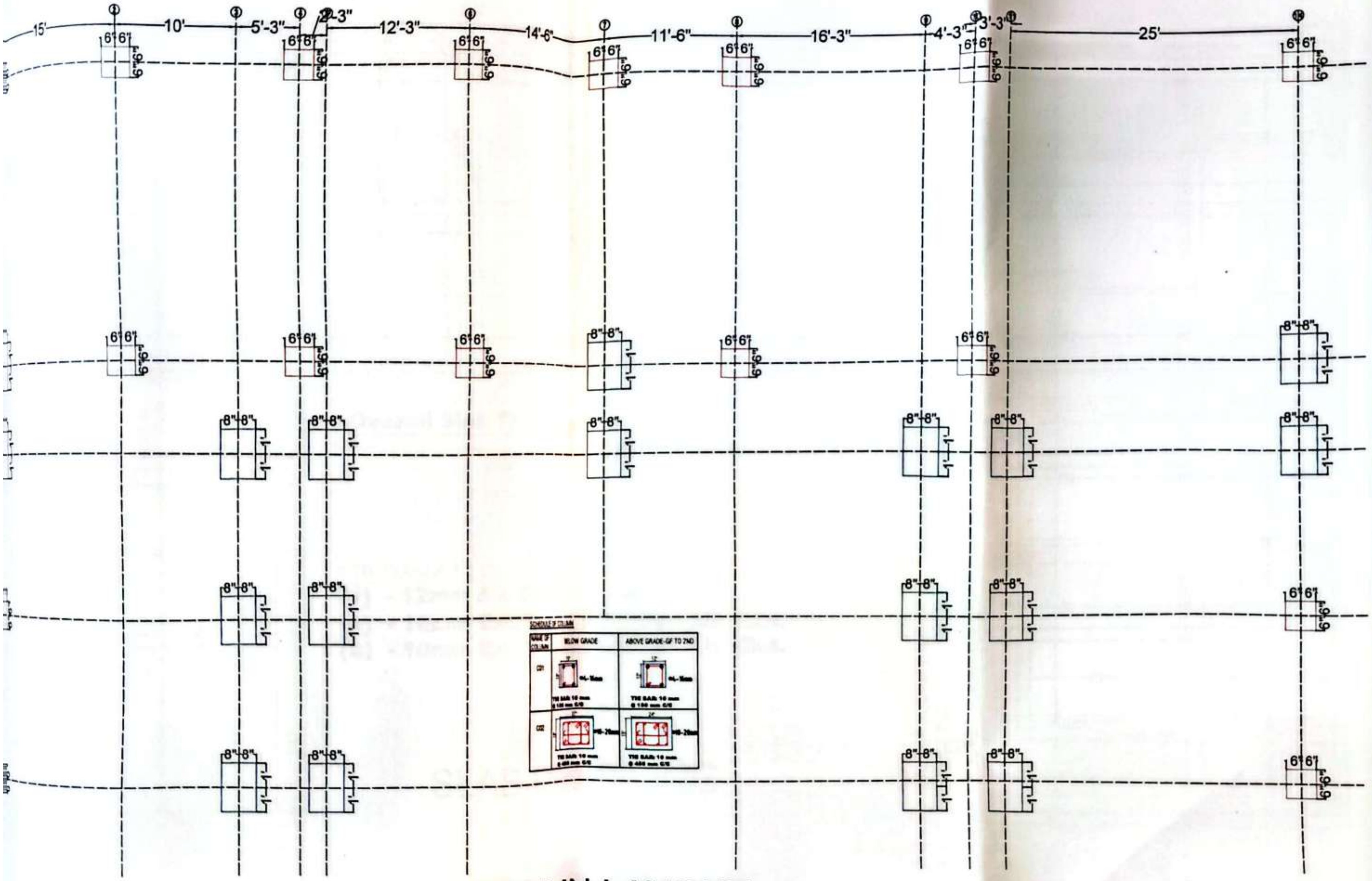
CamScanner



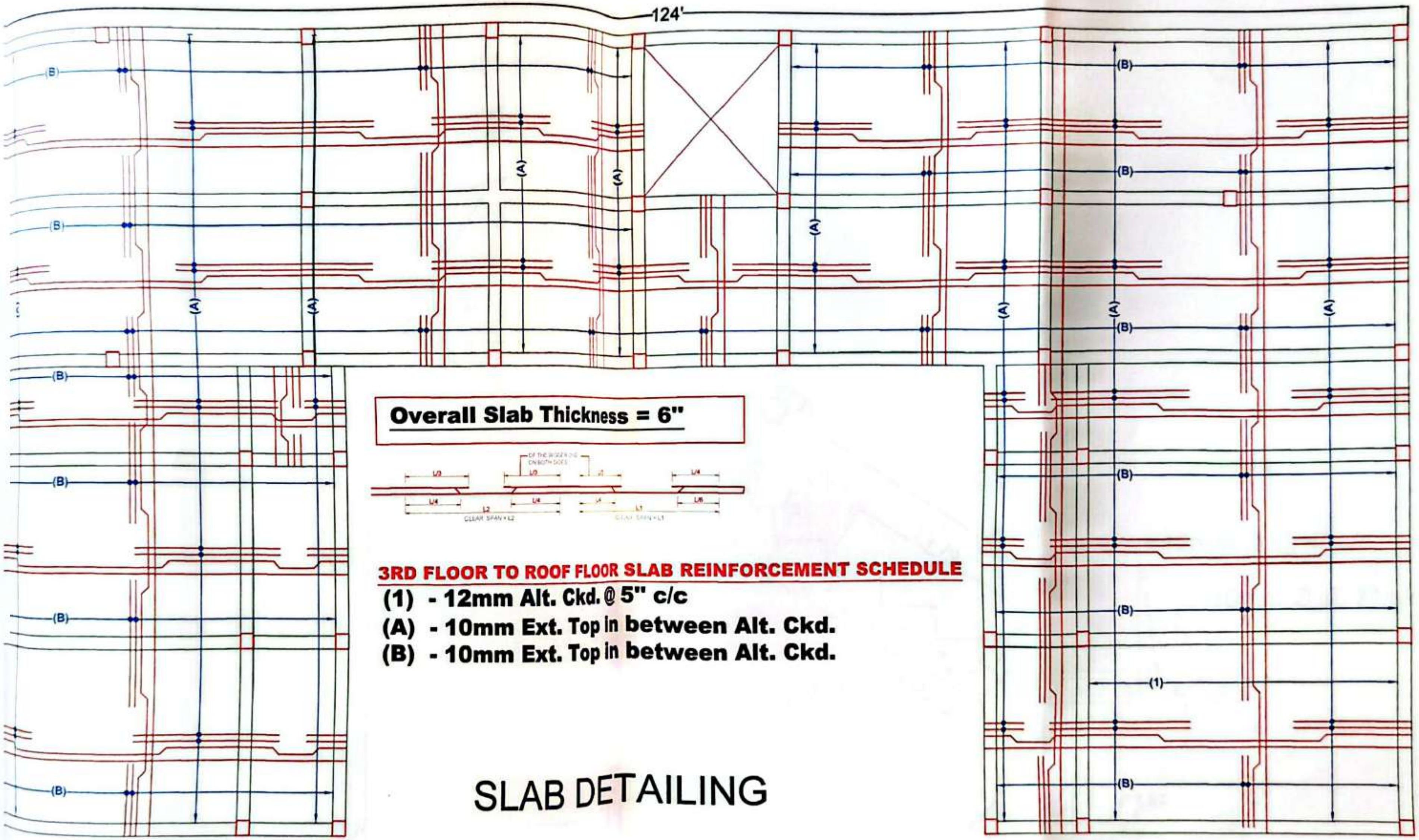
FLOOR BEAM LAYOUT PLAN.



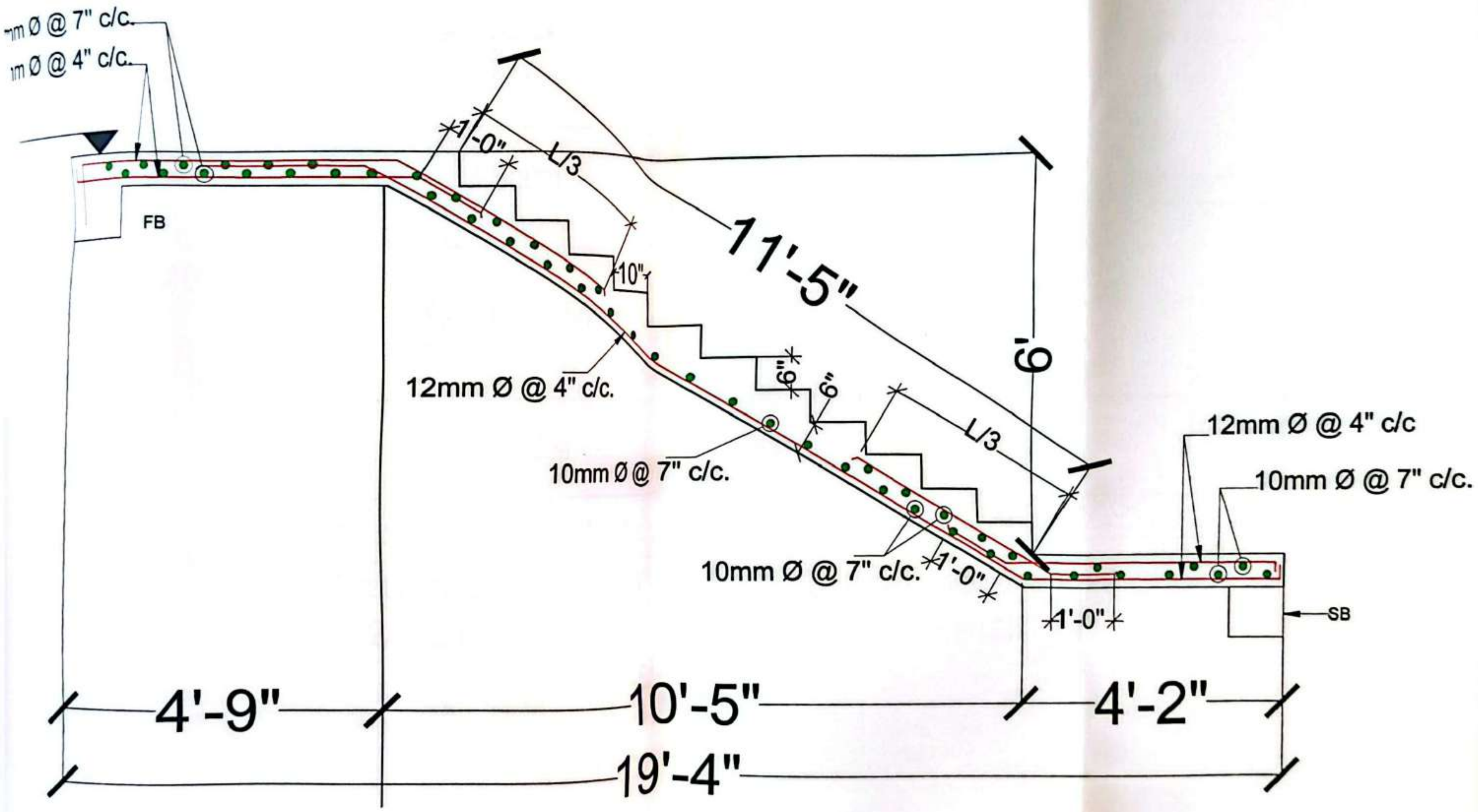
REINFORCEMENT DETAILS OF BEAM



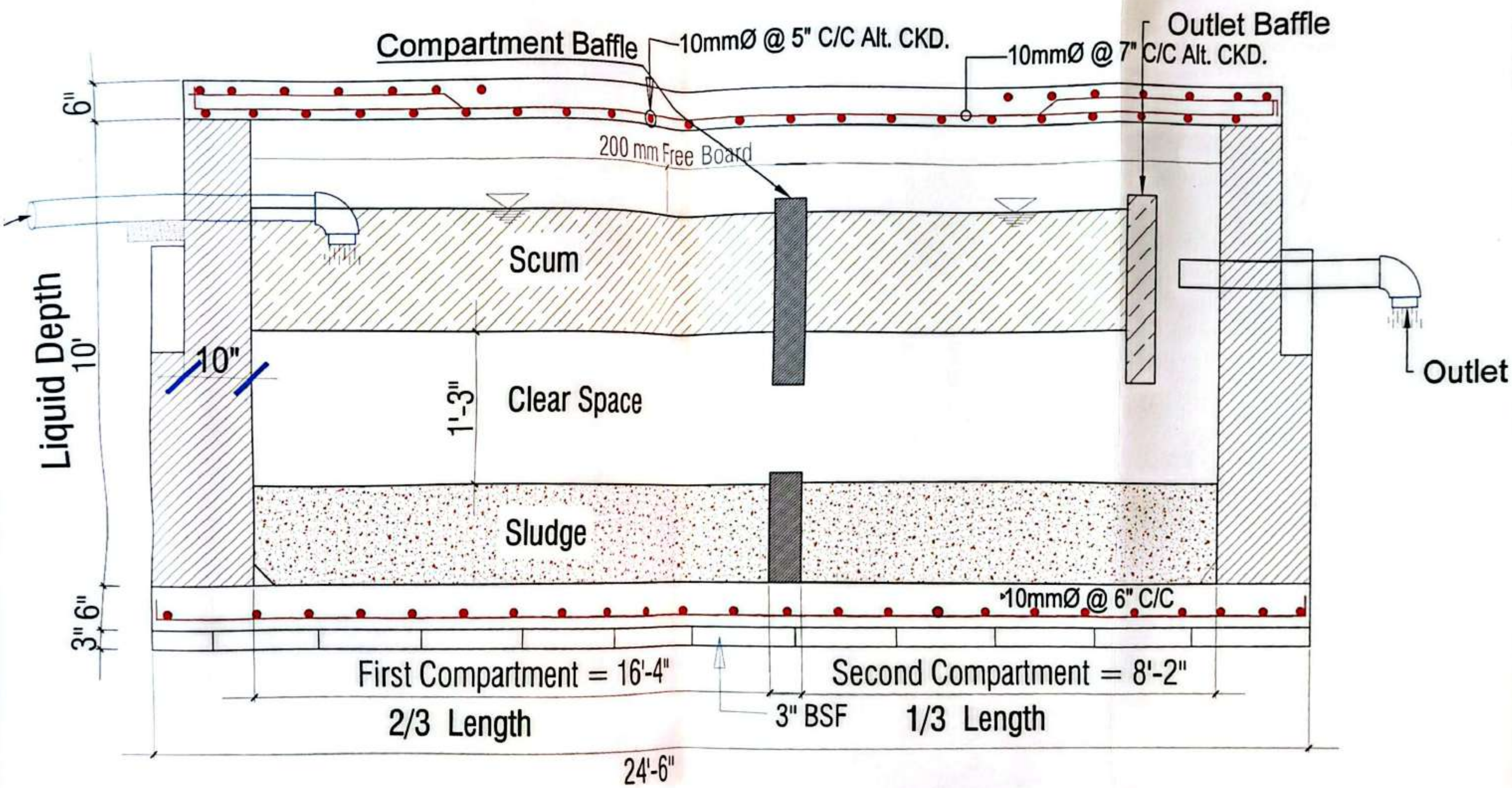
COLUMN LAYOUT



SLAB DETAILING



DETAILING OF STAIRCASE



DETAILING OF SEPTIC TANK