DESIGN OF A TWO-STORED PRIMARY SCHOOL BUILDING (ZONE-2)

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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This is to certify that the student below has completed the Capstone Project titled "**DESIGN OF A TWO-STORED PRIMARY SCHOOL BUILDING**" under my supervision. This project was done as part of the requirements for the Bachelor of Science in Civil Engineering degree.

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ACKNOWLEDGEMENTS

To begin with, I would like to say that I am very grateful to Almighty Allah, whose unconditional mercy, instructions and beneficence assisted me to complete my Capstone Project entitled **Design of a Two- Stored Primary School Building** as well as this report that followed successfully. Without the assistance of His Godhead, this would not have been possible.

I am very thankful to my beloved family and whose support, unconditional affection and provocation gave me the courage and the impetus to finish this design. It helped me a lot and contributed to my success since they were tolerant and understanding in stressful and difficult situations.

This is my personal gratitude to the Department of Civil Engineering to have provided me with the opportunity to carry out this Capstone Project. The design has enabled me to utilize the theoretical information that I have learned during my educational periods into the real world where I have gotten invaluable experience in the field and a clearer look at the real world engineering issues.

I owe a great debt to my so-called administrator **Mr. Kazi Obaidur Rahman** who has always guided, supported and stimulated me during the whole design process. His competency, constructive criticism, and amicable guidance have been really motivating. He never failed to respond to my questions and assist me to break problems and be guided in the right direction. He trusted me and believed in my abilities and this encouraged me to do my stylish.

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To conclude, I want to thank people who helped me along my way or not directly in this trip. It is a valuable literacy experience I will take with me in my future as a civil mastermind.

DECLARATION

The project titled "Design of a Two-Storey Primary School Building with Structural and Environmental Considerations" was done under the supervision of Mr. Kazi Obaidur Rahman, Assistant Professor, Civil Engineering Department, Daffodil International University, Dhaka. It was approved as a part of the Capstone Project, which is required for the Bachelor of Science in Civil Engineering degree.

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ABSTRACT

A two- stored primary academy structure in seismic Zone- 2 of Bangladesh is the subject of the presented culmination design that includes the structural design, cost estimation, and construction planning. The design is grounded on the Bangladesh National Building Code and has Intermediate Moment defying Frame system with insulated footings which are safe, durable and provident. The design and analysis were done in the ETABS and the detailed work was done in AutoCAD with consideration of crossbeams, shafts, columns, foundations, staircases, overhead water tank, and a septic tank. Environmental vittles are also included in the study by coming up with a wastewater treatment system on- point. A detailed Bill of Amounts (BOQ) and Gantt map had been developed to steer the perpetration of the design, streamline the resource distribution, and keep the construction schedules. The result is an illustration of the practical application of theoretical engineering knowledge, which provides a safe, effective, and sustainable literacy institution that fulfills the structural and functional norms.

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1.1 Proposed Structure

The Proposed Two-Story Primary School is to be built completely by RCC with Isolated foundations. The structure is approximately 122 ft 11in by 37ft 3in on the plan and 24 ft high, containing Six classrooms, One Head Teacher Room, One Office Room, and One Teachers Room. A layout Plan is given in Fig. 1.1, Fig. 1.2, and Fig. 1.3.

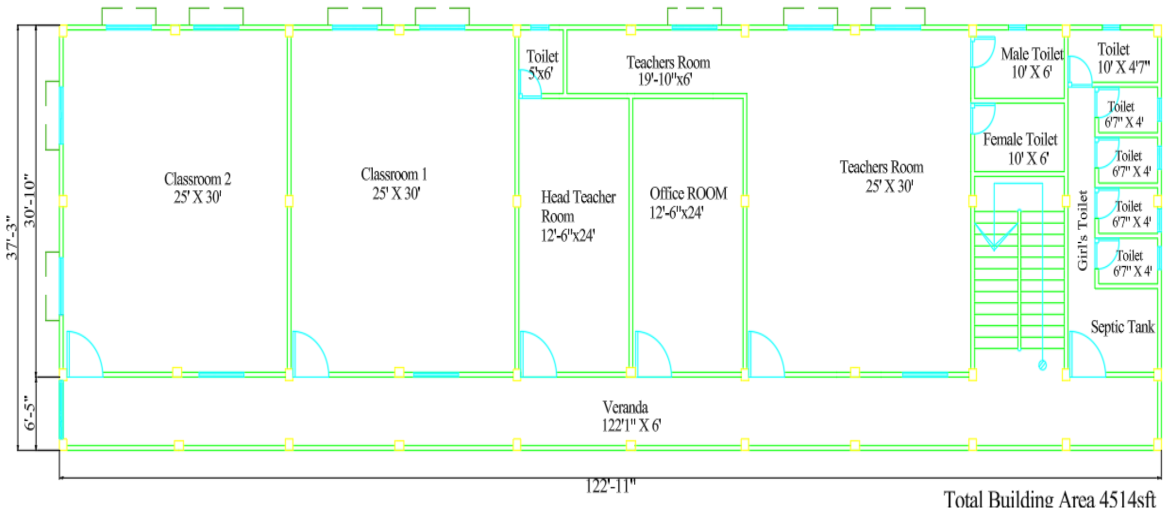

Fig. 1.1: First Floor Plan

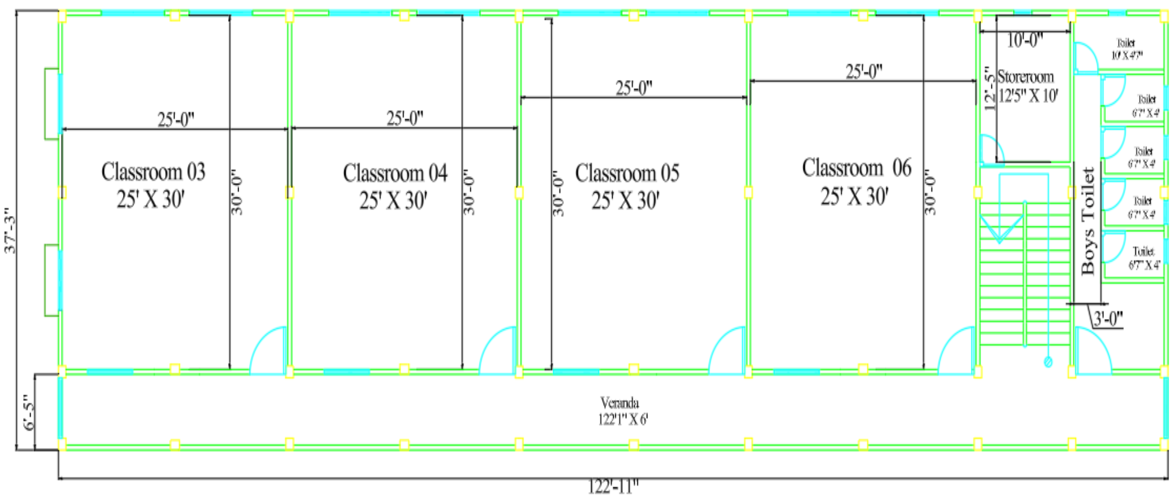

Fig. 1.2: Second Floor Plan

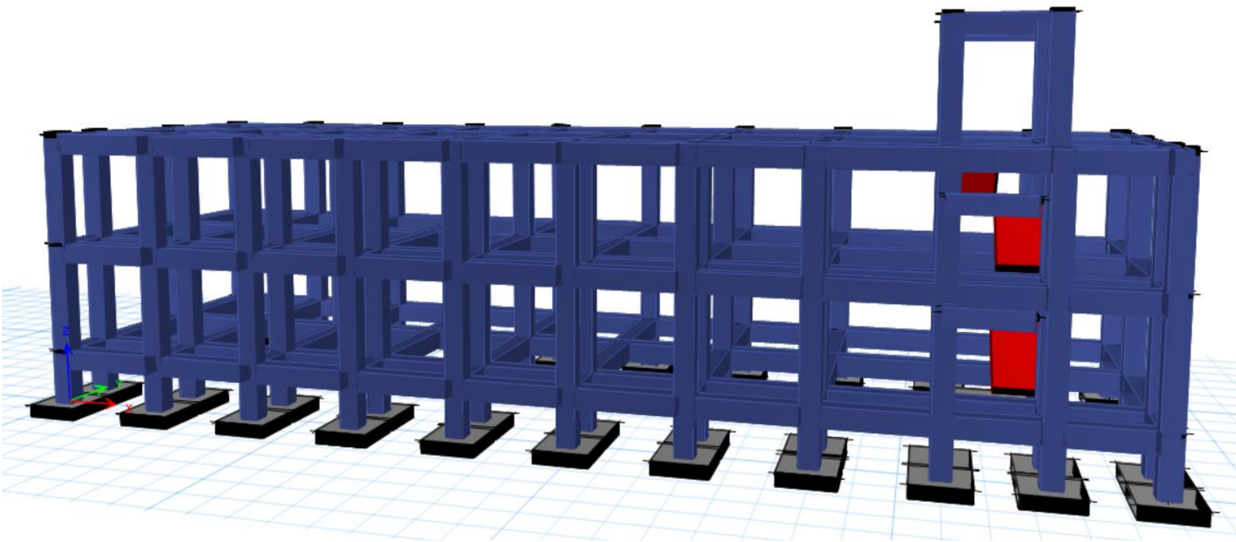

Fig 1.3: Full Layout Plan

1.2 Basic Information

In this Capstone Project, it is proposed to have a two-story corroborated concrete (RC) educational structure using Intermediate Moment defying Frame (IMRF) structural system as indicated in Table 1.1. The system is known as IMRF because it provides a good balance between the strength and the rigidity of the structure as well as the ability of the structure to provide repulsions of the graveness loads and moderate side loads like wind or seismic forces. The reason as to why this type of foundation is so referred is due to their cost effectiveness and alignment with the projected soil- bearing strength. Crossed beam concrete has been used to construct the lower part of the building; to facilitate the process, structural safety and functionality have been put into consideration to help ascertain that the structure can accommodate all the demands of the bottom loads that it will need to bear, safely and efficiently as well. Depending on the graveness cargo combinations and side force conditions, a suitable analysis and design is performed with regards to the relevant canons and norms of structure, which guarantees the safety, continuity, and usefulness of the structure.In such a manner, the structure is projected to give an educational installation a safe and useful literacy terrain.

Table 1.1: Basic Information of the Building

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

1.3 According to the Infrastructure Plan and Planning Guideline

1. Open Area Requirement No less than half of the total area of the academy must be open, which may be utilized as playground in an out of door conditioning, or as temporary.

2. Small Classrooms and Washrooms The academy ought to possess at least Five classrooms and a separate restroom block of manly and womanish scholars must be handed out.

3. Equal Classroom Uniformity of the classrooms All classrooms must be similar in size to ensure that they are uniform and to correspond with the established educational standards (Education, 2018).

4. New Apartments The house ought to have one preceptors room, one independent Head Teachers room and one store room where educational accoutrements and outfit should be stored.

5. Classroom Size Classroom size ought to be 25 ft x 30 ft which is appropriate as it can be easily occupied, ventilated and lit.

Chapter 2

Design Codes, Structural Design, and Requirements

To protect life, health, property, and public safety, every building in Bangladesh must follow basic rules for:

- ❖ Building layout and construction
- ❖ Quality of materials
- ❖ Use and occupancy
- ❖ Location and maintenance of the building

There are also rules for installing and using equipment and services connected to the building. The structural design of this school building follows the Bangladesh National Building Code (BNBC, 2020). The design and analysis were done using ETABS 2020, based on BNBC 2020 guidelines.

2.1 Design Code Rules

- ❖ The structural drawings should be verified against the corresponding architectural drawing.
- ❖ The analysis and design of the building are based on BNBC 2020.
- ❖ In case of nothing being mentioned in the drawings or this report, BNBC 2020 will be adhered to.

2.2 Foundation and Soil

- ❖ This building is suggested to have a footing foundation.
- ❖ The foundation is recommended to have a minimum of clear cover of 3 inches.
- ❖ The depth of foundation should be in line with the construction drawing.

2.3 Material Properties

- ❖ Concrete Strength (f'c): 4000 psi (28-day cylinder strength).

- ❖ Mix Ratio: 1:1:2 for both foundation and columns.
- ❖ Slabs and Beams: 4000 psi concrete with the same 1:1:2 mix ratio.

2.4 Lapping Zone for Beams

The placement of lap splices in beams depends on whether the bar is in tension or compression:

1. Top Bars (Negative Moment / Tension at Supports)

    - ❖ Lap near mid-span (where bending moment is low).
    - ❖ Avoid lapping in the maximum bending moment region near the supports.

2. Bottom Bars (Positive Moment / Tension at Mid-span)

    - ❖ Lap near supports, where bending moment is low.
    - ❖ Avoid lapping at the center span where tension is maximum.

Lap Length (as per Codes)

1. Lap Length in Tension = Ld (Development Length)
2. Lap Length in Compression = Ld or 24 × bar diameter (whichever is more)
3. BNBC 2020 / ACI / IS 456 guidelines:

    - ❖ Tension lap length = 50 × dia of bar (minimum).
    - ❖ Compression lap length = 24 × dia of bar (minimum).
    - ❖ Lapping should not be done for bars > 36 mm diameter (use welding or mechanical couplers instead).

2.5 Corner Reinforcement

BNBC (2020) suggest that to make corners stronger to resist pressure, in seismic areas corner underpinning is required. BNBC recommends to deal with shear and torsional forces.

- ❖ Adding redundant slant bars

- ❖ Installing almost spaced stirrups and ties in shafts, crossbeams and ray- column joints.

❖ Providing decent harbourage and short stage to corner bars (Fig. 2.1)

This supporting framework enhances rigidity, energy immersion, and the general structural strength that allow the structure to push back the side loads and minimize the possibility of cracking or unexpected collapse.

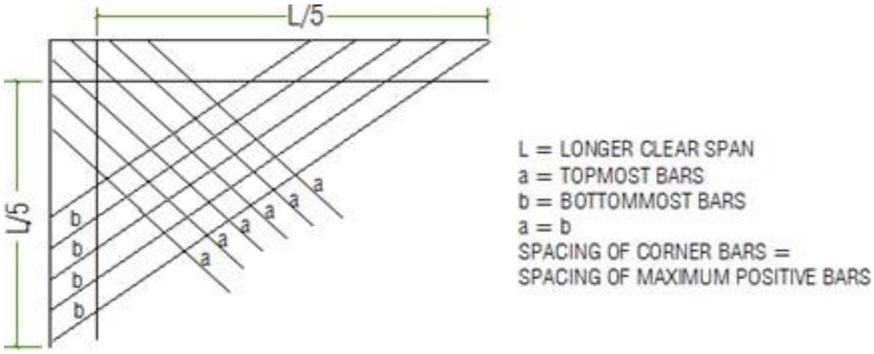

Fig. 2.1: Corner reinforcement

2.6 Material Strength

Table 2.1: Material Strength

Structural Element	Concrete Strength, f'c (psi)	Reinforcement Yield Strength, fy (psi)
Foundation	Minimum 2500 psi	60000 psi
Pedestal Column	Minimum 3000 psi	60000 psi
Grade Beams	Minimum 3000 psi	60000 psi
Columns	Minimum 4000 psi	60000 psi
Beams and Slabs	Minimum 4000 psi	60000 psi

Explanation:

❖ BNBC 2020 usually suggests minimum concrete compressive strengths as related to the structural element and its significance:

  - The foundations may be of lesser concrete strength (approximately 2500 psi or 17 MPa).

  - Columns, beams, and slabs normally demand more powerful concrete (approximately 4000 psi or 28 MPa).

- ❖ Reinforcement steel (fy) has a yield strength that is usually considered 415 Mpa (60,000 psi) per BNB.

2.7 Development Lengths

The Bangladesh National Building Code (BNBC, 2020) defines the development length as the shortest embedded length of the reinforcement bars necessary to grow their maximum yield strength inside the concrete so that the bars do not slip and so that the structure could be stable.

The development length is calculated by the formula:

$$L_d = \phi \times f_y / 4 \times \tau_b$$

Where:

- Ld = Development length (inches or mm)
- ϕ = Diameter of the reinforcing bar
- fy = Yield strength of the reinforcement steel (psi or MPa)
- τb = Strength of bond between concrete and steel (psi or MPa), and this is determined by the conditions of the bars and the concrete.

The beam tends to develop a longer length than slabs since they are exposed to more stresses and loadings.

The adjustment factors are made with regard to:

- ❖ Rebar type (e.g. plain or deformed bars)
- ❖ Location of reinforcement (bar on top or bottom)
- ❖ Conditions of concrete quality and cover.

2.8 Concrete Clear Cover for Reinforcement (BNBC 2020)

BNBC 2020 specifies minimal clear cover to cover underpinning from erosion, fire, and environmental damage, icing continuity and structural safety. The needed clear cover depends on the member type and exposure conditions:

Table 2.2: Concrete Clear Cover

Member	Exposure Condition	Minimum Clear Cover (inches)
Columns	Exposed to earth or water	3.0 (75 mm)
	Not exposed to earth or water	1.5 (38 mm)
Beams	Exterior exposure	2.0 (50 mm)
	Interior exposure	1.5 (38 mm)
Slabs	Exposure to weather or aggressive environments	1.5 (38 mm)
	Interior exposure	0.75 (19 mm)
Stairs	Generally same as slabs	0.75 – 1.5 (19 – 38 mm)

2.9 Summary

This structure design has been designed in strict agreement with the Bangladesh National Building Code (BNBC) 2020 to insure structural safety, continuity, and nonsupervisory compliance. Comprehensive structural analysis and design were performed using ETABS 2020, following all applicable BNBC vittles for accoutrements, construction, and structure services.

Chapter 3

Structural Analysis and Output

3.1 Introduction

The design included structural design of the G 1 structure where all major factors are included in the design through the use of ETABS similar as shafts, columns, crossbeams, footings, and staircases. Beam design involved the entry of correct span lengths and lading conditions that enabled ETABS to develop the needed underpinning in both shear and bending moment. It was also designed similar that it could be reported as serviceable by examining it in respects to implicit deviation and crack conformation. Columns were treated as frame rudiments that were perpendicular and the design was taken to be in terms of the axial loads and moments in commerce formulae of corresponding structural canons.

I calculated the structural loads and the soil parcels applied before the design of the footing to make the foundation system stable. The bearing capacity of ETABS was checked and assured that the soils had proper underpinning by applicable verification of structural integrity. Crossbeams were formulated on the choice of the applicable consistence, loads and performance in terms of moment and deviation performances that were taken to insure that the demands on the crossbeams in terms of strength and utility are fulfilled.

Staircases were planned as a structure of combined crossbeams and shafts where the design conditions fulfilled the whole law- grounded dimensional and lading conditions. ETABS design strategy was holistic design in which all the rudiments of the structure were taken into account in the analysis and design and which was more inclined towards the overall performance and safety of the building. Since the analysis and design of ETABS is made, the detailed construction delineations were made in AutoCAD after the development of the structure. All the rudiments of the structure shafts, columns, crossbeams, footings, and staircases were incorporated in these delineations in their factual sizes, underpinning details and specifications of accoutrements. The detailing process also helped me to increase my understanding of how different structural factors similar as integration of ray with columns and support of crossbeams work together. It was bettered by labelling it with standard symbols to simplify reading. The outgrowth of the ETABS and the real AutoCAD detailing made it possible to insure that the design of the structural design could be successfully imaged and applied in the process of the structure construction.

3.2 Load Consideration

As stated in BNBC (2020), the structural analysis of a primary academy structure according to ETABS implies defining and enforcing colorful types of loads similar as dead cargo, live cargo, bottom finish cargo, and earthquake cargo.

Dead cargo This is the weight of structural rudiments (crossbeams, shafts, columns, walls, and other endless installations) that remains indeed when there's no weight applied on them. Live cargo is a variable lading that's caused by inhabitant and cabinetwork. BNBC 2020 recommends 3.0 ʿ N/ m ^{2} in classrooms and 4.8 ʿ N/ m 2 in locales having lesser bottom business, including corridors, stairways, and lobbies.

The cargo of the bottom finish, which includes accoutrements similar as penstocks, screeds, or carpets is typically assumed as 1.0 to 1.5 1/ m 2. Earthquake loads are determined in terms of the seismic zone, soil type and structural characteristics and conducted in X and Y directions indirectly.

The combination of similar loads is latterly done in ETABS grounded on the cargo combinations, which are specified by the BNBC cargo combinations at both ultimate and serviceable limit countries to guarantee that the structure is safe, stable, and law biddable under a given set of lading conditions.

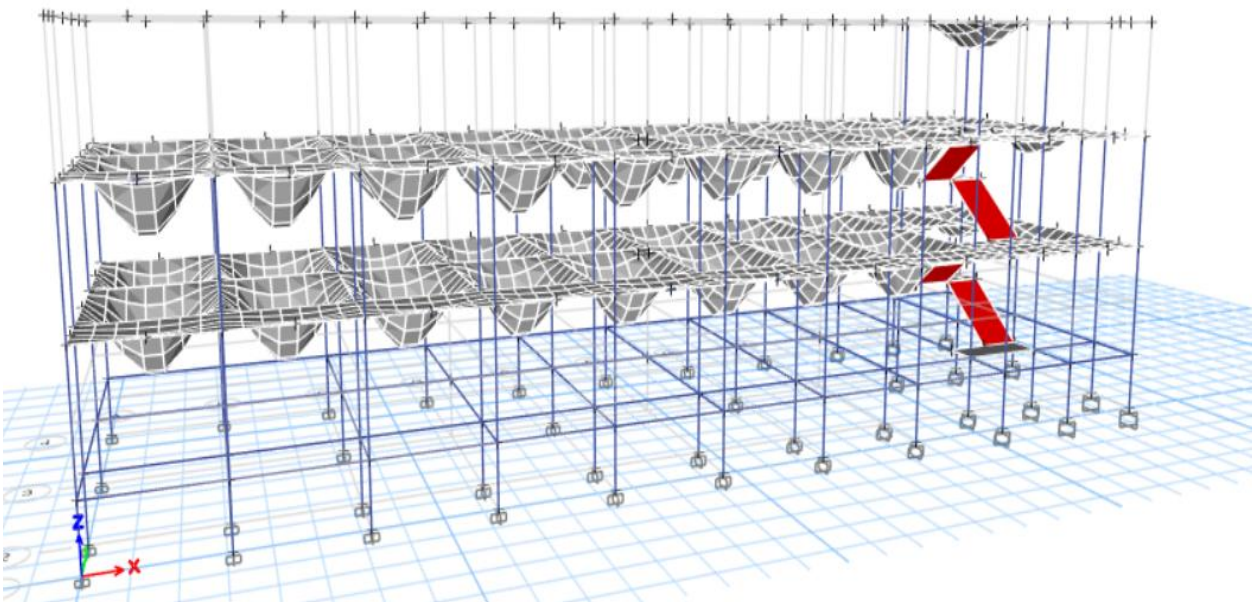

Fig 3.1: Load Combinations

3.3 Design of Slab and Detailing

In the design of the crossbeams in ETABS, a thorough analysis of colorful decisive factors is demanded to insure that the arbor is sufficiently strong and meets the conditions of the structure canons and norms. The programs consider the figure of the arbor and its consistence, the accoutrements parcels of concrete strength and underpinning, and the type of loads applied to it, including dead loads, live loads, and environmental loads similar as wind forces, seismic forces, etc. Boundary conditions that determine the support of the arbor sides which could be simply supported, fixed, and nonstop are modeled with due care to insure that the arbor behaves just like it's in the real- world. ETABS makes use of the state- of- the- art finite element analysis to determine the distribution of stresses and diversions on the arbor. It enables the identification of the critical regions that need underpinning and enables the identification of the stylish underpinning layout to fight the bending moments, shear forces and other stresses. The software also includes cargo combination norms as quested by design canons that take into account different concurrent combinations of loads to make sure that the arbor construction is safe with all the conditions of the anticipated circumstances.

ETABS contains country specific design canons that allow masterminds to customize the analysis and design process to suit the original regulations, similar as minimal underpinning rates, minimal concrete cover conditions and crack control vittles. utility conditions e.g. maximum permissible deviation and cracks range are rigorously vindicated to insure that the arbor will serve satisfactorily during its service life without being seriously misshaped or damaged.

After finishing the arbor design in ETABS, line and common underpinning delineations are created and arbor layout plans are exported into AutoCAD. They act as a vital point of connection between the design and construction stages, as they make sure that the arbor is erected exactly as the design plan. This scrupulous record keeping will affect in the avoidance of crimes in construction, proper communication between the masterminds, contractors and indeed workers, and eventually leads to structural trustability and sustainability of the construction.

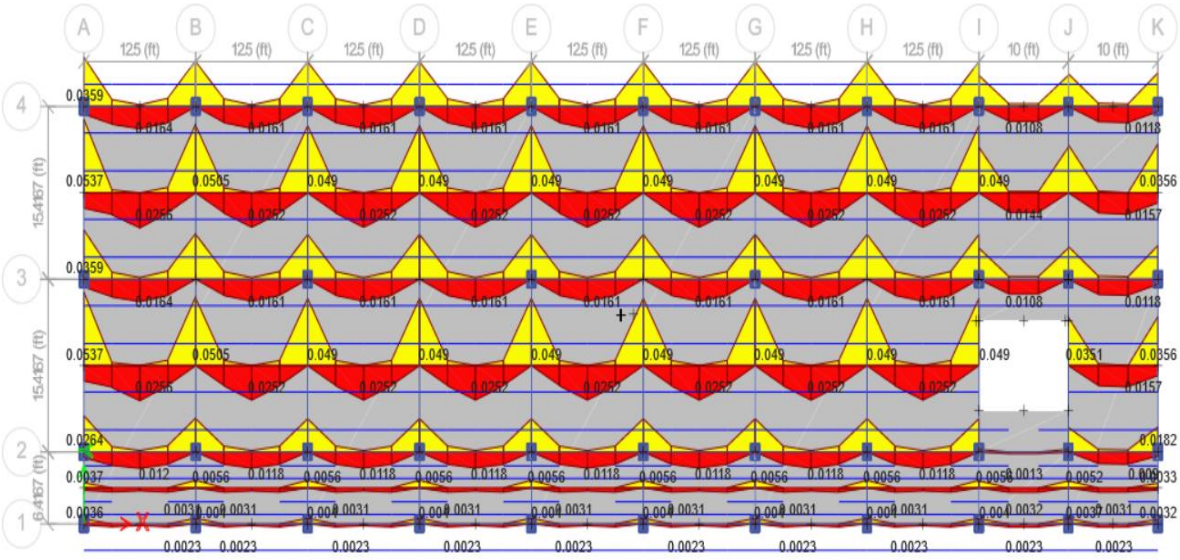

Fig. 3.2: Top and Bottom reinforcement of slab (Layer-A)

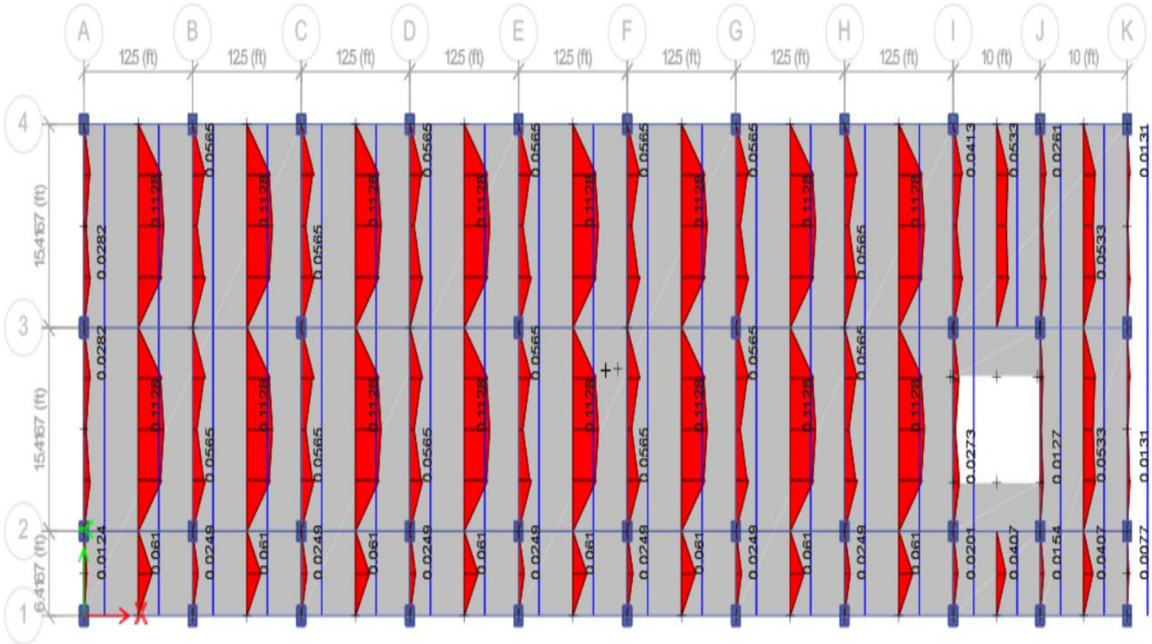

Fig. 3.3: Top and Bottom reinforcement of slab (Layer-B)

Table 3.1: Slab Detail

Slab Reinforcement				
Slab No	**Dimension**	**Bottom Rebar**	**Top Rebar**	**Middle Rebar**
S1	25’x37’3”	#3@5”c/c	#3@6”c/c	#3@4”c/c
S2	25’x37’3”	#3@5”c/c	#3@6”c/c	#3@4”c/c
S3	25’x37’3”	#3@5”c/c	#3@6”c/c	#3@4”c/c
S4	25’x37’3”	#3@5”c/c	#3@6”c/c	#3@4”c/c
S5	20’x15’	#3@5”c/c	#3@6”c/c	#3@4”c/c
S6	10’x15’	#3@5”c/c	#3@6”c/c	#3@4”c/c
S7	10’x6’5”	#3@5”c/c	#3@6”c/c	#3@4”c/c

3.4 Design of Beam and Detailing

The shaft design of G 1 structure was done under the ETABS by initially establishing the confines of the shaft and then evaluating the right loading conditions, of dead and live loads according to the applicable design morals. After the structural model had been created, a study of the shafts was done in ETABS with the consideration of the shear and bending moments of the shafts with the following loads as in Figure 3. It was automatically estimated using the software that the underpinning that is required on both positive and negative moment that would provide the design to meet the structural safety requirements. The bolstering layout was also checked to make sure that it satisfied the minimum requirements as provided by the design canons. also, divagation checks were performed to make sure that the mileage limits were not exceeded under the influence of applied loads.

This test determined that the shafts were adequate in their structure to withstand the expected weight situations, and were adequate in the strength and mileage situations. With ETabS, the design process was simplified since the right analysis and the automatic detail underpinning were incorporated.

3.5 Lap Location

- ❖ Lapping of bottom reinforcement bars in beams should be avoided in the middle third portion of the span to prevent maximum stress concentration in the tension zone.
- ❖ Lapping of top reinforcement bars may be allowed in the middle third zone, where compressive stress is dominant.
- ❖ No more than 50% of the total bars should be lapped or spliced at the same location to maintain continuity and structural integrity

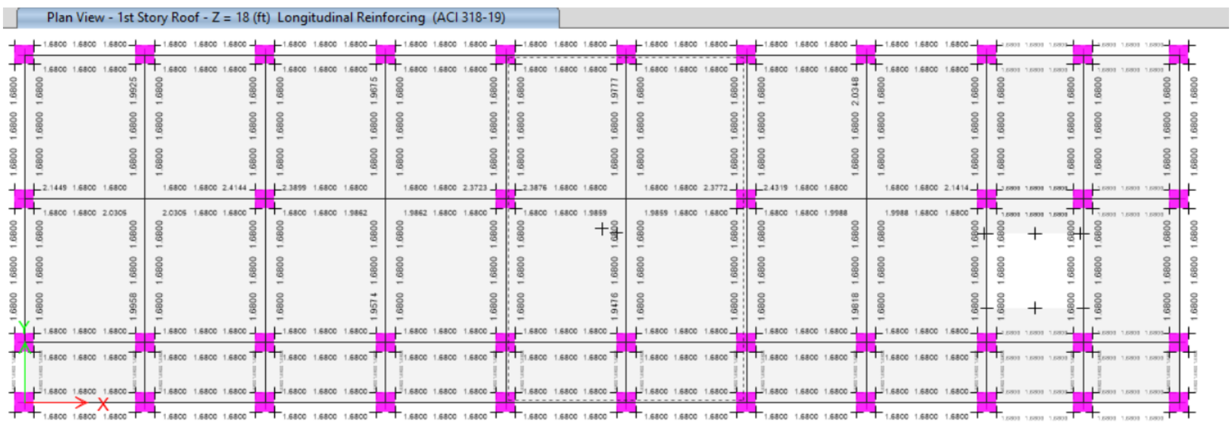

Fig. 3.4: Longitudinal Reinforcement Area of 1st Floor Beam

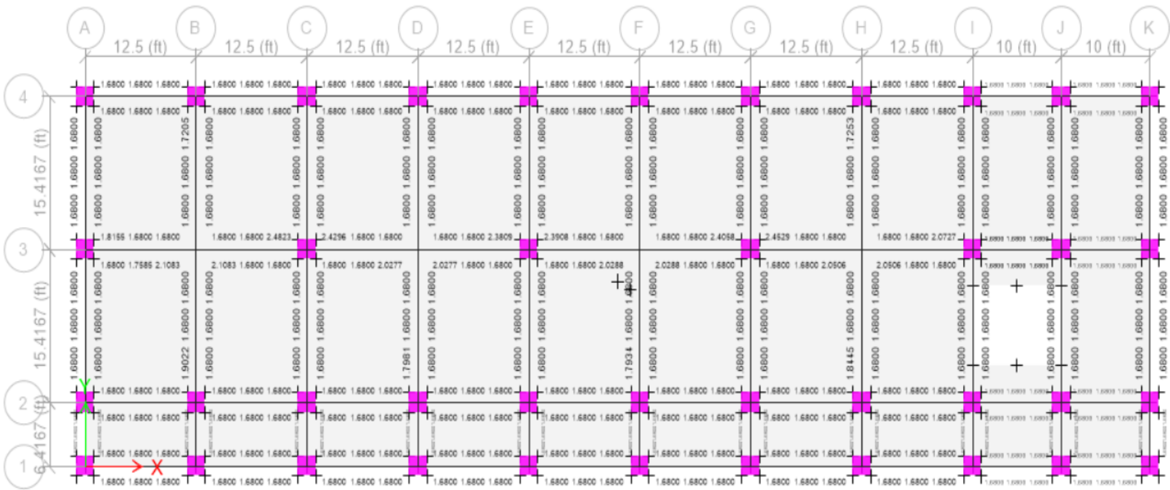

Fig. 3.5: Longitudinal Reinforcement Area of 2nd Floor Beam

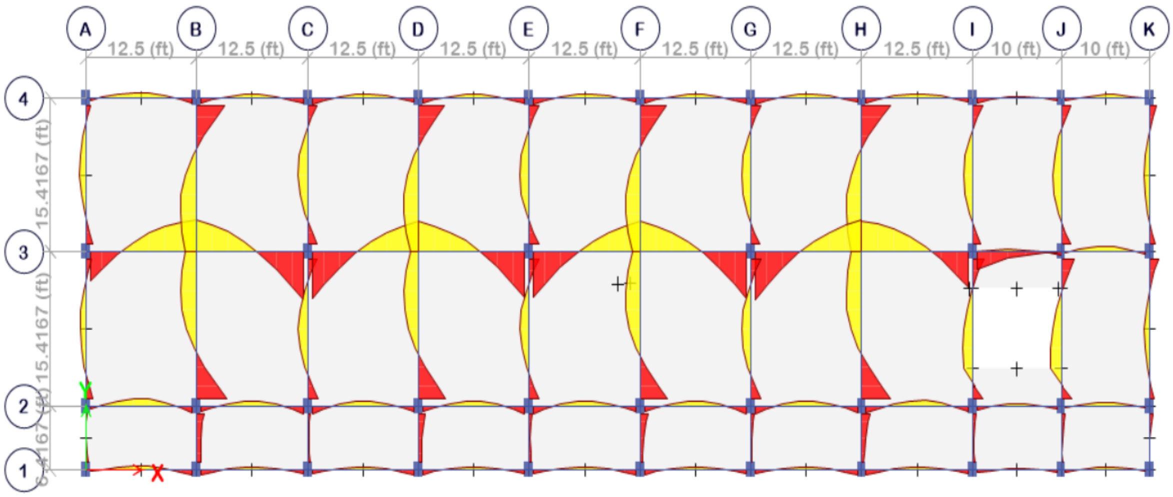

Fig. 3.6: Bending moment diagram

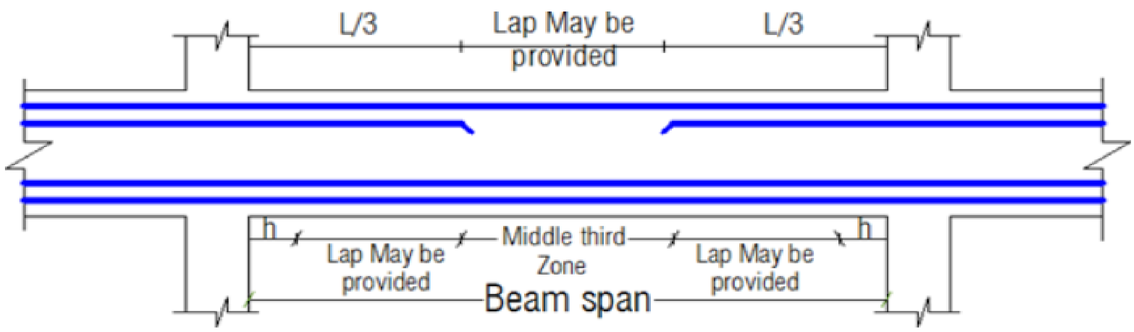

Fig. 3.7: Lap Position

Table 3.2: Beam Details

Beam of Roof				
Beam No	**Dimension**	**Bottom Rebar**	**Top Rebar**	**Stirrups**
B1	12’’x20’’	3# 16mm Dia	3# 16mm Dia	10mm @ 4.5"/9”/4.5” c/c
B2	12’’x20’’	3# 16mm Dia	3# 16mm Dia	10mm @ 4.5"/9”/4.5” c/c
B3	12’’x20’’	3# 16mm Dia	3# 16mm Dia	10mm @ 4.5"/9”/4.5” c/c
B4	12’’x20’’	3# 16mm Dia	3# 16mm Dia	10mm @ 4.5"/9”/4.5” c/c
B5	12’’x20’’	3# 16mm Dia	3# 16mm Dia	10mm @ 4.5"/9”/4.5” c/c
B6	12’’x20’’	3# 16mm Dia	3# 16mm Dia	10mm @ 4.5"/9”/4.5” c/c
B7	12’’x20’’	3# 16mm Dia	3# 16mm Dia	10mm @ 4.5"/9”/4.5” c/c
B8	12’’x20’’	3# 16mm Dia	3# 16mm Dia	10mm @ 4.5"/9”/4.5” c/c
B9	12’’x20’’	3# 16mm Dia	3# 16mm Dia	10mm @ 4.5"/9”/4.5” c/c
B10	12’’x20’’	3# 16mm Dia	3# 16mm Dia	10mm @ 4.5"/9”/4.5” c/c
B11	12’’x20’’	3# 16mm Dia	3# 16mm Dia	10mm @ 4.5"/9”/4.5” c/c
B12	12’’x20’’	3# 16mm Dia	3# 16mm Dia	10mm @ 4.5"/9”/4.5” c/c
B13	12’’x20’’	3# 16mm Dia	3# 16mm Dia	10mm @ 4.5"/9”/4.5” c/c
B14	12’’x20’’	3# 16mm Dia	3# 16mm Dia	10mm @ 4.5"/9”/4.5” c/c
B15	12’’x20’’	3# 16mm Dia	3# 16mm Dia	10mm @ 4.5"/9”/4.5” c/c

3.6 Design of Column and Detailing

In the development of the columns in ETABS, a number of important variables are taken into consideration in the model of the structure to determine the strength and stability of the column. It starts with the assessment of the axial loads and bending moments on the columns, which are substantially as a result of dead loads and live loads among other forces wielded. ETABS examines the effect that these loads have on the geste and the overall performance of the column.

It's also in the software that the stiffness of the column is considered, the rate of slenderness, the buckling possibilities, thecross-sectional size, and the underpinning information, which are major factors in the contraction and flexural forces resistance. ETABS uses applicable design canons and norms to give structural safety and meet the conditions of law compliance, and uses the slenderness effect assessment automatically where applicable. It's also in the software that the stiffness of the column is considered, the rate of slenderness, the buckling possibilities, thecross-sectional size, and the underpinning information, which are major factors in the contraction and flexural forces resistance. ETABS uses applicable design canons and norms to give structural safety and meet the conditions of law compliance, and uses the slenderness effect assessment automatically where applicable.

All these parameters combined, ETABS will allow structural masterminds to produce effective, structurally sound, and at the same time, public and transnational law- biddable columns. After completion of the analysis and design, the specific underpinning delineations (confines of columns, confines of bars to be used, and form of underpinning to be used, etc.) are produced. These elaborate delineations make the columns to be erected rightly and completely considering the norms of structural designs.

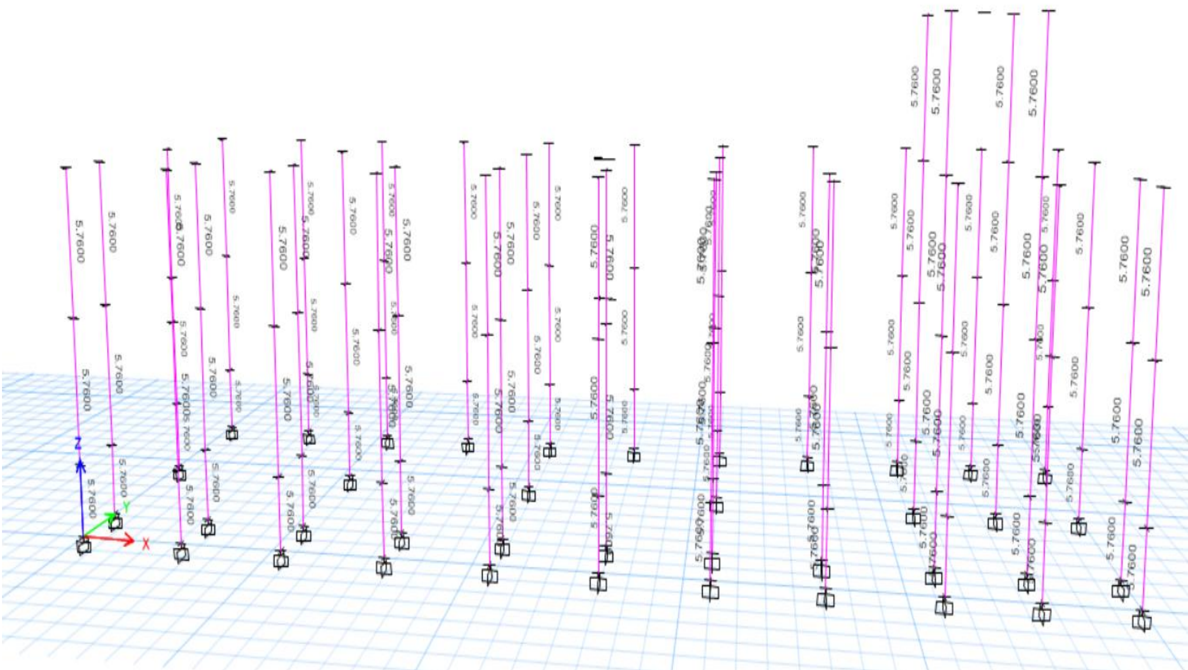

Fig. 3.8: Longitudinal Area Reinforcement of Column

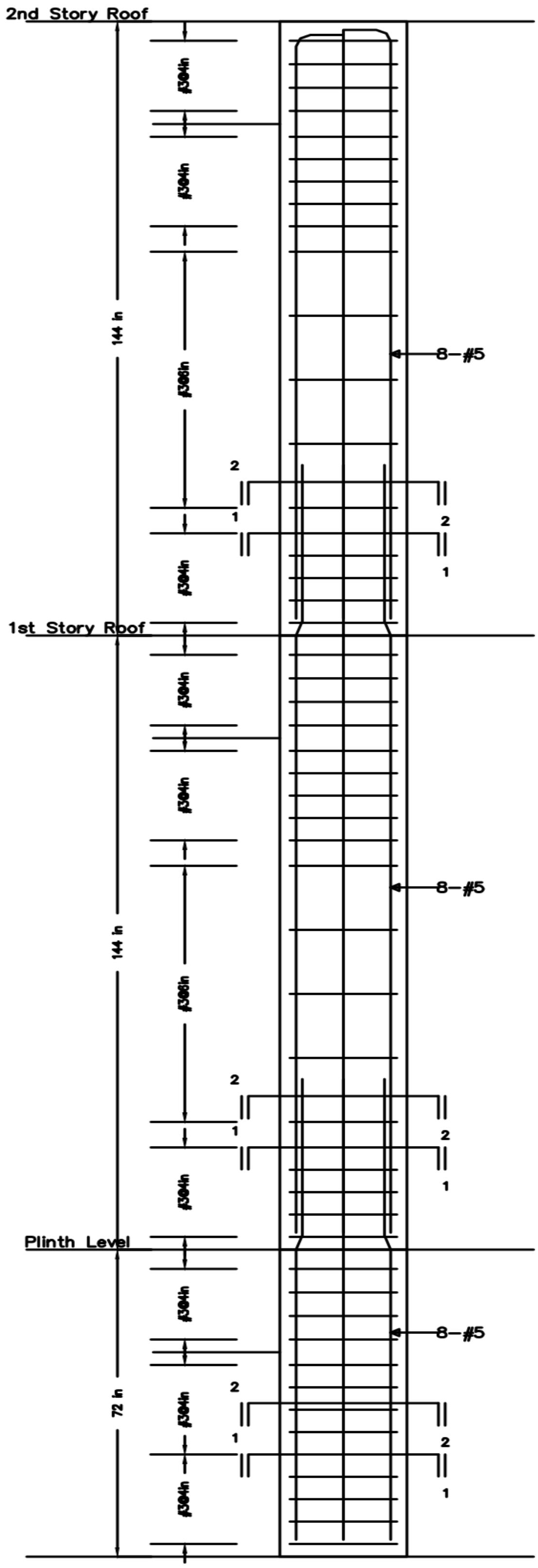

Fig.3.9: View a Column

Table 3.3: Details of Ground to Roof Column

Columns at Basement to Ground Floor			
Column No.	Size of Column	Main Reinforcement	Lateral Ties
1	12"x18"	8# of 16mm dia	10mm @ 4"/6”/4” c/c
2	12"x18"	8# of 16mm dia	10mm @ 4"/6”/4” c/c
3	12"x18"	8# of 16mm dia	10mm @ 4"/6”/4” c/c
4	12"x18"	8# of 16mm dia	10mm @ 4"/6”/4” c/c
5	12"x18"	8# of 16mm dia	10mm @ 4"/6”/4” c/c
6	12"x18"	8# of 16mm dia	10mm @ 4"/6”/4” c/c
7	12"x18"	8# of 16mm dia	10mm @ 4"/6”/4” c/c
8	12"x18"	8# of 16mm dia	10mm @ 4"/6”/4” c/c
9	12"x18"	8# of 16mm dia	10mm @ 4"/6”/4” c/c
10	12"x18"	8# of 16mm dia	10mm @ 4"/6”/4” c/c
11	12"x18"	8# of 16mm dia	10mm @ 4"/6”/4” c/c
12	12"x18"	8# of 16mm dia	10mm @ 4"/6”/4” c/c
13	12"x18"	8# of 16mm dia	10mm @ 4"/6”/4” c/c
14	12"x18"	8# of 16mm dia	10mm @ 4"/6”/4” c/c
15	12"x18"	8# of 16mm dia	10mm @ 4"/6”/4” c/c
16	12"x18"	8# of 16mm dia	10mm @ 4"/6”/4” c/c
17	12"x18"	8# of 16mm dia	10mm @ 4"/6”/4” c/c
18	12"x18"	8# of 16mm dia	10mm @ 4"/6”/4” c/c
19	12"x18"	8# of 16mm dia	10mm @ 4"/6”/4” c/c
20	12"x18"	8# of 16mm dia	10mm @ 4"/6”/4” c/c
21	12"x18"	8# of 16mm dia	10mm @ 4"/6”/4” c/c
22	12"x18"	8# of 16mm dia	10mm @ 4"/6”/4” c/c
23	12"x18"	8# of 16mm dia	10mm @ 4"/6”/4” c/c
24	12"x18"	8# of 16mm dia	10mm @ 4"/6”/4” c/c
25	12"x18"	8# of 16mm dia	10mm @ 4"/6”/4” c/c
26	12"x18"	8# of 16mm dia	10mm @ 4"/6”/4” c/c

27	12"x18"	8# of 16mm dia	**10mm @ 4"/6"/4" c/c**
28	12"x18"	8# of 16mm dia	**10mm @ 4"/6"/4" c/c**
29	12"x18"	8# of 16mm dia	**10mm @ 4"/6"/4" c/c**
30	12"x18"	8# of 16mm dia	**10mm @ 4"/6"/4" c/c**
31	12"x18"	8# of 16mm dia	**10mm @ 4"/6"/4" c/c**
31	12"x18"	8# of 16mm dia	**10mm @ 4"/6"/4" c/c**
33	12"x18"	8# of 16mm dia	**10mm @ 4"/6"/4" c/c**
34	12"x18"	8# of 16mm dia	**10mm @ 4"/6"/4" c/c**
35	12"x18"	8# of 16mm dia	**10mm @ 4"/6"/4" c/c**
36	12"x18"	8# of 16mm dia	**10mm @ 4"/6"/4" c/c**
37	12"x18"	8# of 16mm dia	**10mm @ 4"/6"/4" c/c**
38	12"x18"	8# of 16mm dia	**10mm @ 4"/6"/4" c/c**
39	12"x18"	8# of 16mm dia	**10mm @ 4"/6"/4" c/c**
40	**12"x18"**	**8# of 16mm dia**	**10mm @ 4"/6"/4" c/c**

3.7 Design of Foundation and Detailing

ETABS is an insulated footing model that involves the colorful consummative parameters being anatomized to establish the structural integrity and conformity to the designing parameters. One of the issues that determine the confines and the underpinning of the footing is the bearing capacity of the soil because it defines the amount of weight that the soil is capable of comfortably carrying. ETABS calculates and apportions the loads that the columns carry such as dead loads, live loads and other loads evaluated on the footing space without contravening these soil limitations.

also, the software determines shear stresses and bending moment at bottom of footing, particularly on punching shear and flexural demands. It specifies the required consistence and the supporting layout which would effectively resist these forces and also restrain agreement within an acceptable range of limits.

In the objectification of the design conditions of the concrete grade, standing shape, size and individual parameters as presented in Figure.ETABS, it offers an efficient and law- biddable footing design in conformity to the original structure law and safety vittles.

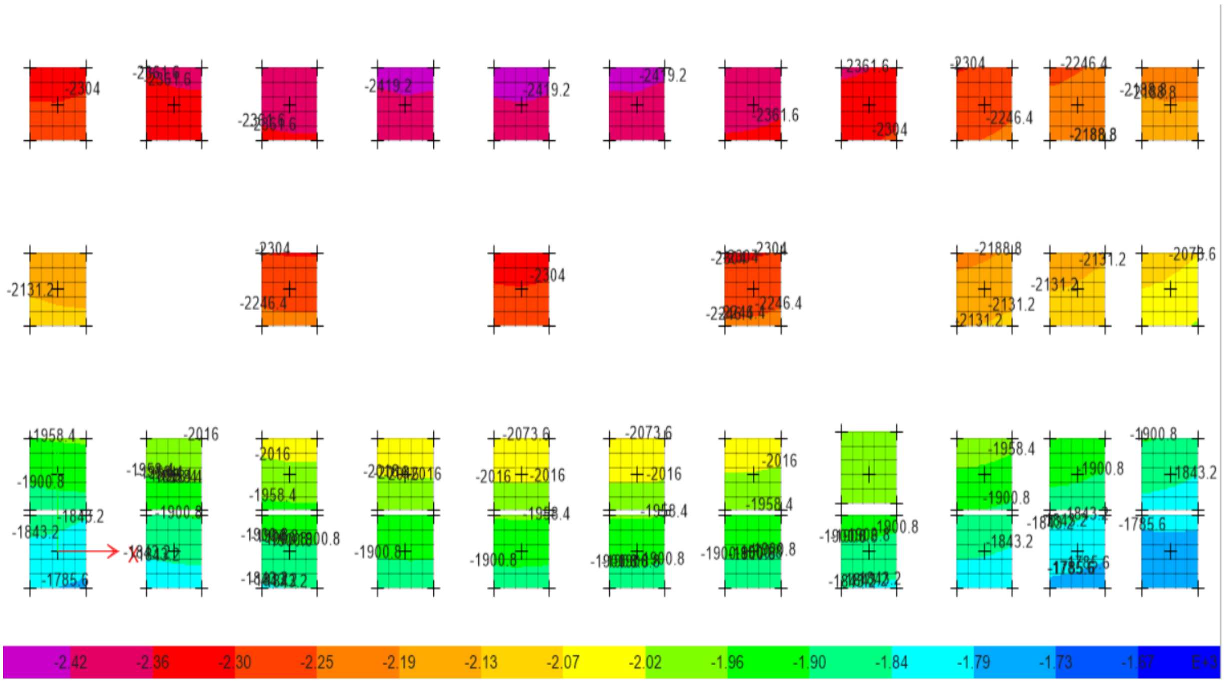

Fig. 3.10: Soil Pressure of Footing

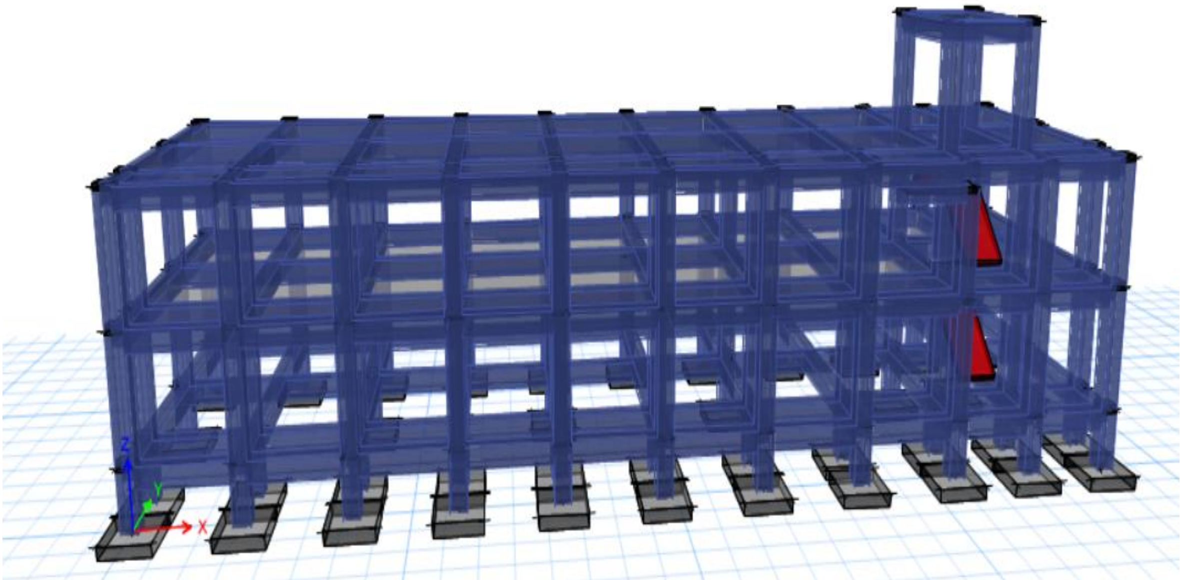

Fig.3.11: ETABS 3D View

Table 3.4: Final Detailing of Footing

DESIGN RESULTS			
Footing No.	Size	Thickness	Reinforcements in Both Directions
1	6’x6’	15" (375mm)	16mm dia. @6” c/c
2	6’x6’	15" (375mm)	16mm dia. @6” c/c
3	6’x6’	15" (375mm)	16mm dia. @6” c/c
4	6’x6’	15" (375mm)	16mm dia. @6” c/c
5	6’x6’	15" (375mm)	16mm dia. @6” c/c
6	6’x6’	15" (375mm)	16mm dia. @6” c/c
7	6’x6’	15" (375mm)	16mm dia. @6” c/c
8	6’x6’	15" (375mm)	16mm dia. @6” c/c
9	6’x6’	15" (375mm)	16mm dia. @6” c/c
10	6’x6’	15" (375mm)	16mm dia. @6” c/c
11	6’x6’	15" (375mm)	16mm dia. @6” c/c
12	6’x6’	15" (375mm)	16mm dia. @6” c/c
13	6’x6’	15" (375mm)	16mm dia. @6” c/c
14	6’x6’	15" (375mm)	16mm dia. @6” c/c
15	6’x6’	15" (375mm)	16mm dia. @6” c/c
16	6’x6’	15" (375mm)	16mm dia. @6” c/c
17	6’x6’	15" (375mm)	16mm dia. @6” c/c
18	6’x6’	15" (375mm)	16mm dia. @6” c/c
19	6’x6’	15" (375mm)	16mm dia. @6” c/c
20	6’x6’	15" (375mm)	16mm dia. @6” c/c
21	6’x6’	15" (375mm)	16mm dia. @6” c/c
22	6’x6’	15" (375mm)	16mm dia. @6” c/c
23	6’x6’	15" (375mm)	16mm dia. @6” c/c
24	6’x6’	15" (375mm)	16mm dia. @6” c/c
25	6’x6’	15" (375mm)	16mm dia. @6” c/c
26	6’x6’	15" (375mm)	16mm dia. @6” c/c

27	6’x6’	15" (375mm)	16mm dia. @6” c/c
28	6’x6’	15" (375mm)	16mm dia. @6” c/c
29	6’x6’	15" (375mm)	16mm dia. @6” c/c
30	6’x6’	15" (375mm)	16mm dia. @6” c/c
31	6’x6’	15" (375mm)	16mm dia. @6” c/c
32	6’x6’	15" (375mm)	16mm dia. @6” c/c
33	6’x6’	15" (375mm)	16mm dia. @6” c/c
34	6’x6’	15" (375mm)	16mm dia. @6” c/c
35	6’x6’	15" (375mm)	16mm dia. @6” c/c
36	6’x6’	15" (375mm)	16mm dia. @6” c/c
37	6’x6’	15" (375mm)	16mm dia. @6” c/c
38	6’x6’	15" (375mm)	16mm dia. @6” c/c
39	6’x6’	15" (375mm)	16mm dia. @6” c/c
40	6’x6’	15" (375mm)	16mm dia. @6” c/c

3.8 Design of Staircase and Detailing

The staircase design in ETABS is done through careful structural analysis to achieve safety and functionality of the structure. The software is used to check the geometric arrangement of the staircase, videlicet the rise, tread (run) and the general pitch of the staircase and validate it with architectural and usability conditions.

ETABS considers the structural property of the used paraphernalia in order to achieve structural responsibility which includes the strength and stiffness of concrete, brand or other paraphernalia that are used in construction. The design process covers both dead and live loads, which correspond of the tone- weight of the stair structure and the movement of occupants and transporting of objects. These are used under the applicable morals of architectural and structure canons.

Further, ETABS evaluates the support conditions and support conditions, counting on the simplicity, cantilevered, or support by intermediate levees of the staircase. These support cases, as depicted in Figure 3.12, are essential in the determination of weight distribution, detailing of mounts and general structural responsibility.

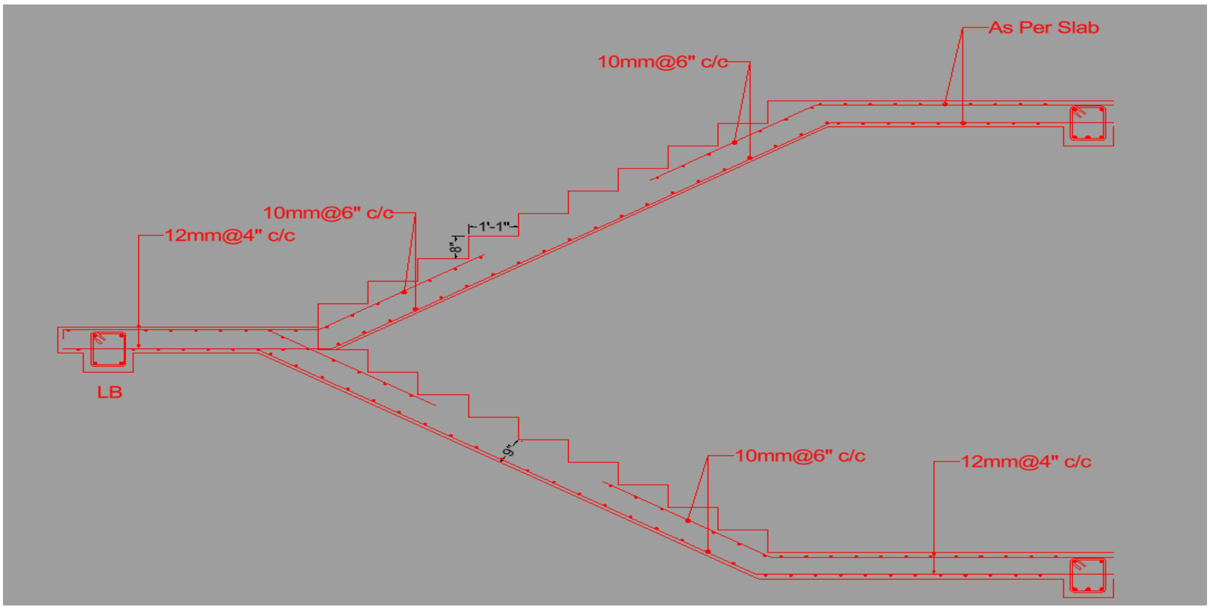

Fig.3.12: Stair & Technical Rebar Bindings

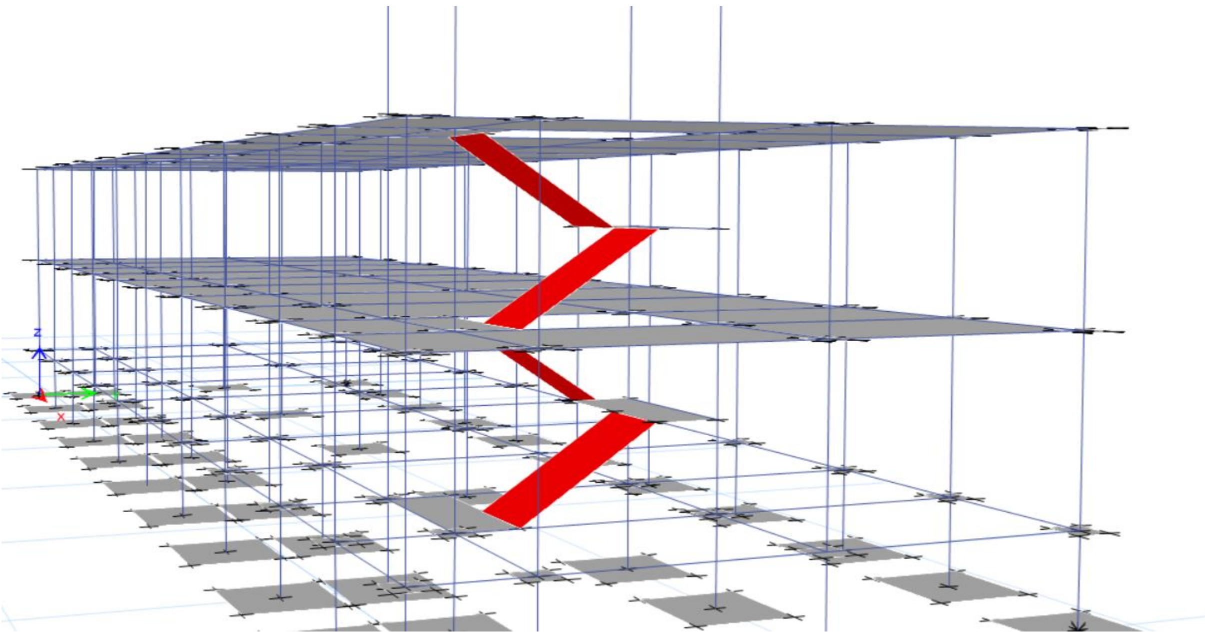

Fig. 3.13: Stair view from ETABS

3.9 Summary

For the present study, the structural analysis and design of all major weight- bearing factors of a G 1(two- story) structure including insulated footings, undermost shafts, vertical columns, perpendicular shafts, and staircases were conducted using ETABS, a vastly recognized software for structural modeling. The design process began with the accurate modeling of the structure's structural system,taking into account the figure, material parcels, boundary conditions, and weight combinations as per applicable structure canons and morals (analogous as BNBC 2020 and ACI 318).

Special attention was given to the weight- bearing capacity and mileage conditions of each structural element. This involved correct allocation of dead loads, live loads and in some cases, environmental and seismic loads. The analysis characteristics of ETABS enabled exploration of internal forces in detail, such as bending moments, shear forces and loads along the axial direction, which informed the acceptable cross- sectional confines and bolstering detailing of each member. The footings have been designed to repel punching shear and control agreement and are based on the bearing capacity of the soil. The proportions of columns and shafts were calculated to repel the vertical and lateral loads effectively, and the vile nature of icing and continuity of structures. shafts were calculated to have reasonable flexural strength and crack propagation. Staircases as well were modeled and studied in terms of architectural design and structural performance and the assessment of the supports and weight paths.

Detailed construction delineations were then made in AutoCAD by means of the completion of the structural design. These outlines included specific dimensional requirements, labeling of members, and schedules of bolstering, which were used in the construction phase, icing clarity, and performance ease of construction.

Each delineation was revewed to maintain viscosity with the structural analysis results and to act up with standard detailing practices. This integrated design methodology combining logical rigor through ETABS with graphical perfection via AutoCAD ensures that the entire structural system is not only stable and economically effective, but also biddable with law- rested safety morals, and is therefore fit for practical prosecution on- point. Such a comprehensive approach enhances the overall responsibility of the structural frame and contributes significantly to the successful consummation of the structure design.

Chapter 4

Design of Overhead Water Tank

4.1 Introduction

An overhead water tank is a raised water storehouse installation that's enforced to maintain the constant force of water within domestic, marketable as well as institutional constructions. It's mounted in a height that will give the needed gravitational head, holding drinkable or mileage water which can be used in the domestic terrain and fighting fire. The Bangladesh National Building Code (BNBC, 2020) states that water storehouse systems should be designed to capture the diurnal demand, have the right quantum of pressure and be aseptic. The overhead tanks are typically corroborated concrete (RCC), sword, or compound material and the structure has to be similar that it can fulfil a structural stability, continuity and safe storehouse of water under different cargo surroundings.

4.2 Components of an Overhead Water Tank

1. Walls

- ❖ perpendicular or slightly twisted.
- ❖ Designed to be resistant to the hydrostatic pressure of the water it contains.

2. Base Arbor

- ❖ Is used as the primary cargo carrier as far as the stored water is concerned.
- ❖ Distributed the staging structure burden of water below.

3. Roof Arbor

- ❖ Prevents the dust, debris and surface contaminating.
- ❖ In order to reduce the growth of algae direct sun to water was avoided using securities.

4. Carrying (Supporting Structure)

- ❖ Constructions grounded on the corroborated cement concrete (RCC) or the structural sword.

- ❖ Fill in the tank to the needed height to have water distribution by graveness.
- ❖ Has columns, bracings and shafts, to give resistance to perpendicular and side loads.

5. Foundation

- ❖ Safely transfers the cargo of structure combination to the ground water.
- ❖ The soil should be delved according to the BNBC conditions so that the bearing capacity is acceptable during construction.

6. Inlet and Outlet Systems

- ❖ Stuffing tank pipe this pipe is linked to a pumping system or water force system.
- ❖ Outlet Pipe This supplies water to the force system to have acceptable water inflow.

7. Accessories

- ❖ Manhole Checked and gutted on a regular base.
- ❖ Vent Pipe This allows movement of air and balancing of pressure during stuffing and discharge.
- ❖ Overflow Pipe Prevents spillage of water in case of over filler.
- ❖ Graduation and rail To prop in the conservation and safe operation.

4.3 Design Considerations (BNBC, 2020)

1. Capacity & Demand

- ➢ Determine the diurnal water demand grounded on the residency of a structure and the BNBC rates of water per capita use (e.g. domestic 135 L/ person/ day; institutional/ academy 45- 90 L/ person/ day).
- ➢ Added fire reserve and peak demand allowances (where applicable).

2. Structural Design

- ➢ Loads Due to BNBC cargo combinations, dead cargo (tone- weight of the tank), live cargo (tone- weight of water), wind cargo, seismic cargo and conservation cargo are to be considered.

- Hydrostatic Pressure Base Arbor and wall- Design to repel the maximum water pressure at the base.
- Seismic Design BNBC should have tanks with advanced capacity and height to be tested on seismic analysis with applicable right seismic zone factors.
- Wind cargo Altitudinous structures involve calculating the wind pressure in altitudinous staging to remove circumstance of capsizing or inordinate sway.

3. Accoutrements & continuity

- RCC tanks uttermost grade of concrete, M20; transparent water cover of structure, clear, according to BNBC (minimal 40 mm).
- Steel strengthening to oppose tensile forces, which are open with erosion- resistance.
- Waterproofing (erected- in waterproofing emulsion, excellent common sealing).

4. Hygiene & Safety

- Roof covering to help impurity.
- Cataplasm finish internal easy to clean.
- Safe entry (BNBC should retain rails, graduations, not slip).
- Over Flow not into the foundation and areas of the public.

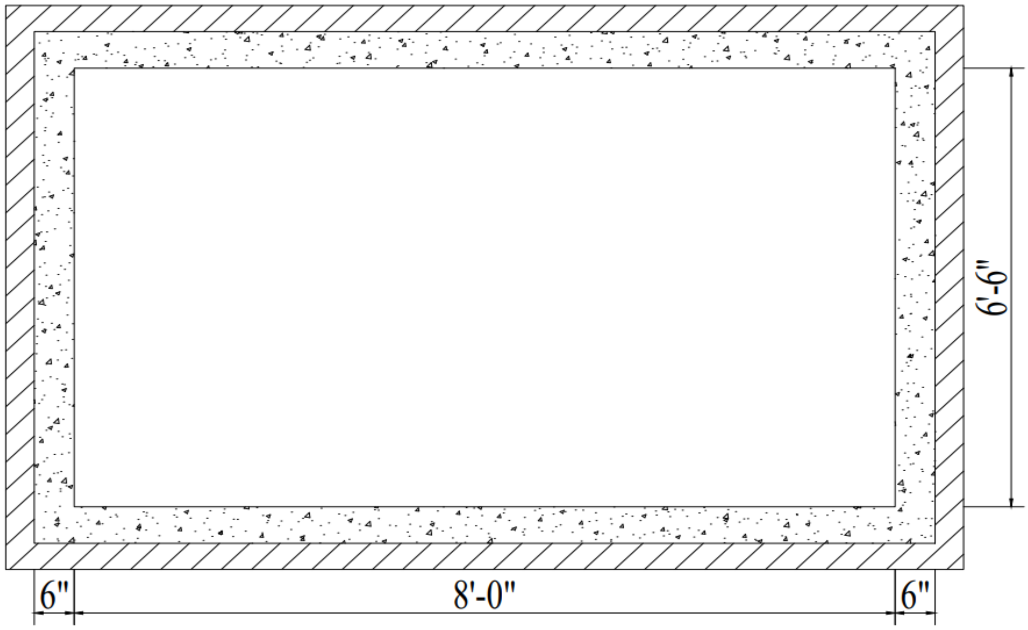

Fig.4.1: Plan of Overhead Water Tank

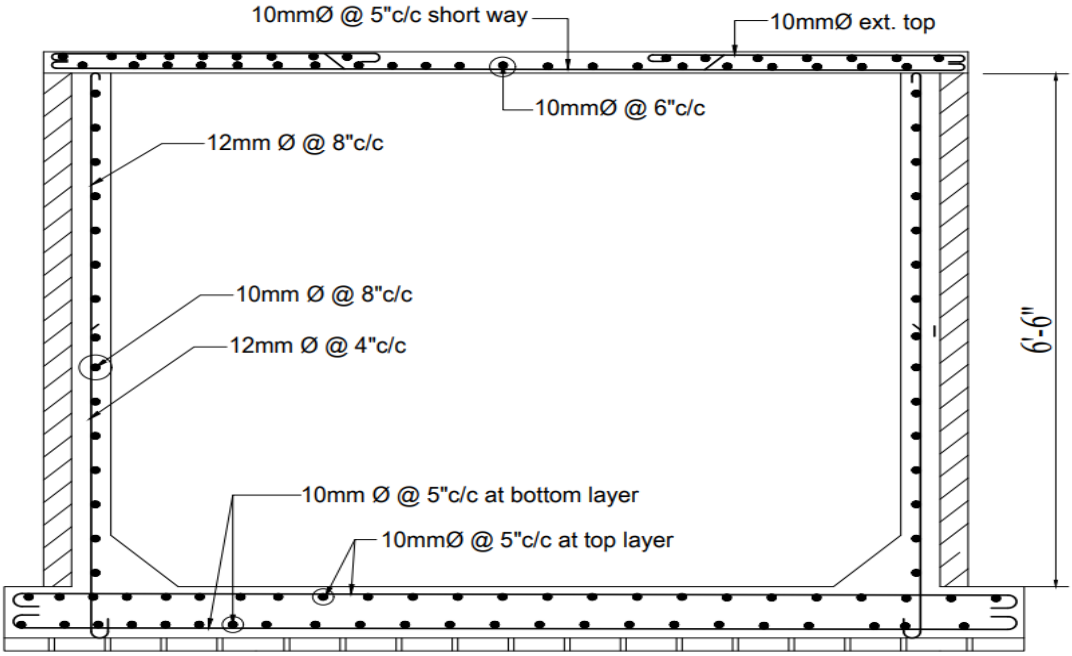

Fig. 4.2: Section of Overhead Water Tank

4.4 Summary

The design of overhead water tanks is important in the provision of continuous and pressurized water in the buildings. According to BNBC, the primary focus is placed on proper capacity estimation, the structural safety during multi-loads, seismic and wind stability, water tight structure, and hygienic protection (BNBC, 2020). A good design comprises of a good foundation, sturdy staging, tank container with a leak proof structure, and secure access. Through the guidelines of BNBC, overhead tanks can be able to provide water service that is reliable, resistance against the environmental forces, and water quality throughout their service life.

Chapter 5

Design and Consideration of Septic Tank

5.1 Introduction

Where it is not accessible by a centralized sewage system, a suitable result to the problem of wastewater treatment is by using a septic tank. These are underground and penetrable holders (generally made of concrete, fiberglass or HDPE) which insulate solids and liquids. Solid waste is accumulated as sludge, and the lightest part is proletariat; incompletely treated effluent goes into a drain field where it's farther filtered by soil.

Anaerobic bacteria contained within the tank grease the declination of organic matter enhancing the effectiveness of treatment. The sizing should be done grounded on the quantum of water used in a ménage and the tank should be at a safe position that is n't in contact with water sources therefore impurity. Pumping must be done as well as examination after every 2 to 5 times. The original regulations govern the installation, the position and the capacity to maintain the safety of the population and the terrain.

5.2 Components of a Septic Tank

Septic tank has a number of major factors that cooperate to treat the ménage wastewater. The wastewater is conducted to bay pipes and also sludge settles at the bottom of the tank as the lighter rudiments similar as fats and canvases rise to form a proletariat. The liquid containing the effluent or incompletely treated liquid is maintained in the middle subcaste.

Baffles or tees are added to the bay and outlet points in order to control the inflow and clogging. These are fitted with the wastewater and make sure that only the effluent overflows to the drain field to be handled further. Access openings or bimahs are also handed and sludge and proletariat can be pumped out as well as regularly checked and gutted.

5.3 Septic Tank Design Guidelines Based on BNBC 2020

The Bangladesh National Building Code (BNBC, 2020) consists of specific standards of designing and construction of septic tanks that is safe and efficient in the management of wastewater. The parameters of a septic system to be designed to serve 240 users are that there are 40 people in each classroom and the system should retain wastewater long enough to treat the water, so it is important to take into account several important parameters, namely the total number of users, average daily water per capita, as well as the necessary wastewater treatment retention period.

1. Capacity and Retention

- The tank must be large enough to hold wastewater of one to two days, which would give time to the solids to settle and the organic matter to breakdown under the action of anaerobic bacteria. The design should be anchored on the daily water consumption to make sure that the design operates correctly and does not overflow.

2. Material and Structural Considerations

- Septic tanks should be made of durable and water tight materials like reinforced concrete, fiberglass or high density plastic to avoid leakage and harmful effects of groundwater around them. In most cases, internal walls or baffles separate the two compartments of the tanks to enhance the treatment process and limit the emission of sludge into the drain field.

3. Flow Control Components

- The inbound and outbound pipes must be installed with tees or baffles to control the flow and reduce the blockages. The outlet should be located a little bit below the inlet in order to enable correct discharge of effluent to the drain field to allow it to be filtered further.

4. Ventilation and Access

- Proper ventilation is needed to eliminate gases, smelly smell and encourage the growth of microbes. BNBC 2020 requires access points or risers to be included in order to be periodically inspected, maintained and the sludge removed. These apertures should be close-ended so as to avoid contamination.

5. Drain Field and Soil Suitability

- The drain field, to which treated wastewater is scattered across the soil, should be designed in accordance with the absorption capacity of the soil. It must also be placed far away buildings and wells and water source to avoid pollution and health hazards.

6. Placement and Maintenance

- The septic tank must be located well in advance of buildings and water sources to eliminate the danger of contamination by ground water or its freezing during colder weather. Regular maintenance is vital, sludge and scum must be pumped out either after 2 to 5 years depending on the use of the system, so as to maintain long term performance and safeguard population health.

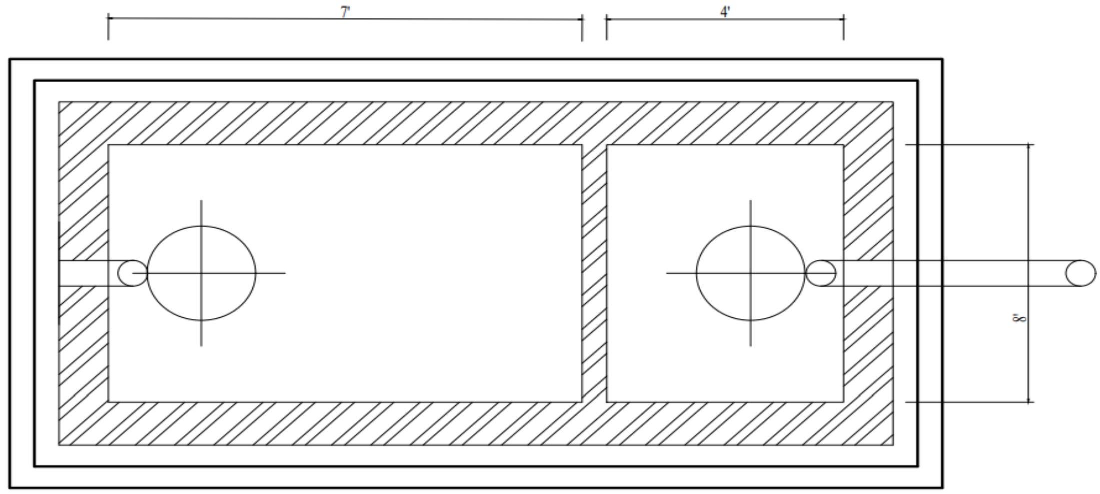

Fig. 5.1: Plan of septic Tank

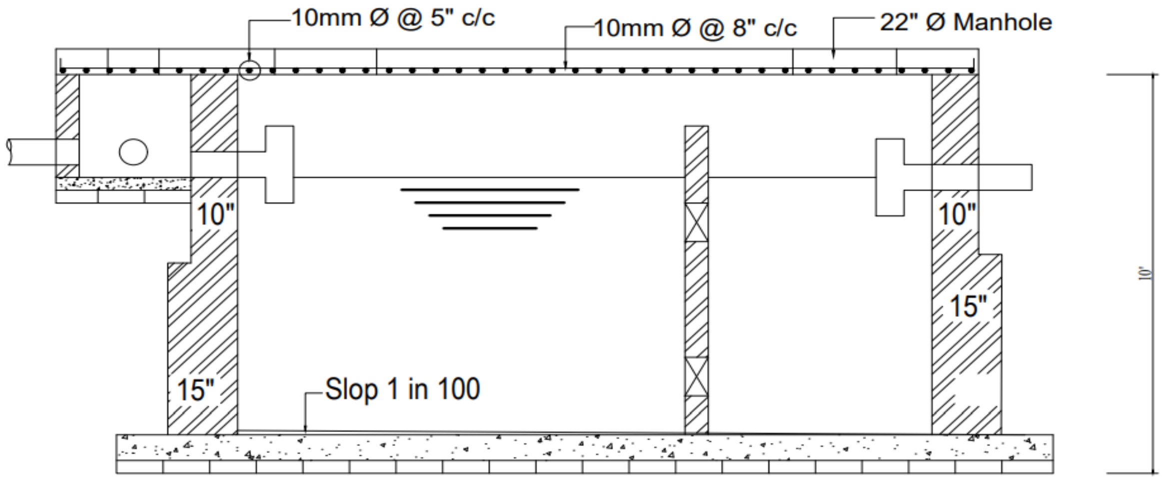

Fig. 5.2: Section view of Septic Tank

5.4 Summary

A septic tank is a system of underground wastewater treatment that is used in a location where the seamsters are absent. It separates the wastewater into three layers namely proletariat (fats and canvases), effluent (incompletely treated liquid) and sludge (settled solids). The effluent is also channeled to a drain field where it is also subjected to natural filtration in the soil. It consists of strong and non leaking materials like concrete or fiberglass material with baffles to contain the inflow, ventilation to dispose the feasts and de-odorize, and access anchorages to aid in the conservation. It is supposed to be sufficiently sized with reference to domestic water usage, it must not be near houses and water sources and it must be deep enough not to indurate. Frequent maintenance such as sludge pumping at least at one time in every 3 to 5 intervals is required that will ensure safe usage and safeguard the health of the people.

Chapter 6

Cost Estimation

6.1 Introduction

The Cost Estimation and Project Schedule Chart is critical towards the successful execution of the proposed two-story primary school construction. It provides a more detailed breakdown of estimated costs that include material costs, labor costs, equipment costs, and others. The section also displays the timeline of the construction and it is divided into the key phases, which include site preparation, foundation construction, structural framing, interior and exterior finishing, and final inspection. The chart allows maximizing the use of resources, ensuring financial discipline, and ensuring the completion is timely by combining the financial analysis with the time-based work plan. The Bill of Quantities (BOQ) was prepared using Microsoft Excel and the project schedule was organized to facilitate clarity, structure and accountability in all the project stages.

6.2 Slabs

Slabs are structural elements that are horizontal and consist of the roofs and floors and pass the loads to the supporting beams and columns. The volume of concrete that is necessary in slabs is computed in cubic meters according to the area and the thickness of the slabs in the Bill of Quantities (BOQ).Concrete of M25 grade, which is a balance of strength and cost, is normally specified. In this project, 420 bags of cement, 1122 cubic feet of sand, 2225 cubic feet of aggregates and 18000 litters of water will be used as slab concrete,Details of reinforcement which include the type, diameter, and the number of steel bars are recorded separately in the BOQ. Depending on the span and the load bearing capacity of the slab, 9.5 tons of reinforcement steel will be required. Slabs are usually designed with a steel grid pattern, with the main bars and distribution bars at a distance of 150200mm, depending on the conditions of the load. This reinforcement will provide sufficient tensile strength to counteract the failure of concrete to be used in tension

6.3 Beams

Shafts are structural rudiments that repel against bending and shear forces of cargo that the crossbeams put on columns. The amounts of concrete per ray that will be used are determined in volume of the shafts in the Bill of Amounts (BOQ) and are calculated depending on the length and cross-sectional size of the ray.

An illustration is a ray of 13 bases in length and sampling of 12 elevation by 18 elevation in the first bottom which only needs about 0.675 boxy measures of concrete. The reason why M25 grade concrete is generally used is that this concrete type has a high compressive strength which effectively counters bending stresses.

The conditions that were needed by the concrete conditions of shafts in this design are

- Cement 650 bags
- Sand 1200 cft
- Aggregate 2400 cft
- Water 15000 liters

Underpinning BOQ is used to describe the nature, periphery, and quantum of sword bars to be buttressing the shafts

- Pressure bars at the bottom to repel tensile forces.
- Compression bars at the top to hold compressive forces.
- Stirrups Stirrups are common, 10 mm in periphery, and they're wound round the primary bars in 150 mm center- to- center distance to help shear as per BNBC norms.

To support a normal G+1 beam, three bars with a periphery of 16 mm are employed at the top and the bottom. The total underpinning weight is determined during the length and bar size so that it can have enough strength against bending, shear, and deviation.

On the whole, the underpinning sword demanded to support the shafts in this design is about 25 tons only.

6.4 Columns

One of the most important perpendicular structural rudiments in a structure is the columns which are the main factors that carry loads of the superstructure which include bottoms, shafts and roofs over to the substructure or the foundation. Their resistance to the conduct of the axial contraction and the side forces is pivotal to the safety and stability of the structure. In order to give sufficient performance, the Bill of Amounts (BOQ) defines the quantum of accoutrements to be used in each column, details of underpinning used, and conditions of the construction to meet the necessary conditions.

This design requires that the cross-sectional size of the columns is 12 elevation by 18 elevation, and that size has been decided after taking into account the structural analysis, BNBC 2020 guidelines, and the issue of cargo bearing. The concrete that's cast is M25 grade, and it provides 25 Mpa of compressive strength, and this will give the asked safety factor to the loads of the structure design. The approximate material volume demanded to cast the columns (calculated by the height and the cross-sectional area of the column) is 380 bags of cement, 800 CF of beach, 1450 CF of coarse total, and 9600 liters of water. The quantities are calculated at standard proportions of blend and guarantee uniformity of quality across the structure.

underpinning is an important factor in adding the cargo bearing capacity of the column and avoiding failure in different loads. There are 8 longitudinal underpinning bars on each column which are 16 mm in periphery and they're meant to survive the axial and bending stresses. To avoid buckling of the longitudinal bars and make it stable, side ties (stirrups), with a periphery of 10 mm, are installed at 4 inch between each other in the height of the column as recommended by BNBC 2020 in seismic and non-seismic regions. The total underpinning demand, including the real lengths, compasses and the number of bars are 8.20 tons.

With these specifications, the columns can safely support the perpendicular and vertical loads in the superstructure on the foundation to grease long- term stability of the structure and lessen the threat of original or progressive failure. The selection of column confines, material grades, and underpinning pattern is careful to insure that the strength structure is in agreement with the safety regulations and it does not affect the overall structure design.

6.5 Isolated Footings

Isolated footings also known as insulated footings are passages created in the structure where individual columns are placed in a balanced way and weight is distributed a bit on the soil that is their foundation. They are important in ensuring that the pressure transferred to the soil lies within the safe bearing capacity of the soil, and hence it does not over-settle or be structurally unsound. Insulated footings The Bill of Amounts (BOQ) of insulated footings provide the exact volume of concrete, underpinning sword and other accoutrements required, based upon the size of the footing and the load that the column was carrying. When compared to columns, the height of which decides the sampling, insulated footings tend to be square or blockish on plan and the design is controlled by the area of the footplan. The size is determined based on the calculations of structural designing according to the soil bearing capacity, column cargo, and the factors of safety mentioned in BNBC 2020. a blockish insulated footing of confines 6 bases by 6 bases and 15 elevation thick (i.e. depth). The amount of concrete may be counted as Volume of the concrete = Length breadthdepth = 6ft 6ft 1.25 ft = 45 boxy bases (CF). The concrete grade to be adopted in this design is the M25 grade concrete because it has adequate compressive strength to sustain the forces to be transferred to the column and the reactions to the soil at the base. Based on standard proportions of blends, the footing will be casted with approximately 80 bags of cement, 180CF of beach, 360CF of coarse total and 1,940 liters of water. support also plays a critical role in the construction of a footing as it gives the structural ability to reject the bending moments and shear force especially at the column base where the highest stresses occur. The underpinning, in this instance, will be 12 mm periphery bars that will be placed in both directions and be spaced 6- inch center- to- center (c/ c) apart at the bottom and the top of the footing arbor. This layout is a good corroborated layout whereby transfer of the cargo and maintenance of the cracks is possible. The underpinning sword that will be required in this footing has a weight of 1.2 tons. Adherence to these requirements will ensure that the footing is appropriate to support the column cargo safely to the soil, and provide structural integrity and ensure that the footing is in accordance with BNBC 2020 of safety and continuity.

6.6 Staircase

Structural parameters of great concern include staircases, which facilitates safety of the bottom of the structure to bear columns and shafts by safely distributing the loads involved in this process. The design must be appropriate to the tone- weight of the stair, calculates the occupants live loads, and lays shells on the stair, and compliance with the safety and availability standards of the structure through the presence of icing in relation to the BNBC 2020 conditions.

The Bill of Amounts (BOQ) of the staircase is estimated of the careful measurement of the stair flight which is the depth of the tread, platform height and confines of a levee. They can be applied in the calculations of the quantity of concrete to be employed in the inclined pate and levee shafts. The process of continuity and structural stability is done through assistance of grade of M25 concrete that can give compressive strength 25 Mpa. The amount of cement, boxy bases of coarse and beach, respectively, of about 28 bags of concrete, 65 boxy bases, 105 boxy bases and 950 liters of water in this instance, respectively, is necessary to build the staircase, owing to the complex distribution patterns of stress at bending, torsional, and shear loads. bolstering detailing is necessary to the budget of the staircase, especially due to complex distributions patterns of the stresses at bending, torsional, and shear loads.

The BOQ for star bolstering bars has 12 mm borderline star bolstering bars that are extended longitudinally along the stair span to accommodate major bending forces.

The loads are slightly redistributed by distribution bars of 8 mm borderline and 6- inch centers firmly bonded perpendicular of main underpinning, to minimize cracking peril.

Fresh underpinning is also offered at levees where weight is a critical concern to offer more structural strength and stiffness.

The volume required of the total brand is calculated using the lengths, compasses and the distance of the resembling underpinning bars and is 0.5 tons. This foundation system renders the staircase able to withstand any weight exerted on it in all the loads that could be applied to it other than ensuring the structural integrity and safety of the stoners throughout the entire duration.

6.7 Overhead Water Tank

The 240 scholars school structure in two stories was structured with an overhead water tank to insure there's sufficient and dependable force of water. The tank has a capacity of roughly 7,360 liters, that's 8 bases, 6.5 bases and 5 bases independently. The size of this capacity is chosen relevantly depending on the rate of water consumption that the scholars need in a day rested on the guidelines of the Bangladesh National Building Code (BNBC 2020). This tank consists of admixture of M25 grade concrete which is a important blend of cement, beach with coarse total as a compositional mix of 11 2 that's strong enough to repel the pressure of water and other forces of the terrain. In this design, about 15 bags of cement, 40 boxy bases of beach, and 80 boxy bases of coarse total will be used and 700 liters of clean water will be employed to blend and cure the cement. The bolstering brand of roughly 0.3 tons is used to strengthen the concrete and give tensile strength to the concrete that eliminates cracks and structural failure. This is necessary to support the brand to hold together the tank as the weight of the stored water and external forces are truly heavy. The construction procedure demands proper mixing, laying and compacting of blend hence it's also continuously cured at least 14 days necessary to achieve the targeted concrete strength and permanence. In addition, the waterproofing on the face of the tank is done, so that the tank does not blunder and provides life to the structure. This overhead water tank is not only safe but it's also durable and suitable of holding water effectively as it complies with the morals of BNBC throughout its design and construction process so as to maintain the quotidian exertion of the school and the good of the 240 scholars that are enrolled in the school.

6.8 Septic Tank

According to Bangladesh National Building Code (BNBC, 2020), the wastewater must be treated safely and effectively in accordance with the assistance of the septic tanks to guarantee the safety of public health and environment. To design a school, the initial steps to be followed are to identify the number of users in the school, water used per person per day, the amount of wastewater that must be held, in a school of 240 users (six classes of 40 students each, 16 square ft/person) the first step will be to determine the number of users, the water used per person per day, and the amount of wastewater that should be held.

BNBC recommends that tank capacity is meant to be computed on total household or institutional water usage that provides retention period of one-two days so that solids can settle and decompose. They will be made in tanks which are made of good and water resistant materials such as reinforced concrete, fiberglass or plastic so that they cannot leaks and destroy the ground water. This is made up of two compartments in the tank, which are defined using internal baffles or partition walls that improve better treatment. The inlet pipe should be raised slightly higher than the outlet in order to ensure the water moves and it may be fitted with fittings to regulate the flow of wastewater. Ventilation is needed to release gases, avoid odours and support the activity of bacteria.

BNBC should also possess well-sealed access points (risers), periodic pumping and observation should also be carried out. The drain field in consideration must be inter-linked and must be designed taking into consideration the soil absorption capacity, spacing between drain field and buildings, wells and water sources. The tanks should be deep enough to avoid freezing and in the way that allows clearances required. After two to five years, the solids have to be removed to ensure the performance and health safety.

Material Requirements:

- ❖ Cement: 25 bags (1,250 kg)
- ❖ Sand: 60 cft
- ❖ Aggregate: 100 cft
- ❖ Water: 800 L
- ❖ Reinforcement steel: 0.3 ton (300 kg)

A concrete of approximately 4.8 m 3 can be provided by this material set that is enough to construct an effective small domestic septic tank but not a large institutional tank with 240 users.

Table 6.1: Summary of BOQ

	Materials Name	Amount of Materials	Estimated
1	Total Cement	1600 bag	960,000.00৳
2	Total Sand	3500 cft	95,000.00৳
3	Total Aggregate	6800 cft	1,700,000.00৳
4	Total Water	47000 liters	470,000.00৳
5	Total Reinforcement steel	46 ton	5060,000.00৳
6	Total Labor Cost		3500,000.00 ৳
7	Estimation of Brick masonry, Plaster, & Painting work		260,000.00 ৳
	Grand Total =		12045,000.00৳

Summary

The construction project is expected to cost around BDT 12045,000 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.

Reference

- BNBC. (2020). Bangladesh National Building Code. HBRI.
- B. Gazette, “Government of the People’s Republic of Bangladesh Ministry of Housing and Public Works BANGLADESH NATIONAL BUILDING CODE 2020, 2021.
- ACI Committee 318 and American Concrete Institute., Building code requirements for structural concrete (ACI 318-11) and commentary. American Concrete Institute, 201

APPENDIX

Column design (C1)

Total load Load W_u = 148.26 kip

$f'_c = 4ksi$ $f_y = 60ksi$

$\rho_g = 1\% - 8\%\ (use = 1\%)$

	∝	∅
Tied	0.8	0.65

$\Rightarrow \frac{W_u}{\propto\emptyset} = A_g\left[0.85f'_c\ (1-\rho_g) + \rho_g f_y\right]$

$\Rightarrow \frac{148.26}{0.8\times 0.65} = A_g[0.85\times 4(1-0.01) + 0.01\times 60]$

$A_g = 71.89in^2$

Use 12×18 $column$

$\Rightarrow \frac{W_u}{\propto\emptyset} = 0.85f'_c(A_g - A_s) + A_s f_y$

$\Rightarrow \frac{148.26}{0.8\times0.65} = 0.85\times 4(71.89 - A_s) + A_s\times 60$

$\Rightarrow A_s = 0.71in^2$

$A_{s(min)}$ = 1% of A_g = 0.01 × 71.89

= 0.71 in^2

Number of Bar needed:

Area of #5 bar=0.31 in^2

Bar needed = $\frac{0.71}{0.31} = 2.29 \cong 3$

But In column we should use at least 4 bars

Use 4#5 bars

Tie Design of Column

Minimum size of the bar ≥ #3 bar, if longitudinal bar is ≤ #10 bar

We use #5 bar,so tiebar#3

Spacing:

01. $S \le 16d_b$ [d_b = $diameter\ of\ main\ reinforcement$]

02. $S \le 48d_t$ [d_t = $diameter\ of\ tie$]

03. $S \le Least\ diameter\ of\ the\ column.$

Design: Use #3 tie bar

01. $S = 16 \times \frac{5}{8} = 10''$

02. $S = 48 \times \frac{3}{8} = 18''$

03. $S = 12''$

$\therefore Spacing$ = 10"@ c/c

The neutral axis for the balanced failure condition is easily found with

ε_u = 0.003 and ε_y = 60/29000 = 0.0021

C_b = 11.5 × 0.003 /0.0051

= 6.76 in

a = 0.85 × 6.76 = 5.75

f'_s= 0.003 × $\frac{29000\ (6.76 - 2.5)}{6.76}$ = 54.83 kips

C = 0.85 × 4 × 5.75 × 12 = 239.6 kips

P_b=0.85f'c ab+fs'As'

= 234.6 + 60 × 5 = 200.75 kips

M_b = 0.85 f'c ab (($\frac{h}{2} - \frac{a}{2}$) + f's A's ((h/2)-d)+Fs As(d- (h/2))

= 234.6 (7 – $\frac{5.75}{2}$) + 54.83 (7 – 11.5)+60×5(11.5-7)

= 2433 kip-in

= 202.75 kip-ft

Eccentricity = $\frac{2433}{208.75}$ = 11.65 in

Yaxis

γ = $\frac{11.6}{14}$ = 0.82

e_{in} = $\frac{6}{14}$= 0.4

$\frac{Act}{bh}$= s$\frac{12}{138}$ = 0.08

Using

GraphA.7(γ=0.)

and A.8=(γ=0.9)

Pny/(f'c xAg=(0.62+0.66)/2= 0.64 kips

Pny0=0.64×4×138=353.28 Kips

X axis Y= $\frac{7}{12}$=0.58 Sasy 0.6

$\frac{PnX0}{f'c \times Ag} = 0.65$

PnX0 = 0.65×4× 138 = 358.8 kips

$\frac{P0}{f'c \times A0} = \frac{0.4}{0.58} = 0.7$

Po = 0.7 × 4 × 138 = 386.4 kips

$\frac{1}{Pn} = \frac{1}{353.28} + \frac{1}{358.28} - \frac{1}{386.4} = 0.003$

Pn = 330.06 kip

Pu = 0.65 × 330.06 = 214.54 kip

DESIGN OF SEPTIC TANK

Design of a septic tank to serve a primary school of 240 persons who produce 30 lpcd of wastewater, and the tank is to be dislodged every 5 years.

Solution:

P = 240 persons

N = 5 years

C= 0.04 m3/person/yr.

T= 25 °C

q = 30 lpcd.

Volume calculation (m^3)

Sedimentation Zone Vh

$Th = 1.5 - 0.3 \log (Pq)$

$= 1.5 - 0.3 \log (240 \times 30)$

$= 1.5 - 0.3 \log (7200)$

$= 1.5 - 0.3 \times 3.85$

$= 1.5 - 1.157$

= 0.34 days

The volume required by the Sedimentation Zone:

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

$= 10^{-3} \times (240 \times 30) \times 0.34$

$= 2.448 \text{ m}^3$

Sludge Digestion Zone Vd

Assuming a design temperature of 25°C

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

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

$= 0.5 \times 10^{-3} \times 240 \times 42.3 = 5.076 \text{ m}^3)$

Sludge Zone Vsl

$Vsl = C \times P \times N$ C = Sludge accumulation constant (0.04 m^3/person/year)

$= 0.04 \times 240 \times 5$

$= 48 \text{ m}^3$

Scum Zone (Sc)

$Vsc = 0.4 \times Vs$

$= 0.4 \times 48$

$= 19.2 \text{ m}^3$

Total Volume $V = Vh + Vd + Vs + Vsc$

$V = 2.448 + 5.075 + 48 + 19.2 = 74.72 \text{ m}^3$

Depth Calculation

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

The maximum depth of sludge:

$dsl = Vsl / A = 48 / 23.4 = 2.05 \text{ m}$

The maximum submerged scum

$dss = 0.4 \times Vsl / A = 0.4 \times 48 / 23.4 = 0.82 \text{ m}$

Sludge clear depth $= 0.3$ m is adopted

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

Depth of the digestion zone

$dd = Vd / A = 5.076/ 23.4 = 0.21 \text{ m} < 0.375$

Depth required for sedimentation

$dh = Vh / A = 2.448 / 23.4 = 0.10 \text{ m}$

Since dh < 0.375 m,

dh $= 0.375$ m is adopted

Total effective depth

$= dsl + dss + dd + dh$

$= 2.05 + 0.82 + 0.21 + 0.375$

$= 3.45m$

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

8 ft $\times$ 6.5 ft $\times$ 6.5ft

V= L*W*H

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

A= abx^3

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

Impose load= 3 KN/m^2

Floor finishes= 1.25 KN/m^2

Beam width (B)= 304.8 mm

Unit wt. of concrete (Υ)= 25 KN/m^3

Grade of steel (fy)= 500 N/mm^2

Grade of concrete (fck)= 20 N/mm^2

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 mm^2

(Ast)min.= 0.12% of bD

= (0.12/100)*1000*190 = 228 mm^2

Spacing= [1000/4824.64/(3.142*12^2)/4}] = 137.147 mm ≈150 mm

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

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

Step 7: Check for shear force

For M20 concrete

Shear strength (Tc)= 0.280 N/mm^2

IS 456:2000, Table-19

Глаах= (39.62*10^3)/(1000*169) = 0.234 N/mm^2 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 = 250mm

Provide a distribution bar of 12mm diameter. @ 250mm 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 AutoCAD 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: Md.Bulbul Ahmed ID: 213-47-468
CO3 (K7, P2, A2)	Analysis presented	Economic and safety considered	Conducted balancing cost, and ethics.
CO4 (K7)	Benefit evaluation	Ethical obligation considered	Incorporated eco-friendly materials and energy-efficient designs.
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.
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 Project Scheduling to manage project timelines and ensure timely completion
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