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COMPARISON OF BUILDING COST FOR THREE TYPES OF REINFORCED CONCRETE FLOORS IN HIGH-RISE BUILDINGS

Hamzah ABDULSATTAR

Master of Science

Supervisor

Prof. Dr.Zeki HASGÜR

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by

Hamzah Zuhair Abdulsattar

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Prof. Dr.Zeki HASGÜR

Supervisor

Thesis Defense Jury Members:

Prof. Dr.Zeki HASGÜR	School of Engineering and Natural Sciences, Altinbas University	
Asst. Prof. Tuncer CELIK	School of Engineering and Natural Sciences, Altinbas University	
Asst. Prof. Erdem DAMCI	School of Engineering and Natural Sciences,, Istanbul University	

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Hamzah Zuhair Abdulsattar

DEDICATION

To my kind father.... my role model and my ideal in life, who taught me how to live with dignity and honor.

To my loving mother...... I don't find words that can ever fully express her prerogative; it is the epic of love and the joy of a lifetime, and an example of dedication and giving.

They made me what I am today. Without them, I would not have been able to get here.

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ABSTRACT

COMPARISON OF BUILDING COST FOR THREE TYPES OF REINFORCED CONCRETE FLOORS IN HIGH-RISE BUILDINGS

[Abdulsattar, Hamzah]

[M.Sc.], [Civil Engineering], Altınbaş University,

Supervisor: Prof. Dr. Zeki HASGÜR

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After the increase in the population, the world resort to high-rise buildings and a lot of researchers and engineers developed this type of building, and because the cost of high-rise buildings is expensive, must search for the best type of flooring to get the best quality of building and the best price, in this thesis a High-rise Building designed with structures software (ETABS-SAFE), with three types of floors and calculating the quantities of concrete and rebar to compare between them and to find which is more economical.

Keywords: High-Rise Buildings, ETABS Software, SAFE Software, Quantities, Cost

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1. INTRODUCTION

Perhaps nothing in the documented history of architecture is more captivating than humanity's aspiration to build ever-taller structures. Building such tremendous works like the Tower of Babel, the Colossi of Egypt, the Great Wall of China, and the Red Fort of the Chinnock Pyramid was done for national pride. Pride may have been the prime motive in the creation of the Egyptian and Mayan pyramids and in the creation of the legendary Indian Maqueda cities. Other factors that affect building height, such as rising land values and population density, remain significant, but a large portion of ego has also contributed to the growth of tall buildings around the world. Until just recently, open country was starting to look like an American city. World city skylines have been cut by distinct and identifiable mounds of mountains, each of which towers above the next to the other. Reaching upward remains difficult and desirable.[1]

One of the most technologically inventive centuries was the 19th century. It saw the implementation of modern methods and mechanics in almost all human activities. It became clear from time to time that queuing the possibilities for the latest materials and techniques would result in architectural creativity. IN the 1830s, revolutionary wood production techniques were established for quick construction and a lack of skilled labor to be solved. Cast iron, along with other innovations, especially the elevator, was transformed into a material that was lighter and more adaptable than masonry and opened up the door to tall buildings which were unprecedented not only for height but for ease of construction. [1]

The viability of large buildings has always depended on the materials available and on the vertical transport required to move people up and down the buildings. This growth, from time to time, can be traced back to the invention of wrought iron and steel, and the addition of an ascent in high elevation buildings, two major technological developments that took place between the middle and the end of the 19th century. With the advent of lifts, the upper floors became as appealing as the lower floors, and the bigger buildings were also financially efficient. [1]

1.1 TALL BUILDINGS

Although the world is full of interesting buildings, big and small, old and new, modern skyscrapers are the most eye-catching and instill the greatest sense of wonder in the onlooker. They are monuments to strength and reputation, supreme engineering and design accomplishments, reassuring landmarks, testimonies to the human spirit, and public relations at the highest level. Until recently, the observer was drawn to great cities such as New York and Chicago while thinking about skyscrapers. Today, after a century in which New York and Chicago were unrivaled as the home of the world's tallest modern buildings, the crown has been snatched first by Kuala Lumpur's twin Petronas Towers, then by Taipei's 101 Tower, and most recently by Dubai's Burj Dubai, a 162-story, mostly residential concrete tower.[1] [2]

1.1.1 General Concepts about Tall Building

The features of a building that classifies it as large are difficult to discern. After all, the external appearance of tallness is subjective. A five-story building will appear tall in a traditional one-story neighborhood. A 50-story structure in a city can be referred to as a high-rise but the townspeople can confidently point out their six-story sky-carper. The framework must pierce the sky between 100-120 floors in big towns like Chicago and Manhattan, and now in the United Arab Republic, with a huge number of large constructions, if it appears high compared to its immediate neighbors. In some terms, no high building or number of floors can be specified. There is no consensus about what constitutes a large building or how large a building can be named at a magical altitude, number of floors or size. Maybe it is necessary to draw the separating line from the area of statics, where the structure design moves into the field of structural dynamics.[3]

From the point of view of the structural design, it is easier to consider the building as tall, if the lateral loads, especially the influence of such loads, in any way affect its construction analyses and design. The magnitude of the relative lateral displacement between a particular floor is the direction or drift. With height, the forces of nature start to dominate, especially the wind. The structural architecture for super-high buildings is therefore designed according to principles entirely consistent with turbulent wind resistance.[3]

1.1.2 Types of Tall Buildings

For tall buildings, the building's various components may be divided into four distinct categories: Rigid and semi-rigid frames, braced structures, shear wall structures, and tube systems, and shear-frame systems, and truss-frame structures. Frames have two sub- and three-dimensional structures, each of which can be further classified as tubing systems or as three-dimensional tubing. A high-efficiency delivery system developed from the original tube design. See figure (1.1) for concrete structures versus structures with tall buildings.[4]

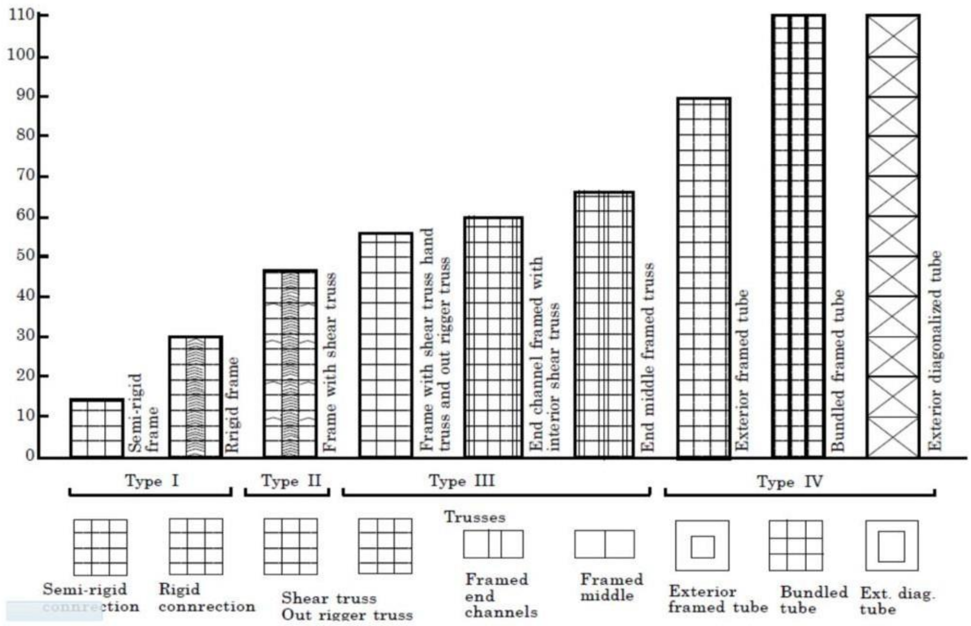


Figure 1.1: Types of Tall buildings

Selection of the structural system as well as awareness of how structural elements interrelate with mechanical and electrical components is crucial to an effective and economical building design. Typically, two to three distinct structural systems are chosen for comparison.[5]

1.2 LATERAL FORCE

In comparison to a linear increment with the height of vertical loads, lateral loads are variable and rapidly increase in height. For instance, under a uniform wind load, the overturning moment at the base varies proportionally to the square of the building's height, while the lateral deflection varies as the fourth force. In comparison to their lower brethren, tall buildings must weigh four factors: strength, rigidity, stability, and, increasingly, legality. Although strength is the primary consideration, as height increases, rigidity and stability requirements become more important and often dictate the design. There are two fundamental approaches to meeting rigidity and stability criteria. The first is to increase the size of members beyond what is needed for power. This method, however, has its own limitations, beyond which it becomes impractical or uneconomical. The second, more elegant solution is to modify the structure's configuration in order to make it naturally more rigid and stable. It's worth noting that there are no records of completed tall buildings collapsing due to wind loads. Analytically, it is possible to demonstrate that a tall building subjected to wind motion can collapse due to the so-called P effect, in which the eccentricity of the gravity load rises to such an extent that crushing of columns occurs as a result of high axial loads. As a result, a critical stability condition is to ensure that expected wind loads are less than the load associated with the stability cap. The second concern is to keep the lateral deflection low enough to avoid damaging architectural finishes and partitions. While less serious than the collapse of the main building, the floor-to-floor deflection, commonly referred to as inter-story drift, and must be restricted due to the expense of repairing windows and the danger of falling glass to pedestrians.[6]

1.2.1 Earthquake

Due to growing urbanization and population growth, there has been an increasing demand for tall building construction. The bane of such tall structures is the earthquake and wind load. Given the risk of earthquake forces, we need accurate mechanical instruments for evaluating structures by these forces. A thorough modeling of such earthquakes and wind loads therefore needs to be performed in order to assess the structure's behavior with a clear view of the potential damages. In recent decades, it has become important to study the structure of the various earthquakes and wind intensities and then to inspect various parameters at each level.[7]

1.3 SLAB

The gravity loads are carried by the floor system both during and after construction. It should be capable of adapting and incorporating fire resistance properties in heating, ventilation and conditioning systems. These systems may be categorized as bidirectional, one-way and beam and plate systems. Two-way systems provide column-supported flat plates, column-supporting flat plates or drop panels. The latter will transport long shears and moments. Constant density plates are used as well. Waffle plates are used as well. There are also two-way joists. One-way systems involve continuous thickness plates with ranges between 3m and 8m. Closely spaced joists are frequently used. The devices Beam and Slab use beams 1 to 4 meters apart. Board trays and girders are useful for the interior ductwork. In addition to integral floor plates, which house pipes, floors of small joists are often used.[8]

1.3.1 Types of Slab

The unilateral plate is one of the simplest solid plate shapes. Because of its low effectiveness and weight, it can only be considered economical for short spans (up to 4.6 m). Often and in particular cases, weight reduction can be accomplished using certain types of elements to generate hollow vacuums in the lath. [9] On the other side, the two-way slab is typically used for applications involving heavy loads and long spans. [10]

1.3.1.1 Flat Slab

A flat Slab is a bidirectional reinforced concrete plate, normally without beams and girders, and loads are passed directly to the supporting concrete columns. Their vertical and lateral loads are also affected. A lateral load of the building will normally rule the architecture, rather than a vertical one because of wind and earthquakes. Vertical load buildings cannot be able to withstand lateral loads. In the top floor instead of the ground floor, the lateral loads are significantly greater, since the building appears to be cantilever. [11]

1.3.1.2 Slab with Beam

The floor in a slab-beam system is made up of a beam and a slab. And the slab thickness is thin, and the beam depth is high, and the minimum slab thickness is 100 mm. The load is transferred from the slab to the beam from the beam to the column, which resists more earthquakes than the flat slab system. This system is more flexible.

1.3.1.3 Ribbed Slab

The ribs' directions are designed to move as much weight as possible to the main beams situated on the short axis. The columns, frame beams and ribs are designated as frame elements in the modeling process and the slab elements are identified as shell elements between the ribs and shear walls .[12]

1.4 COST

The structural costs normally represent 20 –30% of the total construction costs. For buildings above 50 floors, a maximum of one third of the structural expense is covered by the lateral bracing. Consequently, the lateral costs vary from 7 to 10 percent when compared with the overall building expense. It should be noted that, depending on its complexity and composition, only the cost of outer cladding can be half as much or can even exceed the total structural cost. The cost image also stands out for the heating, ventilation and air-conditioning system.[1]

Inherently, towers cost more than low-cost developments per unit floor space, take more to construct and build and are less effective in net terms. They have an intensive and complex interrelation, but are essential for the success of the project. The challenge is to squeeze every ounce of efficiency out of all – every dollar saved, every day removed from the schedule, and every square meter of lettable area generated within the same budget would relieve pressure on the bottom line.[13]

Figure 1.2: The fundamental financial drivers of high-rise buildings

1.4.1 The Increased Costs of a Tall Building Are Due

1- because of its higher wind loads and heaver frames

2- higher lifting numbers, capacity and speeds

3- Longer all due to its impressive capacities and the space required to accommodate MEP (mechanical, electrical, plumbing) plant and system facilities, and the control needs over vertical distances

4- The logistics of having a powerful building, including substantial cranes or hoists and increased onsite time

5- the size and uniqueness of the risks

6- Higher design quality and materials which represent a building that stands out, including the preserves to integrate an attractive interaction with the street scenery and an architectural statement at the pinnacle. [13]

1.4.2 Cost of Concrete

Compared to other materials such as steel, the extensive use of reinforced concrete construction, in particular in developing countries, is relatively low in cost. The cost of building varies with the area and depends heavily on local practice. A typical residential building made of reinforced concrete, for example, costs about US$100/m2 in India, US$250/m2 in Turkey, and US$500/m2 in Italy.[14]

As the building's height rises above 10 levels (high buildings), the weight of the structure both for its functions and its economy needs to be reduced. A 5% decrease in floor weight and wall weight, for example, will contribute to the 50% decrease in ground level weight. This ensures that the columns on the lower floor become smaller and more space available and the base design is reduced.[8]

1.5 THE FINITE ELEMENT SOFTWARE

Reasonable approaches are good starting values to ensure an "accurate" analysis. In small model simulations, we can observe the action of high buildings subject to lateral loads and use matrix analyzing programmes [15] [16], for example ETABS, SAP2000 and STRUDL. Heuristic expertise can also be available in the form of industry experience and high-level construction experts.[15]

A computer is used to ensure that the design is appropriate and measurement accurate, too. The software results are very accurate, but the error may be in the entry parameters. [17]

1.5.1 ETABS Software

ETABS Software: The groundbreaking new ETABS is the most modern, integrated building analysis and design software program. The new ETABS provides a sophisticated and comprehensive range of design capabilities for matelas wedges and intriguing graphic displays, reports and schematic drawings based on modeling and displays, as well as quick linear and nonlinear analytical ability. Direct converting CAD drawings into ETABS models is possible. Design of stainless and cement frames, composite bars, composite columns, shear walls of stainless steel and cement as well as of the stainless steel connecting and base plate's capability control. For all analysis and design production, full and customizable reports are available, with framing plan, specifications, and cross sections for con- and stainless steel structures produced. Design drawings.[18]

1.5.2 SAFE Software

SAFE is a program designed specifically for the design of elevated floor and foundation slab systems. Traditional three-dimensional modeling, analysis, as well as post-tensioning shear and beam detailing, incorporates a variety of other three-dimensional elements, such as soil-column or wall-columns parallel gradients. Uses will import models, loading and displacement fields for further local evaluation of slab systems within larger structures into Safe for interoperability with SAP2000 and ETABS.

1.6 AIM OF THE STUDY

In this study, a high-rise building was designed to resist the lateral force represented by winds and earthquakes through the design of structures software, with three types of floors and calculating the quantities of concrete and reinforcing steel to compare between them and to find which is more economical.

2. LITERATURE REVIEW

Krishna, Chandrashekar and Rajashekar **(2015)** [18] With accu efficient in solution and ensuring that the final design of a structure is serviceable for its intended purpose during its design life, the structural engineer faces the task of seeking the most effective and economical Design. This project consists of an RCC-framed building (Parking floor +5), studied and constructed under the side effects of wind and earthquake loading by ETABS. This project presents (Extended Three Dimensional Analysis of Building system). ETABS has all major static, dynamic, linear, non-linear analytical engines, etc. and this software is used for the study and the design of buildings in particular. The buildings must be designed according to the arrangements of the project participants, and this software takes into consideration the beams, columns, as the members of the line; plates, staircases and walls are as the members of the surrounding areas due to the facility given in this software. The multistoried building structural analysis and design, designed by ETABS. The revolutionary software is much easier than the staad pro. It is more appropriate for constructing high-rise buildings under applied live, dead, wind, earthquake, and seismic loads. Lightweight concrete and lighter materials decrease the dead load of the structure, thereby reducing the size of columns, footings and other load-bearing elements by the structurally constructed builder.

M.Pavani, G.Nagesh Kumar and Dr. Sandeep Pingale **(2015)** [19] The world is often under pressure to develop high-rise buildings with irregular stiffness, despite the fact that these structures are responsive to seismic loading. Today, tall buildings are increasingly slimmer and can have more influence compared to previous high-rise buildings. It is possible to monitor its complex response by improving the structural systems of large buildings. With more suitable structural shapes such as tube and shear walls, enhanced material properties. The overall conception of the modern bearing wall construction method depends on how the floors and the roof structures combine with the walls. The floor structure brings vertical loads and lateral loads to the foundation walls, serving as a diaphragm. Wind and earthquake lateral forces are normally resisted by shear walls that are parallel to lateral load direction.

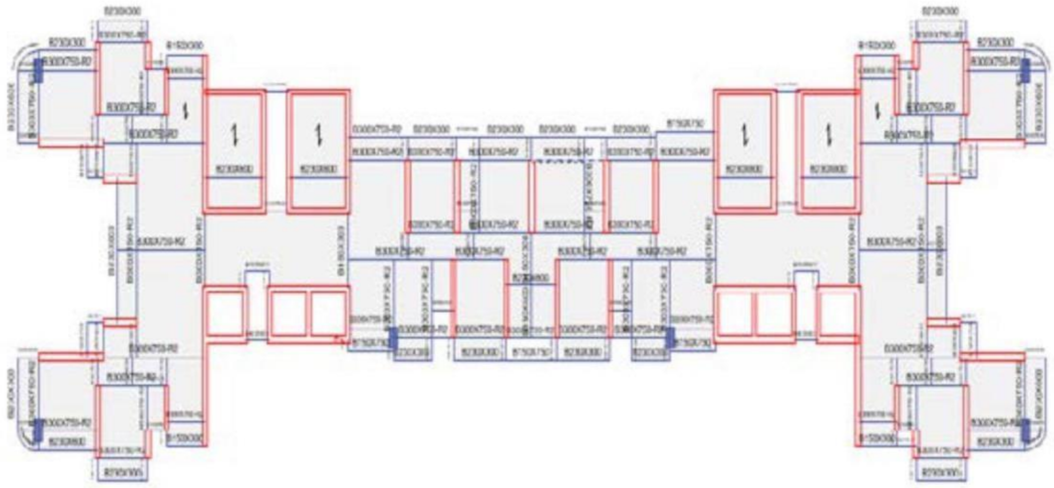


Figure 2.1: Typical Floor

These shear walls transmit lateral loads to the base through their shearing resistance and resistance to overturning. In this study, a building of 45 floors, there is no sudden change in plan since, if sudden changes occur, the structure could be subjected to the rigidity/torsional irregularities of building if the horizontal force is small in size or less. First of all, the optimization methods used in this project are seen as the scale of the shear wall is identical in the house, and the study takes effect from the result that the failed shear wall dimensions are enlarged to resist the entire construction. In this current project, the program is used to build and optimize shear walls Etabs and shear walls are arranged to withstand the lateral forces in the system in the area of Zone III. Due to the presence of shear walls at all potential deflection points, damage caused by wind and earthquake forces can be controlled.

B.Anjaneyulu and K.Jaya Prakash **(2016)** [20] A flat slab is best defined as a plate without beams on supports (such as columns or walls).Due to a large Bending Moment & Shear Forces near the columns are created. The flat plate building system is one in which beams used in traditional building methods are removed. The slab rests directly on the column and the load from the slab is moved straight into the columns and then to the base. The thickness of the slab close to the column is increased to withstand heavy loads and these are referred to as drops, or columns usually come with lengthened heads called column heads. It results in a bland ceiling without beams, making it less prone to damage from fire than when beams are removed.

The simple ceiling provides better light, is easier to build and needs less expensive type of work. Because of differences in local construction techniques and materials, different nations have different methods for building flat roofs. Finite element analysis & Equivalent frame analysis is done using ETABS software. The Equivalent Frame method is performed with a stalled and non-stalled column as defined in the codes as IS 456-2000, ACI 318-08. Moments are distributed as moments of column strip and center strip. The above-noted codes have been applied to implement this project to create an interior panel with flat slab sizes 6.6 x 5.6 m and super-imposed loads 7.75 kN/m2.

Flat plate/slab construction is an emerging technology in India. Flat slabs have many advantages over traditional slabs and can thus be a very good choice for modern constructions requiring structural stability as well as cutting-edge aesthetic aspects and prospects.

The plate may be formed and constructed by either traditional or post-tensioning reinforced concrete. However, the post-tensioning system in India is more expensive, so reinforced concrete should be used for spans that are up to 10 meters long.

Salman I Khan and Ashok R Mundhada **(2015)** [21] Seismic efficiency of high buildings with different systems of reinforced cement slabs. It concentrates on the system of the flat plate and grid plate. These two systems include the most appealing and often used floor systems, in particular during tall building. Due to its reduced floor to floor height, the flat floor building in which columns support a floor was recently built in several buildings. Grid slabs are monolithic slabs with thin beams spaced at regular intervals in perpendicular directions. Buildings with a grid slab and those with a flat slab have similar seismic results, but there are some variations. Tall buildings with flat slab systems are less shear resistant, whereas those with grid/conventional floor systems are more durable but taller and less functionally friendly.

Navyashree and Sahana **(2014)** [22] The behavior of commercial buildings multi-story with flat slabs and traditional RC frame compares with that with two-way slabs with beams, and the impact of building height has been studied on the output by seismic forces in these two types of building. This work provides a valuable knowledge source of parameters such as lateral shifting, store drift, shear, column moments and axial forces. And they found

• For all types of columns, the lateral displacement was greatest at terrace level. As the building level increased, the lateral displacement also increased. The traditional RCC building had less lateral displacement than the flat slab building. The gap between the two ranged from 28 to 57 points (percent).

• As the height increased, the natural time span lengthened (No. of stories).

• The time span was more suited to flat slab construction than traditional construction. The gap between the two ranged between 14 and 33. (percent).

• The story drift in flat slab construction buildings was substantially greater than in traditional RCC buildings. As a result, additional moments were created. As a result, the columns of such structures should be constructed with additional moments induced by drift in mind. The gap between the two ranged from 28 to 60 points (percent).

Makode et al. **(2014)** [23] Discussing flat slab and grid slab system seismic results. The authors have modelled a 12-story building with a flat plate and grid plate in their paper and analysed the structure using the Response Spectrum Process. Axial power, base shear and shelving drift results shall be seen. This has been noticed by the authors:

1. In both the X and Y directions, the base shear of a flat slab building was less than the base shear of a grid slab building.

2. In comparison to grid slab buildings, the axial force in the end columns of flat slab buildings was lower.

3. In flat slab buildings, the axial force in intermediate columns was greater than in grid slab buildings. (Figure 2.2)

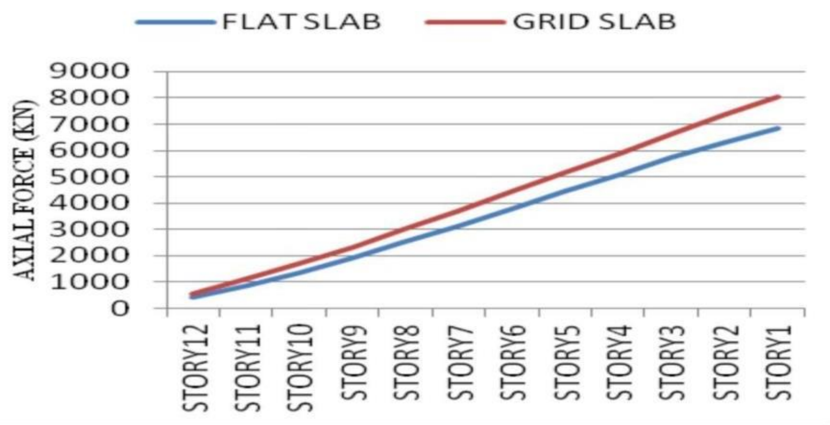


Figure 2.2: Axial Force in End Columns

4. The highest shear force was reported in column of story 3.

5. Building drift in flat slab and grid slab construction was within acceptable limits in both the X and Y directions for zone II and soil type II.

6. In both the X and Y directions, grid slab buildings had less building drift than flat slab buildings in each story.

Mohamed A A El-Shaer's **(2013)** The lateral analysis for tall buildings due to seismic performance for various reinforced concrete slab systems was shown. The author looked at three different systems: flat slab, ribbed slab, and paneled beam slab. The three systems are the most appealing and typically used floor systems, especially in high-rise buildings. The declared non-ductile flat slab structure presents a major risk in high seismicity areas; brittle punching failure results from the transfer of shearing forces and unbalanced moments between slab and columns, which can trigger a progressive building collapse.

Direction	Flat Slab	Panneled Beams	Ribbed Slab
X (m)	0.466	0.415	0.202
Y (m)	1.68	1.3	1.29

Table 2.1: Displacement in X and Y-Direction for Three Systems

Harish et. al. **(2017)** [24] Grid floor/Ribbed floor plate consists of beams that are spaced at regular intervals in • Monolithic and slab direction. These slabs are commonly used for architectural purposes for large spans such as public assembly halls, auditoriums, and show rooms where a large column-free space is needed. Because the gird dalle provides more stiffness, the rectangular voided pattern • is used in the analysis. In this study, the building of G+4 is examined, analysed and planned in accordance with the IS codes for gravitational, seismic and wind load. The design is evaluated by manually using the ETABS program. Seismic activity analysis includes mostly equivalent and spectrum response methods.

P. de Jong and H. Wamelink **(2008)** [25] In developing high buildings, the Netherlands is hardly a leader. Just a few Dutch high-rise buildings have actually been completed. However, there are several proposals that make this an appropriate period to increase the study of construction costs. The integration and evaluation of established European research is based on a cost model. The aim was to obtain a comprehensive estimation of building costs in the initiative and early planning periods for the building of high rise buildings while restricting to those identified during the initiative the number of necessary design parameters. The study started with a literature review and an expert interview that focused on high-level projects and cost modeling.

Construction costs are just part of the management characteristics of a project. The earnings potential of high-rise buildings is more constrained compared to low-rise projects by the efficiency of floor plans (the ratio of lettable floor area to gross floor area). Externalities become very critical when the feasibility limits of high-level projects are reached. The qualities delivered have to persuade many stakeholders. The buildings with larger structures have a higher cost, and subsequently higher rents. Good build cost and better product cost control are both important, but it is the quality of the product that ultimately motivates clients to pay these high rents.

D. Ajema1 and A. Abeyo **(2018)** [26] The aim of this study is to look at issues like careful assessment, comparing overall behavior (shear, bending, and Storey Deflections), and comparing a frame with a solid slab and a ribbed slab when seismic weight is considered. The research was carried out in Ethiopia for frames with solid slabs and ribbed slabs in the same seismic zone (Zone-4) and on the same soil class or form (soil type A). This reduces the column size, foots and other load bearing components, enabling the selection of the most economic structure with a strong bending ability, shear and floor deflection resistance. Found that the Frame with Slab, Shear and Storey Deflection Resistance is more suitable for commercial structures (such as malls, hotels, etc.). In economic terms the frame with ribbed slab using hollow concrete blocks is cheaper than the frame.

The results are shown as follows:

1. Solid slab frame is more cost effective than Ribbed slab frame. Since Ribbed Slab's self-weight is higher than Solid Slab, the dimensions of the columns and beams used are thus often larger and need a larger amount of steel for strengthening.

2. Solid Slab frame has less seismic weight than Ribbed Slab frame which will allow the Structure to have a good shear, bending and store resistance capabilities.

Reema R. Nassar and Imad A. Al-Qasem **(2020)** [27] Estimating costs is an important part of any project's preparation. The quantities, costs, and expense of the resources needed for any project are predicted by the method. The cost of slabs for any building project varies due to variations in construction methods between different types of slabs. The purpose of this study is thus to assess the variations in building costs for four different types of flooring systems between various construction methods available. A 3D structural model was analyzed and modeled using computer software under a static gravity load (ETABS v.16). In this analysis, a 3D model with different slab systems, such as solid, ribbed (one and two way), and flat plate slab, was developed. The quantity and cost estimates for every system were subsequently surveyed and the quantity costs for each of them were prepared. Finally, it is the Flat Plate Slab System that is chosen as the most economical system.

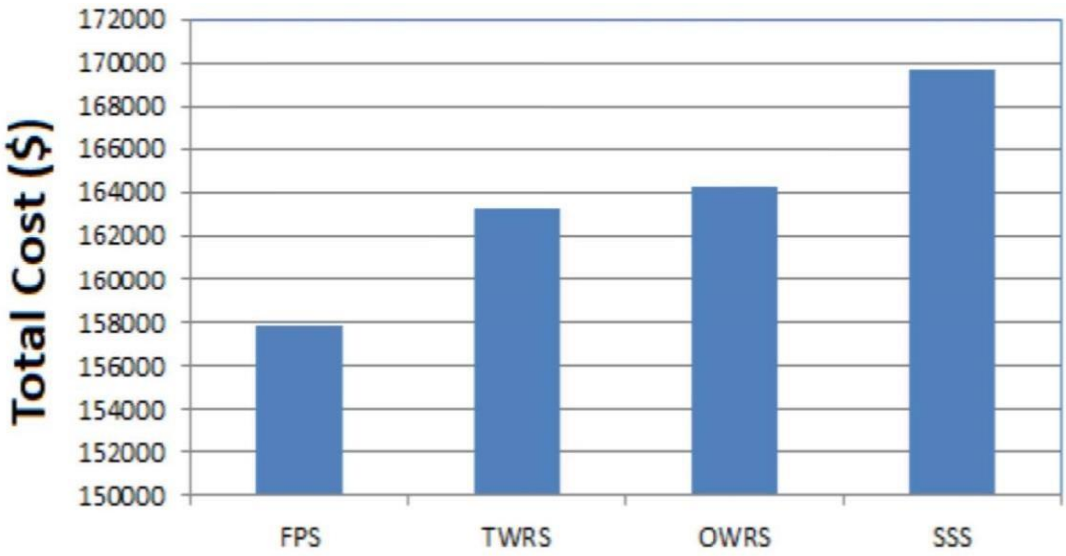


Figure 2.3: The total cost of construction for each type

• The cost of a floor slab in construction will range from 13 to 16 percent of the total cost of the structure. The percentages are as follows: • 13.71 percent for FPS, 16.56 percent for SSS, 16.23 percent for TWSS, and 16.1 percent for OWSS of total structure expense.

• The flat plate system is more economical than any other. It is cost-effective since there are no beams on the flat plate system. This enables the level of the floor to be reduced by (10-15%).

• The results show that the overall cost of construction is reduced by 7 percent with a flat plate system compared with a solid plate system, by 4 percent with the one-way ribbed platform system and by 3,33% in comparison with a two-way ribbed platform system.

3. EXPERIMENTAL WORK AND RESULT

3.1 GENERAL INTRODUCTION

A 15-storey hospital building was designed with three types of floors and their types are as follows (Slab with beam- Flat slab - Ribbed slab) and in this research, ETABS program was used to design a shear wall, column and beam after applying a Lateral force on the building, which is the strength of winds and earthquakes, and the SAFE program was used to design the three Types of floors that were mentioned previously. After designing all the structural sections, the rebar and concrete quantities were calculated in Microsoft Excel, and these quantities were priced in order to know which types are more economical.

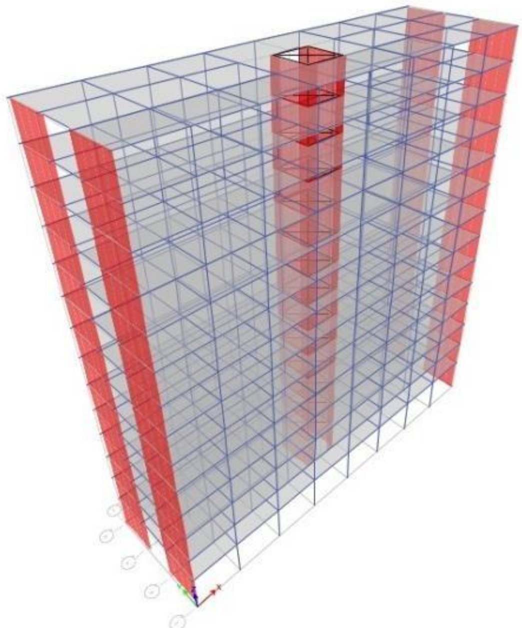


Figure 3.1: Building 15 Story 3D views

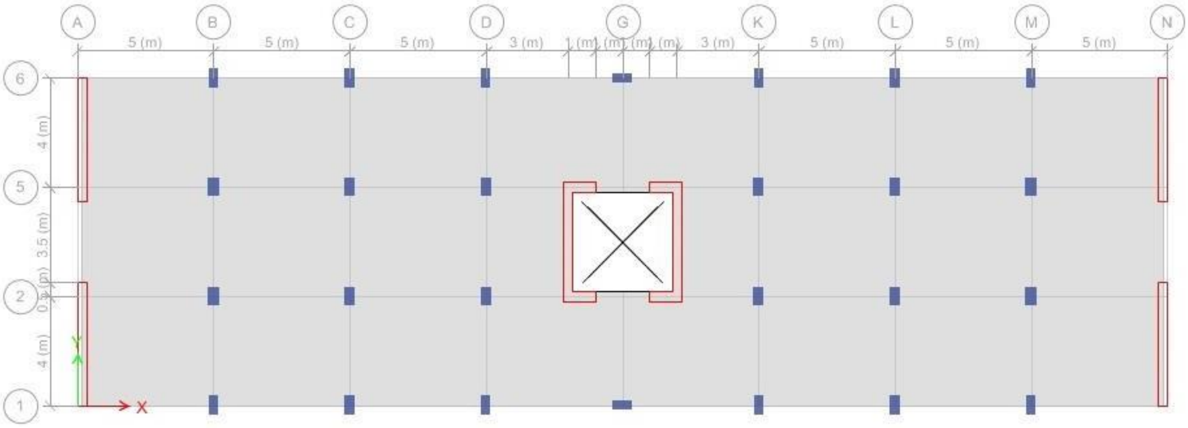


Figure 3.2: Building plan view

3.2 STRUCTURAL DESIGN

3.2.1 Story Data

Name	Height mm	Elevation mm	Master Story	Similar To
roof	3000	43000	No	Story11
Story13	3000	40000	No	Story11
Story12	3000	37000	No	Story11
Story11	3000	34000	Yes	None
Story10	3000	31000	No	Story6
Story9	3000	28000	No	Story6
Story8	3000	25000	No	Story6
Story7	3000	22000	No	Story6
Story6	3000	19000	Yes	None
Story5	3000	16000	No	Story1
Story4	3000	13000	No	Story1
Story3	3000	10000	No	Story1
Story2	3000	7000	No	Story1
Story1	4000	4000	Yes	None
Base	0	0	No	None

Table 3.1: Story Data

3.2.2 Material Properties

A- Concrete Strength FCU 30

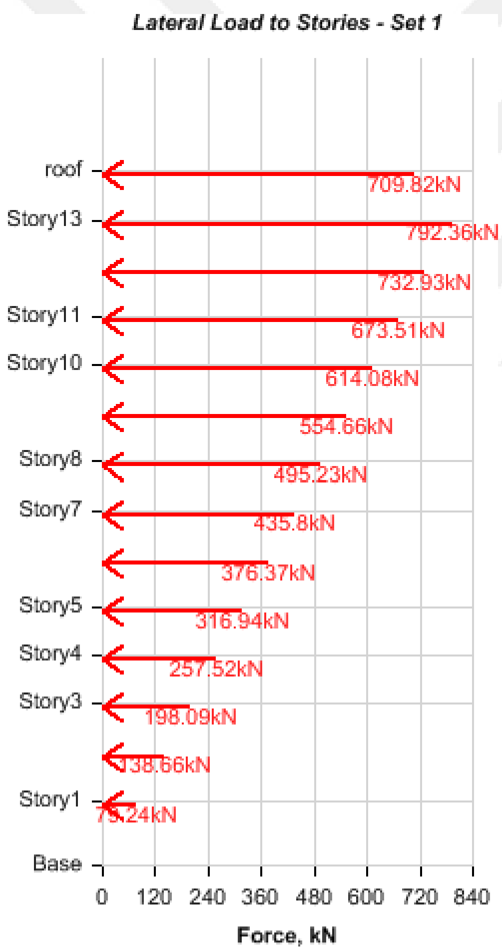
B- Steel Strength FY 420

3.2.3 Load Patterns

A- Live Loads 3 kN/m^2 for normal stories, Live Loads 1.5 kN/m^2 for top floor

B- Finishing 1.5 kN/m^2

C- Lateral Forces



Story	Elevation	Y-Dir
	m	kN
roof	43	709.82
Story13	40	792.36
Story12	37	732.93
Story11	34	673.51
Story10	31	614.08
Story9	28	554.66
Story8	25	495.23
Story7	22	435.8
Story6	19	376.37
Story5	16	316.94
Story4	13	257.52
Story3	10	198.09
Story2	7	138.66
Story1	4	79.24
Base	0	0

Table 3.2: Lateral Forces

3.2.4 Structure Analysis

Load Case/Combo	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m
Dead	0	0	65832.4813	394994.8876	-1316650	0
Live	0	0	21736.4425	130418.655	-434728.8501	0
Finishing	0	0	9712.0275	58272.165	-194240.55	0
EXY	0	-6375.21	-1.057E-06	187608.0301	2.265E-05	-140143.0538

Table 3.3: Base Reactions

Story	Diaphragm	Mass X kg	Mass Y kg	XCM m	YCM m	Cumulative X kg	Cumulative Y kg	XCCM m	YCCM m
roof	D1	473169.92	473169.92	20	6	473169.92	473169.92	20	6
Story13	D1	534199.93	534199.93	20	6	1007369.85	1007369.85	20	6
Story12	D1	534199.93	534199.93	20	6	1541569.78	1541569.78	20	6
Story11	D1	534199.93	534199.93	20	6	2075769.72	2075769.72	20	6
Story10	D1	536914.93	536914.93	20	6	2612684.64	2612684.64	20	6
Story9	D1	540394.71	540394.71	20	6	3153079.35	3153079.35	20	6
Story8	D1	540394.71	540394.71	20	6	3693474.06	3693474.06	20	6
Story7	D1	540394.71	540394.71	20	6	4233868.77	4233868.77	20	6
Story6	D1	540394.71	540394.71	20	6	4774263.48	4774263.48	20	6
Story5	D1	541828.68	541828.68	20	6	5316092.16	5316092.16	20	6
Story4	D1	543434.74	543434.74	20	6	5859526.9	5859526.9	20	6
Story3	D1	543434.74	543434.74	20	6	6402961.64	6402961.64	20	6
Story2	D1	543434.74	543434.74	20	6	6946396.37	6946396.37	20	6
Story1	D1	565473.35	565473.35	20	6	7511869.73	7511869.73	20	6

Table 3.4: Centers of Mass and Rigidity

3.3 REINFORCED CONCRETE DESIGN

3.3.1 Shear Wall

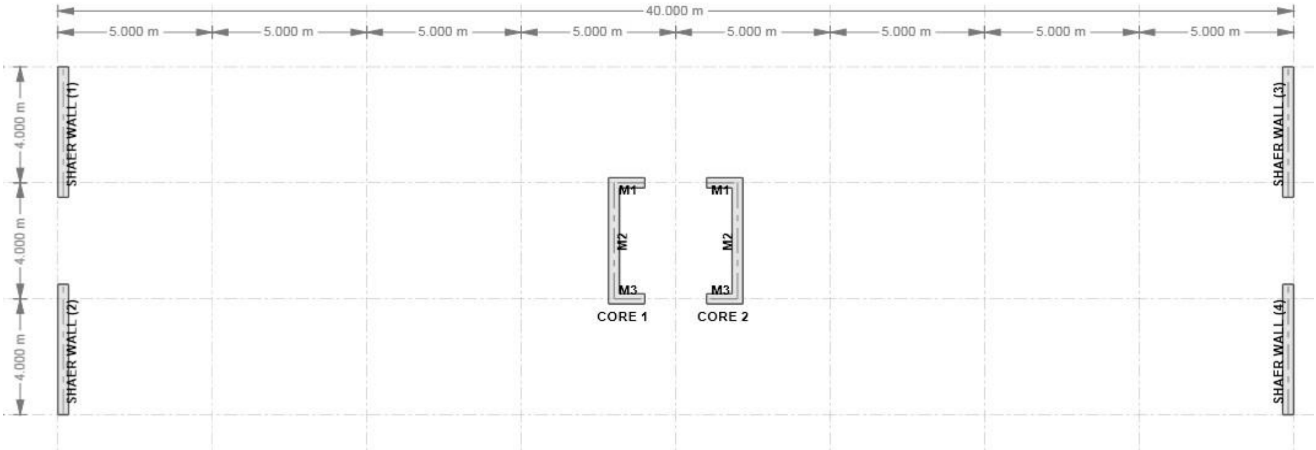


Figure 3.3: Shear wall and Core shear wall

3.3.1.1 Dimensions

The dimensions of the shear wall are the thickness of 35 cm and the width 4 meters, and they are four walls that are similar in corners.

The dimensions of the core shear wall are 25 cm thick, (M1) is 1 meter in width, (M2) is 4 meters, and (M3) is 1 meter, and they are two similar walls.

3.3.1.2 Rebar

The design of the rebar in the shear wall for the three types of buildings is similar because the same lateral force is applied to it.

One structural element for the shear wall and core shear wall will be taken and the details of its rebar will be explained, and another part explanation will be indicated in the Appendices.

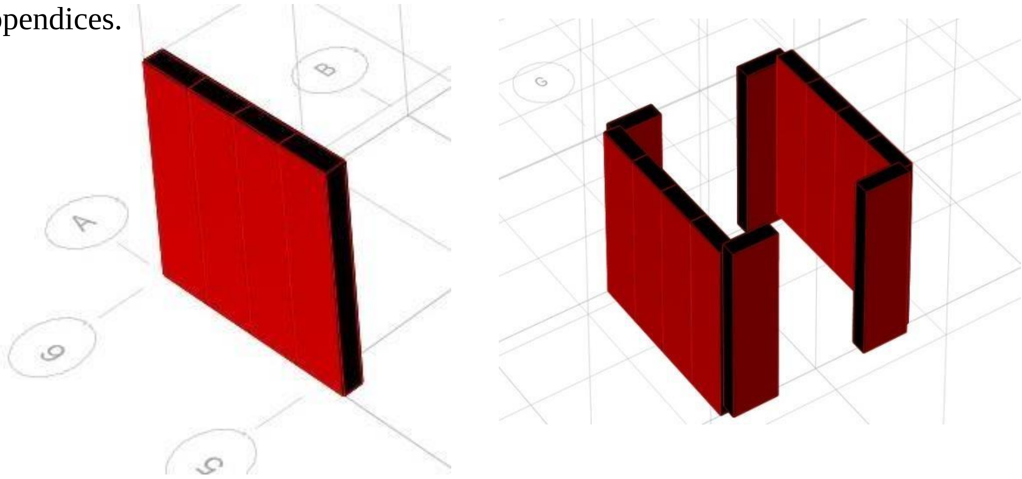


Figure 3.4: Location of Shear Wall and Core Shear Wall

3.3.1.2.a Flexural Design For Shear Wall (1) Story (1)

Table 3.5: Flexural Design for Pu, Mu2 and Mu3

Station Location	Required Rebar Area (mm²)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm²
Top	10785	0.0068	0.0121	UDWal6	-368.1019	-27.505	-6463.4763	1575000
Bottom	15260	0.0097	0.0121	UDWal6	-242.1019	10.7199	-9757.7007	1575000

3.3.1.2.b Shear Design For Shear Wall (1) Story (1)

Table 3.6: Shear Design

Station Location	ID	Rebar mm²/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	ΦV_c kN	ΦV_n kN
Top	Leg 1	875	UDWal3	8671.1035	6347.2808	853.0977	1549.4048	2541.6548
Bottom	Leg 1	875	UDWal3	8875.8535	9759.6716	853.0977	987.4558	1979.7058

3.3.1.2.c Reinforcement Detailing For Shear Wall (1) Story (1)

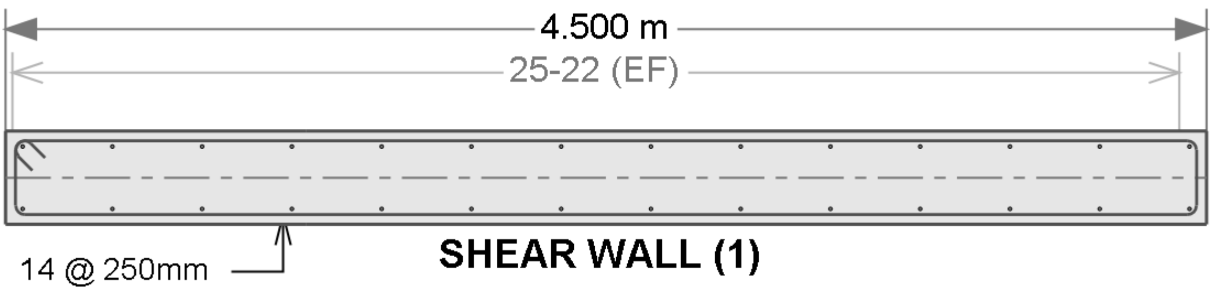


Figure 3.5: Reinforcement Detailing for shear wall

3.3.1.2.d Flexural Design For Core Shear Wall Story (1)

Flexural Design for (M1) and (M3)

Table 3.7: Flexural Design for Pu, Mu2 and Mu3

Station Location	Required Rebar Area (mm²)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm²
Top	6122	0.0175	0.0210	UDWal11	-1829.0698	1.2177	-136.132	350000
Bottom	6007	0.0172	0.0210	UDWal11	-1801.0698	22.8781	127.8449	350000

Flexural Design for (M2)

Table 3.8: Flexural Design for Pu, Mu2 and Mu3

Station Location	Required Rebar Area (mm²)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm²
Top	3500	0.0025	0.0076	UDWal12	2441.9378	-4.8091	-4396.8493	1400000
Bottom	8112	0.0058	0.0076	UDWal11	2553.9378	2.4046	8657.8101	1400000

3.3.1.2.e Shear Design For Core Shear Wall Story (1)

Shear Design for (M1) and (M3)

Table 3.9: Shear Design

Station Location	ID	Rebar mm²/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	ΦV_c kN	ΦV_n kN
Top	Leg 1	875	UDWal9	-1257.7788	-139.1854	67.4539	23.014	243.514
Bottom	Leg 1	875	UDWal9	-1212.2788	130.6301	67.4539	24.3214	244.8214

Shear Design for (M2)

Table 3.10: Shear Design

Station Location	ID	Rebar mm²/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	ΦV_c kN	ΦV_n kN
Top	Leg 1	875	UDWal9	4707.3765	4396.8493	1065.2402	1025.0987	1907.0987
Bottom	Leg 1	875	UDWal9	4889.3765	8657.8101	1065.2402	866.8483	1748.8483

3.3.1.2.f Reinforcement Detailing For Core Shear Wall Story (1)

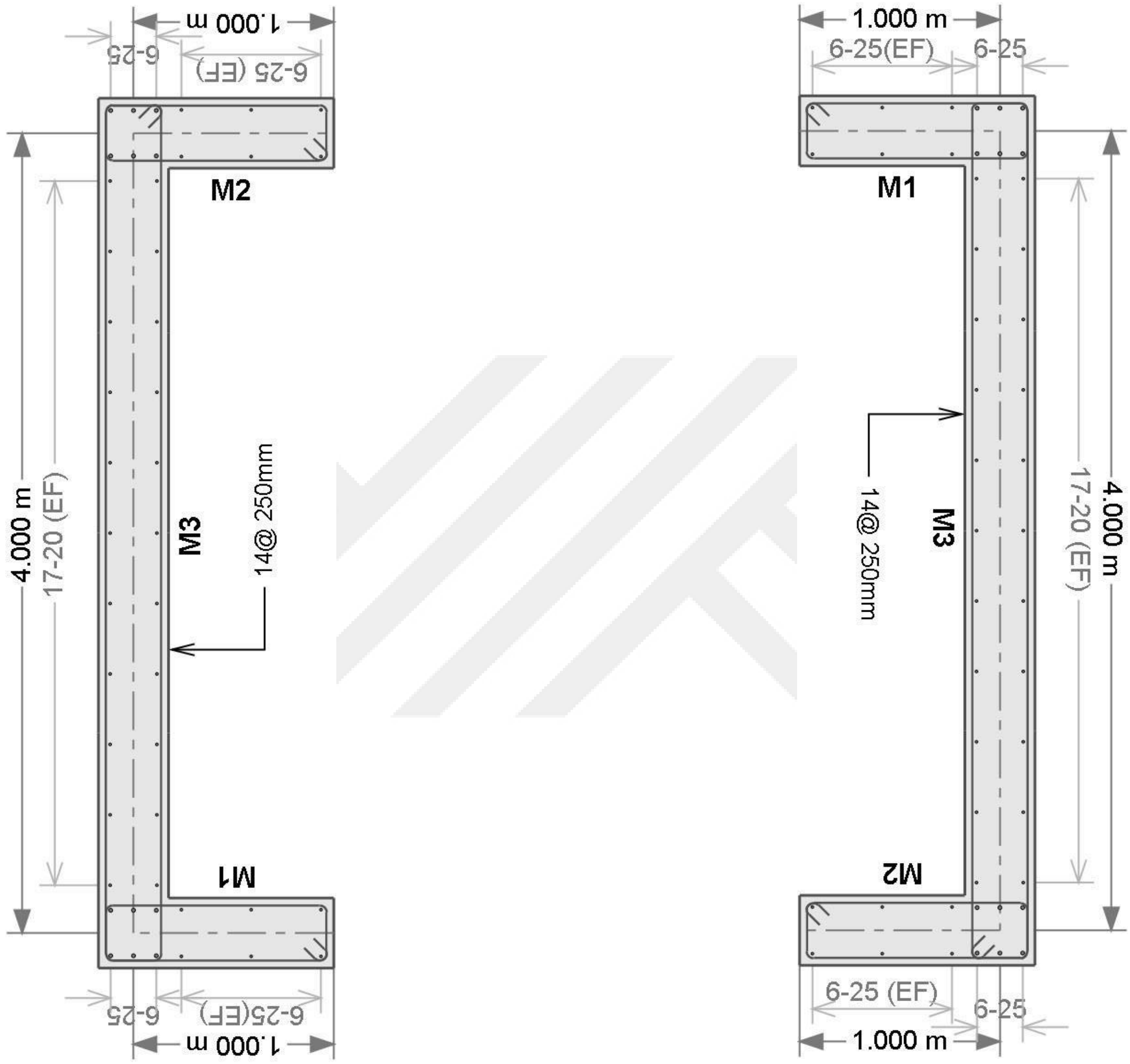
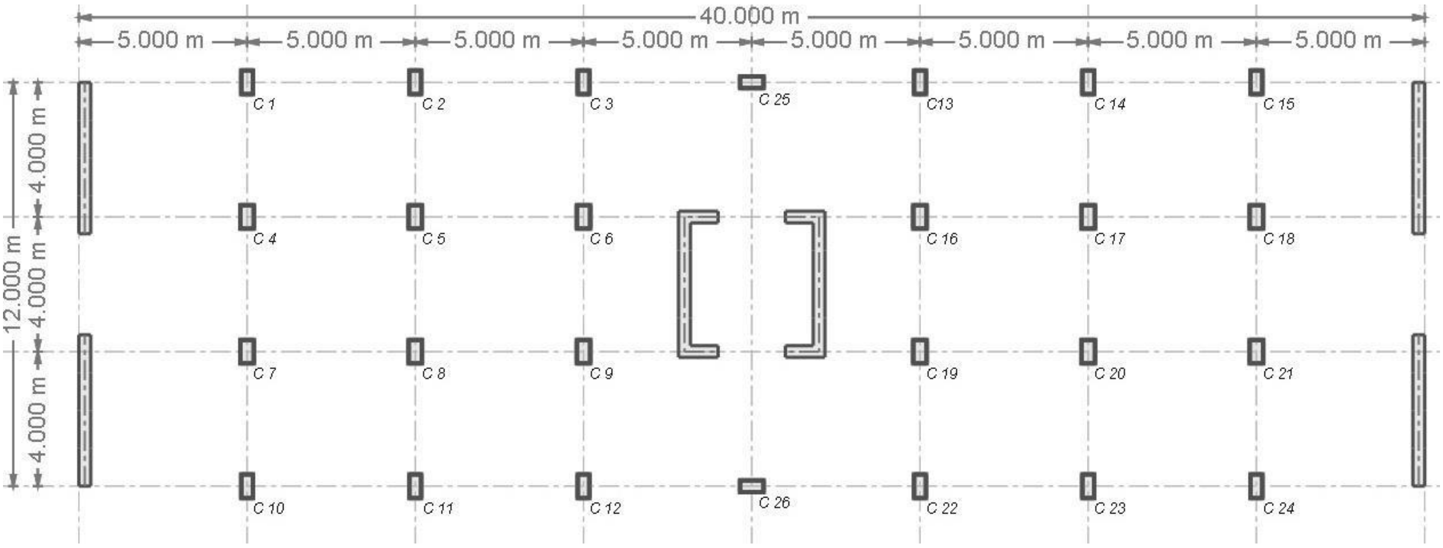


Figure 3.6: Reinforcement Detailing for core shear wall

3.3.2 Column



3.3.2.1 Dimensions

The dimensions of the Column:

A- Between 1-5 floors: 40x70 cm x cm

B- Between 6-10 floors: 35x70 cm x cm

C- Between 11-Roof Floors: 35x60 cm x cm

3.3.2.2 Rebar

The design of the rebar in the Column for the three types of buildings is almost similar because the same load is applied to it

One structural element for the Column will be taken and the details of its rebar will be explained, and another part explanation will be indicated in the Appendices.

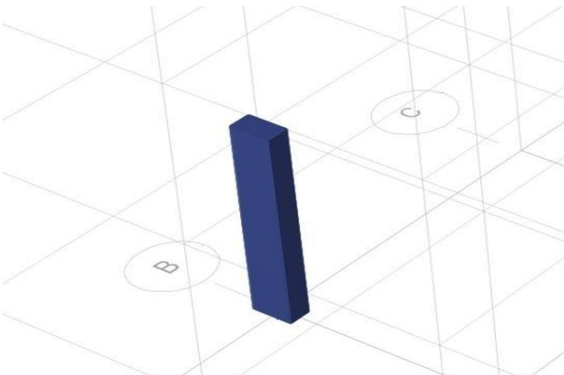


Figure 3.8: Location of Column (C1) Story (1)

3.3.2.2.a Flexural Design For Column (C1) Story (1)

Table 3.11: Axial Force and Biaxial Moment Design For Pu , Mu2 , Mu3

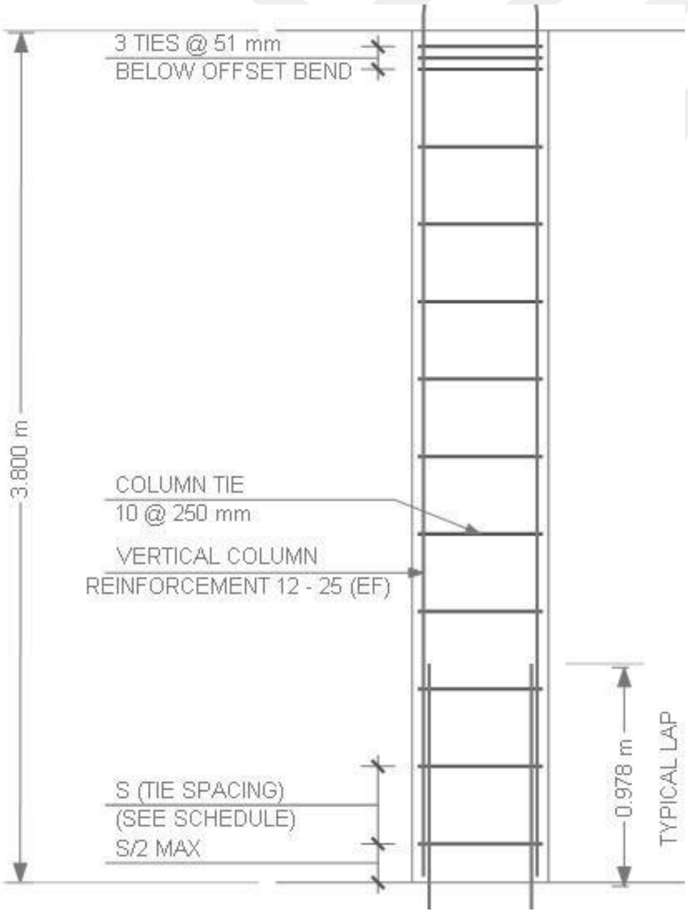
Design P_u kN	Design M_{u2} kN-m	Design M_{u3} kN-m	Minimum M2 kN-m	Minimum M3 kN-m	Rebar Area mm^2	Rebar % %
921.891	-32.9295	25.1123	33.4093	25.1123	2800	1

3.3.2.2.b. Shear Design For Column (C1) Story (1)

Table 3.12: Shear Design for Vu2 , Vu3

	Shear V_u kN	Shear ΦV_c kN
Major, V_{u2}	0.5201	179.8975
Minor, V_{u3}	5.0572	193.5027

3.3.2.2.c Reinforcement Detailing For Column (C1) Story (1)



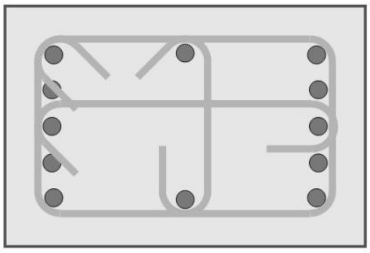


Figure 3.9: Reinforcement Detailing for Column (C1) story (1)

3.3.3 Beams

3.3.3.1 Couple Beam

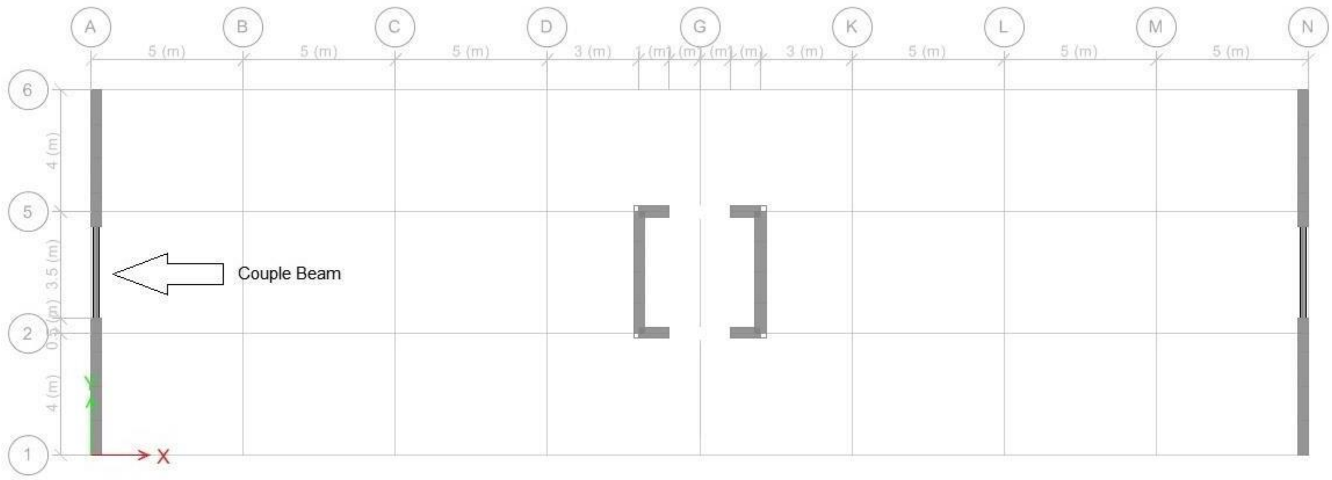


Figure 3.10: Couple Beam

3.3.3.1.a Dimensions

The Dimensions of Couple Beam is Width 20 cm and the Depth 80 cm

3.3.3.1.b Rebar

The design of the rebar in the Couple Beam for the three types of buildings is similar because the same lateral force is applied to it.

One structural element for the Couple Beam will be taken and the details of its rebar will be explained, and another part explanation will be indicated in the Appendices.

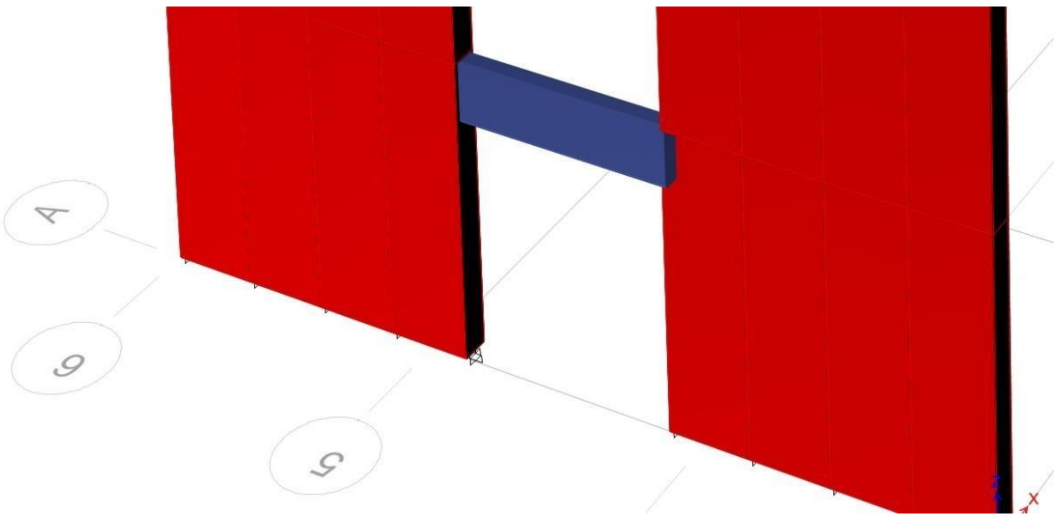


Figure 3.11: Location of Couple Beam Story (1)

3.3.3.1.b1 Design Moment and Flexural Reinforcement for Moment

Table 3.13: Design Moment and Flexural Reinforcement for Moment, Mu3

	Design -Moment kN-m	**Design +Moment kN-m**	**-Moment Rebar mm^2**	**+Moment Rebar mm^2**	**Minimum Rebar mm^2**	**Required Rebar mm^2**
Top (+2 Axis)	-203.0722	+78.791	755	292	755	755
Bottom (-2 Axis)	-182.9149	+86.8847	680	323	680	680

3.3.3.1.b2 Shear Force and Reinforcement for Shear

Table 3.14: Shear Force and Reinforcement for Shear, Vu2

Shear V_{u2} kN	**Shear ΦV_c kN**	**Shear ΦV_s kN**	**Shear V_p kN**	**Rebar A_v /S mm^2/m**
149.4476	91.5267	57.921	143.3063	248.91

3.3.3.1.b3 Torsion Force

Table 3.15: Torsion Force

Φ*T_u kN-m	**Tth kN-m**	**Tcr kN-m**	**Area A_o cm^2**	**Perimeter, p_h mm**
0.1188	3.9051	15.6206	671.5	1644.4

3.3.3.1. b4 Reinforcement Detailing for Couple Beam

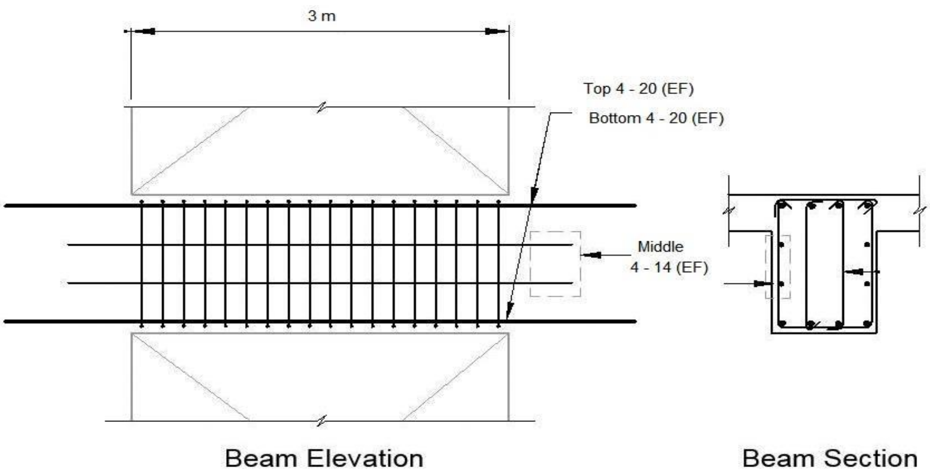


Figure 3.12: Reinforcement Detailing for Couple Beam

3.3.3.2 Drop Beam (Slab with Beam)

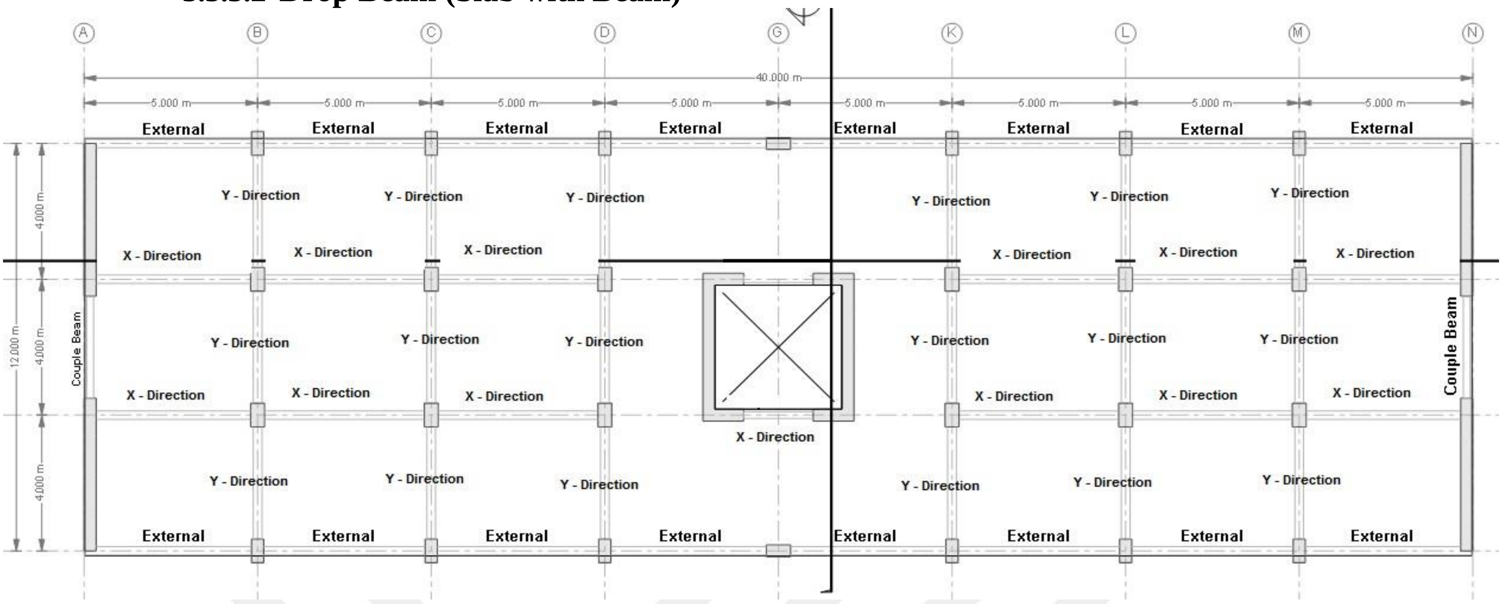


Figure 3.13: Drop Beam in the type (Slab with Beam)

3.3.3.2.a Dimensions

The Dimensions of Drop Beam is Width 25 cm and the Depth 60 cm

3.3.3.2.b Rebar

One structural element for the Drop Beam will be taken and the details of its rebar will be explained, and another part explanation will be indicated in the Appendices.

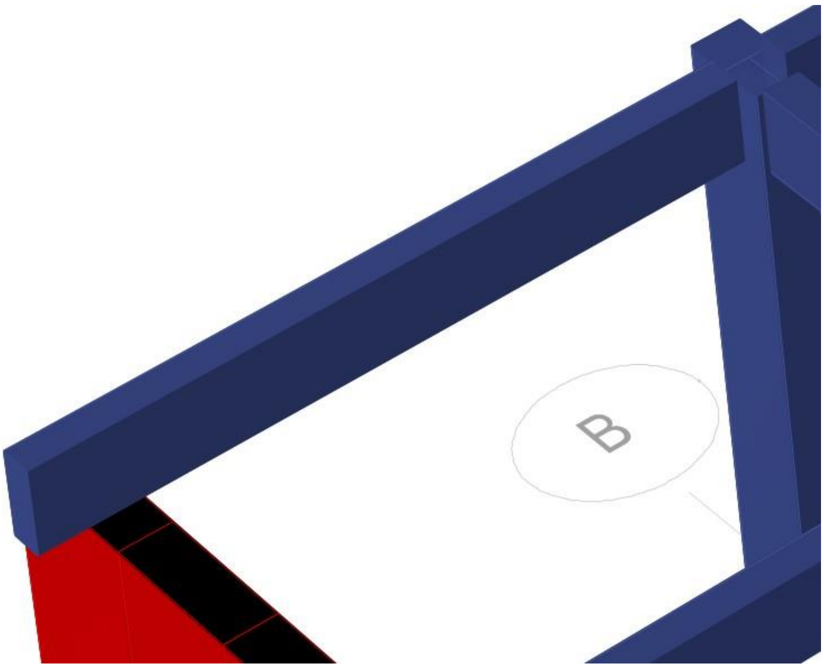


Figure 3.14: Location of External Drop Beam Story (1)

3.3.3.2. b1 Design Moment and Flexural Reinforcement for Moment

Table 3.16: Design Moment and Flexural Reinforcement for Moment, Mu3

	Design -Moment kN-m	Design +Moment kN-m	-Moment Rebar mm^2	+Moment Rebar mm^2	Minimum Rebar mm^2	Required Rebar mm^2
Top (+2 Axis)	-36.8075	+49.0766	183	244	244	244
Bottom (-2 Axis)	-24.6034	+32.1813	120	157	157	157

3.3.3.2.b2 Shear Force

Table 3.17: Shear Force, Vu2

Shear V_{u2} kN	Shear ΦV_c kN	Shear V_p kN
36.0956	82.374	10.5374

3.3.3.2.b3 Torsion Force

Table 3.18: Torsion Force, Tu

$\Phi * T_u$ kN-m	Tth kN-m	Tcr kN-m	Area A_o cm^2	Perimeter, p_h mm
0.4385	4.0379	16.1518	699.9	1344.4

3.3.3.2. b4 Reinforcement Detailing for Drop Beam

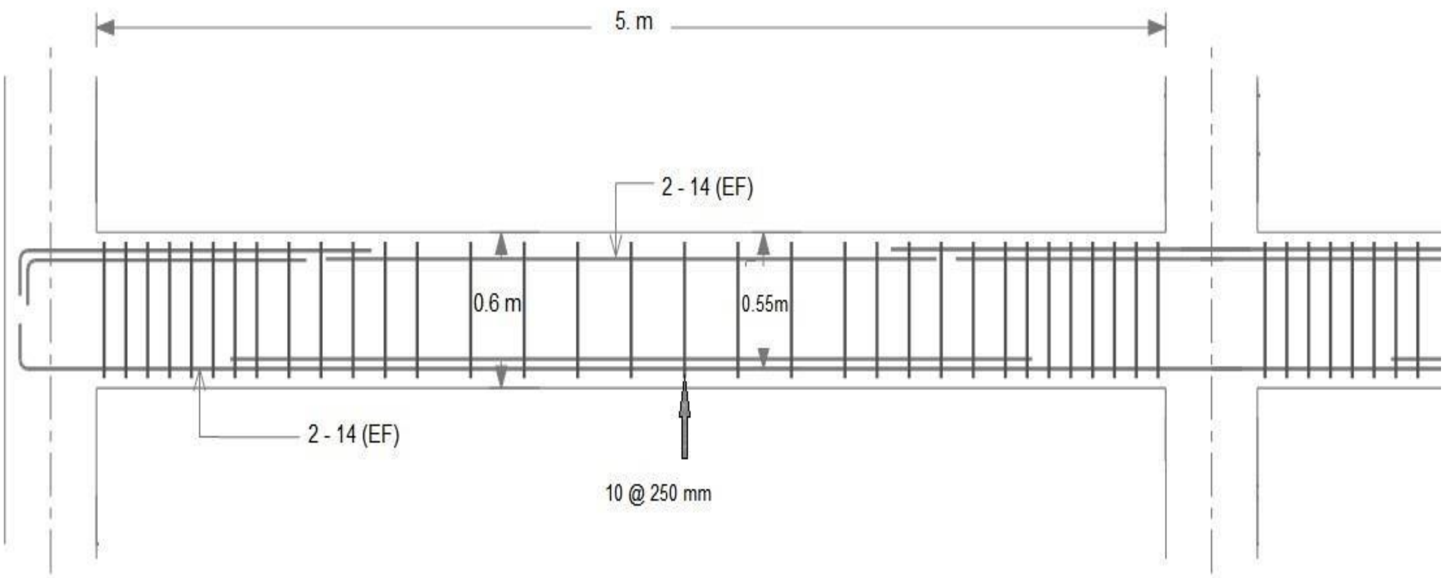


Figure 3.15: Reinforcement Detailing for Drop Beam

3.3.3.3 Drop Beam (Flat Slab)

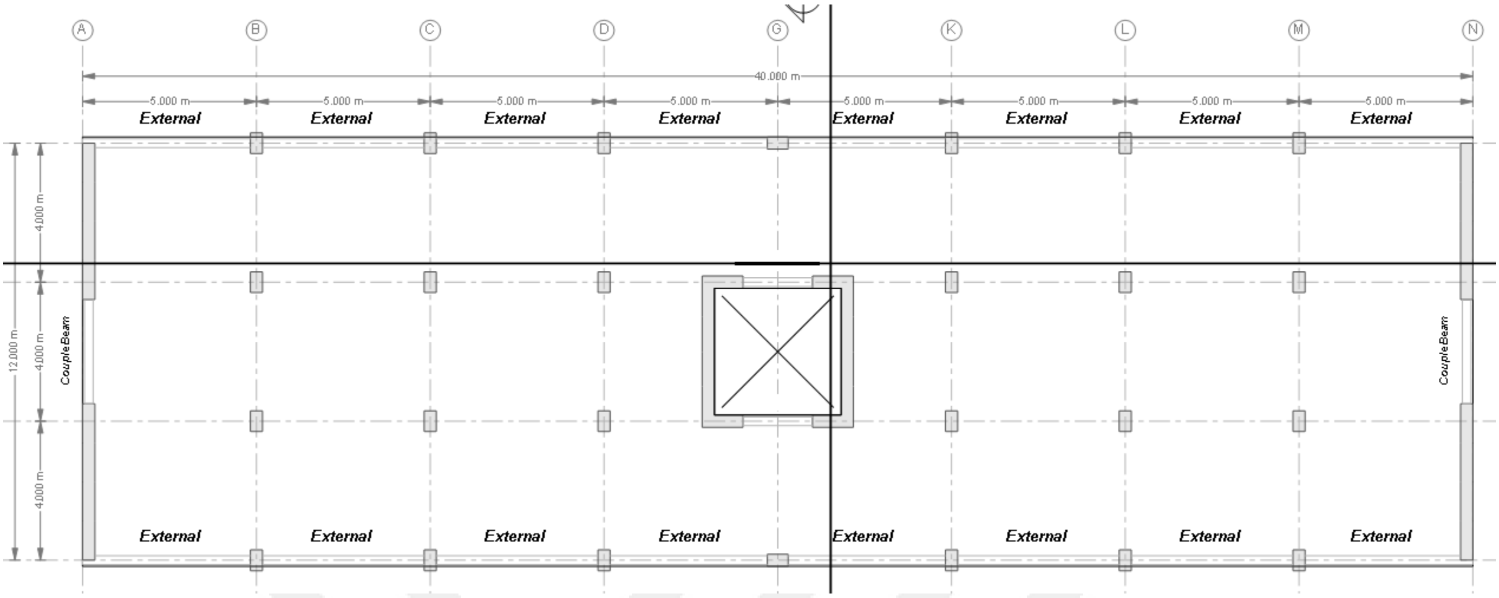


Figure 3.16: Drop Beam in the type (Flat Slab)

3.3.3.3.a Dimensions

The Dimensions of Drop Beam is Width 25 cm and the Depth 60 cm

3.3.3.3.b Rebar

One structural element for the Drop Beam will be taken and the details of its rebar will be explained, and another part explanation will be indicated in the Appendices.

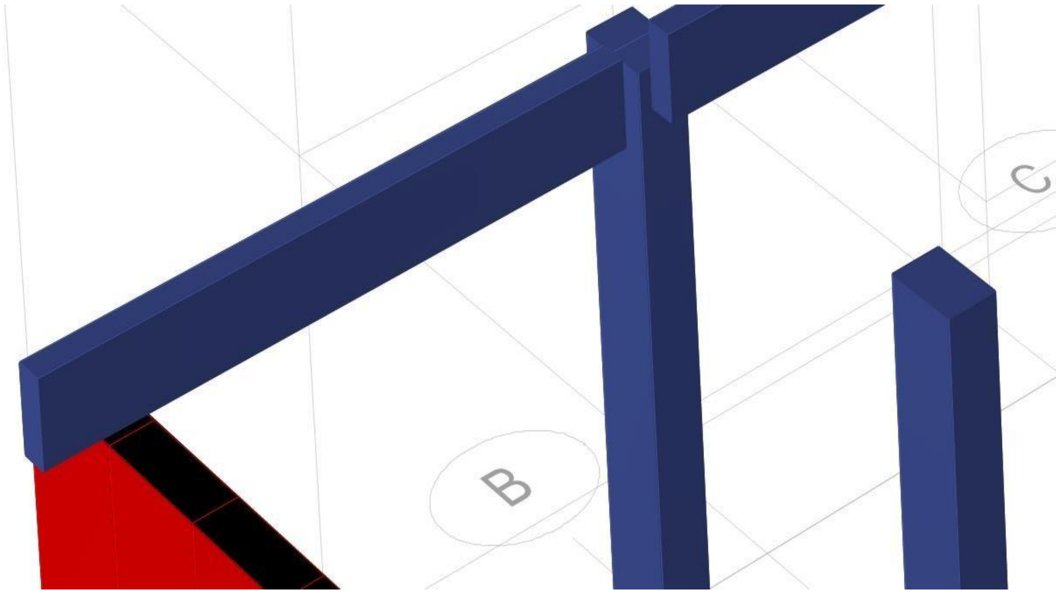


Figure 3.17: Location of External Drop Beam Story (1)

3.3.3.3. b1 Design Moment and Flexural Reinforcement for Moment

Table 3.19: Design Moment and Flexural Reinforcement for Moment, Mu3

	Design -Moment kN-m	Design +Moment kN-m	-Moment Rebar mm^2	+Moment Rebar mm^2	Minimum Rebar mm^2	Required Rebar mm^2
Top (+2 Axis)	-42.3152	+56.4202	211	281	261	281
Bottom (-2 Axis)	-52.0034	+45.5001	169	148	169	169

3.3.3.3.b2 Shear Force

Table 3.20: Shear Force, Vu2

Shear V_{u2} kN	Shear ΦV_c kN	Shear V_p kN
42.3659	82.374	12.9892

3.3.3.3.b3 Torsion Force

Table 3.21: Torsion Force Tu

Φ*T_u kN-m	Tth kN-m	Tcr kN-m	Area A_o cm^2	Perimeter, p_h mm
1.5437	4.0379	16.1518	699.9	1344.4

3.3.3.3. b4 Reinforcement Detailing for Drop Beam

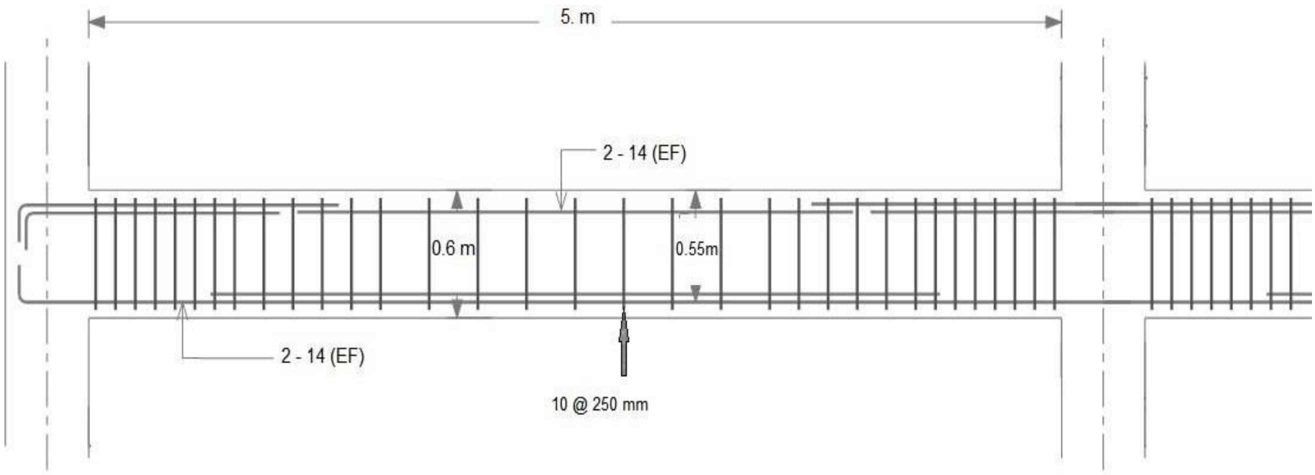


Figure 3.18: Reinforcement Detailing for Drop Beam (flat slab)

3.3.3.4 Hidden Beam (Ribbed Slab)

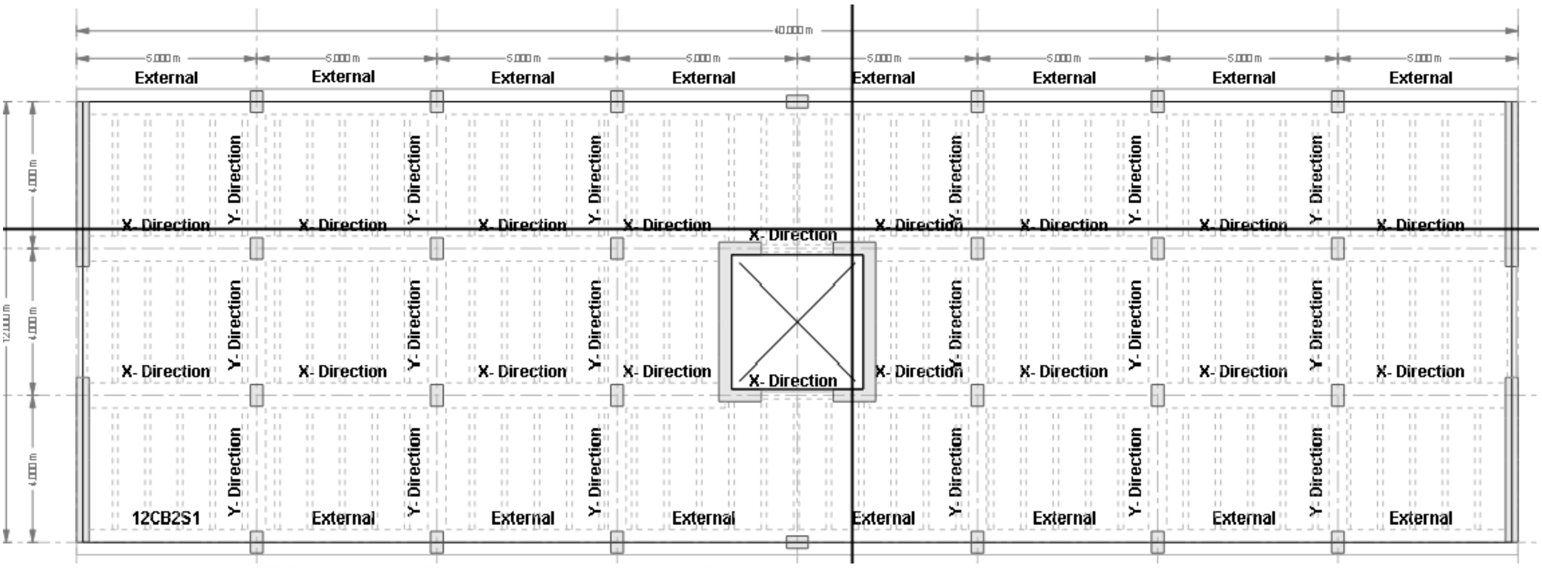


Figure 3.19: Hidden Beam in the type (Ribbed Slab)

3.3.3.4.a Dimensions

The Dimensions of Hidden Beam

A –The External beam Width 70 cm and the Depth 27 cm

B –The Horizontal beam Width 70 cm and the Depth 27 cm

C –The Vertical beam Width 50 cm and the Depth 27 cm

3.3.3.4.b Rebar

One structural element for the Drop Beam will be taken and the details of its rebar will be explained, and another part explanation will be indicated in the Appendices.

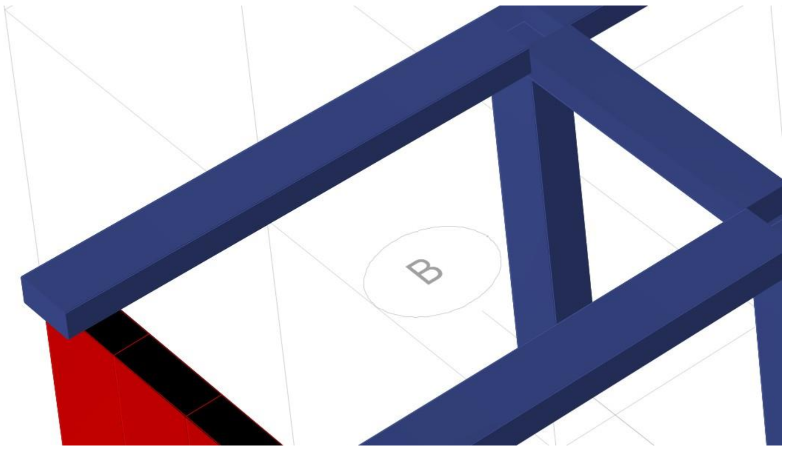


Figure 3.20: Location of External Hidden Beam Story (1)

3.3.3.4. b1 Design Moment and Flexural Reinforcement for Moment

Table 3.22: Design Moment and Flexural Reinforcement for Moment, Mu3

	Design -Moment kN-m	Design +Moment kN-m	-Moment Rebar mm²	+Moment Rebar mm²	Minimum Rebar mm²	Required Rebar mm²
Top (+2 Axis)	-46.4976	+40.4372	612	527	612	612
Bottom (-2 Axis)	-8.6720	+37.0643	113	483	483	483

3.3.3.4.b2 Shear Force

Table 3.23: Shear Force, Vu2

Shear V_{u2} kN	Shear ΦV_c kN	Shear V_p kN
49.1353	89.6961	9.3222

3.3.3.4.b3 Torsion Force

Table 3.24: Torsion Force, Tu

Φ^*T_u kN-m	Tth kN-m	Tcr kN-m	Area A_o cm²	Perimeter, p_h mm
1.077	5.6176	22.4703	940.7	1584.4

3.3.3.4.b4 Reinforcement Detailing for Hidden Beam

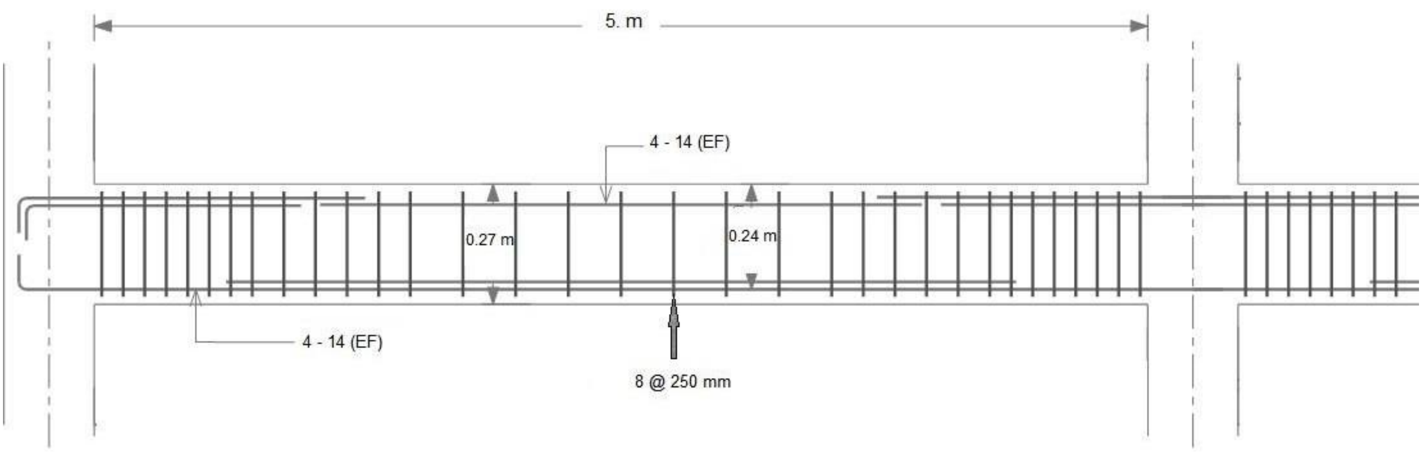


Figure 3.21: Reinforcement Detailing for Hidden Beam (Ribbed slab)

3.3.4 Slab

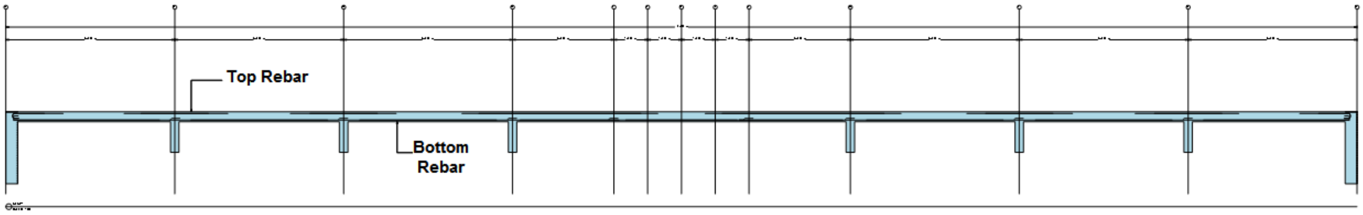


Figure 3.22: X- directions Reinforcement

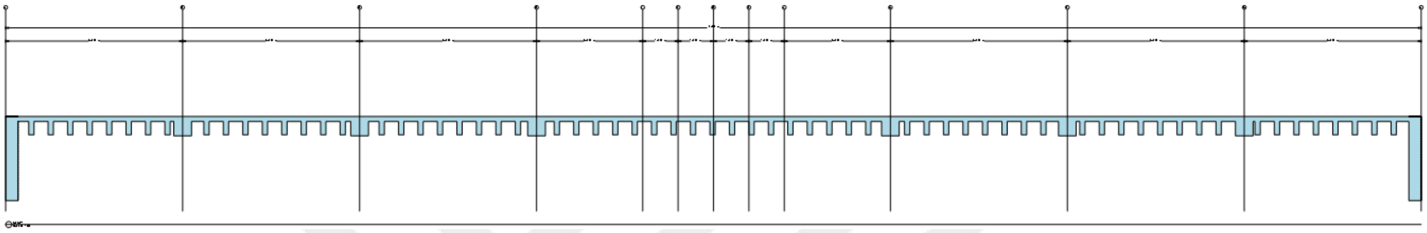


Figure 3.23: X- directions Ribs

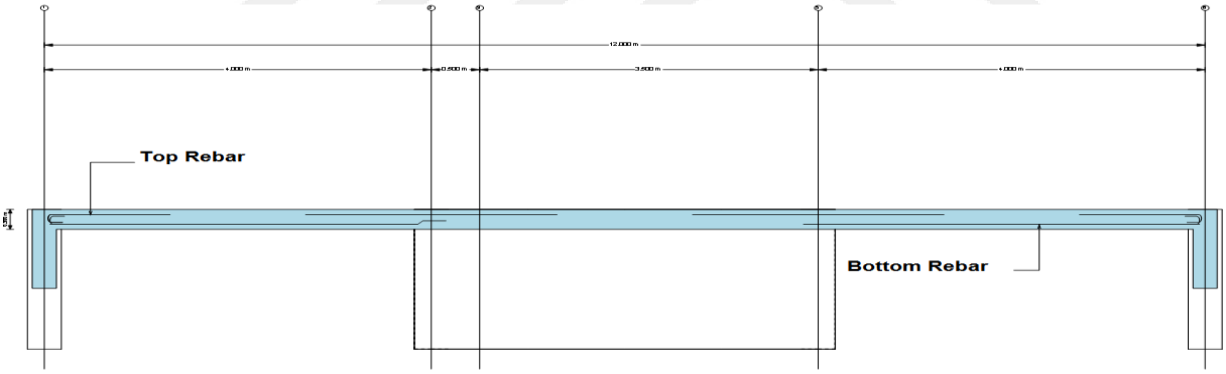


Figure 3.24: Y- directions Reinforcement

3.3.4.1 Slab with Beam

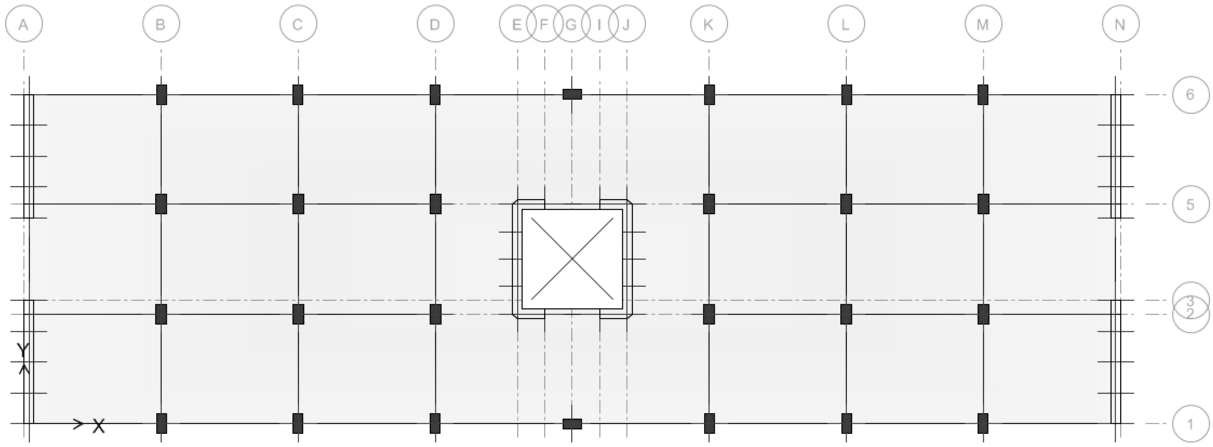


Figure 3.25: Slab with Beam

3.3.4.1.a Dimensions

Thickness is 15 cm

3.3.4.1.b Rebar

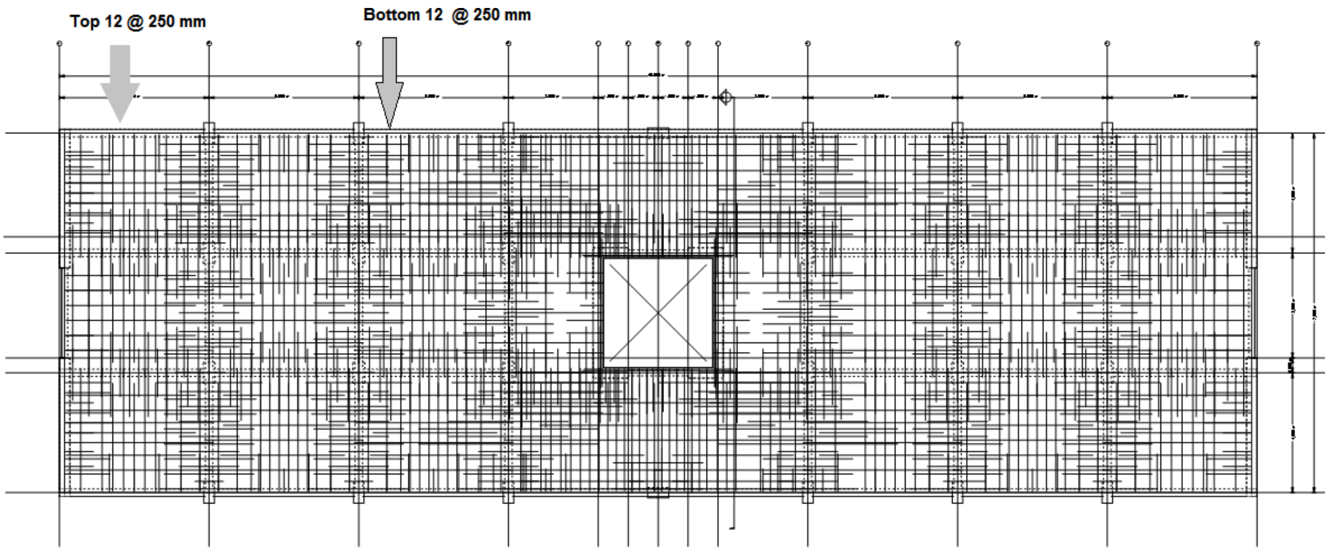


Figure 3.26: Reinforcement Detailing for Slab with Beam

3.3.4.1.c Story Displacement

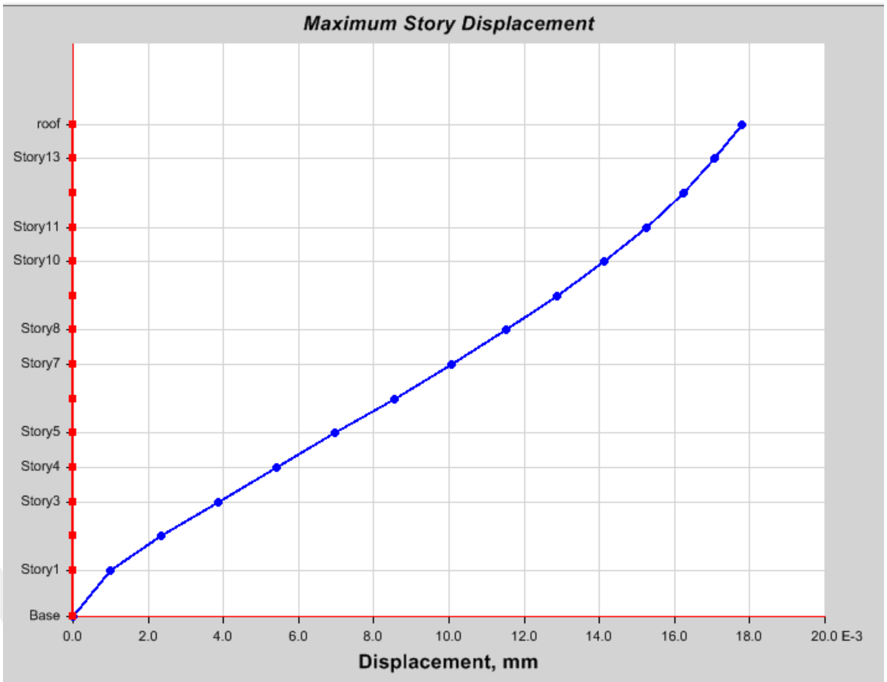


Figure 3.27: Maximum Story Displacement

3.3.4.1.d Story Drifts

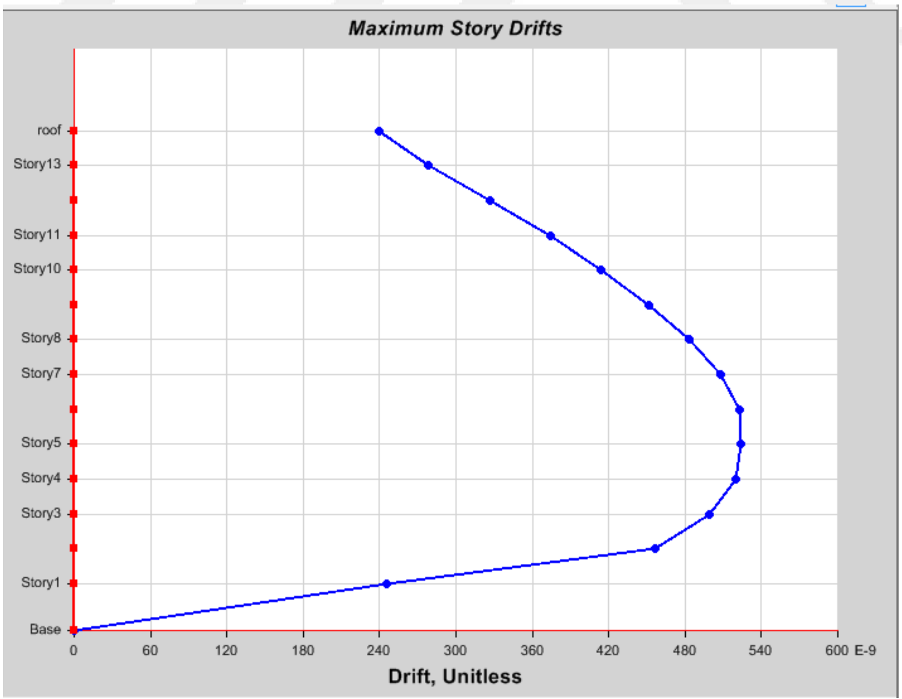


Figure 3. 28: Maximum Story Drifts

3.3.4.2 Flat Slab

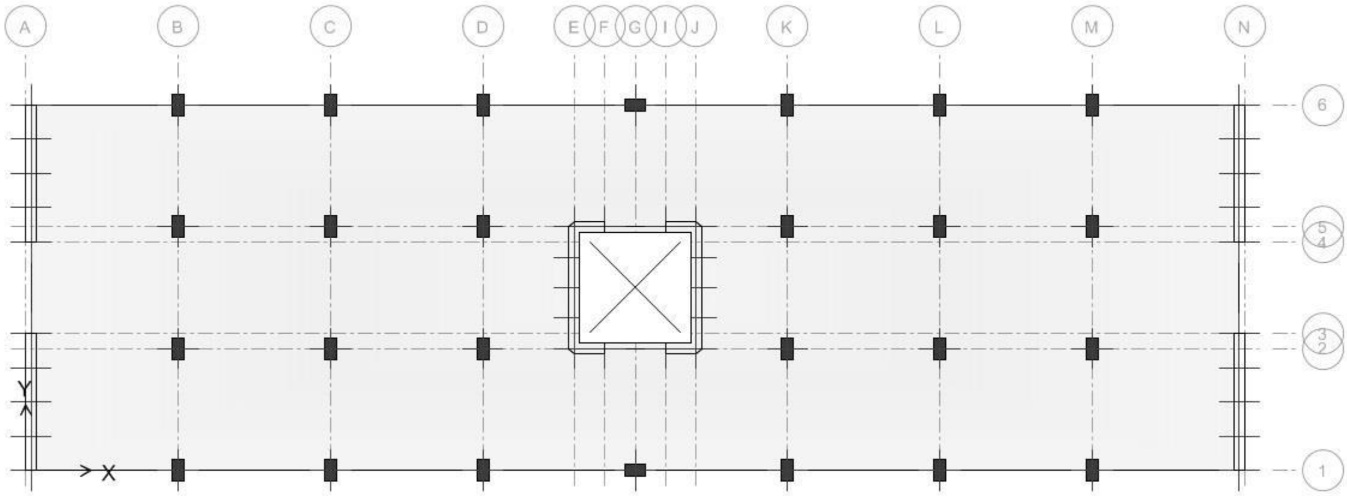


Figure 3.29: Flat Slab

3.3.4.2.a Dimensions

Thickness is 18 cm

3.3.4.2.b Rebar

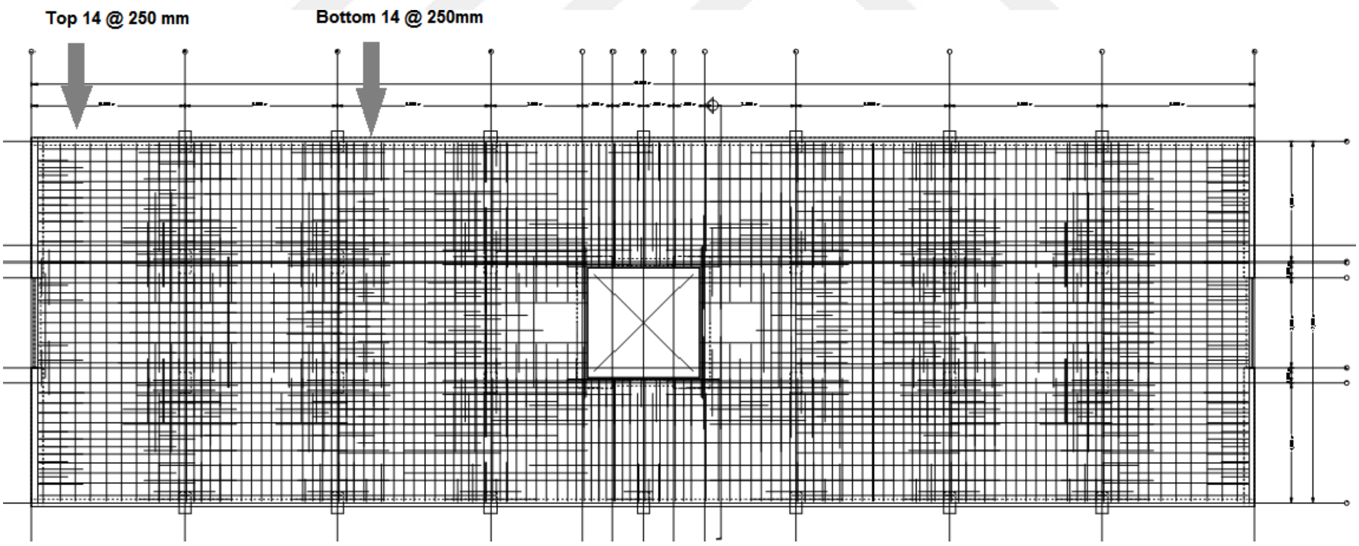


Figure 3.30: Reinforcement Detailing for Flat Slab

3.3.4.2.c Story Displacement

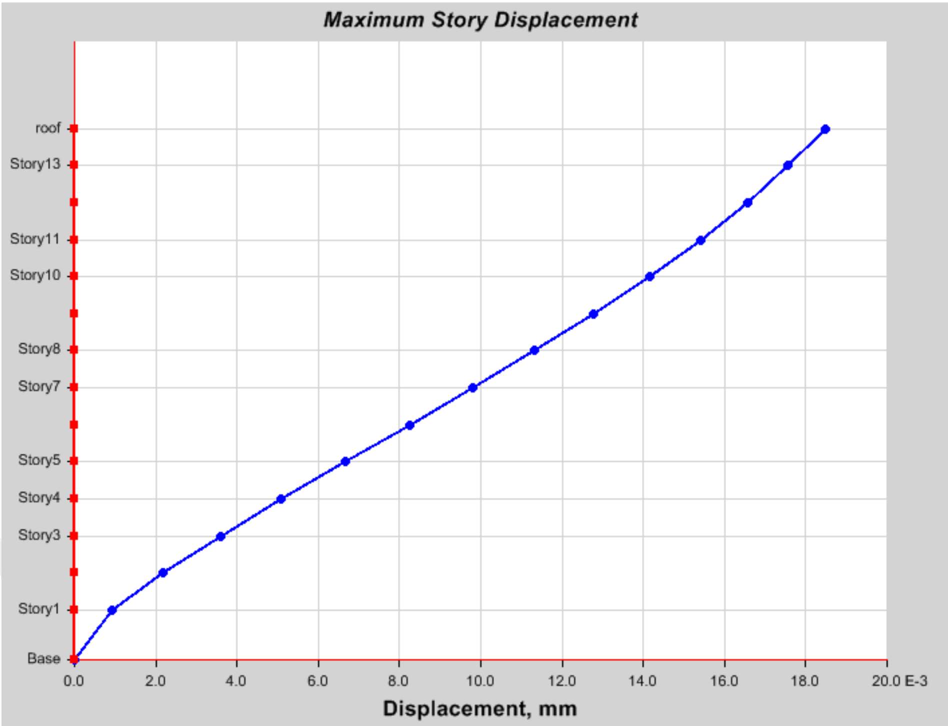


Figure 3 .31: Maximum Story Displacement

3.3.4.2.d Story Drifts

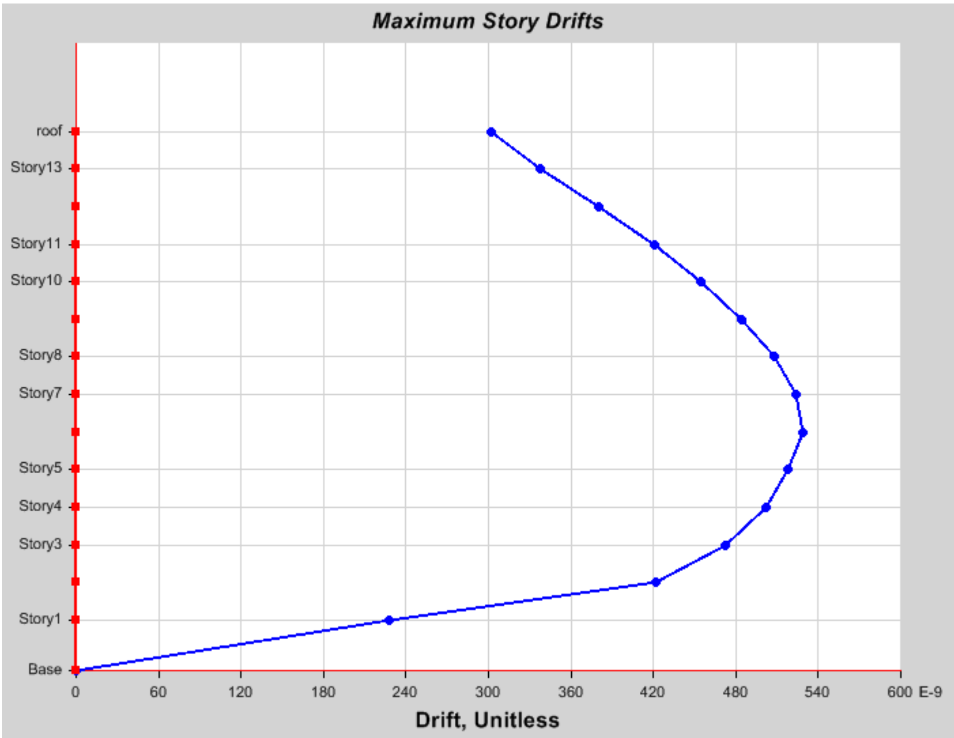


Figure 3.32: Maximum Story Drifts

3.3.4.3 Ribbed Slab

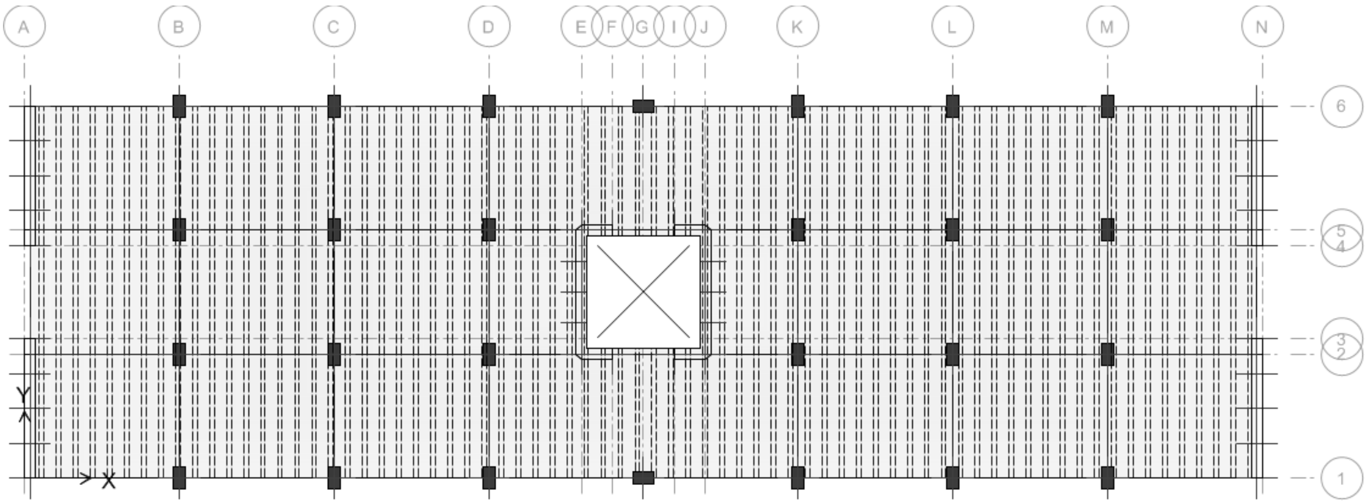


Figure 3.33: Ribbed Slab

3.3.4.3.a Dimensions

Thickness is 27 cm

Thickness of Slab 7 cm

Rips Width 15 cm and Depth 20 cm

Polystyrene Width 40 cm and Depth 20 cm

3.3.4.3.b Filling Material

Polystyrene has a density of 12 kg per cubic meter

3.3.4.3.c Rebar

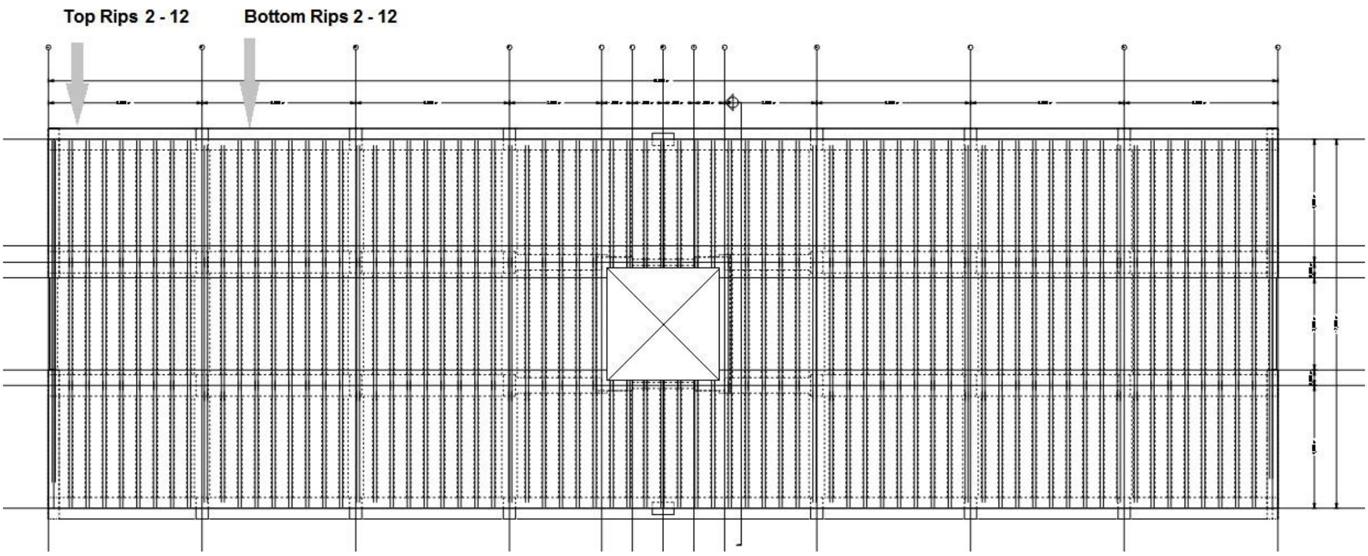


Figure 3.34: Reinforcement Detailing for Ribbed Slab

3.3.4.3.d Story Displacement

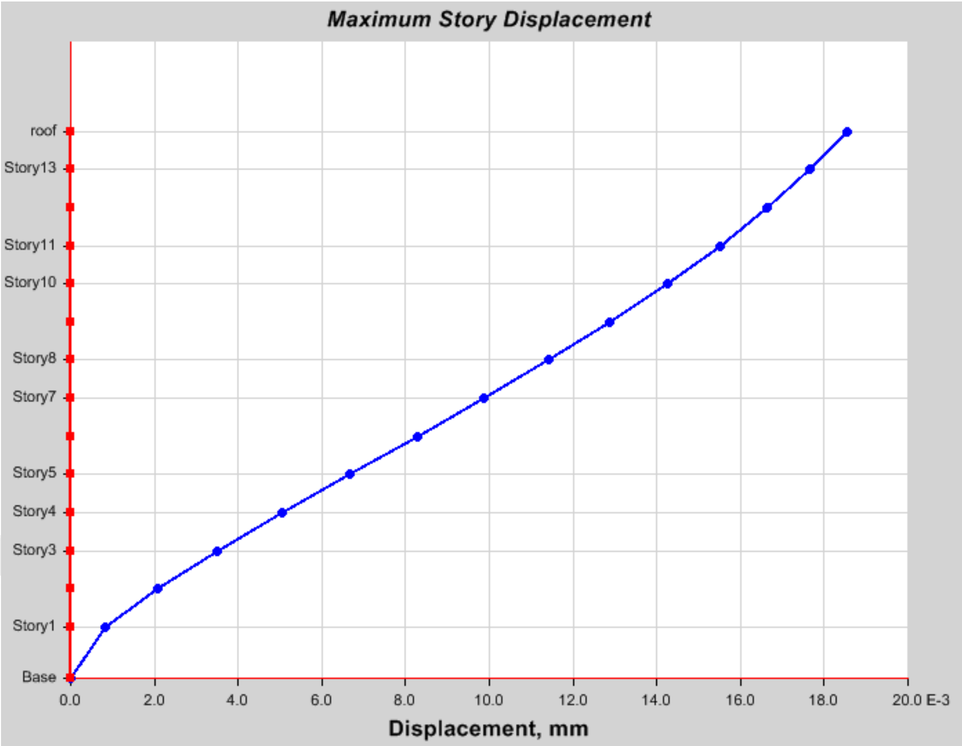


Figure 3.35: Maximum Story Displacement

3.3.4.3.e Story Drifts

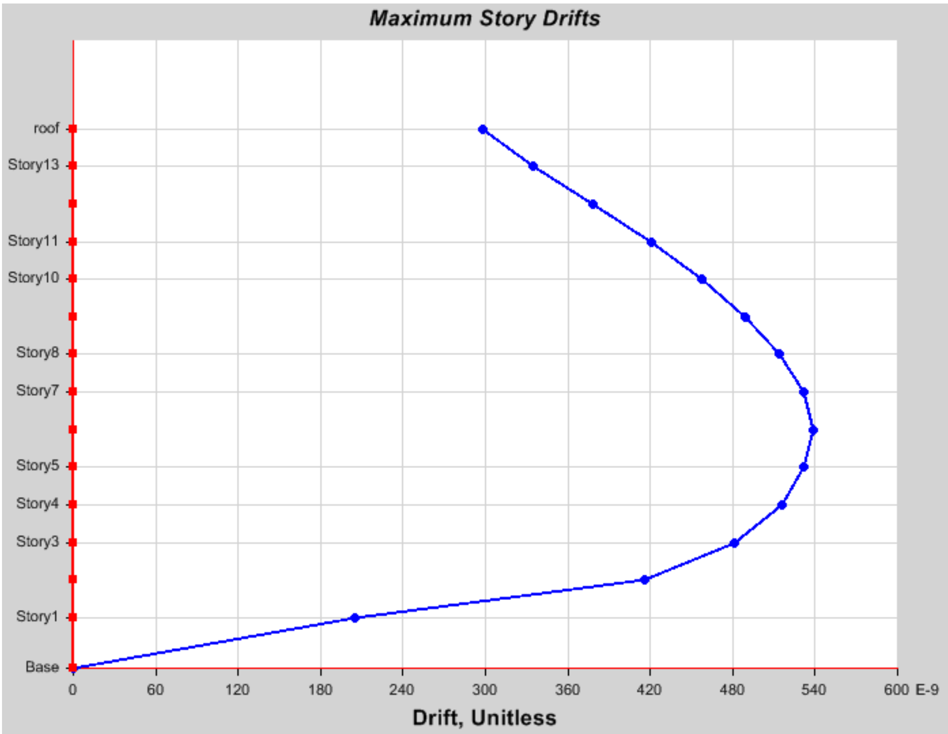


Figure 3. :36 Maximum Story Drifts

3.4 CALCULATION OF QUANTITIES

3.4.1 Building Slab with Beam

3.4.1.1 Weight of Rebar (ton)

Shear walls	
longitudinal bars	30.0165528
Ties bars	37.5528167

Columns	
longitudinal bars	37.945984
Ties bars	5.9929968

Beams	
longitudinal bars	19.300868
Ties bars	13.56373312

Slab 15 cm	
Top - Bottom	66.070713

Total Weight of Rebar (ton)

210.4436644

3.4.1.2 Volume of Concrete (Cubic meter)

Shear walls	389.1
Columns	269.2235
Beams	467.6
Slab 15 cm	974.4

Total Volume of Concrete

2100.3235

3.4.2 Building Flat Slab

3.4.2.1 Weight of Rebar (ton)

Shear walls

longitudinal bars	**30.0165528**
Ties bars	**37.5528167**

Columns

longitudinal bars	**37.945984**
Ties bars	**5.9929968**

Beams

longitudinal bars	**7.809288**
Ties bars	**6.357568**

Slab 18 cm

Top - Bottom	**99.580185**

Total Weight of Rebar (ton)

225.2553913

3.4.2.2 Volume of Concrete (Cubic meter)

Shear walls	**389.1**
Columns	**266.4662**
Beams	**32.9**
Slab 18 cm	**1118.88**

Total Volume of Concrete

1807.3462

3.4.3 Building Ribbed Slab

3.4.3.1 Weight of Rebar (ton)

Shear walls	
longitudinal bars	30.0165528
Ties bars	37.5528167

Columns	
longitudinal bars	37.945984
Ties bars	5.9929968

Beams	
longitudinal bars	40.43776
Ties bars	10.2917427

Slab 27 cm	
slab	35.461476
Ribs	9.23094144

Total Weight of Rebar (ton)

206.9302705

3.4.3.2 Volume of Concrete (Cubic meter)

Shear walls	389.1
Columns	258.1943
Beams	835.856
Slab 27 cm	590.17

Total Volume of Concrete

2073.3203

3.4.3.3 Volume of Polystyrene (Cubic meter)

Total Volume of Polystyrene **618.24**

3.4.4 Compare Quantities

3.4.4.1 Weight of Rebar (ton)

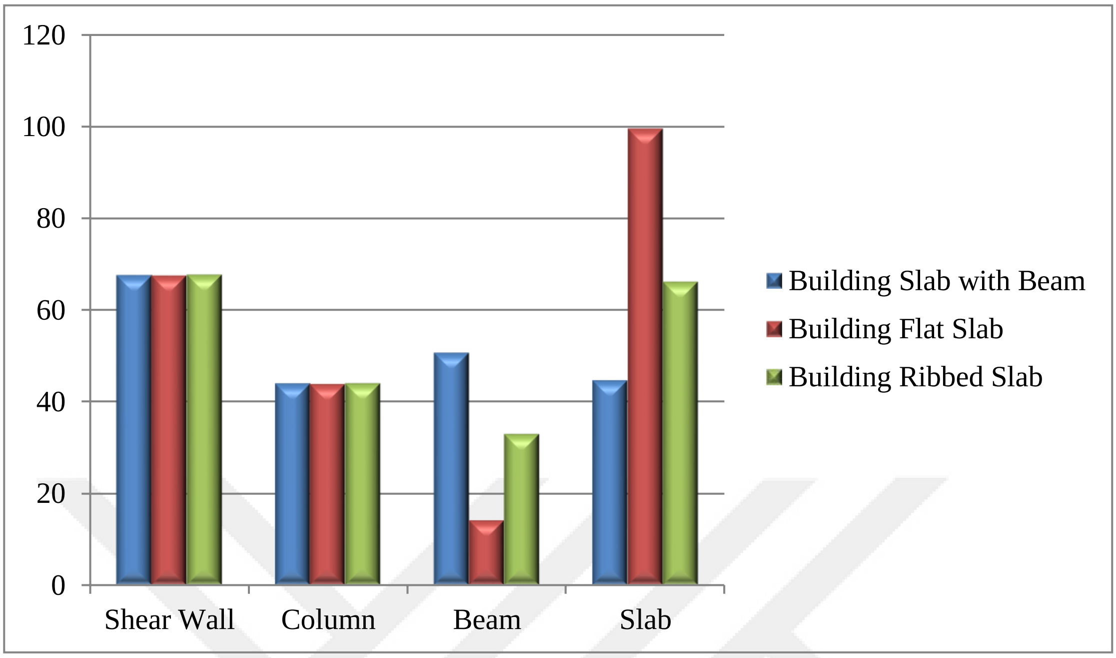


Chart 3.1: Weight of Rebar

3.4.4.2 Volume of Concrete (Cubic meter)

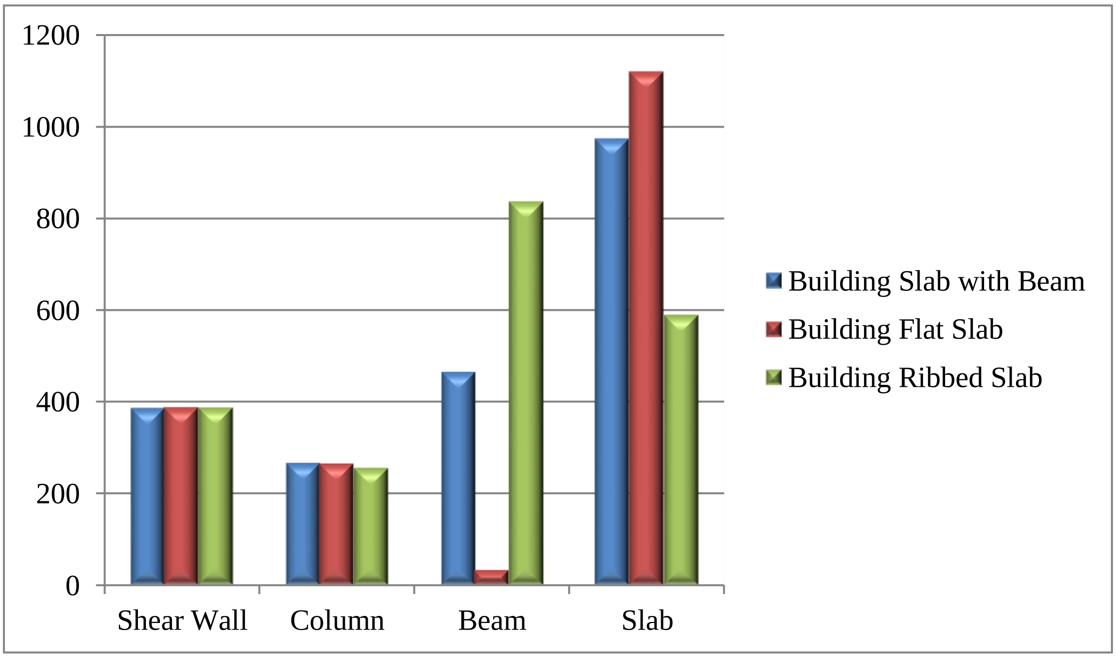


Chart 3.2: Volume of Concrete

3.5 PRICING

The price is according to the Iraqi market, in Iraqi dinars, and converted to US dollars.

1(ton) Rebar 750,000 IQ Dinar equal 520 US Dollar

1(Cubic meter) Concrete 80,000 IQ Dinar equal 55 US Dollar

3.5.1 Pricing of Building slab with beam

Weight of Rebar (ton)	210.4436644
Price of one ton Rebar ($)	520
Total Price of Rebar ($)	109430.7055
Volume of Concrete cubic meter	2100.3235
Price of one cubic meter Concrete ($)	55
Total Price Concrete ($)	115517.7925

Total price ($)

224948.498

3.5.2 Pricing of Building Flat slab

Weight of Rebar (ton)	225.2553913
Price of one ton Rebar ($)	520
Total Price of Rebar ($)	117132.8035
Volume of Concrete cubic meter	1807.3462
Price of one cubic meter Concrete ($)	55
Total Price Concrete ($)	99404.041

Total price ($)

216536.8445

3.5.3 Pricing of Building Ribbed Slab

Weight of Rebar (ton)	206.9302705
Price of one ton Rebar ($)	520
Total Price of Rebar ($)	107603.7406
Volume of Concrete cubic meter	2073.3203
Price of one cubic meter Concrete ($)	55
Total Price Concrete ($)	114032.6165
Volume of Polystyrene cubic meter	618.24
price of one cubic meter Polystyrene ($)	25
	15456
Total price ($)	
237092.3571	

3.6 SUMMARIZE THE RESULT

After designing the three types of buildings and calculating all the quantities of rebar and concrete, and after pricing these quantities, the final prices for each building are shown as follows:

A- Building slab with beam **224948.498 $**
B- Building Flat slab **216536.8445 $**
C- Building Ribbed slab **237092.3571 $**

Chart 3.3: Compare Prices

After comparing these three prices for the three types of buildings (Slab with beam - Flat slab - Ribbed slab), we find that the building whose floors are **Flat slab** is more economical than the rest of the types.

4. CONCLUSION AND RECOMMENDATION

4.1 CONCLUSION

1- Flat slab is more economical than the other types (Slab with beam-Ribbed slab).
2- The building ribbed slab is more expensive and uneconomical for this type of building and these loads
3- Flat slab is less expensive than ribbed slab by (9%) and slab with beam is less expensive than ribbed slab by (5%) and flat slab is less expensive than slab with beam by (4%).
4- Frame structure for building slab with beam is more stable in lateral loads than other types.
5- Beam should be added at the external edges of the flat slab to be more stable for high-rise buildings
6- Hidden beam is uneconomic because it has a large width and more steel reinforcement than a drop beam.

4.2 RECOMMENDATION

A ribbed slab contains the least amount of building materials (concrete-rebar), but a hidden beam is what made this type of flooring uneconomic, so it is recommended to make a ribbed slab with a drop beam to get the most economical flooring.

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APPENDICES

APPENDIX A

A.1 SHEAR WALL DESIGN

A.1.1 Shear Wall Design Results From ETABS

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
Story6	P1	175	9750	4500	350	0.511

Material Properties

E_c (MPa)	f'_c (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
23025.2	24	1	420	420

Design Code Parameters

Φ_T	Φ_C	Φ_v	Φ_v (Seismic)	IP_{MAX}	IP_{MIN}	P_{MAX}
0.9	0.65	0.75	0.6	0.04	0.0025	0.8

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	175	7500	175	12000	4500	350
Bottom	Leg 1	175	7500	175	12000	4500	350

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm²)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm²
Top	3938	0.0025	0.0029	UDWal6	-294.4099	-56.3863	-506.4536	1575000
Bottom	3938	0.0025	0.0029	UDWal6	-199.9099	54.8666	-2360.9808	1575000

Shear Design

Station Location	ID	Rebar mm²/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	ΦV_c kN	ΦV_n kN
Top	Leg 1	875	UDWal3	5645.3377	397.7277	689.7285	1153.236	2145.486
Bottom	Leg 1	875	UDWal3	5798.9002	2466.9131	689.7285	1153.236	2145.486

Boundary Element Check (ACI 21.9.6.3, 21.9.6.4)

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa	C Depth mm	C Limit mm
Top–Left	Leg 1	Not Required	UDWal4	1363.0769	-545.9088	1.33	4.8	450.7	478.2
Top–Right	Leg 1	706.3	UDWal4	5645.3377	397.7277	3.92	4.8	1156.3	478.2
Bottom–Left	Leg 1	Not Required	UDWal4	1516.6394	-2322.544	2.93	4.8	475.2	478.2
Botttom–Right	Leg 1	731.6	UDWal4	5798.9002	2466.9131	5.77	4.8	1181.6	478.2

A.1.2 Core Shear Wall Design Results From ETABS

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
Story9	P9	18000	6000	4000	350	0.578

Material Properties

E_c (MPa)	f'_c (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
23025.2	24	1	420	420

Design Code Parameters

Φ_T	Φ_C	Φ_v	Φ_v (Seismic)	IP_{MAX}	IP_{MIN}	P_{MAX}
0.9	0.65	0.75	0.6	0.04	0.0025	0.8

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	18000	4000	18000	8000	4000	350
Bottom	Leg 1	18000	4000	18000	8000	4000	350

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm²)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm²
Top	3500	0.0025	0.0029	UDWal6	1017.6605	11.2914	699.69	1400000
Bottom	3500	0.0025	0.0029	UDWal6	1101.6605	-11.1738	-104.1722	1400000

Shear Design

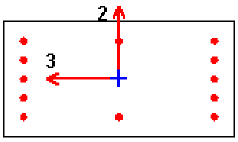
Station Location	ID	Rebar mm²/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	ΦV_c kN	ΦV_n kN
Top	Leg 1	875	UDWal3	1963.0338	-699.69	267.9541	1422.0636	2304.0636
Bottom	Leg 1	875	UDWal3	2099.5338	104.1722	267.9541	1442.5386	2324.5386

Boundary Element Check (ACI 21.9.6.3, 21.9.6.4)

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa	C Depth mm	C Limit mm
Top–Left	Leg 1	Not Required	UDWal3	1963.0338	-699.69	2.15	4.8	521.6	356
Top–Right	Leg 1	Not Required	UDWal3	1963.0338	699.69	2.15	4.8	521.6	356
Bottom–Left	Leg 1	Not Required	UDWal4	2099.5338	-104.1722	1.61	4.8	544.2	356
Botttom–Right	Leg 1	Not Required	UDWal4	2099.5338	104.1722	1.61	4.8	544.2	356

APPENDIX B

B.1 COLUMN DESIGN



Column Element Details (Summary)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF	Type
Story8	C18	407	C 35*70	UDCon6	2400	3000	0.52	Sway Ordinary

Section Properties

b (mm)	h (mm)	dc (mm)	Cover (Torsion) (mm)
700	350	60	27.3

Material Properties

E_c (MPa)	f'_c (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
23025.2	24	1	420	420

Design Code Parameters

Φ_T	Φ_{CTied}	$\Phi_{CSpiral}$	Φ_{Vns}	Φ_{Vs}	Φ_{Vjoint}	Ω_0
0.9	0.65	0.75	0.75	0.6	0.85	2

Axial Force and Biaxial Moment Design For P_u , M_{u2} , M_{u3}

Design P_u kN	Design M_{u2} kN-m	Design M_{u3} kN-m	Minimum M2 kN-m	Minimum M3 kN-m	Rebar Area mm²	Rebar % %
316.1253	10.1345	11.8163	11.4564	8.1371	2450	1

Axial Force and Biaxial Moment Factors

	C_m Factor Unitless	δ_{ns} Factor Unitless	δ_s Factor Unitless	K Factor Unitless	Effective Length mm
Major Bend(M3)	0.355659	1	1	1	2400
Minor Bend(M2)	0.377863	1	1	1	2400

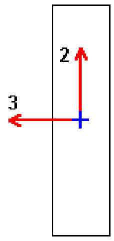
Shear Design for V_{u2} , V_{u3}

	Shear V_u kN	Shear ΦV_c kN	Shear ΦV_p kN
Major, V_{u2}	21.2024	135.4573	28.84
Minor, V_{u3}	39.7238	149.4696	41.6821

APPENDIX C

C.1 BEAM DESİGN

C.1.1 Couple Beam Design Result From ETABS



Beam Element Details (Summary)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF	Type
Story1	B22	50	Couple Beam 20	UDCon10	0	3000	1	Sway Ordinary

Section Properties

b (mm)	h (mm)	b_f (mm)	d_s (mm)	d_{ct} (mm)	d_{cb} (mm)
200	800	200	0	50	50

Material Properties

E_c (MPa)	f'_c (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
23025.2	24	1	420	420

Design Code Parameters

Φ_T	Φ_{CTied}	$\Phi_{CSpiral}$	Φ_{Vns}	Φ_{Vs}	Φ_{Vjoint}
0.9	0.65	0.75	0.75	0.6	0.85

Design Moment and Flexural Reinforcement for Moment, M_{u3}

Design -Moment kN-m	Design +Moment kN-m	-Moment Rebar mm^2	+Moment Rebar mm^2	Minimum Rebar mm^2	Required Rebar mm^2
-203.0722		755	0	492	755

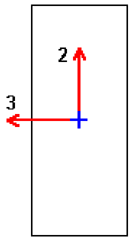
Shear Force and Reinforcement for Shear, V_{u2}

Shear V_{u2} kN	Shear ΦV_c kN	Shear ΦV_s kN	Shear V_p kN	Rebar A_v /S mm^2/m
149.4476	91.5267	57.921	143.3063	248.91

Torsion Force and Torsion Reinforcement for Torsion, T_u

Φ^*T_u kN-m	Tth kN-m	Tcr kN-m	Area A_o cm^2	Perimeter, p_h mm
0.1188	3.9051	15.6206	671.5	1644.4

C.1.2 Beam Design Result From ETABS (Slab With Beam)



Beam Element Details (Summary)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF	Type
Story7	B27	558	B 25*60	UDCon3	175	5000	1	Sway Ordinary

Section Properties

b (mm)	h (mm)	b_f (mm)	d_s (mm)	d_{ct} (mm)	d_{cb} (mm)
250	600	250	0	60	60

Material Properties

E_c (MPa)	f'_c (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
23025.2	24	1	420	420

Design Code Parameters

Φ_T	Φ_{CTied}	$\Phi_{CSpiral}$	Φ_{Vns}	Φ_{Vs}	Φ_{Vjoint}
0.9	0.65	0.75	0.75	0.6	0.85

Design Moment and Flexural Reinforcement for Moment, M_{u3}

Design -Moment kN-m	Design +Moment kN-m	-Moment Rebar mm^2	+Moment Rebar mm^2	Minimum Rebar mm^2	Required Rebar mm^2
-33.9593		169	0	225	225

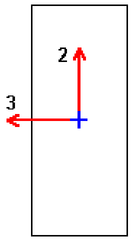
Shear Force and Reinforcement for Shear, V_{u2}

Shear V_{u2} kN	Shear ΦV_c kN	Shear V_p kN
35.7544	82.374	10.7724

Torsion Force and Torsion Reinforcement for Torsion, T_u

Φ^*T_u kN-m	Tth kN-m	Tcr kN-m	Area A_o cm^2	Perimeter, p_h mm
1.0154	4.0379	16.1518	699.9	1344.4

C.1.3 Beam Design Result From ETABS (Flat Slab)



Beam Element Details (Summary)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF	Type
Story7	B17	657	B 25*60	UDCon3	175	5000	1	Sway Ordinary

Section Properties

b (mm)	h (mm)	b_f (mm)	d_s (mm)	d_{ct} (mm)	d_{cb} (mm)
250	600	250	0	60	60

Material Properties

E_c (MPa)	f'_c (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
23025.2	24	1	420	420

Design Code Parameters

Φ_T	Φ_{CTied}	$\Phi_{CSpiral}$	Φ_{Vns}	Φ_{Vs}	Φ_{Vjoint}
0.9	0.65	0.75	0.75	0.6	0.85

Design Moment and Flexural Reinforcement for Moment, M_{u3}

Design -Moment kN-m	Design +Moment kN-m	-Moment Rebar mm²	+Moment Rebar mm²	Minimum Rebar mm²	Required Rebar mm²
-37.7513		188	0	250	250

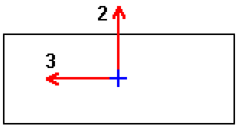
Shear Force and Reinforcement for Shear, V_{u2}

Shear V_{u2} kN	Shear ΦV_c kN	Shear V_p kN
38.2067	82.374	11.9693

Torsion Force and Torsion Reinforcement for Torsion, T_u

$\Phi * T_u$ kN-m	Tth kN-m	Tcr kN-m	Area A_o cm²	Perimeter, p_h mm
2.2567	4.0379	16.1518	699.9	1344.4

C.1.4 Beam Design Result From ETABS (Ribbed Slab)



Beam Element Details (Summary)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF	Type
Story2	B24	667	B 27*70	UDCon2	200	5000	1	Sway Ordinary

Section Properties

b (mm)	h (mm)	b_f (mm)	d_s (mm)	d_{ct} (mm)	d_{cb} (mm)
700	270	700	0	60	60

Material Properties

E_c (MPa)	f'_c (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
23025.2	24	1	420	420

Design Code Parameters

Φ_T	Φ_{CTied}	$\Phi_{CSpiral}$	Φ_{Vns}	Φ_{Vs}	Φ_{Vjoint}
0.9	0.65	0.75	0.75	0.6	0.85

Design Moment and Flexural Reinforcement for Moment, M_{u3}

Design -Moment kN-m	Design +Moment kN-m	-Moment Rebar mm²	+Moment Rebar mm²	Minimum Rebar mm²	Required Rebar mm²
-42.1417		552	0	483	552

Shear Force and Reinforcement for Shear, V_{u2}

Shear V_{u2} kN	Shear ΦV_c kN	Shear V_p kN
53.0156	89.6961	10.1792

Torsion Force and Torsion Reinforcement for Torsion, T_u

$\Phi * T_u$ kN-m	Tth kN-m	Tcr kN-m	Area A_o cm²	Perimeter, p_h mm
1.6372	5.6176	22.4703	940.7	1584.4

APPENDIX D

D.1 SHEAR WALL QUANTITIES

longitudinal bars of Shear Wall

Shear Wall (Two Core)

No. of Stoy	M1 No. of bars	M1 D. of bars	M2 No. of bars	M2 D. of bars	M3 No. of bars	M3 D. of bars	Corner (x2) No. of bars	Corner (x2) D. of bars
Roof	6	14	22	14	6	14	6	20
13	6	14	22	14	6	14	6	20
12	6	14	22	14	6	14	6	20
11	6	14	22	14	6	14	6	20
10	6	14	22	14	6	14	6	20
9	6	14	22	14	6	14	6	20
8	6	14	22	14	6	14	6	20
7	6	14	22	14	6	14	6	20
6	6	14	22	14	6	14	6	20
5	6	14	20	14	6	14	6	20
4	12	20	30	14	12	20	6	20
3	14	20	30	14	14	20	6	20
2	14	22	24	16	14	22	6	22
1	12	25	34	20	12	25	6	25

Shear Wall (Four Wall)

No. of Stoy	No. of bars	D. of bars
Roof	28	14
13	26	14
12	26	14
11	26	14
10	26	14
9	32	14
8	34	14
7	34	14
6	38	18
5	38	18
4	38	20
3	44	20
2	44	20
1	50	22

Sum No.of bars in normal storys height 3 m

D. of bars	No. of bars	D. of bars	No. of bars	D. of bars	No. of bars	D. of bars	No. of bars
14	60	14	278	14	60	14	0
16	0	16	24	16	0	16	0
18	0	18	0	18	0	18	0
20	20	20	0	20	20	20	144
22	14	22	0	22	14	22	12
25	0	25	0	25	0	25	0

Sum No.of bars in normal storys height 3 m (Four Wall)

D. of bars	No. of bars
14	232
16	0
18	76
20	126
22	0
25	0

Sum No.of bars in first story height 4 m

D. of bars	No. of bars	D. of bars	No. of bars	D. of bars	No. of bars	D. of bars	No. of bars
20	0	20	34	20	0	20	0
25	12	25	0	25	12	25	12

Sum No.of bars in first story height 4 m (Four Wall)

D. of bars	No. of bars
22	50

D. of bars	Total No. of bars 3m+ Over lap	Bar Height 1m
14	398	1592
16	24	96
18	0	0
20	196	784
22	40	160
25	0	0

D. of bars	Total No. of bars 3m+ Over lap	Bar Height 1m
14	232	928
16	0	0
18	76	304
20	126	504
22	50	200
25	25	100

D. of bars	Total No. of bars 4m+ Over lap	Bar Height 1m
20	34	170
25	36	180

D. of bars	Total No. of bars 4m+ Over lap	Bar Height 1m
22	50	250

D. of bars	Weight of bar per meter	Sum of weight kg	kg to ton
14	1.209	1924.728	1.924728
16	1.579	151.584	0.151584
18	1.999	0	0
20	2.468	2354.472	2.354472
22	2.986	477.76	0.47776
25	3.856	694.08	0.69408
			5.602624

Total Weight for all core 11.205248

D. of bars	Weight of bar per meter	Sum of weight kg	kg to ton
14	1.209	1121.952	1.121952
16	1.579	0	0
18	1.999	607.696	0.607696
20	2.468	1243.872	1.243872
22	2.986	1343.7	1.3437
25	3.856	385.6	0.3856
			4.70282

Total Weight for all Shear wall 18.81128

Total Weight longitudinal bars of Shear Wall (ton)

30.016528

Ties bars of Shear wall

Core Shear Wall ties

Story	first	2nd - 6th	7th - roof
Height	4	3	3
Diameter of Ties(mm)	14	14	14
Weight of Bar per meter (kg)	1.209	1.209	1.209
Width of Wall M1 (mm)	250	250	250
Length of Wall M1 (mm)	1000	1000	1000
Width of Wall M2 (mm)	250	250	250
Length of Wall M2 (mm)	4000	4000	4000
Width of Wall M3 (mm)	250	250	250
Length of Wall M3 (mm)	1000	1000	1000
Cover in (mm)	25	25	25
No. of Ties in meter	4	4	3
No. of Shear Wall	2	2	2
Length of ties M1 (mm)	2512	2512	2512
Length of ties M2 (mm)	8596	8596	8596
Length of ties M3 (mm)	2512	2512	2512
Total length of ties (m)	13.62	13.62	13.62
No. of ties in Shear wall	16	12	9
Total ties in Shear Wall	32	24	18
Total Length of ties (m)	435.84	326.88	245.16
Total Weight of bars (ton)	0.52693056	0.39519792	0.29639844
Total Weight in all story(ton)	0.52693056	1.9759896	2.37118752

Shear Wall ties

Story	1 story	2nd - 6th	7th - roof
Height	4	3	3
Diameter of Ties(mm)	14	14	14
Weight of Bar per meter (kg)	1.209	1.209	1.209
Width of Wall (mm)	350	350	350
Length of Wall (mm)	4500	4500	4500
Cover in (mm)	25	25	25
No. of Ties in meter	4	4	3
No. of column	4	4	4
Length of ties (mm)	9712	9712	9712
Length of ties (m)	9.712	9.712	9.712
No. of ties in wall	16	12	9
Total ties in wall	64	48	36
Total Length of ties (m)	621.568	466.176	349.632
Total Weight of bars (ton)	0.75147571	0.56360678	0.42270509
Total Weight in all story(ton)	0.75147571	2.81803392	3.3816407

The volume of Concrete in shaer wall (Two core)

No. of Stoy	M1 Width (cm)	M1 Length (cm)	M2 Width (cm)	M2 Length (cm)	M3 Width (cm)	M3 Length (cm)	Height (cm)	Volume (m^3)	No. of Wall	Total volume (m^3)
Roof	25	75	25	400	25	75	300	4.125	2	8.25
13	25	75	25	400	25	75	300	4.125	2	8.25
12	25	75	25	400	25	75	300	4.125	2	8.25
11	25	75	25	400	25	75	300	4.125	2	8.25
10	25	75	25	400	25	75	300	4.125	2	8.25
9	25	75	25	400	25	75	300	4.125	2	8.25
8	25	75	25	400	25	75	300	4.125	2	8.25
7	25	75	25	400	25	75	300	4.125	2	8.25
6	25	75	25	400	25	75	300	4.125	2	8.25
5	25	75	25	400	25	75	300	4.125	2	8.25
4	25	75	25	400	25	75	300	4.125	2	8.25
3	25	75	25	400	25	75	300	4.125	2	8.25
2	25	75	25	400	25	75	300	4.125	2	8.25
1	25	75	25	400	25	75	400	5.5	2	11

The volume of Concrete in the columns in whole building

118.25

The volume of Concrete in shaer wall (Four wall)

No. of Stoy	Width (cm)	Length (cm)	Height (cm)	Volume (m^3)	No. of Wall	Total volume (m^3)
Roof	35	450	300	4.725	4	18.9
13	35	450	300	4.725	4	18.9
12	35	450	300	4.725	4	18.9
11	35	450	300	4.725	4	18.9
10	35	450	300	4.725	4	18.9
9	35	450	300	4.725	4	18.9
8	35	450	300	4.725	4	18.9
7	35	450	300	4.725	4	18.9
6	35	450	300	4.725	4	18.9
5	35	450	300	4.725	4	18.9
4	35	450	300	4.725	4	18.9

3	35	450	300	4.725	4	18.9
2	35	450	300	4.725	4	18.9
1	35	450	400	6.3	4	25.2

Total Weight of ties bars of two core whole building (ton)

9.74821536

Total Weight of ties bars of four shear wall whole building (ton)

27.80460134

Total Weight of ties bars of all shear wall whole building (ton)

37.5528167

The volume of Concrete in the Shear wall in whole building

270.9

Total volume of Concrete in the Shear wall in whole building

389.15

APPENDIX E

E.1 COLUMN QUANTITIES

No. of Stoy	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26
Roof	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
13	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
12	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
11	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
10	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
9	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
8	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
7	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
6	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
5	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
4	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
3	18	18	18	18	25	18	18	25	18	18	18	18	18	18	18	18	25	18	18	25	18	18	18	18	18	18
2	25	25	18	28	32	25	28	32	25	25	25	18	18	25	25	25	32	28	25	32	28	18	25	25	18	18
1	25	25	18	28	32	25	28	32	25	25	25	18	18	25	25	25	32	28	25	32	28	18	25	25	18	18

D. of Bar	No.of Bar	No. of Column	Bar Height 3m+ Over lap	Bar Height 1m
16	12	130	1560	6240
18	12	184	2208	8832
25	12	16	192	768
28	12	4	48	201.6
32	12	4	48	216
First story	No.of Bar	No. of Column	Bar Height 4m+Over lap	Bar Height 1m
16	12	0	0	0
18	12	6	72	288
25	12	12	144	576
28	12	4	48	201.6
32	12	4	48	216

D. of Bar	Weight of Bar per meter	Sum of Weight kg	kg to ton
16	1.579	9852.96	9.85296
18	1.999	18230.88	18.23088
25	3.856	5182.464	5.182464
28	4.837	1950.2784	1.950278
32	6.318	2729.376	2.729376

Total Weight (ton)

37.9459584

Ties bars of column

story	first	2nd - 5th	6th - 10th	11th - roof
Height (m)	4	3	3	3
Diameter of Ties(mm)	10	10	10	10
Weight of Bar per meter (kg)	0.617	0.617	0.617	0.617
Width of Column (mm)	400	400	350	350
Length of column (mm)	700	700	700	650
Cover in (mm)	40	40	40	40
No. of Ties in meter	4	4	4	4
No. of column	26	26	26	26
Length of ties (mm)	2120	2120	2020	1920
Length of ties (m)	2.12	2.12	2.02	1.92
No. of ties in Column	16	12	12	12
Total ties in Column	416	312	312	312
Total Length of ties (m)	881.92	661.44	630.24	599.04
Total Weight of bars (ton)	0.54414464	1.63243392	1.9442904	1.4784307

Total Weight of bars whole building (ton)

5.59929968

The volume of Concrete in the Columns

No. of Stoy	Width (cm)	Length (cm)	Height (cm)	Volume (m^3)	No. of column	Total volume (m^3)
Roof	35	65	285	0.648375	26	16.85775
13	35	65	285	0.648375	26	16.85775
12	35	65	285	0.648375	26	16.85775
11	35	65	285	0.648375	26	16.85775
10	35	70	285	0.69825	26	18.1545
9	35	70	285	0.69825	26	18.1545
8	35	70	285	0.69825	26	18.1545
7	35	70	285	0.69825	26	18.1545
6	35	70	285	0.69825	26	18.1545
5	40	70	285	0.798	26	20.748
4	40	70	285	0.798	26	20.748
3	40	70	285	0.798	26	20.748
2	40	70	285	0.798	26	20.748
1	40	70	385	1.078	26	28.028

The volume of Concrete in the columns in whole building

269.2235

APPENDIX F

F.1 BEAM QUANTITIES

longitudinal bars of Beam and Couple Beam

Beam

External beam

No. of Stoy	Length Beam (m)	Top D. of Bar	Top No. of Bar	Bottom D. of Bar	Bottom No of Bar	No. of Beam	Total Length Meter
Roof	5	14	2	14	2	16	320
13	5	14	2	14	2	16	320
12	5	14	2	14	2	16	320
11	5	14	2	14	2	16	320
10	5	14	2	14	2	16	320
9	5	14	2	14	2	16	320
8	5	14	2	14	2	16	320
7	5	14	2	14	2	16	320
6	5	14	2	14	2	16	320
5	5	14	2	14	2	16	320
4	5	14	2	14	2	16	320
3	5	14	2	14	2	16	320
2	5	14	2	14	2	16	320
1	5	14	2	14	2	16	320
						Total	4480

Couple Beam

Type 1 (Between Shear Wall)

No. of Stoy	Length Beam (m)	Top D. of Bar	Top No. of Bar	Middle D. of Bar	Middle No of Bar	Bottom D. of Bar	Bottom No of Bar	No. of Beam	Total Length (m) 14	Total Length (m) 20
Roof	3	20	3	14	4	20	3	2	24	36
13	3	20	3	14	4	20	3	2	24	36
12	3	20	3	14	4	20	3	2	24	36
11	3	20	4	14	6	20	4	2	36	48
10	3	20	4	14	6	20	4	2	36	48
9	3	20	4	14	6	20	4	2	36	48
8	3	20	4	14	6	20	4	2	36	48
7	3	20	4	14	6	20	4	2	36	48
6	3	20	4	14	6	20	4	2	36	48
5	3	20	4	14	6	20	4	2	36	48
4	3	20	4	14	4	20	4	2	24	48
3	3	20	4	14	4	20	4	2	24	48
2	3	20	3	14	4	20	3	2	24	36
1	3	20	2	14	4	20	2	2	24	24
								Total	420	600

Vertical beam

No. of Stoy	Length Beam (m)	Top D. of Bar	Top No. of Bar	Bottom D. of Bar	Bottom No of Bar	No. of Beam	Total Length Meter
Roof	4	16	2	16	2	18	288
13	4	16	2	16	2	18	288
12	4	16	2	16	2	18	288
11	4	16	2	16	2	18	288
10	4	16	2	16	2	18	288
9	4	16	2	16	2	18	288
8	4	16	2	16	2	18	288
7	4	16	2	16	2	18	288
6	4	16	2	16	2	18	288
5	4	16	2	16	2	18	288
4	4	16	2	16	2	18	288
3	4	16	2	16	2	18	288
2	4	16	2	16	2	18	288
1	4	16	2	16	2	18	288
						Total	4032

Beam Between Core Shear Wall

No. of Stoy	Length Beam (m)	Top D. of Bar	Top No. of Bar	Bottom D. of Bar	Bottom No of Bar	No. of Beam	Total Length Meter
Roof	2	14	2	14	2	2	16
13	2	14	2	14	2	2	16
12	2	14	2	14	2	2	16
11	2	14	2	14	2	2	16
10	2	14	2	14	2	2	16
9	2	14	2	14	2	2	16
8	2	14	2	14	2	2	16
7	2	14	2	14	2	2	16
6	2	14	2	14	2	2	16
5	2	14	2	14	2	2	16
4	2	14	2	14	2	2	16
3	2	14	2	14	2	2	16
2	2	14	2	14	2	2	16
1	2	14	2	14	2	2	16
						Total	224

Horizontal beam

No. of Stoy	Length Beam (m)	Top D. of Bar	Top No. of Bar	Bottom D. of Bar	Bottom No of Bar	No. of Beam	Total Length Meter
Roof	5	16	2	16	2	12	240
13	5	16	2	16	2	12	240
12	5	16	2	16	2	12	240
11	5	16	2	16	2	12	240
10	5	16	2	16	2	12	240
9	5	16	2	16	2	12	240
8	5	16	2	16	2	12	240
7	5	16	2	16	2	12	240
6	5	16	2	16	2	12	240
5	5	16	2	16	2	12	240
4	5	16	2	16	2	12	240
3	5	16	2	16	2	12	240
2	5	16	2	16	2	12	240
1	5	16	2	16	2	12	240
						Total	3360

D. of bars	Weight of Bar per meter	Sum of Weight (ton)
14	1.209	6.1481
16	1.579	11.671968
20	2.468	1.4808

Total Weight longitudinal bars of Beams (ton)

19.300868

Stirrups bars of Beam and Couple Beam

	Beam Horizontal	Beam Vertical	Couple Beam	Beam (Core)
Length of Beam (m)	5	4	3	2
Diameter of Ties(mm)	10	10	10	10
Weight of Bar per meter (kg)	0.617	0.617	0.617	0.617
Width of Beam (mm)	250	250	200	200
Depth of Beam (mm)	600	600	800	800
Cover in (mm)	50	50	40	40
No. of Ties in meter	4	4	3	3
No. of Beam in one story	28	18	2	2
No. of Beam in all story	392	252	28	28
Length of ties (mm)	1580	1580	1920	1920
Length of ties (m)	1.58	1.58	1.92	1.92
No. of ties in Beam	20	16	9	6
Total ties in Beam	7840	4032	252	168
Total Length of ties (m)	12387.2	6370.56	483.84	322.56
Total Weight of bars (ton)	7.6429024	3.93063552	1.19411712	0.79607808

Total Weight of bars whole building (ton)

13.56373312

The volume of Concrete in the Beam and Couple beam

Beam

No. of Stoy	Beam Horizontal Length (cm)	Beam Horizontal No. of Beam	Beam Vertical Length (cm)	Beam Vertical No. of Beam	Width (cm)	Depth (cm)	Volume (m^3)	Volume (m^3)	Total volume (m^3)
Roof	500	28	400	18	25	60	0.75	0.6	31.8
13	500	28	400	18	25	60	0.75	0.6	31.8
12	500	28	400	18	25	60	0.75	0.6	31.8
11	500	28	400	18	25	60	0.75	0.6	31.8
10	500	28	400	18	25	60	0.75	0.6	31.8
9	500	28	400	18	25	60	0.75	0.6	31.8
8	500	28	400	18	25	60	0.75	0.6	31.8
7	500	28	400	18	25	60	0.75	0.6	31.8
6	500	28	400	18	25	60	0.75	0.6	31.8
5	500	28	400	18	25	60	0.75	0.6	31.8
4	500	28	400	18	25	60	0.75	0.6	31.8
3	500	28	400	18	25	60	0.75	0.6	31.8
2	500	28	400	18	25	60	0.75	0.6	31.8
1	500	28	400	18	25	60	0.75	0.6	31.8
								Total	445.2

Couple Beam and Beam core

No. of Stoy	Couple beam Length (cm)	Couple beam No. of Beam	Beam (core) Length (cm)	Beam (core) No. of Beam	Width (cm)	Depth (cm)	Volume (m^3)	Volume (m^ 3)	Total volume (m^3)
Roof	300	2	200	2	20	80	0.48	0.32	1.6
13	300	2	200	2	20	80	0.48	0.32	1.6
12	300	2	200	2	20	80	0.48	0.32	1.6
11	300	2	200	2	20	80	0.48	0.32	1.6
10	300	2	200	2	20	80	0.48	0.32	1.6
9	300	2	200	2	20	80	0.48	0.32	1.6
8	300	2	200	2	20	80	0.48	0.32	1.6
7	300	2	200	2	20	80	0.48	0.32	1.6
6	300	2	200	2	20	80	0.48	0.32	1.6
5	300	2	200	2	20	80	0.48	0.32	1.6
4	300	2	200	2	20	80	0.48	0.32	1.6
3	300	2	200	2	20	80	0.48	0.32	1.6
2	300	2	200	2	20	80	0.48	0.32	1.6
1	300	2	200	2	20	80	0.48	0.32	1.6
								Total	22.4

The volume of Concrete in the columns in whole building

467.6

APPENDIX G

G.1 SLAB QUANTITIES

Reinforced Slab 15 cm

Rectangular Slab

Bottom Rebar

X- direction

No. of Stoy	D.of Bar	Bar Spacing	Bar Distance	No. of Bar	Bar Length (m)	Bar Weight kg/m	Total Weight (ton)
Roof	10	250	5000	21	4.5	0.617	0.0583065
13	12	250	5000	21	4.5	0.888	0.083916
12	12	250	5000	21	4.5	0.888	0.083916
11	12	250	5000	21	4.5	0.888	0.083916
10	12	250	5000	21	4.5	0.888	0.083916
9	12	250	5000	21	4.5	0.888	0.083916
8	12	250	5000	21	4.5	0.888	0.083916
7	12	250	5000	21	4.5	0.888	0.083916
6	12	250	5000	21	4.5	0.888	0.083916
5	12	250	5000	21	4.5	0.888	0.083916
4	12	250	5000	21	4.5	0.888	0.083916
3	12	250	5000	21	4.5	0.888	0.083916
2	12	250	5000	21	4.5	0.888	0.083916
1	12	250	5000	21	4.5	0.888	0.083916
							1.1492145

Top Rebar

X- direction

No. of Stoy	D.of Bar	Bar Spacing	Bar Distance	No. of Bar	Bar Length (m)	Bar Weight kg/m	Total Weight (ton)
Roof	10	250	5000	21	1	0.617	0.012957
13	12	250	5000	21	1	0.888	0.018648
12	12	250	5000	21	1	0.888	0.018648
11	12	250	5000	21	1	0.888	0.018648
10	12	250	5000	21	1	0.888	0.018648
9	12	250	5000	21	1	0.888	0.018648
8	12	250	5000	21	1	0.888	0.018648
7	12	250	5000	21	1	0.888	0.018648
6	12	250	5000	21	1	0.888	0.018648
5	12	250	5000	21	1	0.888	0.018648
4	12	250	5000	21	1	0.888	0.018648
3	12	250	5000	21	1	0.888	0.018648
2	12	250	5000	21	1	0.888	0.018648
1	12	250	5000	21	1	0.888	0.018648
							0.255381

Y- direction (Bottom Rebar)

No. of Stoy	D.of Bar	Bar Spacing	Bar Distance	No. of Bar	Bar Length (m)	Bar Weight kg/m	Total Weight (ton)
Roof	10	250	4000	17	5.5	0.617	0.0576895
13	12	250	4000	17	5.5	0.888	0.083028
12	12	250	4000	17	5.5	0.888	0.083028
11	12	250	4000	17	5.5	0.888	0.083028
10	12	250	4000	17	5.5	0.888	0.083028
9	12	250	4000	17	5.5	0.888	0.083028
8	12	250	4000	17	5.5	0.888	0.083028
7	12	250	4000	17	5.5	0.888	0.083028
6	12	250	4000	17	5.5	0.888	0.083028
5	12	250	4000	17	5.5	0.888	0.083028
4	12	250	4000	17	5.5	0.888	0.083028
3	12	250	4000	17	5.5	0.888	0.083028
2	12	250	4000	17	5.5	0.888	0.083028
1	12	250	4000	17	5.5	0.888	0.083028
							1.1370535

Y- direction (Top Rebar)

No. of Stoy	D.of Bar	Bar Spacing	Bar Distance	No. of Bar	Bar Length (m)	Bar Weight kg/m	Total Weight (ton)
Roof	10	250	4000	17	1	0.617	0.010489
13	12	250	4000	17	1	0.888	0.015096
12	12	250	4000	17	1	0.888	0.015096
11	12	250	4000	17	1	0.888	0.015096
10	12	250	4000	17	1	0.888	0.015096
9	12	250	4000	17	1	0.888	0.015096
8	12	250	4000	17	1	0.888	0.015096
7	12	250	4000	17	1	0.888	0.015096
6	12	250	4000	17	1	0.888	0.015096
5	12	250	4000	17	1	0.888	0.015096
4	12	250	4000	17	1	0.888	0.015096
3	12	250	4000	17	1	0.888	0.015096
2	12	250	4000	17	1	0.888	0.015096
1	12	250	4000	17	1	0.888	0.015096
							0.206737

Center Slab Zone (A) x2

Bottom Rebar

X- direction

No. of Stoy	D.of Bar	Bar Spacing	Bar Distance	No. of Bar	Bar Length (m)	Bar Weight kg/m	Total Weight (ton)
Roof	10	250	10000	41	4.5	0.617	0.1138365
13	12	250	10000	41	4.5	0.888	0.163836
12	12	250	10000	41	4.5	0.888	0.163836
11	12	250	10000	41	4.5	0.888	0.163836
10	12	250	10000	41	4.5	0.888	0.163836
9	12	250	10000	41	4.5	0.888	0.163836
8	12	250	10000	41	4.5	0.888	0.163836
7	12	250	10000	41	4.5	0.888	0.163836
6	12	250	10000	41	4.5	0.888	0.163836
5	12	250	10000	41	4.5	0.888	0.163836
4	12	250	10000	41	4.5	0.888	0.163836
3	12	250	10000	41	4.5	0.888	0.163836
2	12	250	10000	41	4.5	0.888	0.163836
1	12	250	10000	41	4.5	0.888	0.163836
							2.2437045

Top Rebar

X- direction

No. of Stoy	D.of Bar	Bar Spacing	Bar Distance	No. of Bar	Bar Length (m)	Bar Weight kg/m	Total Weight (ton)
Roof	10	250	10000	41	2	0.617	0.050594
13	12	250	10000	41	2	0.888	0.072816
12	12	250	10000	41	2	0.888	0.072816
11	12	250	10000	41	2	0.888	0.072816
10	12	250	10000	41	2	0.888	0.072816
9	12	250	10000	41	2	0.888	0.072816
8	12	250	10000	41	2	0.888	0.072816
7	12	250	10000	41	2	0.888	0.072816
6	12	250	10000	41	2	0.888	0.072816
5	12	250	10000	41	2	0.888	0.072816
4	12	250	10000	41	2	0.888	0.072816
3	12	250	10000	41	2	0.888	0.072816
2	12	250	10000	41	2	0.888	0.072816
1	12	250	10000	41	2	0.888	0.072816
							0.997202

Y- direction (Bottom Rebar)

No. of Stoy	D.of Bar	Bar Spacing	Bar Distance	No. of Bar	Bar Length (m)	Bar Weight kg/m	Total Weight (ton)
Roof	10	250	4000	17	10.5	0.617	0.1101345
13	12	250	4000	17	10.5	0.888	0.158508
12	12	250	4000	17	10.5	0.888	0.158508
11	12	250	4000	17	10.5	0.888	0.158508
10	12	250	4000	17	10.5	0.888	0.158508
9	12	250	4000	17	10.5	0.888	0.158508
8	12	250	4000	17	10.5	0.888	0.158508
7	12	250	4000	17	10.5	0.888	0.158508
6	12	250	4000	17	10.5	0.888	0.158508
5	12	250	4000	17	10.5	0.888	0.158508
4	12	250	4000	17	10.5	0.888	0.158508
3	12	250	4000	17	10.5	0.888	0.158508
2	12	250	4000	17	10.5	0.888	0.158508
1	12	250	4000	17	10.5	0.888	0.158508
							2.1707385

Y- direction (Top Rebar)

No. of Stoy	D.of Bar	Bar Spacing	Bar Distance	No. of Bar	Bar Length (m)	Bar Weight kg/m	Total Weight (ton)
Roof	10	250	4000	17	4	0.617	0.041956
13	12	250	4000	17	4	0.888	0.060384
12	12	250	4000	17	4	0.888	0.060384
11	12	250	4000	17	4	0.888	0.060384
10	12	250	4000	17	4	0.888	0.060384
9	12	250	4000	17	4	0.888	0.060384
8	12	250	4000	17	4	0.888	0.060384
7	12	250	4000	17	4	0.888	0.060384
6	12	250	4000	17	4	0.888	0.060384
5	12	250	4000	17	4	0.888	0.060384
4	12	250	4000	17	4	0.888	0.060384
3	12	250	4000	17	4	0.888	0.060384
2	12	250	4000	17	4	0.888	0.060384
1	12	250	4000	17	4	0.888	0.060384
							0.826948

Center Slab Zone (B) x2

Bottom Rebar

X- direction

No. of Stoy	D.of Bar	Bar Spacing	Bar Distance	No. of Bar	Bar Length (m)	Bar Weight kg/m	Total Weight (ton)
Roof	10	250	3000	13	4.5	0.617	0.0360945
13	12	250	3000	13	4.5	0.888	0.051948
12	12	250	3000	13	4.5	0.888	0.051948
11	12	250	3000	13	4.5	0.888	0.051948
10	12	250	3000	13	4.5	0.888	0.051948
9	12	250	3000	13	4.5	0.888	0.051948
8	12	250	3000	13	4.5	0.888	0.051948
7	12	250	3000	13	4.5	0.888	0.051948
6	12	250	3000	13	4.5	0.888	0.051948
5	12	250	3000	13	4.5	0.888	0.051948
4	12	250	3000	13	4.5	0.888	0.051948
3	12	250	3000	13	4.5	0.888	0.051948
2	12	250	3000	13	4.5	0.888	0.051948
1	12	250	3000	13	4.5	0.888	0.051948
							0.7114185

Top Rebar

X- direction

No. of Stoy	D.of Bar	Bar Spacing	Bar Distance	No. of Bar	Bar Length (m)	Bar Weight kg/m	Total Weight (ton)
Roof	10	250	3000	13	2	0.617	0.016042
13	12	250	3000	13	2	0.888	0.023088
12	12	250	3000	13	2	0.888	0.023088
11	12	250	3000	13	2	0.888	0.023088
10	12	250	3000	13	2	0.888	0.023088
9	12	250	3000	13	2	0.888	0.023088
8	12	250	3000	13	2	0.888	0.023088
7	12	250	3000	13	2	0.888	0.023088
6	12	250	3000	13	2	0.888	0.023088
5	12	250	3000	13	2	0.888	0.023088
4	12	250	3000	13	2	0.888	0.023088
3	12	250	3000	13	2	0.888	0.023088
2	12	250	3000	13	2	0.888	0.023088
1	12	250	3000	13	2	0.888	0.023088
							0.316186

Y- direction (Bottom Rebar)

No. of Stoy	D.of Bar	Bar Spacing	Bar Distance	No. of Bar	Bar Length (m)	Bar Weight kg/m	Total Weight (ton)
Roof	10	250	4000	17	3.5	0.617	0.0367115
13	12	250	4000	17	3.5	0.888	0.052836
12	12	250	4000	17	3.5	0.888	0.052836
11	12	250	4000	17	3.5	0.888	0.052836
10	12	250	4000	17	3.5	0.888	0.052836
9	12	250	4000	17	3.5	0.888	0.052836
8	12	250	4000	17	3.5	0.888	0.052836
7	12	250	4000	17	3.5	0.888	0.052836
6	12	250	4000	17	3.5	0.888	0.052836
5	12	250	4000	17	3.5	0.888	0.052836
4	12	250	4000	17	3.5	0.888	0.052836
3	12	250	4000	17	3.5	0.888	0.052836
2	12	250	4000	17	3.5	0.888	0.052836
1	12	250	4000	17	3.5	0.888	0.052836
							0.7235795

Y- direction (Top Rebar)

No. of Stoy	D.of Bar	Bar Spacing	Bar Distance	No. of Bar	Bar Length (m)	Bar Weight kg/m	Total Weight (ton)
Roof	10	250	4000	17	1.5	0.617	0.0157335
13	12	250	4000	17	1.5	0.888	0.022644
12	12	250	4000	17	1.5	0.888	0.022644
11	12	250	4000	17	1.5	0.888	0.022644
10	12	250	4000	17	1.5	0.888	0.022644
9	12	250	4000	17	1.5	0.888	0.022644
8	12	250	4000	17	1.5	0.888	0.022644
7	12	250	4000	17	1.5	0.888	0.022644
6	12	250	4000	17	1.5	0.888	0.022644
5	12	250	4000	17	1.5	0.888	0.022644
4	12	250	4000	17	1.5	0.888	0.022644
3	12	250	4000	17	1.5	0.888	0.022644
2	12	250	4000	17	1.5	0.888	0.022644
1	12	250	4000	17	1.5	0.888	0.022644
							0.3101055

No. of Rectangular Slab in one Story	18
No. of Center Slab zone (A) in one Story	2
No. of Center Slab zone (B) in one Story	2

Total Rebar Weight of Slab in whole Building (ton)

66.070713

The volume of Concrete in the Slab

No. of Stoy	Total Area (m)	Thickness (m)	Volume (m^3)
Roof	464	0.15	69.6
13	464	0.15	69.6
12	464	0.15	69.6
11	464	0.15	69.6
10	464	0.15	69.6
9	464	0.15	69.6
8	464	0.15	69.6
7	464	0.15	69.6
6	464	0.15	69.6
5	464	0.15	69.6
4	464	0.15	69.6
3	464	0.15	69.6
2	464	0.15	69.6
1	464	0.15	69.6
			974.4

The volume of Concrete in the Slab in whole building

974.4