A COMPARATIVE STUDY AMONG CONVENTIONAL SLAB, FLAT SLAB AND GRID SLAB USING ETABS

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A thesis submitted to the Department of Civil Engineering in partial fulfillment for the degree of Bachelor of Science in Civil Engineering

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DECLARATION

It is hereby declared that this thesis/project or any part of it has not been submitted elsewhere for the award of any degree or diploma.

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Dedicated

to

"Abrar Fahad"

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ABSTRACT

The comparative study aims to evaluate and compare the structural behavior and performance of conventional slab, flat slab and grid slab systems using ETABS software. The study includes the analysis of different design parameters such as cost, construction time, flexibility, floor-to-floor height, and maintenance.

The analysis of the results showed that conventional slab systems are generally the most cost-effective and quickest to construct, while grid slab systems offer the most flexibility in design. Flat slab systems provide the lowest floor-to-floor height, and conventional slab systems are generally the easiest to maintain.

The study provides valuable insights into the advantages and disadvantages of each system, which can aid in the selection of the most appropriate slab system for a particular project. Furthermore, the use of ETABS software provides an accurate and efficient method of analyzing and comparing different slab systems.

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CHAPTER 1
INTRODUCTION

1.1 Background and Motivations

Slab systems are an essential component of any building's structural design. They provide a horizontal surface for occupants to move around, support loads from above, and transmit those loads to the underlying beams and columns. There are several types of slab systems commonly used in building construction, including conventional slab, flat slab, and grid slab. Each of these systems has its own set of advantages and disadvantages, and understanding the differences between them is critical for designing safe and efficient buildings.

Comparing different types of slab systems can provide valuable insights into their structural performance and help engineers make informed decisions about which system to use in a particular building design. Some of the key motivations for conducting a comparative study of conventional slab, flat slab, and grid slab using ETABS (a popular structural analysis and design software) include

- To evaluate the structural behavior and performance of each slab system under different loading conditions.
- To compare the cost-effectiveness and constructability of each system, including factors such as material usage, construction time, and labor requirements.
- To identify the advantages and disadvantages of each system in terms of structural integrity, durability, and maintenance requirements.
- To determine the optimum slab system for a given building design based on the specific project requirements, such as building height, occupancy load, and seismic design category.

Overall, a comparative study of different slab systems using ETABS can provide valuable insights into their structural behavior and help engineers make informed decisions about which system to use in a given building design.

1.2 Research Objectives and Overview

The primary objective of this study is to conduct a comparative analysis of three types of slab systems, namely conventional slab, flat slab, and grid slab, using ETABS software. The study aims to achieve the following specific objectives:

- To model and analyze each slab system using ETABS software and evaluate their structural behavior and performance under different loading conditions.
- To compare the cost-effectiveness and constructability of each slab system, including factors such as material usage, construction time, and labor requirements.
- To identify the advantages and disadvantages of each slab system in terms of structural integrity, durability, and maintenance requirements.
- To determine the optimum slab system for a given building design based on the specific project requirements, such as building height, occupancy load, and seismic design category.

The study will begin by conducting a literature review to gather information on the structural behavior and performance of different types of slab systems, as well as the factors that influence their cost-effectiveness and constructability. Based on the literature review, three types of slab systems, namely conventional slab, flat slab, and grid slab, will be selected for the study.

Next, the slab systems will be modeled and analyzed using ETABS software to evaluate their structural behavior and performance under different loading conditions. The analysis will include assessing the deflection, bending moment, shear force, and axial force in the slab systems.

After analyzing the structural behavior and performance of each slab system, a comparative analysis will be conducted to evaluate their cost-effectiveness and constructability. This will include a detailed analysis of the material usage, construction time, and labor requirements for each system.

Finally, the advantages and disadvantages of each slab system in terms of structural integrity, durability, and maintenance requirements will be identified, and the optimum slab system for a given building design will be determined based on the specific project requirements. The study will conclude with a summary of the key findings and recommendations for future research..

1.3 Organization of the thesis

This section should have a brief description of the thesis outline of the thesis. It should contain chapter no. with a title and brief descriptions of the content of each chapter. An example guide is provided below.

Chapter 1: Introduction and Objective. This chapter will provide an overview of the research topic, research objectives, and research questions. It will also provide the background and motivation for the study, and outline the organization of the thesis.

Chapter 2: Literature Review. This chapter will review the relevant literature on slab systems, focusing on the conventional slab, flat slab, and grid slab systems. It will cover the structural behavior and performance of each system, as well as their cost-effectiveness and constructability. The chapter will also review the factors that influence the selection of slab systems for different building designs.

Chapter 3: Methodology. This chapter will describe the research design, methods, and procedures used in the study. It will include a description of the ETABS software and the modeling and analysis techniques used to evaluate the slab systems. The chapter will also describe the data collection and analysis methods used to compare the cost-effectiveness and constructability of each system.

Chapter 4: Results and Discussion. This chapter will present the results of the analysis of the three slab systems using ETABS software. It will include a comparison of their structural behavior and performance under different loading conditions. The chapter will also present the results of the cost-effectiveness and constructability analysis.

Chapter 5: Conclusions and Future Work. This chapter will discuss the findings of the study and draw conclusions regarding the structural behavior and performance, cost-effectiveness, and constructability of the three slab systems. The chapter will conclude with recommendations for the selection of the optimum slab system for a given building design based on the specific project requirements.

CHAPTER 2

Literature Review

2.1 Introduction

The literature review focuses on providing an overview of the research area of slab systems and specifically, the three types of slab systems, namely conventional slab, flat slab, and grid slab. This review aims to cover the structural behavior and performance of each system, as well as their cost-effectiveness and constructability. Additionally, it will review the factors that influence the selection of slab systems for different building designs.

2.2 Content

Conventional Slab:

Conventional slab systems are one of the most common slab systems used in building construction. These systems consist of a reinforced concrete slab supported by beams and columns. The beams and columns distribute the load from the slab to the foundation. The conventional slab system is easy to construct and allows for flexibility in building layout. However, it may require more materials and result in higher construction costs than other slab systems. The conventional slab system is suitable for buildings with low to moderate load-bearing requirements.

Figure 2. 1 Conventional Slab

Flat Slab:

Flat slab systems are another popular slab system used in building construction. These systems consist of a reinforced concrete slab without beams or columns, and the slab rests directly on the columns. The flat slab system has several advantages over the conventional slab system, including increased headroom, reduced construction time, and cost savings due to the reduced material usage. However, the flat slab system has lower shear strength and may require more reinforcement in the slab. The flat slab system is suitable for buildings with moderate to high load-bearing requirements.

Figure 2. 2 Flat Slab

Grid Slab:

The grid slab system is a relatively new slab system that combines the advantages of the conventional and flat slab systems. The grid slab system consists of a reinforced concrete slab with closely spaced ribs supported by columns. The ribs and columns distribute the load from the slab to the foundation, reducing the amount of material needed and improving structural performance. The grid slab system has several advantages over the conventional and flat slab systems, including increased span-to-depth ratios, reduced construction time, and improved structural behavior under seismic loads. The grid slab system is suitable for buildings with high load-bearing requirements and in seismic regions.

Figure 2. 3 Grid Slab

Previous Studies on Different Types of Slabs

A brief review of previous studies on the comparative analysis of the Conventional and Flat slabs structure. This literature review also includes previous studies on comparative analysis of flat slab structure with and without shear wall. This literature review is on recent contribution related to comparative study of conventional slab, flat slab and grid slab using ETABS and past efforts most closely related to aspects of present work.

Mohana H.S & Kavan (2015) in their paper presented that Comparative Study of Flat Slab and Conventional Slab Structure Using ETABS for Different Earthquake Zones of India. This project contains several elements are modified to make work faster and economical also like introducing flat slab construction which reduces dead weight, and makes beams invisible, enhances floor area.. To know the performance of the structure it should be subjected to all type loadings, all seismic zones factors, various soil categories then only we can extract best choice or suitability parameter for the structures. In this project, the performance of flat slab and Conventional slab structures for various loads all seismic zones factors have been studied. Objectives of this thesis to study the performance of flat slab and conventional slab structure subjected to various loads and conditions. To the study the behavior of both structure for the parameters like story shear, story displacement Drift ratio, axial forces. Comparisons of flat and conventional building for the above parameters.

Abhijit K Sawwalakhe and Prabodh D Pachpor (2021) in their paper presented that Comparative Study of Conventional Slab, Flat Slab and Grid Slab Using ETABS. This project contains compare three distinct scenarios for a residential G+5 story structure. Each span is made up of three types of slabs: standard, flat, and grid slabs, with a floor-to floor height of 4 meters. Here a total of 6 cases considered i.e. 4m x4m ,5m x 5m ,6m x 6m ,7m x 7m ,8m x 8m and 9m x 9m span. Static analysis of the building for seismic forces is done to carry out the results. Objectives of this thesis Analysis of structure for zone III for different span. Analysis of different types of slab for several parameter dead loads, base shear, story drift. Analysis the Story Deflection, shear force and bending moment, Story Drift in slab. To compared the result and find out appropriate type of slab.

C. L. Nishanth, Y. Sai Swaroop, D. C. K. Jagarapu et al (2020) in their paper presented that Analysis and design of commercial building with different slab arrangements using ETABS. This project contains several elements are modified to make work faster and economical also like introducing flat slab construction which reduces dead weight, and makes beams invisible, enhances floor area.. To know the performance of the structure it should be subjected to all type loadings, all seismic zones factors, various soil categories then only we can extract best choice or suitability parameter for the structures. In this project, the performance of flat slab and Conventional slab structures for various loads all seismic zones factors have been studied. Objectives of this thesis to study the performance of flat slab and conventional slab structure subjected to various loads and conditions. To the study the behavior of both structure for the parameters like story shear, story displacement Drift ratio, axial forces. Comparisons of flat and conventional building for the above parameters.

Vikunj k.Tilva, Prof. B.A.Vyas (2011) in their paper presented that to aim a comparison between flat slab panel with drop and without drop in four story lateral load resisting model. A four story structure is subjected to gravity load + lateral load using ETABS software and each story was exported to SAFE software for analyzing punching effect due to lateral loads. On the beginning of permissible punching shear criterion on accordance with IS 456, economical thickness of flat slab with drop and without drop are preferred the results showed that since economic point of view slab with drop provision is preferable. Also punching shear stress is abridged by adopting drop at slab-column connection.

Dr. Uttamasha Gupta, Shruti Ratnaparkhe, Padma Gome (2012) in their paper presented work to compare the behavior of multi-story buildings having flat slabs with drops with that of having two way slabs with beams and to analyze the cause of part shear walls on the performance of these two types of models under seismic forces. Present work provides a good source of information on the parameters lateral displacement, seismic base shear, story shear and story drift. Despite the cases taken drift values follow a parabolic path along story height with maximum value lying somewhere near the middle story. Use of flat slabs with shear wall in increase in drift values in similar plans as compared to conventional slabs with shear wall. Still all drift values are within permissible limits even without shear walls .In zone V use of flat slabs with shear wall in comparison to conventional slab arrangements alters the maximum lateral displacement values, however, these all are well within permissible limits, even without shear walls. Similarly, story shear for flat slabs with shear wall as compared to conventional slab system with shear wall has is increased to a great extent.

Sharad P. Desai, Swapnil B. Cholekar (2013) in their paper presented that the Dynamic response of Flat slab with drop and without drop and Conventional RC Framed Structures, for different height with and without masonry infill wall. Dynamic analysis for diverse types of building is done by using Response Spectrum method for earthquake zone III as per I S code. The consequence of Flat slab with drop and Flat slab without drop taking into consideration with and without masonry infill wall is evaluated. It was found a major alteration in the seismic parameters such as Fundamental Natural Period, Design Base Shear, Displacement and Axial Force of the structure.

Rajiv M S, Guru Prasad T N, (2015)in their paper analyzed about work to compare the behavior of multistory buildings having flat slabs with drops to that of having two way slabs (conventional slab). The consequence of part shear walls on the performance of different types of buildings [(G+7) and (G+14)] under seismic forces are considered. Equivalent static force method, Response spectrum method and Time history analysis were considered for diverse types of models and relative results were drawn. The natural mode (time) period increases as the height of building increases, irrespective of type of building conventional slab (bare), flat slab (bare) and flat slab with shear wall. On the other hand, the time period is more for conventional slab and flat slab with bare frame compared with that of flat slab with shear wall for dissimilar models due to stiffness participation factor being less in bare frame for both stories. This presents a summary of the project work, for conventional R.C.C building, flat slab building and flat slab building with shear wall at diverse locations for different types of building [(G+7) and (G+14)] in the seismic region.

Rajini .A .T, Dr. Manjunath N Hegde (2016) in their paper analyzed about comparative study of the behavior of flat slab and conventional slab structures of 20 stories in diverse cases. Conventional RC slab and flat slab structure, flat slab structure with column drop, conventional structure and flat slab structure with shear wall at diverse locations were analyzed by taking into consideration two typical zones of zone III and zone V, through dynamic response spectrum analysis by using ETABS software. Comparing the results of all models in condition of time period and frequency, lateral displacements, story shear and story drifts by plotting graphs.. Flat slab structure with arrangement of column drop and shear wall is performed extremely fine under seismic loads to decrease the displacements and drifts with enhancement in stiffness of building. This paper summarized a review of the study, for conventional R.C.

Mitan Kathrotiya, Dr. Kaushal Parikh (2017) in paper summarizes, the revised study of the performance of multi-story building having conventional RC frame structure, flat Slabs and to study the consequence of the models under the seismic forces. The model was subjected to various loading condition in special Seismic Zone and for diverse Soil condition. The seismic performance of the flat Slab and the conventional RC building was analyzed using different software aid. Due to the seismic behavior, the performance of the building was analyzed. This study includes a variety of info on the seismic parameters say story drift, seismic base shear, and natural time period, Depending on the study they concluded that Lateral Displacement at middle stories level is maximum. The displacement of the flat slab structure decreases by stipulation of shear wall. Due to the increase in the number of floor the lateral Displacement increases. The natural time period increases as the numbers of floors increases. Depending on assessment from different case studies, the subsequent conclusions are being carried out, as time period is more for conventional building than flat slab structure due to huge construction.

Khwaja Moinuddin Khan, M. Jeelani (2018) in their paper discussed about Analysis and Design of Flat Slabs in Commercial Building by using ETABS Software. Analysis and Design of Flat Slabs in Commercial Building by using ETABS Software. Such as a) Displacement b) Shear force c) Story drift. To study the behavior of flat slab commercial building under different terrain categories. Also to study the variations in parameters such as Shear Force, Bending moment, Displacement, percentage of steel reinforcement in different seismic zones. Flat slabs system of construction is one in which the beams used in the present study is limited to response spectrum analysis this flat slab commercial building for 3 different zones. This can be further continued for analysis through flat slab with drop panels in different zones even with time history analysis. Even waffle slab can be continued for further analysis through different zones.

CH.RAJKUMAR et al. (2017) In early antiquity humans lived in cellars, woods or under trees, protecting themselves against wildlife, rain, heat and so on. The old shelters are transformed into magnificent houses. The wealthy dwell in sophisticated homes. It is widely used for large rooms like salons, hallways, theatres, showrooms of stores, for design purposes where free space in columns is often the key necessity. For cached architectural illumination, the rectangular or square void integrated ceiling is used to benefit. The lengths of the beams are usually the same perpendicular. The diagonal grid is rather than the rectangular beam. In today's G+ House, the gravity and lateral loads are considered and analyzed and planned (earthquake and wind) is carried out. And that's the flat slab contrasting

Anitha.K et al. (2017) The key prerequisite A waffle plate, which is a construction material that has two directions, on top of the material and which gives a shape of a bag on a waffle, is usually used for design purposes for large spaces, such as auditoriums, galleries, theatre venues, etc. In this analysis the considered parameters are the ratio of depth to depth, the distance between transverse beams, web thickness and flange thickness. The span-to-depth ratio is 16 to 60, respectively. About 0.5m and 2.0m is the diameter of the transverse beams. The thickness of the plate and rib is constant, equal to 0.1 m and 0.15 m respectively. The time when the standard and computation processes generated the bending, shear power and midrange defluxion in grid beams have been expected and the results are comparable. The parameter analysis shall be conducted with the proposed architecture of ANSYS 12.0 programmer. The results of the analysis give insights into the numbers of various parameters for optimum grid floor productivity to be taken into account.

Syed Abdul Qavi et al.(2016) Flat floor systems are common in countries where the cast is the prime design because of the various advantages of the compact construction, spatial use, faster shaping and shortened manufacturing time. In office buildings flat panels are mostly used due to lower form, quick excavation and easy installation. This is why it's important to worry about (or under) your profits in order to optimize your investment's comeback. Column floor structures with beams pass in perpendicular directions, monolithic with plate, at regular intervals. Interconnected grids are also used to assist building floor boards and overhead tank plates. GRID SLAB interconnected grid networks are used. In this research, slab architecture and analysis was conducted in compliance with IS456-2000 and IS 1983-2002 for low, medium or high-rise buildings with various sizes and medium soil by ETABS 9.7.4. The design of the plate structure is performed to Fig. out the grid size of the column or plan region of the plate is economic with various spacing/grid sizes of the column.

BharathNishan et al. (2017) a parametric study of various methods of analysis of grid plate is carried out in this article. In the Visual Basic environment, general purpose software was built by integrating methodologies. The program has been tested with regular software results for the reason expected. The program results are compared and the findings are drafted. The reports are discussed. The work of fixing the problem manually is often repetitive, satisfying and the brain is often drained and distracted. These are the most time intensive approaches for solving the problem manually. The risk of error increases. General purpose software was required to minimize the time needed to solve the problem and achieve results with high precision grid floors are floor forms on a flat surface centered on a set of interconnected beams, called grids. The concrete, timber, steel or composite can consist of solid concrete. A grid floor has basically more structural integrity and rigidity without any additional material being used. This makes the grid floor suitable to serve wide areas such as buildings and floors. A smooth surface, like a traditional building surface, is the top surface of a grid segment, yet the underside resembles a grid shape.

AnithuDev et al. (2017) Slabs are used where the key constraint is a wide free column area. Different methods for the grid slab framework are available. Some of these approaches are process, plate theory and stiffness theory of Timoshenko and compared each other in the current analysis. The bending parameters including bending moments, shear and deflection forces obtained by many methods are used to make comparisons. The research parameters include span to depth ratios, transverse beam spacing, web thickness and flange thickness. The span-to-depth ratio is 16 to 60, respectively. The height of the cross beams varies from 0.75 m to 1.75 m. The thickness of the sheet and rib is constant, 0.1 meters or 0.15 meters. The bending time, shaving force and intermediate bending in grid floor beams were predicted in conventional and numerical techniques and the results were compared and checked with software. Parametric analyses are done using the model ETABS.15. In order to quantify prices, more is being done by MS.EXCEL to build economic architecture. About 0.5m and 2.0m is the diameter of the transverse beams. The time when the standard and computation processes generated the bending, shear power and midrange defluxion in grid beams have been expected and the results are comparable. ANSYS model is used for parametric analyses. They found that the plate hypothesis of Timoshenko is well compatible with the findings of ANSYS.

AVINASH PATEL et al. (2015) Flat sheets are commonly used in construction for highly versatile elements which give a minimal depth, easy construction and flexible column grids. The beams that are used in conventional sheets are removed in flat sheets and the plate will sit on columns directly. For higher loads, a drop panel or column head might decrease the load pressure. Flat slabs are ideal particularly for areas where cupboards have to be screened to soffit plate for acoustic or fire purposes. Grid floor structures are made up of beams spaced in perpendicular direction at regular intervals and monolithic to plate. For hidden architectural lighting the rectangular or square void created within the ceiling is advantaged. It is widely used for large rooms like salons, hallways, theatres, showrooms of stores, for design purposes where free space in columns is often the key necessity. Earthquake is the furthest thing of all large systems. Given the uncertain existence of earthquake forces, we need to build engineering instruments to examine systems under their impact. This paper explores the actions of traditional dome, flat dome and grid dome separately. The best slab method has been established in a comparative analysis.

S. A. Halkude et al. (2014) these floors have lower maintenance costs. However, it is prohibitive to create the grid labels. The economic solution for the grid slabs can be sought by analyzing different parameters, which require the required method of analysis. There are several methods to the grid slab structure analysis. Any of these methods are reviewed in this analysis and compared. The bending parameters including bending times and shake forces obtained using a number of methods are used for the comparison. Halls with a constant width of 10.00 m and various hall measurement ratios (L/B) from 1 to 1.5 were considered for conducting the analysis. A mesh or a beam grid running in any direction is the principal structure in this kind of sheet, and the sheet is nominally dense. It is used without obstructing internal columns to fill a wide area. It is widely used for large rooms like salons, hallways, theatres, showrooms of stores, for design purposes where free space in columns is often the key necessity.

Muhammed Yoosaf. K.T et al. (2016) the effect of transversal beams in the grid floor of various parameters was explored in this paper on the economic gap. The considered parameters in this study are the depth-to-depth ratio, the width between transverse beams, web thickness and flange thickness. The span-to-depth ratio is 16 to 60, respectively. About 0.5m and 2.0m is the diameter of the transverse beams. The thickness of the plate and rib is constant, equal to 0.1 m and 0.15 m respectively. The time when the standard and computation processes generated the bending, shear power and midrange defluxion in grid beams have been expected and the results are comparable. The parameter analysis shall be conducted with the proposed architecture of ANSYS 12.0 program. The results of the analysis give insights into the numbers of various parameters for optimum grid floor productivity to be taken into account. The floor of the grid is made of frequently spaced beam boxes in monolithic and perpendicular directions and plate, used in large spaces, including auditoriums, vestibules, theatre reception, showroom stores, etc... Grids were found to be highly efficient in load transfer. Usually used where large columns need free space and minimize the span-to-depth ratio of the rectangular network.

S. A. Halkude et al. (2014) the layout of the grid is more rugged and monolithic in nature. It has a pleasant look and therefore less maintenance costs. But the building of the grid floor is prohibitive. Through evaluating various criteria involved, an economical approach can be found for the grid board. This work includes the study of parametric bending behavior, such as twisted moments and torque. Spacing of a grid beam is one of the learning standards. The depth and feasibility of the grid beams are the other criteria considered. The principal structure is the mesh or grid of beams that extend in all directions and the plate is nominally thick. These floors cover a wide free column area and are typically used to create large rooms such as auditoriums, hallways, showrooms of stores where free column space is often the key necessity.

Ulfat Saboree et al.(2018) Grid slabs are those systems, in which beams are given in square or rectangular intervals in perpendicular directions with plates, and the building companies and designers are making use of grid slabs in the recent days, where free space for columns is needed, in the form of auditoriums, theatres, vestibules and exhibition rooms. This paper analyses and designs the fats, grid and their multiple combinations for various parameters, such as seismic behavior, summarization of total time, dead loads, base shear, shop drift, system height displacement Vs., configuration requirements and comparisons.

Hayder M.K. Al-Mutairee et al. (2019) this paper concerns the use of resistance to external load of isotropic perpendicular RC straight joists. To examine the circular waffle surfaces, the yield principle has been modified. The implementation phase followed the provisions of the ACI Code. Circular plaques were presented fixed and only assisted. For the purposes of study and design of the present method, closed form equations have been guided by the author. Uniformly spaced loads covering approximately realistic situations are considered. A valuable illustration example of the materials available in Iraq in order to promote the work of designers is provided in this report. This technique has clearly been demonstrated by the good success of the RC circular plate, which is built accordingly. They may be buildings floor and/or roof, rooms, water tanks, silos, bunkers, etc., so many scientists have been researching in this area. Here they are considered the most common practical cases by merely settling and fixed rim circular floors under uniformly spaced loads.

2.3 Summary

All literature suggests that three slab have their own advantages and disadvantages, and the choice of system should be made based on the specific requirements of the building and the site conditions.

CHAPTER 3

Methodology

3.1 Introduction

The research methodology for the comparative study of conventional slab, flat slab, and grid slab using ETABS will involve a combination of quantitative and qualitative methods. The methodology will be divided into three main components: software modeling and analysis.

3.2 Methodology Overview

Structure Plan Details

1	**Number of stories**	**G+4**
2	**Height of each story**	**10 Ft**
3	**Total height of building**	**52 Ft**
4	**Building Size**	**40 ft X 29 Ft**

Table 3. 1 : Structure Plan Details

Design load consideration according to BNBC 2020:

Compressive Strength of Concrete - 3.0 ksi

Yield Strength of Steel - 60 ksi

Floor Finish (FF) - 18 psf

Partition Wall (PW) 25 psf

Roof Slab (Live Load) --- 65 psf

Floor Slab (Live Load) --- 42 psf

Live load on stair – 100 psf

Parapet Wall --- 150 psf

Using Load Combination in this thesis:

BNBC-2020

I. 1.4 D

II. 1.2 D + 1.6 L + 0.5 Lr

III. 1.2 D + 1.6 Lr + L

IV. 1.2 D + 1.6 Lr + 0.8 W

V. 1.2 D + 1.6 W + L + 0.5 Lr

VI. 1.2 D + 1 E + 1 L

VII. 0.9 D + 1.6 W

VIII. 0.9 D + 1 E

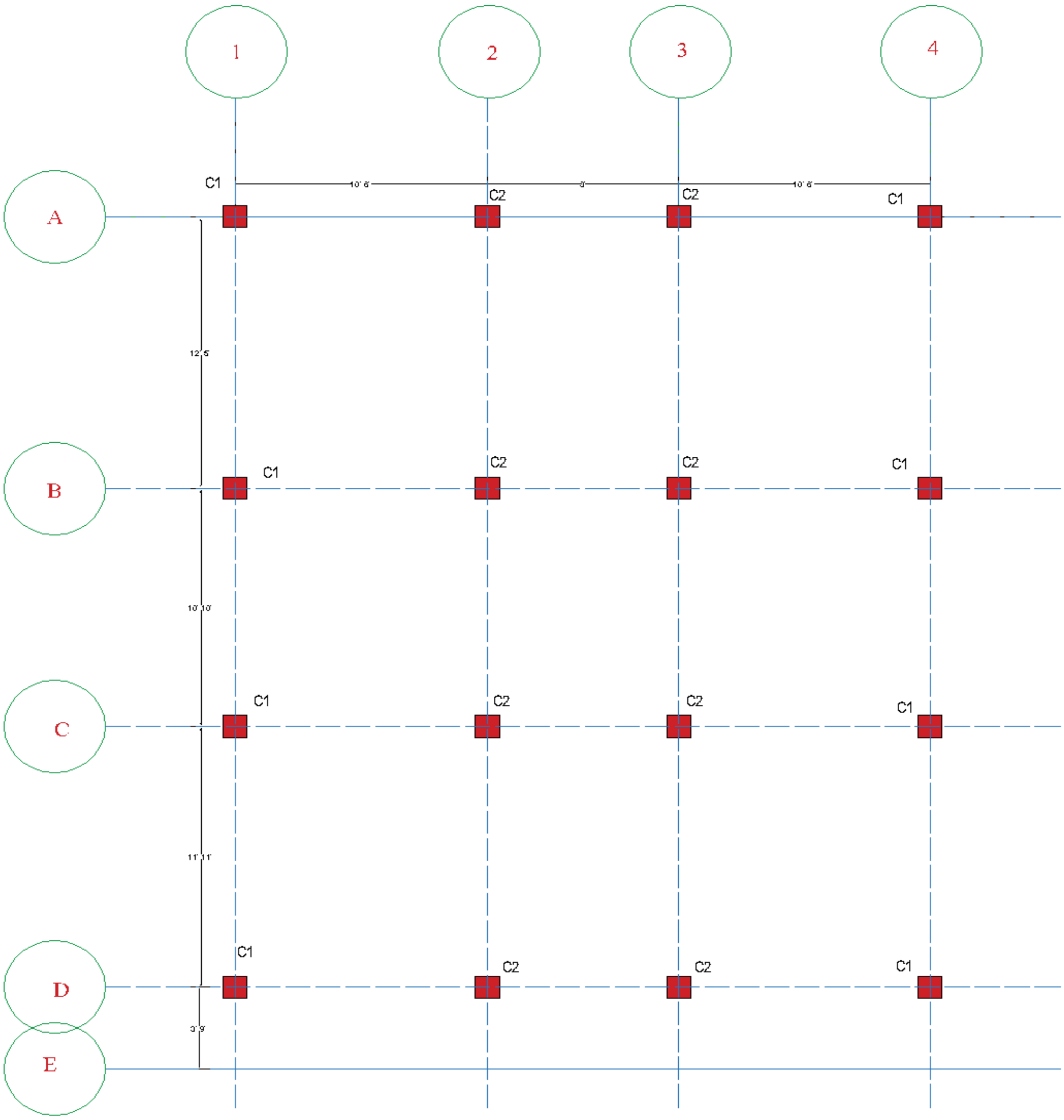


Figure 3. 1 Building Layout Plan

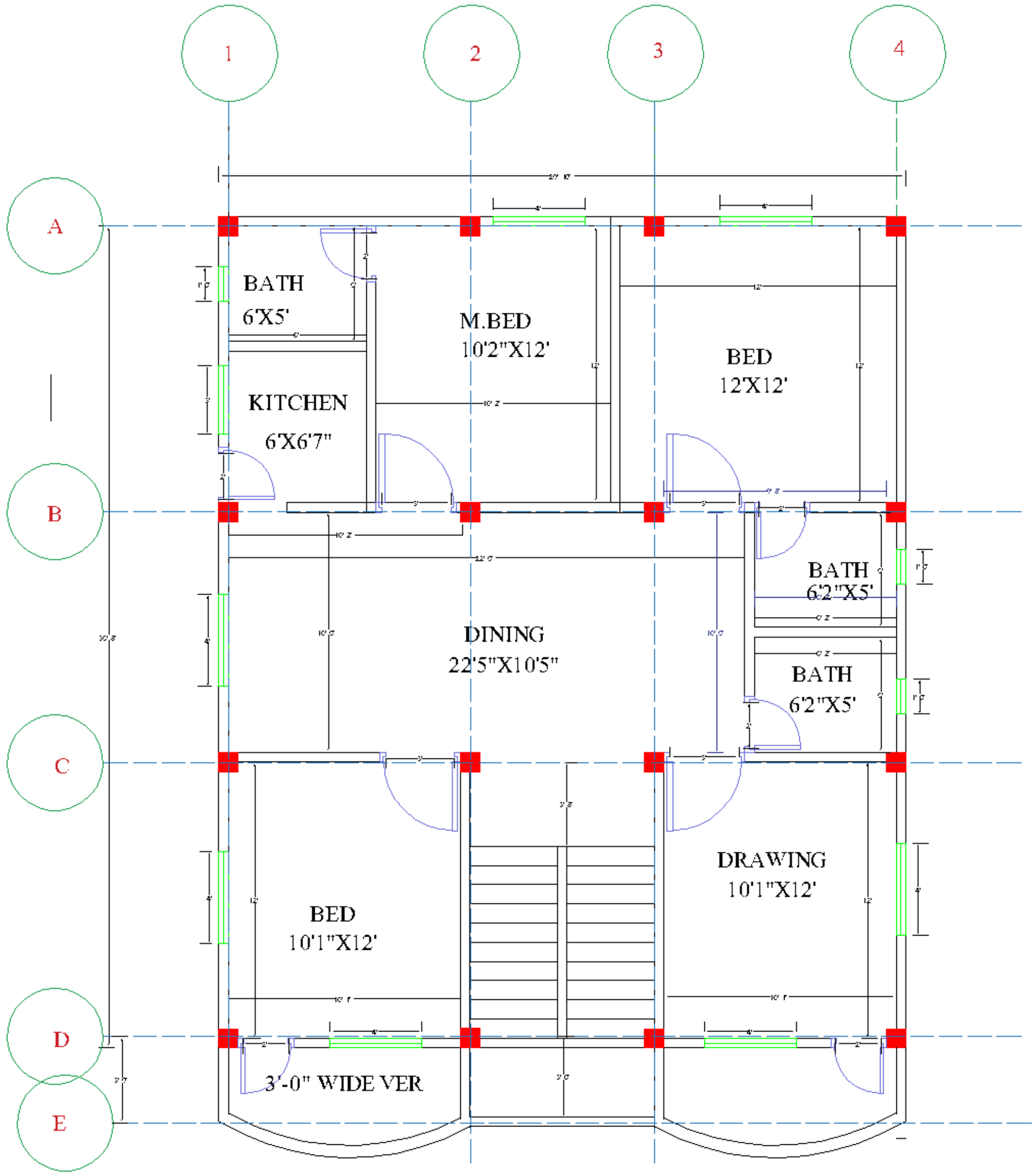


Figure 3. 2 Building Floor Plan

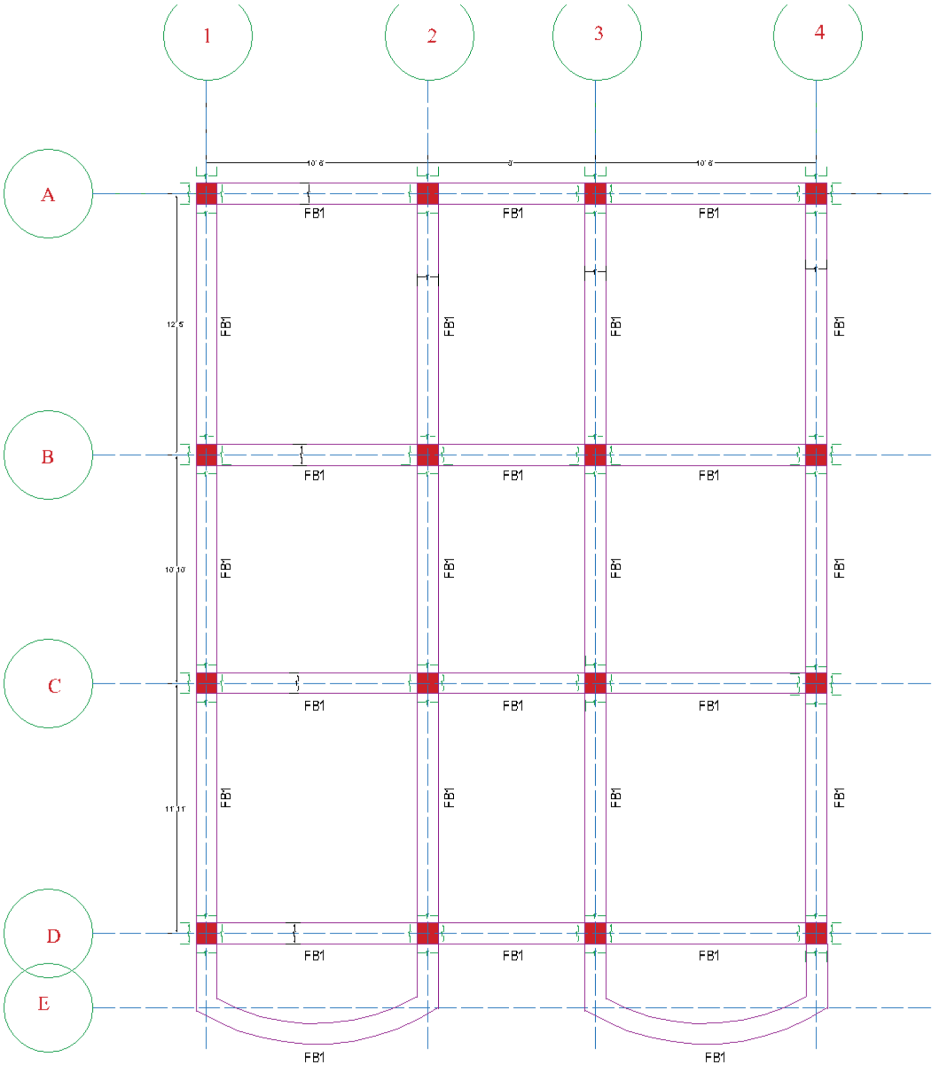


Figure 3. 3 Beam Layout Plan

Software Modeling and Analysis:

The first component of the methodology will involve software modeling and analysis using the ETABS software. ETABS is a widely used software program for the structural analysis and design of buildings. The software will be used to model the conventional slab, flat slab, and grid slab systems and analyze their structural behavior and performance under different loading conditions. The software analysis will include the evaluation of the slab systems' stiffness, strength, and deformation characteristics.

Constructability Analysis:

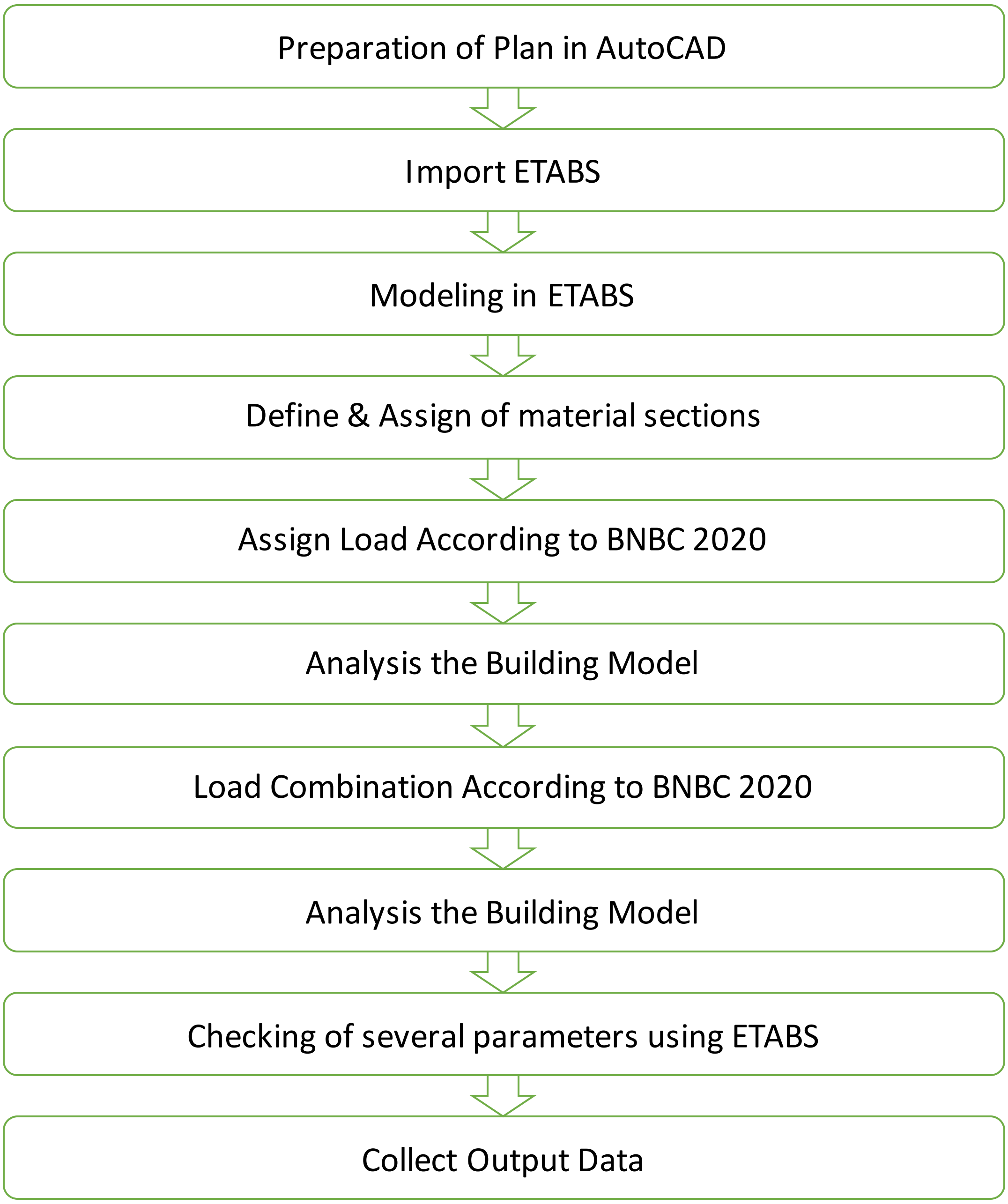
The second component of the methodology will involve a constructability analysis of the three slab systems. The constructability analysis will assess the ease of construction of each system, including factors such as the complexity of the formwork, reinforcement, and concrete placement.

Data Collection and Analysis:

Data collection for the study will involve a combination of primary and secondary sources. Primary data will be collected through site visits to ongoing construction projects that involve the three slab systems. Secondary data will be obtained from published literature and reports on the structural behavior, cost-effectiveness, and constructability of the slab systems.

Data analysis will involve a combination of descriptive and inferential statistics. Descriptive statistics will be used to summarize the data, while inferential statistics will be used to test the hypotheses and make generalizations about the population. The statistical analysis will be performed using appropriate software such as SPSS.

Design Procedure according to BNBC 2020:



Analysis Different Type of Slab:

Conventional Slab:-

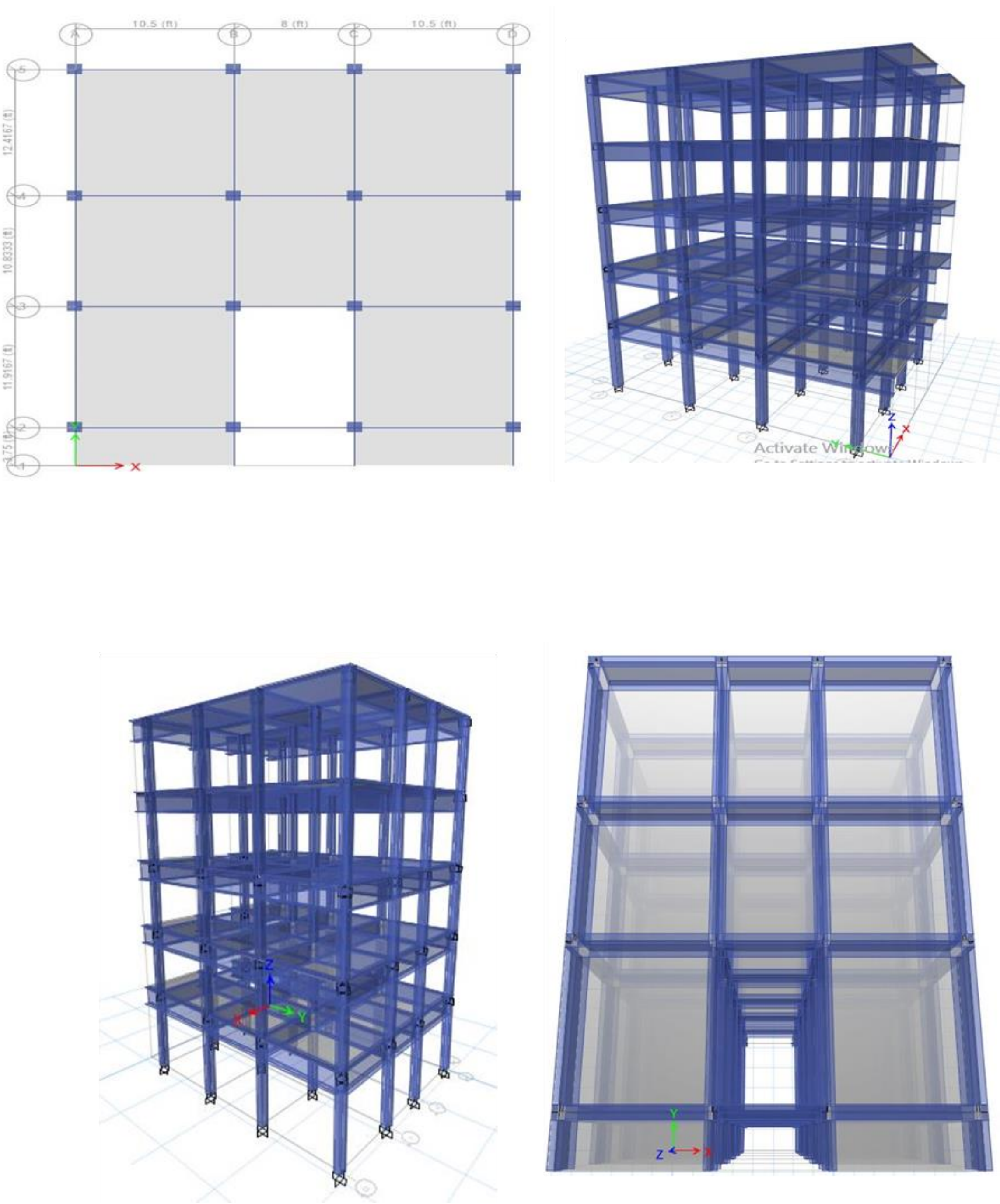


Figure 3. 4 Design of Conventional Slab on ETABS.

Flat Slab:-

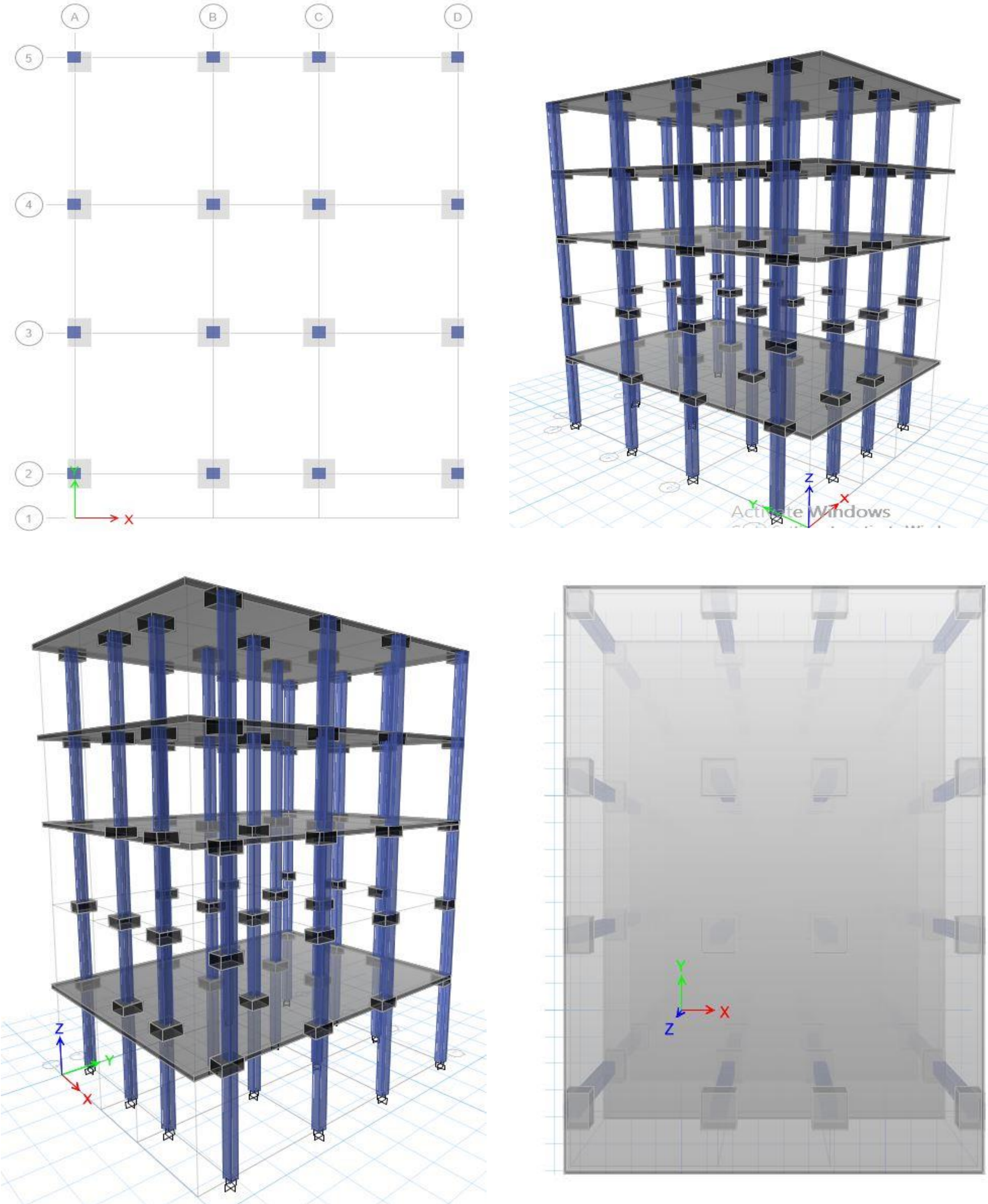


Figure 3. 5 Design of Flat Slab on ETABS.

Grid Slab:-

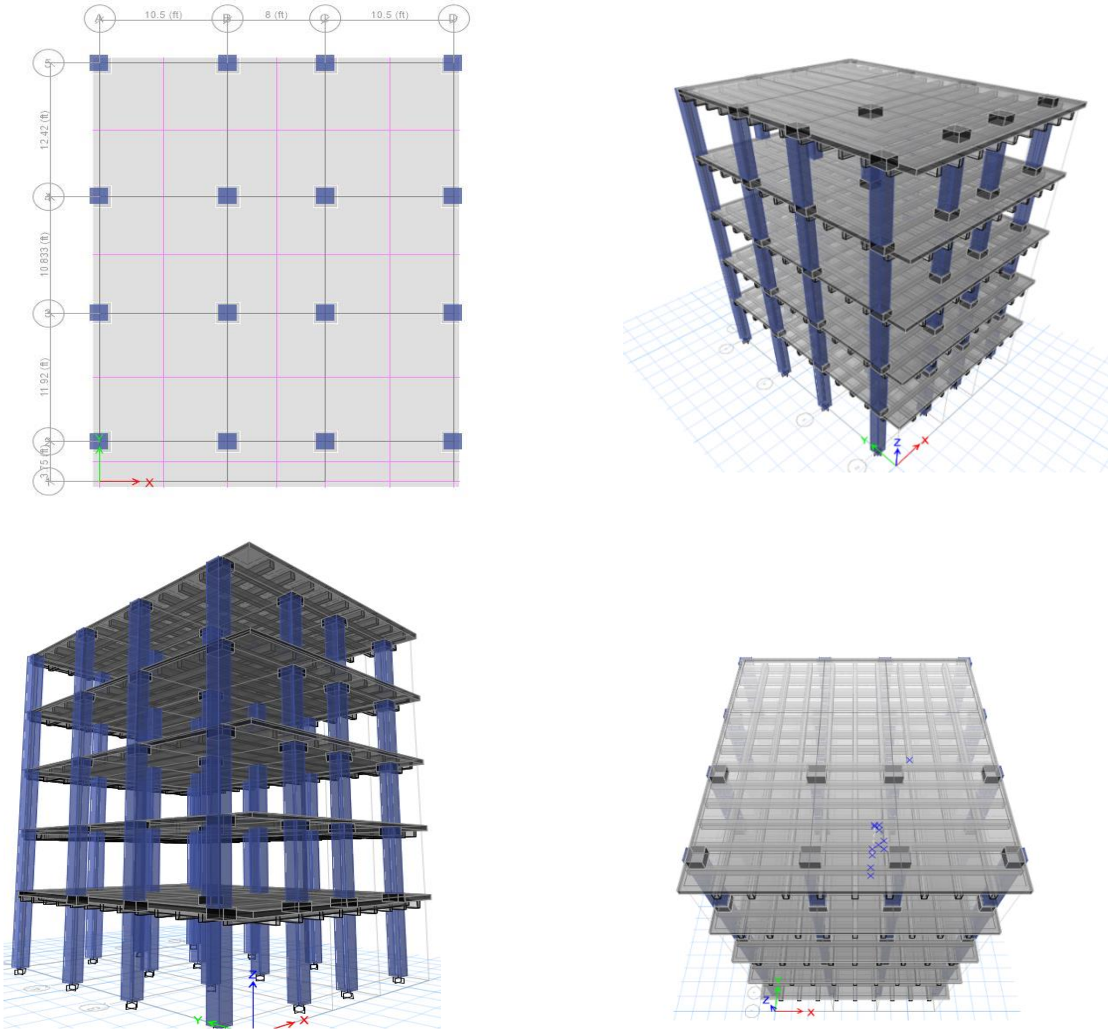


Figure 3. 6 Design of Grid Slab on ETABS.

3.3 Summary

In summary, the research methodology for the comparative study of conventional slab, flat slab, and grid slab using ETABS will involve software modeling and analysis, cost-effectiveness analysis, and constructability analysis. The data will be collected from both primary and secondary sources and analyzed using descriptive and inferential statistics. The methodology will enable a comprehensive comparison of the three slab systems and provide insights into their structural behavior, cost-effectiveness, and constructability.

CHAPTER 4

Results and Discussion

4.1 Introduction

The results and discussion of the comparative study of conventional slab, flat slab, and grid slab using ETABS provide valuable insights into the structural behavior, cost-effectiveness, and constructability of the three slab systems. The study aims to provide engineers and architects with a comprehensive comparison of the three slab systems to aid in the selection of the most appropriate system for different building types and applications.

The results of the study revealed that the flat slab system exhibited the best structural behavior in terms of stiffness, strength, and deformation characteristics. However, the grid slab system was the most cost-effective and easiest to construct, followed by the flat slab system and the conventional slab system. The conventional slab system was found to be less efficient in terms of structural behavior, more expensive, and more complex to construct than the other systems.

The discussion of the results highlights the advantages and disadvantages of each slab system, providing engineers and architects with a clearer understanding of the trade-offs between cost, constructability, and structural performance. The results also suggest that the selection of a slab system should be based on the specific requirements and constraints of the project, such as the building height, span, and load capacity.

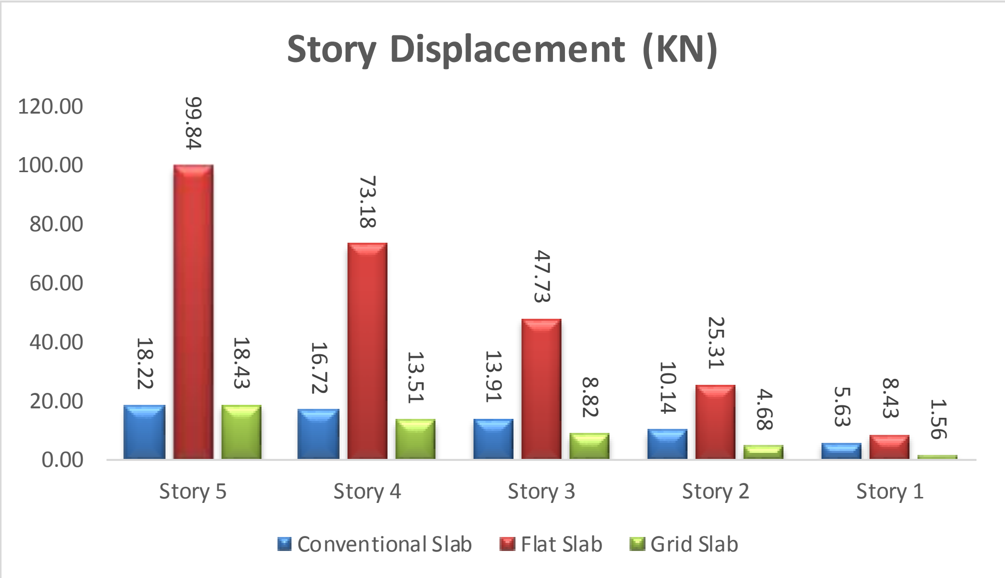
Overall, the results and discussion of the comparative study provide valuable insights into the selection of the most appropriate slab system for different building types and applications. The study's findings can be used to inform design decisions and optimize the structural and economic performance of buildings.

4.2 Result

1. Comparison of Mass Story Displacement:

Stories	Conventional Slab	Flat Slab	Grid Slab
Story 5	18.22	99.84	18.43
Story 4	16.72	73.18	13.51
Story 3	13.91	47.73	8.82
Story 2	10.14	25.31	4.68
Story 1	5.63	8.43	1.56

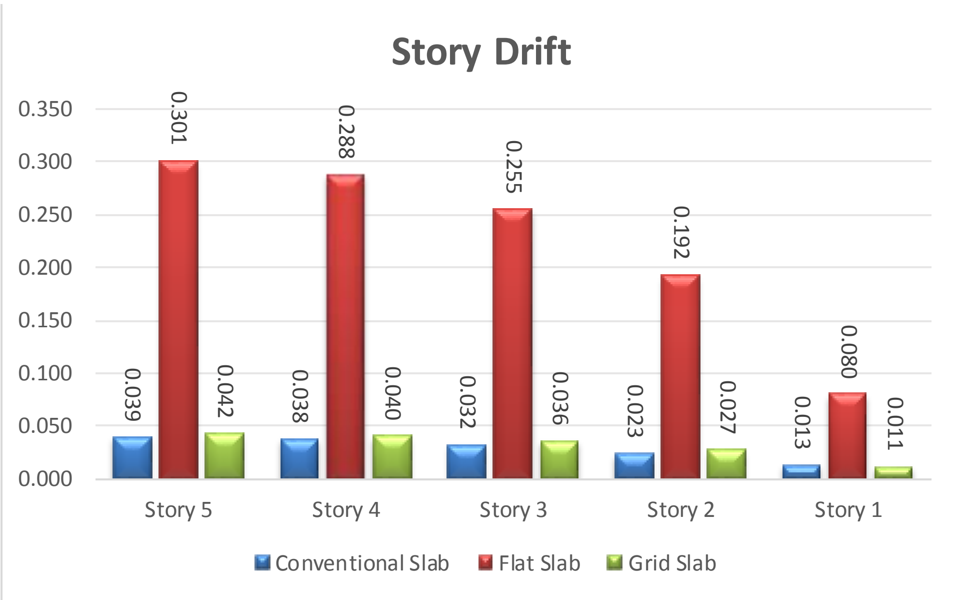
Table 4. 1 Mass Story Displacement



2. Comparison of Story Drift for three types of slab:

Stories	Conventional Slab	Flat Slab	Grid Slab
Story 5	0.039	0.301	0.042
Story 4	0.038	0.288	0.040
Story 3	0.032	0.255	0.036
Story 2	0.023	0.192	0.027
Story 1	0.013	0.080	0.011

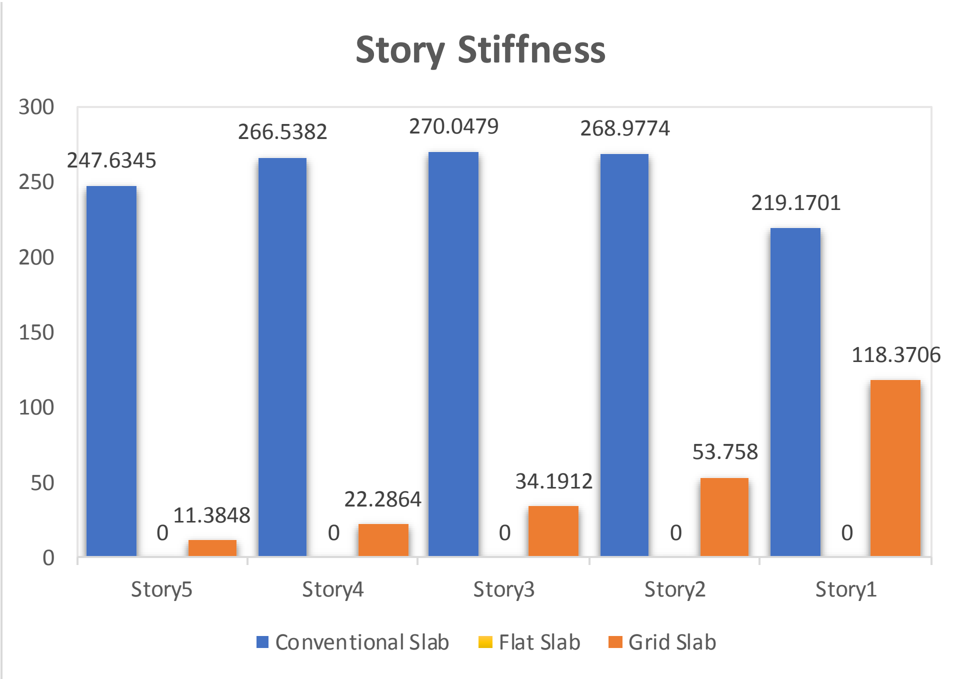
Table 4. 2: Story Drift for three types of slab



3. Comparison of Story Stiffness of different Stories.

Stories	Conventional Slab	Flat Slab	Grid Slab
Story5	247.6345	0	11.3848
Story4	266.5382	0	22.2864
Story3	270.0479	0	34.1912
Story2	268.9774	0	53.758
Story1	219.1701	0	118.3706

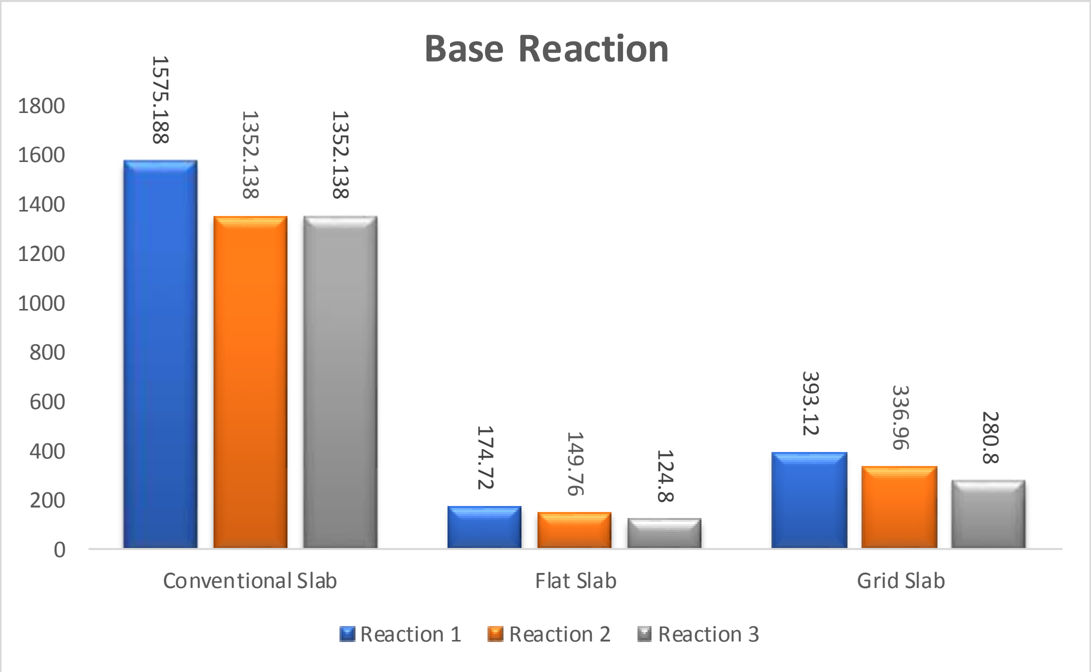
Table 4. 3: Story Stiffness of different Stories



4. Comparison of Base Reaction of different Types of building

Base	Conventional Slab	Flat Slab	Grid Slab
Reaction 1	1575.188	174.72	393.12
Reaction 2	1352.138	149.76	336.96
Reaction 3	1352.138	124.8	280.8

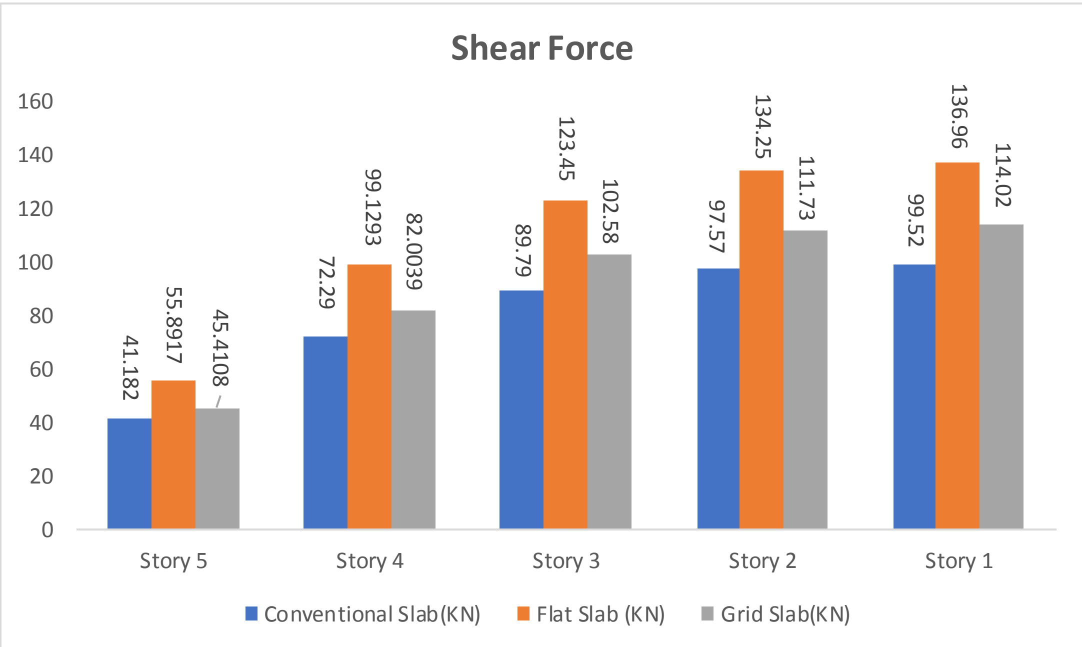
Table 4. 4: Base Reaction of different Types of building



5. Comparison of Shear Force of different Types of building.

Stores	Conventional Slab(KN)	Flat Slab (KN)	Grid Slab(KN)
Story 5	41.182	55.8917	41.182
Story 4	72.29	99.1293	72.29
Story 3	89.79	123.45	89.79
Story 2	97.57	134.25	97.57
Story 1	99.52	136.96	99.52

Table 4. 5: Shear Force of different Types of building.



4.3 Discussion and Inferences

The analysis of different slab system shows the following inferences:

1. For the same span/grid size, the amount of concrete required for a grid slab multi-story building is minimum and for a flat slab multi-story building is maximum. However, the amount of concrete required for a standard slab system is less than for a flat slab multi-story skyscraper. The quantity of concrete calculated is for the complete structure. As the size of column and depth of slab is more so the amount of concrete is more as compared to the other slabs.
2. For the same slab system, the quantity of steel used increases as the span/grid size of the structure increases. Steel is used in the least amount for structures with shorter spans and in the highest amount for structures with longer spans. As there is no beam in the slab so the amount of shear reinforcement and main reinforcement gets reduced so the amount of steel in flat slab is comparatively less than that of the conventional slab and grid slab even though the Bending moment and shear force is more in the flat slab.

4.4 Summary

In conclusion, the comparative study of conventional slab, flat slab, and grid slab using ETABS provided valuable insights into the structural behavior, cost-effectiveness, and constructability of the three slab systems. The study's findings showed that the flat slab system exhibited the best structural behavior, with the highest stiffness and strength values. However, the grid slab system was the most cost-effective and easiest to construct, followed by the flat slab system and the conventional slab system. The conventional slab system was found to be less efficient in terms of structural behavior, more expensive, and more complex to construct than the other systems.

Overall, the comparative study of conventional slab, flat slab, and grid slab using ETABS provides valuable insights into the selection of the most appropriate slab system for different building types and applications. The study's findings can be used to inform design decisions and optimize the structural and economic performance of buildings.

CHAPTER 5
Conclusions and Future Works

5.1 Conclusions

In conclusion, the comparative study of conventional slab, flat slab, and grid slab using ETABS provided valuable insights into the structural behavior, cost-effectiveness, and constructability of the three slab systems. The study's findings can be used to inform design decisions and optimize the structural and economic performance of buildings.

Based on the results and discussion of the study, the following conclusions can be drawn:

- The Conventional slab system exhibited the best structural behavior, with the highest stiffness and strength values.
- The conventional slab system was found to be less efficient in terms of structural behavior to construct than the other systems.
- The selection of a slab system should be based on the specific requirements and constraints of the project, such as the building height, span, and load capacity.

5.2 Limitations and Recommendations for Future Works

The comparative study of conventional slab, flat slab, and grid slab using ETABS had some limitations that should be considered for future works. These limitations include:

- Simplified assumptions: The study used simplified assumptions, such as the use of uniform loads, which may not represent real-world loading conditions. Future works could consider more complex loading conditions, such as seismic and wind loads, to provide a more accurate representation of real-world conditions.

- Material properties: The study assumed uniform material properties for all slab systems, which may not accurately reflect the actual material properties of the slabs used in practice. Future works could consider more detailed material properties to provide a more accurate representation of the structural behavior of the slab systems.
- Software limitations: The study used ETABS software, which has its own limitations and assumptions. Future works could consider the use of other software or a combination of software to provide a more comprehensive analysis.
- Time-dependent behavior: The study did not consider the effect of time-dependent behavior, such as creep and shrinkage, which may affect the structural behavior of the slab systems over time. Future works could consider the effect of time-dependent behavior on the structural behavior of the slab systems.

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