

Comparative Analysis and Design of Flat and Grid Slab System in Multi-Storeyed Building Under Seismic Condition

Akshay Solanke ,Dr. V. S. Rajamanya, Prof. P. A. Vedpathak, Prof. J. M. Chavan

¹Research Scholar, M. B. E. Society's College of Engineering, Ambajogai – 431517

²Research Scholar, M. B. E. Society's College of Engineering, Ambajogai – 431517

Abstract

Flat slab and grid slab systems are widely adopted in modern reinforced concrete buildings due to their architectural flexibility, efficient space utilization and suitability for medium- to high-rise construction. However, their behaviour under seismic loading differs significantly because of variations in stiffness, load transfer mechanism and lateral resistance. The present study focuses on the comparative analysis and design of flat slab, grid slab and conventional two-way slab systems in multi-storeyed buildings under seismic conditions. The main objective of the study is to evaluate the seismic response of reinforced concrete building systems by comparing parameters such as bending moment, shear force, base shear, storey drift and storey displacement. Building models of different heights, including G+2, G+5 and G+8 structures, were analysed for different slab systems. The analytical results show that grid slab systems develop higher bending moment, shear force and base shear, indicating greater stiffness and load-carrying capacity. Flat slab systems provide architectural and construction advantages but require careful design against punching shear and lateral deformation. Storey drift and displacement increase with building height, confirming the importance of stiffness control in seismic design. The study concludes that slab system selection plays a critical role in improving seismic performance and structural stability of multi-storeyed buildings.

Keywords: *Flat slab, Grid slab, Two-way slab, Seismic analysis, Storey drift, Base shear, Multi-storeyed building.*

1. INTRODUCTION

Reinforced concrete multi-storeyed buildings are widely used in urban construction due to their durability, adaptability and ability to accommodate different architectural and functional requirements. In conventional reinforced concrete construction, slabs are generally supported by beams, and beams transfer loads to columns. This system provides a clear structural load path and adequate stiffness against vertical and lateral loads. However, the presence of beams increases floor depth, reduces clear ceiling height, complicates formwork and may restrict service line installation. To overcome these limitations, flat slab and grid slab systems have become popular alternatives in modern building construction.

Flat slab construction is a special reinforced concrete system in which the slab is directly supported by columns without the use of beams. This system offers several advantages such as reduced storey height, faster construction, simplified formwork, better architectural appearance and improved flexibility for internal space planning. It is particularly useful in offices, commercial buildings, parking structures, hospitals and residential towers where open floor areas are required. The absence of beams also allows easier installation of electrical, plumbing and HVAC services. However, the major structural limitation of flat slabs is their relatively lower lateral stiffness. Since the slab directly transfers load to the column, the slab-column connection becomes highly critical, especially under earthquake loading. This region is vulnerable to punching shear failure due to the concentration of shear force and bending moment around the column.

In seismic zones, buildings are subjected to lateral forces that generate storey displacement, storey drift, base shear and internal forces in structural members. A structural system with insufficient lateral stiffness may experience excessive deformation, damage to non-structural elements or even failure at critical connections. In flat slab buildings, the absence of beams reduces the lateral load-resisting capacity, making seismic performance a major concern. Therefore, flat slab structures must be carefully checked for punching shear, deformation compatibility and additional moments caused by lateral drift. In high seismic regions, flat slab systems are often combined with shear walls or other lateral load-resisting systems to improve overall stability.

Grid slab systems, also known as waffle slab systems, consist of closely spaced ribs running in two directions. This arrangement improves load distribution, stiffness and structural efficiency. Grid slabs are suitable for larger spans and areas requiring reduced slab thickness with improved strength. The intersecting ribs help transfer load more effectively and control deflection. Under seismic loading, the grid slab system may provide higher stiffness than a flat slab system

due to its ribbed configuration. However, its behaviour depends on grid spacing, rib depth, column arrangement and overall building configuration. The comparison between flat slab, grid slab and conventional two-way slab systems is therefore important for identifying the most suitable structural system for earthquake-prone regions.

The present study focuses on the comparative analysis and design of flat and grid slab systems in multi-storeyed buildings under seismic conditions. The work considers different slab systems and evaluates their performance using important structural parameters such as bending moment, shear force, base shear, storey drift and storey displacement. The models are prepared for an $8\text{ m} \times 8\text{ m}$ building plan, and different building heights such as G+2, G+5 and G+8 are considered for comparative evaluation. The study helps in understanding how slab configuration influences seismic response and lateral stability.

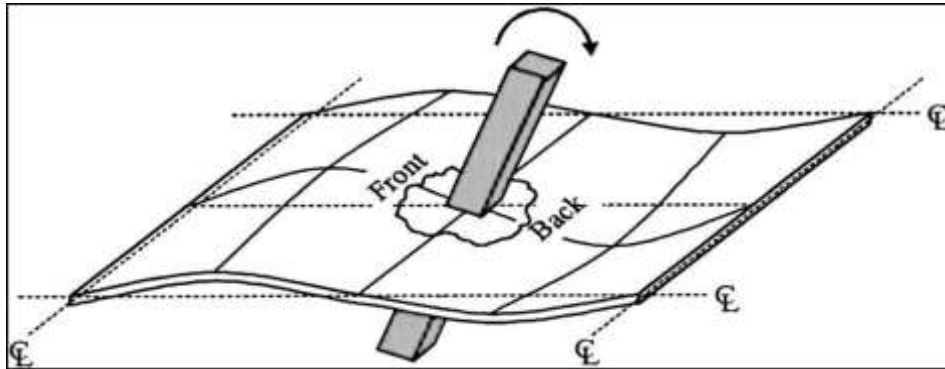


Figure 1: Typical Slab Systems Considered in the Study

The need for this study arises from the increasing use of flat slab and grid slab systems in modern construction and the requirement to evaluate their suitability in seismic zones. Although flat slabs provide construction and architectural benefits, their seismic performance needs detailed investigation due to the absence of beams and the risk of punching shear. Similarly, grid slabs provide better stiffness and load distribution but require comparative assessment under seismic forces. By analysing different slab systems, the present study provides useful information for structural engineers in selecting appropriate slab systems for multi-storeyed buildings. The findings also support safe and economical design practices by identifying the behaviour of each slab type under seismic loading.

2. OBJECTIVES

The present work consists of analysis of reinforced concrete building systems. The main focus is to compare the seismic behavior of two types of multistoried buildings, one is conventional building i.e. slab, beam & column the other one is flat slab building.

1. To analyze the reinforced concrete building systems.
2. To compare the seismic behavior of two types of multistoried buildings, one is conventional building i.e. slab, beam & column the other one is flat slab building.
3. To construct building of different number of stories for analyzing and to perform comparative analysis.
4. To compare the axial force, bending moment, base shear, time period of RCC and flat slab.

3. SCOPE OF WORK

The scope of the present study is limited to the comparative seismic performance evaluation of reinforced concrete slab systems in multi-storeyed buildings. The study considers conventional two-way slab, flat slab with drop and grid slab systems. The building models are prepared for an $8\text{ m} \times 8\text{ m}$ plan and analysed for different heights such as G+2, G+5 and G+8. The comparison is based on structural response parameters such as bending moment, shear force, base shear, storey drift and storey displacement. The study focuses on analytical and software-based evaluation rather than experimental testing. The results are useful for understanding the effect of slab system selection on seismic behaviour and structural stability.

4. LITERATURE REVIEW

The seismic performance of flat slab and grid slab systems has been widely studied in relation to multi-storeyed buildings located in high seismic zones. **Verma et al. (2024)** compared G+12 and G+15 buildings using static and dynamic seismic analysis. Their abstract focused on lateral displacement, storey drift, stiffness variation and overall structural stability. The study observed that flat slab systems provide architectural benefits such as reduced floor depth and flexible planning; however, their seismic response becomes critical because of the absence of beams. In comparison, grid slab systems

showed better performance due to higher stiffness and improved load distribution. A similar comparative study was carried out by **Arora et al. (2021)** using ETABS and STAAD Pro for G+8, G+12 and G+15 buildings. Their abstract highlighted lateral displacement, base shear, storey drift and stiffness as major response parameters. The authors found that flat slab systems are more vulnerable to lateral deformation because loads are transferred directly from slab to column. On the other hand, grid slab systems provide better resistance due to their ribbed slab arrangement. **Joshi et al. (2022)** also investigated G+10 and G+15 high-rise buildings using dynamic analysis. Their abstract emphasized storey displacement, drift control and base shear response. The study concluded that flat slabs require additional seismic detailing, whereas grid slabs show better earthquake resistance. Further, **Gupta et al. (2021)** examined buildings of different heights in seismic Zone V and assessed lateral displacement, base shear, storey drift and structural stability. Their study indicated that flat slabs show higher displacement due to lower stiffness, while grid slabs with shear walls reduce drift effectively. **Raghavan et al. (2022)** evaluated G+6 to G+12 buildings under lateral seismic forces. Their abstract focused on lateral stiffness, storey displacement and overall stability. The authors concluded that grid slab systems offer improved seismic resistance due to better rigidity and efficient force distribution.

The role of slab configuration and shear wall placement was further discussed by **Yadav et al. (2023)**, who analysed G+8, G+12 and G+15 buildings under static and dynamic loading. Their study showed that grid slabs control lateral movement and storey drift more effectively than flat slabs. **Kothari et al. (2021)** analysed G+7 to G+20 buildings using ETABS and highlighted the importance of shear wall positioning. Their abstract showed that optimized shear wall placement improves seismic resilience by reducing drift and displacement. In another study, **Sharma et al. (2021)** used response spectrum analysis for G+12 and G+18 structures with different slab systems and shear wall arrangements. Their results showed that grid slabs with properly placed shear walls provide lower displacement and higher stiffness. **Patel et al. (2023)** studied G+6 to G+20 buildings using ETABS for static and dynamic analysis. Their abstract focused on base shear, lateral displacement and storey drift, concluding that grid slabs maintain structural integrity more effectively during seismic events. Finally, **Singh et al. (2022)** conducted parametric analysis on G+8, G+12 and G+16 buildings to evaluate the effect of slab systems on lateral displacement, drift and base shear. Their study concluded that flat slabs are beneficial for architectural flexibility, but grid slabs provide better seismic resistance due to enhanced stiffness and improved load transfer. Overall, the reviewed literature confirms that slab system selection directly affects seismic performance, and grid slab systems generally perform better in high seismic zones.

5. RESEARCH GAP

Previous studies have investigated flat slab and grid slab systems individually or in comparison with conventional slab systems. However, many studies focus only on selected parameters or simplified building models. There is still a need for comparative analysis of different slab systems under seismic conditions using multiple response parameters such as bending moment, shear force, base shear, storey drift and storey displacement. In addition, the influence of building height on the seismic behaviour of flat slab, grid slab and two-way slab systems requires further attention. The present study addresses this gap by comparing these systems for G+2, G+5 and G+8 buildings.

6. METHODOLOGY

The methodology adopted for the present research paper is developed to compare the seismic performance of different reinforced concrete slab systems in multi-storeyed buildings. The study mainly focuses on conventional two-way slab, flat slab with drop, and grid slab systems. The complete methodology is explained in the following 7 major steps.

1. Problem Identification and Study Background

The first step of the methodology is to identify the structural problem related to the seismic performance of different slab systems used in multi-storeyed reinforced concrete buildings. In modern construction, flat slab and grid slab systems are widely used because they provide architectural flexibility, better space utilization, reduced floor height, simpler formwork and faster construction. However, their behaviour under earthquake loading is different from conventional beam-slab systems. Flat slab systems transfer loads directly from slab to columns, which makes slab-column connections critical under seismic forces. These connections are vulnerable to punching shear and excessive lateral deformation. Grid slab systems, on the other hand, contain ribs in both directions and provide improved load distribution and stiffness. Therefore, the main problem identified in this study is to evaluate which slab system performs better under seismic loading. The research aims to compare structural parameters such as bending moment, shear force, base shear, storey drift and storey displacement for different slab systems.

2. Selection of Structural Systems

In the second step, three different reinforced concrete slab systems are selected for comparative study. These include conventional two-way slab, flat slab with drop, and grid slab system. The conventional two-way slab system consists of slabs supported by beams, and beams are supported by columns. This system provides a clear load transfer mechanism from slab to beam, beam to column and column to foundation. The flat slab system is selected because it is commonly used in commercial and residential buildings where open space and reduced floor depth are required. In this system, the slab is directly supported by columns, and drop panels are provided around the column region to improve punching shear resistance. The grid slab system is selected because it consists of closely spaced ribs in two directions, which improve stiffness and distribute loads more effectively. By selecting these three systems, the study provides a meaningful comparison between conventional and modern slab systems under seismic conditions.

3. Development of Building Models

The next step involves the development of building models for seismic analysis. The models are prepared for a plan size of $8\text{ m} \times 8\text{ m}$. A regular grid layout is considered to maintain uniformity in geometry and structural comparison. The bay spacing is taken as 4 m in both X and Y directions for conventional and flat slab systems, while the grid slab system consists of closely spaced ribs at 2 m spacing. Three different building heights are considered, namely G+2, G+5 and G+8 buildings. These different heights are selected to study the effect of increasing storey height on seismic behaviour. As the number of storeys increases, lateral displacement and storey drift generally increase due to greater flexibility and larger seismic demand. Separate analytical models are prepared for each slab system and each building height. This helps in evaluating the performance of low-rise and medium-rise reinforced concrete buildings under similar loading and geometric conditions.

4. Assignment of Material and Section Properties

After preparing the building models, material and section properties are assigned to all structural members. Reinforced concrete is considered as the main construction material for slabs, beams, columns, drops and grid ribs. The slab thickness, beam dimensions, column sizes, drop panel details and grid rib dimensions are assigned according to structural requirements. In the conventional two-way slab model, beams are provided along column lines to support the slab and transfer loads to columns. In the flat slab model, beams are removed and drop panels are assigned around columns to resist high bending moment and punching shear near slab-column junctions. In the grid slab model, ribs are assigned in both directions to form a stiff grid system. The assignment of proper section properties is important because stiffness, mass and load distribution depend directly on member dimensions and material properties. This step ensures that all slab systems are analysed under realistic structural conditions.

5. Application of Loads and Seismic Parameters

In this step, different types of loads are applied to the building models. Dead load, live load and seismic load are considered for analysis. Dead load includes the self-weight of structural members such as slabs, beams, columns, drops and grid ribs. Live load is applied according to the functional use of the building. Seismic load is applied to evaluate the earthquake response of the structures. The seismic parameters are considered as per Indian seismic design provisions. These parameters include seismic zone factor, importance factor, response reduction factor, soil type and damping ratio. Load combinations are applied to study the combined effect of gravity and earthquake forces. The application of seismic load is important because earthquake forces produce lateral displacement, storey drift, base shear and additional internal forces in structural members. In flat slab buildings, seismic loading is especially critical because the absence of beams reduces lateral stiffness and increases the importance of slab-column connection performance.

6. Structural Analysis and Extraction of Results

After assigning loads and seismic parameters, structural analysis is performed for all building models. The analysis is carried out for G+2, G+5 and G+8 buildings with conventional two-way slab, flat slab and grid slab systems. The main purpose of the analysis is to obtain structural response parameters under seismic loading. The important results extracted from the analysis include bending moment, shear force, base shear, storey drift and storey displacement. Bending moment is used to evaluate flexural demand in the slab system. Shear force is used to understand the shear demand and possible punching shear risk, especially in flat slabs. Base shear represents the total lateral seismic force transferred to the foundation. Storey drift indicates relative displacement between two consecutive storeys and is one of the most important parameters for seismic safety. Storey displacement shows the total lateral movement of each floor level. These results are extracted separately for each slab system and then compared systematically.

7. Comparative Evaluation and Interpretation

The final step of the methodology is the comparative evaluation of all analytical results. The results obtained for conventional two-way slab, flat slab and grid slab systems are compared in terms of bending moment, shear force, base shear, storey drift and storey displacement. The comparison helps in identifying the structural advantages and limitations of each slab system. The grid slab system shows higher bending moment, shear force and base shear, indicating greater stiffness and load-carrying capacity. The flat slab system shows lower force values in the tabulated results, but due to direct load transfer from slab to column, its slab-column connections require special attention. Storey drift results show that drift increases with building height for all slab systems. This indicates that taller buildings are more sensitive to lateral deformation under seismic loading. Based on the comparison, conclusions are drawn regarding the suitability of each slab system for seismic-resistant construction. Future scope is also suggested for advanced studies such as response spectrum analysis, time history analysis, shear wall optimization, punching shear evaluation and cost comparison.

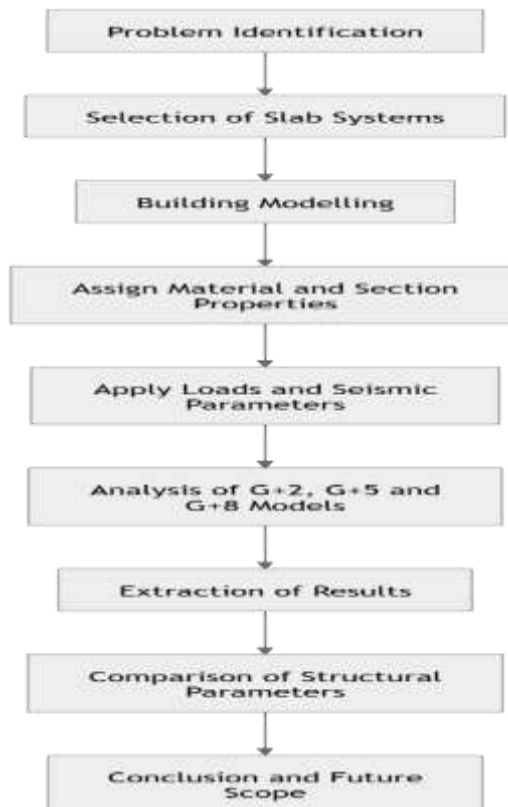


Figure 2: Methodology Flowchart

7. RESULTS AND DISCUSSION

7.1 Modelling of Building

The building models were prepared for an $8\text{ m} \times 8\text{ m}$ plan. Three slab systems were considered: conventional two-way slab, flat slab with drop and grid slab. The conventional slab model consists of beams and columns arranged in a regular grid. The flat slab model consists of slab panels directly supported on columns with drop panels around the columns. The grid slab model consists of closely spaced ribs in both directions, forming smaller slab panels and improving load distribution.

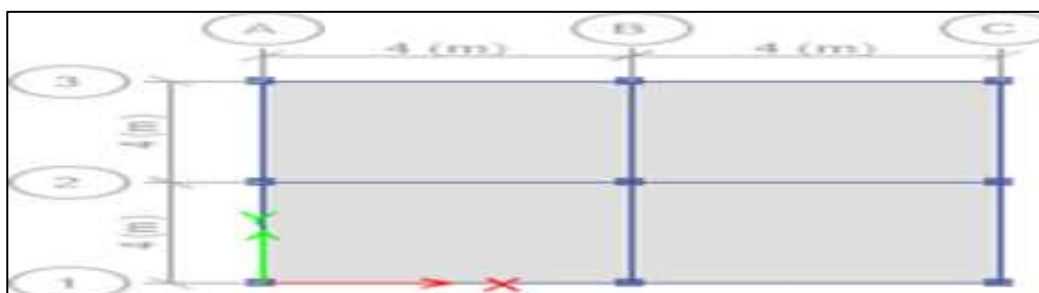


Figure 3: Conventional Slab Model

Figure 3 shows the plan layout of a conventional slab system with a regular grid arrangement. Columns are placed at grid intersections, and beams connect the columns along both directions. The slab is supported by beams, indicating a typical reinforced concrete slab-beam-column system.

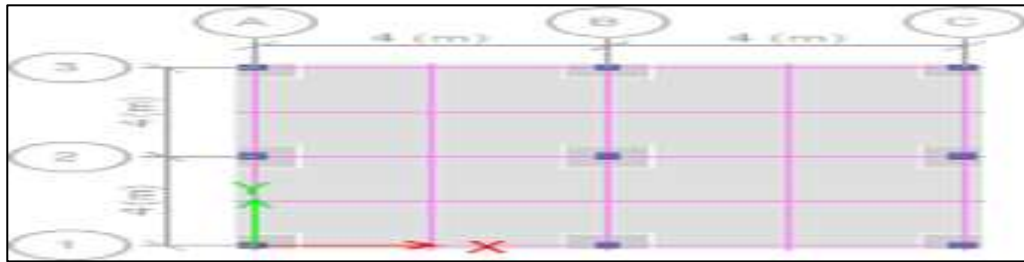


Figure 4: Flat Slab with Drop Model

Figure 4 shows the plan layout of a flat slab system with drop panels. The slab is directly supported by columns without beams. Drop panels are provided around columns to increase punching shear resistance and improve local stiffness.

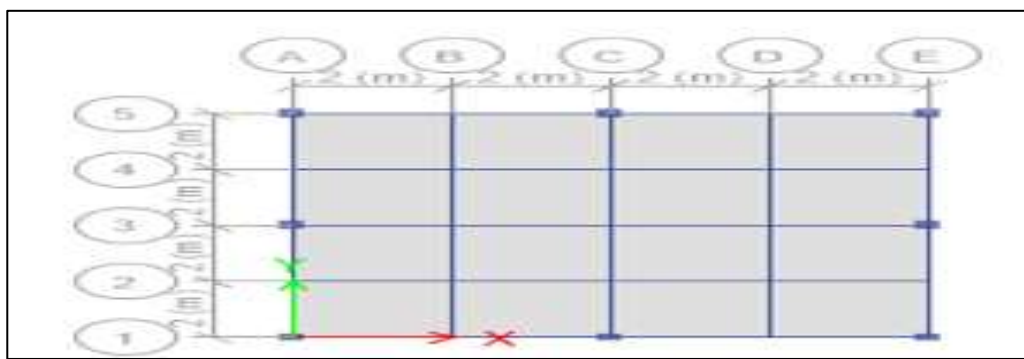


Figure 5: Grid Slab Model

Figure 5 shows the grid slab system with ribs in both X and Y directions. The close spacing of ribs forms smaller panels and improves stiffness, load transfer and deflection control.

7.2 Comparison of Bending Moment, Shear Force and Base Shear

Table 1: Comparison of Bending Moment, Shear Force and Base Shear for Different Slab Systems

Slab Type	Bending Moment (kN-m)	Shear Force (kN)	Base Shear (kN)
Two-Way Slab	7.8771	14.8846	101.812
Flat Slab	0.3316	8.771	40.1124
Grid Slab	12.276	20.2247	116.64

Table 1 presents the comparison of bending moment, shear force and base shear for two-way slab, flat slab and grid slab systems. The grid slab shows the highest bending moment, shear force and base shear, indicating greater stiffness and load-carrying capacity. The flat slab shows the lowest values, which reflects reduced lateral resistance due to the absence of beams. The two-way slab gives moderate performance between flat slab and grid slab systems.

7.3 Bending Moment Comparison

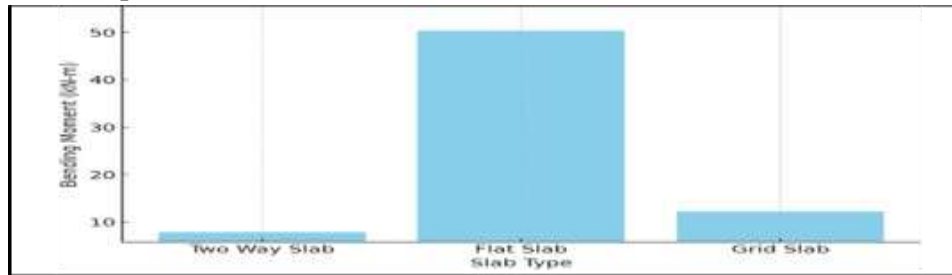


Figure 6: Comparison of Bending Moment

The flat slab has the highest bending moment of 50.3316 kN-m because its beamless construction transfers moments directly to the columns, resulting in increased internal forces. In comparison, the grid slab has a moderate bending moment of 12.276 kN-m due to effective load distribution and increased structural stiffness. The two-way slab has the lowest bending moment of 7.8771 kN-m because the presence of beams improves moment transfer and reduces internal stresses.

7.4 Shear Force Comparison

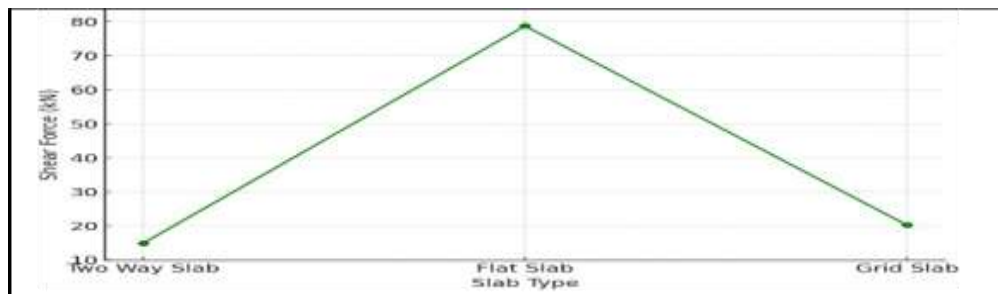


Figure 7: Comparison of Shear Force

The flat slab has a substantially larger shear force of 78.771 kN than the grid slab and two-way slab. The absence of beams in the flat slab increases shear force at column connections and raises the risk of punching shear failure. Grid slabs show moderate shear force due to their closely spaced ribs and better load distribution. The two-way slab has the least shear force because its beam-supported system improves shear resistance and provides a clearer load transfer path.

7.5 Base Shear Comparison



Figure 8: Comparison of Base Shear

In terms of base shear, the flat slab has the highest value of 140.1124 kN due to its flexibility and seismic force transmission to the foundation. The grid slab has a base shear of 116.6454 kN, indicating higher seismic resistance due to its rigid grid structure. The two-way slab has a base shear of 101.8121 kN and shows better lateral stability because its beam-supported construction improves seismic performance.

7.6 Storey Drift for G+2 Building

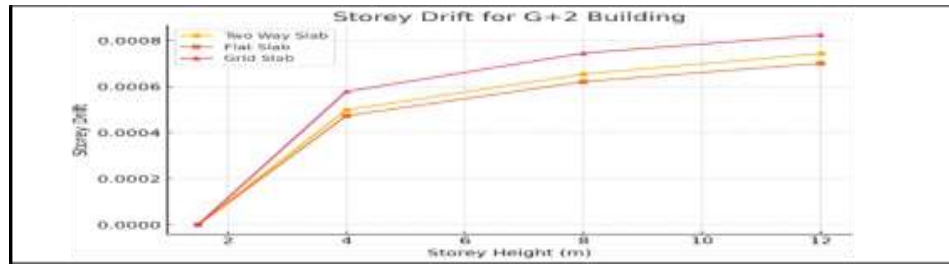


Figure 9: Storey Drift for G+2 Building

Figure 9 shows the variation of storey drift with height for the G+2 building using two-way slab, flat slab and grid slab systems. Storey drift increases gradually from the lower storey to the upper storey for all slab types. The grid slab records the highest drift, reaching about 0.00082 at the top level, followed by the two-way slab and flat slab. This indicates that the grid slab model experiences comparatively greater lateral deformation under seismic loading.

7.7 Storey Drift for G+5 Building

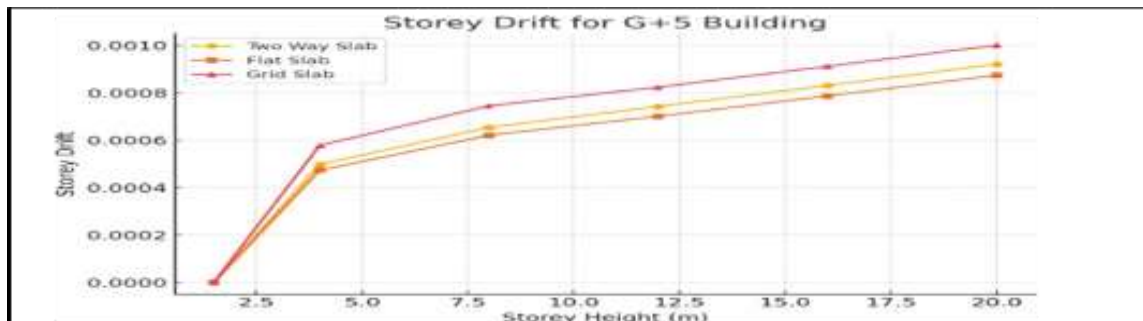


Figure 10: Storey Drift for G+5 Building

Figure 10 illustrates the storey drift variation for the G+5 building with two-way slab, flat slab and grid slab systems. Storey drift increases continuously with storey height, showing maximum drift at the top level. The grid slab records the highest drift, reaching nearly 0.0010, indicating greater lateral deformation under seismic loading. The two-way slab shows moderate drift values, while the flat slab gives slightly lower drift compared with the other systems.

7.8 Storey Drift for G+8 Building



Figure 11: Storey Drift for G+8 Building

Figure 11 presents the storey drift variation for the G+8 building with two-way slab, flat slab and grid slab systems. The drift increases steadily with storey height and reaches maximum values at the top storey. The grid slab shows the highest drift, reaching about 0.0012, which indicates greater lateral deformation. The two-way slab shows slightly lower drift than the grid slab, while the flat slab records the lowest drift among the three systems.

7.9 Storey Displacement

For the G+2 building, displacement increases gradually with storey height for all slab systems. The grid slab shows the highest displacement due to its flexibility, while the flat slab shows slightly higher displacement than the two-way slab

because of the absence of supporting beams. In the G+5 building, displacement increases significantly with height, and grid slab models show higher displacement values. In the G+8 building, displacement increases more rapidly, especially for grid slabs. The two-way slab shows lower displacement, indicating better control of lateral movement.

8. DISCUSSION

The comparative analysis shows that slab system configuration has a major influence on seismic performance. Conventional two-way slabs provide a clear beam-slab-column load path and show balanced structural behaviour. Flat slabs provide advantages in construction speed, floor height reduction and architectural flexibility, but the absence of beams makes slab-column connections critical. Grid slabs improve load distribution through intersecting ribs and show higher stiffness and load-carrying capacity. The results indicate that bending moment, shear force and base shear vary significantly among the slab systems. Grid slabs show higher values in the tabulated comparison, suggesting greater stiffness and resistance capacity. However, the figure-wise results indicate that flat slabs may develop higher internal force demand due to direct load transfer to columns. This highlights the need for careful interpretation of flat slab behaviour and the importance of checking punching shear at column locations.

Storey drift and displacement results show that lateral response increases with building height. G+2 buildings show relatively lower drift, while G+5 and G+8 buildings show higher drift values. This confirms that taller buildings require greater stiffness control and proper seismic detailing. The results also show that lateral deformation is an important design consideration for slab systems in seismic regions. Overall, grid slabs are suitable where higher stiffness and load distribution are required. Flat slabs may be used where architectural flexibility and reduced floor depth are important, but they must be supported by suitable strengthening measures such as drop panels, punching shear reinforcement and lateral load-resisting systems. Two-way slabs remain reliable for balanced seismic behaviour due to their beam-supported framing system.

9. CONCLUSION

The study concludes that the seismic performance of slab systems depends on stiffness, load transfer mechanism, structural configuration and lateral force resistance. Flat slab systems provide architectural flexibility, reduced floor height and faster construction, but they are more sensitive at slab-column junctions due to punching shear risk. Grid slab systems show higher bending moment, shear force and base shear, indicating greater stiffness, better load distribution and improved load-carrying capacity. Two-way slab systems provide balanced seismic performance and controlled structural response compared with flat slab and grid slab systems. Storey drift and displacement increase with building height in G+2, G+5 and G+8 models, showing the need for proper stiffness control in seismic design. Overall, grid slabs are suitable for higher stiffness requirements, while flat slabs should be used with shear walls, drop panels and proper seismic detailing.

10. FUTURE SCOPE

1. The study can be extended to taller buildings such as G+10, G+15 and G+20 to understand the seismic response under greater lateral load demand.
2. Future research may include seismic Zones II, III, IV and V separately to compare slab system performance under different earthquake intensities.
3. Response spectrum analysis and nonlinear time history analysis can be used for more accurate seismic performance evaluation.
4. The effect of different shear wall locations can be studied for improving lateral stiffness, reducing storey drift and controlling displacement.
5. A detailed punching shear analysis should be performed for flat slab-column connections, especially in high seismic zones.
6. Cost comparison can be included by considering material quantity, reinforcement requirement, formwork cost and construction duration.

7. Soil-structure interaction can be included to evaluate realistic foundation flexibility and seismic response.
8. Irregular building plans such as L-shape, C-shape and asymmetric layouts can be analysed to study torsional effects.
9. Experimental validation using small-scale models or shake table testing may be performed to verify analytical results.
10. Design optimization techniques can be applied to identify the most economical and structurally efficient slab system for seismic-resistant construction.

References

1. Patel, A., & Padamwar, S. (2017). Studying the response of flat slabs and grid slabs systems in conventional RCC buildings. *Indian Journal Scientific Research*, 14(2), 516–521.
2. Coelho, E., Candeias, P., & Anamateros, G. (2004). Assessment of the seismic behaviour of RC flat slab building structures. *13th World Conference on Earthquake Engineering*, 2630.
3. Durrani, A. J., Mau, S. T., AbouHashish, A. A., & Li, Y. (1994). Earthquake response of flat-slab buildings. *Journal of Structural Engineering*, 120(3), 947–964.
4. El-Dardiry, E., Wahyuni, E., Ji, T., & Ellis, B. R. (2002). Improving FE models of a long-span flat concrete floor using natural frequency measurements. *Computers and Structures*, 80(27–30), 2145–2156.
5. Erberik, M. A., & Elnashai, A. S. (2004). Fragility analysis of flat-slab structures. *Engineering Structures*, 26(7), 937–948.
6. Erberik, M. A., & Elnashai, A. S. (2006). Loss estimation analysis of flat-slab structures. *Natural Hazards Review*, 7(1), 26–37.
7. Harish, M. K., Ashwini, B. T., Chethan, V. R., & Sharath, M. Y. (2017). Analysis and design of grid slab in building using response spectrum method. *International Journal for Research Trends and Innovation*, 2(6).
8. Jamle, S., Verma, M. P., Dhakad, V., & Prof, A. (2017). Flat slab shear wall interaction for multistoried building under seismic forces. *International Journal of Software & Hardware Research in Engineering*.
9. Kaulkhere, R. V., & Shete, G. N. (2017). Analysis and design of flat slab with various shapes. *International Journal of Scientific Development and Research*.
10. Bakale, M. Seismic behavior of multi-story structure with different types of slabs. *International Journal of Civil Engineering and Technology*.
11. Kumar, P., & Dutt, S. (2016). Analysis of a tall structure considering seismic force under rigid frame structure. *Journal of Engineering Research and Application*, 7(7), 29–34.
12. Srinu, P., & Kumar, S. A. (2018). Analysis and design of two-way rectangular orthotropic slab with interior enclosed opening using yield line theory. *International Journal of Engineering Sciences & Research Technology*, 7(3), 514–518.
13. Bhaduria, S. S., & Chhugani, N. (2017). Comparative analysis and design of flat and grid slab system with conventional slab system. *International Research Journal of Engineering and Technology*, 4(8).