International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 08 | Aug - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Performance Evaluation of Grid Slab and Conventional Slab in Long-Span Structures: A Case Study on Automobile Showroom Design

Sayed Zaid Jameel Attar [1], Ravish H. Khan[2]

[1]*PG Student, Masters of Technology in Computer Aided Structural Engineering – Deogiri Institute of Engineering and Management Studies, Chhatrapati Sambhajinagar*

[2]*Assistant Professor, Civil Engineering Department - Deogiri Institute of Engineering and Management Studies, Chhatrapati Sambhajinagar*

---***---

Abstract - This study compares the performance of conventional slab systems and grid (waffle) slab systems in long-span buildings, with a focus on an automobile showroom design. The models were created and analyzed using ETABS software according to ACI 318-14 and ASCE 7 standards. The comparison was based on bending moments, shear forces, deflection, reinforcement needs, and material use. Results showed that the conventional slab required deeper beams and had higher bending moments and shear values, while the grid slab gave better load distribution, lower deflection, and more clear headroom. Although the grid slab used more material, it provided better serviceability and space efficiency. The study concludes that grid slabs are more suitable for large-span structures like showrooms and malls, while conventional slabs may still be practical for smaller spans.

Key Words: Grid slab, Conventional slab, Long-span structures, ETABS analysis, Deflection and bending moment, Automobile showroom design

1.INTRODUCTION

1.1 Background

Designing floor systems for long-span reinforced concrete (RC) structures is a critical task. In buildings like automobile showrooms, the floor should be strong, safe, and provide wide open spaces with fewer columns. Two common systems used are conventional slabs with beams **and** grid (waffle) slabs**.**
Conventional slabs are easy to design and construct. They use beams and columns arranged in a rectangular pattern. But in large spans, the beams need to be very deep to control bending and deflection. This reduces headroom and affects the architectural appearance of the space .

Grid slabs, also known as waffle slabs, are formed by intersecting ribs cast with the slab. This ribbed system is lightweight and stiff, making it effective for carrying long-span loads. It reduces beam depths, gives better distribution of loads, and creates attractive ceiling patterns. However, it requires complex formwork and often uses more steel and concrete than conventional slabs .

1.2 Problem Statement

Many studies have been done on grid slabs and conventional slabs separately. Some works have compared them in residential or multi-storey buildings . However, there is very little research focused on long-span commercial structures like automobile showrooms, where both strength and open architectural space are equally important. The lack of comparative data for such cases makes it difficult for designers to choose the most suitable system.

1.3 Aim of the Study

The main aim of this study is to **evaluate and compare the structural performance of grid slab and conventional slab systems for long-span structures, using the case study of an automobile showroom design**.

1.4 Objectives of the Study

The specific objectives are:

- To model an automobile showroom structure using ETABS software.
- To design both conventional slab and grid slab systems using ACI 318-14 and ASCE 7 standards.
- To compare the two systems in terms of bending moments, shear forces, deflections, reinforcement, and member sizes.
- To check both systems for serviceability aspects such as deflection control and headroom.
- To evaluate material quantity and construction considerations for both systems.
- To identify which system is more efficient and suitable for automobile showroom buildings.

1.5 Scope of the Work

The study is limited to one case study of an automobile showroom. The comparison is made only between conventional slab with beams and grid slab systems. Other slab types like flat slab or post-tensioned slab are not included. The analysis is carried out using ETABS software, and the design follows ACI 318-14 and ASCE 7 code provisions. The focus is on structural behavior, serviceability, and architectural suitability, not on detailed cost estimation.

2. METHODOLOGY

2.1 Case Study: Automobile Showroom

The study is based on the design of an automobile showroom building. Such buildings need large open floors with minimum columns for easy movement of vehicles and display space. This makes it important to select a slab system that can span longer distances without losing strength or serviceability.

2.2 Structural Systems Considered

Two types of floor systems are compared:

- **Conventional slab system**: a slab supported on beams and columns arranged in a rectangular grid.
- **Grid slab system (waffle slab)**: a slab with intersecting ribs forming a grid, supported on columns at wider spacing.

Both systems are modeled for the same showroom plan so that results can be compared fairly.

2.3 Material Properties

The materials are assumed as per standard design practice:

- Concrete compressive strength: fc′ = 5000 psi (approximately 34.5 MPa)
- Reinforcement steel: ASTM A615
- Unit weight of concrete: 25 kN/m³
- Unit weight of steel: 78.5 kN/m³

2.4 Codes and Standards Used

The design and analysis are done as per:

- **ACI 318-14**: Building Code Requirements for Structural Concrete
- **ASCE 7**: Minimum Design Loads for Buildings and Other Structures
- IS codes are referred for material properties and cross-checks where needed.

2.5 Load Calculations and Combinations

The following loads are considered:

- **Dead Load**: self-weight of slab, beams, columns, walls, and finishes.
- **Live Load**: as per showroom requirement, taken from ASCE 7.
- **Superimposed Load**: floor finishes, partitions, etc.
- **Load Combinations**: factored combinations as per ACI 318-14 and ASCE 7.

2.6 ETABS Modeling and Analysis

The showroom is modeled in **ETABS software**. Key steps include:

- Creating the building plan with the same layout for both slab systems.
- Assigning material properties for concrete and steel.
- Defining slab types: conventional slab with beams, and grid slab with ribs.
- Applying loads and load combinations.
- Running linear static analysis.
- Extracting results for bending moments, shear forces, deflections, reinforcement, and member sizes.

3. RESULTS

The ETABS analysis of the automobile showroom was carried out for both conventional slab system **and** grid slab system (waffle slab)**.** The results are compared in terms of structural response, bending moments, shear forces, deflection, reinforcement requirement, and material quantities.

3.1 Structural Response

The overall structural response showed that the conventional slab system required much deeper beams to resist bending, whereas the grid slab system distributed loads more efficiently.

Table 3.1: Beam Depth Requirement

System	**Slab Thickness (mm)**	**Overall Depth (mm)**
Conventional Slab	150	1300
Grid Slab (Waffle)	230	580

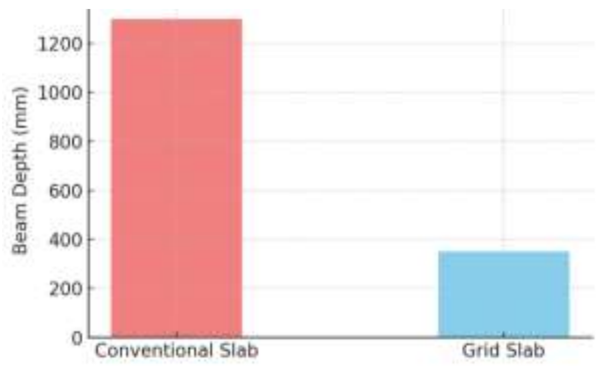

Figure 3.1 Beam Depth Comparison

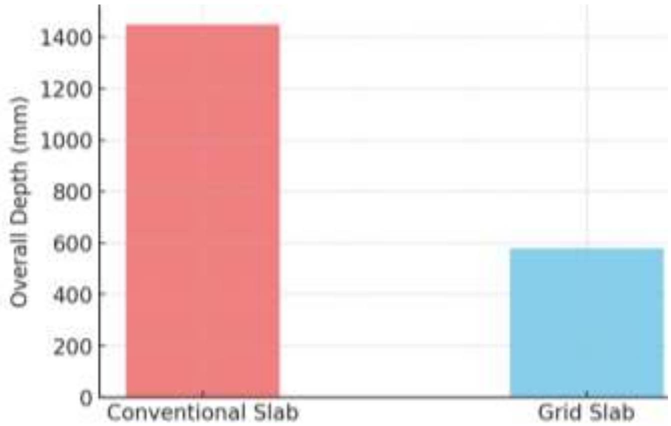

Figure 3.2 Overall Depth of Slab Systems

3.2 Bending Moment Comparison

The bending moments in conventional beams were significantly higher than those in grid ribs.

- **Conventional slab beams** carried larger positive and negative moments.
- **Grid slab ribs** distributed the moment across multiple ribs, reducing peak values.

Figures from ETABS results:

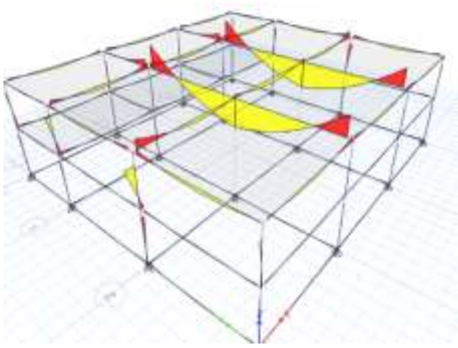

Figure 3.3 Bending Moment Diagram – Conventional Slab

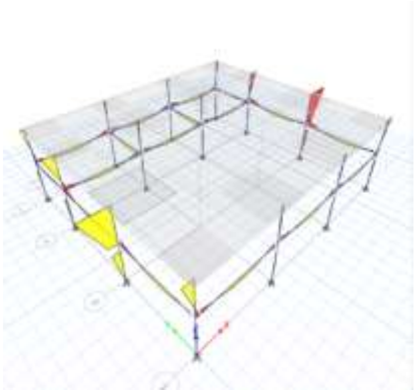

Figure 3.4 Bending Moment Diagram – Grid Slab

3.3 Shear Force Comparison

The shear forces in conventional beams were higher at supports, while grid ribs showed lower shear due to load sharing.

Figures from ETABS results:

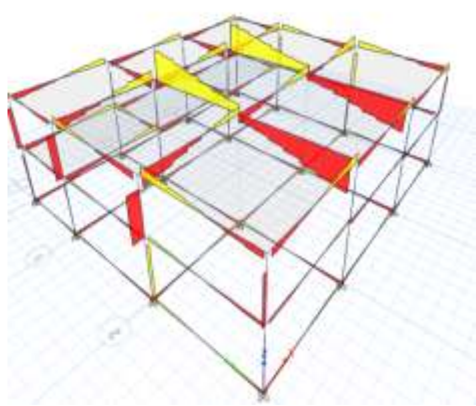

Figure 3.5 Shear Force Diagram – Conventional Slab

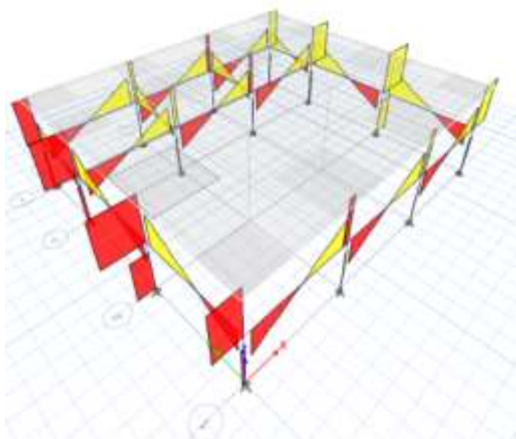

Figure 3.6 Shear Force Diagram – Grid Slab

3.4 Deflection and Serviceability

Maximum deflection in the conventional system was **21.5 mm**, which is close to the serviceability limit of **25 mm**. The grid slab system had a maximum deflection of **14.2 mm**, well within limits.

Table 3.2: Maximum Deflection Values

System	Maximum Deflection (mm)	Limit (mm)	Status
Conventional Slab	21.5	25	Safe (close)
Grid Slab (Waffle)	14.2	25	Safe (better)

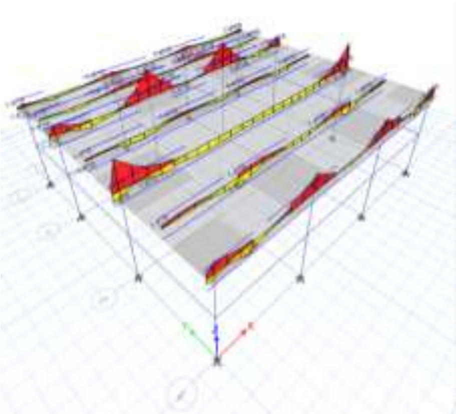

Figure 3.7 Maximum Deflection in Slab Systems

3.5 Reinforcement Requirement

- Conventional beams required **heavy reinforcement** because of higher moments.
- Grid slab ribs required **distributed reinforcement**, but in smaller amounts per rib.

Figures from ETABS results:

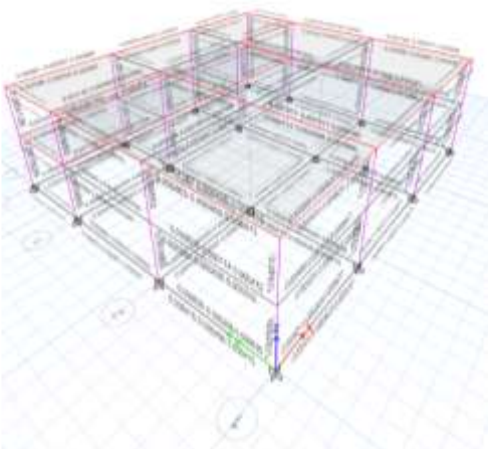

Figure 3.9 Reinforcement Layout – Conventional Beam

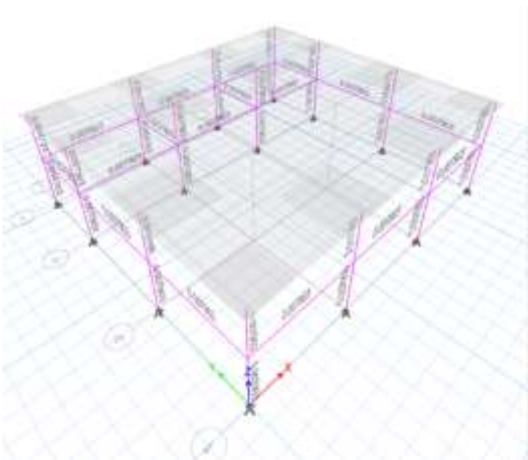

Figure 3.10 Reinforcement Layout – Grid Rib

3.6 Quantity Aspects

The material requirement was also compared:

Table 3.3: Material Quantity Comparison

Parameter	Conventional Slab	Grid Slab (Waffle)
Concrete Volume	Less	More
Steel Requirement	Less (per beam)	More (overall)
Beam Depth	Higher	Lower
Headroom Availability	Lower	Higher

3.7 ETABS Model Snapshots

For clarity, the ETABS models are shown:

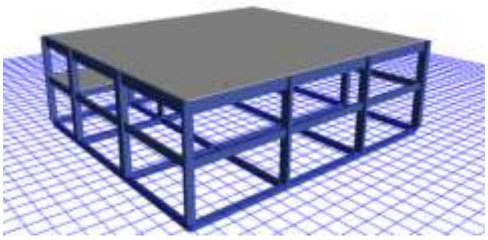

Figure 3.11 ETABS 3D Model – Conventional Slab

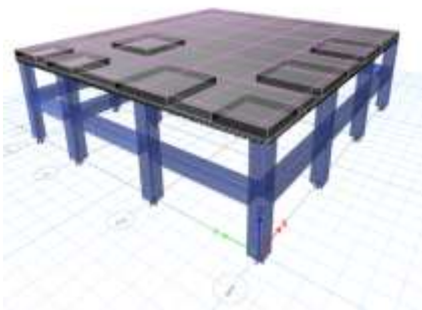

Figure 3.12 ETABS 3D Model – Grid Slab

4. CONCLUSION

This study compared the performance of a conventional slab system and a grid (waffle) slab system for an automobile showroom structure using ETABS modeling and design as per ACI 318-14 and ASCE 7. The key findings are:

1. **Structural depth**:
   - The conventional slab required very deep beams, giving a total depth of about 1300 mm.
   - The grid slab required only about 580 mm overall depth, which increases clear headroom and provides better architectural space.

2. **Bending moment and shear**:
   - Conventional beams carried larger bending moments and shear forces.
   - Grid slab ribs distributed the load more evenly, reducing peak values.
3. **Deflection**:
   - Maximum deflection for the conventional slab was 21.5 mm, very close to the serviceability limit of 25 mm.
   - Grid slab deflection was only 14.2 mm, which is much safer.
4. **Reinforcement**:
   - Conventional beams required heavy reinforcement because of high bending moments.
   - Grid ribs required reinforcement spread across many ribs, but in smaller quantities per rib.
5. **Material quantity**:
   - Grid slabs used more concrete and steel overall, but gave better performance in terms of serviceability and usable space.
   - Conventional slabs used less material but caused problems of large beam depth and reduced headroom.
6. **Practical use**:
   - For **large-span showrooms, malls, and auditoriums**, the grid slab system is more suitable because it balances strength, serviceability, and architectural needs.
   - The conventional slab may still be economical for smaller spans but is less effective for long spans.

REFERENCES

1. Chintha, S., Peddana, V., & Suresh, R. (2014). *Analysis of grid slab using ETABS*. International Journal of Research in Engineering and Technology, 3(8), 177–182.
2. Nikam, A., & Pujari, A. (2019). *Analysis and design of conventional slab and grid slab system using ETABS*. International Journal of Research and Analytical Reviews, 6(2), 800–806.
3. Patel, A., & Padamwar, S. (2017). *Comparative study of flat slab, grid slab and conventional slab*. International Research Journal of Engineering and Technology, 4(7), 2395–2400.
4. Kiran, M., & Rao, K. (2018). *Performance evaluation of waffle slab and conventional slab systems*. International Journal of Civil Engineering and Technology, 9(10), 652–659.
5. Rajesh, G., & Kumar, A. (2016). *Comparison of conventional slab and grid slab structures*. IOSR Journal of Mechanical and Civil Engineering, 13(3), 55–62.
6. Shukla, R., & Patel, H. (2018). *Comparative analysis of grid slab and flat slab*. International Journal of Advance Engineering and Research Development, 5(6), 140–145.
7. Momin, A., & Shaikh, I. (2017). *Analysis of conventional slab, flat slab, and grid slab structures*. International Journal for Research in Applied Science & Engineering Technology, 5(5), 978–983.
8. Patel, D., & Solanki, H. (2016). *Structural behavior of waffle slab systems*. International Journal of Engineering Research, 5(3), 214–220.
9. ACI Committee 318. (2014). *Building Code Requirements for Structural Concrete (ACI 318-14)*. American Concrete Institute.
10. ASCE. (2010). *Minimum Design Loads for Buildings and Other Structures (ASCE 7-10)*. American Society of Civil Engineer.