

Analysis and Design of Multistory Building with Different Types of Slabs

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Abstract—In today's construction, the traditional slab is mostly supported by a beam, with a small slab thickness and a large beam depth, and the weight is carried from beam to column. The flat slab allows architects to place partition walls wherever they are needed. It is widely used because it reduces weight, speeds up building, and is cost effective. Similarly, since its inception, the conventional slab has provided benefits such as increased stiffness, increased weight carrying ability, as well as being safe and cost effective. Grid slabs are necessary where the span is greater, and grid beams are provided to lessen the spanning. Grid slabs reduce dead load due to voids and are appropriate for longer spans with heavy loads. The Grid slab is less expensive and provides superior vibration resistance. The project's goal is to find the most cost-effective slab among standard slab, flat slab with drop, and grid slab. A G+5 Commercial multi-story structure with flat slab, conventional slab, and grid slab was investigated for characteristics such as storey displacement, shear force, bending moment, and storey drift in this study. There are a total of 18 structures examined. The performance and behavior of all structures in India's seismic zone III have been investigated with the application of dead load, live load and seismic load. The results of shear force, Bending Moment, story shear, story displacement, story drift and quantity of concrete and steel shows that the overall result values make flat slab a suitable structure as compared to the conventional and grid slab.

Index Terms—Flat slab, conventional slab, Grid Slab, Seismic analysis, Staad Pro.

I. INTRODUCTION

Slabs are plate elements that form the building's floor and roof, as well as supporting loads predominantly through flexure. For multi-story parking garages, incline slabs can be used as ramps. An inclined slab

can be thought of as a staircase. Beams or walls can be used to embellish a slab, and the flanges of a Tor L-beam can be used as well.

1.1 Flat Slab: A flat slab rests directly on a supporting column without the use of beams, providing strength in both directions. The load from the flat slab is immediately transferred to the column in a flat slab, and we add extra thickness to the slab above the column to increase the column's shear capacity, which is known as a drop panel. The flat slab is commonly used in the basement of commercial or residential buildings to reduce storey height while simultaneously lowering the overall height of the structure.

Types of flat slab:

- Flat slab with drop panel.
- Flat slab with column head.
- Flat slab with drop panel and column head.
- Flat slab without drops panel and column head.

1.2 Design of Flat Slab: -

Two approximate methods are used for design of flat slab as per IS456:2000

I. DDM (Direct Design Method).

II. EMF (Equivalent Frame Method).

1.3 Grid Slab:- Grid or coffered floor system consisting of beams spaced at regular intervals in the slab's perpendicular direction. Waffle slabs are often thicker than ribbed slabs. Grid slabs are commonly utilised for architectural purposes in large areas such as auditoriums and retail showrooms. The rectangular and square gaps that are generated in the ceiling can be used to conceal architectural lighting.

1.4 Objectives: -

- Analysis of structure for zone III for different span.
- Analysis of different types of slabs 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.

1.5 Research Gap: -

- Many researchers have found that the when the comparison of flat slab, grid slab and conventional slab was done, for some criteria's the flat slab was found to be suitable sometime grid slab has better towards longer spans and sometimes conventional slab gets suitable for lateral stiffness.
- In this study an attempt is made to find out the results for not just the slab spans but also the results from the entire structure. The effective results when the slab is subjected to the seismic load and the effect on the columns and base is also found.

II. METHODOLOGY

- The goal of this study is to compare three distinct scenarios for a residential G+5 storey structure.
- Each span is made up of three types of slabs: standard, flat, and grid slabs, with a floor-to-floor height of 4 metres.
- Here a total of 6 cases considered i.e. 4m x 4m ,5m x 5m ,6m x 6m ,7m x 7m ,8m x 8m and 9m x 9m span.
- In this paper only 3 cases and their results are mentioned.
- IS875 (PART 1):1987 and IS875 (PART 2):1987 dead and live loading conditions, as well as IS1893:2016 seismic analysis in ZONE III.
- Static analysis of the building for seismic forces is done to carry out the results.

III. LOAD CONSIDERATION

(i). Dead Load: As per IS-875(PART1):1987

- Wall Load= $0.23 \times 20 \text{ kN/m}^3$ (Density of Brick) $\times$ (4m-0.45) (Storey Height) =16.33kN/m

- Parapet wall Load= 3kN/m

- Slab load = $0.125 \text{ m} \times 25 \text{ kN/m}^3 = 3.125 \text{ kN/m}^2$

- Floor finished = 1.5 kN/m^2

(ii) Live Load: As per IS-875(PART1):1987

- Live load on floor = 3 kN/m^2

(iii) Earthquake Load: As per IS1893:2016

- Seismic Definition Earthquake zone – III ($Z=0.16$)
- Response reduction factor – 5
- importance Factor – 1.2 (Residential building)
- Rock and Soil Site Factor-2 (Medium Soil Building)
- Type of Structure- 1 Damping - 5% (0.05)

IV. MODELLING OF BUILDING

This Model Are Prepared 4m x 4m Case I And Similar Model Are Prepared for All Remaining 5 Cases.

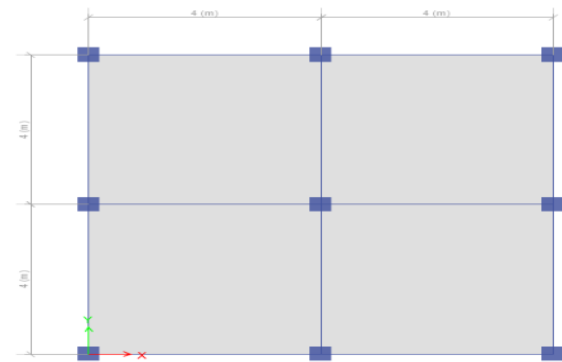


Figure 1. Conventional slab

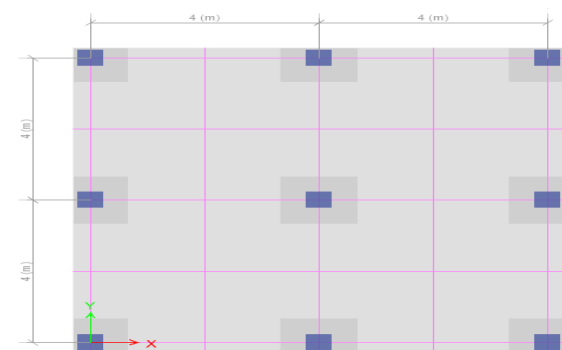


Figure 2. Flat Slab with drop

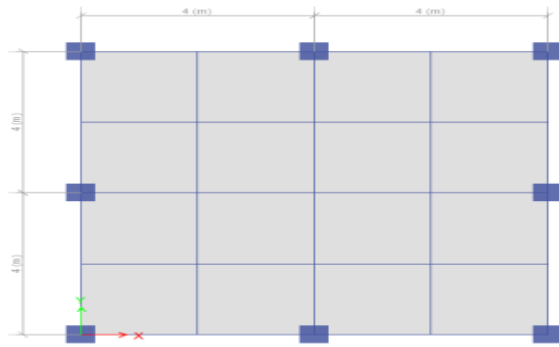


Figure 3. Grid Beam Slab

V. RESULT

This are the result for three cases and Remaining 3 cases, I found it similar result for case IV, Case V, Case VI.

Table 1 Comparison Of Bending Moment Result For Three Different Cases

Slab/ span	Case I (kN-m)	Case II (kN-m)	Case III (kN-m)
Two Way Slab	7.7	16.18	24
FLAT SLAB	49.2	112	200
GRID SLAB	12	19.69	28.5

Table 2: - Comparison Of Shear Force Result for Three Different Cases

Slab/ span	Case I (kN)	Case II (kN)	Case III (kN)
TWO WAY SLAB	14.55	27.2	28
FLAT SLAB	77	120	126
GRID SLAB	19.77	39.032	25.64

Table 3:- Comparison Of Base Shear Result For Three Different Case

TYPES OF SLAB	Case I (kN)	Case II (kN)	Case III (kN)
Two way slab	99.5231	156.4367	251.2931
Flat slab	136.9623	202.6163	136.9623
Grid slab	114.0229	163.2785	208.6901

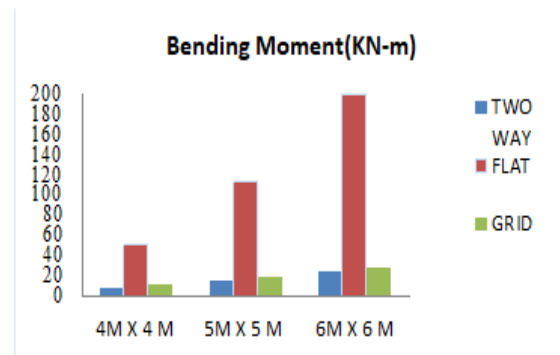


Fig 4. Comparison Of Bending Moment For 3 Different Span

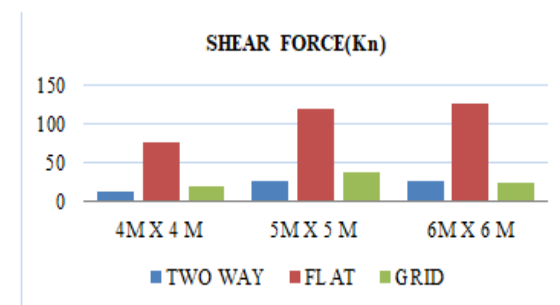


Fig 5. Comparison of Shear Force for 3 Different cases

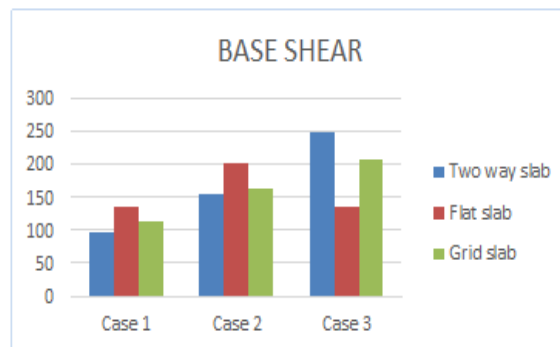


Fig 6. Comparison of Base Shear for 3 Different cases

Table 4. Comparison of Storey Drift Result for Case I

Storey height	Two-way slab	Flat slab	Grid slab
20	0.000434	0.000413	0.00054
16	0.000699	0.000651	0.000779
12	0.000863	0.0008	0.000934
8	0.0009	0.000818	0.000904
4	0.000601	0.000507	0.000485
0	0	0	0

Table 5. Comparison of Storey Displacement Result for Case I

Storey height	Two-way slab (mm)	Flat slab (mm)	Grid slab(mm)
20	13.979	12.758	14.54563
16	12.246	11.105	12.38584
12	9.451	8.502	9.26785
8	5.999	5.3	5.535863
4	2.405	2.027	1.940095
0	0	0	0

Table 6. Comparison of Storey Shear Result for Case I

Storeys	Two-way slab (kN)	Flat slab (kN)	Grid slab(kN)
Storey5	41.182	55.8917	45.4108
Storey4	72.2973	99.1293	82.0039
Storey3	89.7996	123.4505	102.5875
Storey2	97.5784	134.2599	111.7358
Storey1	99.5231	136.9623	114.0229
0	0	0	0

Table 7. Total Quantity Of Steel For 3 Different Cases

Types Of Slab	Case I (kg)	Case II (kg)	Case III (kg)
Two way slab	14072.112	21843.5	28819.2
Flat slab	10152.2	17228.3	25842.45
Grid slab	16300.6	24450.9	36676.35

Table 8. Total Quantity of Concrete For 3 Different Cases

Types Of Slab	Case I (m ³)	Case II (m ³)	Case III (m ³)
Two way slab	86.968	146.55	235.71
Flat slab	116.2902	188.97	301.05
Grid slab	104.376	149.65	199.8

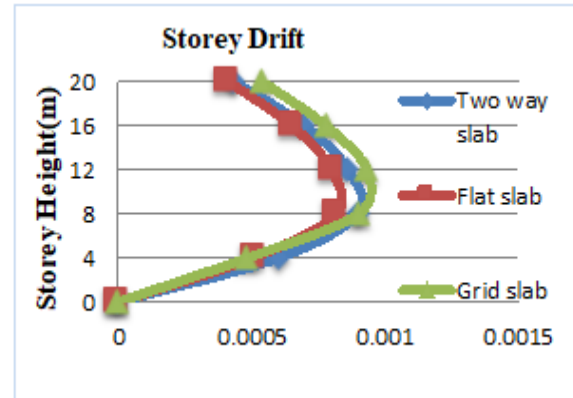


Figure 7. Comparison Of Storey Drift for case I

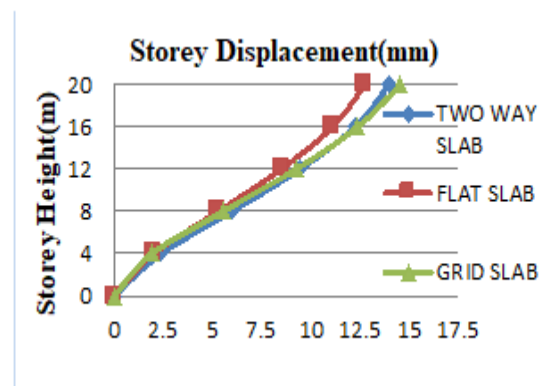


Figure 8. Comparison Of Storey Displacement for case I

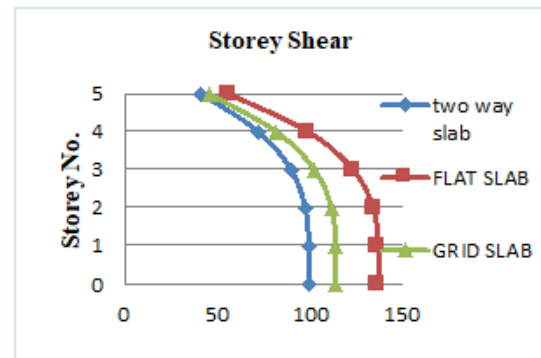


Figure 9. Comparison Of Storey Shear For Case I

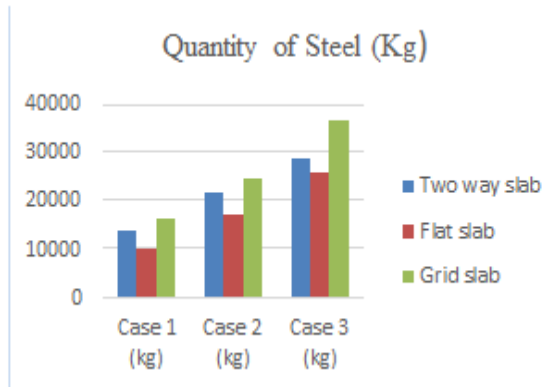


Figure 10. Comparison of quantity of steel for all cases

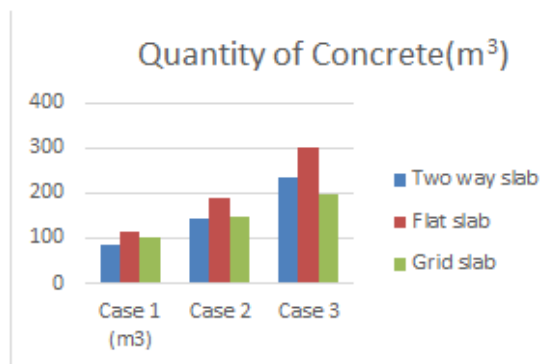


Figure 11 Comparison of quantity of steel for all cases of concrete for all cases.

VI. DISCUSSION AND INFERENCES

The analysis of different slab system shows the following inferences:

- [i]. For the same span/grid size, the amount of concrete required for a grid slab multistorey building is minimum and for a flat slab multistorey 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.
- [ii]. 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.

VII. CONCLUSION

The following conclusions are obtained from the analysis findings.

- When compared to typical slab structures, the weight of flat slab structures is relatively more.
- Flat slab having more bending moment and shear force when compared with grid slab and two-way slab.
- Flat slab constructions, on the other hand, increase the aesthetic perspective while allowing the architect enormous flexibility of form work, ease of placement of flexural reinforcement, ease of casting concrete, open space for water, air pipes, and so on. between slab and a possible furred ceiling, the reduction of building height in multi-story structures by saving one story height, etc.
- This makes the Flat slab more economical as compared to the conventional and Grid slab. Flat slab structures are the best solution for high rise structures as compared to conventional slab structures and Grid Slab.
- Whereas the Conventional slab is more suitable for Residential and small span structures, while Grid Slab is more suitable for bigger span structures.

REFERENCES

- [1] R. Balaramireddy and K. Dhanasri, "Parametric study of flat slab structure with soft storey against earthquake forces," International Journal of Science and Research (IJSR), 2013.
- [2] S. Pahwa and V. Tiwari, "Comparative study of flat slab with old traditional two-way slab," International Research Journal of Engineering and Technology (IRJET), vol. 4, 2014.
- [3] M. Pradeep and S. M. V., "Seismic behaviour of flat slab building strengthened with perimeter beams, shear walls and beam slab in alternate storeys," International Journal of Innovative Research in Science, Engineering and Technology, 2016.
- [4] G. Patil and S. G. S., "Comparative study of lateral displacement and storey drift of flat slab and conventional slab structure in different

- seismic zones,” International Journal of Scientific Development and Research (IJSDR), 2017.
- [5] S. D. Madavi and S. M. Gajbhiye, “Comparative analysis of flat slab and grid slab,” International Journal of Creative Research Thoughts (IJCRT), vol. 8, no. 7, Jul. 2020.
- [6] A. A. Sathawane and R. S. Deotale, “Analysis and design of flat slab and grid slab and their cost comparison,” International Journal of Engineering Research and Applications (IJERA), vol. 1, no. 3, pp. 837–848, 2020.
- [7] Bureau of Indian Standards, IS 456:2000, Plain and Reinforced Concrete – Code of Practice, New Delhi, India, pp. 52–61, 2000.
- [8] Bureau of Indian Standards, IS 1893 (Part 1): 2016, Criteria for Earthquake Resistant Design of Structures, New Delhi, India, 2016.
- [9] Bureau of Indian Standards, IS 13920:2016, Ductile Design and Detailing of Reinforced Concrete Structures Subjected to Seismic Forces – Code of Practice, New Delhi, India, 2016.
- [10] P. C. Varghese, Advanced Concrete Design, vol. 2. New Delhi, India: Prentice-Hall of India Pvt. Ltd., pp. 158–170.