Comparative Study Of Conventional Slab, Flat Slab And Grid Slab Using ETABS

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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 behaviour 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 makes flat slab a suitable structure as compared to the conventional and grid slab.

Keywords:- Flat slab, conventional slab, Grid Slab, Seismic analysis, Etabs.

1. 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:
   a) Flat slab with drop panel.
   b) Flat slab with column head.
   c) Flat slab with drop panel and column head.
   d) Flat slab without drop panel and column head.

1.2 Design of Flat Slab:-
Two approximate method 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 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.

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.

2. 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 x4m,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 (PART1):1987 and IS875(PART2):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.

3. Load Consideration:-
(i). Dead Load: As per IS-875(PART1):1987
  a. Wall Load = 0.23x20 KN/m$^3$ (Density of Brick) x (4m-0.45m) (Storey Height)=16.33kN/m
  b. Parapet wall Load= 3 KN/m
  c. Slab load = 0.125m x 25 kN/m$^3$= 3.125 KN/m$^2$
  d. Floor finished = 1.5 kN/m$^2$
(ii) Live Load: As per IS-875(PART2):1987
  a. Live load on floor = 3 KN/m$^2$
(iii) Earthquake Load: As per IS1893:2016
  a. Seismic Definition Earthquake zone – III (Z=0.16)
  b. Response reduction factor – 5
  c. importance Factor – 1.2 (Residential building )
  d. Rock and Soil Site Factor-2 (Medium Soil Building)
e. Type of Structure- 1 Damping - 5% (0.05)

**Table 1:** Building Parameter for Case Number I

| Sr. No. | Specification     | Different Types Of Slab System |     |     |
|---------|-------------------|-------------------------------|-----|-----|
|         |                   | Conventional Slab             | Flat Slab | Grid Slab |
| 1.      | Plan Dimensions   | 8mx8m                         | 8mx8m | 8mx8m  |
| 2.      | Length In X Direction | 4m                          | 4m    | 4m    |
| 3.      | Length In Y Direction | 4m                          | 4m    | 4m    |
| 4.      | Storey Height     | 4m                            | 4m    | 4m    |
| 5.      | No. Of Storey     | 5                             | 5     | 5     |
| 6.      | Slab Thickness    | 125mm                         | 150mm | 100mm |
| 7.      | Beam Size         | 230mm X 380mm                 | --    | 230mm X 380mm |
| 8.      | Column Size       | 380mm X 380mm                 | 450mm X 450mm | 500mm X 500mm |
| 9.      | Grid Spacing      | --                            | --    | 2m    |
| 10.     | Grid Beam Size    | --                            | --    | 200mm X 200mm |
| 11.     | Drop Depth.       | --                            | 400mm | --    |

**Table 2:** Building Parameter For Case Number II

| Sr. No. | Specification     | Different Types Of Slab System |     |     |
|---------|-------------------|-------------------------------|-----|-----|
|         |                   | Conventional Slab             | Flat Slab | Grid Slab |
| 1.      | Plan Dimensions   | 10m X10m                      | 10m X 10m | 10m X10m  |
| 2.      | Length In X Direction | 5m                          | 5m    | 5m    |
| 3.      | Length In Y Direction | 5m                          | 5m    | 5m    |
| 4.      | Storey Height     | 4m                            | 4m    | 4m    |
| 5.      | No. Of Storey     | 5                             | 5     | 5     |
| 6.      | Slab Thickness    | 165mm                         | 175mm | 100mm |
| 7.      | Beam Size         | 230mm X 400mm                 | --    | 230mm X 450mm |
| 8.      | Column Size       | 450mm X 450mm                 | 500mm X 500mm | 550mm X 550mm |
| 9.      | Grid Spacing      | --                            | --    | 1.67m |
| 10.     | Grid Beam Size    | --                            | --    | 200mm X 250mm |
| 11.     | Drop Depth.       | --                            | 450mm | --    |

**Table 3:** Building Parameter For Case Number III

| Sr. No. | Specification     | Different Types Of Slab System |     |     |
|---------|-------------------|-------------------------------|-----|-----|
|         |                   | Conventional Slab             | Flat Slab | Grid Slab |
| 1.      | Plan Dimensions   | 12m x12m                      | 12m x 12m | 12mx12m  |
| 2.      | Length in X Direction | 6m                          | 6m    | 6m    |
| 3.      | Length in Y Direction | 6m                          | 6m    | 6m    |
| 4.      | Storey Height     | 4m                            | 4m    | 4m    |
| 5.      | No. Of Storey     | 5                             | 5     | 5     |
| 6.      | Slab Thickness    | 200mm                         | 200mm | 100mm |
| 7.      | Beam Size         | 230mm x 450mm                 | --    | 230mm x 500mm |
| 8.      | Column Size       | 550mm x 550mm                 | 650mm x 650mm | 600mm x 600mm |
| 9.      | Grid Spacing      | --                            | --    | 2m    |
| 10.     | Grid Beam Spacing | --                            | --    | 200mm x 300mm |
| 11.     | Drop Depth.       | --                            | 450mm | --    |
3.1 Material consideration:
Concrete grade – M30
Steel grade – Fe500

3.1 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](image1)

![Figure 2. Flat Slab with drop](image2)

![Figure 3. Grid Beam Slab](image3)

4. 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 4:** Comparison of Bending Moment Result for Three Different spans

| 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 5:** Comparison of Shear Force Result for Three Different spans

| 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 6:** 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 Spans

Fig 5. Comparison of Shear Force for 3 Different spans

Fig 6. Comparison of Base Shear for 3 Different cases

Table 7. 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 8. 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 9. 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 10. 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 11. Total Quantity of Concrete For 3 Different Cases

| Types Of Slab | Case I (m³) | Case II (m³) | Case III (m³) |
|---------------|-------------|--------------|---------------|
| 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 concrete for all cases.

5. 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 multi-storey building is minimum and for a flat slab multi-storey 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.
6. 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.

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