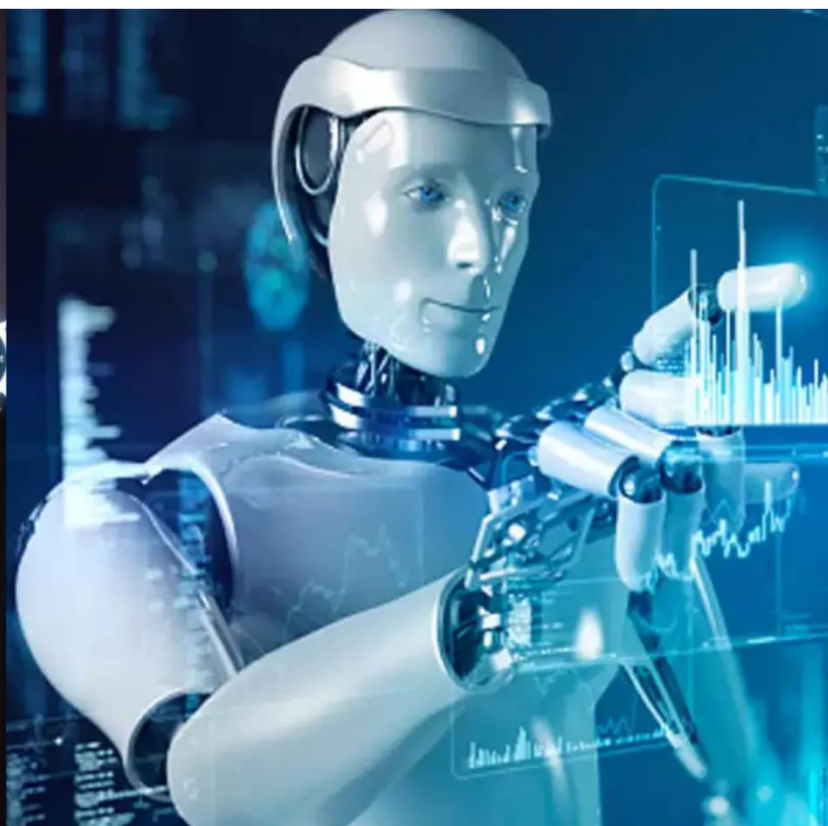




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# **Comparison of Flat Slab with Conventional Slab using STAAD Pro**

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**ABSTRACT:** India at instant is rapid developing country in economy which brings stipulation in growing in construction amenities along with the evolution of population. The dictate of property in urban areas is upraises gradually, In order to counteract this demand in these urban areas upright development is the only choice. This type of circumstance brings challenges to counteract additional lateral loads due to wind and seismic. The multi storeyed structures is fetching an obligatory part of our living glossy and tasteful from with enlargement seek for space The delicate amount of space is forcing us to lift the high level of structure which give space to greatest point and number of persons in general, and also in consistency with the to do with buildings design things essential. The adventure of design and structure is to hold the bits of material using extensive supports and hold using columns. This type of structures are called as beam- slab structures. The main group as per arrangement of slab is beams and girders, and columns are framed structures and flat slab structures. The flat slab structure is structure in which slab is held up by column. Flat slab provides clear height more and structure becomes cost effective.

**KEYWORDS:** Flat Slab, Conventional slab, Bending moment, stress, displacement, Shear force.

## **I. INTRODUCTION**

### **1.1: General**

Flat slab are found by Eddy and Turner in 1914. The flat slab is directly held up columns and walls. Which gives better lightning, cheap cost, and higher efficiency of appearance, faster construction and developing safety. Flat slabs have been accessible to structural engineers from the time when the start of reinforced concrete design. In flat slab arrangement slab is directly supported by column as well as the load coming on slab slabs is directly conveyed to the columns and column transferred to the footing. This type of slab is generally provided by column heads or capitals. Flat slabs are more commonly using in commercial structures due to reduced formwork cost, faster excavation, and easy construction. These slabs which are directly rest on columns are called Flat slabs. These slabs are known as beamless slabs. The parts of slab surrounded on each of the four sides by centre line of column is called panel. Panel are categorised into column stripe and middle stripe. Guidelines for design of flat slab are mention in Indian standard codes. Standard experiments carry on layouts and different configuration of slab which indicates that Design procedure is limited to scope and application. Currently, irregular layouts are more come therefore standard code procedures seem inadequate for design. Flat slab is analysed by following methods.

1. Direct design method
2. Equivalent Frame method

### **1.2 TYEPS OF FLAT SLAB**

Types of flat slab construction are the following.

1. Simple flat slab.
2. Flat slab with drop panels.
3. Flat slab with column heads.
4. Flat slab with both drop panels and column heads.

**1.3 ADVANTAGES OF FLAT SLAB**

- 1) The ease construction of formwork easy.
- 2) The positioning of flexural reinforcement is easy.
- 3) The casting of concrete work is easy.
- 4) In ground plan arrangement of wall is easy.
- 5) Reduce building height which is more helpful in multi-storey construction work.
- 6) Flexibility.
- 7) Construction is quick.

**1.4 DISADVANTAGES OF FLAT SLAB**

- 1) Construction cost is more.
- 2) Suitable for medium span length.
- 3) Not suitable brittle masonry supporting structures.
- 4) Mechanical ducting is large by the use of drop panel.
- 5) Slab thickness is more.
- 6) Deflection is critical in middle strip.

**1.5 SEISMIC ANALYSIS**

Seismic analysis is essential part for any structural analysis and it will provide the performance of the structure due to the underground vibrations or accelerations. It is considered as process of structural design where seismic work is relevant. Structural analysis categorised in following groups.

1. Linear static analysis or Equivalent static analysis
2. Nonlinear static analysis or Pushover analysis
3. Linear dynamic analysis or Response spectrum analysis
4. Nonlinear dynamic analysis or Time history analysis

**II. LITERATURE SURVEY**

**Amit A. Sathwane (2016)[1]** This studies about flat slab, this flat slab provided with drop with grid slab which is economical to the nexus point near the vidhan bhavan beside MNC office. The analysis is carried out by both manually and stadd pro software. From this studies stated that the flat slab with drop is more economical. The quantity of concrete for flat slab is less and quantity of steel required for flat slab with drop and grid slab is more as compared to flat slab without drop.

**Navjot Kaur Bhatia (2016)[2]** This studies shows comparison of dynamic performance of grid and flat slab with the conventional slab. This research work conducted dynamic analysis for wind and seismic forces for high rise RC structures with different shape of flat slab, grid slab and conventional slab. This analysis carried for 10, 20 and 30 story structures with various earthquake zones as per IS 1893:2002. It gives the relationship between earthquake response and intensity. From this analysis results observe that flat slab and grid slab structural performance is better than conventional slab. This represents with respect to the cost of ingredients and deflections.

**K.N.Mate (2015)[3]** Flat slab is analysed. The flat slab consist of simple RC structure with clear span, clear good height, form work withoutt delaying in construction time. This analysis gives why flat slab is more flexible than other type of slabs. This studies gives complete analysis and design of flat slab by using IS 456:2000. From this analysis is shows that flat slab is more flexible and economical compares to conventional slab. This analysis provides information to decide drop size, panel size, depth of slab and reinforcement details.

**R.K.Makode et.al (2014)[4]** This research work shows discussion about flat slab structure analysis which is directly supported by columns. This type of slab presently using in structures because of advantage of reduction in floor to floor height. It is economical and give better architectural benefits.

**K. S. Patil et.al (2013)[5]**The studies gives optimum design of RC structures by providing drop as per IS 456: 2000. The objection is overall cost of structures includes cost of slab as well as cost of column. The cost involves ingredient cost, workmanship, formwork, reinforcement and concrete. The design is carried by direct design method. The

optimization is done for various grade of steel and concrete. The optimization of flat slab compare with conventional design. The modelling, and analysis done by software.

### III. METHODOLOGY

#### 3.1 OBJECTIVES OF THE WORK

Keeping in view the above literature works following objectives are fixed.

1. To study the plan and analyze the conventional and flat slab as per given data.
2. To determine the maximum bending moment and shear force.
3. To review the lateral displacement, rotation and maximum stress for different earthquake zones.
4. To study the quantity of concrete and steel and cost of structure.

#### 3.2 METHODOLOGY OF WORK

The process of analysis and design of structure performed on STAAD-Pro V8i.

##### 3.2.1 Model details

Table 3.1: Specification for Model-1

| Specification               | Conventional Slab | Flat Slab |
|-----------------------------|-------------------|-----------|
| Dimension                   | 25×25 m           | 25×25 m   |
| Size of Grid in x Direction | 5m                | 5m        |
| Size of Grid in y Direction | 5m                | 5m        |
| Floor Height                | 3.5m              | 3.5m      |
| Number of Stories           | 8                 | 8         |
| Thickness of slab           | 150mm             | 150mm     |
| Thickness of drop           | -                 | 150mm     |
| Beam size                   | 0.3×0.3 m         | -         |
| Column Size                 | 0.4×0.4 m         | 0.4×0.4 m |

Table 3.2: Specification for Model-2

| Specification               | Conventional Slab | Flat Slab |
|-----------------------------|-------------------|-----------|
| Dimension                   | 30×30 m           | 30×30 m   |
| Size of Grid in x Direction | 6m                | 6m        |
| Size of Grid in y Direction | 6m                | 6m        |
| Floor Height                | 3.5m              | 3.5m      |
| Number of Stories           | 8                 | 8         |
| Thickness of slab           | 150mm             | 150mm     |
| Thickness of drop           | -                 | 150mm     |
| Beam size                   | 0.3×0.3 m         | -         |
| Column Size                 | 0.4×0.4 m         | 0.4×0.4 m |

Table 4.3.2: Specification for Model-3

| Specification               | Conventional Slab | Flat Slab |
|-----------------------------|-------------------|-----------|
| Dimension                   | 35×35m            | 35×35m    |
| Size of Grid in x Direction | 7m                | 7m        |
| Size of Grid in y Direction | 7m                | 7m        |
| Floor Height                | 3.5m              | 3.5m      |
| Number of Stories           | 8                 | 8         |
| Thickness of slab           | 150mm             | 150mm     |
| Thickness of drop           | -                 | 150mm     |
| Beam size                   | 0.3×0.3 m         | -         |
| Column Size                 | 0.4×0.4 m         | 0.4×0.4 m |

Table 3.4: Specification for Model-4

| Specification               | Conventional Slab | Flat Slab |
|-----------------------------|-------------------|-----------|
| Dimension                   | 40×40m            | 40×40m    |
| Size of Grid in x Direction | 8m                | 8m        |
| Size of Grid in y Direction | 8m                | 8m        |
| Floor Height                | 3.5m              | 3.5m      |
| Number of Stories           | 8                 | 8         |
| Thickness of slab           | 150mm             | 150mm     |
| Thickness of drop           | -                 | 150mm     |
| Beam size                   | 0.3×0.3 m         | -         |
| Column Size                 | 0.4×0.4 m         | 0.4×0.4 m |

### 3.2.2 Material details

- Grade of concrete : M25 → Grade of steel : Fe 250
- Density of concrete : 25 Kn/m<sup>3</sup>
- Self-weight of slab : 5.5 Kn/m<sup>3</sup> → Live load : 2.0 Kn/m<sup>3</sup>

- Primary load cases and load combinations 4.4 Seismic parameters Seismic analysis is done as per IS: 1893:2002 part-1
- Soil profile type : Medium Soil
- Seismic zone factor : Zone-II, Zone-III,
- Response reduction factor : 5
- Importance factor : 1.5
- Reduction factors : 2.0

### 3.2.3 3D view of modelling

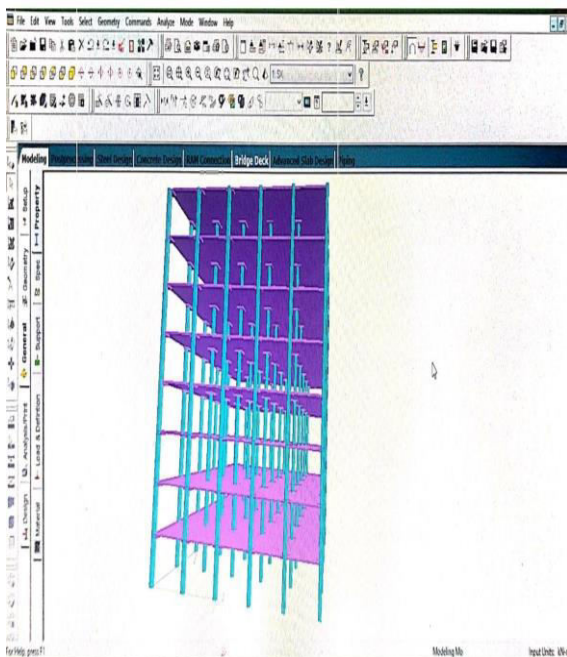


Fig 3.1: 3D View of Flat Slab

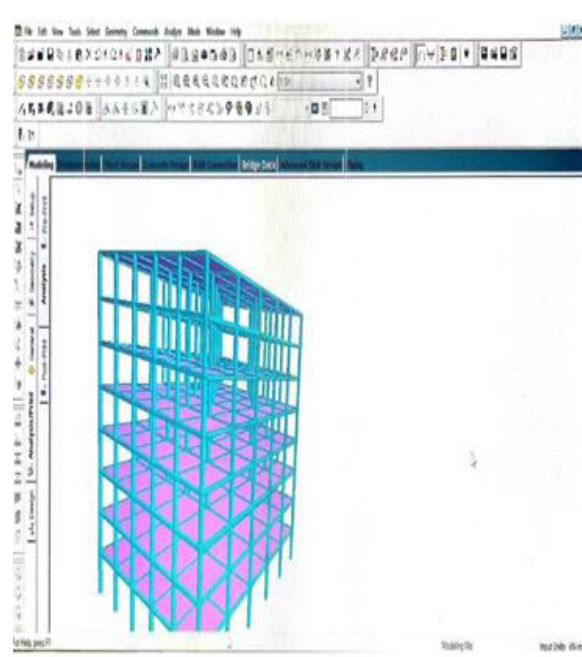


Fig3.2: 3D View of Conventional Slab

## IV. EXPERIMENTAL RESULTS

### 4.1 DISPLACEMENT

Table 4.1: Maximum Displacement in X direction

| Models  | Earthquake zone | Conventional Slab mm | Flat Slab mm |
|---------|-----------------|----------------------|--------------|
| Model-1 | Zone-II         | 37.18                | 26.12        |
|         | Zone-III        | 59.48                | 45.96        |
| Model-2 | Zone-II         | 49.65                | 31.65        |
|         | Zone-III        | 79.437               | 61.35        |
| Model-3 | Zone-II         | 64.09                | 43.28        |
|         | Zone-III        | 102.698              | 83.12        |
| Model-4 | Zone-II         | 80.312               | 63.16        |
|         | Zone-III        | 128.81               | 92.73        |

Table 4.2: Maximum Displacement in Y direction

| Models  | Earthquake zone | Conventional Slab mm | Flat Slab mm |
|---------|-----------------|----------------------|--------------|
| Model-1 | Zone-II         | 37.18                | 26.12        |
|         | Zone-III        | 59.48                | 45.96        |
| Model-2 | Zone-II         | 49.65                | 31.65        |
|         | Zone-III        | 79.437               | 61.35        |
| Model-3 | Zone-II         | 64.09                | 43.28        |
|         | Zone-III        | 102.698              | 83.12        |
| Model-4 | Zone-II         | 80.312               | 63.16        |
|         | Zone-III        | 128.81               | 92.73        |

#### 4.2 SHEAR FORCE

**Table 4.3:** Maximum Shear force in X direction

| Models         | Earthquake zone | Conventional Slab Kn | Flat Slab Kn |
|----------------|-----------------|----------------------|--------------|
| <b>Model-1</b> | Zone-II         | 985.27               | 856.23       |
|                | Zone-III        | 985.27               | 796.115      |
| <b>Model-2</b> | Zone-II         | 1332.05              | 1520.91      |
|                | Zone-III        | 1332.05              | 1025.11      |
| <b>Model-3</b> | Zone-II         | 1734.66              | 1456.02      |
|                | Zone-III        | 1734.66              | 1566.230     |
| <b>Model-4</b> | Zone-II         | 2193.34              | 1965.70      |
|                | Zone-III        | 2193.34              | 1832.140     |

**Table 4.4:** Maximum Shear force in Y direction

| Models         | Earthquake zone | Conventional Slab Kn | Flat Slab Kn |
|----------------|-----------------|----------------------|--------------|
| <b>Model-1</b> | Zone-II         | 47.841               | 25.365       |
|                | Zone-III        | 62.313               | 44.936       |
| <b>Model-2</b> | Zone-II         | 71.400               | 38.400       |
|                | Zone-III        | 82.945               | 59.125       |
| <b>Model-3</b> | Zone-II         | 99.519               | 65.835       |
|                | Zone-III        | 106.848              | 78.133       |
| <b>Model-4</b> | Zone-II         | 132.147              | 89.761       |
|                | Zone-III        | 134.750              | 96.230       |

#### 4.3 BENDING MOMENT

**Table 4.5:** Maximum Bending Moment in X direction

| Models         | Earthquake zone | Conventional Slab Kn-m | Flat Slab Kn-m |
|----------------|-----------------|------------------------|----------------|
| <b>Model-1</b> | Zone-II         | 0.958                  | 0.450          |
|                | Zone-III        | 1.294                  | 0.755          |
| <b>Model-2</b> | Zone-II         | 1.229                  | 0.993          |
|                | Zone-III        | 1.620                  | 1.110          |
| <b>Model-3</b> | Zone-II         | 1.602                  | 1.438          |
|                | Zone-III        | 1.981                  | 1.436          |
| <b>Model-4</b> | Zone-II         | 2.064                  | 1.744          |
|                | Zone-III        | 2.375                  | 1.898          |

**Table 4.6:** Maximum Bending Moment in Y Direction

| Models         | Earthquake zone | Conventional Slab Kn-m | Flat Slab Kn-m |
|----------------|-----------------|------------------------|----------------|
| <b>Model-1</b> | Zone-II         | 70.585                 | 46.925         |
|                | Zone-III        | 112.851                | 80.569         |
| <b>Model-2</b> | Zone-II         | 97.376                 | 65.237         |
|                | Zone-III        | 149.234                | 110.136        |
| <b>Model-3</b> | Zone-II         | 139.113                | 89.433         |
|                | Zone-III        | 191.876                | 140.002        |
| <b>Model-4</b> | Zone-II         | 191.260                | 102.419        |
|                | Zone-III        | 244.457                | 171.50         |

#### 4.4 ROTATIONAL

**Table 4.7:** Maximum Rotational in X direction

|                | Earthquake zone | Conventional Slab rad | Flat Slab rad |
|----------------|-----------------|-----------------------|---------------|
| <b>Model-1</b> | Zone-II         | 0.002                 | 0.002         |
|                | Zone-III        | 0.001                 | 0.001         |
| <b>Model-2</b> | Zone-II         | 0.002                 | 0.002         |
|                | Zone-III        | 0.001                 | 0.001         |
| <b>Model-3</b> | Zone-II         | 0.003                 | 0.003         |
|                | Zone-III        | 0.001                 | 0.001         |
| <b>Model-4</b> | Zone-II         | 0.004                 | 0.004         |
|                | Zone-III        | 0.001                 | 0.001         |

**Table 4.8:** Maximum Rotational in Y direction

| Models         | Earthquake zone | Conventional Slab rad | Flat Slab rad |
|----------------|-----------------|-----------------------|---------------|
| <b>Model-1</b> | Zone-II         | 0.000                 | 0.819         |
|                | Zone-III        | 0.000                 | 0.569         |
| <b>Model-2</b> | Zone-II         | 0.000                 | 0.963         |
|                | Zone-III        | 0.000                 | 0.869         |
| <b>Model-3</b> | Zone-II         | 0.000                 | 1.101         |
|                | Zone-III        | 0.000                 | 1.021         |
| <b>Model-4</b> | Zone-II         | 0.000                 | 1.245         |
|                | Zone-III        | 0.000                 | 1.225         |

#### 4.5 ABSOLUTE PREASURE

Table 4.9: Maximum Principal Stress at Top

| Models  | Earthquake zone | Conventional Slab kn/m <sup>2</sup> | Flat Slab kn/m <sup>2</sup> |
|---------|-----------------|-------------------------------------|-----------------------------|
| Model-1 | Zone-II         | 0.369                               | 0.563                       |
|         | Zone-III        | 0.457                               | 0.125                       |
| Model-2 | Zone-II         | 0.445                               | 0.611                       |
|         | Zone-III        | 0.541                               | 0.319                       |
| Model-3 | Zone-II         | 0.533                               | 0.763                       |
|         | Zone-III        | 0.639                               | 0.416                       |
| Model-4 | Zone-II         | 0.664                               | 0.951                       |
|         | Zone-III        | 0.905                               | 0.694                       |

Table 4.10: Maximum Principal Stress at Bottom

| Models  | Earthquake zone | Conventional Slab kn/m <sup>2</sup> | Flat Slab kn/m <sup>2</sup> |
|---------|-----------------|-------------------------------------|-----------------------------|
| Model-1 | Zone-II         | 0.032                               | 0.012                       |
|         | Zone-III        | 0.032                               | 0.029                       |
| Model-2 | Zone-II         | 0.040                               | 0.014                       |
|         | Zone-III        | 0.040                               | 0.076                       |
| Model-3 | Zone-II         | 0.046                               | 0.026                       |
|         | Zone-III        | 0.046                               | 0.098                       |
| Model-4 | Zone-II         | 0.063                               | 0.033                       |
|         | Zone-III        | 0.063                               | 0.123                       |

#### 4.6 QUANTITY OF CONCRETE

Table 4.11: Quantity Of Concrete

| Models  | Earthquake zone | Conventional Slab m <sup>3</sup> | Flat Slab m <sup>3</sup> |
|---------|-----------------|----------------------------------|--------------------------|
| Model-1 | Zone-II         | 377.28                           | 145.28                   |
|         | Zone-III        | 391.20                           | 153.23                   |
| Model-2 | Zone-II         | 421.00                           | 225.36                   |
|         | Zone-III        | 386.88                           | 193.56                   |
| Model-3 | Zone-II         | 444.08                           | 298.11                   |
|         | Zone-III        | 389.20                           | 236.19                   |
| Model-4 | Zone-II         | 504.18                           | 361.55                   |
|         | Zone-III        | 223.76                           | 310.56                   |

#### 4.7 QUANTITY OF STEEL

Table 4.12: Quantity of Steel

| Models  | Earthquake zone | Conventional Slab kg | Flat Slab kg |
|---------|-----------------|----------------------|--------------|
| Model-1 | Zone-II         | 404292.91            | 201536.99    |
|         | Zone-III        | 516819.12            | 332156.22    |
| Model-2 | Zone-II         | 571773.00            | 320469.43    |
|         | Zone-III        | 604172.62            | 445691.29    |
| Model-3 | Zone-II         | 831934.38            | 552693.55    |
|         | Zone-III        | 894658.19            | 595236.94    |
| Model-4 | Zone-II         | 853107.62            | 572364.12    |
|         | Zone-III        | 871296.33            | 623149.76    |

#### 4.8 COST OF STRUCTURE

**Table 4.13:** Cost Of Structure

| Models         | Earthquake zone | Conventional Slab Rs | Flat Slab Rs |
|----------------|-----------------|----------------------|--------------|
| <b>Model-1</b> | Zone-II         | 25200074             | 12455419     |
|                | Zone-III        | 31986647             | 22031248     |
| <b>Model-2</b> | Zone-II         | 35358880             | 19791540     |
|                | Zone-III        | 37172557             | 27225377     |
| <b>Model-3</b> | Zone-II         | 51026262             | 33889355     |
|                | Zone-III        | 54652491             | 36304691     |
| <b>Model-4</b> | Zone-II         | 52446907             | 35245722     |
|                | Zone-III        | 52837179             | 31653855     |

#### V. CONCLUSION

The analysis of conventional slab and flat slab is carried out for different grid size using staad pro software. By keeping above results in view some conclusions are obtained which listed below.

1. The maximum displacement in all the direction is increases with increase in size of the grid for both zone-II and zone-III. Whereas displacement is more in conventional slab compared to flat slab.
2. The maximum shear force in all the direction is increases with increase in size of the grid for both zone-II and zone-III. Whereas shear force is more in conventional slab compared to flat slab.
3. The maximum bending moment in all the direction is increases with increase in size of the grid for both zone-II and zone-III. Whereas bending moment is more in conventional slab compared to flat slab. It also observed that bending moment in y and z direction is same.
4. The rotation in x direction is increases with increases in grid size and same for both conventional and flat slab in zone-II and zone-III. The rotation in y direction is negligible for conventional and it increases for flat slab with increases in dimension of slab. The rotation in z direction is constant in case of conventional slab for both zones.
5. The maximum absolute pressure increases with increases in size of grid for both conventional slab and flat slab for both zone-II and Zone-III.
6. The quantity of concrete increases with increases in grid size in zone-II and zone III. Quantity of concrete is more in case of conventional slab then flat slab.
7. The quantity of steel increases with increases in grid size in zone-II and zone-III. Quantity of steel is more in case of conventional slab then flat slab.
8. The cost of structure is more for conventional slab.

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