Analysis of Flat Slab Structures in Comparison with Conventional Slab Structures

Shital Borkar, Kuldeep Dabhekar, Isha Khedikar, Santosh Jaju

1, 2, 3Department Civil Engineering, G H Raisoni College of Engineering Nagpur, Maharashtra, India
4 Department Mechanical Engineering, G H Raisoni College of Engineering Nagpur, Maharashtra, India
1borkar_shital.mtechstr@ghrce.raisoni.net 2kuldeep.dabhekar@raisoni.net 3isha.khedikar@raisoni.net 4santosh.jaju@raisoni.net

Abstract. The main aim of this analysis is to study the seismic behaviour of different types of slab structures i.e. flat slab structure, conventional slab structure, flat slab structure with drop under different earthquake zones. These buildings are multi-storey building. For our analysis, we have use G+5 storey building. The analysis used ETAB software. We also analyzed to make a comparison of behavior of flat bit of material building with old common 2 way bit of material system for different bands, parts like band, part zone-II, part zone-III, part zone-IV, part zone-V in respect with greatest point making bent moment.

Keywords: Base shear, Column head, Drop panel, Storey drift, Storey shear.
Abbreviations- RCC (Reinforced Cement Concrete), ETAB (Extended Three-dimensional Analysis of Building Systems)

1. Introduction
The multistoried building is becoming a necessary part of our living polished and tasteful from with increase in request for space The feeble amount of space is forcing us to lift the high level of structure as much as possible to give space to greatest point number of persons in general, and also in harmony with the to do with buildings design things necessary. The experience of design and building is to support the bits of material using long supports and hold the rays using columns. These types of structures are called as beam-slab buildings. Two main groups according to the arrangement of slab, beams and girders, and columns are framed building and flat slab building. The flat slab structure are the structures in which slab is supported directly by column. In this, the floor to floor height reduces. As a result the structure becomes cost effective. The flat bit of material buildings in which bit of material is directly supported using columns, have been took up in many buildings made in near in times because of, in relation to more chances of made lower, less floor to floor heights to have meeting with the price working well and to do with buildings design demands. The long support drop the able to get net clear top high level [1][2].
A slab held directly using columns without beams is stated as reinforced touchable unappetizing slab, moreover named as whiz gigging less slab. The slab part which restricted on all sides by Centerline is called as panel. The slab stiffened to support column. It provide strength in shear and it reduces negative reinforcement. The unappetizing slab is often stiffened sealed to supporting columns to unhook unobjectionable strength in shear and to reduce the value of negative reinforcement in the support regions. The stiffened portion is said to be waif or waif panel [3].

1.1 History of adsorption of flat slab system
Flat slabs have been accessible to structural engineers from the time when the start of reinforced concrete design. In Europe one of the first of group father of flat bit of material was Robert Millar, a design and building one building by agreement. He carried out a series of full-scale tests on flat slabs on 1909. These bits of materials knows as Millar.

The analysis of flat slab were solved with various loads tests on flat slabs, the design rules which have ensured are also empirical. This different side between design and observations procedures is particularly serious for flat buildings. Observations of flat bit of materials has slower to have undergone growth because it has to do with complex three to do with measures behavior, as made a comparison of with two to do with measures behavior of ray column frame.

1.2 Some terminologies involved in flat slab

1.2.1 Drop flat square bits
The drop cap committee is worked by the nearby thickening of the bit of material in the field, range of the supporting column. They in addition suggests the moving to a lower level of the steel requirement for the bad, less than zero short times at the post support [3].
The lawmaking suggests that drops should be rectangular in map, and have measure end to end in every direction not less than one third of the committee measure end to end measured upright to the with spaces be taken as one half of the separate direction from side to side of without friend or living place for the middle part, space committee [4].

1.2.2 Column Capital
The code keeps inside limits the through structure right part of column money to that part which lies within the larger (up-side down) pyramid or right going round in circles form with a round base and a pointed at the end which has a top part angle of 90 and can be taken into point to be taken into account with in the out-lines of the column capital and the column capital head. This is based on the thing taken as certain of a 45 unsuccessful person plan, outside of which making greater of the support is taken into account as having little effect in getting moved from one position to another get cut to the column [5].

1.3 Method of seismic analysis
For seismic analysis purpose, both linear static analysis and linear dynamic analysis is performed and results are presented separately.

A. Linear static wringer [6,7]
Linear static analysis is preferred for moderate height buildings and dynamic analysis is performed for multistory building. Since, the models analyzed in this work are both of moderate height and of high rise buildings, both linear static wringer and linear dynamic wringer is performed so as to put convenience in studying response. In this method, seismic response of structures is carried out on the principle of horizontal gravity unsupportable to be respective to the very earthquake loading.

B. Linear dynamic wringer (Response Spectrum Method)
Response spectrum wringer be regarded as resurgence over linear static analysis. The noteworthy difference between linear static and response spectrum method is lies in the level of gravity and their diffusion withal the height of the structure stuff analyzed. In response spectrum, the response of Multi Degree is represented as modal response.

2. Objectives

- To study the effect of seismic level over the intensities of various parameter like displacement, base shear etc.
- Seismic analysis of flat slab structure by linear static method and response spectrum method.
- A by comparison learning process between different types of flat bits of materials in terms of parameters like base get cut, storey drift, story drift.
- Analysis of G+5 buildings for all zone factors and there comparative study for various parameters.
- The parametric studies comprise of base shear of structure. Maximum lateral displacement developed and generation of story drift, axial forces in the column.

3. Methodology

3.1 Methods and procedure adopted [11, 12]

- Selections of 5 variegated types of slab models are considered (conventional slab modal, unappetizing slab, unappetizing slab with dropcap, unappetizing slab with post heads and combination of drops and post heads).
- There are two methods of seismic analysis (linear static analysis and linear dynamic analysis) for different seismic zone factor.
- The 5 slab models are examined for different zone factors.
- Analysis is conducted using ETABS 2015 software.

3.2 Plan and elevation view of models

A plan is designed and is used same for all models i.e. conventional slab structure, flat slab structure, flat slab with drop cap structure. It consists of slab, columns and beams for conventional building on the other hand consist of slab with drop cap structure, slab with column head structures and columns for flat slab building [8, 9, 10].

![Figure 1. Plan of structure](image1)

![Figure 2. Elevation of structure](image2)

(Total height = 24m)
The plan of Structure is as shown in above figure 1 and Elevation of structure shown in figure 2. Total height of the structure is 24m. The plan consists of slab, columns and beams. It also consists of slab with drop and slab with column head.

| Table 1. Data Required for Analysis |
|-----------------------------------|
| Preliminary Data                  | Seismic Data                      |
| No of stories                     | G+5                                |
| Seismic loading                   | As per IS1893 part I               |
| Plan dimension                    | 30 x 20 m                          |
| Type of structure                 | Commercial building                |
| Floor to Floor height             | 4 m                                |
| Total height of Structure         | 24 m                               |
| Size of Column                    | 400 x 400 mm                       |
| Size of Beam                      | 300 x 300 mm                       |
| Live load                         | 4 kN/m² (IS 875 part2)             |
| Floor finish load                 | 0.75 kN/m²                         |
| Roof live                         | 1.5 kN/m²                          |
| Grade of Concrete                 | M25, Fe415                         |
| Type of soil                      | Medium                             |
| Seismic part Zone                 | 0.10                               |
| Part Zone III                    | 0.16                               |
| Part Zone IV                     | 0.24                               |
| Part Zone V                      | 0.36                               |
| Part Zone IV reduction factor     | 3                                  |

The analysis is carried out using software ETABS. The data required for analysis is shown in above table 1.

The 3-D model of flat slab structure in ETABS is as shown in above figure 3.

The figure 4 represents the 3-D model of flat slab structure without drop as per ETABS.
The 3-D model of conventional slab structure is shown in figure 5 as per ETABS. As per the input data, as represent in table: Analysis data above, we get the outputs as shown in above figure (3), (4), and (5). This is the 3-D representation of data. This is done using ETABS software.

4. Calculation

4.1 Calculation of parameters for flat slab
This section includes calculation of data that are used in the project and their properties like density. In IS 456-2000, there is a provision for flat slab structure, from this we can know the various terminology used in flat slab structure. Let’s we are calculating the thickness of slab from given data.

Thickness of flat slab
( By referring IS 456-2000, Clause No- 31.2.1) 6000 / (0. 5 (20+26) = 1.6)
Total Thickness = 163.04 + 15 + 16/2
= 186.00 mm
Drop Size (IS 456-2000, clause No- 31.2.2)
1/3 * 6
= 2.000 m
1/3* 5
= 1.600 m
Thickness of Column Drop = 1.25*186
= 233.00 mm

Calculation of dead load
Slab Thickness
= 186.00 mm
Density of Concrete
= 25 kN/m²
Self-wt. of slab
= 25*0.186
= 4.63 kN/m² *30*20
= 2970 kN
Floor finish at floor level
= 0.75 kN/m
Total Floor load = 0.75*30*20
= 450kN
Load on beam
= 3645 kN
Load on column
= 2640 kN
4.2 Flat slab towers policies under lateral loading

The policies of the unappetizing slab structures for gravity loads is well established. For towers taller than 10 stories, framing whoopee provided by unappetizing slab and post is often insufficient. IS 1893-2002 says that (Clause.7.11.2) as the lateral load resistance of slab column is small, flat slab are design only for gravity loads and shear wall resisted the seismic force.

The bit of material post connections are subject to weight get cut and unbalance short time during earth shocks. Giving in law of get cut and unbalance short times is hair-trigger in unappetizing bit of material behavior, especially for horizontal adding weight, amount which has need of with substance unbalance short time to get moved from one position to another between bit of material and column. The touchable will be responsible for a certain and clear level of get cut stopping effect almost the post but this may lead to be added to by giving blow get cut support massed on concentric edges.

5. Results and Discussions

The observation is done by using an observations software named ETABS 2015 software individually and then comparison is done.

The calculation of variations in base shear, effect of adsorption of drop, column head parameters are conducted and there trends with load variation is presented graphically and analyzed. The comparison of various performance parameters between conventional structure and flat slab structure was done.

5.1 Effect of seismic load on base shear in kN

| Base shear in X-Axis                  | Part Zone II | Part Zone III | Part Zone IV | Part Zone V |
|--------------------------------------|--------------|---------------|--------------|-------------|
| Convention structure                 | 871.95       | 1395.13       | 2092.70      | 3139.05     |
| Flat slab                            | 768.80       | 1230.08       | 1845.13      | 2767.70     |
| Flat slab with drop                  | 875.70       | 1401.12       | 2101.69      | 3152.53     |
| Flat slab with column head           | 799.58       | 1279.32       | 1918.95      | 2878.43     |
| Flat slab with drop and column head  | 904.86       | 1447.77       | 2171.66      | 3257.49     |

Live load and roof live load calculation

Load intensity specified (50% load is considered) = 4.0 kN/m²
L.L. = 4*0.5*30*20 = 1200 kN
R.L. = 1.5*0.5*30*20 = 450 kN

Seismic Loading

Calculated seismic load as mentioned in IS 1893-2002
Calculated seismic parameters as Tₐ = 0.8132 s
Building is located on medium soil site, Therefore Sₛ/g = 1.6724
Design horizontal seismic coefficient Aₘ = 0.02787
Base shear, Vₜ = 871.63 kN
Table 2 shows variations in base shear for different zones in the X direction. The base shear is an important parameter considered for evaluation of the performance of structural systems.

Table 3. Base shear in Y-Direction

| Part Zone | Zone II | Zone III | Zone IV | Zone V |
|-----------|---------|----------|---------|--------|
| Convention structure | 872.50   | 1396.00  | 2094.00 | 3141.00 |
| Flat slab   | 764.34   | 1222.94  | 1834.42 | 2751.63 |
| Flat slab with drop | 874.49   | 1399.18  | 2098.77 | 3148.53 |
| Flat slab with column head | 799.56   | 1279.30  | 1918.95 | 2876.2  |
| Flat slab with drop and column head | 904.86   | 1447.77  | 2167.66 | 3250.49 |

And Table 3 shows variations in base shear for different zones in the Y direction. The base shear is an important parameter considered for evaluation of the performance of structural systems. In structural systems, dependency of these parameters on the dead weight of the building and Ah factor is observed. Increment in base shear of the structure is noticed with an increase in dead weight of the building as well as with an increase in the zone factor. There is not much difference in base shear in the X and Y direction [13, 14, 15].

5.2 Effect of story shear

The graphical representation of a conventional slab structure with story shear is as shown in Figure 6. The graphical representation of a flat slab structure with story shear is as shown in Figure 7.

The graphical representation of a flat slab structure with drop cap story shear is as shown in Figure 8.
In Story shear, we have in mind the possible ruling side amount on an unrepeatable floor at a given direction story get cut is greatest point in flat bit of material system and least in flat slab with drop system in all the seismic band, the different proposed models of flat slab compared with conventional slab in both regular and irregular structural condition. The story shear rises with rise in number of story, but in flat slab structure it is observed to be less than the conventional structure.

5.3 Effect of story drift in X and Y dir. For Zone II

| Story No. | Conventional Structure | Flat Slab Structure | Flat Slab with Drop cap | Flat Slab with Column Head | Flat Slab with Drop cap and Column Head |
|-----------|------------------------|---------------------|-------------------------|---------------------------|----------------------------------------|
|           |                        |                     |                         |                           |                                        |
| 6         | 0.00071                | 0.00125             | 0.00071                 | 0.00113                   | 0.000809                               |
| 5         | 0.00123                | 0.00195             | 0.0012                  | 0.00173                   | 0.001333                               |
| 4         | 0.001587               | 0.00249             | 0.0016                  | 0.00221                   | 0.00173                                |
| 3         | 0.001861               | 0.00288             | 0.0018                  | 0.00255                   | 0.00202                                |
| 2         | 0.002034               | 0.00297             | 0.002                   | 0.00264                   | 0.00217                                |
| 1         | 0.001424               | 0.0017              | 0.0014                  | 0.00164                   | 0.001451                               |

The story drift along X-axis for 5+G building with no infill are given in Table 4 for zone II. The story drift represented the highest value that we get when all load combinations are applied.

| Story No. | Conventional Structure | Flat Slab Structure | Flat Slab with Drop cap | Flat Slab with Column Head | Flat Slab with Drop cap and Column Head |
|-----------|------------------------|---------------------|-------------------------|---------------------------|----------------------------------------|
|           |                        |                     |                         |                           |                                        |
| 6         | 0.00071                | 0.00125             | 0.00071                 | 0.00113                   | 0.000809                               |
| 5         | 0.00123                | 0.00195             | 0.0012                  | 0.00173                   | 0.001333                               |
| 4         | 0.001587               | 0.00249             | 0.0016                  | 0.00221                   | 0.00173                                |
| 3         | 0.001861               | 0.00288             | 0.0018                  | 0.00255                   | 0.00202                                |
| 2         | 0.002034               | 0.00297             | 0.002                   | 0.00264                   | 0.00217                                |
| 1         | 0.001424               | 0.0017              | 0.0014                  | 0.00164                   | 0.001451                               |

The story drift along Y-axis for 5+G building with no infill are given in Table 5 for zone II. The story drift represented the highest value that we get when all load combinations are applied.

5.4 Effect on torsional moment on bottom, z = 16m, on top for all different zones

| Type of Slab               | Part Zone II | Part Zone III | Part Zone IV | Part Zone V |
|---------------------------|--------------|---------------|--------------|-------------|
| Convention structure      | 28.452       | 47.807        | 79.733       | 127.62      |
| Flat slab                 | 85.468       | 136.153       | 215.036      | 333.361     |
| Flat slab with drop       | 37.057       | 66.383        | 108.428      | 170.84      |
| Flat slab with column head| 85.188       | 146.24        | 227.643      | 349.74      |
| Flat slab with drop and column head | 31.336 | 51.028 | 77.282 | 116.665 |

Table 6 represents the Torsional Moment on bottom slab for different seismic zones.
Table 7. Torsional Moment at Z=16m

| Type of Slab                     | Part Zone II | Part Zone III | Part Zone IV | Part Zone V |
|---------------------------------|-------------|---------------|--------------|-------------|
| Convention structure            | 24.531      | 36.849        | 55.274       | 83.954      |
| Flat slab                       | 81.819      | 108.909       | 173.283      | 269.845     |
| Flat slab with drop             | 30.736      | 49.178        | 75.996       | 121.026     |
| Flat slab with column head      | 70.142      | 119.456       | 186.618      | 287.36      |
| Flat slab with drop and column head | 20.063    | 36.547        | 56.048       | 85.299      |

Table 7 represents the Torsional moment when the value of Z is taken as 16m for all seismic zones.

Table 8. Torsional Moment on Top

| Type of Slab                     | Part Zone II | Part Zone III | Part Zone IV | Part Zone V |
|---------------------------------|-------------|---------------|--------------|-------------|
| Convention structure            | 14.995      | 15.577        | 16.577       | 24.835      |
| Flat slab                       | 46.332      | 57.682        | 72.815       | 104.562     |
| Flat slab with drop             | 15.345      | 17.627        | 20.688       | 30.082      |
| Flat slab with column head      | 35.349      | 47.099        | 73.892       | 117.37      |
| Flat slab with drop and column head | 12.746    | 13.924        | 20.081       | 30.868      |

Table 8 represents torsional moment on top for all seismic zones.

Table 6, 7, 8 shows effect of torsional moment in KN-m/m on bottom, z=16m, on top for different types of zone factor. On comparison between bottom, z=16m and at top, the value of torsional moment on bottom for all zones is more than z=16m and top. This result is because of gravitational load that shows torsional moment is more on bottom and as the zone factor increases the torsional shear increases.

6. Conclusion

From the above analysis we can conclude that Story displacement is maximum in flat system and least in conventional slab system in all the seismic zone for both regular and irregular structure. Story shear is maximum in flat slab system and least in flat slab with drop system in all the seismic zone for both regular and irregular structure.

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