# COMPARATIVE STUDY OF SEISMIC PERFORMANCE OF HIGH RISE 30 STOREY BUILDING WITH BEAM SLAB, FLAT SLAB AND ALTERNATE FLAT - BEAM SLAB SYSTEMS IN ZONE V

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## Abstract

*In present era, Flat slab buildings are capturing much importance and are commonly adopted for the construction. In high seismic regions, the structural efficiency of flat slab system poses a significant risk due to lowly-ductile. The collapse of the structure is due to brittle punching shear due to transfer of shearing forces and unbalanced moments between slab and columns. In the present work another model is generated by using alternate arrangement of conventional beam slab and Flat Slab building model. The performance of conventional RC Frame building, flat slab RC Frame building and alternate flat slab - beam slab building models with shear walls of G+30 storey under different load conditions were studied and for the analysis, seismic zone V is considered. The object of the present work is to study the performance of alternate flat slab – beam slab structure and compare the behaviour of three structures i.e. conventional beam slab structure, flat slab structure with that of alternate flat slab – beam slab structure under seismic loads. This paper presents good source of information on the parameters modal participation mass ratios, spectral acceleration, time period, storey drift, storey shear, column forces and shear wall forces.*

***Keywords:*** *conventional beam slab, flat slab and alternate flat slab-beam slab structures.*

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## 1. INTRODUCTION

The strength requirement is the ruling factor in the design of any structure. As the height of structure increases the rigidity that is the resistance to lateral deflection and stability, which is resistance to overturning moment of any structure gets altered. Therefore it becomes necessary to design those type of structures for lateral forces and storey drifts that are caused due to seismic loads.

Frame action that is acquired by the connection of slab, beam and column is inadequate to yield the required lateral stiffness for the buildings that are taller than 15 stories. It is because of the deflection that is produced by the seismic effect. To satisfy those limitations there are two ways. First one is to increase member sizes beyond the required strength and second is to change the configuration so that the structure becomes more rigid and stable. First approach has its own limits like sizes, whereas second one is more elegant which increases rigidity and stability of the structure. In case of seismic design, the structure is designed for critical loads that are obtained from different load combinations.

## 2. LITERATURE REVIEW

**K S S**able, **V A G**hodechor and **S B K**andekar[1] investigated the effect of seismic forces on the structures of various heights using relevant software. They concluded that the time period increases with the height of building. They are also of the view that the flat slab buildings have higher drifts than conventional structures.

## 3. LOADING

Loads on high rise buildings are different from that of loading on other buildings. In seismic region, inertial forces due to shaking of ground and forces due to wind influence the structures design and cost. The building's dynamic response plays a major role in estimating the load on the structure.

### 3.1 Gravity Loads:

Dead loads that are due to the self-weight and superimposed loads of the structure and live loads that are acting on the structure when in service constitute gravity loads. The dead loads are calculated from the cross-sectional and their material properties. Live loads are prescribed by standard codes.

### 3.2 Seismic Loads:

Seismic ground motion consists of horizontal as well as vertical ground shaking, but the effect of horizontal ground shaking will be dominant. Vertical ground motion will be of very smaller magnitude and can be neglected for short span buildings as the weight of the structure can accommodate vertical shaking.

The dynamic response of buildings plays a major role in estimating the effective loading on the structure. The seismic loads are estimated by Response spectrum method for high rise buildings in high seismic prone areas which takes into account the dynamic properties of the structure along with ground motions.

## 4. MODELING

The structures are modelled in 3D in the commercial structural analysis and design software. X and Y axis are considered as the global horizontal axis and Z as global vertical axis .The buildings are analysed as space frames. The modelled space frame is analysed for dead loads, live loads, earthquake loads and their combinations.

### 4.1 Assumptions

All models have the same architecture plan and the same columns sections and also the same area, Figure 1 and 2 represents the plans on beam slab and flat slab structures from Software program.

G+30 storey building with lateral dimensions of 42mx42m of total area of 1764 $m^2$ is considered for the present study.Height of each Story considered as 3.2m

### 4.2 Group Properties

The properties considered for the three structure are tabulated.

**Table 1** Beam sizes

| Structure | Beam 300x600 | Beam 350x450 |
|---|---|---|
| Beam slab | All beams | Lift and stair case |
| Flat slab | Plinth, Peripheral | Lift and stair case |
| Alternate | Plinth, Peripheral | Lift and stair case |

**Table I** Column sizes considered

**Internal columns**

| Size | Storey level |
|---|---|
| 900x900 | Base -8th storey |
| 750x750 | 8th storey – 16th storey |
| 600x600 | 17th storey- 24th storey |
| 450x450 | 25th storey-30th storey |

**External peripheral columns**

| Size | Storey level |
|---|---|
| 600x600 | Base -15th storey |
| 450x450 | 16th storey-30th storey |

### Details of the Structure:

- Thickness of flat slab 180mm
- Thickness of drop 120mm
- Sizes of drop 3m x 3m
- Thickness of normal slab 150mm
- Thickness of roof slab 150mm
- Thickness of shear wall 250mm
- Grade of steel Fe415
- Density of concrete 25kN/$m^3$
- Grade of concrete
  - Columns and shear wall M40
  - Beams and slab M30
- Live loads
  - Typical floors 5 kN/$m^2$
  - Roof level 3 kN/$m^2$
- Super imposed load (including furnishings)
  - Typical floors 4 kN/$m^2$
  - Roof level 2 kN/$m^2$
- Live load contribution 50%
- Zone factor (seismic) 0.36
- Type of soil Medium
- Damping 5%
- Importance factor 1.5
- Response reduction factor 5

## 5. RESULTS AND DISCUSSION

For the response spectrum analysis the current code[6] is followed. Therefore number of modes to be evaluated must satisfy the requirement. For trial 15 modes have been considered for all the three structures. After analysis results had shown that beam slab building is achieving 90% mass participation at 9th mode with a time period of 0.547sec in both X and Y Directions. For flat slab building 90% mass participation is achieved at 11th mode with a time period of 0.356 sec in both X and Y Directions. Whereas for alternate flat slab - beam slab structure 90% mass participation is achieved at 11th mode with a time period of 0.355 sec in both X and Y Directions.

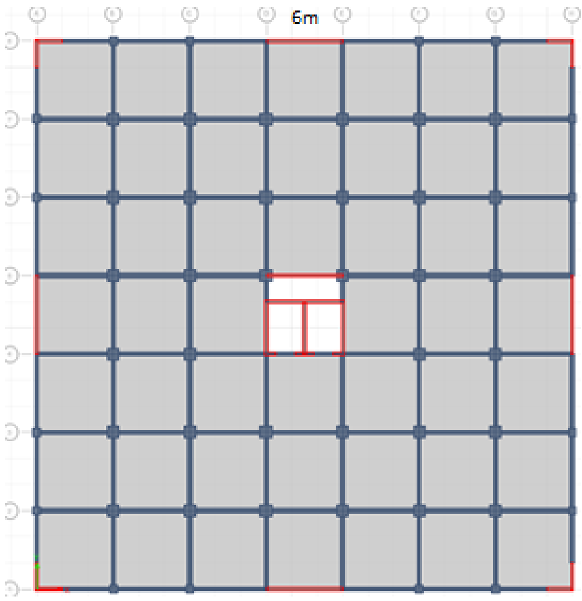


**Fig 1:** Plan of Beam slab structure

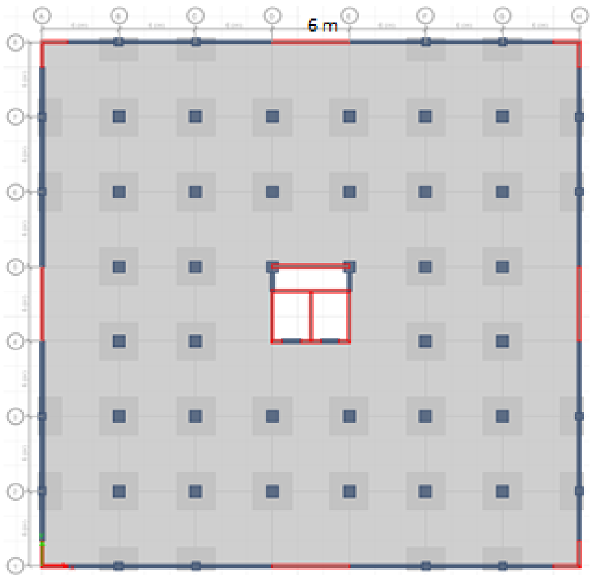


**Fig 2:** Plan of flat slab building

### Parameters studied on Base shear:

It is an estimate of the maximum expected lateral force that occurs due to seismic ground motion at the base of a structure.

It can be observed from the graph that beam slab building is having higher base shear when compared to flat slab and alternate flat slab - beam slab buildings. This is shown in Fig.3.

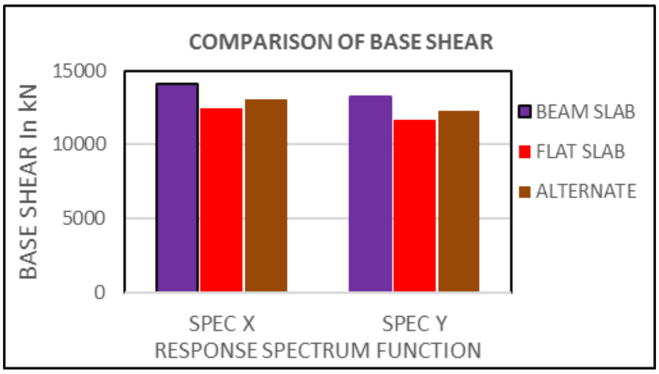


**Fig 3:** Comparison of base shear

### Parameters studied on Storey shear:

It can be observed that the storey shear is maximum at plinth level for all the three structures. After plinth level the base shear decreases as the height of the buildings increases.

It can be observed from the figure that the storey shear of beam slab building is more when compared with flat slab building and alternate flat - beam slab buildings. The difference between the beam slab and flat slab building varies from 12 to 14 % for different load combinations. While the difference between the beam slab and alternate flat - beam slab building varies from 7 to 9 % for different load combinations. Storey shear for response spectrum function Spec X is represented graphically in Figure 4.

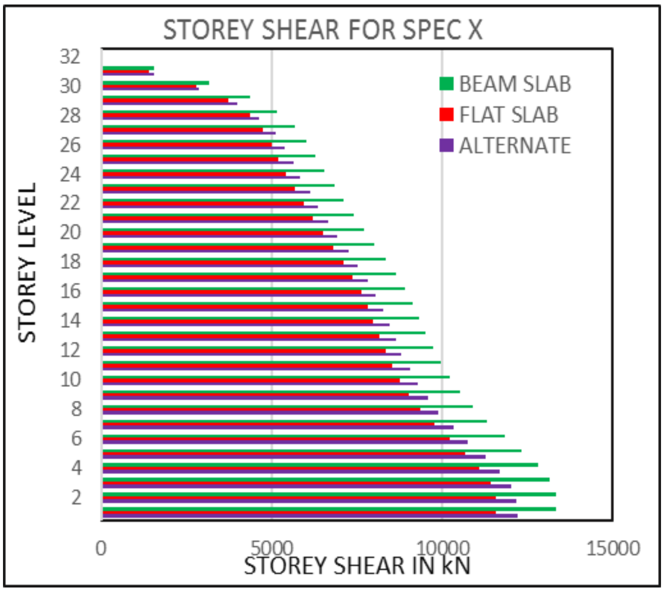


**Fig 4:** Comparison of Storey Shears for Spec X

### Parameters studied on Time period:

Due to the symmetry of the building the time period will be same in both directions

- The time period is on an average more for flat slab building by 8% and for alternate flat slab - beam slab building by 4.5% compared to conventional beam slab building.
- The Response Spectral acceleration coefficient is on an average more flat slab building by 5% and for alternate flat slab and beam slab building it is less by 2% compared to conventional beam slab building.

Graphical representation of Time period v's Response spectral acceleration is shown in the Figure 5.

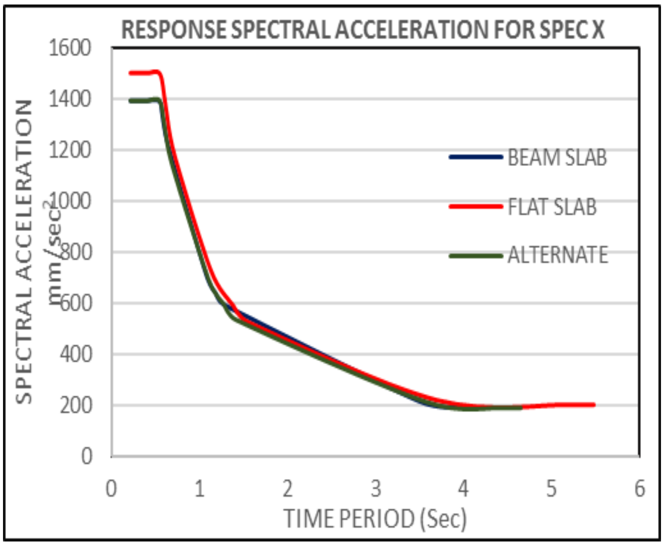


**Fig 5:** Comparison of Time period vs Response spectral accelerations.

**Parameters studied on Storey Drifts:**

The storey drift in any storey due to minimum specified design lateral force with partial safety factor of unity shall not exceed 0.004 times the storey height. Higher the lateral stiffness lesser is the likely damage.

The Story Drift is on an average more flat slab building by 60 – 80 % and for alternate flat slab and beam slab building by 20 – 30 % when compared to conventional beam slab building for load combinations considered.

As Storey drifts in buildings with flat slab structure and alternate flat – beam slab structure is more when compared to conventional R.C.C buildings due to which additional moments will be developed. Therefore, the columns of those buildings has to be designed by considering additional moments.

Graphical representation of storey drifts for different load combinations are shown in the figures 6 and 7

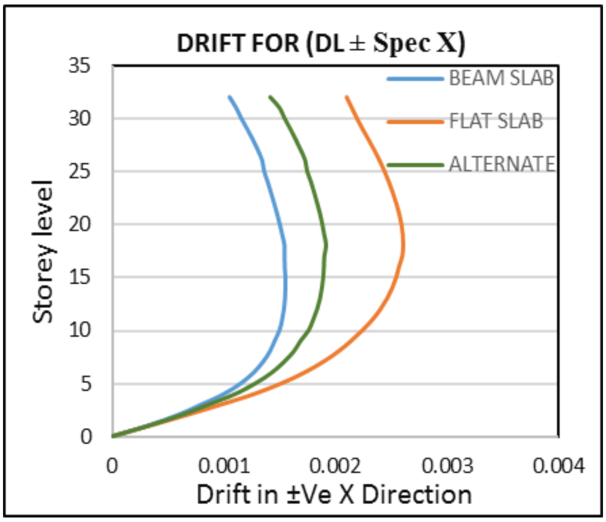


**Fig 6:** Comparison of Storey drifts for (DL ±SpecX)

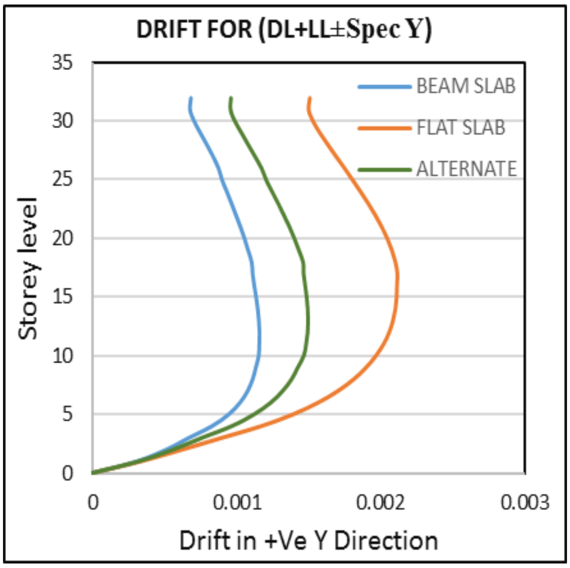


**Fig 7:** Comparison of Storey drifts for (DL+LL ± Spec Y)

**Parameters studied on column forces:**

For the study of column forces one external column was selected from the 15th storey and the following results have been found.

- Axial load is on an average less for flat slab building by 17 - 19 % and for alternate flat slab and beam slab building it is 6 - 8% less when compared to conventional beam slab building for different load combinations.
- Shear forces are on an average more for flat slab building by 68-95 % and for alternate flat slab and beam slab building it is 38 - 70 % less when compared to conventional beam slab building for different load combinations.
- Moments are on an average more for flat slab building by 14 - 35 % and for alternate flat slab and beam slab building it is 10 - 16 % more when compared to conventional beam slab building for different load combinations.

Graphical representation of column forces for different load combinations are shown in the figures 8 and 9.

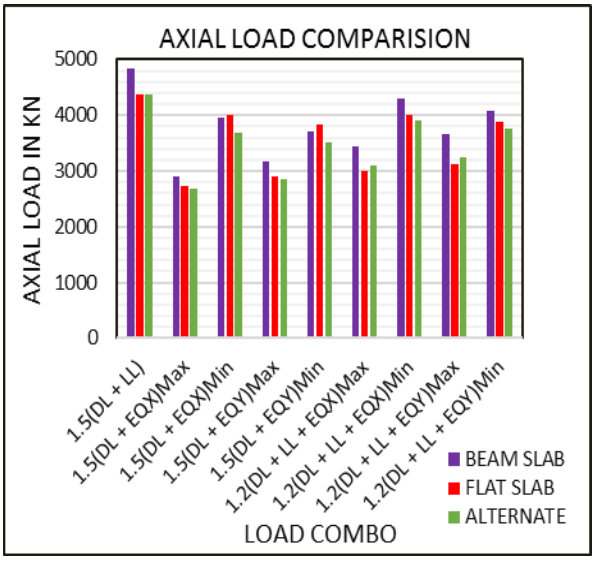


**Fig 8:** Axial load comparison for end column A7 at story 15

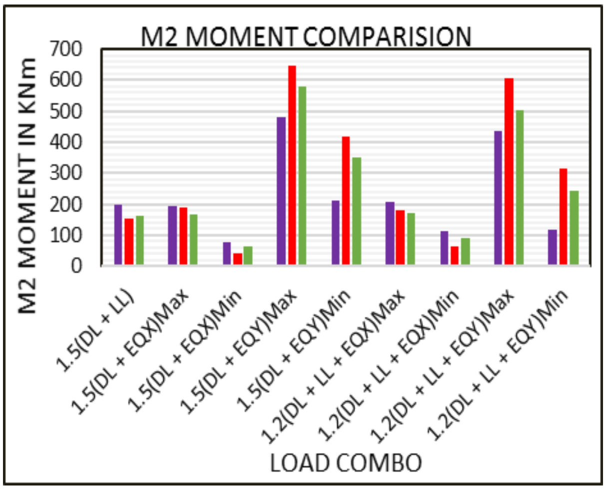


**Fig 9:** M2 moment comparison of end column A7 at story15

## 6. CONCLUSION

Based on the observations and the results obtained during the course of this study, the following conclusions can be arrived:

- When comparing the time period at 90 % mass participation in both x and y directions the time period of beam slab structure is more when compared with flat slab structure and alternate flat – beam slab structure.
- The time period of flat slab structure and alternate flat slab – beam slab structure was found to be same at 90% mass participation.
- The response spectrum accelerations of the flat slab structure is found to be more when compared with beam slab building and alternate flat slab – beam slab building.
- Base shear of beam slab building is more when compared with both flat slab building and alternate flat slab – beam slab building.
- For all the cases considered, drift values follow a parabolic path along storey height with maximum value lying near the middle storey.
- Story drift in buildings with flat slab is significantly high as compared to beam slab building. The drift values of alternate flat slab – beam slab buildings lies in between the two structures but somewhat nearer to the beam slab building. This is due to rigidity of the beam slab structure.
- As a result of high drift ratios in flat slab building, additional moments will be developed. Columns of such buildings should be designed by considering additional moments.
- The axial forces for the flat slab building and alternate flat slab – beam slab building are less when compared with the beam slab building for the cross sectional properties of the slabs and beams considered.
- Shear forces and moments for columns are significantly low for beam slab building when compared with flat slab and alternate flat slab – beam slab building.
- By considering same columns cross-sectional properties for all the three structures, the columns sizes required for the alternate flat – beam slab is more. This requires further investigation.

## REFERENCES

[1] K.S.Sable, Ghodechor, V.A., B., Kandekar, S.B., ―Comparative Study of Seismic Behavior of multistory flat slab and conventional reinforced concrete framed structures, International Journal of Computer Technology and Electronics Engineering, Volume 2, Issue 3, June 2012.

[2] Navyashree K, Sahana T.S― Use of flat slabs in multi-storey commercial building situated in high seismic zone, International Journal of Research in Engineering and Technology(ISSN: 2319-1163, ISSN: 2321-7308)

[3] Sumit Pahwa, Vivek Tiwari, Madhavi Prajapati―*Comparative Study of Flat Slab with Old Traditional TwoWay Slab,* International Journal of Latest Trends in Engineering and Technology

[4] *Concrete Frame Design Manual* as per IS 456:2000 For ETABS® 2013

[5] *Reinforced Concrete Design of Tall Buildings* by Bungale S Taranath, Ph.d., P.E., S.E.

[6] *IS 1893(Part 1):2002 `Criteria for Earthquake Resistant Design of Structures : Part 1 General provisions and Buildings'*