USE OF FLAT SLABS IN MULTI-STOREY COMMERCIAL BUILDING SITUATED IN HIGH SEISMIC ZONE

Navyashree K[1], Sahana T.S[2]
[1] *Post graduation Student, Dept.of civil engineering, SSIT, Tumkur, Karnataka, India*
[2] *Asst. professor, Dept.of civil engineering, SSIT, Tumkur, Karnataka, India*

Abstract

In present era, conventional RC Frame buildings are commonly used for the construction. The use of flat slab building provides many advantages over conventional RC Frame building in terms of architectural flexibility, use of space, easier formwork and shorter construction time. The structural efficiency of the flat-slab construction is hindered by its poor performance under earthquake loading. In the present work six number of conventional RC frame and Flat Slab buildings of G+3, G+8, and G+12 storey building models are considered. The performance of flat slab and the vulnerability of purely frame and purely flat slab models under different load conditions were studied and for the analysis, seismic zone IV is considered. The analysis is done with using E-Tabs software. It is necessary to analyze seismic behaviour of building for different heights to see what changes are going to occur if the height of conventional RC Frame building and flat slab building changes. Therefore, the characteristics of the seismic behaviour of flat slab and conventional RC Frame buildings suggest that additional measures for guiding the conception and design of these structures in seismic regions are needed and to improve the performance of building having conventional RC building and flat slabs under seismic loading, The object of the present work is to compare the behaviour of multi-storey commercial buildings having flat slabs and conventional RC frame with that of having two way slabs with beams and to study the effect of height of the building on the performance of these two types of buildings under seismic forces. Present work provides a good source of information on the parameters lateral displacement, storey drift, storey shear, column moments and axial forces, time period.

Keyword: *Reinforced Concrete Frame; ETABS 9.7.4; Flat Slab.*

--***--

1. INTRODUCTION

The scarcity of space in urban areas has led to the development of vertical growth consisting of low-rise, medium-rise and tall buildings. Generally framed structures are used for these buildings. They are subjected to both vertical and lateral loads. Lateral loads due to wind and earthquake governs the design rather than the vertical loads. The buildings designed for vertical load may not have the capacity to resist the lateral loads. The lateral loads are the premier ones because in contrast to vertical load that may be assumed to increase linearly with height; lateral loads are quite variable and increase rapidly with height. Under a uniform wind and earthquake loads the overturning moment at the base is very large and varies in proportion to the square of the height of the building. The lateral loads are considerably higher in the top storey rather than the bottom storey due to which building tends to act as cantilever. These lateral forces tend to sway the frame. In many of the seismic prone areas there are several instances of failure of buildings which have not been designed for earthquake loads. All these reaction makes the study of the effect of lateral loads very important.

Pure rigid frame system or frame action obtained by the interaction of slabs, beam and column is not adequate. The frame alone fails to provide the required lateral stiffness for buildings taller than 15 to 20 (50m to 60m) stories. It is because of the shear taking component of deflection produced by the bending of columns and slab causes the building to deflect excessively. There are two ways to satisfy these requirements. First is to increase the size of members beyond and above the strength requirements and second is to change the form of structure into more rigid and stable to confine deformation. First approach has its own limits, whereas second one is more elegant which increases rigidity and stability of the structure and also confine the deformation requirement. In earthquake engineering, the structure is designed for critical force condition among the load combination.

In the present study the response of multi-storey commercial R.C. frame and R C flat slab to the lateral and vertical loads have been done.

1.1 Framed Structure

Framed structures can be considered as an assemblage of one dimensional and two dimensional members. The length of a one dimensional member of a structure is large compared to its other dimensions where as the thickness of a two dimensional member is smaller than its other two dimensions. A structure made of line members joined together is referred to as framed structure. In general, framed structures have three dimensional configurations.

While transferring loads acting on the structure, the members of the structure are subjected to internal forces like axial forces, shearing forces, bending and torsion moments. Structural Analysis deals with analyzing these internal forces in the members of the structures. The process of analysis commences with planning of a structure, primarily to meet the functional requirement of the user.

Planning a structure involves the selection of the most suitable type of structure and the choice of its general layout and overall dimension on the basis of economic, aesthetic, functional and other criteria. Designing a structure entails determining the disturbances to which it is expected to be exposed during its life time and then choosing the dimensions of its members as well as the details of their connections. The structure is then analyzed, i.e., the internal forces and moments in its members and the displacements of some of its cross sections are computed. The member of structure must have sufficient strength and rigidity so that when the structure subjected to the disturbances to which it is expected to be exposed, the components of stress and displacement at any of its point do not exceed the maximum allowable values given in the appropriate design course.

If the results of the analysis show that the members of the structure do not have sufficient strength and rigidity to satisfy the aforementioned requirements the structure is redesigned, i.e., new dimensions of cross section are chosen. The process is repeated until the structure is obtained which satisfies all the aforementioned requirements.

1.2 Flat Slab

Common practice of design and construction is to support the slabs by beams and support the beams by columns. This may be called as beam-slab construction. The beams reduce the available net clear ceiling height. Hence in warehouses, offices and public halls sometimes beams are avoided and slabs are directly supported by columns. These types of construction are aesthetically appealing also. These slabs which are directly supported by columns are called Flat Slabs**.**

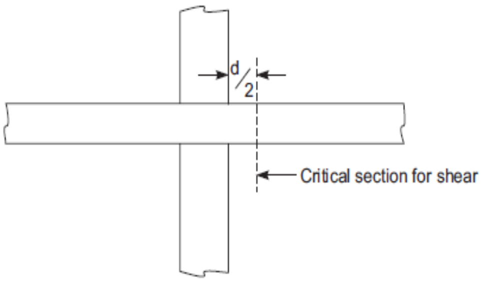

Fig -1: Typical Flat Slab (Without column head and drop)

The column head is sometimes widened so as to reduce the punching shear in the slab. The widened portions are called column heads**.** The column heads may be provided with any angle from the consideration of architecture but for the design, concrete in the portion at 45º on either side of vertical only is considered as effective for the design.

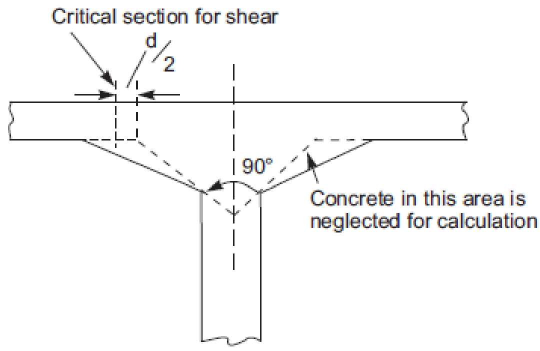

Fig -2: Slab without drop and column with column head

Moments in the slabs are more near the column. Hence the slab is thickened near the columns by providing the drops as. Sometimes the drops are called as capital of the column. Thus we have the following types of flat slabs.

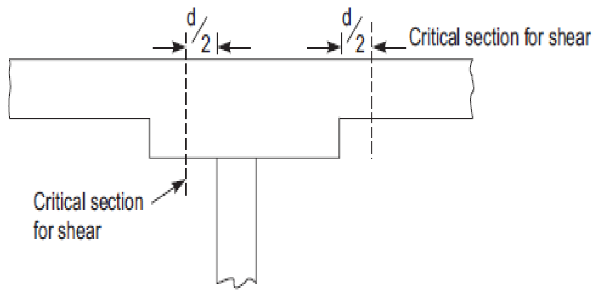

Fig -3: Slab with drop and column without column head

(*i*) Slabs without drop and column with column head
(*ii*) Slabs without drop and column without column head
(*iii*) Slabs with drop and column with column head

Flat-slab building structures possesses major advantages over traditional slab-beam-column structures because of the free design of space, shorter construction time, architectural –functional and economical aspects. Because of the absence of deep beams and shear walls, flat-slab structural system is significantly more flexible for lateral loads then traditional RC frame system and that make the system more vulnerable under seismic events.

The system consists of columns resting directly on floor slabs for which sufficient strength and ductility should be provided to enable sustaining of large inelastic deformations without failure. The absence of beams, i.e., the transferring of their role to the floor RC structure which gains in height and density of reinforcement in the parts of the hidden beams, the bearing capacity of the structural system, the plate-column and plate-wall connection, all the advantages and disadvantages of the system have been tested through long years of analytical and experimental investigations. For the last 20 to 30 years, the investigations have been directed toward definition of the actual bearing capacity, deformability and stability of these structural systems designed and constructed in seismically active regions.

A flat slab is a highly indeterminate structure and its exact analysis is difficult. An approximate analysis can be made by considering an interior panel of slab. IS456-2000 provides an empirical approach Direct Design Method and Equivalent Frame Analysis for the analysis of flat slab. Via Direct Design Method this it's easy to calculate bending moment and shear force in flat slab without use of computer. But the Equivalent Frame Analysis gives more exact results.

The behaviour and design of flat slabs structures for gravity loads are well established but their seismic behaviour is not well understood and generally found to be unsatisfactory. Flat slab is susceptible to progressive brittle punching shear failure under seismic loading. In flat slab building the most vulnerable part is slab-column joint. Flat slabs with drop panels or column capitals are generally constructed as these extra projections provide safety against punching shear and also reduce the heavy negative moment. If drop panels are not provided then the system is termed as Flat Plate.

Extensive research has been carried out to find out the behaviour of slab-column connection. The failure mode depends upon the type and extent of loading. Punching shear strength of slab-column connection is of importance which very much depends on the gravity shear ratio. The mechanism of transfer of moments from slab to column is very complex when subjected to lateral loading and unbalance moments. These unbalanced moments produce additional shear and torsion at the connections and then get transferred into the column which results in excessive cracking of slab leading to further reduction in the stiffness of the slab.

A flat-plate structure, as shown in Figure 4, consists of a slab with uniform thickness supported on the columns with no beams or drop panels. The economy of flat plate buildings has lead to their wide spread utilization throughout the world. Conventionally flat-plate structure is generally used for lightly loaded structures such as apartments, hotels, and office buildings with relatively short spans, typically less than 6m. For longer spans or heavier loads, flat-slabs system with shear capitals or drop panels would be more feasible.

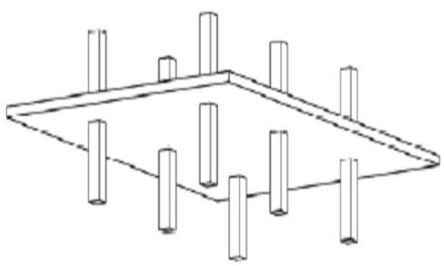

Fig -4: Flat-plate structure

Flat-plates have been widely used due to the reduced construction cost associated with the simple formwork and simple arrangement of flexural reinforcement. An additional advantage of a flat-plate is reduced building storey heights that result in more usable space in a building for a given or limited height and reduces lateral loads acting on the system, as well as mechanical, electrical, and cladding costs.

2. OBJECTIVES

The objectives of the study are:

- The main objective of the analysis is to study the different forces acting on a building. The analysis is carried out in ETABS 9.7.4. Software. Results of conventional R.C.C structure i.e. slab, beam and column and flat slab R.C.C structure for different heights are discussed below.
- Conventional R.C.C structure and flat slab R.C.C for different height are modeled and analyzed for the different combinations of Dynamic loading. The comparison is made between the conventional R.C.C structure and flat slab R.C.C. Buildings are situated in seismic zone IV.
- To study the vulnerability of purely frame and purely flat-slab models under different factors which are Storey drift, lateral displacement, time period and base shear have been obtained for SPECX (EX) and SPECY (EY) in zone IV. The axial load and moments in columns have been obtained for various load combination in zone IV.

3. BUILDING DETAILS, PROGRAM AND PRELIMINARY DESIGN

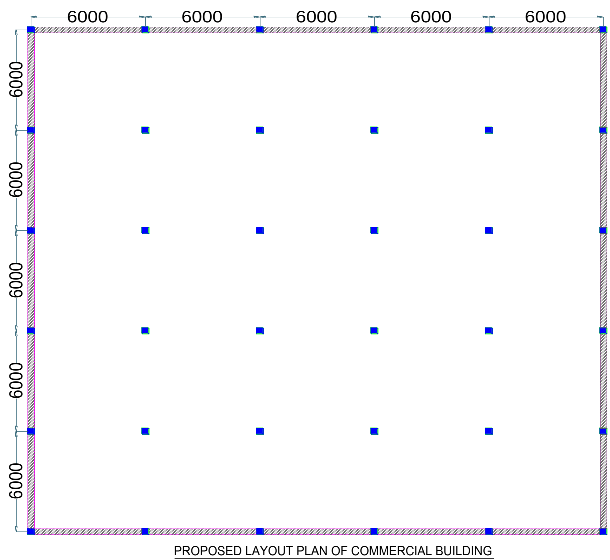

Fig -5: Plan of the Commercial building

Following are details of the number of floors considered in both RC frame and Flat slab building that have taken up for the analysis and design.

- Model 1 and 2 : Four storey (i.e. G+3)
- Model 3 and 4 : Nine storey (i.e. G+8)
- Model 5 and 6 : Thirteenth storey(i.e. G+12)

The height of each floor is 3.0m. The total height of Ground plus three, eight and twelve storey building is 12.0 m, 27.0 m and 39.0 m. The plinth beam is provided above the ground at the height of 1.5m from below ground level. 3D Models of RC frame and flat plate for Ground plus three, eight and twelve storey buildings is shown in figure 6 to 11

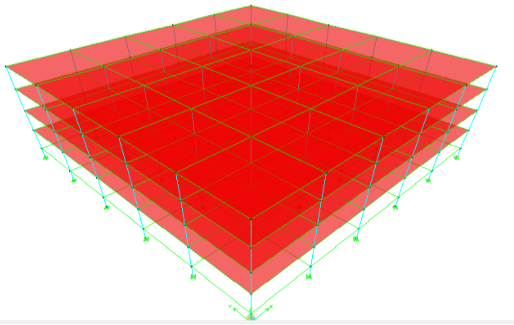

Fig -6: Model 1: 3D of RC Frame of G+3 storey building

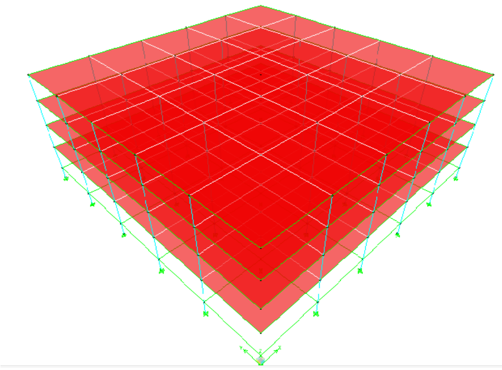

Fig -7: Model 2: 3D Model of flat plate of G+3 storey building

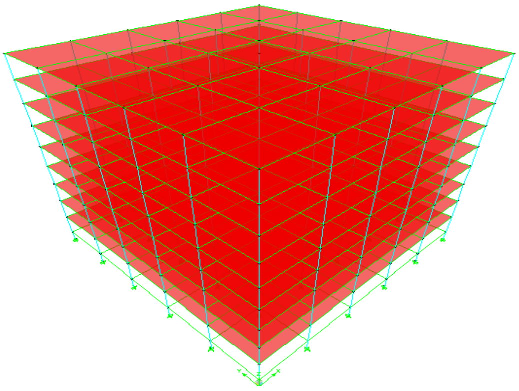

Fig -8: Model 3: 3D Model of RC frame of G+8 storey building

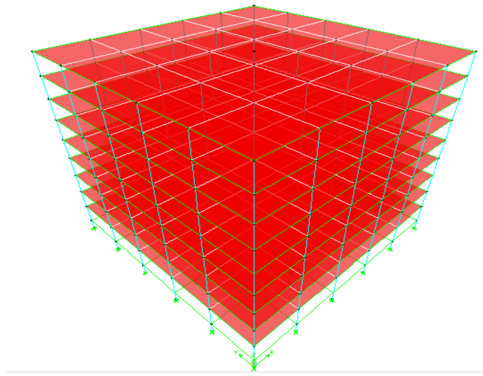

Fig -9: Model 4: 3D Model of flat plate of G+8 storey building

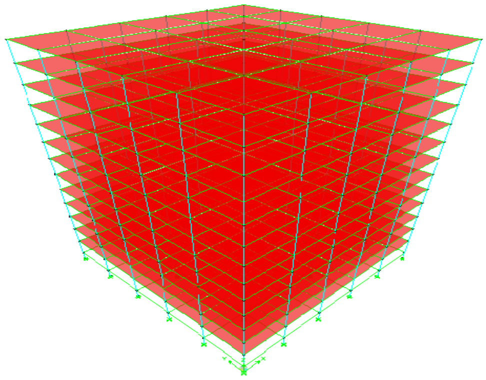

Fig -10: Model 5: 3D Model of RC frame of G+12 storey building

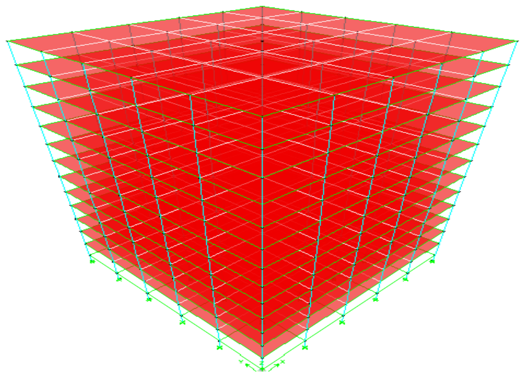

Fig -11: Model 6: 3D Model of flat plate of G+12 storey flat plate building

3.1 Preliminary Sections

The preliminary sections of columns and beams have been fixed on the basis of deflection criteria [i.e. span to depth ratio]. The sections were found to be satisfactory for the given loads for a four storey model. These sections were maintained uniform throughout the height. Similarly, all other models, nine and thirteenth stories, were analyzed and designed to meet the current Codes (IS 456:2000 and IS 1893:2002) and their structural member sizes chosen for the study are given in below Table

Table -1: Sizes of structural element

Sl No	Name of element	Width (mm)	Depth (mm)
1	Column (floor & roof) for four, eight and thirteenth storey	350	350
2	Beam (floor & roof) for four, eight and thirteenth storey	300	600
3	Slabs for both four; eight and thirteenth storey		200

3.2 Materials

The Young's modulus of elasticity of concrete was 35,000 MPa while the Poisson's ratio was 0.2. The densities were 22 kN/m^3 and 25 kN/m^3 for solid concrete block and concrete members respectively. For structural components M 35 and F_e 500 grade was considered.

3.3 Positions and Orientation of Columns

Figure 12 shows the position and orientation of columns and beams. The building consists of 36 columns. The orientations of member are chosen so that maximum moment of inertia is achieved.

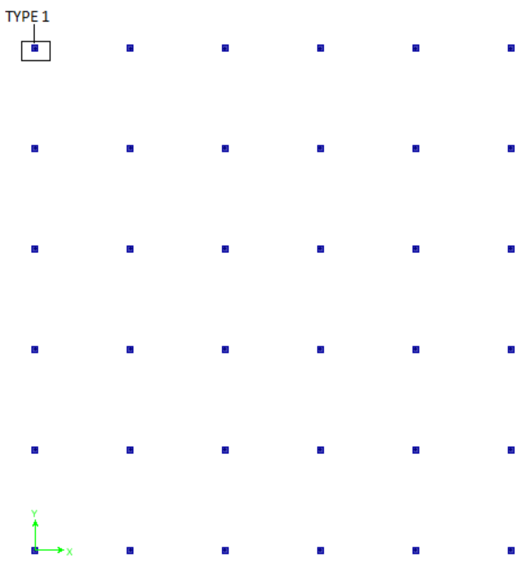

Fig -12: Position of the columns

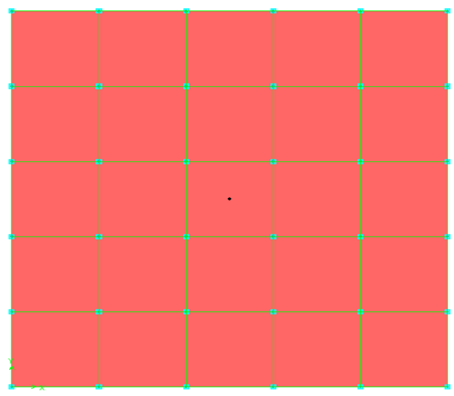

Fig -13: Layout Plan of the Conventional frame Building

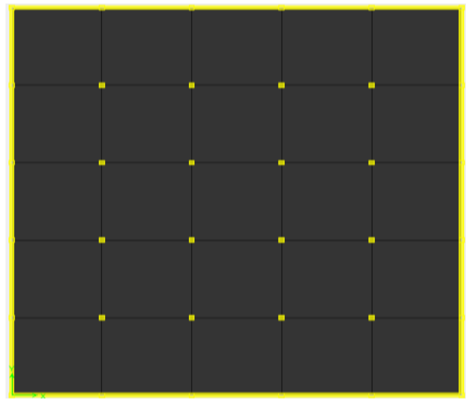

Fig -14: Layout Plan of the Flat plate Building

3.4 Program

The program consists of analyzing each of the multi-storey buildings by using ETABS 9.7.4. In particular, the effects of following with respect to the behaviour of columns, drift, displacement, time period have been studied.

- Flat plate (FP)
- Height of the buildings
- Convention RC frame (CF)

4. ANALYSIS OF THE BUILDING

4.1 Loads Considered:

Dead Load: The loads realized due to the following has been considered

- Self weight of structural members
- Wall load
- Unknown partition
- Floor finish

The self weight of the members is calculated by assuming the density as 25 kN/m^3 and 22 kN/m^3 for concrete and solid concrete block. Grade of Concrete is M35 and Grade of Steel (Fy) is Fe500.
The self weight of slab =0.2 x 1 x 1 x 25 = **5** kN/m^2
Load due to Unknown partition =**1** kN/m^2
Load due to floor finish= **1** kN/m^2
Load due to wall: 0.2x (3.0-0.6) x22 **= 10.56** kN/m^2

Live Load

Live load on floor slab and roof: **4**kN/m^2. Allowance for the reduction in live load is considered for determining the column moments.

Earthquake Load

This load has been taken into account by specifying the zone in which the building is located. Table 2 shows the details of the earthquake parameters as the earthquake zone is concerned.

Table -2: Earthquake Parameters

Zone (Z)	IV
Response Reduction Factor (RF)	5
Importance Factor (I)	1
Rock and Soil Factor (SS)	2
Type of structures	1
Damping Ratio (DM)	0.05
Time Period	T_a=0.075h$^{0.75}$

4.2 Load Combinations:

The following combination of loads with appropriate partial safety factor satisfying the Indian standard code provision i.e. IS456:2000, table 18, clause 18.2.3.1 and IS 1893:2002, clause6.3.2.1 are as follows,

1.5[DL + LL]
1.2[DL + LL+SPECX]
1.2[DL + LL+ SPECY]
1.2[DL + LL - SPECX]
1.2[DL + LL - SPECY]
1.5[DL + SPECX]
1.5[DL + SPECY]
1.5[DL - SPECX]
1.5[DL - SPECY]
0.9[DL] + 1.5[SPECX]
0.9[DL] + 1.5[SPECY]
0.9[DL] - 1.5[SPECX]
0.9[DL] -1.5[SPECY]

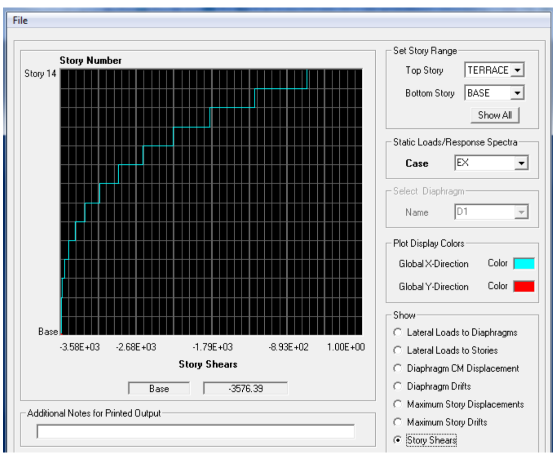

Fig -15: Storey Shear of EQX for Flat plate (Typical)

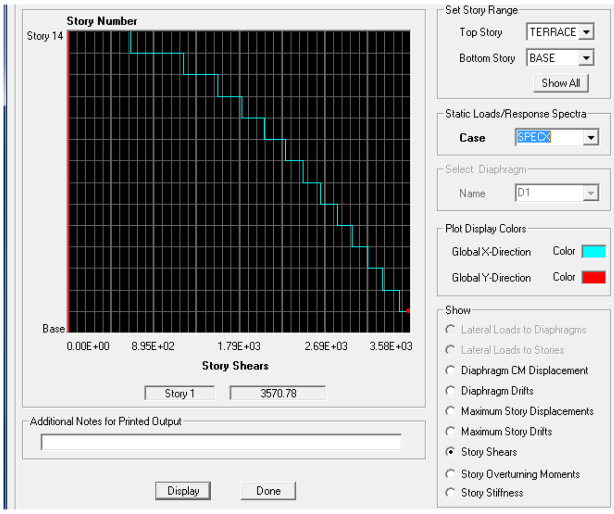

Fig -16: Storey Shear of Specx for Flat plate (Typical)

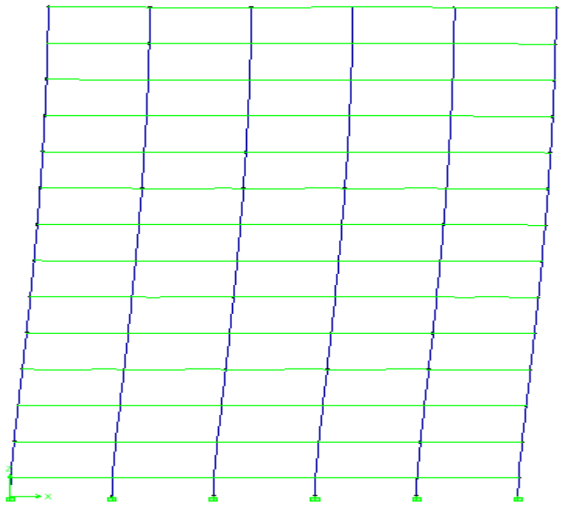

Fig -17: Displacement of Flat plate

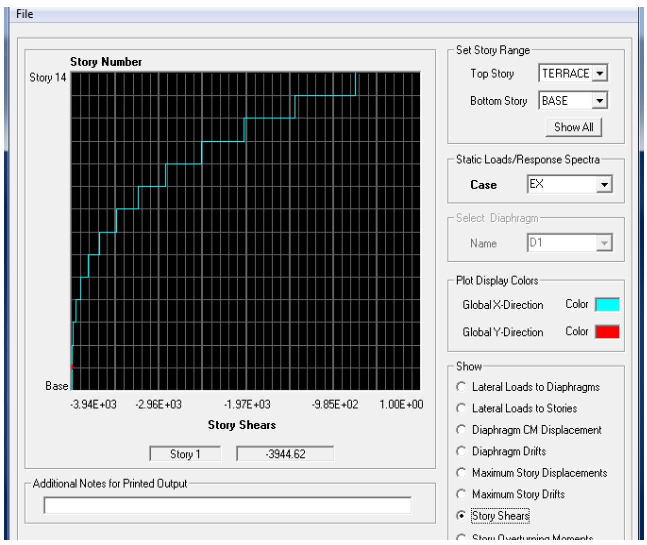

Fig -18: Storey Shear of EQX for conventional Frame (Typical)

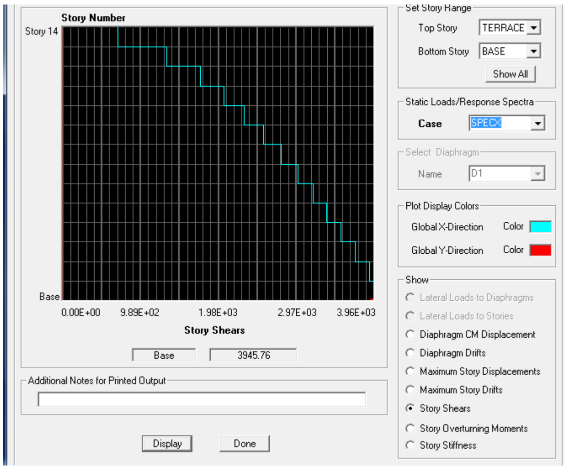

Fig -19: Storey Shear of Specx for conventional Frame (Typical)

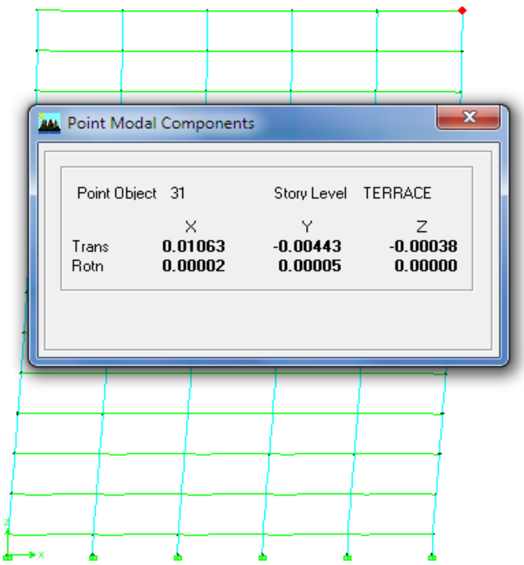

Fig -20: Displacement of conventional frame

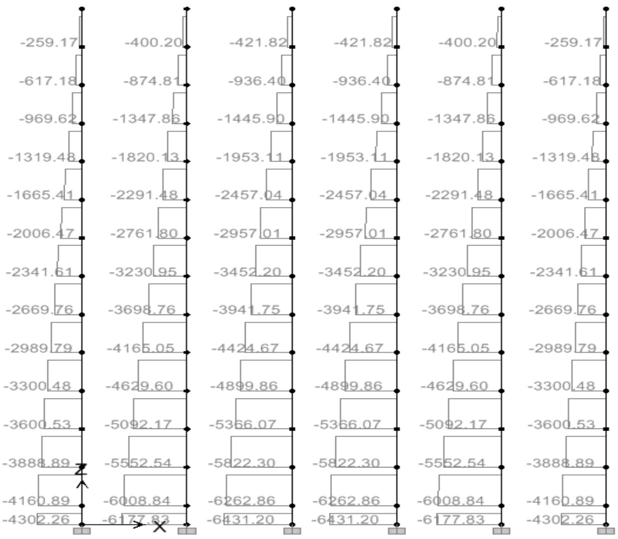

Fig -21: Column axial load (Typical)

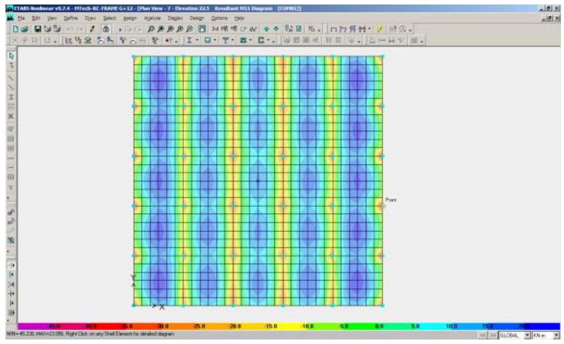

Fig -22: Slab moments along Mx for Conventional frame System

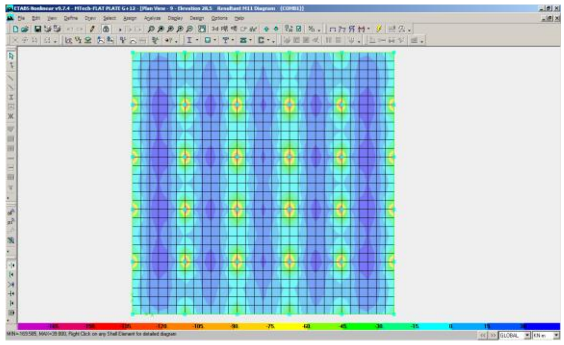

Fig -23: Slab moments along Mx for Flat plate System

5. RESULTS AND DISCUSSION

The forces and displacements developed in each of the members of the structure are got from the analysis. These results obtained from the analysis have been discussed detail in this chapter. Further these results have been used for the understanding of the behaviour of the structure between the conventional RC frames and flat plate under the effects of lateral loads.

5.1 Column Moments

The critical columns i.e. type I have been chosen for the study. Chart 1-7 shows the details of the column moments and axial load obtained for columns. Chart 1-7 represents the column results obtained for the structures which are subjected to lateral loads only. The lateral load analysis for flat plate is done to compare the same with that of Conventional RC frame.

From the lateral load analysis results it can be observed that in four storey building the moments (M_z) is maximum at first and terrace level for types I of column. Thus a column at first and terrace level attracts maximum steel as compared to the other positions. From the results it can be observed that the column moment for flat plate analysis is more than that of the column moments of conventional RC frame analysis in zone IV. The difference between the two varies from 15 to 25(%).

From the lateral load analysis results it can be observed that in nine storey building the moments (M_z) is maximum at second level for types I of column. Thus a column at second level attracts maximum steel as compared to the other positions. From the results it can be observed that the column moment for flat plate analysis is more than that of the column moments of conventional RC frame analysis in zone IV. The difference between the two varies from 15-20(%).

From the lateral load analysis results it can be observed that in thirteenth storey building the moments (M_z) is maximum at plinth and first level for types I of column. After second level the moment's decreases and increases as the height of the building increases. Thus a column at plinth and first level attracts maximum steel as compared to the other positions. From the results it can be observed that the column moment for flat plate analysis is more than that of the column moments of conventional RC frame analysis in zone IV. The difference between the two varies from 15-30(%).

From the lateral load analysis results it can be observed that, the axial load is more in flat plate compared to conventional RC frame. The difference between the two varies up to 10(%).For all columns the columns have been designed for the combination of dead load and earthquake load this shows that earthquake combination is the worst combination giving rise to the most critical sections. Earthquake is more predominant than other loads. The behaviour of column moments changes as the height of the building increases.

Height of the Building

The effect of height of the building is studied by considering a thirteenth storey building. This study has been made for conventional RC frame and flat plate. The results have been represented in Chart 1-7. From the Charts it can be observed that at level plinth, first, second and terrace the moments are maximum in the column is most critical. Further after level 2 as the height increases the column moments criticality decreases and increases at the top storey. The base shear, time period, displacement and storey drift increases drastically as the height increases

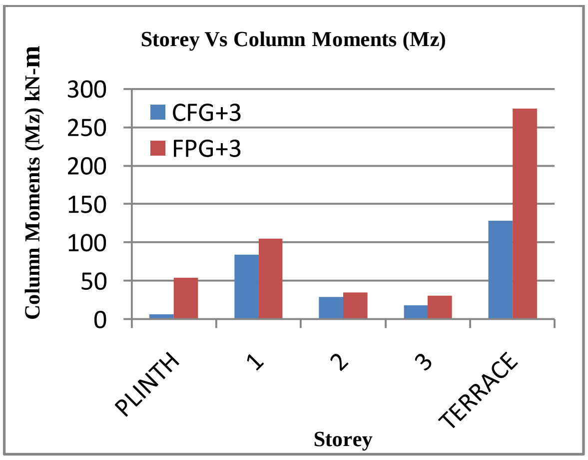

Chart -1: Design moments, three storey building Subjected to vertical loads

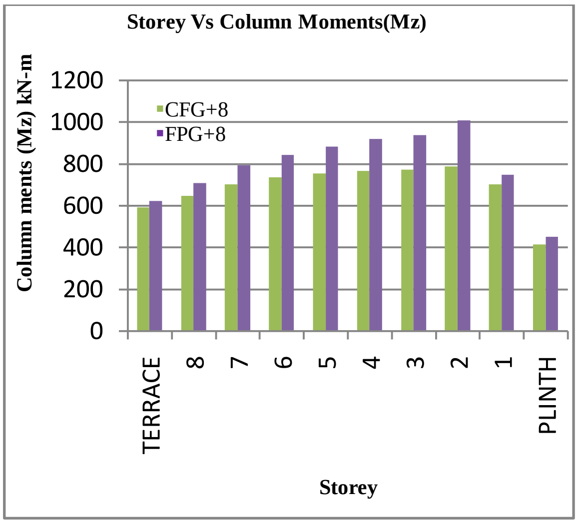

Chart -2: Design moments, nine storey building Subjected to vertical loads

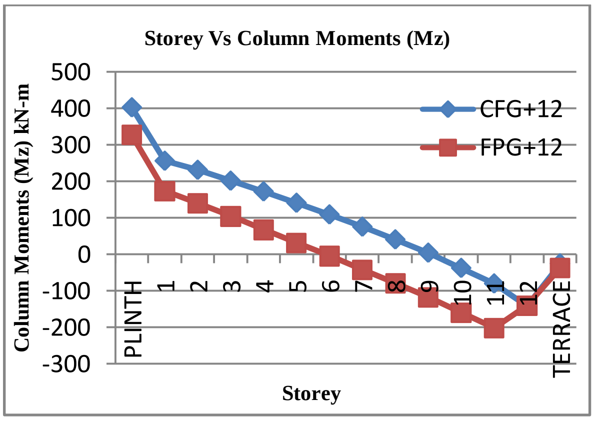

Chart -3: Design moments, thirteen storey building Subjected to vertical loads

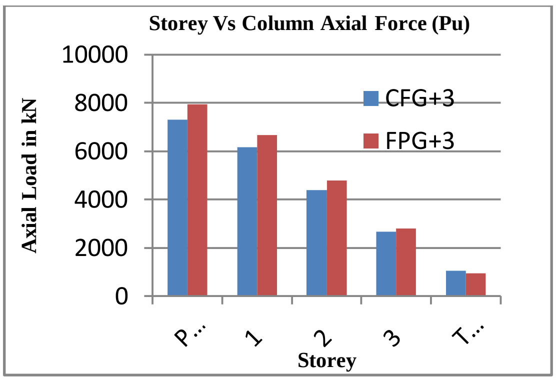

Chart -4: Axial force, four storey building Subjected to vertical load

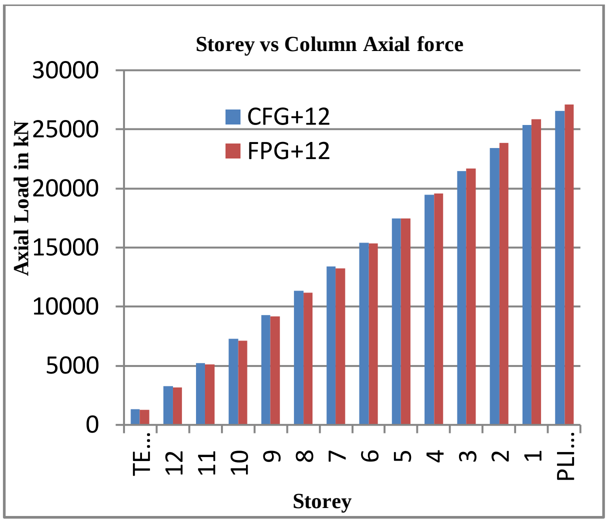

Chart -5: Axial force, thirteen storey building Subjected to vertical loads

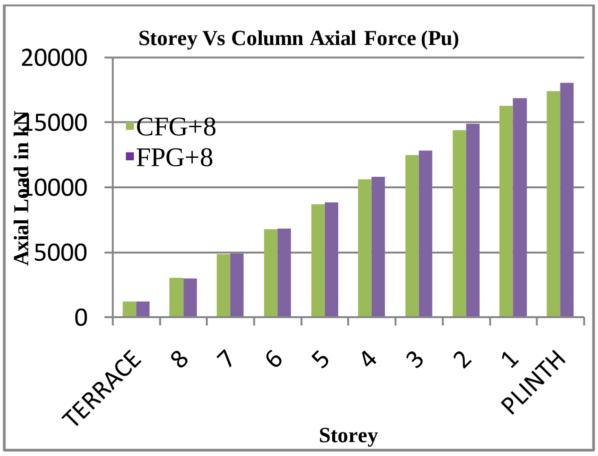

Chart -6: Axial force, nine storey building Subjected to vertical loads

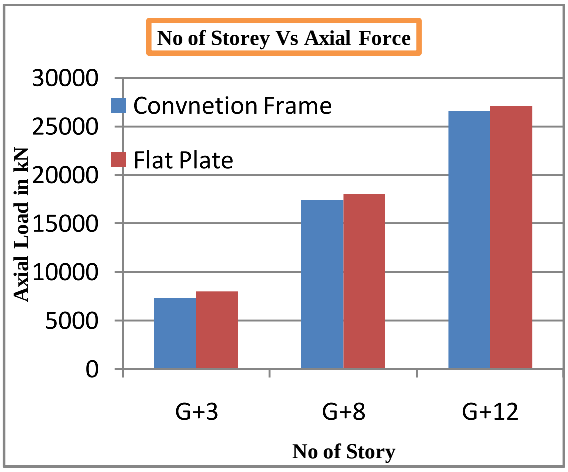

Chart -7: Axial force, four, nine and thirteen storey building Subjected to vertical loads

5.2 Storey Shear

The results have been represented in Chart 8-11. From the Chart it can be observed that the base shear is maximum at plinth level for all types of column. After plinth level the base shear decreases as the height of the building increases. Due to the symmetric of the building the base shear will same in both directions (Vx and Vy). Chart 8-11 it can be observed that, the base shear will increase drastically as the height increases. Base shear of flat plate building is less than the conventional R.C.C building. The difference between the two varies from 8 to 12(%)

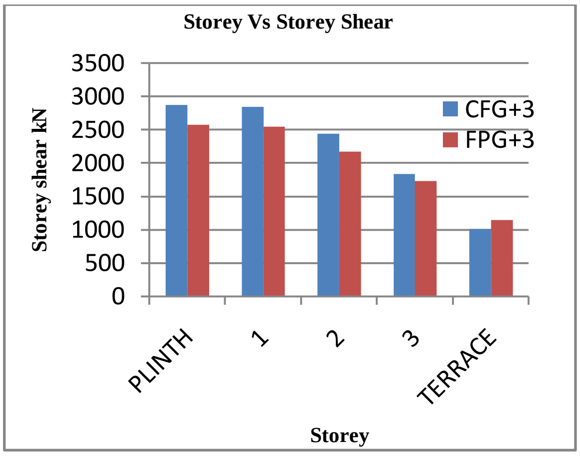

Chart -8: Effect of storey shear on behaviour of column of four storey building

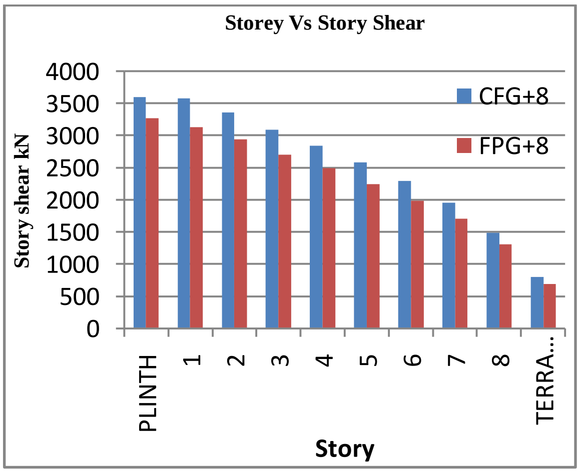

Chart -9: Effect of storey shear on behaviour of column of nine storey building

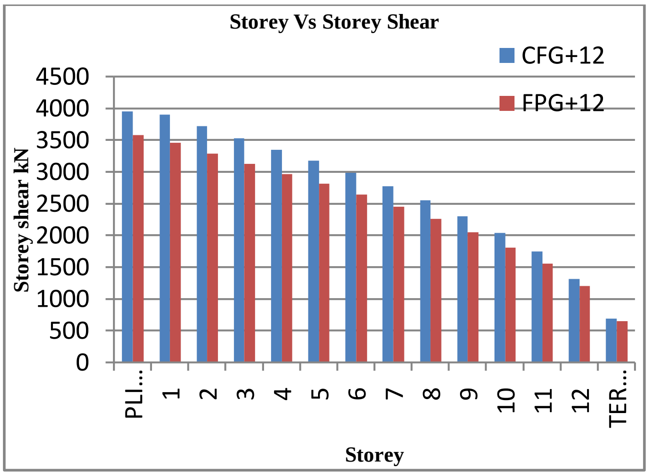

Chart -10: Effect of storey shear on behaviour of column of thirteen storey building

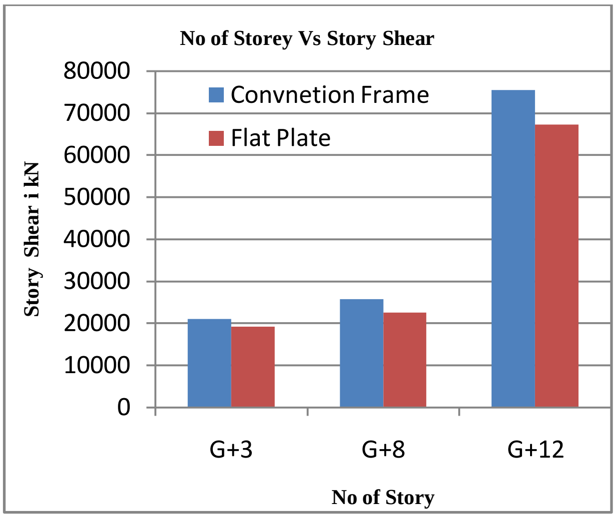

Chart -11: Effect of storey shear on behaviour of column of four, nine and thirteen storey building

5.3 Lateral Displacement

The results have been represented in Chart 12-15. From the Chart it can be observed that the lateral displacement (both Ux and Uy) is maximum at terrace level for all types of column. Lateral displacement increases as the storey level increases. Lateral displacement will be minimum at plinth level and maximum at terrace level. Due to the symmetric of the building the lateral displacement will be same in both directions (Ux and Uy). From Chart it can be observed that, the lateral displacement will increase drastically as the height increases. Lateral displacement of conventional R.C.C building is less than the flat plate building. The difference between the two varies from 28 to 57(%).

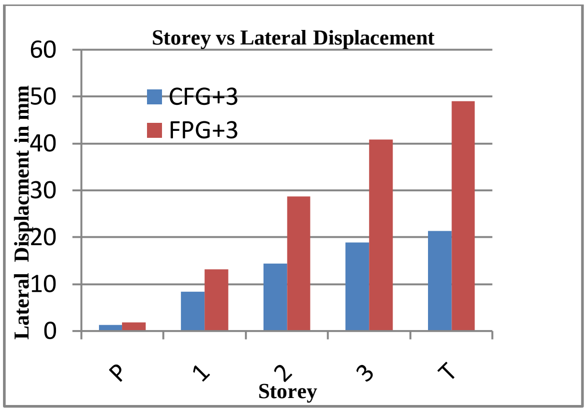

Chart -12: Effect of lateral displacement on behaviour of column of fourth storey building

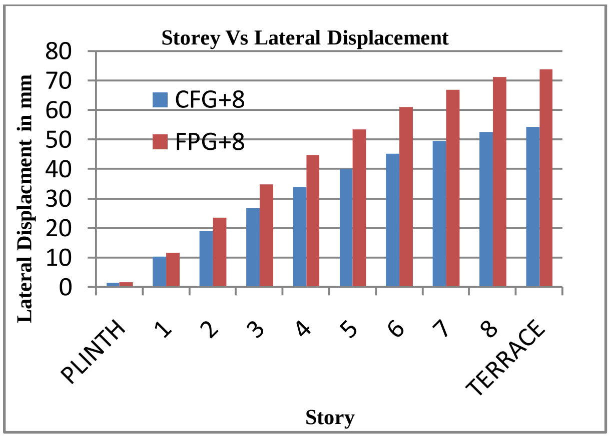

Chart -13: Effect of lateral displacement on behaviour of column of nine storey building

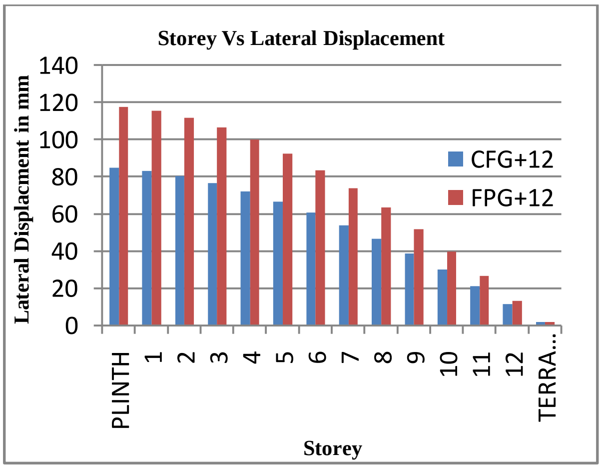

Chart -14: Effect of lateral displacement on behaviour of column of thirteen storey building

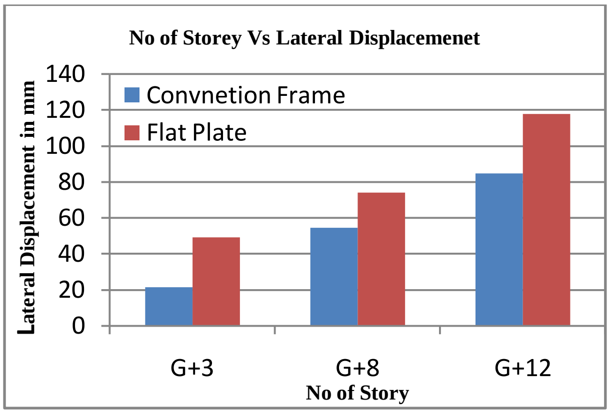

Chart -15: Effect of lateral displacement on behaviour of column of four, nine and thirteen storey building

5.4 Time Period

The results have been represented in Chart 16-19. From the Chart it can be observed that the time period (both Tx and Ty) is maximum at mode 1 and 2. The natural time period increases as the height increases (No of stories). Due to the symmetric of the building the time period will be same in both directions (Tx and Ty). From Chart 19 it can be observed that, the time period will increase drastically as the height increases. In comparison of the conventional R.C.C building and flat slab building, the time period is more for flat slab building than conventional building. The difference between the two varies from 14 to 33(%).

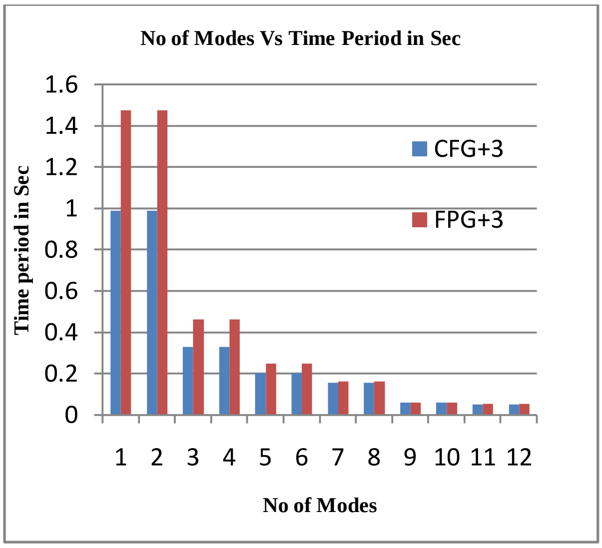

Chart -16: Effect of time period on behaviour of modes shapes on fourth storey building

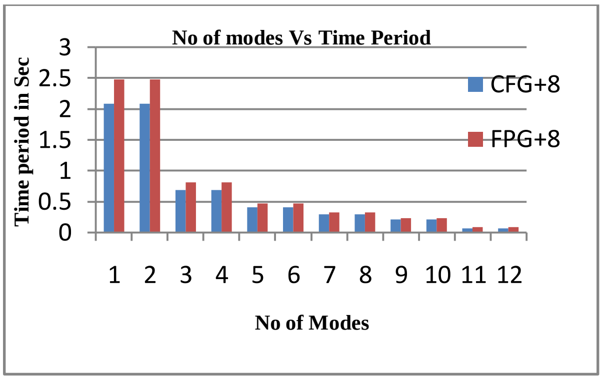

Chart -17: Effect of time period on behaviour of modes shapes on nine storey building

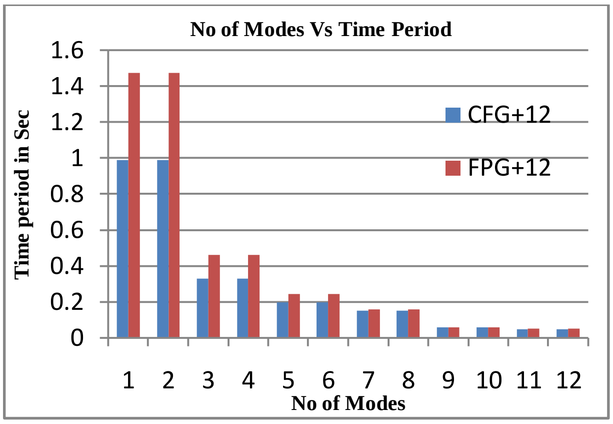

Chart -18: Effect of time period on behaviour of modes shapes on thirteen storey building

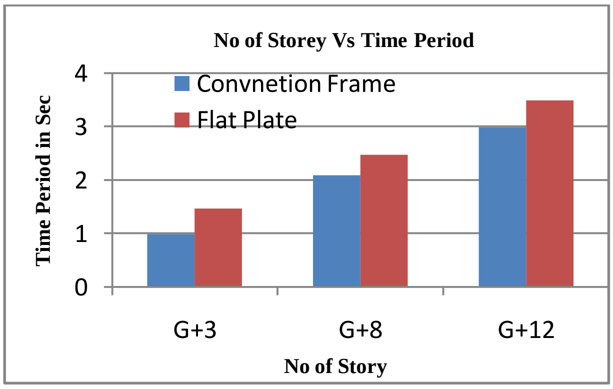

Chart -19: Effect of time period on behaviour of modes shapes on fourth, nine and thirteen storey building

5.5 Storey Drift

The results have been represented in Chart 20-23. From the Chart it can be observed that the storey drift (both Ux and Uy) is maximum at second level for all types of column. After second level the storey drift decreases as the height of the building increases. Due to the symmetric of the building the lateral displacement will be same in both directions (Ux and Uy). From Chart it can be observed that, the storey drift will increase drastically as the height increases. Storey drift in building with flat slab construction is significantly more as compared to conventional R.C.C building. As a result of this, additional moments are developed. Therefore, the columns of such buildings should be designed by considering additional moments caused by the drift. The difference between the two varies from 28-60(%).

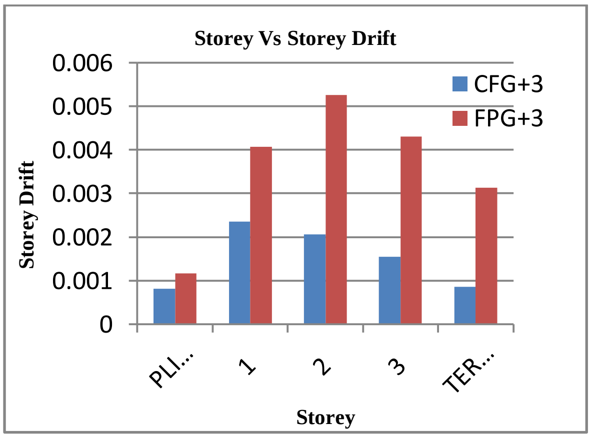

Chart -20: Effect of storey drift on behaviour on fourth storey building

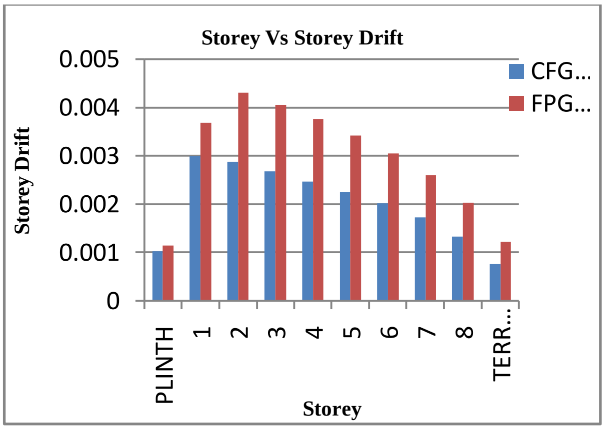

Chart -21: Effect of storey drift on behaviour on nine storey building

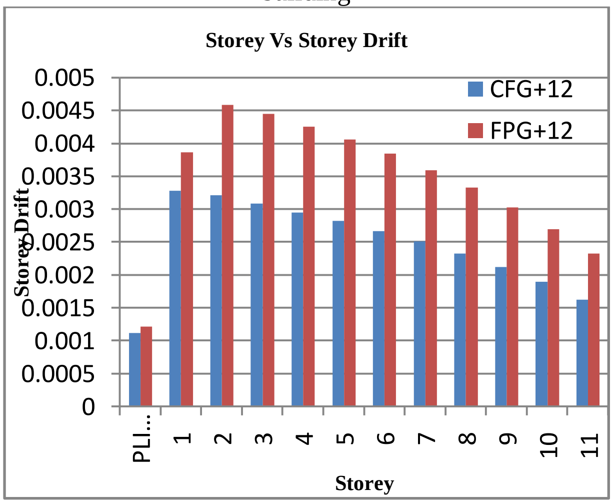

Chart -22: Effect of storey drift on behaviour on thirteen storey building

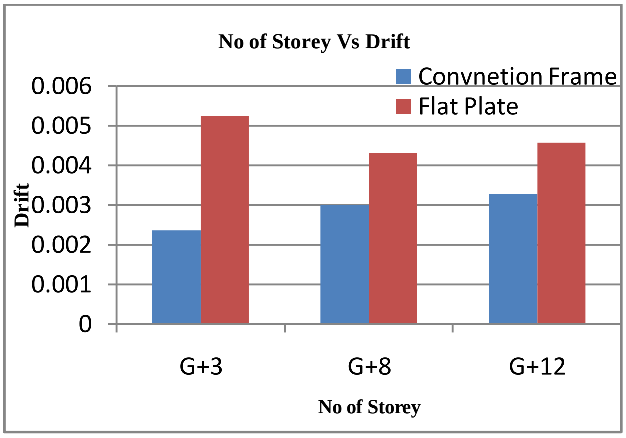

Chart -23: Effect of storey drift on behaviour on four, nine and thirteen storey building

6. CONCLUSIONS

This study presents a summary of the project work, for conventional R.C.C building and flat slab building for different floor height in the seismic region. The effect of seismic load has been studied for the two types of building with different height. On the basis of the results following conclusions have been drawn:

1. The moment is maximum at plinth, first and second level. After second level moments decreases and increases at the top storey.
2. The column behavior changes as height of the building increases.
3. The columns have been designed for the combination of dead load and earthquake load for all cases and the load combination 1.5[DL±EX] is the most critical.
4. The column moments are more in flat plate compared to conventional R.C.C building.
5. Column moments in flat plate vary from 10 to 20 (%) as compared to that of conventional R.C.C frames depending upon the storey.
6. The base shears is maximum at plinth level for all types of column. After plinth level the base shear decreases as the height of the building increases. The base shear will increase drastically as the height increases. Base shear of flat plate building is less than the conventional R.C.C building. The difference between the two varies from 8-13(%).
7. The lateral displacement (both Ux and Uy) is maximum at terrace level for all types of column. Lateral displacement increases as the storey level increases. The lateral displacement will increase drastically as the height increases. Lateral displacement of conventional R.C.C building is less than the flat plate building. The difference between the two varies from 28-57(%).
8. The natural time period increases as the height increases (No of stories).
9. In comparison of the conventional R.C.C building and flat slab building, the time period is more for flat slab building than conventional building. The difference between the two varies from 14-33(%).
10. The time period will be maximum at mode 1 and 2. After mode 2, time period will reduce drastically.

11. The storey drift (both Ux and Uy) is maximum at second level for all types of column. After second level the storey drift decreases as the height of the building increases.
12. Storey drift in building with flat slab construction is significantly more as compared to conventional R.C.C building. As a result of this, additional moments are developed. Therefore, the columns of such buildings should be designed by considering additional moments caused by the drift. The difference between the two varies from 28-60(%).
13. The earthquake forces is more predominant than others loads.
14. Lateral displacement will be minimum at plinth level and maximum at terrace level

SCOPE OF FUTURE STUDIES

1. The structure can be compared with post tensioned slab designed methods
2. The structure behaviour different Seismic zones and its Behaviour of Buildings having Flat Slabs with Drops.
3. The structure can be analysed with effect of Shear Wall,

REFERENCES

1. Agarwal. P. and Shirkhande.M, *"Earthquake resistant Design of Structures*" Printice- Hall of India Private Ltd. New Delhi, India.

2. Alpa Sheth*"Effect of perimeter frames in seismic performance of tall concrete buildings with shear wall core and flat slab system"* The 14th World Conference on Earthquake Engineering October 12-17, 2008, Beijing, China.

3. Apostolska1 R.P *and* Necevska-Cvetanovska G. S, *"Seismic performance of flat-slab building structural systems"* The 14th World Conference on Earthquake Engineering October 12-17, 2008, Beijing, China.

4. Bhavikatti S.S, *"Advance R.C.C. Design" ,* New Age International (p) Limited, Publishers, New Delhi, India.

5. Ema COELHO, Paulo CANDEIAS, Raul ZAHARIAand Artur V. PINTO, *"Assessment of the seismic behavior of R C flat slab building structures",* 13th World Conference on Earthquake Engineering Vancouver, B.C., Canada August 1-6, 2004 Paper No. 2630

6. Garg c.s, Yogendrasingh, Pradeep Bhargava and Bhandari N.M, *"Seismic performance of flat slab shear wall system",* Journal of structural Engineering, Vol.37, No.3, August-September2010, PP.203-207.

7. Lan N .Robertson, *"Analysis flat slab structures subjected to combined lateral and gravity load",* ACI Structural Journal.

8. Pankaj Agarwal and Manish Shrikande (2007), *"Earthquake Resistant Design of Structures"*, Prentice Hall of India Private Limited, New Delhi, India.

9. Shyh-jiann Hwang and Jack p. moehle, *"Models for laterally loaded slab-column frames",* ACI Structural Journal, March-April 2000.

10. IS: 456:2000, *"Indian Standard Code for Plain and Reinforced Concrete",* Bureau of Indian Standards, New Delhi.

11. Prof. K S Sable, Er. V A Ghodechor, Prof. S B Kandekar,*" Comparative Study of Seismic Behavior of Multistorey Flat Slab and Conventional Reinforced Concrete Framed Structures",* Volume 2, Issue 3, June 2012

BIOGRAPHIES

Mrs. Navyashree K resident of Mysore received her degree in Civil Engineering from NIE, Mysore in the year August 2010.

Mrs. Sahana T.S (Asst.Professor) received her M.E (Pre-stressed concrete) from Banglore University. Her area of interest includes Earthquake engineering and Dynamics of Structures. She has 5 years of teaching experience.