[Muntaqim, 4(8): August 2017] ISSN 2348 – 8034
DOI- 10.5281/zenodo.843989 Impact Factor- 4.022

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

SEISMIC PERFORMANCE ON FLAT SLABS AND BEAM SLAB IN MULTI STOREY BUILDING

Md Abdul Muntaqim[*1],Noor Mohammed[2] & Syed Farrukh Anwar[3]
[*1]Department Of Civil Engineering, Nawab Shah Alam Khan College Of Engg & Tech.
[2]Assistant Prof. Department Of Civil Engineering, Nawab Shah Alam Khan College of Engg & Tech.
[3]Head Of Department Civil Engineering, Nawab Shah Alam Khan College of Engg & Tech

ABSTRACT

Now a days 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. Whereas the conventional beam slab buildings perform better in seismic regions. In the present work another model with alternate floor flat slab and beam slab is considered and all the nine structures are compared. Conventional RC frame structure, Flat Slab structure and alternate floor flat-beam slab structure of G+10story of plan size of 30mx30m have been considered. The performance of Conventional RC frame structure, Flat Slab structure and alternate floor flat-beam slab structure were studied and for the analysis, seismic zone II is considered. The analysis is done with using E-Tabs 2015 software. It is necessary to analyze seismic behavior of building to see what parameters are going to changes in conventional RC Frame building, flat slab building and alternate floor flat-beam slab building with corner shear wall, middle shear wall and without shear wall. Therefore, the characteristics of the seismic behavior 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 objective of the present work is to examine the feasibility of Alternate floor flat slab-beam slab structure and compare the behavior of these nine types of buildings under seismic forces. Present work provides a good source of information on storey drift, storey displacement, base shear, storey shear, column forces and time period**.**

I. INTRODUCTION

The world's population has grown by leaps and bounds and so have man's requirements for a place to live in and to work on. The land available to keep space with man's needs is strictly limited and is becoming prohibitively expensive. Many urban areas in India have already reached the limits of horizontal growth and, as a result, the only alternative left is vertical development. High-rise buildings are already familiar feature of the Indian skyline. Such buildings call for meticulous planning and design, if the large investments made in them are to give the maximum benefits in functional utility, comfort and safety.

Seismic analysis procedure as per the code

The basic intent of design theory for earthquake resistant structures is that buildings should be able to resist minor earthquakes without damage, resist moderate earthquakes without structural damage but with some non-structural damage, and resist major earthquakes without collapse but with some structural and non-structural damage. To avoid collapse during a major earthquake, members must be ductile enough to absorb and dissipate energy by post-elastic deformation. Redundancy in the structural system permits redistribution of internal forces in the event of the failure of key elements. When the primary. Element or system yields or fails, the lateral force can be redistributed to a secondary system to prevent progressive failure. IS 1893 (part-l) code recommends that detailed dynamic analysis, or pseudo Static analysis should be carried out depending on importance of the problem. In India, IS 1893(Part-I): 2002 is the main code that provides outline for calculating seismic design forces for buildings. This force depends on the mass and seismic coefficient of the structure and the latter in turn depends on properties like seismic zone in which structure lies, importance of the structure, its stiffness, the soil on which it rests, and its ductility. The whole code centers on the calculation of base shear and its distribution over height. Depending on the height of the structure and zone to which it belongs, type of analysis i.e., static analysis or dynamic analysis is performed.

Objective

The main objective of this research is to study and compare the seismic performance of reinforced concrete buildings with conventional beam slabs, flat slabs and alternate floor flat slab and beam slab that are analysed as per India Standard IS 1893(2002). Response history analysis was used as the tool to generate the necessary responses to allow for an in-depth comparison. The primary deliverables of this study are:

- An evaluation of the seismic performance of nine structures, which are geometrically identical excluding the slabs,
- Examine the Performance of Alternate floor Flat slab-beam slab building structure and check the feasibility of the structure.

II. LITERATURE REVIEW

A.A.Sathawane[1]The aim of the project is to determine the most economical slab between flat slab with drop, Flat slab without drop and grid slab. The proposed construction site is Nexus point apposite to Vidhan Bhavan and beside NMC office, Nagpur. The total length of slab is 31.38 m and width is 27.22 m. total area of slab is 854.16 sqm. It is designed by using M35 Grade concrete and Fe415 steel. Analysis of the flat slab and grid slab has been done both manually by IS 456-2000 and by using software also. Flat slab and Grid slab has been analyzed by STAAD PRO. Rates have been taken according to N.M.C. C.S.R. It is observed that the FLAT slab with drop is more economical than Flat slab without drop and Grid slabs.

Apostolska[2]states that, 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 results from the analysis for few types of construction systems which is presented in the paper show that flat slab system with certain modifications (design of beam in the perimeter of the building and/or RC walls) can achieve rational factor of behavior considering EC8 and can be consider As a system with acceptable seismic risk. Modifications with additional construction elements improve small bearing capacity of the system and Increase strength and stiffness, improving seismic behavior of flat-slab construction system. Selected result from the analysis are presented in the paper.

K S Sable, V A Ghodechor, S B Kandekar[3]] Investigated the effect of seismic forces on three types of buildings with different height using STAAD Pro2007 software. On the basis of the results he concludes that the natural time period increases as the height of building or no. of stories increases, irrespective of type of building viz. conventional structure, flat slab structure and flat slab with shear wall. Story drift in buildings 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 moment caused by the drift. A structure with a large degree of indeterminacy is superior to one with less indeterminacy, this is primarily because of more members are monolithically connected to each other and if yielding takes place in any one of them, then a redistribution of forces takes place. As a result, the structure can sustain to take additional load. Additionally, redistribution reduces as the number of member reduces in a selected lateral load resisting system

Navyashree K, Sahana T.S[4]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. 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.

Critical Appraisal of Literature View Most of the literatures indicate that many research have studied on Conventional RC Frame buildings and Flat slab buildings however these literatures help us to make Alternate floor flat-beam slabs building models.

- Now we are comparing the nine buildings
- Normal Beam slab without shear wall
- Normal Beam slab @ corner shear wall
- Normal Beam slab @ middle shear wall
- Flat slab without shear wall
- Flat slab @ corner shear wall
- Flat slab @ middle shear wall
- Alternate floor Flat-Beam slab without shear wall
- Alternate floor Flat-Beam slab @ corner shear wall
- Alternate floor Flat-Beam slab @ middle shear wall

III. METHODOLOGY

Response Spectrum Method

In order to perform the seismic analysis and design of a structure to be built at a particular location, the actual time history record is required. However, it is not possible to have such records at each and every location. Further, the seismic analysis of structures cannot be carried out simply based on the peak value of the ground acceleration as the response of the structure depend upon the frequency content of ground motion and its own dynamic properties. To overcome the above difficulties, earthquake response spectrum is the most popular tool in the seismic analysis of structures. There are computational advantages in using the response spectrum method of seismic analysis for prediction of displacements and member forces in structural systems. The method involves the calculation of only the maximum values of the displacements and member forces in each mode of vibration using smooth design spectra that are the average of several earthquake motions. This chapter deals with response spectrum method and its application to various types of the structures. The codal provisions as per IS:1893 (Part 1)-2002 code for response spectrum analysis of multi-story building is also summarized.4.2 Response Spectra Response spectra are curves plotted between maximum response of SDOF system subjected to specified earthquake ground motion and its time period (or frequency). Response spectrum can be interpreted as the locus of maximum response of a SDOF system for given damping ratio. Response spectra thus helps in obtaining the peak structural responses under linear range, which can be used for obtaining lateral forces developed in structure due to earthquake thus facilitates in earthquake-resistant design of structures.Usually response of a SDOF system is determined by time domain or frequency domain analysis, and for a given time period of system, maximum response is picked. This process is continued for all range of possible time periods of SDOF system. Final plot with system time period on x-axis and response quantity on y-axis is the required response spectra.

Modelling

Three different structures are considered by keeping column properties same with flat slabs, beam slabs and alternate floor flat and beam slab. The structures are modelled in 3D in the commercial structural analysis and design software ETABS 2015 (Version 15.1 Build 1102). X and Y axis are the global horizontal axis and Z is the global vertical axis .The buildings are analysed as space frames. The modelled space frame is analysed for dead loads, live loads, earthquake loads. The buildings are compared for base shear, story shears, story displacements, story drifts, time periods and Column forces of these nine models. The location of the structure is considered to be located in seismic zone II as per Indian standard code. All the supports are considered to be fixed at the base.

ISSN 2348 – 8034
Impact Factor- 4.022

Effective length of columns are considered as per the standard code of practice. Effect of rigid diaphragm for slabs is considered in the analysis.

IV. CASE STUDY

Building Description

Model 1:In the first model, of G+10 storied Normal Beam Slab reinforced concrete frame buildings (without shear wall, corner shear wall and middle shear wall) situated in zone II is taken for the purpose of study. The total plan area of buildings is 900 Sq.mts each and with 3.2m as height of each typical storey.

Structural System Of The Building

The column, beam dimensions are detailed in the below tables

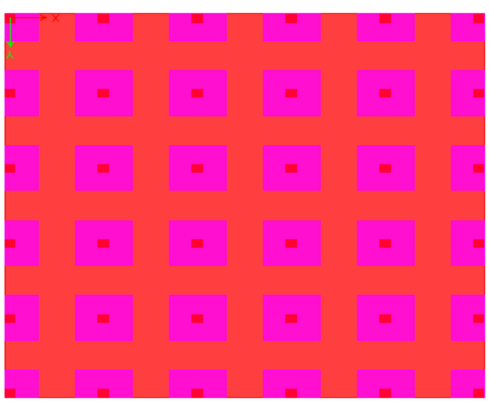
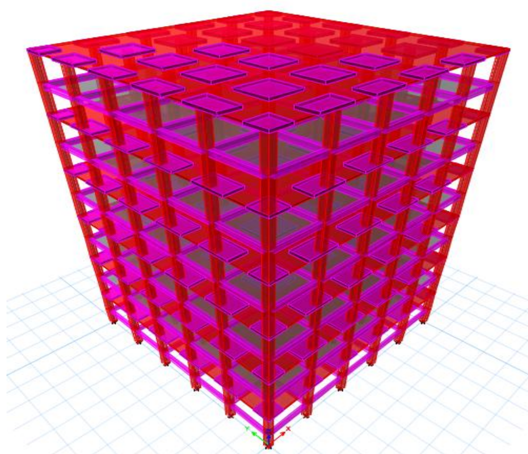
S.No.	Specifications	G+10 storey
1	Flat Slab Thickness	180mm
2	Drop Thickness	120mm
3	Slab Thickness	150mm
4	Beam Dimensions	300 X600mm
5	Column Dimension	600 X600mm
6	Grade of concrete for Columns	M30
7	Grade of concrete for Beams and Slabs	M25
8	Grade of Steel	415
9	Unit Weight of Concrete	$25Kn/m^3$
10	Live Load	$5Kn/m^2$
11	Super Imposed Load (SDL)	$1.55Kn/m^2$
12	Importance Factor	1.0
13	Seismic Zone	II
14	Response Reduction Factor	5

General Data Collections

The buildings located in Zone II. Table 4.2 presents a summary of the building parameters. The details of the building are given below.

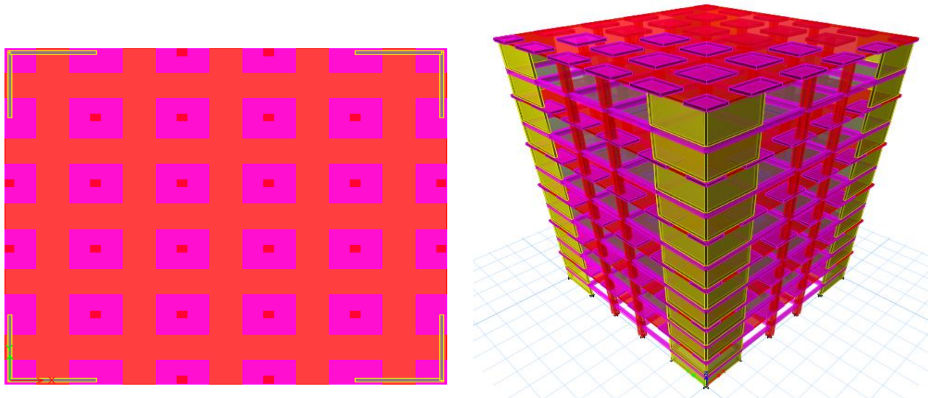
ISSN 2348 – 8034
Impact Factor- 4.022

S. No.	Description	Information
1	Plan size	$900m^2$
2	Building heights	37.7 m
3	Number of story's above ground level	G+10
4	Number of basements below ground	0
5	Type of structure	RC frame
6	Open ground story	Yes
7	Special hazards	None
8	Type of building	Regular frame with open ground story
9	Horizontal floor system	Beams & Slabs
10	Software used	ETABS 2015

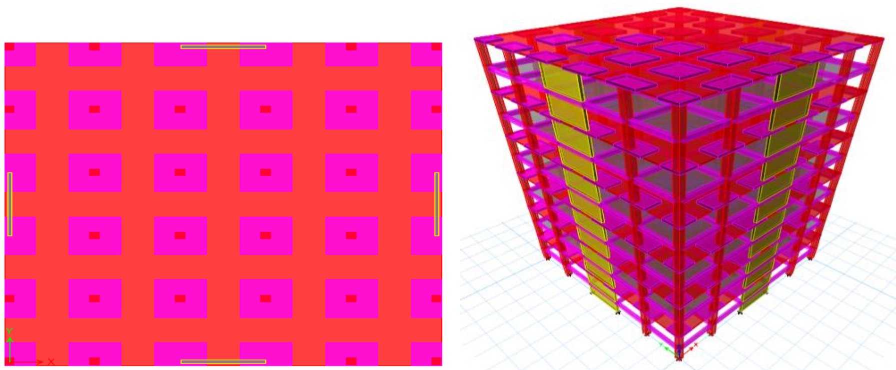



Plan and 3D view of Alternate Floor Flat-Beam Slab Structure without shear wall

ISSN 2348 – 8034
Impact Factor- 4.022



Plan and 3D view of Alternate Floor Beam Slab and Flat Slab Structure @ Corner shear wall



Plan of Alternate Floor Beam Slab and Flat Slab Structure @ Middle shear wall

V. RESULTS AND DISCUSSION

Parameters studied on Base Shear

Base shear is an estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure. It can be observed from the graph and tables that the beam slab building is having higher base shear when compared with flat slab and alternate flat slab and bean slab buildings. In normal beam slab structure corner shear having higher base shear when compare to without shear and middle shear wall, shown in Fig 5.2.1, Fig 5.2.2, Fig 5.2.3

In flat slab corner shear and middle shear having higher base shear when compare to without shear wall,shown in Fig 5.2.4.In Alternate floor flat-beam slab middle shear having higher base shear when compare to without shear wall and middle shear wall, shown in Fig 5.2.5, Fig 5.2.6. Table 5.2.1 shows values of base shear for the nine models for response spectrum functions SPEC X and SPEC Y.

Base Shear for Without Shear Wall

Seismic response in	NORMAL SLAB	DROP SLAB	ALTERNATE SLAB
SPEC X	2320.265	185.9593	282.8813
SPEC Y	2320.265	185.9592	282.8813

[Muntaqim, 4(8): August 2017]
DOI- 10.5281/zenodo.843989

ISSN 2348 – 8034
Impact Factor- 4.022

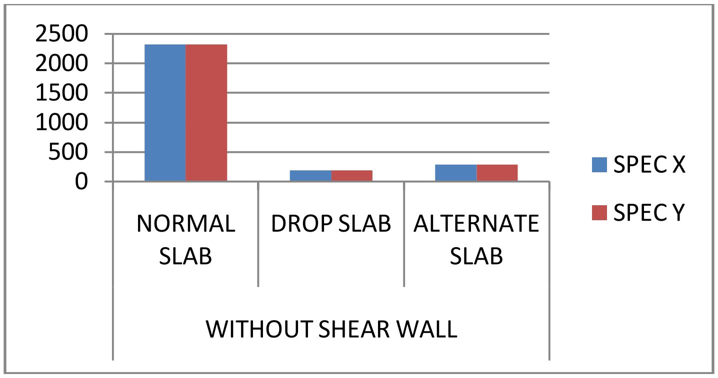
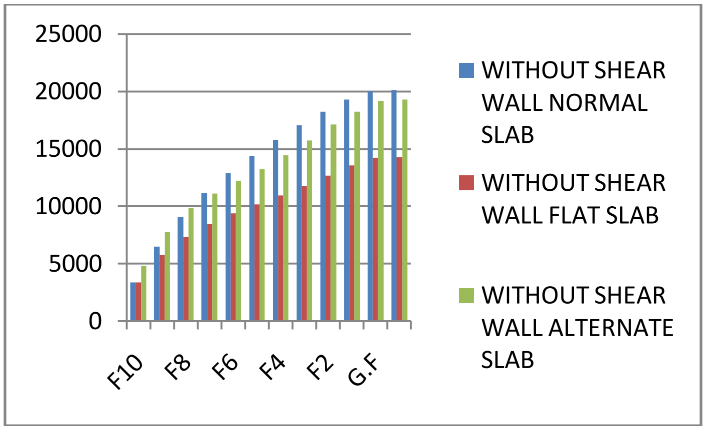
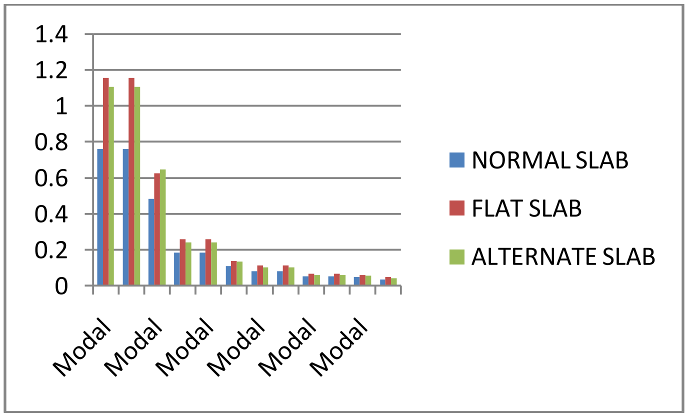


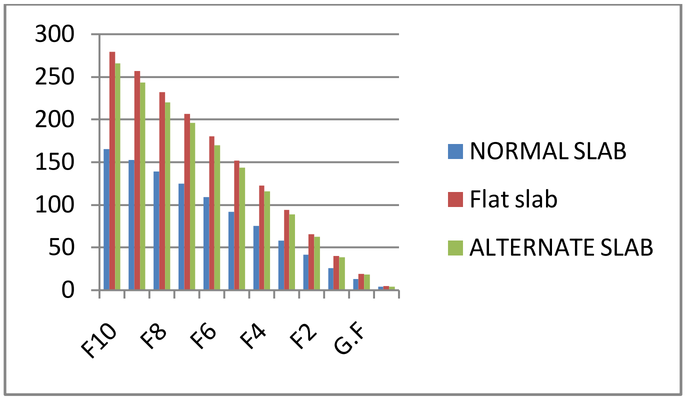
Figure 5.2.1 Comparison of Base Shear (Kn) with Without Shear wall

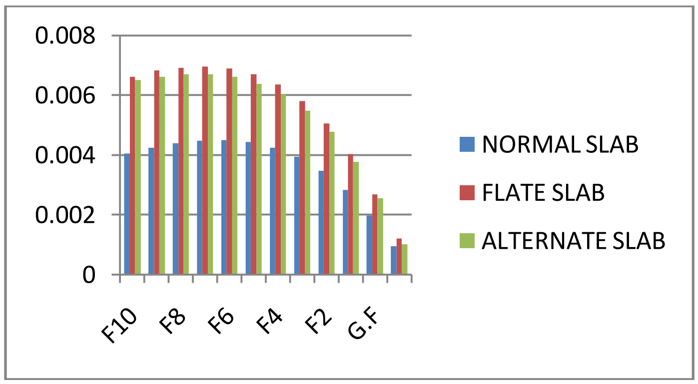




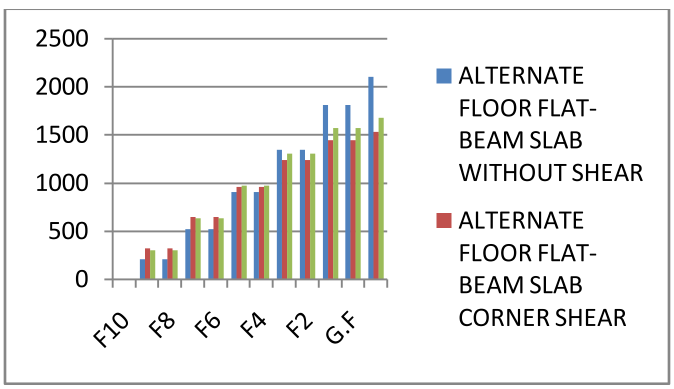
Comparison of Storey shear (Kn) with Without Shear wallTime period (sec) bar chart for corner shear wall

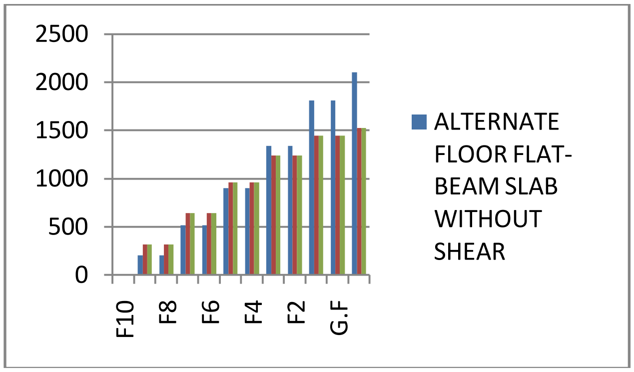
ISSN 2348 – 8034
Impact Factor- 4.022





Story Displacement for Middle Shear Spec XStory Drift for Corner Shear Spec





Column Foresees for Alternate Floor Flat-Beam Slab Spec X ColumnForesees for Alternate Floor Flat-Beam Slab Spec Y

VI. CONCLUSION

This chapter presents a summary of the study, for conventional R.C.C Structure, flat slab Structure and alternate floor flat-beam slab Structure. The effect of seismic forces has been studied. Based on the observations and the results obtained during the course of this study, the following conclusions can be arrived:

- Base shear of normal beam slab structure is more when compared with both flat slab structure and alternate floor flat-beam slab structure.
- It is observed that the base shear in corner shear model is higher when comparing to without shear and middle shear model.
- In story shear comparing of nine models it is observed that the story shear decreases as the height of the building increases.
- The time period flat slab structure and alternate floor flat-beam slab structure was found to be same at 90% mass participation.
- The result of time period comparing with nine models observed that the time period increases when the number of story or height of the building increases.
- Normal beam slab, Flat slab and alternate floor flat-beam slab structure with shear wall found to be same at 90% in story displacement.
- The story displacement increase with height of the building.
- The story displacement is higher in flat slab without shear wall model when compare to normal beam slab and alternate floor flat-beam slab model.
- Story drift in buildings with flat slab construction is significantly more as compared to normal beam slab building. The drift value of alternate floor flat-beam slab structure and flat slab structure with shear model is having 90%same.
- The column foresees increases from top to bottom level. The column foresees is higher in flat slab structure with middle shear and without shear when compare to normal beam slab and alternate floor beam slab structure.
- The axial force acting on the corner shear walls considered for the flat slab structure and alternate floor flat-beam slab structure are less when compared with the normal beam slab structure for the cross sectional properties of the slabs and beams considered.
- By considering the same cross-sectional properties of the columns for all the nine structures, the columns sizes required for the alternate floor flat–beam slab is more. This requires further investigation.

VII. SCOPE OF FURTHER STUDY

- The current study is limited to the comparison of the seismic performances of structures that are symmetrical in plan and elevation. The performance of the buildings with plan and elevation irregularities needs to be accessed and compared.
- Column forces of alternate flat slab – beam slab structure needs further investigation.

[Muntaqim, **4(8): August 2017]** **ISSN 2348 – 8034**
DOI- 10.5281/zenodo.843989 **Impact Factor- 4.022**

- The Study can be extended to the structure by altering the position of flat slabs and beam slabs at different floors.
- The study presented here should be extended to include different seismic zones with varying heights.
- The performance of structures to wind loads should be studied and compared.
- This work can be extended to unsymmetrical buildings considering the torsional provisions.

REFERENCES

1. *A.A Sathawane, Deotale, R.S., "Analysis and design of flat slab and grid slab and their Cost comparison" International Journal of Engineering Research and Applications, Vol. 1, Issue 3, pp.837-848.*
2. *Apostolska1 R.P and Necevska-Cvetanovska G. S, "Seismic performance of flat-slab*
3. *building structural systems" The 14th World Conference on Earthquake Engineering October 12-17, 2008, Beijing, China*
4. *K.S.Sable, Ghodechor, V.A., B., Kandekar, S.B., —Comparative Study of SeismicBehavior of multistory flat slab and conventional reinforced concrete framed structures, International Journal of Computer Technology and ElectronicsEngineering, Volume 2, Issue 3, June 2012.*
5. *Erberik, M. A., Elnashai, S. A. "Vulnerability analysis of flat slab structures", 13th*
6. *World Conference on Earthquake Engineering, Vancouver, B.C., Canada, August 1-6, 2004, Paper No.31.*
7. *Erberik, M. A., Elnashai, S. A., "Fragility analysis of flat-slab structures", ELSEVIER,*
8. *23 February2004.*
9. *Mohamed A. A. El-Shaer —Seismic Load Analysis of different R.C. Slab Systemsfor Tall Building, International Journal of Current Engineering and TechnologyISSN 2277 – 4106*
10. *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)*
11. *Sumit Pahwa, Vivek Tiwari, Madhavi Prajapati—Comparative Study of Flat Slab withOld Traditional TwoWay Slab, International Journal of Latest Trends inEngineering and Technology*
12. *Gupta,U., Ratnaparkhe ,S., Gome,P.,"Seismic behavior of building having flat slabs with Drops", International Journal of Emerging Technology and Advanced Engineering Volume 2, Issue 10, October 2012.*
13. *Concrete Frame Design Manual as per IS 456:2000 For ETABS® 2013*
14. *Reinforced Concrete Design of Tall Buildings by Bungale S Taranath, Ph.d., P.E., S.E.*
15. *Structural Analysis and Design of Tall Buildings by Bungale S Taranath, Ph.d., P.E., S.E.*
16. *Explanatory Examples on Indian Seismic Code IS 1893 (Part I) by Dr. Sudhir K Jain Document No. :: IITK-GSDMA-EQ21-V2.0*
17. *IS 1893(Part 1):2002 `Criteria for Earthquake Resistant Design of Structures : Part*
18. *1 General provisions and Buildings'*
19. *http://en.wikipedia.org/wiki/Seismic_analysis*
20. *http://www.dbh.govt.nz/consultingon-epbp*