Seismic Response of Low, Mid And Highrise R. C. Building With Floating Column And Soft Storey At Different Level

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Abstract- *The columns which are supported on a beam instead of rigid foundation are called as floating columns. Buildings with first storey not filled with masonry walls, which has done in upper stories, suffered extensive damage during earthquake, Stiffness is lesser than 50% when compare to first storey to upper storey, this building is called as soft storey. In present scenario buildings with Floating Column and soft storey is a typical feature in the modern multi-storey construction in urban India. Such features are highly undesirable in building built in seismically active areas. Seismic analysis is a subset of structural analysis and is the calculation of the response of a building structure to earthquakes. In this project the seismic performance of building with floating columns are presented in terms of various parameters such as time and Frequency, Storey displacement, storey drift, El Centro Ground Motion etc. and these values are established with Graphs. The Response Spectrum Analysis is used to find out these different Terms.This project studies the analysis of a G+5,G+10,G+15 storey normal building and a G+5,G+10,G+15 storey floating column building with soft Storey and comparison of these models are been presented. The analysis is done by the use of Etabs 2015 and structure was assumed to be situated in earthquake Zone III.*

Keywords- floating column, Soft storey, time and frequency, storey displacement, storey Drift, El Centro ground motion

I. INTRODUCTION

Many urban multi-storey buildings in India today have open first storey as an unavoidable feature. There are many projects in which floating columns are adopted, especially above the ground floor, so that more open space is available in the ground floor. These open spaces may be required for assembly hall or parking purpose. The behaviour of a building during earthquakes depends critically on its overall shape, size and geometry, in addition to how the earthquake forces are carried to the ground. The earthquake forces developed at different floor levels in a building need to be brought down along the height to the ground by the shortest path; any deviation or discontinuity in this load transfer path results in poor performance of the building.

Buildings with columns that hang or float on beams at an intermediate storey and do not go all the way to the foundation have discontinuities in the load transfer path.

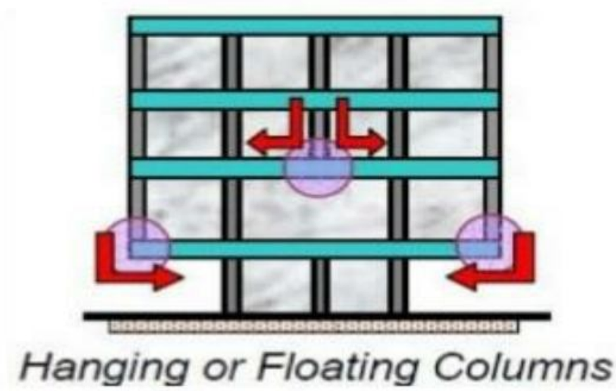


Fig.1: Floating columns in a multi-storey building

II. SCOPE OF STUDY

The aim of this work is to compare the response of RC frame buildings with floating columns and soft storey building under earthquake loading and under normal loading. The major objectives of this work are as follows:

- The primary aim of this work is the comparative study of seismic behavior of floating columns and non-floating columns at low Mid and Highrise R.C. Building.
- Determination of seismic response of the models by using response spectrum analysis in ETABS15 software.

- To study the effect of external floating columns on the building under earthquake loading for seismic zone.
- Finding out effects on various parameters of RC building under seismic events due to presence of floating columns.
- To check the seismic response of any existing structure with floating columns.
- To determine which structure is superior to another in higher earthquake zones.

III. PREVIOUS WORK

Karishma I.patel and Hitesh K. Dhameliya, they review the old Literature Survey related to seismic analysis of floating column and made some conclusions for their review [1]. Trupanshu Patel and Jasmin Gadhiya, they evaluate seismic behavior of building with and without infill walls subjected to seismic force using SAP 2000. The entire work consists of 29 models and these models were modelled and analysed by SAP 2000. It was analysed for local zone III (surat), medium soil condition, and results are tabulated for horizontal and vertical displacements.[2] SK. Abdul Rehaman find out parameters like Base shear, Storey drift, and Displacement. In this Equivalent static method, response spectrum and time history method were used for analysis in ETABS-2015. Software was used and structure was assumed to be situated in earthquake Zone III [3]. Yeruvakota sanjeeva reddy In this thesis the seismic performance of building with floating columns are presented in terms of various parameters such as displacement, storey drift, maximum column forces, time period of vibration etc. The building having various locations of floating columns ie floating columns starting from different stories are considered for the study. The building is modeled by using finite element software ETABS. Equivalent static analysis and response spectra dynamic analysis are performed on the various buildings and their seismic performance is evaluated[4]. Ms.Waykule .S.B and Dr.C.P.Pise In this Investigation A five storied building with floating column at 1st floor and building with floating column at 2nd floor and building without floating column located in zone v of india as per code IS 1893(Part1):2002 were taken for the investigation. linear static analysis of buildings were done under gravity loads and seismic loads. Then compare base shear and storey displacement of each building. Modeling and analysis was carried out in sap 2000v17[5]. Ms.Waykule.S.B review the old Literature Survey, From the study of all literature review it was observed that study is required for floating column building for safe point of view during earthquake. Most of all literature review gives better result For normal building as compared to floating column building so more study required for this[6]. Nabeel Musthafa ,The present work focuses on the seismic behaviour of buildings, i.e., the effect on Lateral Displacement and Storey drift when Floating Columns are introduced in the structure. The Floating columns are varied in numbers and at various locations in plan. The transfer girders are varied in sizes (making it safe against the loads) and are compared with its regular counterpart. It is observed that by introducing Floating Columns into the framed structure, the criticality of the structure increases in terms of storey drift. Conclusions drawn from the study stipulates that introducing Floating Columns increases the criticality of the structure under seismic forces[7].

IV. METHODOLOGY

Methodology of this project consists of analysis of two type of structure floating column structure and without floating column structure i.e. Regular structure by using the software ETABS. They are explained in details below:

- A Response Spectrum Analysis (RSA) will be done utilizing ETABS15 programming.
- ETABS15 is a completely incorporated program that permits display creation, alteration, execution of examination, outline improvement, and results survey from inside a solitary interface.
- ETABS15 is an independent limited component based auxiliary program for the examination and plan of common structures.
- Two (2) number of issues will be brought with and without floating sections to concentrate seismic conduct.
- The yield results will be communicated as far as Time and Frequency, Storey displacement, storey drift, Elcentro Ground Motion.

A. Modeling of the structure

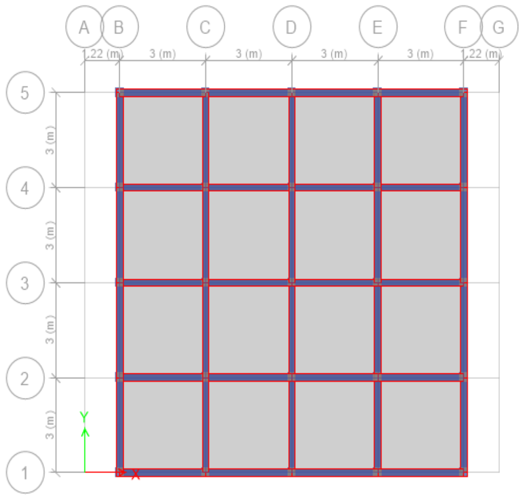
Modeling of this project consists of analysis of two type of structure floating column structure and without floating column structure i.e. Regular structure with different Storeys i.e.G+5, G+10, G+15 . They are explained in details below.

- There are 6 types of structures floating column structure with soft storey and without floating column structure i.e. Regular structure analysized in this work, these are G+5, G+10, G+15 under seismic zone III.
- At Ground level we remove columns at corners and also we make floor soft storey and combined effect is studied in case of floting column structure.

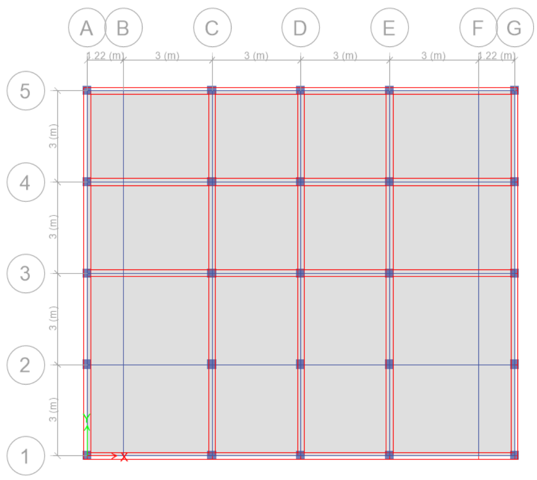
- All Structures are analysized design for Dead load, Live load, Earthquake Load and wind in seismic III.
- Considering Different hight of structure how the seismic response effect is changed is studied.
- Finding out effects on various parameters of RC building under seismic events due to presence of floating columns.

B. Structure and its details

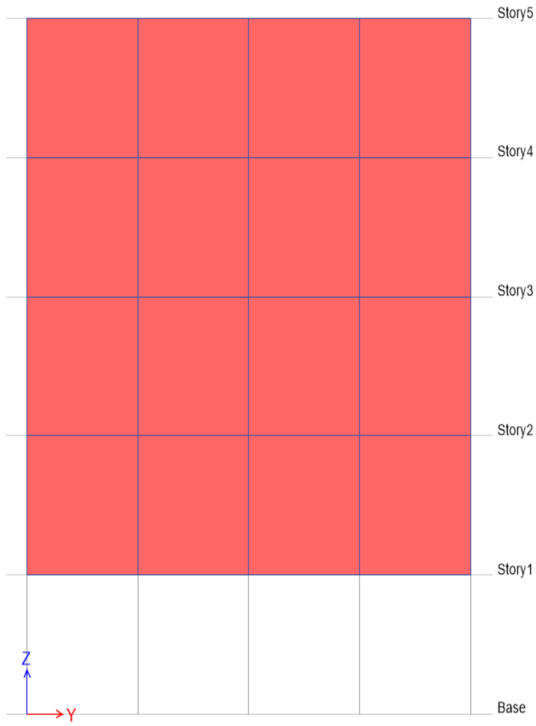
A G+5, G+10, G+15 structure used for analysis. A plan as case study is used for the analysis of floating column. In this building, the ground floor is made for the purpose of parking. First, second, third floor plans are made typical. Following figure shows the plan of the building-



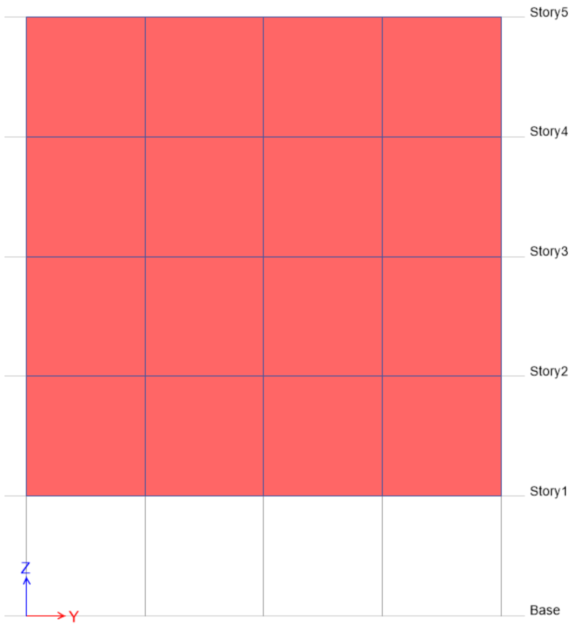
Regular Structure Plan for G + 5



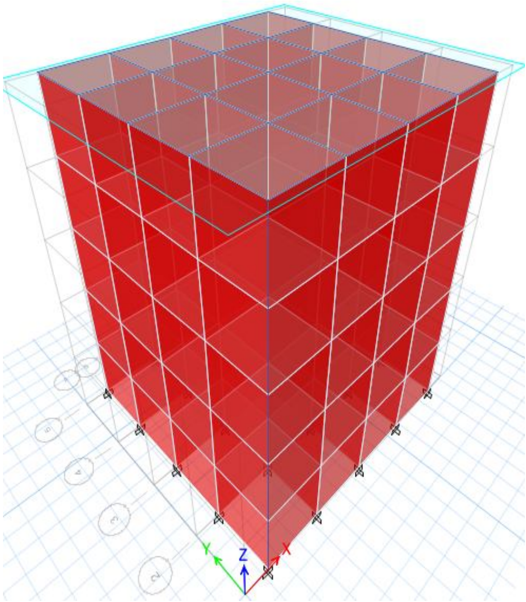
Soft Storey cum Floating Column (SSFC) Structure Plan for G + 5



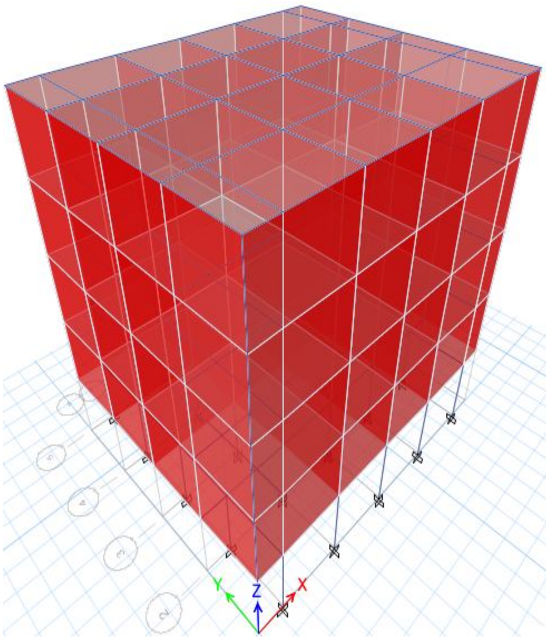
Regular Structure Elevation for G + 5



Soft Storey cum Floating Column (SSFC) Structure Elevation for G + 5



Regular Structure Three Dimentional view for G + 5



Soft Storey cum Floating Column (SSFC) Structure Three Dimentional View for G + 5

C. *Sizes of beams and columns and slabs used for analysis*

All the sizes of beams and columns used for analysis are kept same for both type of structure

The column sizes are –

- For G+5 = 300 mm X 300 mm
- For G+10 = 450 mm X 450 mm
- For G+15 = 600 mm X 600 mm

The beam sizes are –

- For G+5 = 300 mm X 230 mm
- For G+10 = 300 mm X 230 mm
- For G+15 = 300 mm X 230 mm

The slab thicknesses are taken as per the plan Slab that is S=100 mm.

D. *Details of parameters for seismic analysis*

Analysis is carried out as per IS 1893 following parameters are considered:

- Zone factor as zone III
- Soil type is taken as II
- Reduction factor is taken as 5
- Importance factor is taken as 1

E. *General considerations of the structure*

- Reference Code is IS 456-2000, IS 875-1987, IS 2911(part III).
- Grade of concrete M:25.
- Grade of steel to be Fe415 confining to IS 1786-1985 except 6mm bar which Fe250 grade confining to IS 432-1982 (part I).
- Clear cover to the main reinforcement of column should be 40 mm.
- Clear cover to footing should be 50 mm from all the sides.
- Clear cover to beam must be 25 mm and
- For the slab cover should be 15 mm.

Use of vibrator is mandatory.

F. *Loading*

There were three types of loading consideration taken into account while analyzing both the type of the structure that is floating column structure and without floating column structure.

- Dead load
- Live load
- Seismic load
- Wind load

V. RESULTS AND DISCUSSONS

Response spectrum and static analysis was done for both the models of G+5, G+10, G+15 building models of floating column structure, and without floating column structure. The Time & frequency, storey displacement, storey drifts, El centro Ground motion, in the members are studied. Following are the result of analysis.

I. Time and Frequency

The Frequency of earthquake on building is determined by Cycles per seconds. The movement of structure per second under earthquake is calculated by the frequency. Calculated Frequency is shown below.

1) For G+ 5 Structure

Mode Number	5 Storey			
	Regular		SSFC	
	Time (sec)	Frequency (Cycles/sec)	Time	Frequency
Modal 1	0.006	179.355	0.556	1.799
Modal 2	0.006	181.605	0.552	1.812
Modal 3	0.006	181.605	0.536	1.866
Modal 4	0.004	242.958	0.052	19.243
Modal 5	0.004	266.098	0.05	20.149
Modal 6	0.004	266.098	0.014	70.323
Modal 7	0.003	304.154	0.013	77.879
Modal 8	0.003	314.676	0.011	90.915
Modal 9	0.003	335.153	0.009	110.222
Modal 10	0.003	335.153	0.007	136.944
Modal 11	0.002	454.643	0.006	168.262
Modal 12	0.002	454.643	0.006	168.405

2) For G+ 10 Structure

Mode Number	10 Storey			
	Regular		SSFC	
	Time (sec)	Frequency (Cycles/sec)	Time	Frequency
Modal 1	0.016	62.052	0.431	2.318
Modal 2	0.016	62.052	0.425	2.353
Modal 3	0.011	94.869	0.376	2.657
Modal 4	0.008	126.137	0.097	10.262
Modal 5	0.006	164.965	0.094	10.662
Modal 6	0.006	164.965	0.015	67.028
Modal 7	0.005	206.645	0.014	71.805
Modal 8	0.005	215.836	0.012	86.192
Modal 9	0.004	233.601	0.009	105.43
Modal 10	0.004	239.593	0.008	130.343
Modal 11	0.004	239.593	0.007	152.84
Modal 12	0.004	249.878	0.006	160.376

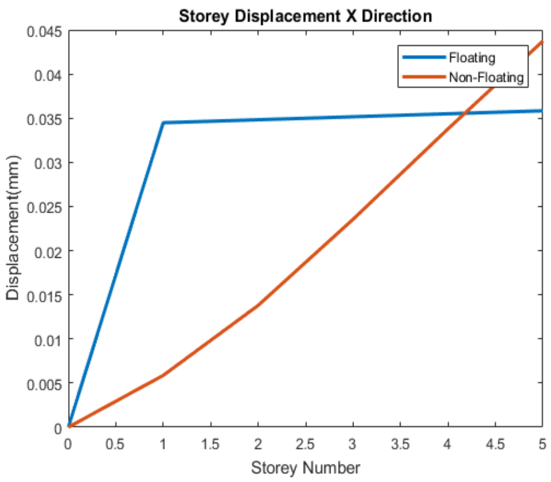
3) For G+ 15 Structure

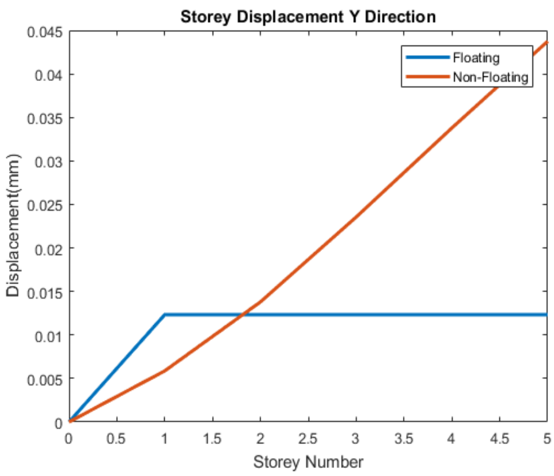
Mode Number	15 Storey			
	Regular		SSFC	
	Time (sec)	Frequency (Cycles/sec)	Time	Frequency
Modal 1	0.034	28.999	0.429	2.33
Modal 2	0.034	28.999	0.415	2.412
Modal 3	0.012	80.541	0.287	3.489
Modal 4	0.012	81.064	0.11	9.126
Modal 5	0.008	132.118	0.108	9.283
Modal 6	0.008	132.118	0.016	63.816
Modal 7	0.007	135.547	0.015	67.221
Modal 8	0.007	135.547	0.012	81.505
Modal 9	0.007	135.887	0.01	100.49
Modal 10	0.006	176.344	0.008	123.445
Modal 11	0.005	190.439	0.008	129.434
Modal 12	0.004	222.622	0.007	142.298

II. Storey Displacement

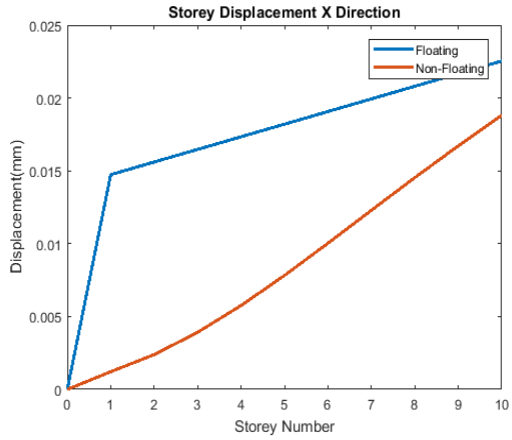
Storey displacement is the earthquake parameter in with on the account of an earthquake the relative displacement of each storey takes place. The storey displacement is found to be more on the top most storeys. Following is the figure shows the storey displacement of the floating column and without floating column structures.

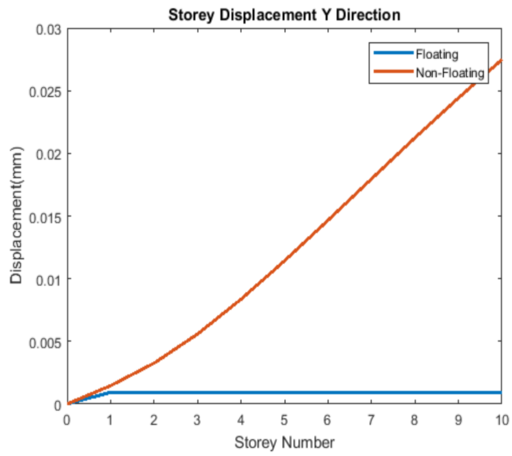
1) For G+ 5 Structure



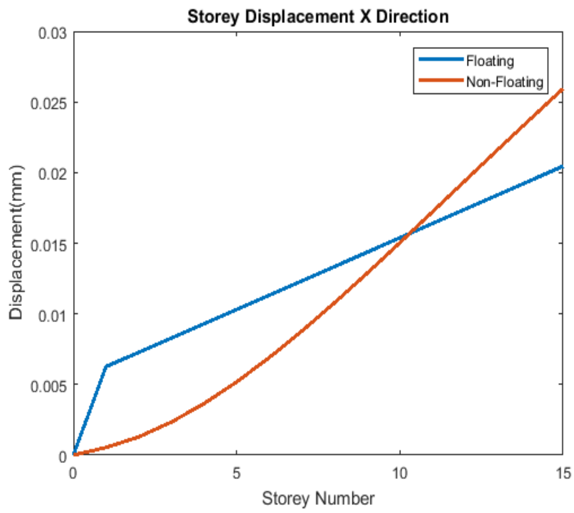


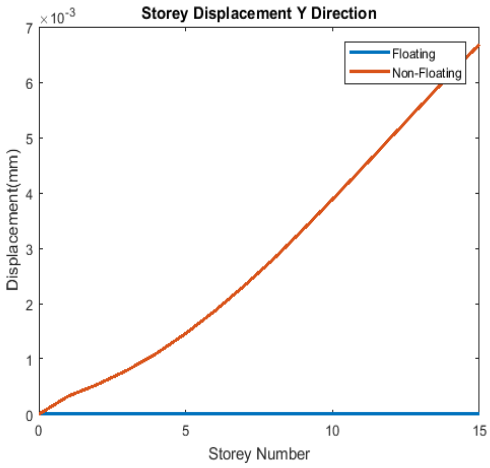
2) For G+ 10 Structure





3) For G+ 15 Structure

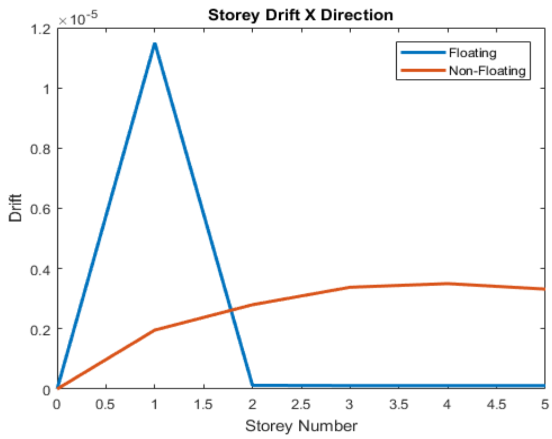


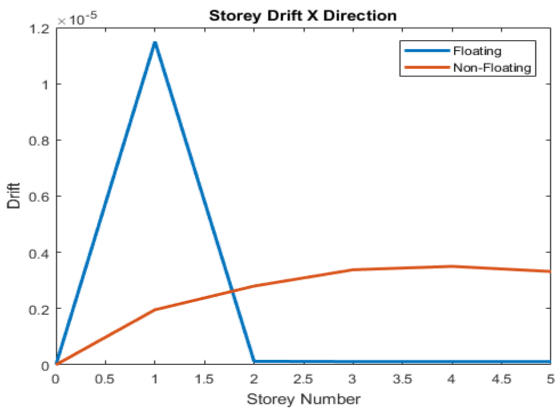


III. Storey Drift

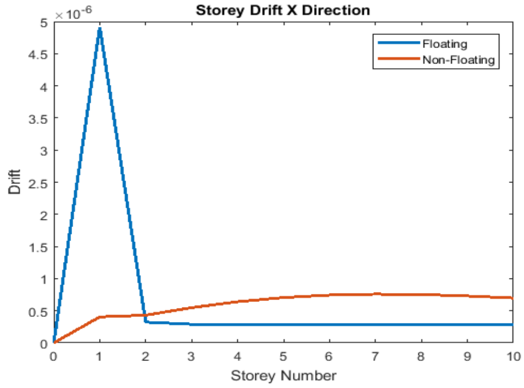
Storey drifts is usually interpreted as inter-storey drifts, the lateral displacement of one level relative to the other level above or below prescribes the limitation on storey drift. It is the ratio of two consecutive floor to height of that floor. Following figure shows the maximum story drifts of the structures.

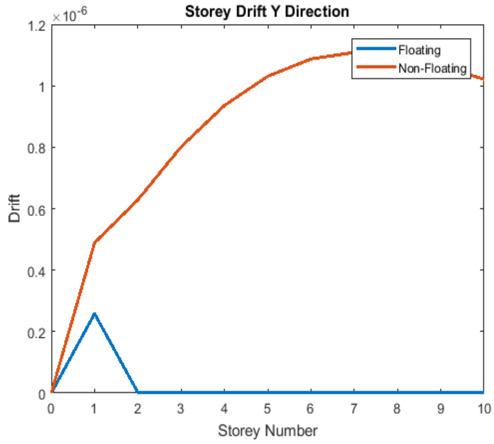
1) For G+ 5 Structure



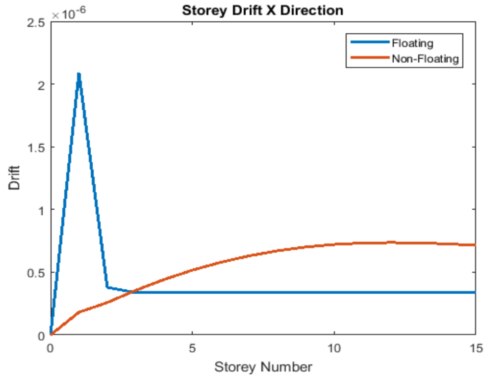


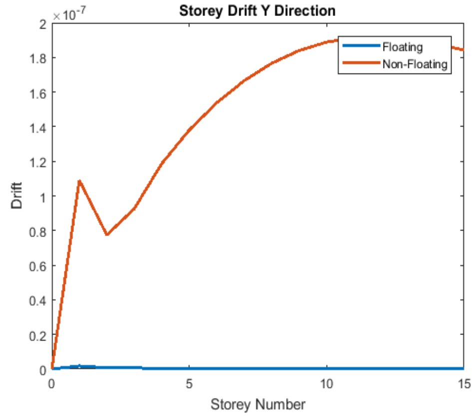
2) For G+ 10 Structure





3) For G+ 15 Structure

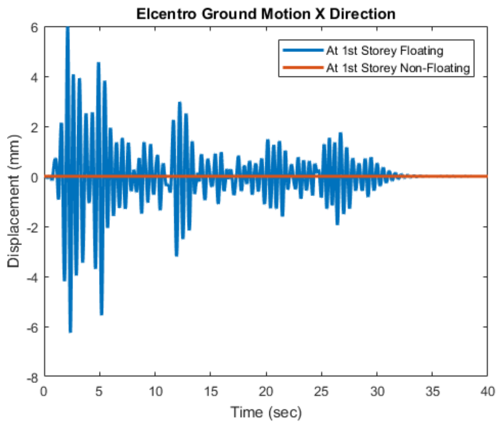


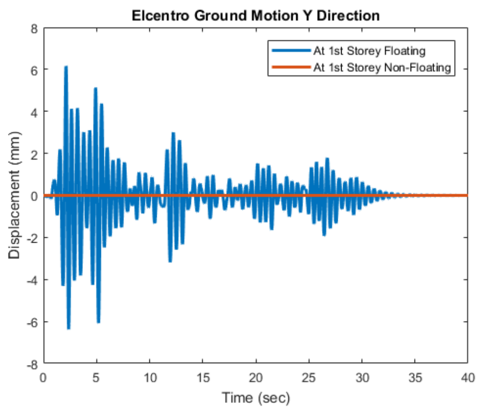


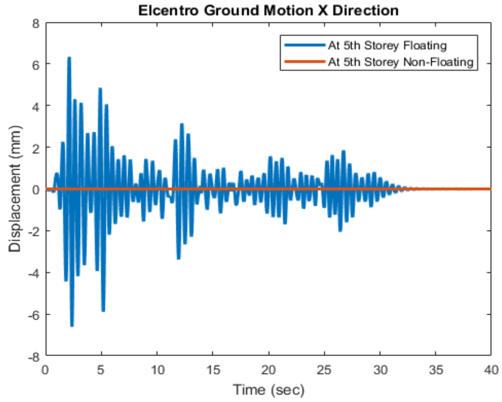
IV. El Centro Ground Motion

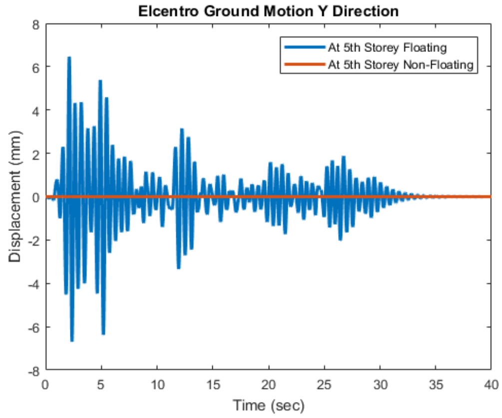
The El centro earthquake occurred at on May 18 1940 in the imperial Valley in southeastern southern California near the international border of United States and Mexico.It had a moment magnitude of 6.9 and a maximum perceived intensity of 6.9 and a maximum perceived intensity of X on the Mercalli intensity scale. In this work, we apply the El centro magnitude earthquake on the Structure and calculate its Displacements in X & Y Direction.

1) For G+ 5 Structure

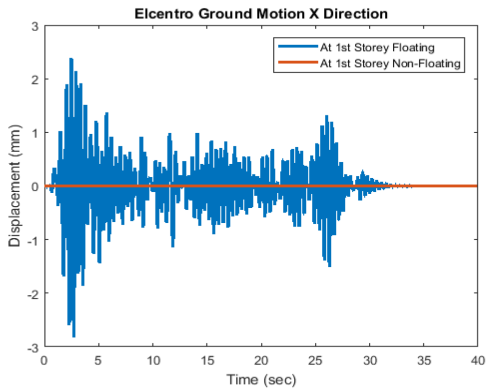


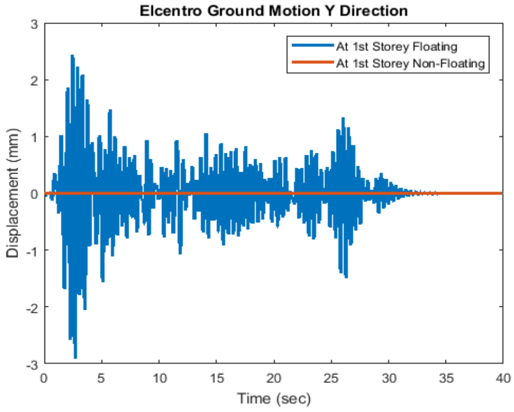


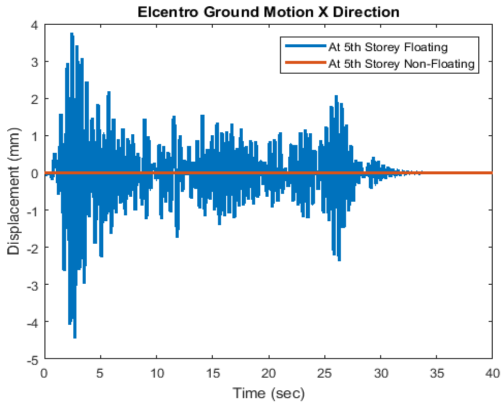


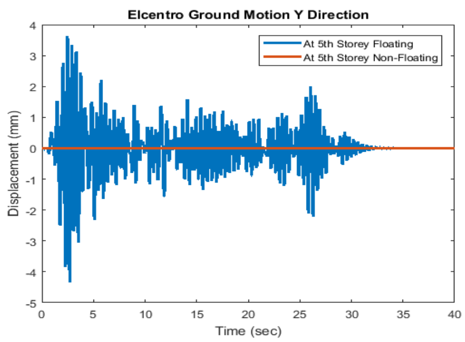


2) *For G+ 10 Structure*

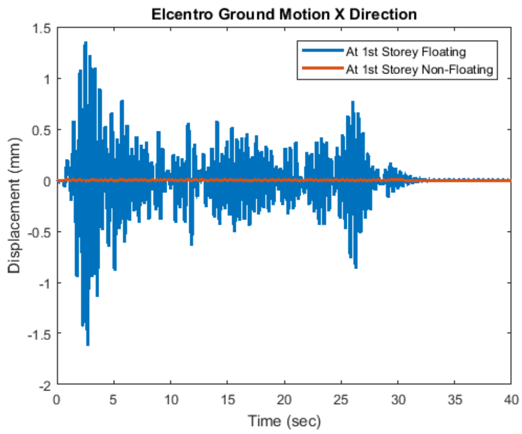


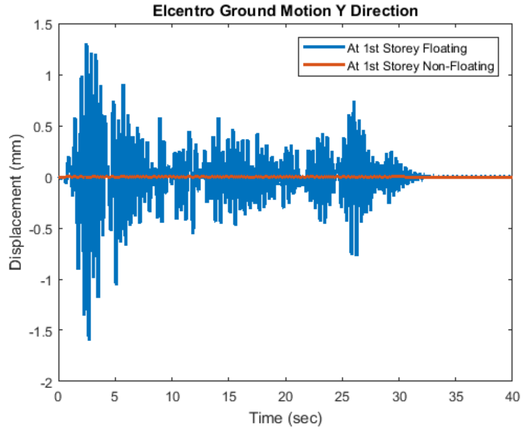


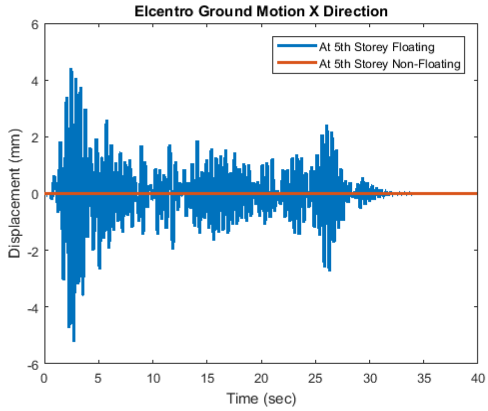


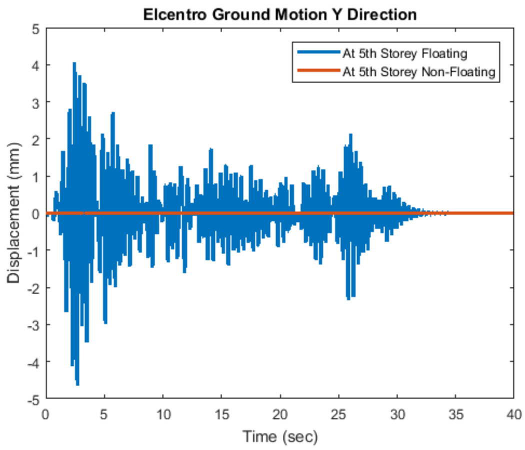


3) For G+ 15 Structure









VI. CONCLUSION

On the basis of the result following conclusions are made:

- This study shows that in building with Soft Storey cum Floating Column Structure (SSFC) has more Frequency as compared to regular structure.
- This study shows that displacement in SSFC is more as compared to regular structure .

- This study shows that the maximum storey drifts is more in the case of floating column structure than without floating column structure.
- This study shows that El centro ground motion displacement SSFC is more as compared to regular structure .
- It was also observed that shifting of floating column from 1st storey towards top storey of the Structure results in increasing storey drift.
- It was also observed that shifting of Floating Column Structure from 1st storey towards top storey of the building results in increasing storey displacement.

VII. ACKNOWLEDGMENT

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REFERENCES

[1] Karishma I.patel,Hitesh K. Dhameliya, KrutarthS.patel "a review on seismic analysis of multistorey building with floating column"

[2] Trupanshu Patel, Jasmin Gadhiya, Aditya Bhatt "Effect of floating column on RCC building with and without infill wall subjected seismic force"

[3] SK. Abdul Rehaman "seismic analysis of framed structures with and without floating columns"

[4] Yeruvakota sanjeeva reddy "earthquake resistance of multistoried building with floating columns using e tabs"

[5] Ms.Waykule .S.B, Dr.C.P.Pise, Mr.C.M.Deshmukh "Comparative Study of floating column of multi storey building by using software"

[6] Ms.Waykule.S.B, Prof. Kadam.S.S "review on study of behavior of floating column for seismic analysis of multistorey building"

[7] Nabeel Musthafa, Annapurna B.P "seismic response of multi-storey buildings incorporating floating columns"

[8] Vinod Kumar Meena, Dr. Om Prakash, Avanish Kumar Mishra "Seismic Response Evaluation of RC Frame Building with Floating Column"

[9] Apurv Joshi, Mohd. Afaque Khan, Abhishek Kumar "seismic analysis of multistorey building with floating column: a review"

[10] Nakul A. Patil, Riyaz Sameer Shah "Comparative Study of Floating and Non-Floating Columns With and Without Seismic Behaviour"

[11] Trupanshu Patel, Jasmin Gadhiya, Aditya Bhatt "Effect of Floating Column on RCC Building With and Without Infill Wall Subjected Seismic Force"

[12] Ms.Waykule.S.B , Mr.Kadam.S.S, Ms.Lale S.V "study of behaviour of floating column for seismic analysis of multistorey building"

[13] Kavya N, Dr. K.Manjunatha, Sachin.P.Dyavappanavar "seismic evaluation of multistorey rc building with and without floating column"

Books:

[14] Pankaj Agarwal and Manish Srikhande, "Earthquake Resistant Design of Structures", PHI learning Private Limited, New Delhi,(2012)

[15] IITK-BMTPC -Earthquake tips

Codes:

[16] IS 1893 Part 1 ,(2002).Indian Standard „Criteria for Earthquake Resistant Design of Structures"

[17] IS 456:2000 Plain and Reinforced Concrete code of Practice.

[18] IS 13920 Ductile detailing of reinforced concrete structures subjected to seismic forces

[19] SP-16 Design aids for RCC structures.

[20] IITK-BMTPC -Earthquake tips

Websites:

[21] www.ijert.org

[22] nicee.org

[23] www.sciencedirect.com

[24] www.wikipedia.com

[25] www.scihub.in