A COMPARATIVE STUDY ON BEHAVIOUR OF RC AND COMPOSITE STRUCTURE WITH AND WITHOUT FLOATING COLUMN SUBJECTED TO SEISMIC LOADING IN ZONE V

B.S. Meghana[1],

Post graduate Student,

Department of Civil Engineering,

The National Institute of Engineering, Mysore.

T.H. Sadashiva Murthy[2]

Associate Professor,

Department of Civil Engineering,

The National Institute of Engineering, Mysore.

Abstract

In recent times, many buildings are planned and constructed with architectural complexities. The complexities include various types of irregularities like floating columns at various level and locations. These floating columns are highly disadvantageous in building built in seismically active areas. The earthquake forces that are developed at different floor levels in building need to be carried down along the height to ground by shortest path, but due to floating column there is discontinuity in the load transfer path which results in poor performance of building.

In this paper we focus on the building to be analyzed as a whole by Liner static analysis for RC and composite structure consisting parameters such as floating columns in different positions in plan, in buildings of various height such as G+3, G+10 and G+15 in earthquake zones V. Comparison of various parameters such as storey shear, storey drift and storey displacement is done.

Keywords: Floating column, irregular building, earthquake behavior, composite structure, linear static analysis, ETABS.

1. Introduction

A column is supposed to be a vertical member starting from foundation level and transferring the load to the ground. The term floating column is also a vertical element which at its lower level rests on a beam which is a horizontal member. 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. The beams in turn transfer the load to other columns below it. Such columns where the load was considered as a point load.

There are many projects in which floating columns are already adopted, especially above the ground floor, so that more open space is available on the ground floor. These open spaces may be required for assembly hall or parking purpose. The column is a concentrated load on the beam which supports it. The structures already made with these kinds of discontinuous members are endangered in seismic regions.

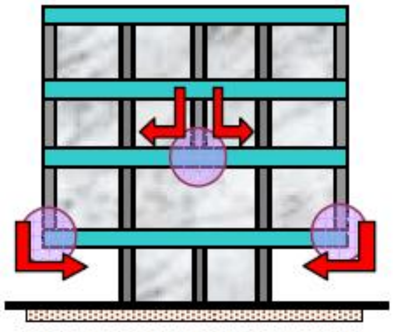

Figure 1: Hanging or floating column

Floating columns are competent enough to carry gravity loading but transfer girder must be of adequate dimensions (Stiffness) with very minimal deflection.

Steel concrete composite construction is built in place of RC structures to get maximum benefits from steel and concrete to produce economic structures. Structures are failing in earthquake prone zone due to irregularity in structure hence proper design is required. In India most of the building systems were low rise buildings. Now a days due to greater migration towards cities increases population in most of the major cities. In order fulfill the requirement of this increased population in the limited land the height of building becomes medium to high-rise. Along with this there is necessity for efficient and economical construction of buildings. The best way to produce efficient and economical design of building system is composite steel-concrete construction. Composite steel concrete design and construction has wide range of scope as well as necessity in present construction world.

The performance of building during an earthquake depends upon several factors, stiffness, ductility, lateral strength and Simple and regular configuration. Buildings having uniformly distributed mass, stiffness and simple and regular configuration cause less damage compared to buildings having irregular configuration. Vertical Mass irregularity is an important factor which is to be considered while designing multistoried building. This paper work focuses on study of multistoried R.C.C. & Composite building vertical irregularity in buildings using ETABS v9.7.4 software. The analysis between R.C.C and composite building involves parametric study of storey displacement, storey shear and storey drifts. Linear static analysis is carried out in order to know the seismic performance of R.C.C and Composite structure

2. Objectives

- To study the behaviour of RCC and composite multistorey building of various height of same dimension.
- To study the behaviour of RCC and composite structure at different zones with floating column in different positions in plan area.
- To find the critical position of floating column in both RCC and composite structure.

3. Literature review

Isha Rohilla, S.M. Gupta, Babita Saini [4] have conducted response spectrum analysis for critical position of floating columns in vertically irregular buildings has been discussed for G+5 and G+7 RC building for zone II and Zone V. Also the effect of size of beams and columns carrying the load of floating column has been assessed using ETABS software. Kavya.N, Dr.K.Manjunatha and Sachin.P.Dyavappanavar [5] the study is carried out on seismic behavior of the RC multi storey buildings with and without floating column are considered. The analysis is carried out for multi storey building of G+3 situated at zone IV, using ETABS software linear static and response spectrum analysis is done and parameters such as displacement, storey drift and base shear is compared. A.P.Mundada and S.G. Sawdatkar[6] studied equivalent static analysis on existing building comprising of G+7. The load distribution on the floating columns and the various effects due to it is also been studied in the paper. The importance and effects due to line of action of force is also studied. In this paper they are dealing with comparative study of seismic analysis of multistoried building with and without floating columns. The equivalent static analysis is carried out for entire project mathematically 3D model using software STAAD *Pro V8i* and the comparison of these models and to get very systematic and economical design of structure. Prof.Swapnil B. Cholekar and Basavalingappa.S.M[9] investigation is done on the mass irregularity of the building and its behavior in seismic regions, they have considered the Irregularity in the form of Mass in G+9 multistoried R.C.C. and Composite building and compared both R.C.C. and Composite structures. Equivalent static and Response spectrum methods are used to analyze the building as per IS 1893(Part 1):2002 using SAP 2000 software. Mass irregularity at upper or middle floor should be considered. The study shows that Composite structures having mass irregularity will better perform than R.C.C. structures.

The literature study reveals that a number of works has been carried out on seismic behavior of RC structures with and without floating columns and they have given conclusions such as not to recommend floating columns in seismically active areas due to stiffness irregularity , discontinuous load transfer path and increase in values of parameters such as storey drift displacement when compare to regular RC structure without floating column and in few papers they have given suggestions to improve stiffness of column by retrofitting , providing bracings they can be decrease in the lateral deformations. as we know that composite structure are more stiffer than RC we carry out a linear static analysis to know the behaviour of composite structure with floating column on the behaviour of RC structures with floating column.

4. Analytical study

In linear static analysis most of the structures are still carried out on the basis of lateral (horizontal) force assumed to be equivalent to the actual (dynamic) loading. The base shear which is the total horizontal force on the structure is calculated on the basis of structure mass and fundamental period of vibration and corresponding mode shape. The base shear is distributed along the height of structures in terms of lateral forces according to the IS 1893 (part 1): 2002 code formula.

The present study is done by using ETABS v9.7.4(Extended Three-dimensional Analysis of Building Systems) it is fully integrated program that allows model creation, modification, execution of analysis, design optimization, and results review from within a single interface ETABS v9.7.4 is a standalone finite element based structural program for the analysis and design of civil structures. It offers an intuitive, yet powerful user interface with many tools to aid in quick and accurate construction of models, along with sophisticated technique needed to do more complex projects.

The structure considered here is a regular building with plan dimension of 30m X 30m, different height of building such as G+3, G+10, G+15 storey model located in Seismic Zone V. Table1 &

2shows the Structural data for RC and composite structure and Figure shows the positions of floating column considered in building.

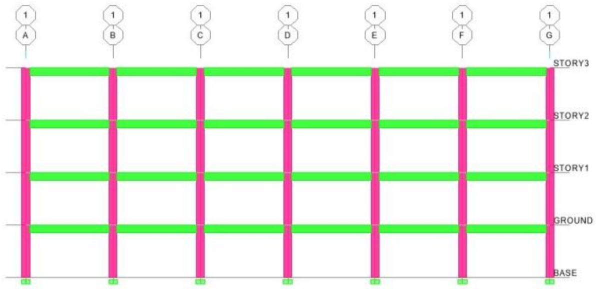

Figure 2: Elevation of G+3 storey building

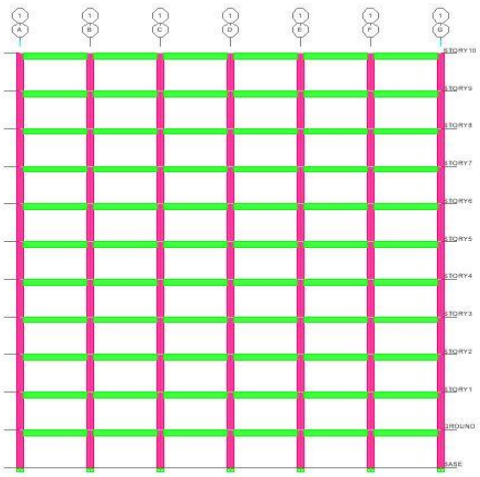

Figure 3: Elevation of G+10 storey building

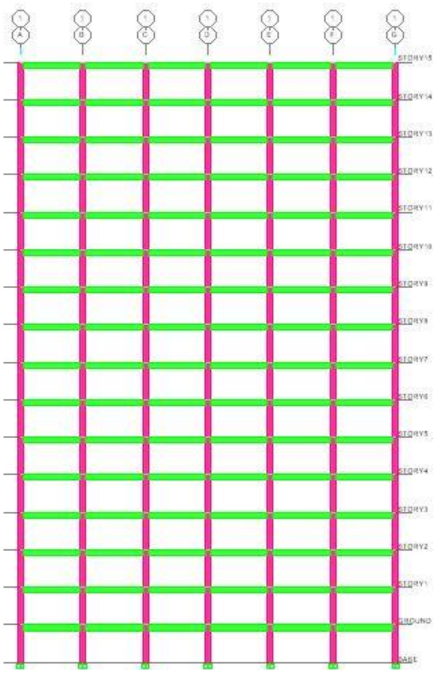

Figure 4: Elevation of G+15 storey building

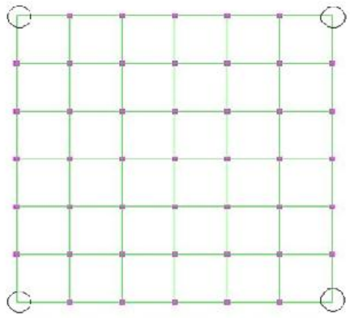

Figure 5a: Columns removed in edges of exterior frame (plan view)

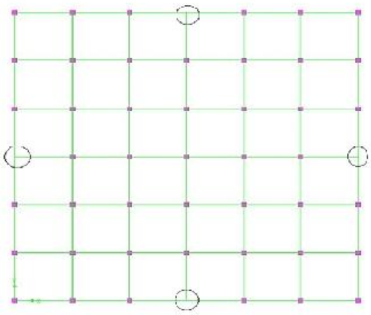

Figure 6a: Columns removed in outer face of exterior frame (plan view)

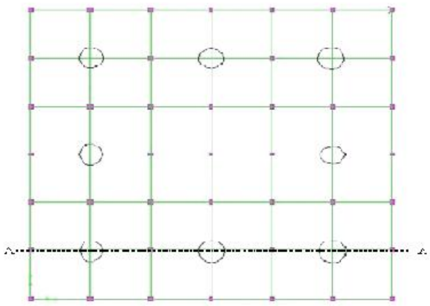

Figure 7a: Columns removed in middle of interior frame (plan view)

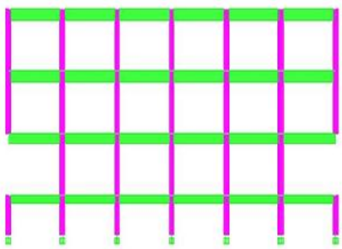

Figure 5b: Columns removed in edges of exterior frame in ground floor (elevation view)

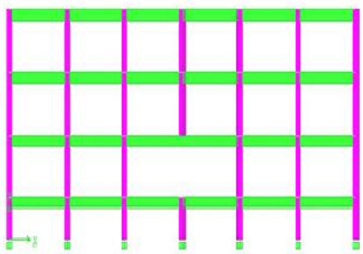

Figure 6b: Columns removed in outer face of exterior frame in ground floor (elevation view)

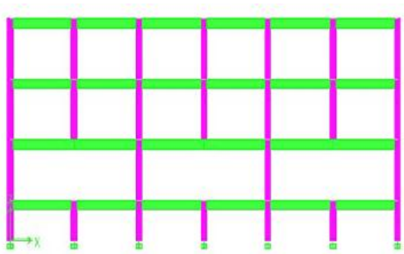

Figure 7b: Columns removed in middle of interior frame in ground floor (Section view A-A)

Table 1: Structural data for RCC structure

Dimension of building	30m X 30m		
Number of storeys	G+3	G+10	G+15
Height of each floor	3m	3m	3m
Beam dimension	300 X 450 mm	300 X 450 mm	300 X 450 mm
Column dimension	300 X 300 mm	450 X 450 mm	600 X 600 mm
Thickness of slab	150 mm	150 mm	150 mm
Thickness of exterior wall	230mm	230mm	230mm
Thickness of interior wall	150mm	150mm	150mm
Seismic zone	V	V	V
Zone factor	0.36	0.36	0.36
Importance factor	1	1	1
Type of soil	Medium soil	Medium soil	Medium soil
Response reduction factor	5	5	5
Live load	3kN/m^2	3kN/m^2	3kN/m^2
Floor finish	1.5 kN/m^2	1.5 kN/m^2	1.5 kN/m^2
Floor load on roof	1.5 kN/m^2	1.5 kN/m^2	1.5 kN/m^2
Wall load on exterior beam	12 kN/m	12kN/m	12kN/m
Wall load on interior beam	6 kN/m	6kN/m	6kN/m
Grade of concrete	M25	M25	M25
Grade of steel	Fe415	Fe415	Fe415

Table 2: Structural data for composite structure

Dimension of building	30m X 30m		
Number of storeys	G+3	G+10	G+15
Height of each floor	3m	3m	3m
Beam dimension	300 X 450 mm of ISMB 350	300 X 450 mm of ISMB 350	300 X 450 mm of ISMB 350
Column dimension	300 X 300 mm of ISHB 250	450 X 450 mm of ISHB 300	600 X 600 mm of ISHB 450
Thickness of deck slab	150mm with 20mm dia shear connectors	150mm with 20mm dia shear connectors	150mm with 20mm dia shear connectors
Thickness of exterior wall	230mm	230mm	230mm
Thickness of interior wall	150mm	150mm	150mm
Seismic zone	V	V	V
Zone factor	0.36	0.36	0.36
Importance factor	1	1	1
Type of soil	Medium soil	Medium soil	Medium soil
Response reduction factor	5	5	5
Live load	3kN/m^2	3kN/m^2	3kN/m^2
Floor finish	1.5 kN/m^2	1.5 kN/m^2	1.5 kN/m^2
Floor load on roof	1.5 kN/m^2	1.5 kN/m^2	1.5 kN/m^2
Wall load on exterior beam	12 kN/m	12kN/m	12kN/m
Wall load on interior beam	6 kN/m	6kN/m	6kN/m
Grade of concrete	M25	M25	M25
Grade of steel	Fe350	Fe350	Fe350

5. Results and discussion

The present study is to compare, how the behavior of RCC structure and composite structure with and without floating column in different zones and to find the critical position of floating column by linear static analysis.

Model 1: G+15 storeys RCC and composite building without floating column

Model 2: G+ 15 storeys RCC and composite building with floating column in outer face of exterior frame in ground floor

Model 3: G+ 15 storeys RCC and composite building with floating column in middle of interior frame in ground floor

Model 4: G+ 15 storeys RCC and composite building with floating column in edges of exterior frame in ground floor

Table 3: Storey displacement values of G+15 storey composite building in X-direction at zone V

Storey No.	Model 1-RCC	Model 1-Comp	Model 2-RCC	Model 2-Comp	Model 3-RCC	Model 3-Comp	Model 4-RCC	Model 4-Comp
1	2.208	1.765	2.353	1.883	2.36	1.884	2.43	1.962
2	9.984	7.997	10.422	8.339	10.521	8.41	10.69	8.57
3	18.924	15.258	19.589	15.776	19.532	15.722	20.1	16.218
4	28.187	22.802	29.059	23.481	28.813	23.279	29.818	24.138
5	37.522	30.408	38.595	31.244	38.152	30.889	39.605	32.118
6	49.651	39.982	50.922	40.973	50.28	40.462	52.194	42.068
7	61.611	49.418	63.079	50.559	62.239	49.896	64.616	51.879
8	73.21	58.567	74.87	59.859	73.838	59.045	76.672	61.401
9	84.303	67.317	86.152	68.758	84.931	67.7971	88.216	70.519
10	94.722	75.537	96.758	77.123	95.35	76.0178	99.082	79.102
11	104.282	83.081	106.503	88.811	104.912	83.563	109.087	87.007
12	112.789	89.79	115.186	91.663	113.415	90.274	118.028	94.074
13	120	95.493	122.589	97.507	120.64	95.98	125.688	100.133
14	125.715	100	128.48	102.161	126.3535	100.497	131.835	105.001
15	129.687	103.156	132.631	105.451	130.329	103.64	136.242	108.504
16	131.894	104.925	135.019	107.362	132.54	105.422	138.89	110.634

Table 4: Storey displacement values of G+15 storey composite building in Y-direction at zone V

Storey No.	Model 1-RCC	Model 1-Comp	Model 2-RCC	Model 2-Comp	Model 3-RCC	Model 3-Comp	Model 4-RCC	Model 4-Comp
1	2.208	1.1915	2.353	2.045	2.36	2.037	2.43	2.143
2	9.984	8.582	10.422	8.932	10.521	9.0044	10.69	9.178
3	18.924	16.17	19.589	16.696	19.532	16.633	20.1	17.161
4	28.187	23.983	29.059	24.672	28.813	24.454	29.818	25.361
5	37.522	31.839	38.595	32.687	38.152	32.311	39.605	33.6
6	49.651	42.307	50.922	43.314	50.28	42.778	52.194	44.458
7	61.611	52.624	63.079	53.788	62.239	53.093	64.616	55.166
8	73.21	62.625	74.87	63.943	73.838	63.093	76.672	65.553
9	84.303	72.187	86.152	73.657	84.931	72.654	88.216	75.497
10	94.722	81.166	96.758	82.786	95.35	81.633	99.082	84.854
11	104.282	89.404	106.503	91.172	104.912	89.871	109.087	93.467
12	112.789	96.728	115.186	98.642	113.415	97.196	118.028	101.162
13	120	102.949	122.589	105	120.64	103.418	125.688	107.753
14	125.715	107.865	128.48	110.069	126.3535	108.336	131.835	113.038
15	129.687	111.277	132.631	113.626	130.329	111.75	136.242	116.818
16	131.894	113.144	135.019	115.639	132.54	113.61	138.89	119.06

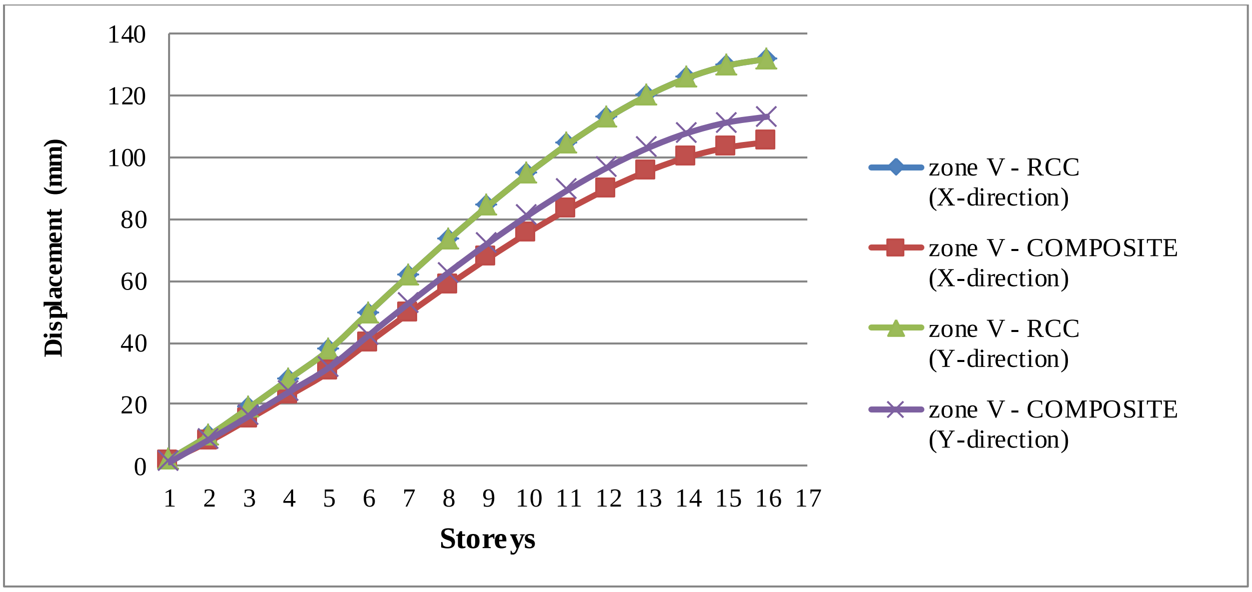

Figure 8: Storey Displacement value of G+ 15 storeys RCC and Composite building in X and Y direction without floating column at zone V

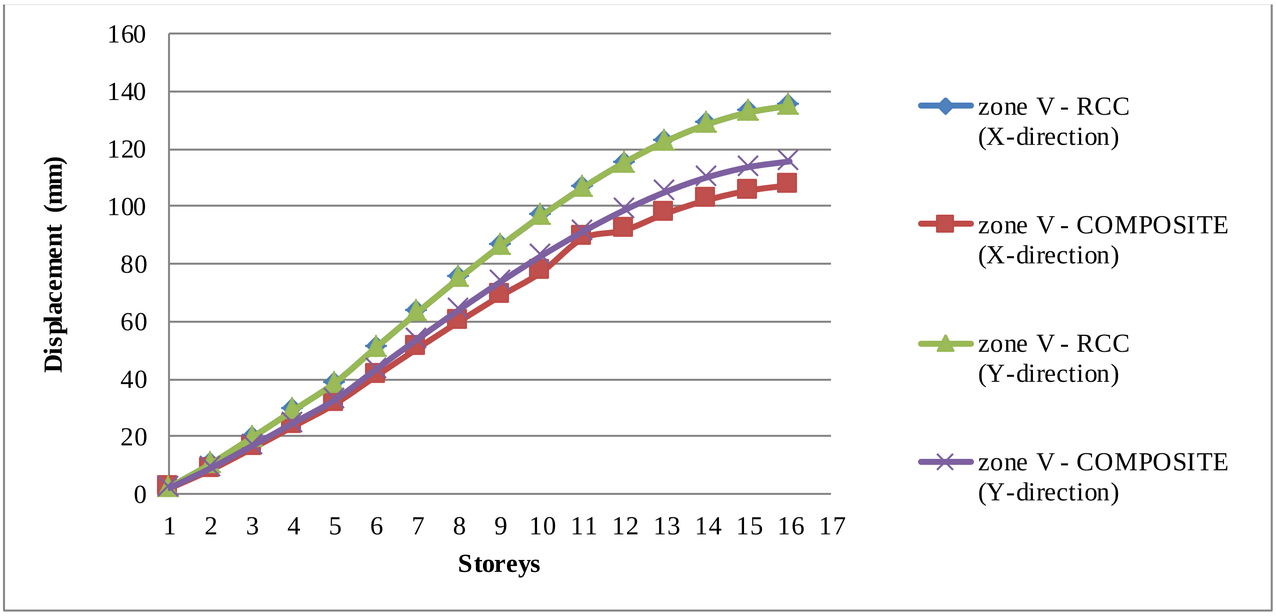

Figure 9: Storey Displacement value of G+ 15 storeys RCC and Composite building in X and Y direction with floating column in exterior position at zone V

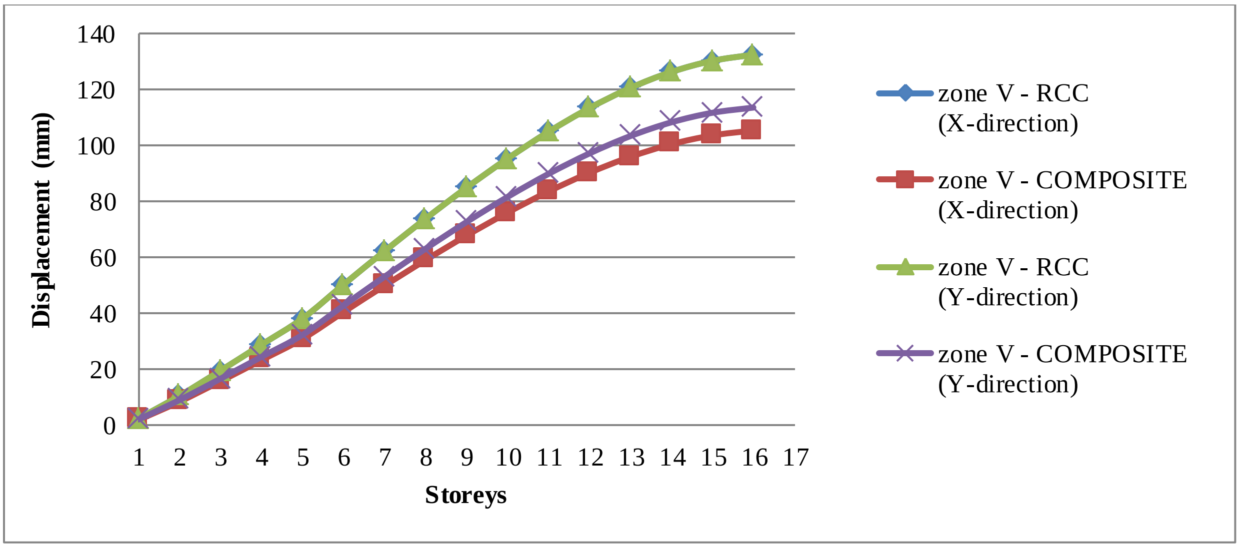

Figure 10: Storey Displacement value of G+ 15 storeys RCC and Composite building in X and Y direction with floating column in interior position at zone V

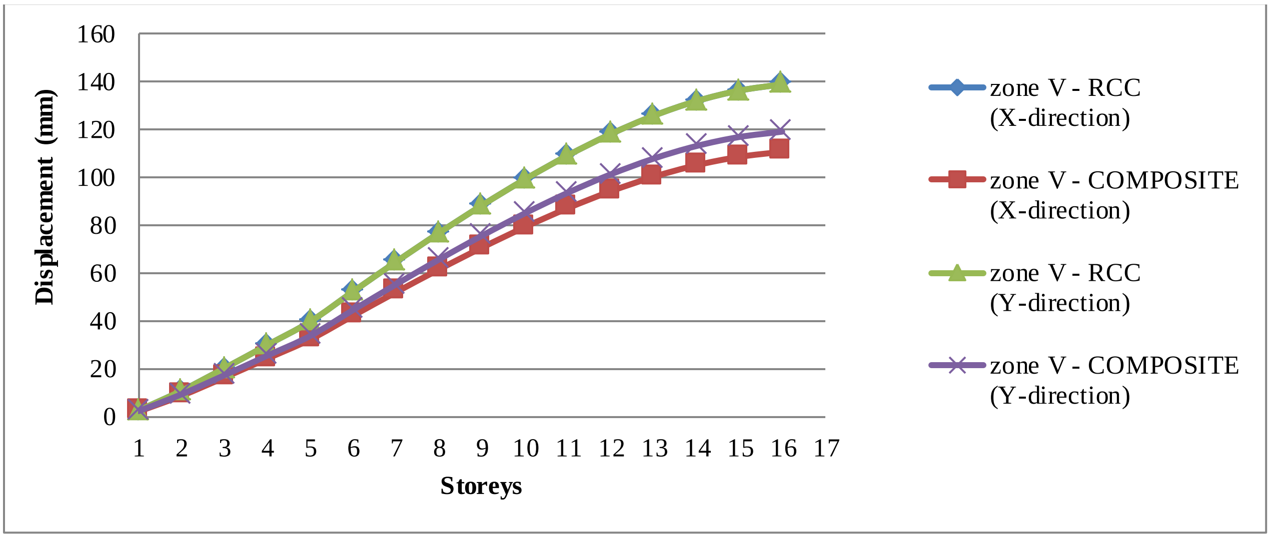

Figure 11: Storey Displacement value of G+ 15 storeys RCC and Composite building in X and Y direction with floating column in edges at zone V

From the tables and graphs the following observations are made in G+ 15 storeys building the displacement value obtained is as follows:

- Composite structure without floating column is decreased by 20.44% in X- direction and 14.21% in Y- direction when compared to RCC without floating column.
- Composite structure with floating column in outer face of exterior frame is decreased by 20.61% in X- direction and 14.35% in Y- direction when compared to RCC with floating column outer face of exterior frame.
- Composite structure with floating column in middle of interior frame is decreased by 20.44% in X- direction and 14.26% in Y- direction when compared to RCC with floating column in middle of interior frame.

- Composite structure with floating column in edges of exterior frame is decreased by 20.34% in X- direction and 14.28% in Y- direction when compared to RCC with floating column in edges of exterior frame.

Table 5: Storey drift values of G+15 storey composite building in X-direction at zone V

Storey No.	Model 1-RCC	Model 1-Comp	Model 2-RCC	Model 2-Comp	Model 3-RCC	Model 3-Comp	Model 4-RCC	Model 4-Comp
1	1.144	0.909	1.222	0.978	1.382	1.104	1.23	0.979
2	2.592	2.077	2.69	2.154	2.72	2.175	2.758	2.213
3	2.98	2.42	3.056	2.479	3.004	2.437	3.137	2.549
4	3.088	2.515	3.157	2.568	3.094	2.519	3.239	2.64
5	3.112	2.535	3.179	2.588	3.113	2.536	3.262	2.66
6	4.043	3.191	4.109	3.243	4.043	3.191	4.196	3.317
7	3.987	3.145	4.052	3.196	3.986	3.144	4.141	3.27
8	3.866	3.05	3.931	3.1	3.866	3.05	4.019	3.174
9	3.698	2.917	3.761	2.966	3.698	2.917	3.848	3.039
10	3.473	2.74	3.535	2.788	3.473	2.74	3.622	2.861
11	3.187	2.515	3.348	2.563	3.187	2.515	3.335	2.635
12	2.834	2.236	2.894	2.284	2.834	2.237	2.98	2.356
13	2.407	1.901	2.468	1.984	2.408	1.902	2.553	2.02
14	1.903	1.505	1.964	1.551	1.908	1.506	2.049	1.623
15	1.324	1.05	1.384	1.096	1.325	1.051	1.469	1.168
16	0.736	0.59	0.796	0.637	0.737	0.591	0.884	0.71

Table 6: Storey drift values of G+15 storey composite building in Y-direction at zone V

Storey No.	Model 1-RCC	Model 1-Comp	Model 2-RCC	Model 2-Comp	Model 3-RCC	Model 3-Comp	Model 4-RCC	Model 4-Comp
1	1.144	0.986	1.222	1.063	1.382	1.212	1.23	1.059
2	2.592	2.223	2.69	2.299	2.72	2.322	2.758	2.362
3	2.98	2.529	3.056	2.588	3.004	2.543	3.137	2.661
4	3.088	2.604	3.157	2.659	3.094	2.607	3.239	2.733
5	3.112	2.618	3.179	2.672	3.113	2.619	3.262	2.746
6	4.043	3.487	4.109	3.542	4.043	3.489	4.196	3.619
7	3.987	3.439	4.052	3.491	3.986	3.438	4.141	3.569
8	3.866	3.334	3.931	3.385	3.866	3.333	4.019	3.463
9	3.698	3.187	3.761	3.238	3.698	3.187	3.848	3.315
10	3.473	2.993	3.535	3.045	3.473	2.993	3.622	3.119
11	3.187	2.746	3.348	2.795	3.187	2.746	3.335	2.871
12	2.834	2.441	2.894	2.49	2.834	2.441	2.98	2.565
13	2.407	2.074	2.468	2.122	2.408	2.074	2.553	2.197
14	1.903	1.639	1.964	1.687	1.908	1.639	2.049	1.762
15	1.324	1.137	1.384	1.185	1.325	1.138	1.469	1.26
16	0.736	0.622	0.796	0.671	0.737	0.623	0.884	0.747

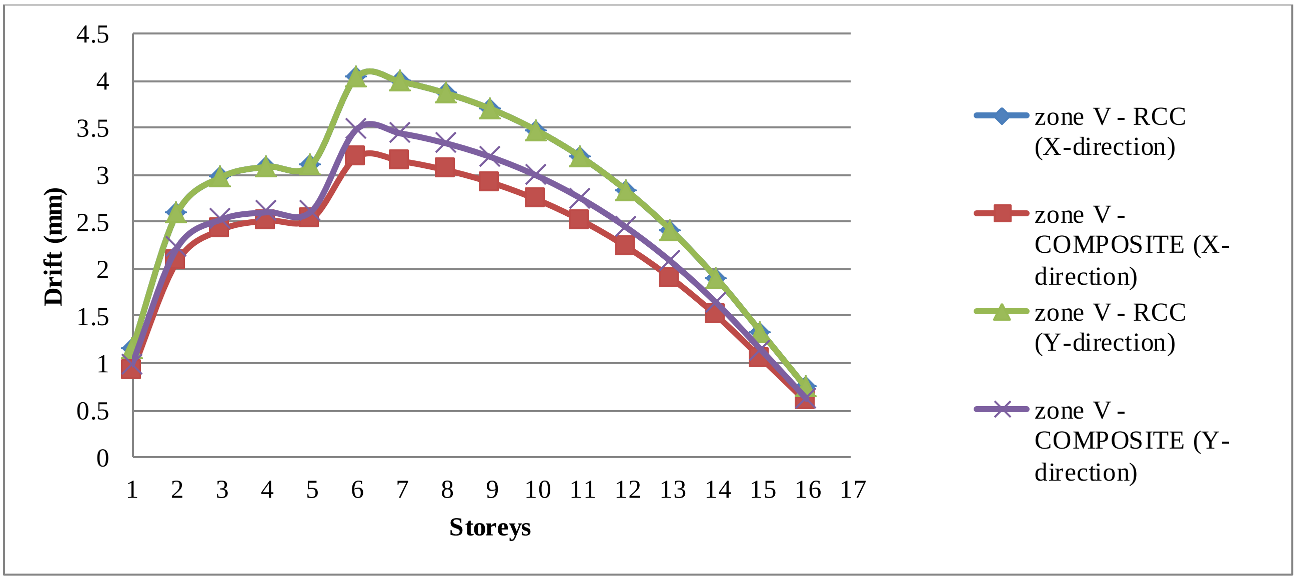

Figure 12: Storey drift value of G+ 15 storeys RCC and Composite building in X and Y direction without floating column at zone V

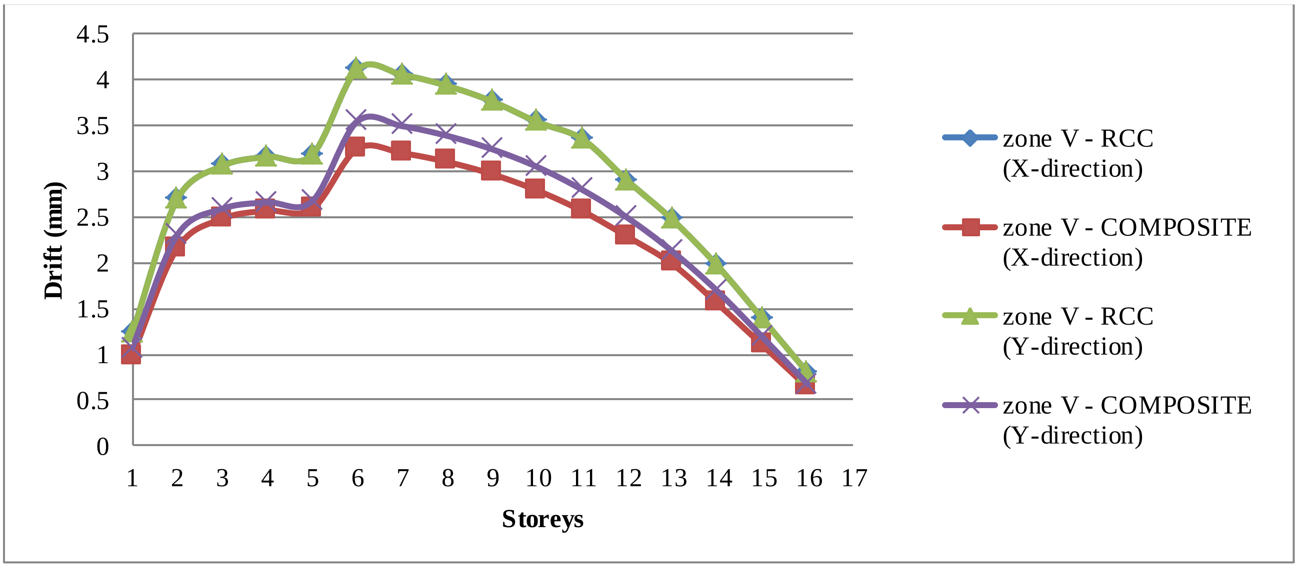

Figure 13: Storey drift value of G+ 15 storeys RCC and Composite building in X and Y direction with floating column in exterior position at zone V.

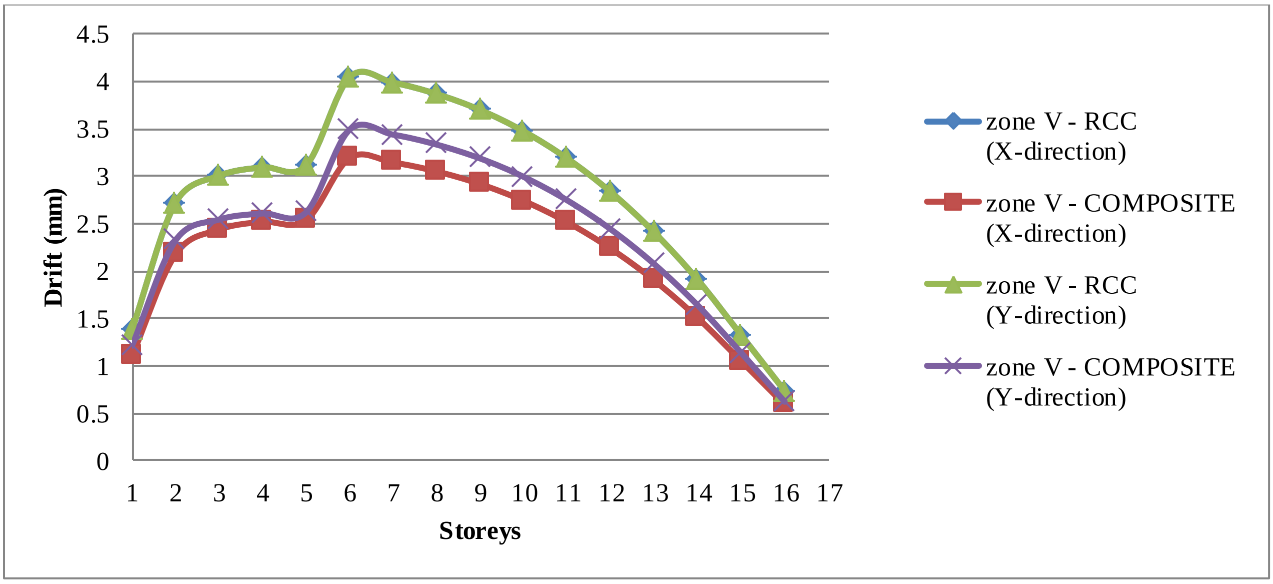

Figure 14: Storey drift value of G+ 15 storeys RCC and Composite building in X and Y direction with floating column in interior position at zone V.

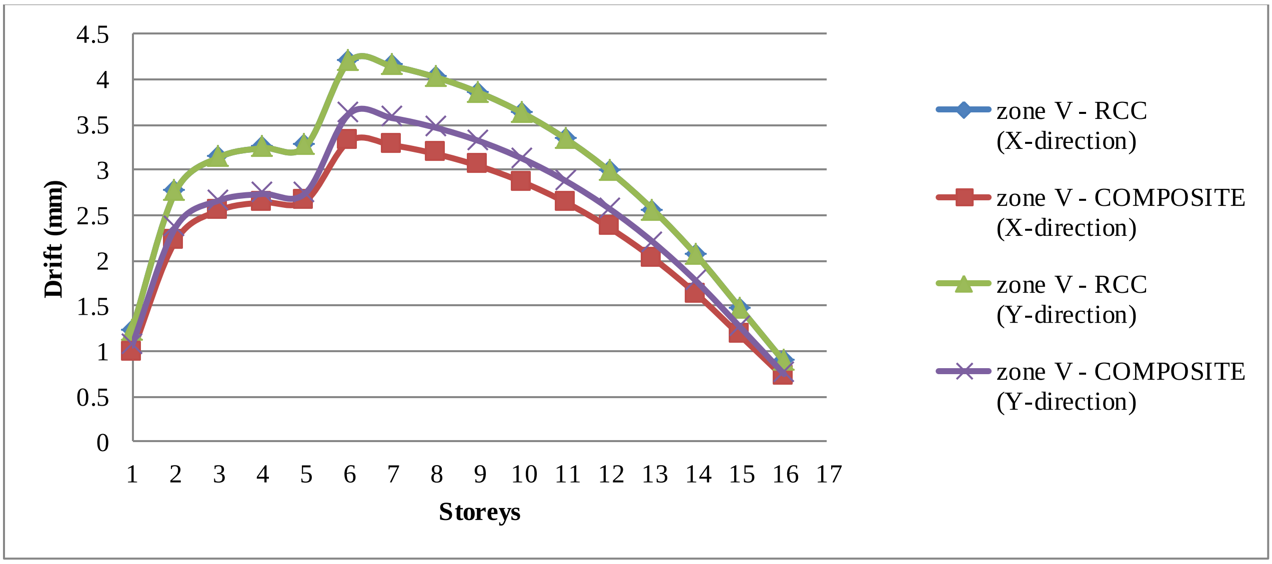

Figure 15: Storey drift value of G+ 15 storeys RCC and Composite building in X and Y direction with floating column in edges at zone V.

From the tables and graphs the following observations are made in G+ 15 storeys building the drift value obtained is as follows:

- Composite structure without floating column is decreased by 21.1% in X- direction and 13.7% in Y- direction when compared to RCC without floating column.
- Composite structure with floating column in outer face of exterior frame is decreased 21% in X- direction and 13.7% in Y- direction when compared to RCC with floating column outer face of exterior frame.
- Composite structure with floating column in middle of interior frame is decreased by 21.1% in X- direction and 13.7% in Y- direction when compared to RCC with floating column in middle of interior frame.

- Composite structure with floating column in edges of exterior frame is decreased by 21% in X- direction and 13.8% in Y- direction when compared to RCC with floating column in edges of exterior frame.

Table 7: Storey Shear values of G+ 15 storeys RCC and composite building in zone V

Storey No.	Model 1-RCC	Model 1-Comp	Model 2-RCC	Model 2-Comp	Model 3-RCC	Model 3-Comp	Model 4-RCC	Model 4-Comp
1	7527.91	7685.22	7526.76	7684.01	7525.99	7683.23	7526.56	7683.79
2	7526.52	7683.77	7525.36	7682.57	7524.6	7681.8	7525.17	7682.35
3	7509.58	7666.49	7508.43	7665.29	7507.67	7664.25	7508.24	7665.07
4	7466.22	7622.25	7546.08	7621.06	7464.32	7620.29	7464.88	7620.85
5	7384.24	7538.62	7383.12	7537.44	7382.37	7535.88	7382.92	7537.22
6	7255.05	7406.86	7253.94	7405.7	7253.21	7404.95	7253.76	7405.49
7	7069.09	7217.2	7068.01	7216.07	7067.29	7215.34	7067.82	7215.87
8	6811.69	6954.7	6810.65	6953.61	6809.96	6952.91	6810.47	6953.41
9	6470.29	6607.54	6470.3	6606.5	6469.64	6605.84	6470.13	6606.32
10	6036.29	6163.91	6030.37	6162.94	6034.76	6162.32	6035.21	6162.77
11	5495.12	5612	5949.28	5611.12	5493.73	5610.55	5494.14	5610.96
12	4836.19	4393.99	4835.45	4939.22	4834.96	4938.72	4835.32	4939.08
13	4047.92	4136.07	4047.3	4135.43	4046.89	4135.01	4047.19	4135.31
14	3118.72	3188.44	3118.25	3187.94	3117.93	3187.62	3118.17	3187.85
15	2037.02	2085.27	2036.71	2084.95	2036.51	2084.74	2036.66	2084.89
16	791.23	814.76	791.11	814.63	791.03	814.55	791.09	814.61

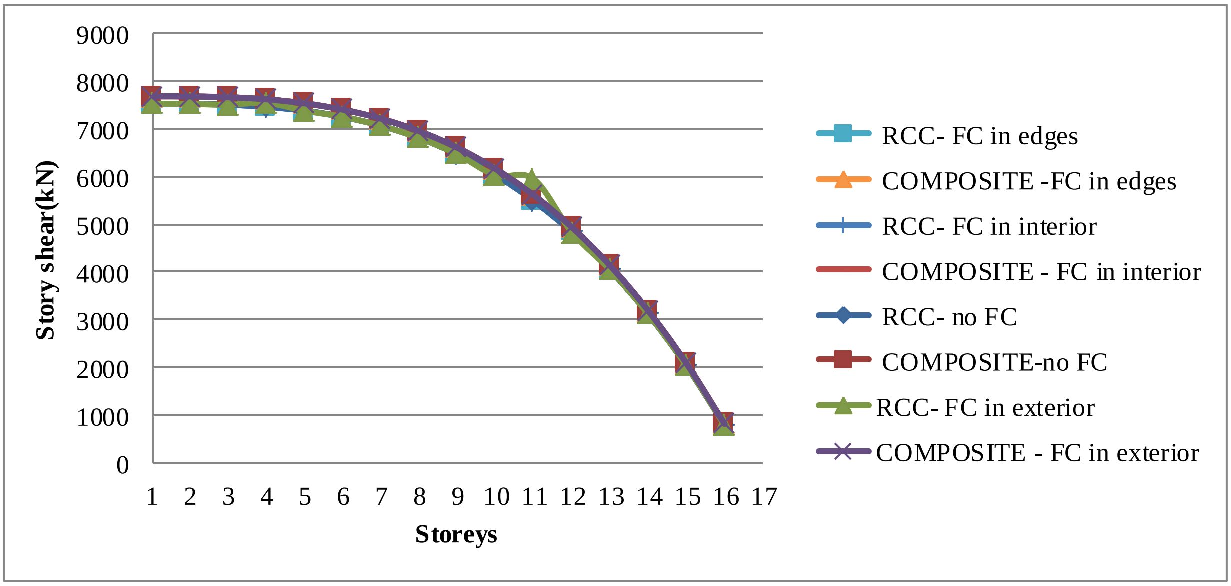

Figure 16: Storey shear value **of G+ 15 storeys RCC and Composite building at zone V.**

From the table and graph the following observations are made in G+ 15 storeys building the drift value obtained is as follows:

- The base shear value of composite is 2% more compare to RCC in zone V G+15 storey building
-

6. Conclusions

- Displacement in composite building with and without floating column is less when compare RCC building with and without floating column.
- The floating column provided in edges of outer face of building is more critical because it shows more displacement and drift values in both composite and RCC building.
- Storey shear value will be more for lower floors, than the higher floors due to the reduction in weight when we go from bottom to top floors.
- The base shear value decreased due to introduction of floating column i.e. reduction in mass of column in both RCC and composite structure.
- The base shear values obtained in composite is more than RCC in our study due to increase in weight of structure which can be reduced by using smaller size I-section in steel concrete composite section so that it becomes economical in high rise building.

Reference

[1] **Euro Code 4** ,*"Design of composite steel and concrete structure"*, European committee for standardization.

[2] **IS- 1893: PartI (2002),** *"Criteria for Earthquake Resistant Design of Structures",* Bureau of Indian Standards, New Delhi.

[3] **IS-11384:**1985, *"code of practice for design of composite structure"*, Bureau of Indian Standards, New Delhi.

[4] **Isha Rohilla ,Gupta S.M. et.al,** "Seismic response of multi- storey irregular building with floating column", *International journal of engineering research and technology,* Vol4.,issue 3,Mar-2015, pp 506-518.

[5] **Kavya.N, Manjunatha.K et.al,** "Seismic evaluation of multistory RC building with and without floating column", *International journal of engineering research and technology,* Vol.2.,issue 6,Sep-2015, pp 361-365.

[6] **Mundada.A.P and Sawdatkar.S.G.,** "Comparative seismic analysis of multistory building with and without floating column", *International Journal of current Engineering and technology*, vol.4, No.5, Oct-2014, pp 3395-3400.

[7] **Nikhil Bandwal, Anant Pande et.al,** "To study seismic behaviour of RC building with floating columns", *International journal of scientific engineering and technology research,* vol.03,issue.08,May-2014, pp1593-1596.

[8] **Shweta.A. Wagh and Waghe.U.P,** "Comparative study of RCC and steel concrete composite structures", *International journal of engineering research and application,* vol.4, issue4 (version 1), April-2014, pp 369-376.

[9] **Swapnil.B.Cholekar and Basavlingappa.S.M,** "Comparative analysis of multistoried RCC and composite building due to mass irregularity", *International research journal of engineering and technology,* vol.2, issue.4,July-2015, pp-603-608.