EFFECT OF FLOATING COLUMN ON THE BEHAVIOUR OF COMPOSITE MULTISTORIED BUILDING SUBJECTED TO SEISMIC LOAD

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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 steel concrete composite structure with floating column in different positions in plan, in buildings of various heights such as G+3, G+10 and G+15 in lower and higher earthquake prone zones. Linear static analysis is carried using ETABS software, Comparison of various parameters such as storey shear, storey drift and storey displacement is done.*

Key words:*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.

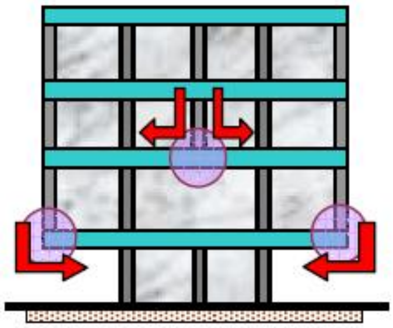

Fig- 1: Hanging or floating column

In the past, for the design of a building, the choice was normally between concrete structure and masonry structure. But the failure of many multi-storied and low rise RCC and masonry building due to earthquake has forced the structural engineers to look for alternative method of construction. Steel concrete composite systems have become quite popular in recent times because of their advantages against conventional construction. Composite construction combines the better properties of the both i.e. concrete and steel results in speedy construction, extremely economical structural systems with high durability, rapid erection and superior seismic performance characteristics.

2. LITERATURE REVIEW

IshaRohilla, S.M. Gupta, BabitaSaini [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.Manjunathaand 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 analysisis 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.Shweta.A.Wagh and Dr.U.P.Waghe[7], have done comparative study of R.C.C. with Steel Concrete Composite (G+12, G+16, G+20, G+24) story buildings which situated in Nagpur earthquake zone II and wind speed 44m/s. Equivalent Static Method of Analysis is used. For modeling of Composite & R.C.C. structures, STAAD-Pro software is used and the results are compared. Comparative study includes deflection, axial force and shear force, bending moment in column and beam, cost. It is found that composite structure is more economical and speedy than R.C.C structure.Prof.Swapnil B. Cholekar and Basavalingappa.S.M[8] 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 stiffer than RC and it is economical with speedy construction we carry out a linear static analysis to know the behaviour of composite structure with and without floating column.

3.OBJECTIVES

1) To study the behaviour of composite multistorey building of various height.
2) To study the behaviour of composite structure at different zones with floating column in different positions in plan area.
3) To find the critical position of floating column in composite structure.

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 two different Seismic zones at Zone II and Zone V. Table shows the details of model and the load considered, Figure shows the positions of floating column considered in building.

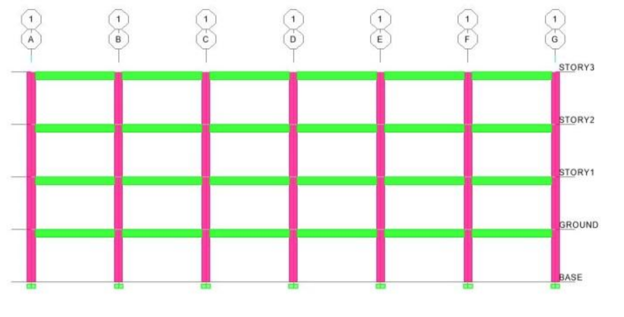

Fig- 2: Elevation of G+3 storey building

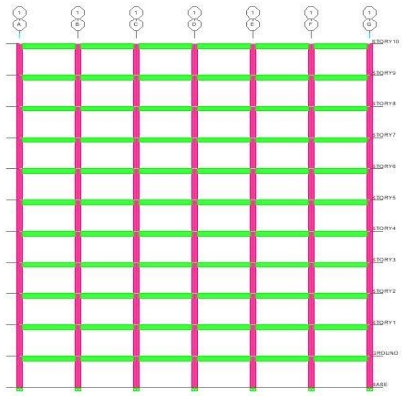

Fig- 3: Elevation of G+10 storey building

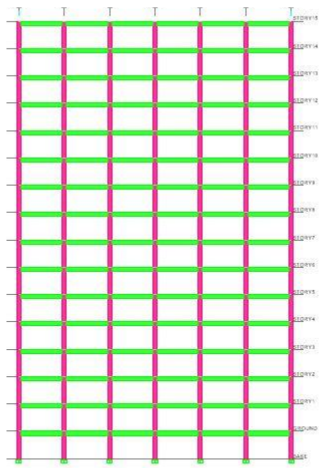

Fig-4: Elevation of G+15 storey building

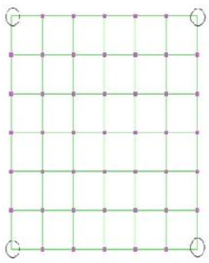

Fig- 5a: Columns removed in edges of exterior frame (plan view)

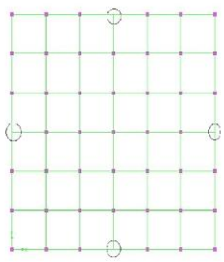

Fig- 6a: Columns removed in outer face of exterior frame (plan view)

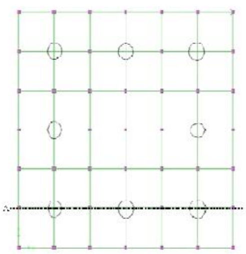

Fig- 7a: Columns removed in middle of interior frame (plan view)

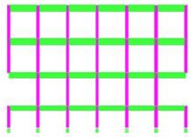

Fig- 5b: Columns removed in edges of exterior frame in ground floor (elevation view)

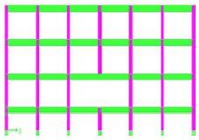

Fig-6b: Columns removed in outer face of exterior frame in ground floor (elevation view)

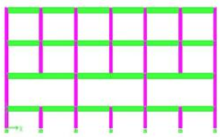

Fig-7b: Columns removed in middle of interior frame in ground floor (Section view A-A)

Table-1: 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	II	V	II	V	II	V
Zone factor	0.10	0.36	0.10	0.36	0.10	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/m²		3kN/m²		3kN/m²	
Floor finish	1.5 kN/m²		1.5 kN/m²		1.5 kN/m²	
Floor load on roof	1.5 kN/m²		1.5 kN/m²		1.5 kN/m²	
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

The present study is to compare, how the behavior of composite structure with and without floating column in different zones and to find the critical position of floating column by linear static analysis. The results obtained in terms of displacement, storey drift and storeys shear.

Model 1 (M-1): G+15 storey composite building without floating column

Model 2 (M-2): G+15 storey composite building with floating column in outer face of exterior frame in ground floor

Model 3 (M-3): G+15 storey composite building with floating column in middle of interior frame in ground floor

Model 4 (M-4): G+15 storey composite building with floating column in edges of exterior frame in ground floor

Table-2: Storey drift values of G+15 storey composite building in X-direction

Storey No.	M-1 Zone II	M-1 Zone V	M- 2 Zone II	M- 2 Zone V
1	0.253	0.909	0.272	0.978
2	0.577	2.077	0.598	2.154
3	0.672	2.42	0.689	2.479
4	0.699	2.515	0.713	2.568
5	0.704	2.535	0.719	2.588
6	0.886	3.191	0.901	3.243
7	0.874	3.145	0.888	3.196
8	0.847	3.05	0.816	3.1
9	0.81	2.917	0.824	2.966
10	0.761	2.74	0.775	2.788
11	0.669	2.515	0.712	2.563
12	0.612	2.236	0.634	2.284
13	0.528	1.901	0.541	1.984
14	0.418	1.505	0.431	1.551
15	0.292	1.05	0.305	1.096
16	0.164	0.59	0.117	0.637

Storey No.	M- 3 ZoneII	M-3 Zone V	M- 4 ZoneII	M-4 Zone V
1	0.307	1.104	0.272	0.979
2	0.604	2.175	0.615	2.213
3	0.677	2.437	0.708	2.549
4	0.7	2.519	0.733	2.64
5	0.705	2.536	0.739	2.66
6	0.886	3.191	0.921	3.317
7	0.873	3.144	0.908	3.27
8	0.897	3.05	0.882	3.174
9	0.81	2.917	0.844	3.039
10	0.761	2.74	0.795	2.861
11	0.669	2.515	0.732	2.635
12	0.621	2.237	0.654	2.356
13	0.528	1.902	0.516	2.02
14	0.418	1.506	0.451	1.623
15	0.292	1.051	0.324	1.168
16	0.164	0.591	0.197	0.71

Table-3: Storey drift values of G+15 storey composite building in Y-direction

Storey No.	M-1 Zone II	M-1 Zone V	M- 2 Zone II	M- 2 Zone V
1	0.274	0.986	0.295	1.063
2	0.617	2.223	0.639	2.299
3	0.703	2.529	0.719	2.588
4	0.723	2.604	0.739	2.659
5	0.727	2.618	0.742	2.672
6	0.969	3.487	0.984	3.542
7	0.955	3.439	0.97	3.491
8	0.926	3.334	0.94	3.385
9	0.885	3.187	0.899	3.238
10	0.831	2.993	0.845	3.045
11	0.763	2.746	0.776	2.795
12	0.678	2.441	0.692	2.49
13	0.576	2.074	0.589	2.122
14	0.455	1.639	0.469	1.687
15	0.316	1.137	0.329	1.185
16	0.173	0.622	0.186	0.671

Storey No.	M- 3 Zone II	M-3 Zone V	M- 4 Zone II	M-4 Zone V
1	0.337	1.212	0.294	1.059
2	0.645	2.322	0.656	2.362
3	0.706	2.543	0.739	2.661
4	0.724	2.607	0.759	2.733
5	0.727	2.619	0.763	2.746
6	0.969	3.489	1.005	3.619
7	0.955	3.438	0.991	3.569
8	0.98	3.333	0.962	3.463
9	0.885	3.187	0.921	3.315
10	0.831	2.993	0.886	3.119
11	0.763	2.746	0.797	2.871
12	0.678	2.441	0.713	2.565
13	0.576	2.074	0.61	2.197
14	0.45	1.639	0.489	1.762
15	0.316	1.138	0.35	1.26
16	0.173	0.623	0.208	0.747

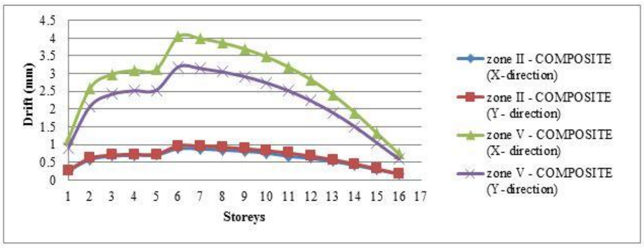

Chart-1: Drift value of G+ 15 storeys building in X and Y direction without floating column at zone II and zone V.

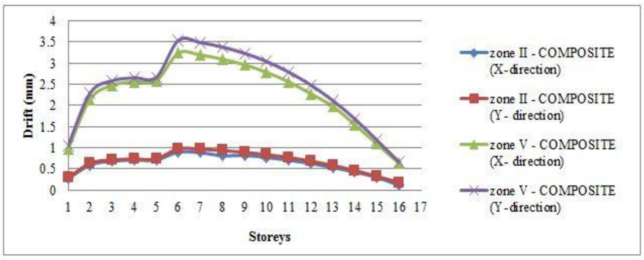

Chart-2: Drift value of G+ 15 storeys building in X and Y direction with floating column in exterior position at zone II and zone V

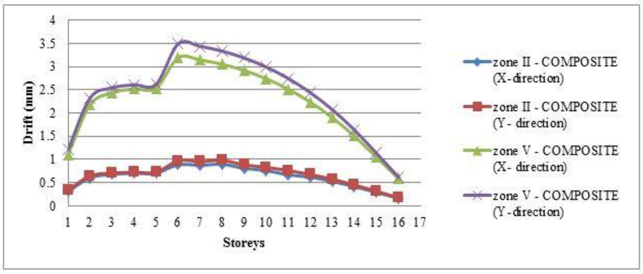

Chart-3: Drift value of G+ 15 storeys building in X and Y direction with floating column in interior position at zone II and zone V.

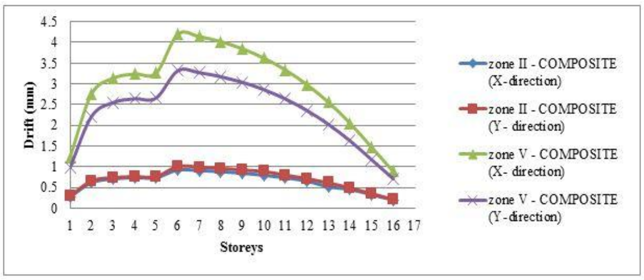

Chart-4: Drift value of G+ 15 storeys building in X and Y direction with floating column in edges at zone II and zone V

Table-4: Storey displacement values of G+15 storey composite building in X-direction

Storey No.	M-1 Zone II	M-1 Zone V	M- 2 Zone II	M- 2 Zone V
1	0.49	1.765	0.523	1.883
2	2.221	7.997	2.316	8.339
3	4.238	15.258	4.382	15.776
4	6.334	22.802	6.522	23.481
5	8.446	30.408	8.679	31.244
6	11.16	39.982	11.381	40.973
7	13.726	49.418	14.044	50.559
8	16.268	58.567	16.627	59.859
9	18.699	67.317	19.099	68.758
10	20.982	75.537	21.423	77.123
11	23.078	83.081	23.558	88.811
12	24.941	89.79	25.462	91.663
13	26.526	95.493	27.085	97.507
14	27.778	100	28.378	102.161
15	28.654	103.156	29.291	105.451
16	29.145	104.925	29.022	107.362

Storey No.	M- 3 Zone II	M-3 Zone V	M- 4 Zone II	M-4 Zone V
1	0.523	1.884	0.545	1.962
2	2.336	8.41	2.38	8.57
3	4.367	15.722	4.505	16.218
4	6.466	23.279	6.705	24.138
5	8.58	30.889	8.921	32.118
6	11.239	40.462	11.685	42.068
7	13.86	49.896	14.41	51.879
8	16.401	59.045	17.055	61.401
9	18.832	67.7971	19.588	70.519
10	21.116	76.0178	21.973	79.102
11	23.212	83.563	24.168	87.007
12	25.076	90.274	26.131	94.074
13	26.661	95.98	27.814	100.133
14	27.915	100.497	29.167	105.001
15	28.791	103.64	30.14	108.504
16	29.284	105.422	30.731	110.634

Table-5: Storey displacement values of G+15 storey composite building in Y-direction

Storey No.	M-1 Zone II	M-1 Zone V	M- 2 Zone II	M- 2 Zone V
1	0.531	1.1915	0.568	2.045
2	2.384	8.582	2.481	8.932
3	4.491	16.17	4.637	16.696
4	6.662	23.983	6.853	24.672
5	8.844	31.839	9.079	32.687
6	11.752	42.307	12.031	43.314
7	14.617	52.624	14.941	53.788
8	17.396	62.625	17.621	63.943
9	20.052	72.187	20.46	73.657

10	22.546	81.166	22.996	82.786
11	24.834	89.404	25.325	91.172
12	26.869	96.728	27.4	98.642
13	28.596	102.949	29.169	105
14	29.962	107.865	30.575	110.069
15	30.904	111.277	31.562	113.626
16	31.429	113.144	32.122	115.639

Storey No.	M- 3 Zone II	M-3 Zone V	M- 4 Zone II	M-4 Zone V
1	0.565	2.037	0.595	2.143
2	2.501	9.0044	2.549	9.178
3	4.62	16.633	4.767	17.161
4	6.793	24.454	7.044	25.361
5	8.975	32.311	9.333	33.6
6	11.882	42.778	12.349	44.458
7	14.748	53.093	15.323	55.166
8	17.525	63.093	18.209	65.553
9	20.181	72.654	20.971	75.497
10	22.676	81.633	23.57	84.854
11	24.964	89.871	25.963	93.467
12	26.998	97.196	28.1	101.162
13	28.727	103.418	29.931	107.753
14	30.093	108.336	31.399	113.038
15	31.041	111.75	32.449	116.818
16	31.561	113.61	33.072	119.06

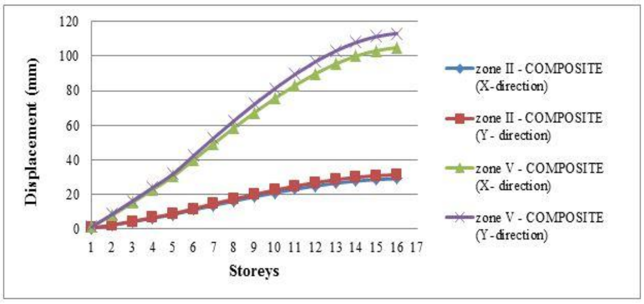

Chart-5: Displacement value of G+ 15 storeys building in X and Y direction without floating column at zone II and zone V

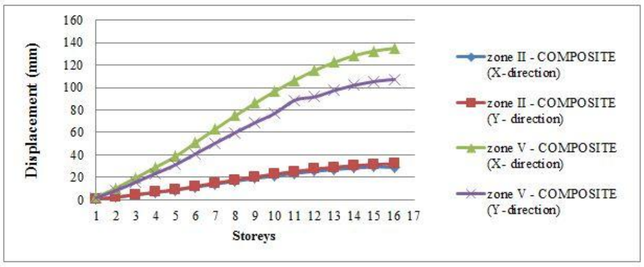

Chart-6: Displacement value of G+ 15 storeys building in X and Y direction with floating column in exterior position at zone II and zone V

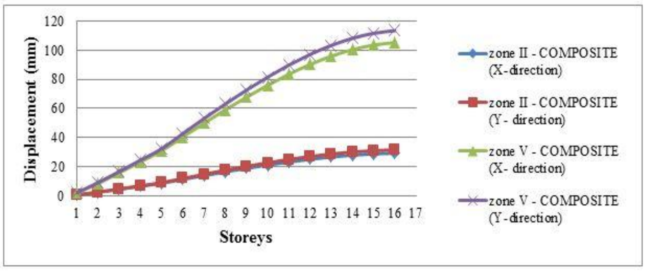

Chart-7: Displacement value of G+ 15 storeys building in X and Y direction with floating column in interior position at zone II and zone V

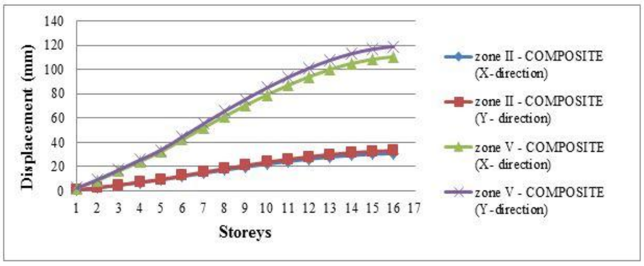

Chart-8: Displacement value of G+ 15 storeys building in X and Y direction with floating column in interior position at zone II and zone V

Table-6: Storey Shear values of G+15 storey composite building.

Storey No.	M-1 Zone II	M-1 Zone V	M- 2 Zone II	M- 2 Zone V
1	2134.78	7685.22	2134.45	7684.01
2	2134.38	7683.77	2134.05	7682.57
3	2129.58	7666.49	2129.25	7665.29
4	2117.29	7622.25	2116.96	7621.06
5	2094.06	7538.62	2093.73	7537.44
6	2057.46	7406.86	2057.14	7405.7
7	2004.78	7217.2	2004.46	7216.07
8	1931.86	6954.7	1931.56	6953.61
9	1835.43	6607.54	1835.14	6606.5
10	1712.2	6163.91	1711.93	6162.94
11	1558.86	5612	1558.64	5611.12
12	1372.22	4393.99	1372	4939.22
13	1148.91	4136.07	1148.73	4135.43
14	885.68	3188.44	885.54	3187.94
15	579.24	2085.27	579.15	2084.95
16	226.32	814.76	226.29	814.63

Storey No.	M- 3 Zone II	M-3 Zone V	M- 4 Zone II	M-4 Zone V
1	2134.23	7683.23	2134.39	7683.79
2	2133.83	7681.8	2133.99	7682.35
3	2129.03	7664.25	2129.19	7665.07
4	2116.75	7620.29	2116.9	7620.85

5	2093.52	7535.88	2093.67	7537.22
6	2056.93	7404.95	2057.08	7405.49
7	2004.26	7215.34	2004.41	7215.87
8	1931.36	6952.91	1931.5	6953.41
9	1834.96	6605.84	1835.09	6606.32
10	1711.76	6162.32	1711.88	6162.77
11	1558.49	5610.55	1558.6	5610.96
12	1371.87	4938.72	1371.97	4939.08
13	1148.61	4135.01	1148.7	4135.31
14	885.47	3187.62	885.51	3187.85
15	579.09	2084.74	579.14	2084.89
16	226.26	814.55	226.28	814.61

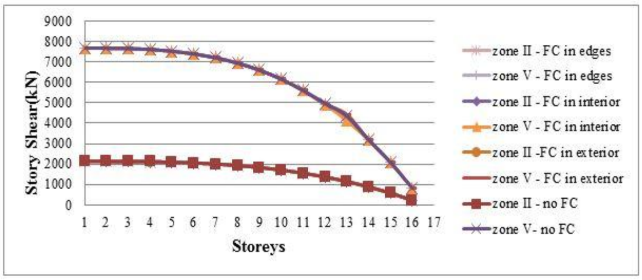

Chart-9: Storey shear value of G+ 15 storeys building at zone II and zone V

6. CONCLUSIONS

In the present investigation, an attempt has been made to compare the seismic behaviour of multi-storeyed composite structures with and without floating column, and the following are the conclusions are drawn from observing the above graphs. The analysis outputs were noted in terms of storey displacements, storey drifts, and storey shear and were tabulated on the basis of linear static analysis. Based on the study the conclusions are as follows:

- The displacement of building increases from lower zone to higher zone, because the magnitude of intensity will be more for higher zones, similarly for drift, because it is correlated with the displacement. The obtained displacement and drift values are within the limit according to code IS 1893(part-1):2002.
- 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 composite structure.
- The floating column provided in edges of outer face of building is more critical because it shows more displacement and drift values in composite building.
- The multi storey building with floating column undergoes large displacement than model having no floating column.

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