Study of Multi-Storey Building with & without Floating Column

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Abstract- *In this project analysis and design of a G+14 RC building is done by introducing the floating column in different conditions such as internal floating column, external floating column and alternate level floating column for determining parameter like displacement, forces and moments is done by using ETABS software. Also conclusion is carried out on the basis of following ways. Significant outcome of the study includes, provision of Internal and External floating columns increases the torsion values at all floors and provision of alternate level floating column there is reduction in torsion value. Provision of Internal floating columns & Alternate floor floating columns may increase displacement at various nodes. Introduction of floating column increases torsion in beam at all floors for all zones. The quantity of steel and concrete gets increase as compared to the individual cases due to floating column so floating column may be provided at appropriate places as per requirement of the plan.*

Keywords- Floating Columns, Seismic Zones, Critical Load Combinations, Response Spectrum etc.

I. INTRODUCTION

A typical Column is a vertical structural member which support to horizontal structural members by means of their weights, moments, and shear force, axial load etc., to keep the structure in safe condition and transfer these loads to the ground. But now a day's some columns are designed in such a manner that it does not reach to the ground, because of various architectural aspects. In those cases the columns transfer above loads as a point load on a beam. This type of column is termed as Floating column. This Point load increases too much bending moment on beam so that area of steel required will be more in such cases. While earthquake occurs, the building with floating columns damages more as compared to the building without any floats columns because of discontinuity of structure & load transfer path

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The overall size, shape and geometry of a structure play a very important roll to keep structure safe while earthquake occurs. As theory and practical study on buildings says that, earthquake forces developed at different floor levels in a building needs to be brought down along the height to the ground by the shortest path; any deviation of discontinuity in this load transfer path results in poor performance of the building. In Earthquake analysis the main response parameters are storey displacement, Storey drift, storey shear. These parameters are evaluated in this paper and critical position of floating column building is observed. In this critical position the effect of increasing section of beam and column in irregular building and regular building has been observed.

The Response of a structure to the ground vibration is a function of the nature of foundation soil; materials, form, size and mode of construction of structure; and the duration and characteristics of ground motion. IS 1893 (part I):2002 specifies the various criteria for design of structure considering earthquake zones, type of structure, soil type, Importance factor of structure, response reduction factor etc. The basic criteria of earthquake resistant design should be based on lateral strength as well as deformability and ductility capacity of structure with limited damage, but no collapse.

A. ADVANTAGES AND DISADVANTAGES OF FLOATING COLUMNS

1. Advantages

- By using floating columns large functional space can be provided which can be utilizing for storage and parking.
- In some situations floating columns may prove to be economical in some cases.
- The floating column is important for dividing the rooms and some portion can raise without whole area

2. Disadvantages

- Not suitable in high seismic zone since abrupt change in stiffness was observed.
- Required large size of girder beam to support floating column.
- Floating columns leads to stiffness irregularities in building.

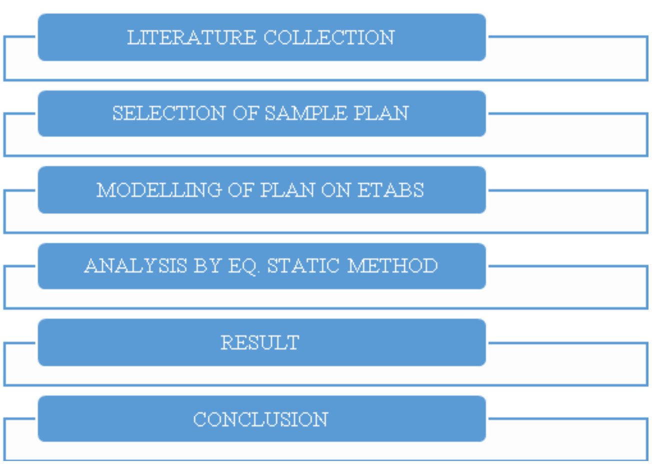
- Flow of load path increases by providing floating columns. The load from structural members shall be transfer to the foundation by the shortest possible path.

B. OBJECTIVES

- The objective of the present work is to study the behaviour of multi-storey buildings with and without floating columns under earthquake excitations.
- Seismic Coefficient Method is carried out for the multi-storey buildings under different load combination. The base of the building frame is assumed to be fixed.
- To study of Internal floating columns & Alternate floor floating columns observation of displacement at various nodes.
- To know the axial forces at various nodes due to provision of External floating columns.
- To observe the effect of storey drift on structure due to floating column.

Case 1: RC Building without floating columns
Case 2: RC Building with Internal floating columns
Case 3: RC Building with External floating columns
Case 4: RC Building with Alternate floor floating columns

II. MATERIALS & METHODOLOGY



A. PROBLEM STATEMENT

A RCC medium rise building of G+14 stories with floor height 3m subjected to earthquake loading in Zone II, III, IV, V has been considered .In this regard, ETAB software have been considered as tool to perform. Hence in this chapter we will discuss the parameters defining the computational models, the basic assumptions and the geometry of the selected building considered for this study. Displacements, axial forces, shear force, bending moment. Have been calculated for different columns and beams to find out the effect in the building.

a) Description of structure

1. Length of building -26 m
2. Width of building-26 m
3. Storey Height of building – 3m
4. Total height of building – 45 m
5. Dimension of column - 0.8x0.5 m for zone v
6. Dimension of beam - 0.5x 0.3 m for zone v
7. Thickness of slab – 150 mm
8. Dead load on building for 0.23m thick wall - 14 kN/m
9. Dead load on building for 0.15m thick wall – 9kN/m
10. Live load on building -3 kN/m^2
11. Response Spectra - As per IS 1893 (Part-1): 2002
12. Damping - 5%
13. Importance Factor - 1.5
14. Response reduction factor
    i. For SMRF - 5
15. Seismic load as per zone factor and Response Reduction Factor
    a. Earthquake load in X –Direction
16. Earthquake load in Z –Direction

b) Assumption

1. The material is homogeneous and isotropic.
2. All columns supports are considered as fixed at the foundation.
3. Tensile strength of concrete is ignored in sections subjected to bending.
4. The maximum target displacement of the structure is calculated in accordance with the guidelines given by IS Code for maximum roof level lateral drift and displacement.
5. The building is designed by according to I.S. 456:2000 for Dead Load and Live load.

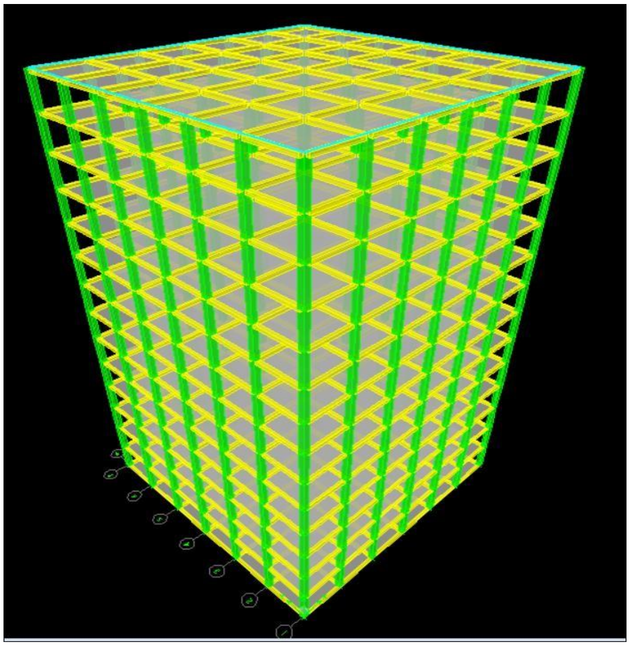


Fig 1 Modelling in ETABS

III. RESULTS AND OBSERVATIONS

A. Axial force (f_x) for all zones (corner column)

			Case 1				Case 2				Case 3				Case 4			
Category of column	L/C	Floor Level	II	III	IV	V	II	III	IV	V	II	III	IV	V	II	III	IV	V
			SMRF	SMRF	SMRF	SMRF	SMRF	SMRF	SMRF	SMRF	SMRF	SMRF	SMRF	SMRF	SMRF	SMRF	SMRF	SMRF
			Fx	Fx	Fx	Fx	Fx	Fx	Fx	Fx	Fx	Fx	Fx	Fx	Fx	Fx	Fx	Fx
Corner column	1.5(DL+EQX)	0	3747.21	3878.71	4103.75	4409.35	3798.75	3932.45	4161.27	4472.00	3651.49	3788.50	4022.99	4341.42	3939.51	4103.00	4320.99	4647.98
	1.5(DL+EQX)	1	3504.46	3623.09	3826.11	4101.81	3552.84	3673.50	3880.00	4160.42	3416.57	3540.14	3751.64	4038.83	3658.66	3805.30	4000.81	4294.07
	1.5(DL+EQX)	2	3255.20	3360.06	3539.51	3783.20	3300.63	3407.40	3590.12	3838.24	3175.56	3284.88	3471.99	3726.08	3448.32	3580.67	3757.14	4021.84
	1.5(DL+EQX)	3	3001.90	3093.09	3249.14	3461.05	3043.99	3136.93	3295.99	3511.99	2930.25	3025.46	3188.41	3409.69	3207.42	3324.39	3480.36	3714.31
	1.5(DL+EQX)	4	2745.72	2823.69	2957.11	3138.30	2784.32	2863.89	3000.05	3184.97	2681.77	2763.33	2902.92	3092.48	2948.57	3050.23	3185.78	3389.11
	1.5(DL+EQX)	5	2487.46	2552.85	2664.74	2816.70	2522.51	2589.35	2703.73	2859.06	2430.88	2499.46	2616.83	2776.22	2694.81	2781.65	2897.43	3071.10
	1.5(DL+EQX)	6	2227.82	2281.42	2373.14	2497.70	2259.29	2314.19	2408.14	2535.73	2178.26	2234.67	2331.22	2462.32	2427.65	2500.34	2597.27	2742.65
	1.5(DL+EQX)	7	1967.43	2010.16	2083.29	2182.59	1995.30	2039.18	2114.29	2216.28	1924.56	1969.74	2047.06	2152.07	2149.07	2208.64	2288.05	2407.17
	1.5(DL+EQX)	8	1706.87	1739.77	1796.07	1872.52	1731.11	1765.02	1823.05	1901.85	1670.37	1705.37	1765.27	1846.61	1876.02	1923.20	1986.10	2080.44
	1.5(DL+EQX)	9	1447.36	1471.93	1513.98	1571.08	1467.83	1493.20	1536.60	1595.55	1416.39	1442.44	1487.02	1547.56	1596.59	1633.08	1681.74	1754.74
	1.5(DL+EQX)	10	1188.96	1206.56	1236.69	1277.60	1205.98	1224.33	1255.75	1298.42	1164.32	1183.34	1215.90	1260.11	1311.67	1339.18	1375.85	1430.86
	1.5(DL+EQX)	11	931.49	943.25	963.37	990.70	944.96	957.39	978.68	1007.58	912.76	925.80	948.12	978.43	1030.77	1049.94	1075.51	1113.86
	1.5(DL+EQX)	12	675.34	682.43	694.58	711.07	685.13	692.79	705.89	723.68	662.09	670.25	684.21	703.18	747.32	759.59	775.95	800.49
	1.5(DL+EQX)	13	420.92	424.57	430.82	439.30	426.88	430.93	437.85	447.25	412.70	417.10	424.64	434.88	464.38	471.52	481.04	495.33
	1.5(DL+EQX)	14	167.52	168.86	171.16	174.28	169.50	171.02	173.63	177.17	163.94	165.65	168.58	172.56	171.06	173.75	177.34	182.73

Axial Force for Corner Column

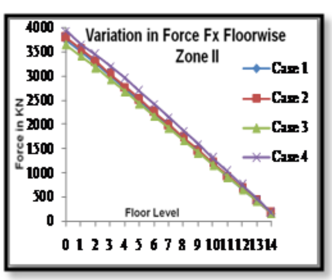


Fig 2

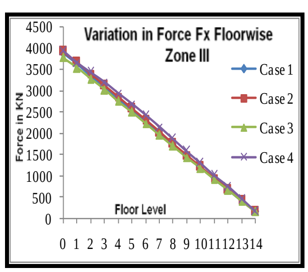


Fig 3

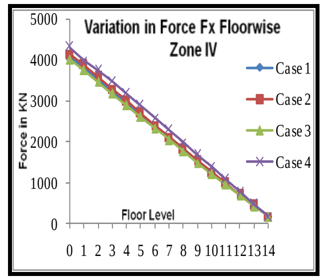


Fig 4

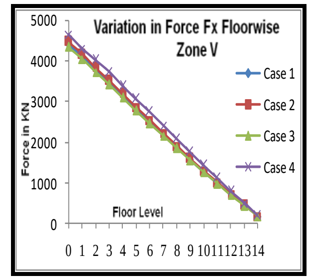


Fig 5

B. Axial force (fx) for all zones (intermediate column)

			Case 1				Case 2				Case 3				Case 4			
Category of column	L/C	Floor Level	II	III	IV	V	II	III	IV	V	II	III	IV	V	II	III	IV	V
			SMRF	SMRF	SMRF	SMRF	SMRF	SMRF	SMRF	SMRF	SMRF	SMRF	SMRF	SMRF	SMRF	SMRF	SMRF	SMRF
			Fx	Fx	Fx	Fx	Fx	Fx	Fx	Fx	Fx	Fx	Fx	Fx	Fx	Fx	Fx	Fx
Intermediate column	1.5(DL+EQX)	0	3862.8	3917.7	4011.5	4139	5355.4	5392.4	5455.9	5542.1	3921.4	3978.9	4077.2	4210.7	3935.5	4001.5	4089.5	4221.5
	1.5(DL+EQX)	1	3607.6	3652.1	3728.2	3831.6	4778.2	4809.2	4862.4	4934.5	3656.9	3703.5	3783.2	3891.5	3658.7	3712.1	3783.2	3889.8
	1.5(DL+EQX)	2	3347.4	3381.7	3440.3	3520	4267.1	4291.3	4332.7	4388.8	3388.3	3424.3	3485.9	3569.7	3416.9	3458.7	3514.3	3597.9
	1.5(DL+EQX)	3	3084.4	3109.5	3152.4	3210.6	3806.5	3824	3853.9	3894.6	3118.2	3144.7	3190.1	3251.7	3157.6	3188.7	3230.1	3292.2
	1.5(DL+EQX)	4	2819.6	2836.6	2865.6	2905.1	3386	3397.4	3416.9	3443.3	2847.3	2865.5	2896.6	2938.8	2886.6	2908.2	2936.9	2980.1
	1.5(DL+EQX)	5	2553.4	2563.4	2580.5	2603.8	2997.2	3003.1	3013.2	3026.9	2576	2587	2605.8	2631.3	2624.8	2638	2655.6	2682
	1.5(DL+EQX)	6	2286.3	2290.4	2297.4	2306.9	2633.4	2634.5	2636.4	2639.1	2304.5	2309.4	2317.8	2329.2	2354.4	2360.5	2368.7	2380.9
	1.5(DL+EQX)	7	2021.5	2022.3	2023.6	2025.3	2300.2	2303	2307.9	2314.6	2033.4	2033.5	2033.7	2033.9	2076.5	2076.8	2077.3	2078
	1.5(DL+EQX)	8	1768.3	1772.9	1780.6	1791.2	1983.7	1989.7	2000	2014	1777.5	1781.5	1788.4	1797.7	1820.8	1825.2	1831	1839.7
	1.5(DL+EQX)	9	1511.2	1518.5	1531	1547.9	1676.1	1684.4	1698.6	1717.8	1518	1524.9	1536.6	1552.6	1557.2	1564.9	1575.2	1590.5
	1.5(DL+EQX)	10	1250.4	1259.4	1274.7	1295.5	1374.8	1384.4	1400.8	1423.1	1255.1	1263.8	1278.6	1298.6	1285.1	1294.7	1307.6	1326.9
	1.5(DL+EQX)	11	986.19	995.66	1011.9	1033.9	1077.4	1087.3	1104.2	1127.1	989.07	998.33	1014.2	1035.7	1015.1	1025.5	1039.5	1060.5
	1.5(DL+EQX)	12	718.71	727.52	742.58	763.03	782.24	791.26	806.71	827.68	719.95	728.63	743.5	763.68	739.1	748.93	762.05	781.71
	1.5(DL+EQX)	13	448.51	455.44	467.29	483.38	488.38	495.4	507.42	523.74	448.17	455.06	466.87	482.9	458.6	466.29	476.54	491.92
	1.5(DL+EQX)	14	173.44	177.2	183.63	192.36	191.22	194.97	201.39	210.11	172.06	175.86	182.37	191.21	170.06	174.28	179.9	188.33

Axial Force for Intermediate Column

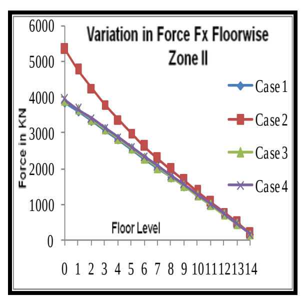


Fig 6

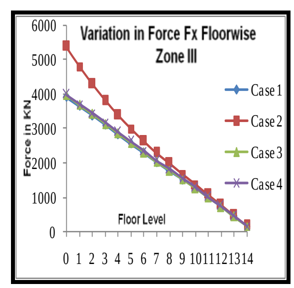


Fig 7

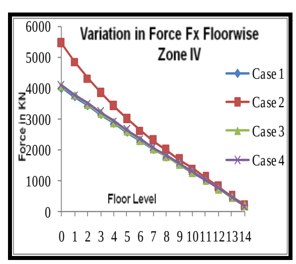


Fig 8

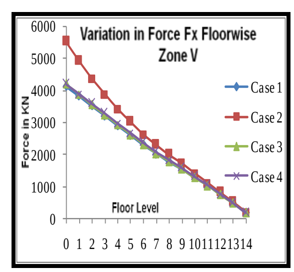


Fig 9

C. Shear force (f_Z) for all zones (corner column)

Category of column	L/C	Floor Level	Case 1				Case 2				Case 3				Case 4			
			II SMRF	III SMRF	IV SMRF	V SMRF	II SMRF	III SMRF	IV SMRF	V SMRF	II SMRF	III SMRF	IV SMRF	V SMRF	II SMRF	III SMRF	IV SMRF	V SMRF
			Fz	Fz	Fz	Fz	Fz	Fz	Fz	Fz	Fz	Fz	Fz	Fz	Fz	Fz	Fz	Fz
Corner column	1.5(DL+EQZ)	0	53.46	68.88	95.267	131.1	71.768	82.061	106.4	142.89	48.59	64.464	91.632	128.53	29.889	43.472	61.583	88.749
	1.5(DL+EQZ)	1	52.281	65.456	88.883	120.7	71.671	82.037	102.85	133.74	45.751	59.649	83.435	115.73	69.551	91.1	119.83	162.93
	1.5(DL+EQZ)	2	52.244	65.426	87.921	118.47	71.567	81.834	102.8	133.14	44.657	57.909	80.588	111.39	77.983	89.959	105.93	129.88
	1.5(DL+EQZ)	3	52.031	64.647	85.873	114.7	71.143	81.681	101.93	131.48	43.546	55.969	77.231	106.11	65.289	76.858	92.285	115.42
	1.5(DL+EQZ)	4	51.766	63.674	83.598	110.65	71.136	81.466	101.91	128.87	42.412	54.009	73.856	100.81	80.307	98.745	123.33	160.2
	1.5(DL+EQZ)	5	51.746	62.66	81.337	106.7	70.462	80.786	100.68	126	41.399	52.221	70.743	95.895	74.103	83.947	97.073	116.76
	1.5(DL+EQZ)	6	51.494	61.763	79.336	103.2	70.097	80.552	99.405	123.27	40.57	50.721	68.094	91.685	66.194	75.761	88.517	107.65
	1.5(DL+EQZ)	7	51.241	60.927	77.504	100.02	70.037	79.557	98.063	120.6	39.871	49.431	65.793	88.011	77.54	92.957	113.51	144.35
	1.5(DL+EQZ)	8	50.851	59.946	75.511	96.649	69.341	79.532	96.385	117.57	39.144	48.117	63.476	84.332	71.983	80.143	91.023	107.34
	1.5(DL+EQZ)	9	50.137	58.534	72.904	92.418	68.235	78.503	93.968	113.54	38.172	46.459	60.642	79.903	66.612	74.554	85.143	101.03
	1.5(DL+EQZ)	10	48.928	56.428	69.262	86.69	67.521	77.562	90.442	107.93	36.761	44.163	56.83	74.032	73.345	85.412	101.5	125.64
	1.5(DL+EQZ)	11	47.085	53.422	64.268	78.996	65.972	74.601	85.495	100.29	34.758	41.007	51.702	66.225	67.142	72.541	79.74	90.538
	1.5(DL+EQZ)	12	44.637	49.515	57.863	69.199	64.815	71.039	79.282	90.69	32.153	36.943	45.14	56.272	64.4	69.406	76.081	86.093
	1.5(DL+EQZ)	13	41.781	44.388	49.928	57.452	63.834	70.881	72.651	77.999	28.828	31.981	37.378	44.707	59.331	64.656	71.756	82.406
	1.5(DL+EQZ)	14	41.151	42.672	44.196	46.266	61.544	64.812	70.404	74.841	25.705	26.505	27.873	29.732	63.539	63.922	64.434	65.2

Shear Force for Corner Column

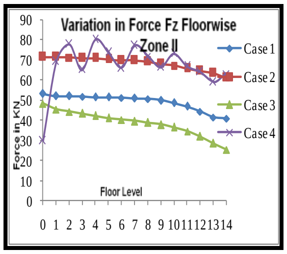


Fig 10

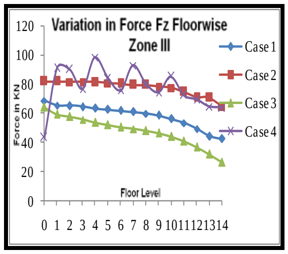


Fig 11

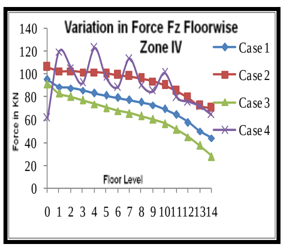


Fig 12

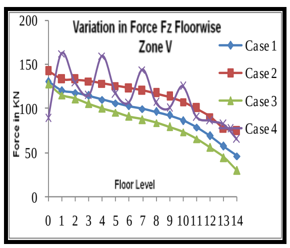


Fig 13

D. Shear force (f_Z) for all zones (intermediate column)

Category of column	L/C	Floor Level	Case 1				Case 2				Case 3				Case 4			
			II SMRF	III SMRF	IV SMRF	V SMRF	II SMRF	III SMRF	IV SMRF	V SMRF	II SMRF	III SMRF	IV SMRF	V SMRF	II SMRF	III SMRF	IV SMRF	V SMRF
			Fz	Fz	Fz	Fz	Fz	Fz	Fz	Fz	Fz	Fz	Fz	Fz	Fz	Fz	Fz	Fz
Intermediate column	1.5(DL+EQZ)	0	60.093	88.209	136.32	201.66	64.002	93.227	143.24	211.17	60.925	90.101	140.03	207.84	53.772	83.333	122.75	181.87
	1.5(DL+EQZ)	1	60.803	88.973	137.18	202.64	61.927	89.905	137.79	202.81	61.382	90.413	140.1	207.57	75.052	116.82	172.51	256.04
	1.5(DL+EQZ)	2	59.03	85.996	132.14	194.81	60.317	87.076	132.87	195.06	59.592	87.292	134.7	199.08	57.371	86.316	124.91	182.8
	1.5(DL+EQZ)	3	56.716	82.224	125.88	185.16	57.843	83.157	126.48	185.31	57.357	83.517	128.29	189.09	54.191	81.711	118.41	173.45
	1.5(DL+EQZ)	4	54.186	78.15	119.16	174.85	55.111	78.933	119.7	175.07	54.946	79.508	121.54	178.63	66.324	102.42	150.55	222.74
	1.5(DL+EQZ)	5	51.75	74.242	112.73	165	52.37	74.761	113.08	165.12	52.656	75.718	115.19	168.79	49.723	73.72	105.72	153.71
	1.5(DL+EQZ)	6	49.579	70.759	107.01	156.23	49.847	70.962	107.1	156.17	50.636	72.378	109.59	160.12	47.161	69.863	100.13	145.54
	1.5(DL+EQZ)	7	47.595	67.584	101.79	148.24	47.495	67.441	101.58	147.94	48.8	69.352	104.53	152.29	56.945	87.025	127.13	187.29
	1.5(DL+EQZ)	8	45.519	64.291	96.415	140.04	45.059	63.803	95.883	139.45	46.855	66.198	99.303	144.26	43.521	63.442	90.004	129.85
	1.5(DL+EQZ)	9	42.971	60.304	89.964	130.24	42.181	59.495	89.126	129.37	44.411	62.321	92.975	134.6	41.012	59.604	84.394	121.58
	1.5(DL+EQZ)	10	39.597	55.084	81.587	117.58	38.525	53.998	80.48	116.44	41.1	57.166	84.664	122	46.099	69.497	100.69	147.49
	1.5(DL+EQZ)	11	35.14	48.245	70.671	101.13	33.85	46.944	69.354	99.786	36.663	50.34	73.747	105.53	33.41	47.152	65.475	92.959
	1.5(DL+EQZ)	12	29.531	39.674	57.031	80.602	28.099	38.235	55.583	79.141	31.018	41.713	60.016	84.872	28.606	39.579	54.209	76.155
	1.5(DL+EQZ)	13	22.814	29.498	40.936	56.469	21.361	28.044	39.482	55.015	24.169	31.363	43.676	60.396	23.931	34.124	47.715	68.102
	1.5(DL+EQZ)	14	16.055	18.776	23.431	29.754	14.217	16.942	21.607	27.942	17.53	20.733	26.215	33.66	15.317	17.785	21.076	26.012

Shear Force for Intermediate Column

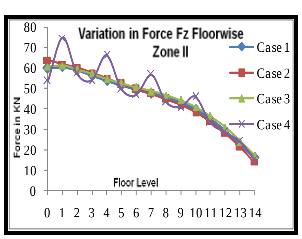


Fig 14

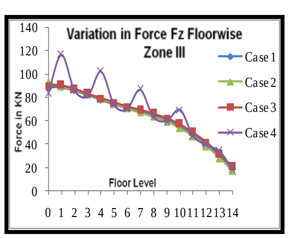


Fig 15

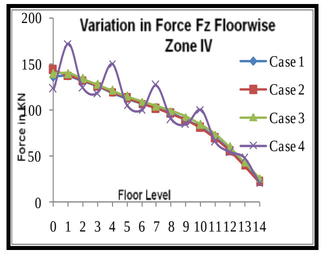


Fig 16

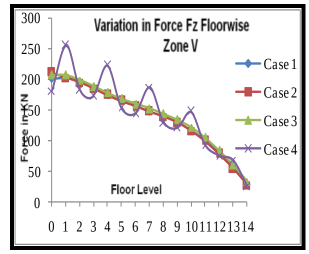


Fig 17

IV. CONCLUSION

1. With the provision of Internal floating columns & Alternate floor floating columns may increase in axial force & shear force at all floors.
2. It is observed that Internal floating columns & External floating columns increases the torsion values at all floors for all zones
3. It is observed that provision of Alternate floor floating columns there is reduction in the Torsion values
4. With the provision of Internal floating columns there is increase in moment at corner column but reduction in moment at intermediate column at all floors. For Alternate floor floating columns the result were exactly opposite to the results obtained in Internal floating columns
5. Provision of Internal floating columns & Alternate floor floating columns may increase displacement at various nodes
6. Provision of External floating columns may decrease displacement at various nodes
7. Provision of floating column increases torsion in beam at all floors for all zones
8. Due to the increase in the value of bending moment in the beams adjacent to the floating columns up to 4^{th} floor the size of the beam increases hence increases in overall quantity of steel & concrete of the structure
9. The quantity of steel and concrete gets increase as compared to the individual cases due to floating column so floating column may be provided at appropriate places as per requirement of the plan
10. Placement of Internal or External floating column may result development of additional forces on adjoining beams and columns adequate checks should be carried out before designing the structure. Precaution must also be taken for smooth transfer of lateral forces to ground

REFERENCES

[1] Shaikh Abdul Aijaj Abdul Rahman, GirishDeshmukh., ―Seismic Response of Vertically Irregular RC Frame with Stiffness Irregularity at Fourth Floor‖, Journal of

Structural EngineeringInternational Journal of Emerging Technology and Advanced Engineering Volume 3, Issue 8, August 2013)

[2] Ravikumar C M, Babu Narayan K S, Sujith B V, Venkat Reddy D., “Effect of Irregular Configurations on Seismic Vulnerability of RC Buildings”, Architecture Research 2012, 2(3): 20-26

[3] Sadashiva V.K V. K., MacRae G. A. and Deam B. L. , , “Determination Of Irregularity Limits ”, The 14th World Conference on Earthquake Engineering October 12-17, 2008, Beijing, China

[4] Dr.Dubey S.K., Sangamnerkar P.D., “ Seismic Behaviour Of AssymetricRc Buildings”, International Journal of Advanced Engineering Technology Vol.II October-December, 2011

[5] C.M. Ravi Kumar, K.S. Babu Narayan, M.H. Prashanth, H.B Manjunatha and

[6] D. Venkat Reddy, “Seismic Performance Evaluation of Rc Buildings With Vertical Irregularity”, Indian Society of Earthquake Technology Department of Earthquake Engineering Building IIT Roorkee, Roorkee October 20-21, 2012

[7] Konakalla Ramesh, Ramesh DuttChilakapati, Dr.HarinadhaBabuRaparla, “Effect of Vertical Irregularity in Multi-Storied Buildings Under Dynamic Loads Using Linear Static Analysis”, International Journal of Education and applied research Vol. 4, Issue Spl-2, Jan - June 2014

[8] Sharma Mohit, Dr.MaruSavita, “Dynamic Analysis of Multi-storeyed Regular Building”, IOSR Journal of Mechanical and Civil Engineering Volume 11, Issue 1 Ver. II (Jan. 2014)

[9] SapateOnkar V. , “Inter-Relationship between Moment Values of Columns in a Building with Different Architectural Complexities and Different Seismic Zones”, International Journal of Engineering Research and Development Volume 5, Issue 2 (December 2012)

[10] NautiyalPrerna, AkhtarSaleem and BathamGeeta A., “Seismic Response Evaluation of RC frame building with Floating Column considering different Soil Conditions ”, International Journal of Current Engineering and Technology Vol.4, No.1 (February 2014)

[11] Dennis C.K. Poon P.E., Managing Principal, Thornton Tomasetti, “Analysis and Design of a 47-story Reinforced Concrete Structure” , -Futian Shangri-La Hotel Tower‖

[12] Ravikumar C M, Babu Narayan K , Sujith B V, Venkat Reddy D, “Effect of Irregular Configurations on Seismic Vulnerability of RC Buildings”, Architecture Research 2012, 2(3): 20-26

[13] Eggert V. Valmundsson1 and James M. Nau/ Member, ASCE, “Seismic Response of Building Frames With Vertical Structural Irregularities”, Journal Of Structural Engineering / January 1997

[14] ArlekarJaswant N, Jain Sudhir K. and Murty C.V.R, (1997), “Seismic Response of RC Frame Buildings with Soft First Storey’s”, Proceedings of the CBRI Golden Jubilee Conference on Natural Hazards in Urban Habitat, New Delhi.