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Comparative Study of Structural Responses of Floating Column and Non-Floating Column Structural Frames

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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.

- X -

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.

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/m2
11. Response Spectra - As per IS 1893 (Part-1): 2002

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12. Damping - 5%

13. Importance Factor - 1.5

14. Response reduction factor

    a. 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.

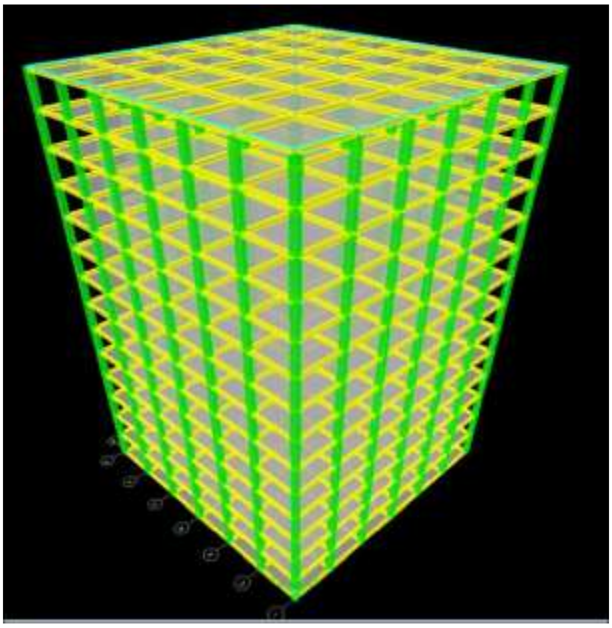


Fig 1 Modelling in ETABS

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 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
			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

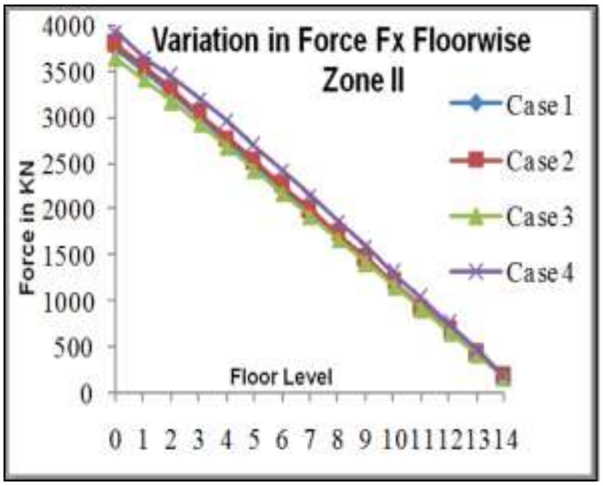
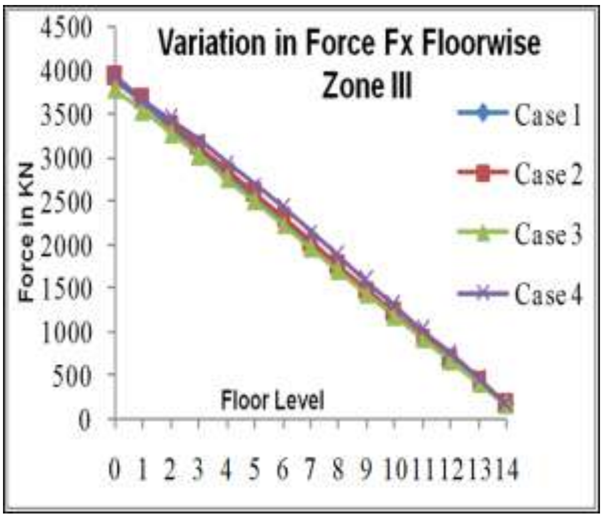


Fig 2



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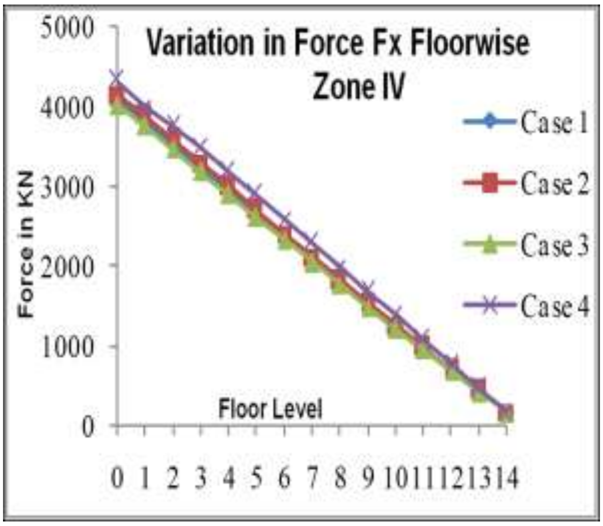

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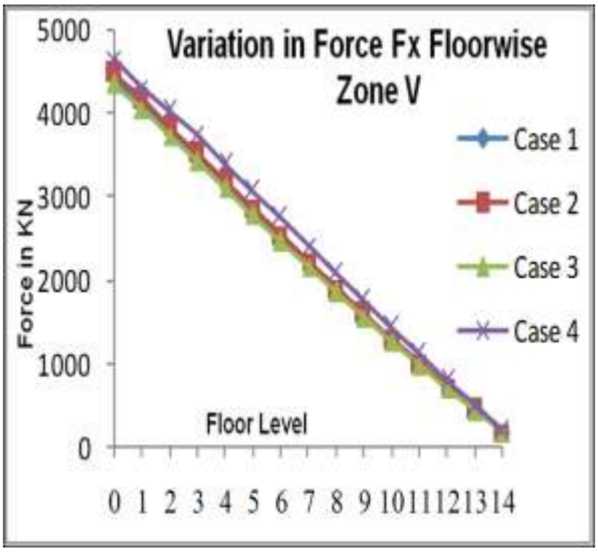

Fig 5

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

Category of column	LC	Floor Level	Case 1 II SMRF Fx	Case 1 III SMRF Fx	Case 1 IV SMRF Fx	Case 1 V SMRF Fx	Case 2 II SMRF Fx	Case 2 III SMRF Fx	Case 2 IV SMRF Fx	Case 2 V SMRF Fx	Case 3 II SMRF Fx	Case 3 III SMRF Fx	Case 3 IV SMRF Fx	Case 3 V SMRF Fx	Case 4 II SMRF Fx	Case 4 III SMRF Fx	Case 4 IV SMRF Fx	Case 4 V SMRF Fx
Intermediate column	1.5(DL+EQX)	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1.5(DL+EQX)	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1.5(DL+EQX)	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1.5(DL+EQX)	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1.5(DL+EQX)	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1.5(DL+EQX)	5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1.5(DL+EQX)	6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1.5(DL+EQX)	7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1.5(DL+EQX)	8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1.5(DL+EQX)	9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1.5(DL+EQX)	10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1.5(DL+EQX)	11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1.5(DL+EQX)	12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1.5(DL+EQX)	13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1.5(DL+EQX)	14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Axial Force for Intermediate Column

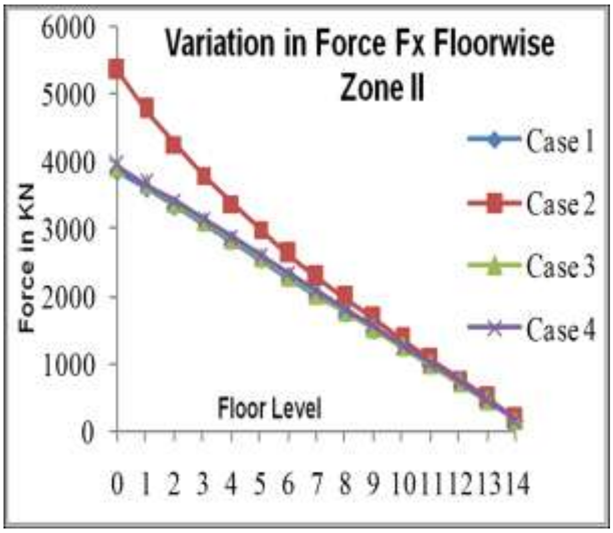

Fig 6

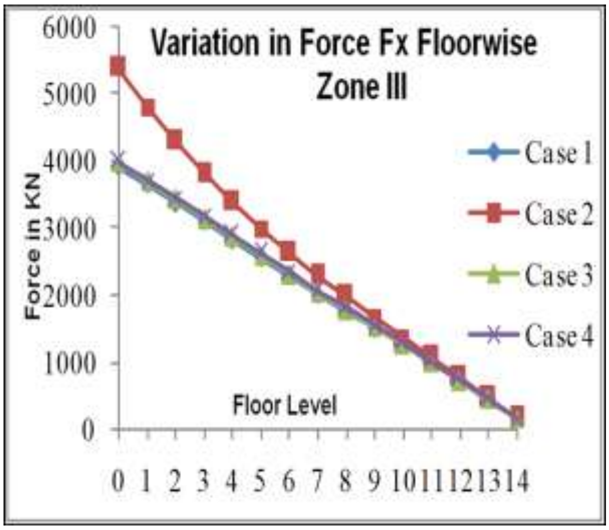

Fig 7

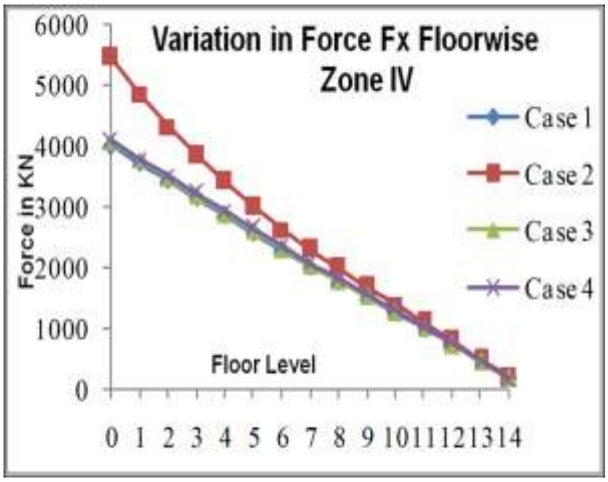

Fig 8

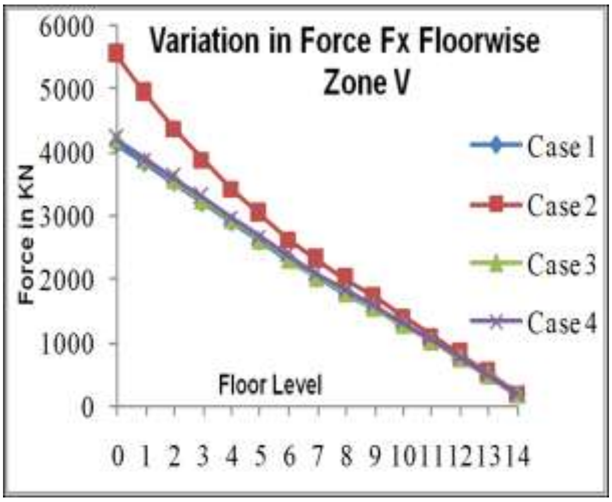

Fig 9

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

Category of column	LC	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	68.98	93.207	131.1	71.768	82.861	106.4	142.89	48.59	64.484	81.632	129.53	29.888	43.472	61.563	86.749
	1.5(DL+EQZ)	1	52.281	65.496	88.868	120.7	71.671	82.673	102.85	133.74	45.751	59.649	83.435	115.74	69.551	91.1	110.65	162.93
	1.5(DL+EQZ)	2	52.244	65.456	87.921	118.47	71.567	81.634	102.6	133.14	44.657	57.909	80.598	111.39	77.968	90.959	105.95	120.88
	1.5(DL+EQZ)	3	52.031	64.647	85.873	114.7	71.149	81.461	101.93	131.48	43.566	55.969	77.231	106.11	65.289	78.808	92.285	115.42
	1.5(DL+EQZ)	4	51.766	63.674	83.598	110.65	71.136	81.466	101.91	128.67	42.412	54.009	73.896	100.81	80.307	98.745	123.39	166.2
	1.5(DL+EQZ)	5	51.746	62.66	81.377	106.7	70.462	80.766	100.69	126	41.399	52.225	70.745	95.895	74.104	83.947	97.079	116.76
	1.5(DL+EQZ)	6	51.484	61.765	79.336	103.2	70.067	80.932	99.483	122.57	40.57	50.723	68.894	91.685	66.894	75.781	88.527	107.69
	1.5(DL+EQZ)	7	51.241	60.927	77.504	100.22	70.077	79.577	98.863	120.6	39.871	49.491	65.795	88.011	77.54	92.987	115.51	144.35
	1.5(DL+EQZ)	8	50.853	59.946	75.311	96.649	69.541	79.502	96.367	117.57	39.144	48.117	63.476	84.352	71.998	80.148	98.029	107.34
	1.5(DL+EQZ)	9	50.137	58.534	72.904	92.416	68.229	78.593	93.908	113.54	38.172	46.459	60.642	79.969	66.652	74.594	85.149	101.83
	1.5(DL+EQZ)	10	48.926	56.426	69.202	86.69	67.523	77.562	90.442	107.98	36.781	44.161	56.65	74.032	73.345	85.412	101.5	125.64
	1.5(DL+EQZ)	11	47.085	53.422	64.208	78.996	65.972	74.681	85.485	100.29	34.736	41.007	51.702	66.229	67.142	72.543	79.74	86.596
	1.5(DL+EQZ)	12	44.677	49.519	57.868	69.199	64.825	71.086	76.282	90.69	32.159	36.940	45.14	56.272	64.4	69.806	76.081	86.693
	1.5(DL+EQZ)	13	41.761	44.388	46.926	57.452	65.854	76.881	72.451	77.996	28.828	31.881	37.376	44.707	59.551	66.686	71.796	82.486
	1.5(DL+EQZ)	14	41.151	42.472	44.196	45.266	61.344	64.802	70.444	74.841	25.705	26.505	27.878	26.732	63.599	65.922	66.454	65.2

Shear Force for Corner Column

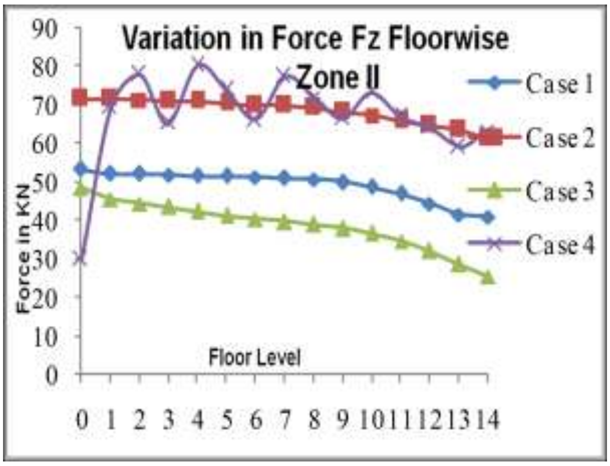

Fig 10

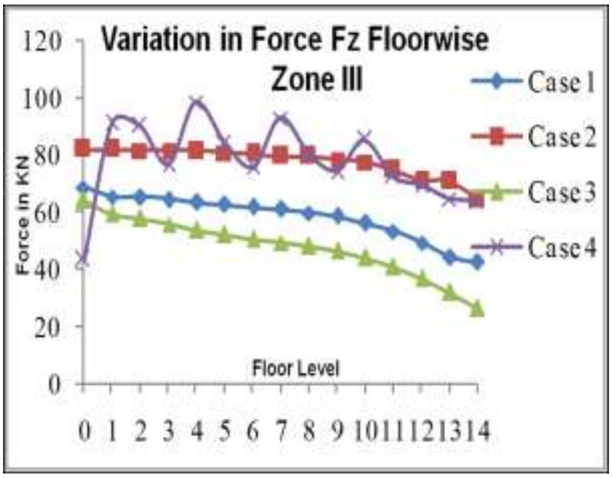

Fig 11

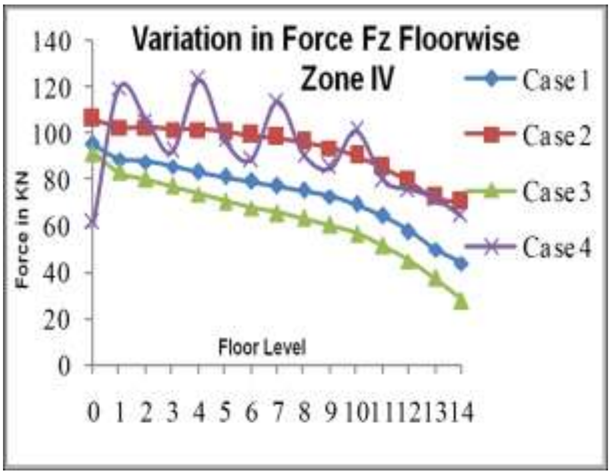

Fig 12

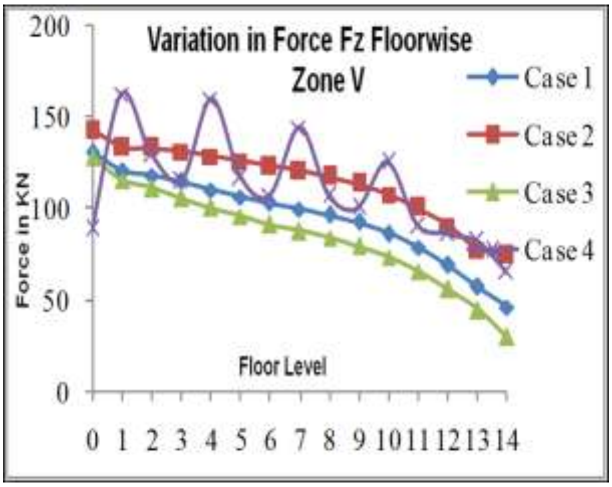

Fig 13

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Mr. Chetan R. Limkar[4] Ms. Amruta L. Lugade[5]

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	60.098	88.206	136.32	201.66	64.062	90.227	140.24	211.17	60.825	90.101	140.00	207.84	53.772	83.553	122.75	181.87
	1.5(DL+EQZ)	1	60.808	88.973	137.18	202.64	61.927	88.985	137.79	202.81	61.302	90.413	140.1	205.57	73.952	116.82	172.51	256.0
	1.5(DL+EQZ)	2	59.05	85.996	132.14	194.81	60.317	87.676	132.67	195.06	59.592	87.282	134.7	199.08	57.571	86.518	124.91	182.[illegible]
	1.5(DL+EQZ)	3	56.716	82.224	123.88	185.16	57.641	83.157	126.48	186.31	57.377	85.517	128.29	189.08	54.186	81.711	118.61	175.45
	1.5(DL+EQZ)	4	54.186	78.17	116.16	174.85	55.111	78.653	118.7	175.07	54.946	79.588	121.54	178.65	66.324	102.42	150.55	222.74
	1.5(DL+EQZ)	5	51.75	74.242	112.73	168	52.37	74.761	113.88	166.12	52.696	75.708	115.19	168.78	49.725	73.72	105.72	155.71
	1.5(DL+EQZ)	6	48.579	70.759	107.01	156.23	48.847	70.962	107.1	156.17	50.686	72.378	109.59	160.12	47.166	69.665	100.13	145.54
	1.5(DL+EQZ)	7	47.598	67.584	101.79	140.24	47.695	67.441	101.58	147.94	48	69.352	104.53	152.26	56.945	87.325	127.13	187.26
	1.5(DL+EQZ)	8	45.519	64.291	96.415	140.04	45.859	65.003	95.881	139.45	46.655	66.398	99.301	146.26	43.521	61.442	90.004	129.85
	1.5(DL+EQZ)	9	42.971	60.304	89.964	130.24	42.081	58.469	89.326	129.37	44.411	62.321	92.875	134.6	41.862	59.604	84.394	121.58
	1.5(DL+EQZ)	10	39.597	55.064	81.597	117.58	38.525	55.998	80.46	116.44	41.1	57.066	84.664	125	46.099	69.497	100.69	147.49
	1.5(DL+EQZ)	11	35.14	48.285	70.671	101.13	35.95	46.944	69.354	98.766	36.663	50.34	73.747	105.53	35.41	47.152	65.475	92.959
	1.5(DL+EQZ)	12	29.531	36.674	57.031	80.602	28.099	38.239	55.581	79.541	31.038	41.713	60.066	84.872	28.686	39.576	54.209	76.155
	1.5(DL+EQZ)	13	22.014	29.498	40.556	56.469	22.361	28.044	39.482	55.918	24.369	31.363	45.676	60.596	23.951	34.124	47.715	68.102
	1.5(DL+EQZ)	14	16.055	18.776	23.431	28.754	14.217	16.942	21.867	27.942	17.55	20.733	26.235	30.66	15.267	17.769	21.076	26.012

Shear Force for Intermediate Column

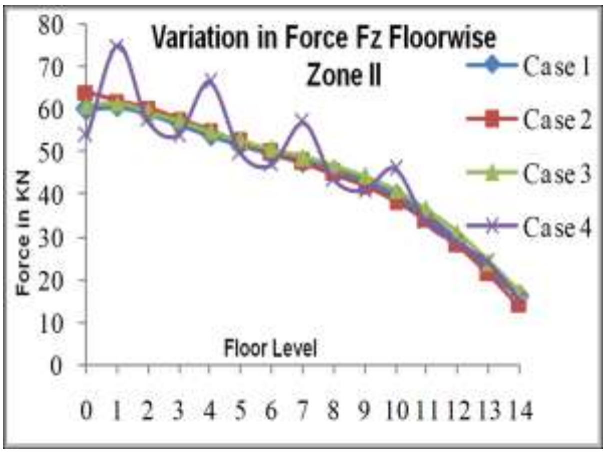

Fig 14

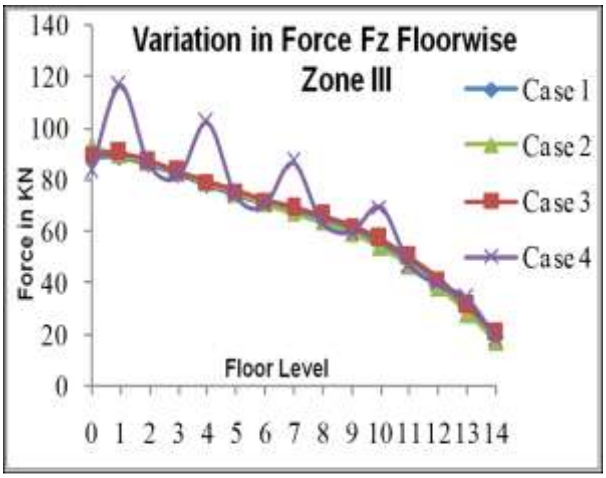

Fig 16

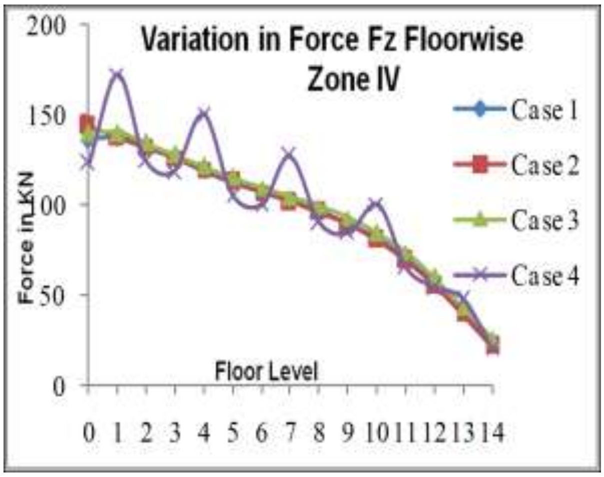

Fig 15

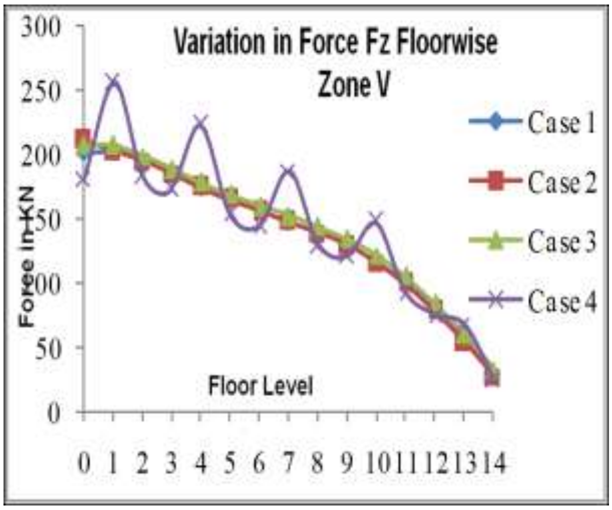

Fig 17

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 4th 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

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