

Seismic Analysis of a Multi Storey Building with and Without Floating Columns

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ABSTRACT: In present scenario buildings with floating column is a typical feature in the modern multi-storey construction in urban India. Such features are possible in building built in seismically active areas. This study highlights the importance of explicitly recognizing the presence of the floating column in the analysis of building. In the present study effect of floating columns on RC frame (G+9) structure has been studied for zone3. The models include R.C regular frame and irregular frames with floating columns. The three models are considered are one is RCC framed building without floating column regular frame building, second one is RCC framed building with one floating column on beam in third floor, third one is RCC framed building with two floating column on beam in third floor. Linear dynamic analysis *.i.e.*, response spectra analysis has been used to calculate variation response quintiles using E-tabs. The comparative results for the structure have been studied for various parameters like beam forces, column forces, storey shear, storey drift, max displacement and storey stiffness.

KEYWORDS: Floating column, Response spectra analysis, Column forces, Beam force.

I. INTRODUCTION

Earthquakes are natural hazards is capable of damaging or collapsing structures depending on magnitude and intensity of ground vibration. Objective of seismic analysis and design is that structure should be able to resist earthquake without major damage, thus leaving the structure serviceable after the event. Buildings are symbol of modern city, with the increasing pressure of population, commerce and trade, the cost of land in cities have raised very high this results in increases in the number of high rise buildings and also introduction of floating column in different positions due to architectural and plan requirements. There are many projects in which floating columns are adopted, especially above the ground floor, where transfer girders are employed, so that more open space is available in the ground floor. These open spaces may be required for assembly hall or parking purpose. The transfer girders have to be designed and detailed properly. As per the Indian standard code the country is classified into different zones for which it specifies the seismic zone factor and it is very important to design the buildings for seismic force to prevent the losses occurs due to earthquake.

In present paper we are considering RCC framed building with floating column with different lengths of spans and different number of floating columns.

II. METHODOLOGY

There are various methods to analyse structure for dynamic loading conditions like earthquake or blasting or other dynamic features like industries handling vibrating machines. This includes following:

- 1) Seismic coefficient method,
- 2) Response spectrum method,
- 3) Pushover analysis method,

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4) Time history analysis method

For the Present study Response spectrum method describes in IS 1893(Part 1): 2002 is adopted.

A. RESPONSE SPECTRUM METHOD:

The method is applicable to those structures where modes other than the fundamental one significantly affect the response of the structure. Generally, the method is applicable to analysis of the dynamic response of structures, which are asymmetrical or have areas of discontinuity or irregularity, in their linear range of behaviour. In particular, it is applicable to analysis of forces and deformations in multi-story buildings due to medium intensity ground shaking, which causes a moderately large but essentially linear response in the structure.

III. STRUCTURAL MODELLING

A. DESCRIPTION OF BUILDING

No. of stories	: G+9
Plan size	: 28.79 m x 29.61 m
External wall	: 0.23 m
Internal wall	: 0.115 m
Thickness of slab	: 150 mm
Material used	: Concrete (M-30) and reinforcement (Fe-550)
Height of each storey	: 3 m
Seismic Zone	: III
Soil type	: Type II (Medium soil)

B. THREE MODELS ARE CONSIDERED FOR ANALYSIS PURPOSE AND THE MODELS ARE:

MODEL 1:

G+9 RCC frame building without floating column that is regular building.

MODEL2:

G+9 RCC frame building with one floating column on beam in the third floor.

MODEL 3:

G+9 RCC frame building with two floating column on beam in the third floor.

IV. FRAME CONSIDERATION

For comparison of results we consider two frames for every model one along X direction and another along Y direction, consider the four columns C3, C4 along X, C8, C41 along Y direction, and also two continuous beams along X, Y direction in storey 3 in considered two frames. The two frames are Frame-11ACDFGJKM, Frame-A136789 10 11 respectively X, Y directions.

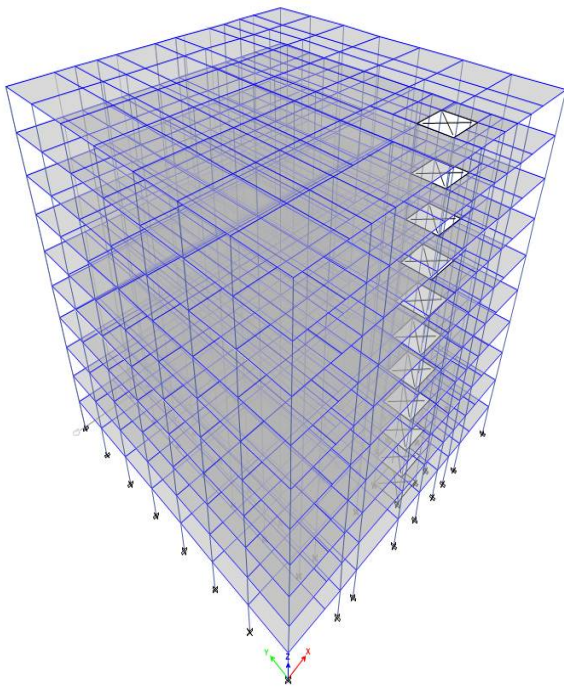


Fig.1: 3-D view of model-1 regular building

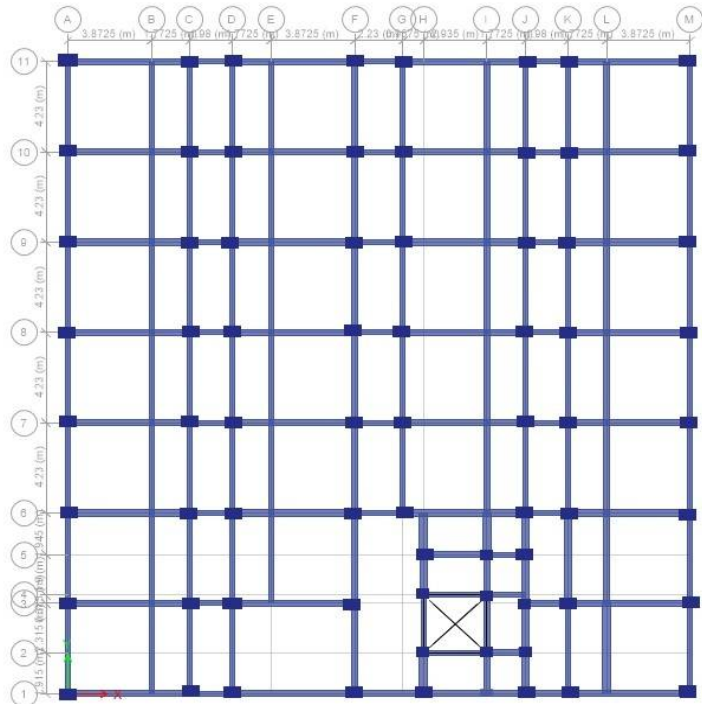


Fig.2: Beam column layout of model-1 Regular building

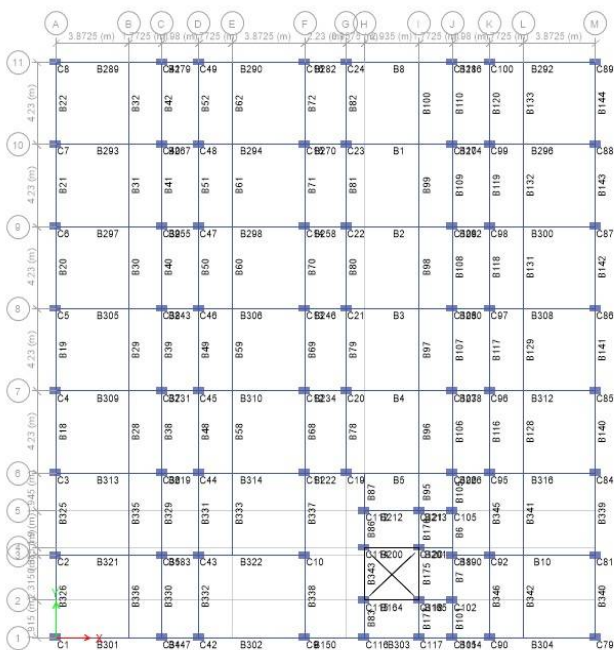


Fig.3: Central line diagram for regular building

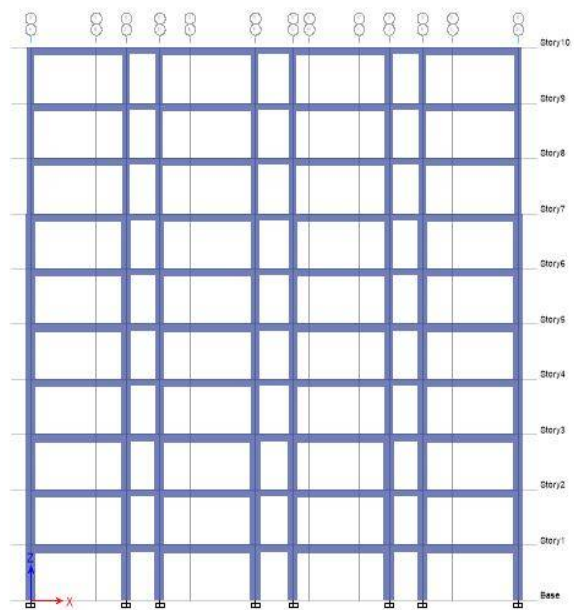


Fig.4: Elevation view of frame 6ACDFGJKM in model-1

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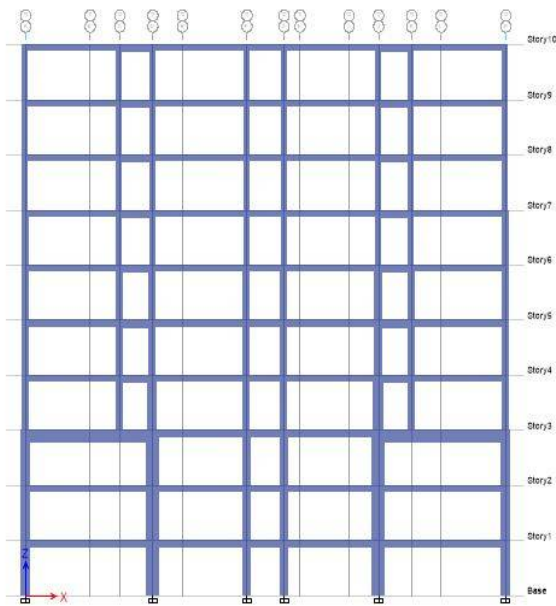


Fig.5:Elevation view of frame 6ACDFGJKM in model-2

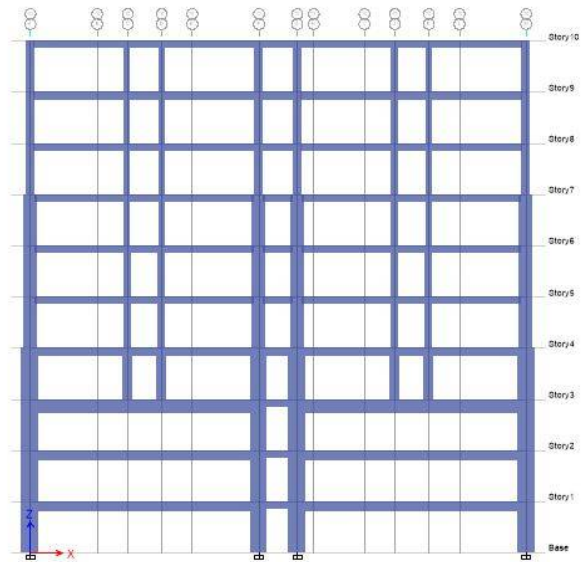


Fig.6:Elevation view of frame 6ACDFGJKM in model-3

V. ANALYSIS RESULTS

Seismic analysis carried out by the help of E-Tabs and results of for various parameters like beam forces, column forces, storey shear, story drift, max displacement and story stiffness are compare for considered three models

A. AXIAL FORCE AND MAXIMUM MOMENT IN COLUMN

To understand the axial force and Maximum Moment behaviour of column in regular and floating column building c41 is studied

Table 1:Column axial force for floating columnC41 (kNm)

Location	Model 1	Model 2	Model 3
Storey10	148.869	77.9285	45.8197
Storey9	322.214	229.875	156.053
Storey8	520.289	374.274	278.866
Storey7	404.973	506.020	388.551
Storey6	1088.90	750.151	552.552
Storey5	1334.94	880.825	665.485
Storey4	1581.07	967.871	746.674
Storey3	1837.43	-	-
Storey2	2090.73	-	-
Storey1	2338.11	-	-

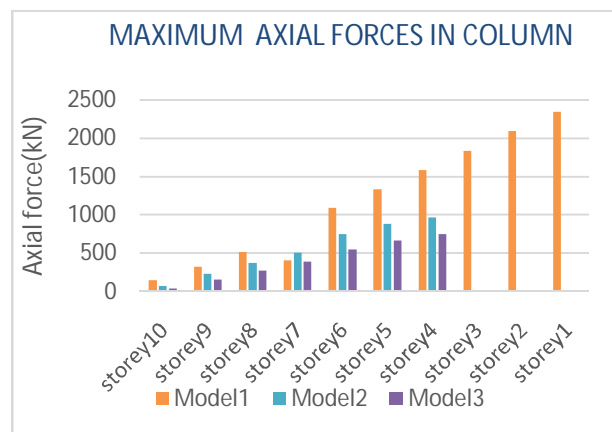


Fig.7: MaximumAxial forces in Column C41 (KN)

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Table 2: Maximum Moment in Column C41 (kNm)

Location	Model 1	Model 2	Model 3
Storey10	41.328	40.391	137.473
Storey9	50.487	55.246	135.358
Storey8	50.939	58.703	145.075
Storey7	48.610	79.594	149.271
Storey6	67.042	90.076	157.132
Storey5	73.737	85.098	120.44
Storey4	67.258	230.842	466.298
Storey3	89.450	-	-
Storey2	100.663	-	-
Storey1	79.929	-	-

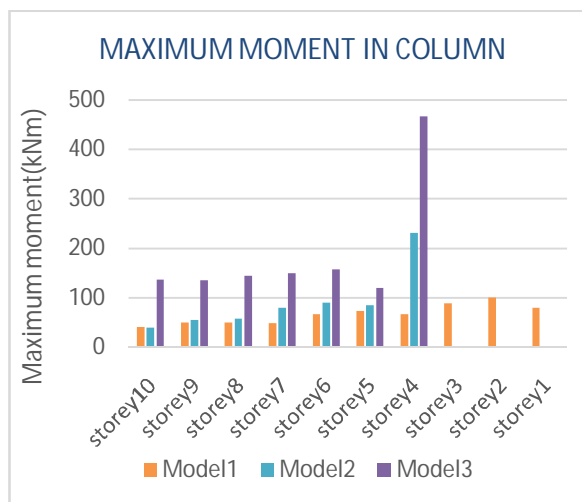


Fig.8: Maximum Moment in Column C41 (kNm)

B. SHEAR FORCE AND BENDING MOMENT IN BEAM

To study the variation of Shear Force and Bending Moment along continuous beam for regular and floating column building.

Table 3: Shear Force along Continuous Beam in X Direction (KN)

Label	Location	Model 1	Model 2	Model 3
B289	End-I	179.9975	478.9034	1401.234
B289	Middle	152.7365	220.619	956.132
B289	End-J	179.9013	693.8623	815.2497
B279	End-I	147.6673	693.8623	815.2497
B279	Middle	136.1831	844.3621	219.675
B279	End-J	147.4248	1059.226	905.8542
B290	End-I	183.2038	411.8336	905.8542
B290	Middle	156.0389	358.499	108.6005
B290	End-J	180.4701	303.8598	1439.223
B282	End-I	128.8272	76.0181	171.0321
B282	Middle	119.1249	66.2287	48.796
B282	End-J	129.2222	74.97	171.0321
B8	End-I	180.0474	248.7898	1445.099
B8	Middle	153.5645	358.2931	1006.685
B8	End-J	171.0321	392.1669	860.9132
B286	End-I	143.5698	1068.713	860.9132
B286	Middle	137.3118	909.32	219.675
B286	End-J	148.796	872.1816	854.41
B292	End-I	207.8003	872.1816	854.41
B292	Middle	180.6354	248.471	974.1244
B292	End-J	196.7875	470.3201	1385.319

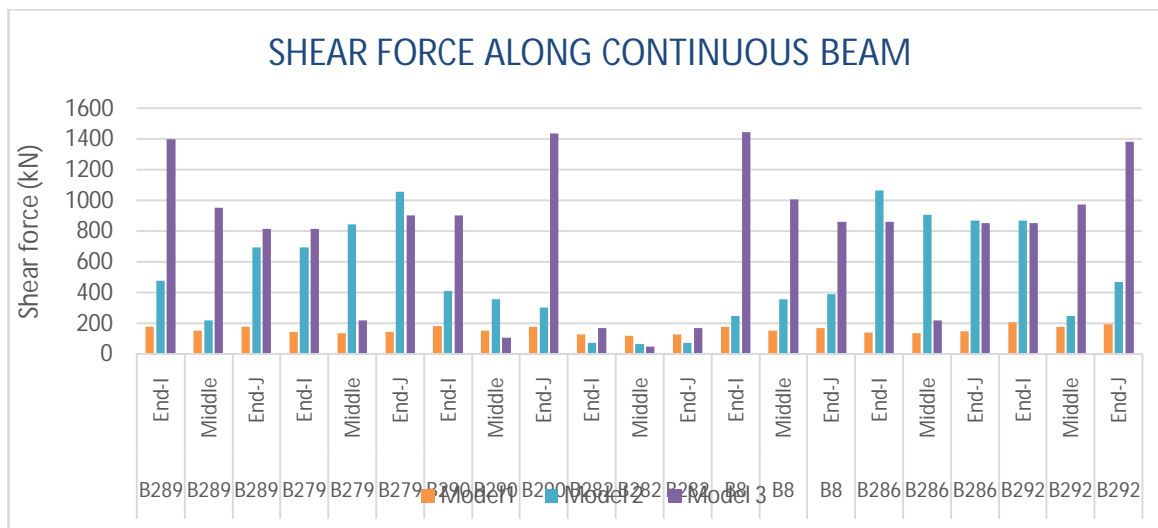


Fig.9: Shear Force along Continuous Beam in X Direction (KN)

Table 4: Bending Moment along Continuous Beam in X Direction (kNm)

Label	Location	Model 1	Model 2	Model 3
B289	End-I	-174.97	-547.46	-2432.4
B289	Middle	66.23	228.557	51.8958
B289	End-J	-174.79	740.017	2530.65
B279	End-I	-66.495	744.336	2075.39
B279	Middle	18.059	-125.64	2057.24
B279	End-J	-66.23	-672.57	2070.59
B290	End-I	-180.61	-485.52	2467.22
B290	Middle	66.5541	12.7159	-103.65
B290	End-J	-169.31	-144.13	-2626.4
B282	End-I	-65.513	-17.17	-1432.1
B282	Middle	10.384	7.9486	-1320.7
B282	End-J	-53.494	-16.349	-1390.5
B8	End-I	-170.75	-115.85	-2667.6
B8	Middle	67.31	18.519	-163.64
B8	End-J	-176.65	-479.18	2472.79
B286	End-I	-63.228	-679.84	2085.23
B286	Middle	16.0234	-126.63	2061.15
B286	End-J	-66.873	542.546	2061.86
B292	End-I	-184.14	495.509	2455.78
B292	Middle	74.0467	239.95	-62.056
B292	End-J	-183.15	-568.43	-2388.8

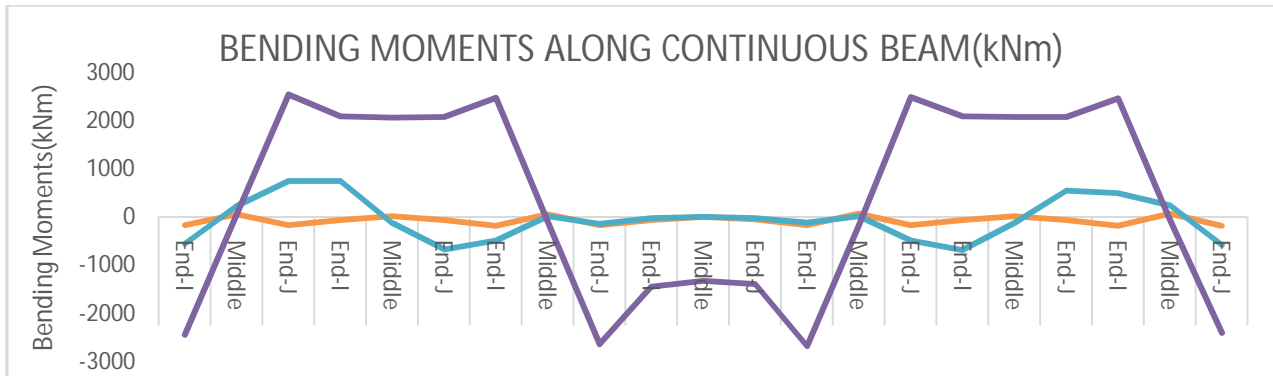


Fig.10: Bending Moment along Continuous Beam in X Direction (kNm)

C. BASE SHEAR

Base shear is an estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure.

Table 5: Base Shear along X Direction (kN)

Base Shear , $V_B(KN)$			
Direction	model1	model2	model3
X	2899.146	2939.785	2959.865

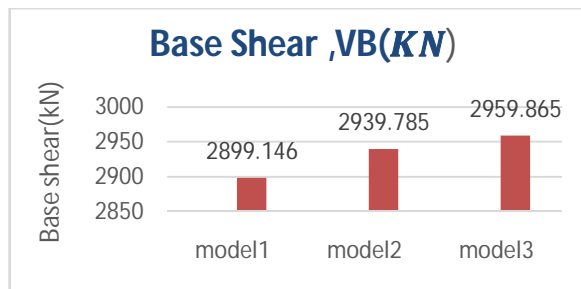


Fig.11: Base Shear along X Direction (KN)

Table 6: Base Shear along Y Direction (kN)

Base Shear , $V_B(KN)$			
Direction	model1	model2	model3
Y	2877.015	2939.196	2947.561

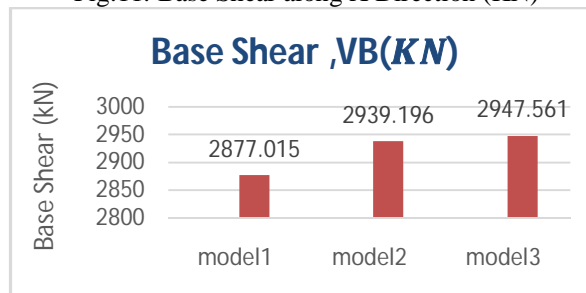


Fig.12: : Base Shear along Y Direction (KN)

D. STORY DRIFT

It is the displacement of one level relative to the other level above or below. As per IS 1893 (Part 1):2002, the storey drift in any storey due to the minimum specified design lateral force, with partial load factor of 1.0, shall not exceed 0.004 times the storey height.

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Table 7: Storey Drift along X Direction (m)

Location	Model 1	Model 2	Model 3
Base	0	0	0
Storey1	0.000659	0.000323	0.000361
Storey2	0.001169	0.000531	0.000629
Storey3	0.001314	0.000542	0.000568
Storey4	0.001417	0.000889	0.000884
Storey5	0.001329	0.001078	0.001097
Storey6	0.001222	0.001029	0.001056
Storey7	0.001099	0.000934	0.000965
Storey8	0.001066	0.00092	0.000954
Storey9	0.000788	0.000691	0.000712
Storey10	0.000433	0.00038	0.000385

Table 8: Storey Drift along Y Direction (m)

Location	Model 1	Model 2	Model 3
Base	0	0	0
Storey1	0.001113	0.000879	0.001013
Storey2	0.001819	0.001613	0.001764
Storey3	0.002199	0.001695	0.00149
Storey4	0.002296	0.002271	0.002032
Storey5	0.002126	0.002169	0.002165
Storey6	0.001946	0.001998	0.002022
Storey7	0.001744	0.001806	0.00184
Storey8	0.001602	0.001677	0.001711
Storey9	0.001192	0.001246	0.00127
Storey10	0.000623	0.000637	0.000659

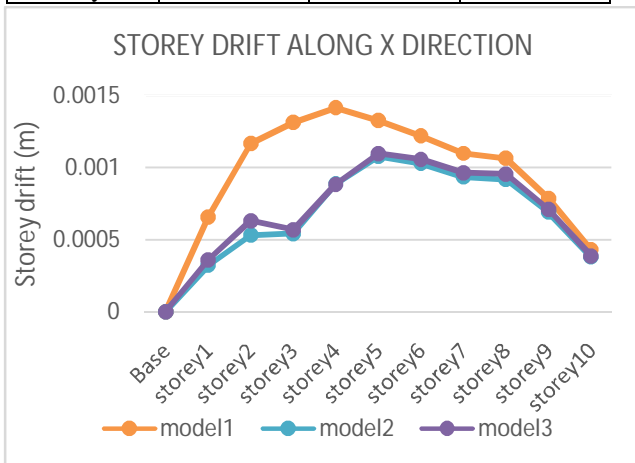


Fig.13: Storey Drift along X Direction (m)

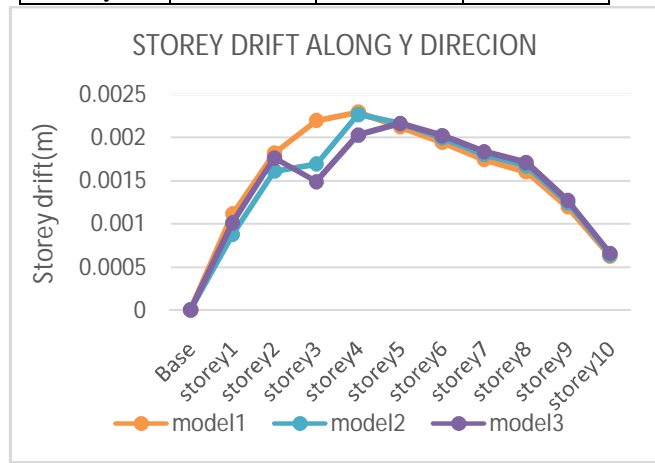


Fig.14: Storey Drift along Y Direction (m)

E. STOREY STIFFNESS

The lateral stiffness K_s of a story is generally defined as the ratio of story shear to story drift, is affected by vertical distribution of lateral loads. The variation of storey stiffness due to floating column is studied.

Table 9: Storey Stiffness along X Direction (kN/m)

Location	Model 1	Model 2	Model 3
Storey10	368497.3	401164.2	395245.4
Storey9	499577.1	551257	543827
Storey8	515266.6	565677.5	561788.3
Storey7	593377.3	652120.8	653265.7
Storey6	604456.3	670633.5	675137.7
Storey5	614544.5	713657.6	724642.9
Storey4	630763.3	988497.2	1044052
Storey3	740015	1917522	1930655
Storey2	888132.4	2072235	1644643
Storey1	1632171	3392042	2882617

Table 10: Storey Stiffness along Y Direction (kN/m)

Location	Model 1	Model 2	Model 3
Storey10	289328.3	281087.8	262308.4
Storey9	343814.7	342427.6	331872.4
Storey8	345428.9	344485.6	337051.6
Storey7	371235.5	369698.7	362266.3
Storey6	373808.5	372207.4	365671.2
Storey5	376325.4	376202	373468.6
Storey4	381045	396351.9	436883.2
Storey3	432206.3	619689.8	707273.9
Storey2	574347.9	659002.4	611860.1
Storey1	964203.9	1236597	1098002

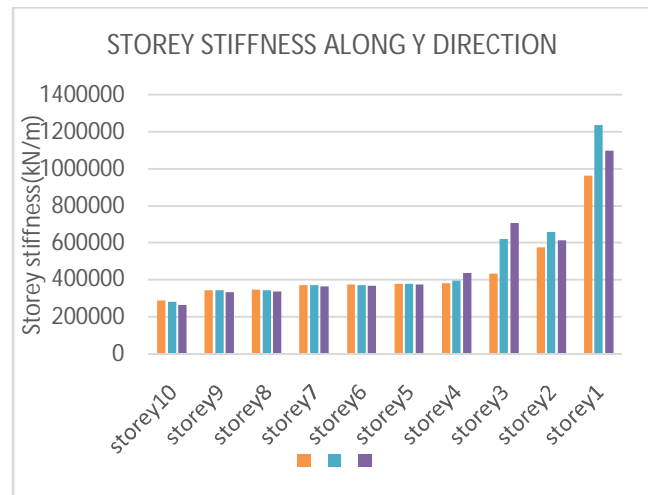
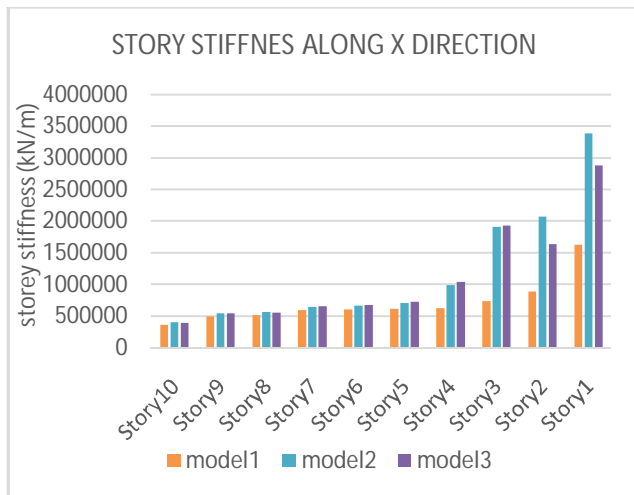


Fig.15: Storey Stiffness along X Direction (kN/m)

Fig.15: Storey Stiffness along Y Direction (kN/m)

VI. CONCLUSIONS

- Axial force in floating column C41 decreases in the sequence of Model-1(1581.073), Model-2(967.8714), and Model-3(746.6742).
- Axial force in columns C3, C4, and C8 (column near to floating column) increases in the sequence of Model-1(1590.591), Model-2(1841.472), and Model-3(2405.639).
- Shear force in columns C3, C4, and C8 increases in the sequence of Mode-1(76.7703), Model-2(78.3307), and Model-3(79.1892).
- Bending moment in columns C3, C4, and C8 increases in the sequence of Mode-1(117.4862), Model-2(221.4957), and Model-3(465.4106).
- Regarding Shear force along Y direction for continuous beam (B326, B325, B18, B19, B20, B21, B22) in storey 3 the variations are less for Mode-1(122.4317), Model-2(121.2017), and Model-3(115.0948).
- Regarding Hogging bending moment along Y direction for continuous beam (B326, B325, B18, B19, B20, B21, B22) in storey 3 the variations are less for Mode-1(47.5551), Model-2(44.5558), and Model-3(42.5558).
- Regarding Sagging bending moment along Y direction for continuous beam (B326, B325, B18, B19, B20, B21, B22) in storey 3 the variations are less for Mode-1(109.482), Model-2(105.7006), and Model-3(97.2807).
- For continuous beam (B289, B279, B290, B282, B8, B286, B392 of Model-1, B9, B290, B282, B8, B23 of Model-2, B36, B282, B37of Model-3) in storey 3 along X direction shear forces increases in the sequence of Model-1(179.9975), Model-2(478.9034), and Model-3(1401.234).
- For continuous beam (B289, B279, B290, B282, B8, B286, B392 of Model-1, B9, B290, B282, B8, B23 of Model-2, B36, B282, B37of Model-3) in storey 3 along X direction Hogging bending moment increases in the sequence of Model-1(174.97), Model-2(547.46), and Model-3(2432.4).
- For continuous beam in storey 3 (B289, B279, B290, B282, B8, B286, B392 of Model-1, B9, B290, B282, B8, B23 of Model-2, B36, B282, B37of Model-3) along X direction Sagging bending moment increases in the sequence of Model-1(74.0467), Model-2(744.336), and Model-3(2467).
- Along X direction the storey maximum displacement decreases in the sequence of Mode-1(29.2556), Model-3(20.8214), and Model-2(20.1868).
- The storey Maximum displacement variations is less along Y direction for Mode-1(45.1357), Model-2(42.9485), and Model-3(42.78627).
- Along X direction the storey drift reduced in the sequence of Mode-1(0.000659), Model-3(0.000361), and Model-2(0.000323).

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- Along Y direction the storey drift reduced in the sequence of Mode-1(0.000623), Model-3(0.000659), and Model-2(0.000637).
- The floating column effect is more predominant when the span of beam and number of floating columns increases.

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