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Effect of floating column on RCC building with and without infill wall subjected seismic force

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Abstract:— *In recent times, multi-storey buildings in urban cities are required to have column free space due to shortage of space, population and also for aesthetic and functional requirements. For this buildings are provided with floating columns at one or more storey. These floating columns are highly disadvantageous in a building built in seismically active areas. The earthquake forces that are developed at different floor levels in a building need to be carried down along the height to the ground by the shortest path. Deviation or discontinuity in this load transfer path results in poor performance of the building. In the present work is to study the behaviour of G+3 buildings having floating columns. However recent studies based on floating columns, which mostly concentrated on higher seismic zones and very few works is available for lower seismic zones Also to obtain the effects of mass variations and infill walls on behaviour of normal and floating column building, one forth portion of typical floor has been provided with higher mass compare to other portions and different building models were analysed with and without provisions of infill walls.*

Analytical study based on SAP 2000 version 18, shows that corner provisions floating columns on ground floor is worst case provisions. And base on this results cost comparison between normal building and critical floating column building has been done.

Keywords — *floating column, hanging column, performance point, Seismic Behavior, Lateral Displacement, Storey Drift*

I. INTRODUCTION

A Many multi-storey buildings in India today have open first storey as an unavoidable feature. This is primarily being adopted to accommodate parking or reception lobbies in the first storey. Whereas the total seismic base shear as experienced by a building during an earthquake is dependent on its natural period. The seismic force distribution is dependent on the distribution of stiffness and mass along the height.

The behavior of a building during earthquakes depends critically on its overall shape, size and geometry, in addition to how the earthquake forces are carried to the ground. The earthquake forces developed at different floor levels in a building need to be brought down along the height to the ground by the shortest path; any deviation or discontinuity in this load transfer path results in poor performance of the building. Buildings with vertical setbacks (like the hotel buildings with a few storey's wider than the rest) cause a sudden jump in earthquake forces at the level of discontinuity. Buildings that have fewer columns or walls in a particular storey or with unusually tall storey tend to damage or collapse which is initiated in that storey. Many buildings with an open ground storey intended for parking collapsed or were severely damaged in Gujarat during the 2001 Bhuj earthquake. 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.

1.1 Floating Column

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 (due to architectural design/ site situation) at its lower level (termination Level) rests on a beam which is a horizontal member. The beams in turn transfer the load to other columns below it. [1]

II. PROBLEM STATEMENT

The entire work consists of 29 models and these models were modelled and analysed by SAP 2000. It was analysed for local zone III (surat), medium soil condition, and results are tabulated for horizontal and vertical displacements.

Table 1 given below shows the information about different models and their specifications:

Table 1 information about different models

Model No.	Specification
All 1-20 models are analysed without infills and 21-30 are analysed with infills	
1	Normal building without floating column
2	Corner floating columns @ G.F
3	Internal floating columns @ G.F
4	Centre floating column @ G.F
5	Corner floating columns @ F.F
6	Internal floating columns @ F.F
7	Centre floating column @ F.F
8	Corner floating columns @ S.F
9	Internal floating columns @ S.F
10	Centre floating column @ S.F
Increment in Live load on ¼ portion of typical floor above the discontinues columns (As shown in fig.)	
11	Corner floating columns @ G.F
12	Internal floating columns @ G.F
13	Centre floating column @ G.F
14	Corner floating columns @ F.F
15	Internal floating columns @ F.F
16	Centre floating column @ F.F
17	Corner floating columns @ S.F
18	Internal floating columns @ S.F
19	Centre floating column @ S.F
20-29	Similar as model 1-10 but with infill walls provision

Followings are the data which is used for design and analysis of model

- Plan dimensions : 14m X 14m (bay width 4m,1m projection beyond columns)
- Floor height : 12m (3m for each)
- Base column : 0.550 X 0.550 m
- Other columns : 0.450 X 0.450 m
- Beam : 0.350 X 0.450 m
- Slab thickness : 0.150 m
- Live load (for model 1 to 10) : 3 Kn/m^2
- Live load (¼ th portion in model 11 to 19) : 4 Kn/m^2
- Importance factor : 1
- Response reduction factor : 5
- Zone : III
- Soil type : Medium

Size of infill wall : 0.230 m

Followings are pictures showing plan, sectional elevation and 3-dimentional representation of various designed models:

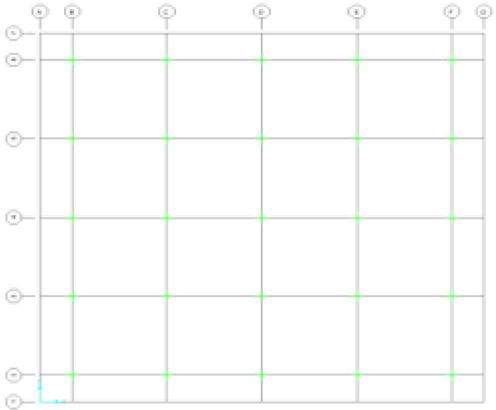


Figure 1 Plan of building

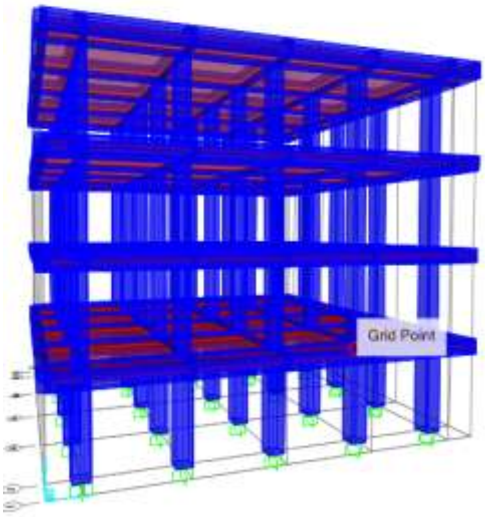


Figure 2 3-D model

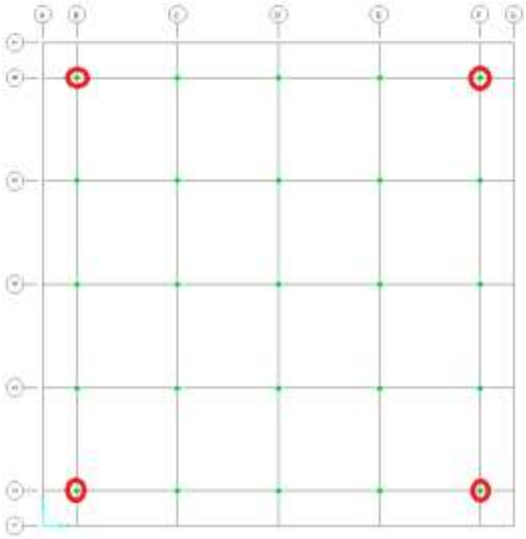


Figure 3 Position of floating columns (corners)

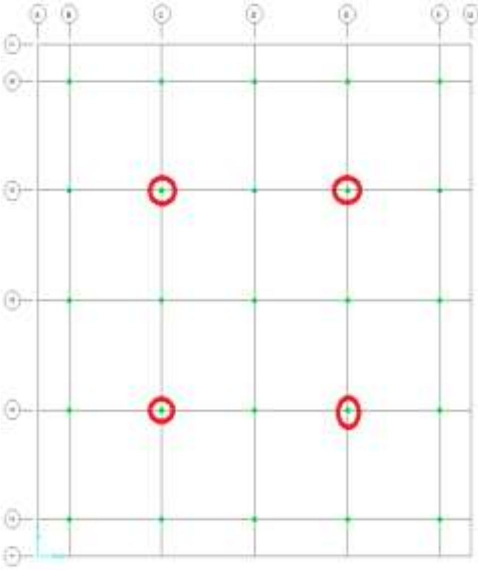


Figure 4 Position of floating columns (internal)

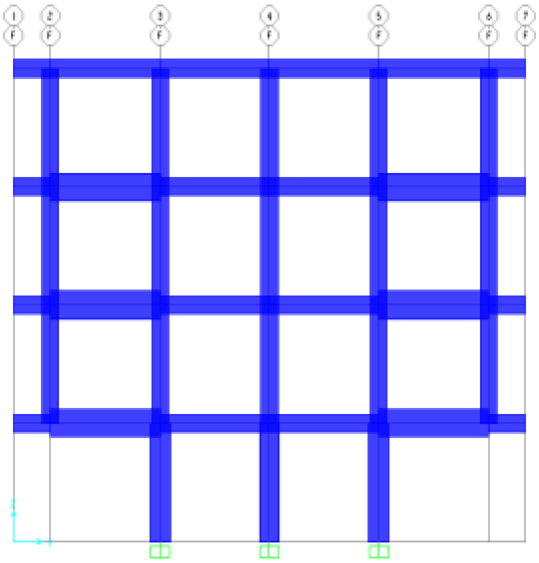


Figure 7 Floating columns @ G.F (corner)

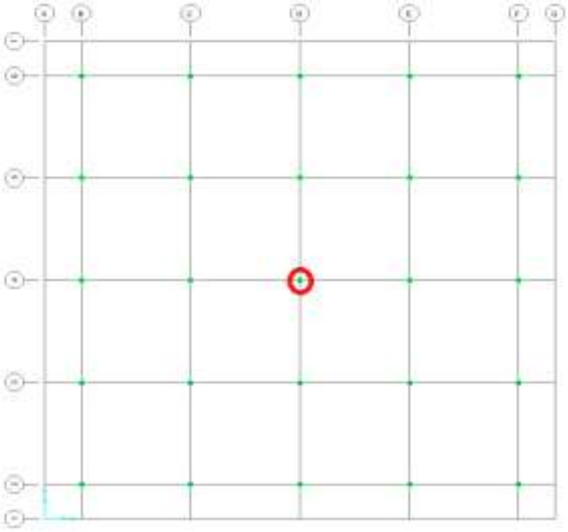


Figure 5 Position of floating columns (centre)

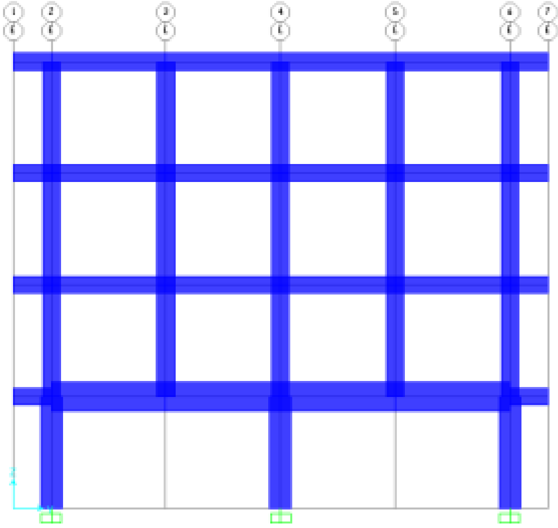


Figure 8 Floating columns @ G.F (internal)

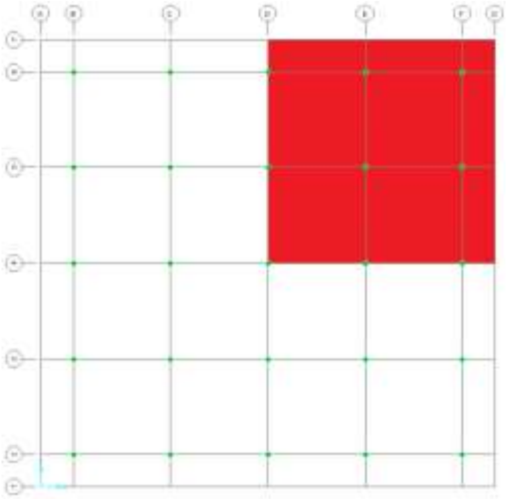


Figure 6 Area of load increment

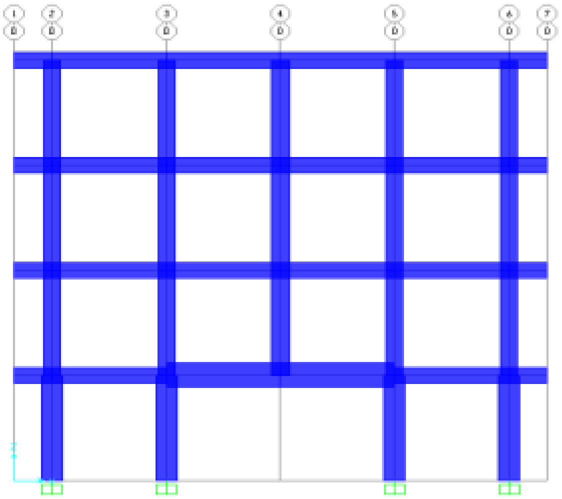


Figure 9 Floating columns @ G.F (centre)

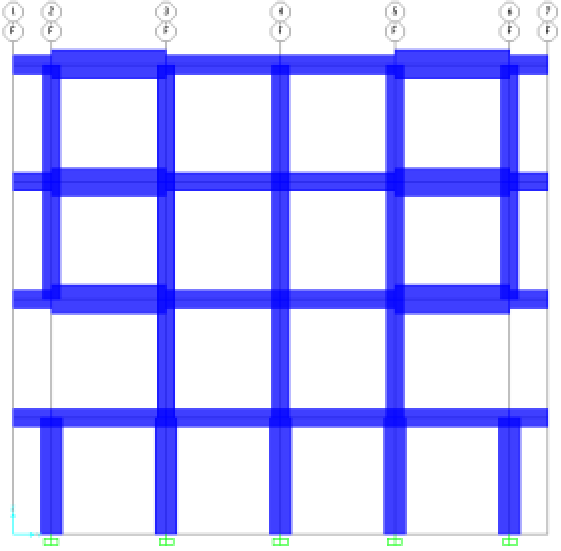


Figure 10 Floating columns @ F.F (corner)

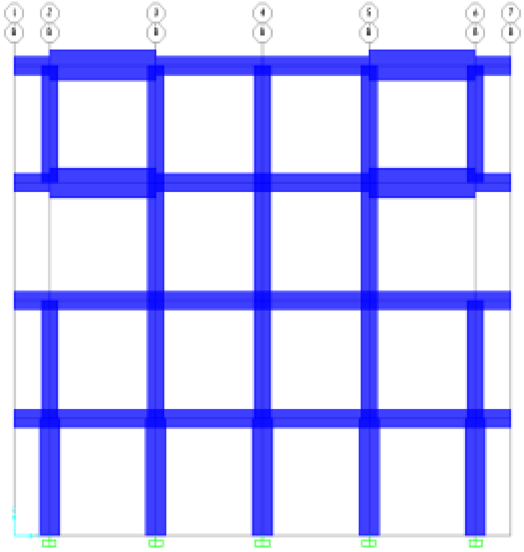


Figure 13 Floating columns @ S.F (corner)

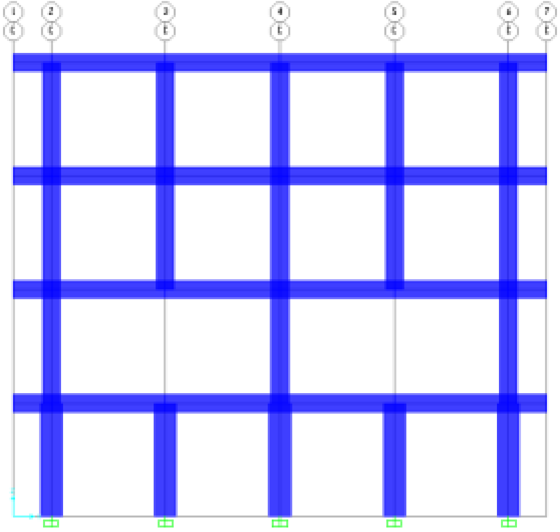


Figure 11 Floating columns @ F.F (internal)

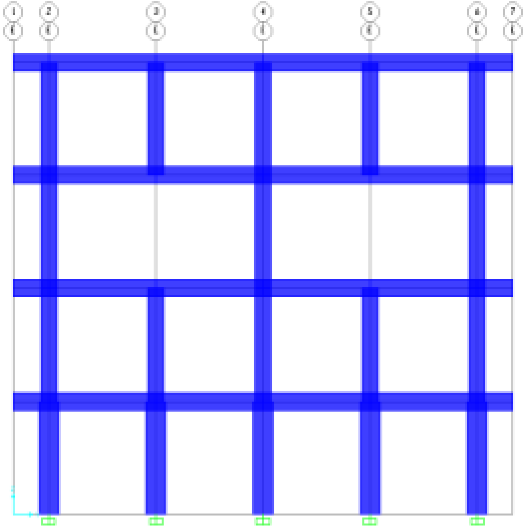


Figure 14 Floating columns @ S.F (internal)

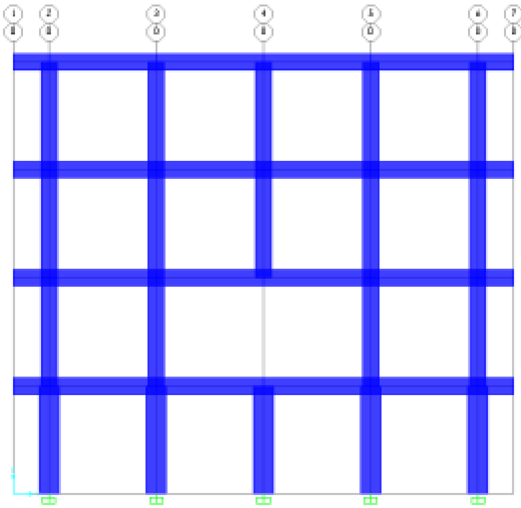


Figure 12 Floating columns @ F.F (centre)

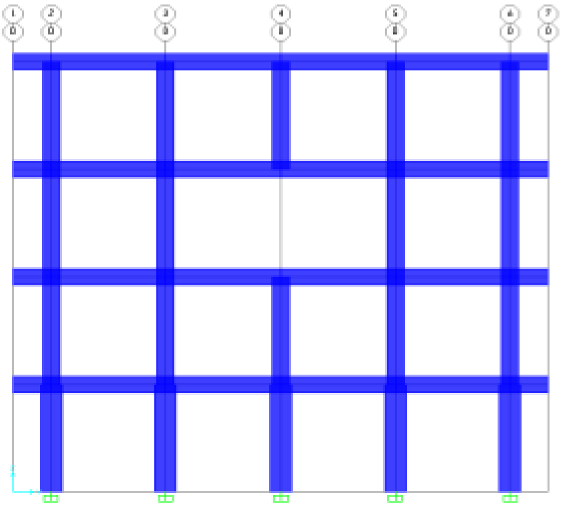


Figure 15 Floating columns @ S.F (centre)

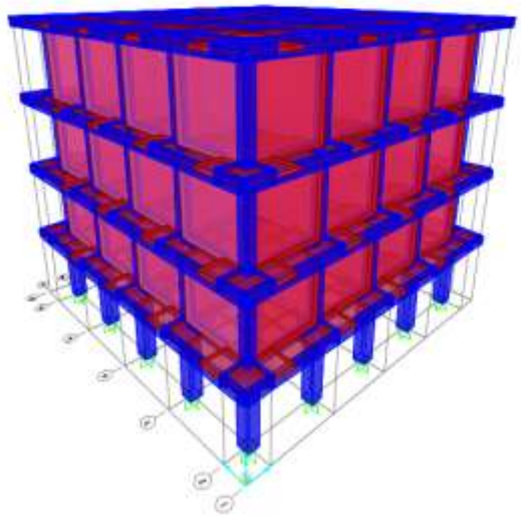


Figure 16 Building with infill

The software used for the present study is SAP 2000 version 18, used for analysing general structures including bridges, stadium, tower, industrial plants, off shore structure, buildings, dams, soils, etc. It is fully integrated programme that allows model creation, modification, execution of analysis, design optimization, and result review from within a single interface. SAP 2000 is finite element based structural programme for analyse and design of civil structures.

III.RESULTS AND DISCUSSION

Various models listed above were analysed using SAP 2000. Results were obtained in form of maximum horizontal and vertical displacements of typical floor for each case. To obtain the worst condition, results were taken by applying different load combination. That gives the idea about maximum possible displacements.

Results includes the comparison of various models with each other according to the position of floating columns, storey wise comparison , and comparison between models with and without increment of live load, and comparative study for building with and without effect of infills.

3.1 Tabular and graphical comparison:

Following comparisons are based on analytical results obtained by considering effects of infills,

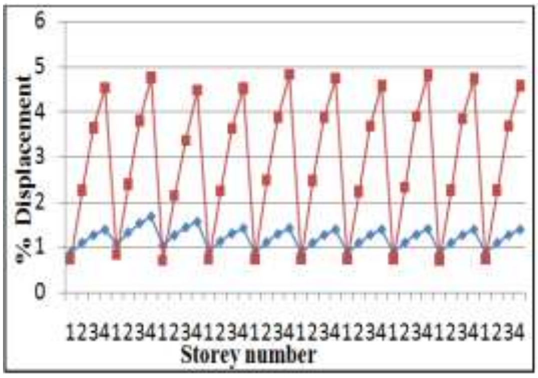
Here in the table 2, data shows the obtained values of horizontal displacements for both with and without infills

Table 2 Comparative % horizontal displacements for critical case no 2

DESIGN	STOREY	HORIZONTAL DISP. WITH INFILL(MM)	HORIZONTAL DISP. WITHOUT INFILL(MM)	% COMPARISON
1	1	0.884	0.727	-17.76
	2	1.108	2.261	104.06
	3	1.277	3.646	185.51
	4	1.398	4.535	224
2	1	1.075	0.834	-22.41
	2	1.333	2.394	79.59
	3	1.535	3.798	147.42
	4	1.686	4.759	182.26

from the results we conclude that floating columns provided at corner of ground floor is critical case

here is the graphical comparison between horizontal displacements based on data:



*RED LINE-without infill wall

*BLUE LINE with infill wall

Figure 17 Comparison between Horizontal displacement

Numerical percentage comparison for critical case of corner floating columns given below gives the idea of how the infills provisions, tends to reduce the vertical movement of structure during earthquake:

Here in the table 3, data shows the obtained values of vertical displacements for both with and without infills

DESIGN	STOREY	VERTICAL DISPL. WITH INFILL	VERTICAL DISPL. WITHOUT INFILL	% COMPARATIVE
1	1	0.799	0.695	-13.016
	2	0.998	0.999	0.100
	3	1.162	1.066	-8.261
	4	1.232	1.068	-13.311
2	1	1.963	4.355	121.86
	2	1.676	3.973	137.05
	3	1.626	3.903	140.036
	4	1.664	3.848	131.25

Table 3 Comparative % vertical displacements for critical case no 2

here is the graphical comparison between vertical displacements based on data:

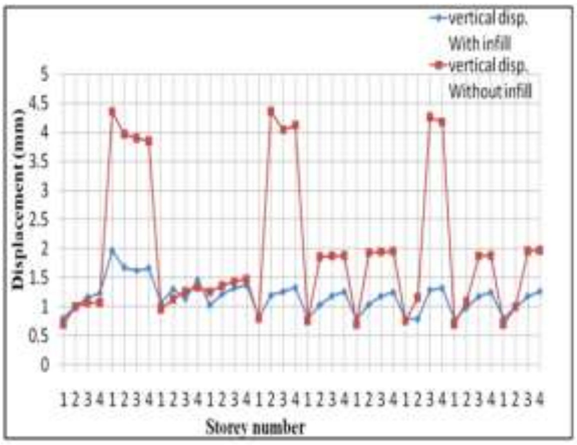


Figure 18 Comparison of storey wise vertical displacements between model 1-10 and 20-29

3.2Cost comparative study between normal building and critical case-2 floating column building:

(WITHOUT INFILLS)			
		STEEL (KG)	CONCRETE(M^3)
DESIGN (1)	QUANTITY	10171	174.1
	COST	457708	626760
DESIGN (2)	QUANTITY	13894	244.6
	COST	625225	880560

(WITH INFILLS)			
		STEEL (KG)	CONCRETE (M^3)
DESIGN (1)	QUANTITY	7655.2	115
	COST	344484	414000
DESIGN (2)	QUANTITY	9168	137
	COST	412560	493200

Comparative analysis of c/s of various members for different models shows that there is considerable reduction in the cross sectional area of various elements after provisions of infill walls. Reduction in size is directly proportional to reduction in the cost of overall building.

Hence given table shows the comparison of total quantities of steel and concrete required in construction of normal building model 1 and critical floating column building model 2.

IV. CONCLUSIONS

1. Results from all graphs shows that, buildings with provisions of floating columns at corners, on any floor shows the poor performance compare to other cases. Hence corner provisions of floating columns should be considered as critical case.
2. As the position of floating columns changes from corner to the centre of stiffness of typical floor, there is decrement in value of displacements, Higher decrement can be seen in vertical displacements, comparison to the horizontal one.

3. As the position of floating columns changes from 1st – 2nd – 3rd – 4th floor there is higher vertical displacements can be shown in floors, above the floor provided with floating columns.
   i.e provisions of floating columns at 1st floor shows higher vertical displacements at 2nd, 3rd and 4th floor.
4. The incremental load considered in the model on one side amounts to about 5% increases in eccentricity. This small increase does not make any major changes in displacements etc., which may found if higher eccentricity is generated.
5. Infill walls provide seismic strengthening of the floating column building. It also helps to reduce seismic response of the building.
6. An analytical result shows that, a horizontal displacement reduces by 182.26% (max) and a vertical displacement reduces by 140.03% (max) after infill provisions.
7. A graphical comparison shows that in cases without infiills, there is sudden increment in value of displacements compare to the cases with infills.
8. Revising the design of structural members after provision of infill walls shows that revision tends to reduce the quantity of steel and concrete. Hence it will not only reduce the seismic response but also make the structure economical.
9. Comparative cost analysis shows that, critical case 2 building required higher quantity of steel and concrete compare to the normal building. Also a provision of infill walls tends to reduce the size and cost of structural members compares the buildings without infill walls.

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