Design and Analysis of a High-Rise Building with and without Floating Columns

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Abstract— At present buildings with floating column is a typical feature in the modern multistory construction in urban India. 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. As the load path in the floating columns is not continuous, they are more vulnerable to the seismic activity. Sometimes, to meet the requirements these type of aspects cannot be avoided though these are not found to be of safe. Hence, an attempt is taken to study the behavior of a G+15 multi storey building in which some storey's are considered for commercial purpose and remaining storey's are for residential purpose. This paper studies the comparison & seismic analysis of the multistory buildings with floating column and without floating column. Finally, analysis & results in the high rise building such as storey drifts, storey displacement, and Base shear were shown in this study. Design and Analysis was carried out by using Extended Three Dimensional Analysis of Building Systems (ETABS) Software.

Key words: Floating Columns, High-rise buildings, seismic analysis, ETABS

I. Introduction

Many urban multi storey buildings today have open first storey as an unavoidable feature. This is primarily being adopted to accommodate parking or reception lobbies in the first storey. 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 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 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. This can be done by Transfer beams. The floating column rests on the transfer beam and this beam transfer the forces to the columns below it. In High-rise buildings this is a common feature now.

A. *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.

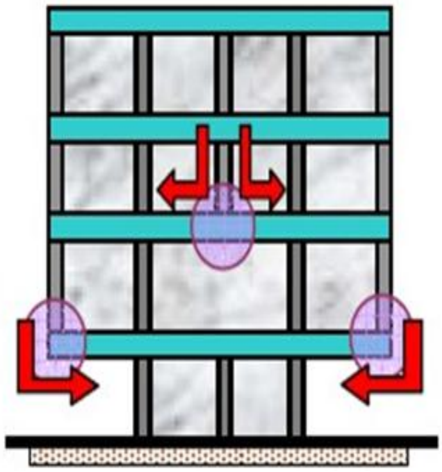

Fig. 1: Hanging or Floating Columns

In this century due to huge population the no. of areas in units are decreasing day by day. Few years back the populations were not so vast so they used to stay in Horizontal system (due to large area available per person). But now a day's people preferring Vertical System(high rise building due to shortage of area). Hence, the structures already made with these kinds of discontinuous members are endangered in seismic regions. But those structures cannot be demolished, rather study can be done to strengthen the structure or some remedial features can be suggested.

B. *Transfer Beam:*

In Frame as load carrying system when column is not allowed to continue downward due to some restriction, problem is resolved by using transfer beam. A transfer beam carries the load of an especially heavy load, typically a column. It is used to transfer the load of a column above to two separate columns below. This is often needed in cases where you need different or larger column spacing. One example where we often see transfer beams is in high rise buildings. These buildings often have retail spaces and parking garages at the lower levels and residential or office units on the upper levels.

C. *High-rise buildings:*

High-rise buildings in general are defined as buildings 35 meters or greater in height which are divided at regular intervals into occupable levels. Undeniably the high-rise buildings are also seen as a wealth-generating mechanism working in an urban economy. High-rise buildings are constructed largely because they can create a lot of real estate out of a fairly small piece of land. Because of the availability of global technology and the growing demand for real estate, high rise buildings are seen as the most fitting solution to any city that is spatially challenged and can't comfortably house its inhabitants.

D. Objective:

In this thesis a G+15 High-rise building with and without floating column in which some storey's are considered for commercial purpose and remaining storey's are for residential purpose. It should withstand against all potential loading conditions and fulfills the task for which it is built. It should also ensure that the structure will be designed economically. Safety necessities must be met so that the structure will able to serve its purpose· with the minimum cost. The analysis and design of the super structure was done by using ETABS which has been recognized as the industry standard for Building Analysis and Design Software and the comparison and seismic analysis is done by applying all the loads and combinations and to find whether the structure is safe or unsafe with floating column and the analysis and results are shown in this study.

E. Modelling:

This paper deals with the comparison of a G+15 High-rise building with normal columns and with floating column. Here a normal G+15 storey building is considered in the first case and in the second case another building in which first 10 storeys are for commercial purpose and from11th storey to roof it is for residential purpose in which we considered floating column. Here the plan configurations of both the building are shown. Upto 10th storey they are same and from 11th storey they differ. By applying the static loads both the structures are safe.

1) Model – 1:

Here a G+15 building with all normal columns which is nothing but a normal building is considered as model 1 with dimensions of beams as 230 mm X 450 mm and column as 600mm X 600mm upto fourth storey and 450mm X 450mm from there. For the overall building the dimensions of beams are same in both X and Y directions.

BEAMS - 230mmX450mm
COLUMNS - 450mmX450mm
600mmX600mm

2) Model – 2:

Here a G+15 building with floating columns is considered as model 2 with dimensions of beams as 230 mm X 450 mm and column as 600mm X 600mm up to fourth storey and 450mm X 450mm from there. Here upto 10 floors both buildings are same, but from there floating columns are introduced. The structure is not safe with same beam dimensions. To make the structure safe beams and columns are to be increased Due to this transfer beams are considered. A transfer beam carries the load of an especially heavy load, typically a column. It is used to transfer the load of a column above to two separate columns below. This is often needed in cases where you need different or larger column spacing.

BEAMS - 230mmX450mm
375mmX600mm
COLUMNS - 450mmX450mm
600mmX600mm

II. ANALYSIS IN ETABS

The first step in ETABS is to set the grid dimensions. This includes setting number of lines in X direction, Y direction and the spacing between grid lines. Then the storey data is defined which includes setting the number of stories, height of typical and bottom storey. The type of slab is also mentioned in the grid data.

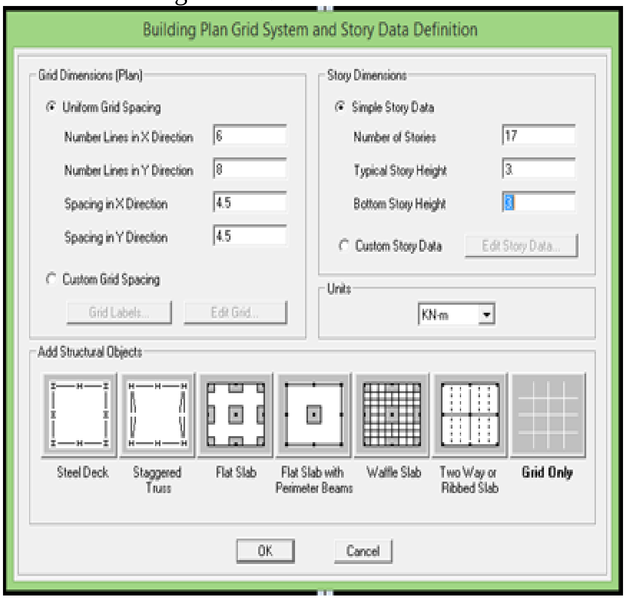

Fig. 2:

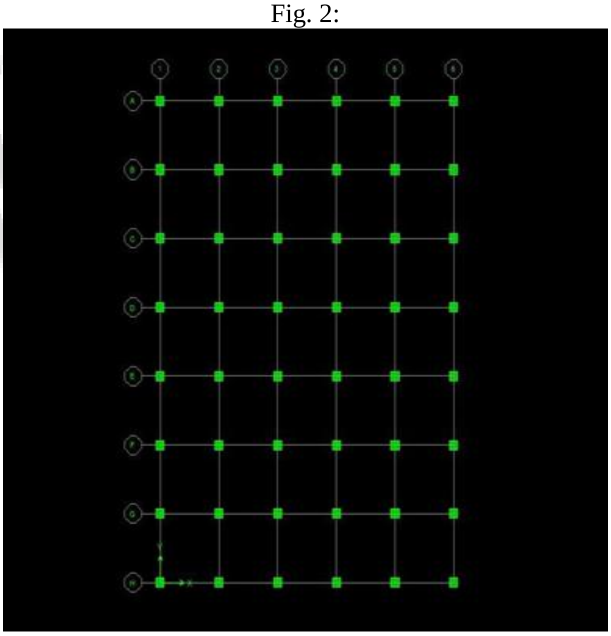

Fig. 3: Plan of Model-1 Building

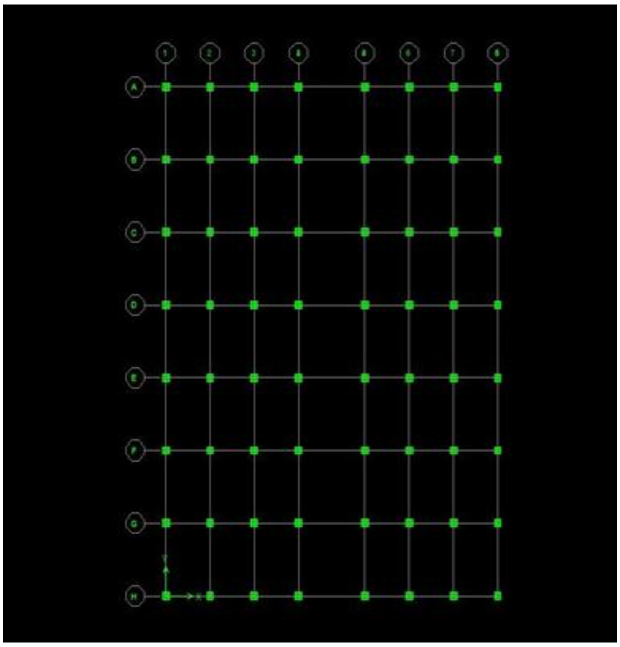

Fig. 4: Plan of Model-2 Building

A. Modelling:

After defining the sections and materials a three dimensional modal of the structure is . created using various modeling tools and techniques available in the ETABS. ETABS offers some of most advanced modeling tools such as snaps, replicate, mirror insert storey, delete storey etc

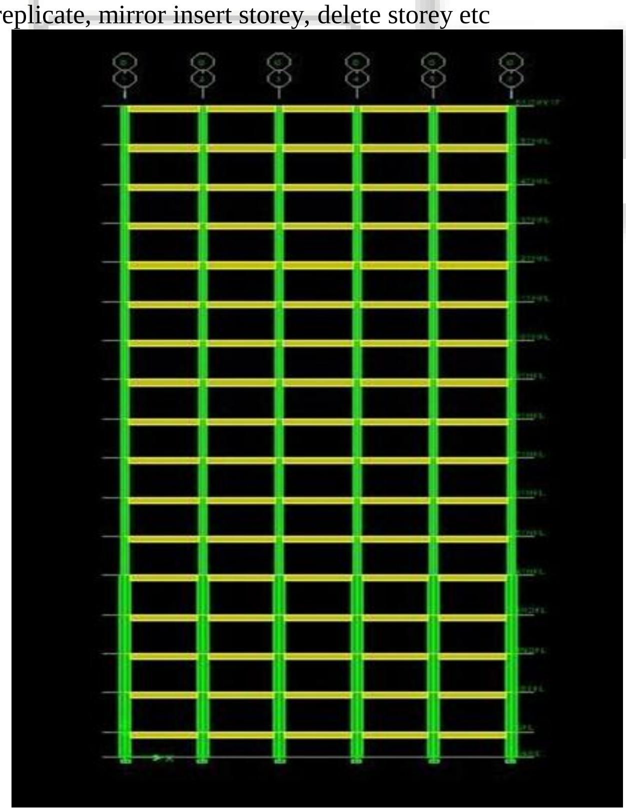

Fig. 5: Elevation of Model-1

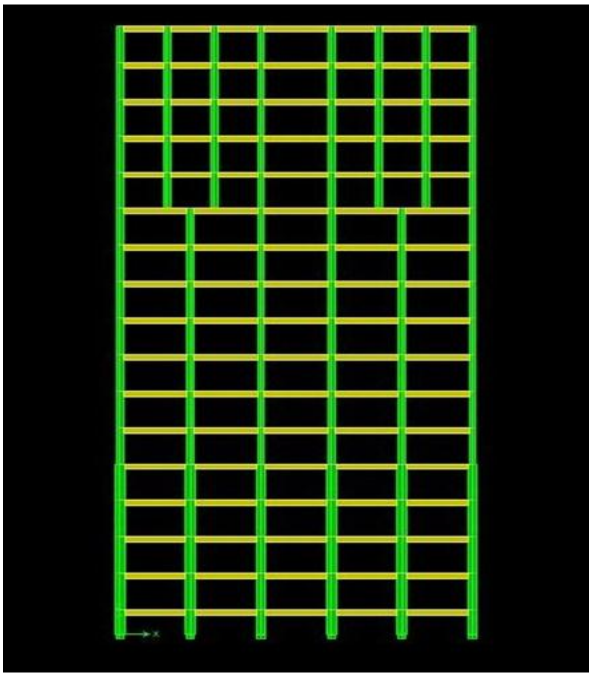

Fig. 6: Elevation of Model-1

B. Building parameters:

Utility of Building Commercial & Residential Building

- Number of Stories G+15
- Geometry of Building Symmetric
- Type of Construction RCC framed
- Type Of Walls Brick walls
  External walls 0.20m
  Internal walls 0.10m
- Floor to floor height 3.0 m
- Height of the plinth 2.0 m above the ground
- Grade of Concrete M25
- Grade of Steel Fe 500

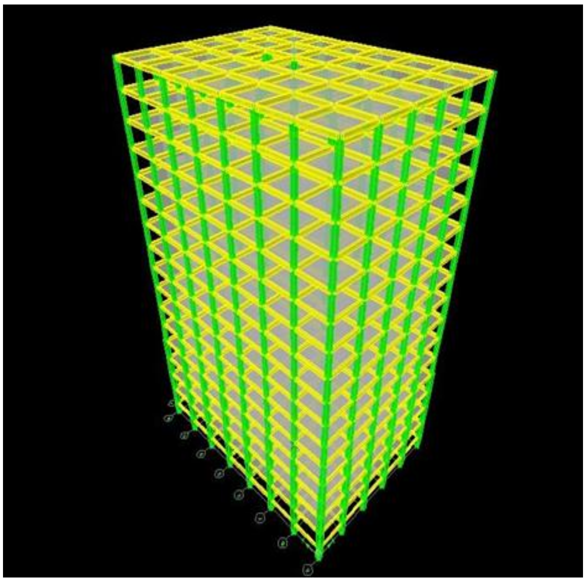

Fig. 7: Elevation of Model-1

III. RESULTS AND DISCUSSIONS

A. Lateral Displacement Due To EQPX:

STOREY	WITH FC	WITHOUT FC

15	0.001865	0.001485
12	0.001822	0.001455
9	0.001429	0.000948
6	0.001219	0.000616
3	0.000659	0.000356

Table 1: Lateral Displacement Due To EQPX

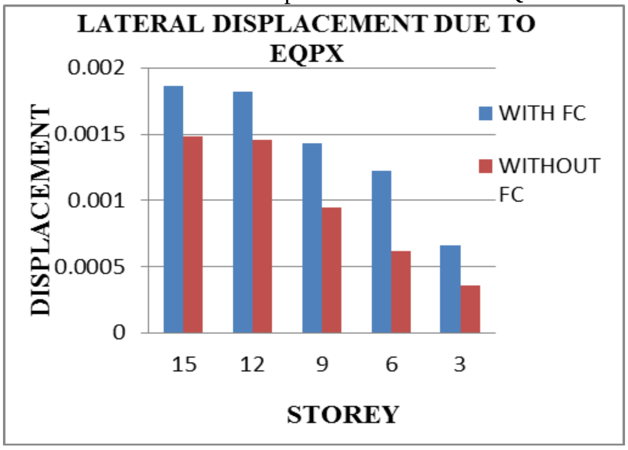

Fig. 8:

B. *Lateral Displacement Due To EQPY:*

STOREY	WITHOUT FC	WITH FC
15	0.00129	0.001734
12	0.001277	0.001692
9	0.00088	0.001316
6	0.000559	0.001137
3	0.000322	0.000616

Table 2: Lateral Displacement Due To EQPY

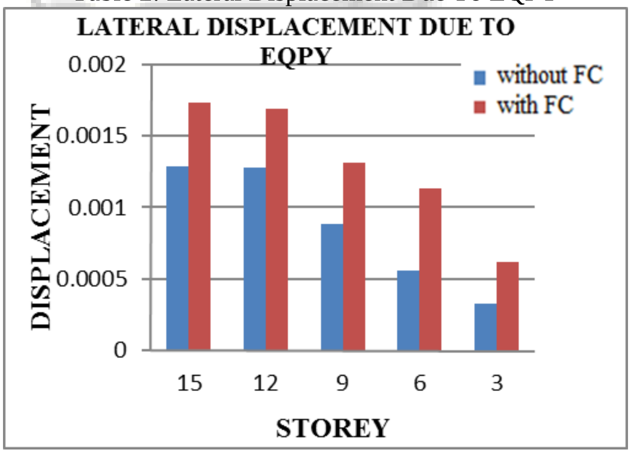

Fig. 9:

C. *Lateral Displacement Due To EQNX:*

STOREY	WITHOUT FC	WITH FC
15	0.001482	0.001876
12	0.001455	0.001828
9	0.000948	0.001435
6	0.000616	0.001223
3	0.000356	0.000661

Table 3: Lateral Displacement Due To EQNX

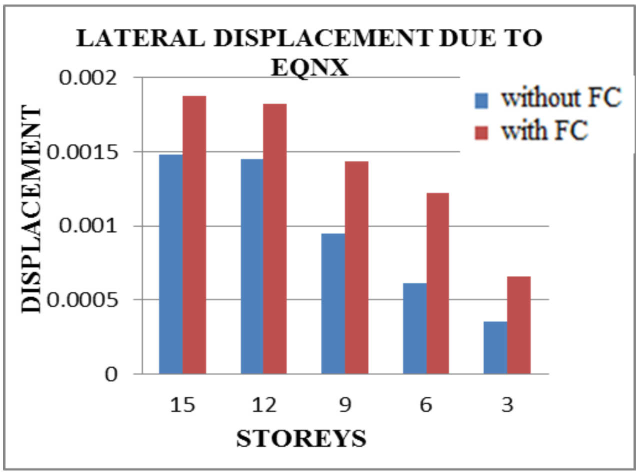

Fig. 10:

LATERAL DISPLACEMENT DUE TO EQNYSTOREY	WITHOUT FC	WITH FC
15	0.001289	0.001734
12	0.001276	0.001692
9	0.000881	0.001316
6	0.000559	0.001137
3	0.000322	0.000616

Table 4:

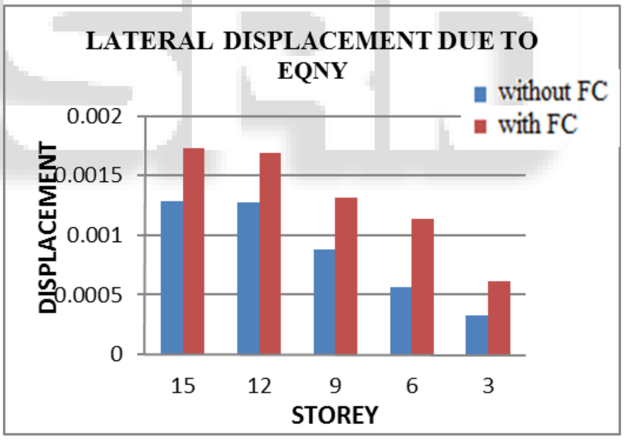

Fig. 11:

D. *Storey Drift EQPX:*

STOREY	WITHOUT FC	WITH FC
16	0.000519	0.000645
15	0.000725	0.001032
14	0.000919	0.001419
13	0.001044	0.001762
12	0.001092	0.002359
11	0.001121	0.002461
10	0.001196	0.002529
9	0.001597	0.002707
8	0.001776	0.002847
7	0.001891	0.002951
6	0.001967	0.003022

5	0.002004	0.003044
4	0.001703	0.002568
3	0.001661	0.002497
2	0.001531	0.002295
1	0.00117	0.001752
GF	0.000454	0.00068

Table 5: Storey Drift EQPX

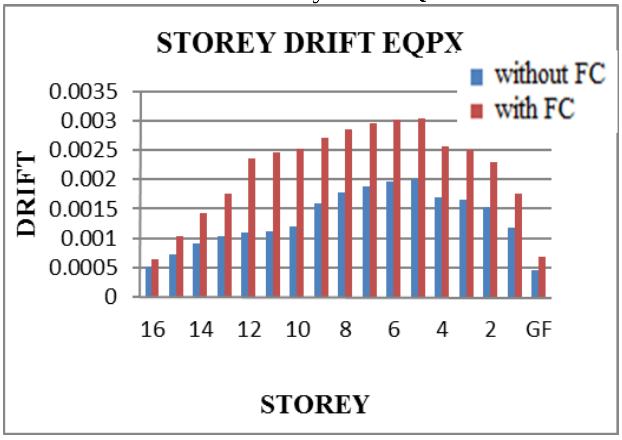

Fig. 12:

E. Storey Drift EQPY:

STOREY	WITHOUT FC	WITH FC
16	0.000096	0.000119
15	0.000152	0.000211
14	0.000215	0.000317
13	0.000278	0.000424
12	0.000335	0.000581
11	0.000359	0.000696
10	0.000426	0.000738
9	0.000578	0.000838
8	0.000685	0.000936
7	0.000782	0.001029
6	0.000874	0.00112
5	0.000963	0.001206
4	0.000872	0.001073
3	0.000898	0.001093
2	0.000873	0.001052
1	0.0007	0.000837
GF	0.000278	0.000331

Table 6: Storey Drift EQPY:

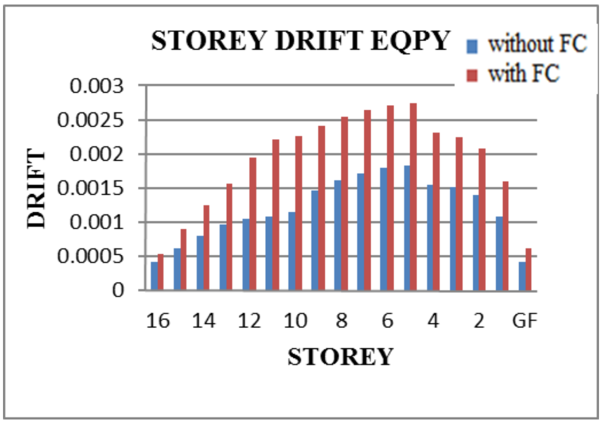

Fig. 13:

F. Storey Drift WLX:

STOREY	WITHOUT FC	WITH FC
16	0.000203	0.000197
15	0.000294	0.000329
14	0.000396	0.000483
13	0.000497	0.000638
12	0.000581	0.000891
11	0.000574	0.001041
10	0.000675	0.001089
9	0.000942	0.001231
8	0.001103	0.001369
7	0.001242	0.001501
6	0.001371	0.001628
5	0.001493	0.001745
4	0.001348	0.001558
3	0.001378	0.00158
2	0.001329	0.001515
1	0.001056	0.001197
GF	0.000417	0.000471

Table 7: Storey Drift WLX

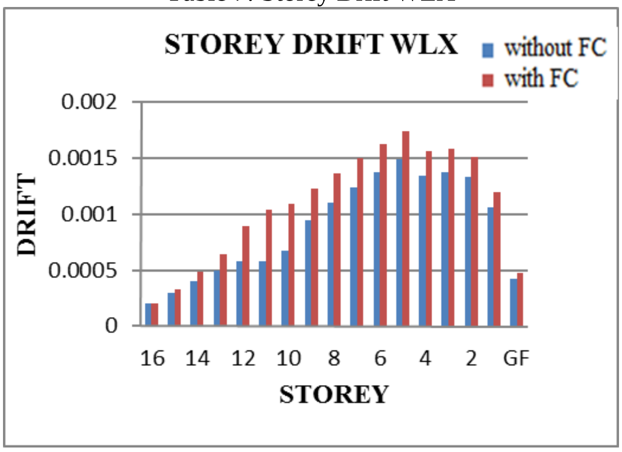

Fig. 14:

G. Storey Shear in X DIR:

STOREY	WITH FC	WITHOUT FC
16	413.64	271.39

15	871.68	527.89
14	1273.12	752.69
13	1621.68	947.88
12	1921.1	1115.56
11	2175.11	1257.8
10	2403.51	1470.08
9	2591.09	1650.86
8	2741.86	1796.18
7	2859.85	1909.9
6	2949.07	1995.88
5	3013.53	2058.01
4	3058.41	2101.26
3	3086.91	2128.73
2	3101.99	2143.27
1	3107.88	2148.94
GF	3108.29	2149.33

Table 8: Storey Shear in X DIR:

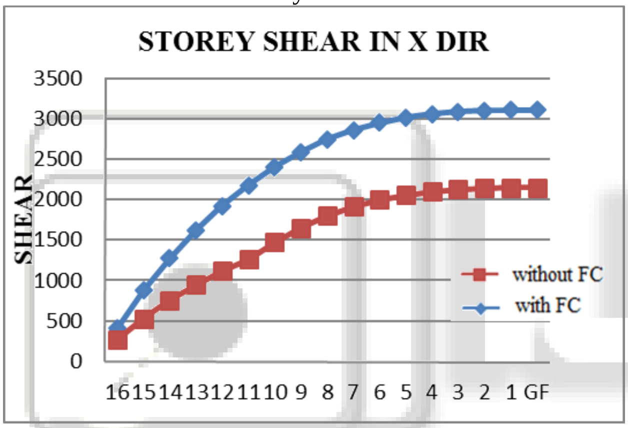

Fig. 15:

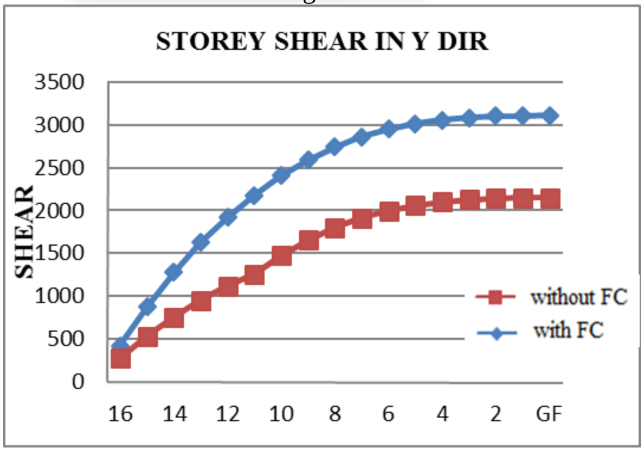

Fig. 16:

IV. Conclusion

The study presented in the paper compares the difference between normal building and a building on floating column. The following conclusions were drawn based on the investigation

1) By the application of lateral loads in X and Y direction at each floor, the lateral displacements of floating column building in X and Y directions are more compared to that of a normal building. So the floating column building is unsafe for construction when compared to a normal building
2) By the calculation of storey drift at each floor for the buildings it is observed that floating column building will suffer extreme storey drift than normal building. The storey Drift is maximum at 5th and 6th storey levels in both the cases.
3) The building with floating columns experienced more storey shear than that of the normal building. This is due to the use of more quantity of materials than a normal building. So the floating column building is uneconomical to that of a normal building
4) The final conclusion is that do not prefer to construct floating column in buildings unless there is a proper purpose and functional requirement for those. If they are to be provided then proper care should be taken while designing the structure

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