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Comparison of Seismic Analysis of a Floating Column Building and a Normal Building

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Abstract

Now a days multistorey buildings are constructed for the purpose of residential, commercial etc., with open ground storey is becoming common feature. For the purpose of parking all, usually the ground storey is kept free without any construction except columns.

Buildings which have discontinuity of columns and building having columns which transfer load to the beams in lateral direction are called as floating column building. In the present analysis, a residential building with 6 Storeys and 12 Storeys are analyzed with column,Beams & Slabs. The buildings are analysed & designed with and without edge columns at base storey. The Buildings are analysed in two Earth Quake zones according to IS 1893-2002 with medium soil. Static Load combinations and Response Spectrum Analysis is done to compare the results.

Results are compared in the form of Storey displacements, Storey Shear, Storey Over turning Moments with & with out columns at base storey in both Static and Dynamic Analysis. Also the Zone wise results are compared using tables & graph to find out the most optimized solution.

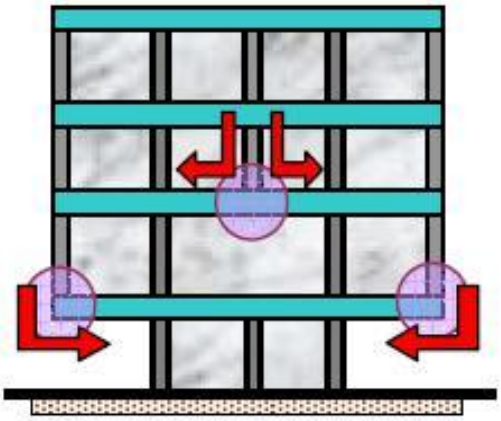
A Evaluation package of ETABS 2013 has been utilized for analyzing the above Building Structure.

1. INTRODUCTION

Many urban multistorey 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 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.

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.



Hanging or Floating Columns

2. LITERATURE REVIEW

Current literature survey includes earthquake response of multi storey building frames with usual columns. Some of the literatures emphasized on strengthening of the existing buildings in seismic prone regions.

Maison and Neuss , (1984), Members of ASCE have preformed the computer analysis of an existing forty four story steel frame high-rise Building to study the influence of various caseing aspects on the predicted dynamic properties and computed seismic response behaviours. The predicted dynamic properties are compared to the building's true properties as previously determined from experimental testing. The seismic response behaviours are computed using the response spectrum (Newmark and ATC spectra) and equivalent static load methods.

Mortezaei *et al* (2009) recorded data from recent earthquakes which provided evidence that ground motions in the near field of a rupturing fault differ from ordinary ground motions, as they can contain a large energy, or ‘‘directivity” pulse. This pulse can cause considerable damage during an earthquake, especially to structures with natural periods close to those of the pulse. Failures of modern engineered structures observed within the near-fault region in recent earthquakes have revealed the vulnerability of existing RC buildings against pulse-type ground motions. This may be due to the fact that these modern structures had been designed primarily using the design spectra of available standards, which have been developed using stochastic processes with relatively long duration that characterizes more distant ground motions. Many recently designed and constructed buildings may therefore require strengthening in order to perform well when subjected to near-fault ground motions. Fiber Reinforced Polymers are considered to be a viable alternative, due to their relatively easy and quick installation, low life cycle costs and zero maintenance requirements.

Ozyigit (2009) performed free and forced in-plane and out-of-plane vibrations of frames are investigated. The beam has a straight and a curved part and is of circular cross section. A concentrated mass is also located at different points of the frame with different mass ratios. FEM is used to analyze the problem.

Williams, Gardoni & Bracci [24] (2009) studied the economic benefit of a given retrofit procedure using the framework details. A parametric analysis was conducted to determine how certain parameters affect the feasibility of a seismic retrofit. A case study was performed for the example buildings in Memphis and San Francisco using a modest retrofit procedure. The results of the parametric analysis and case study advocate that, for most situations, a seismic retrofit of an existing building is more financially viable in San Francisco than in Memphis.

3. METHODOLOGY

Geometrical Properties

1. Height of typical storey = 3 m

2. Height of ground storey = 3 m

3. Length of the building = 48m
4. Width of the building = 48 m
5. Height of the building = 48 m
6. Number of stories = 16
7. Wall thickness = 230 mm
8. Slab Thickness = 125 mm
9. Grade of the concrete = M30
10. Grade of the steel = HYSD500
11. Thickness of shear wall = 230 mm
12. Support = fixed
13. Column sizes first floor to 8th floor = 0.975m X 0.975 m
    9th floor to 12th floor = 0.75m X 0.75m
    13th floor to 16th floor = 0.45 m X 0.45m

    Column sizes after change First floor = 1.02 m X 1.025m
    2nd floor to 8th floor = 0.975m X 0.975 m
    9th floor to 12th floor = 0.75m X 0.75m
    13th floor to 16th floor = 0.45 m X 0.45m

14. Beam sizes First floor to 8th floor = 0.4m X 0.8m

    9th floor to 16th floor = 0.3m X 0.6m
    Beam sizes after change First floor = 0.5m X 1m
    2nd floor to 8th floor = 0.4m X 0.8m
    9th floor to 16th floor = 0.3m X 0.6m

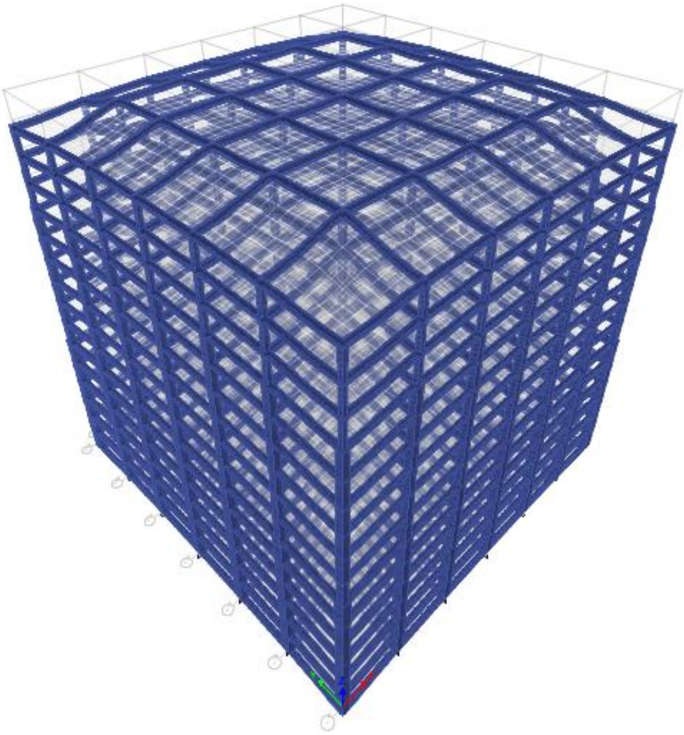


Fig:1 DIMENSIONAL VIEW OF WITH FLOATING COLUMN

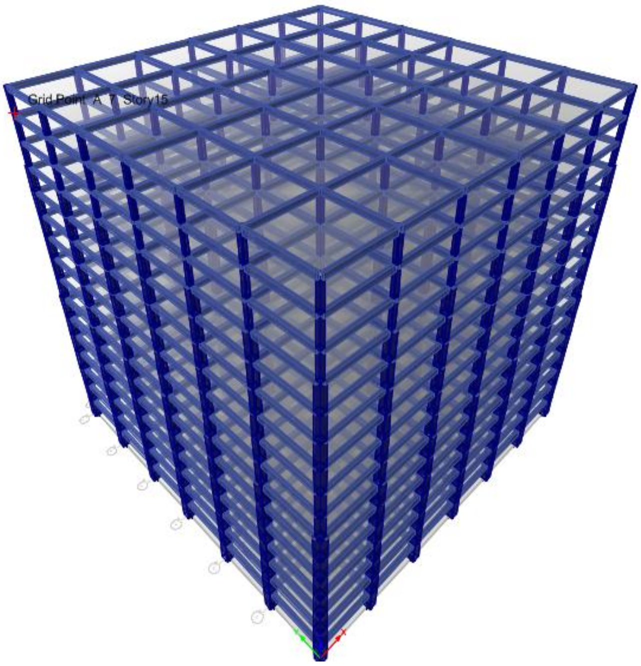
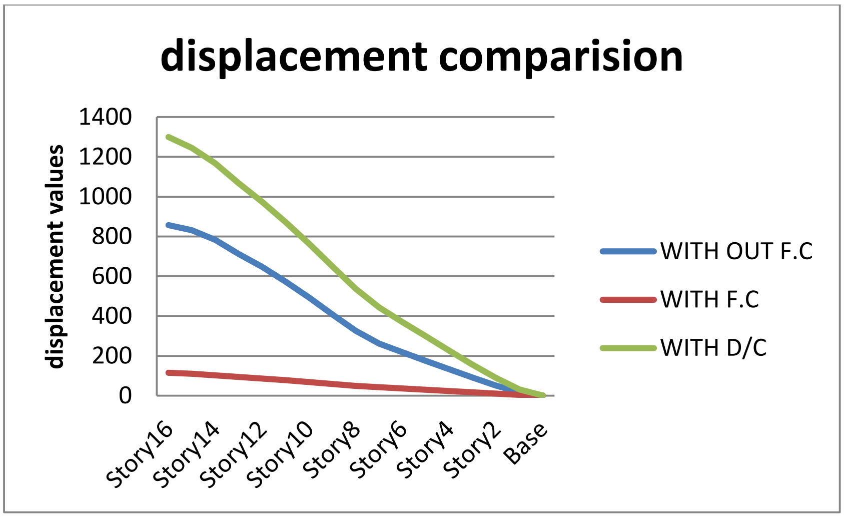


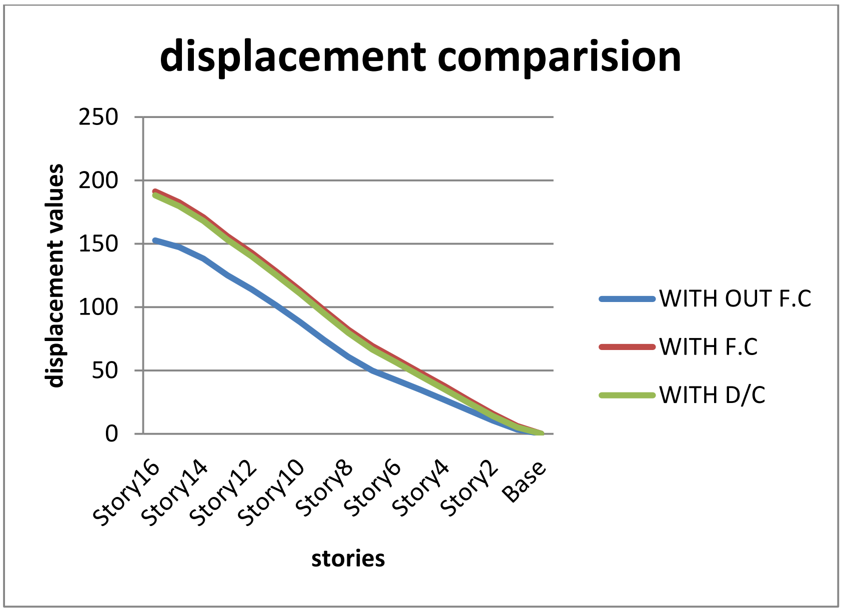
Fig:2 DIMENSIONAL VIEW OF WITH OUT FLOATING COLUMN

4. RESULTS

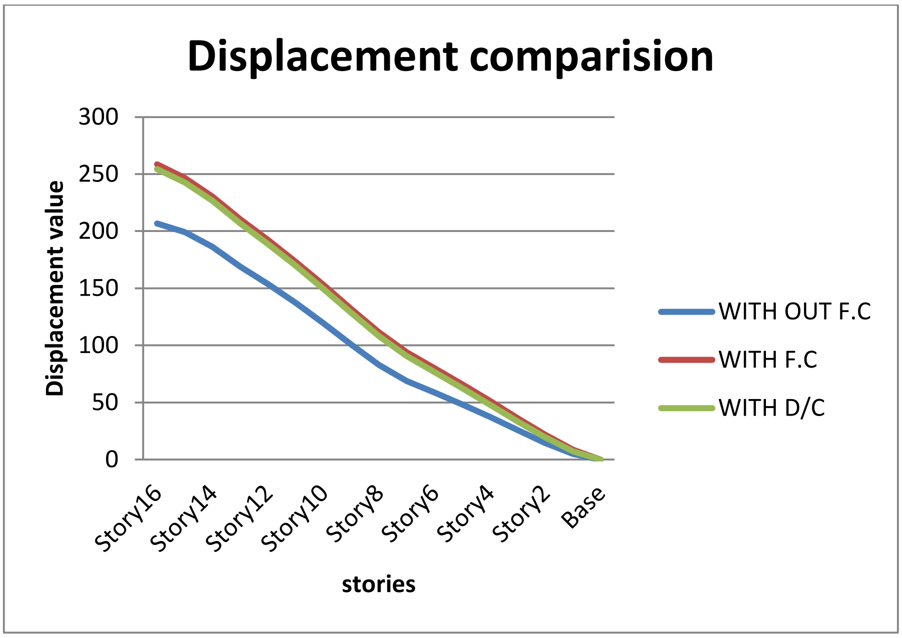
Comparison of Displacement in Response Spectrum Method in Seismic Analysis of Floating Column of Building With, Without and With Change in Dimensions



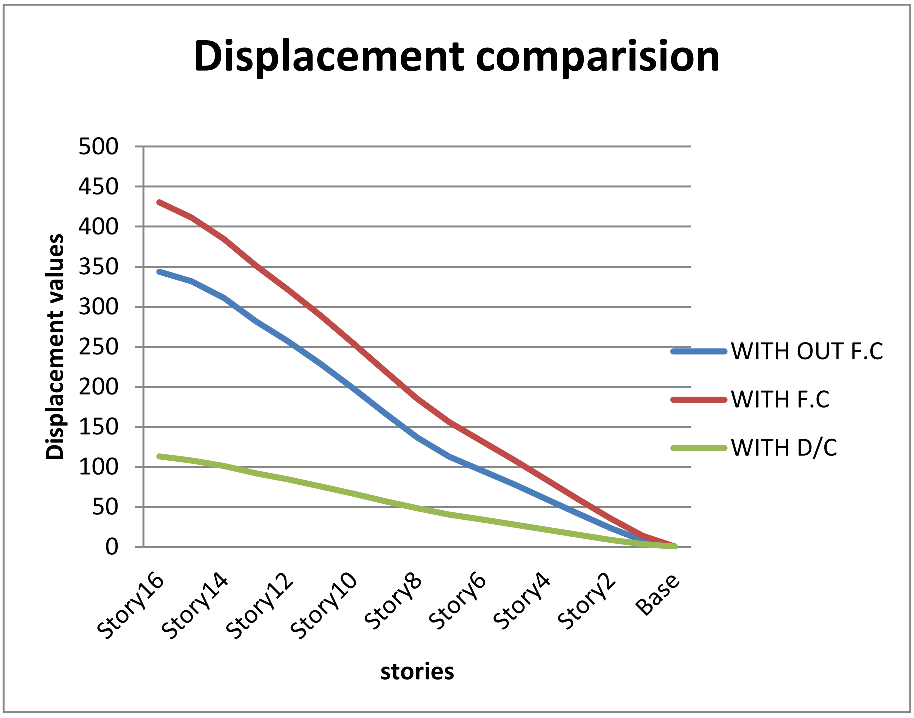
GRAPH 1:RESPONSE SPECTRUM METHOD IN ZONE-III,SOIL-I



GRAPH 2:RESPONSE SPECTRUM METHOD IN ZONE-III,SOIL-III



GRAPH 3: RESPONSE SPECTRUM METHOD IN ZONE-V, SOIL-I

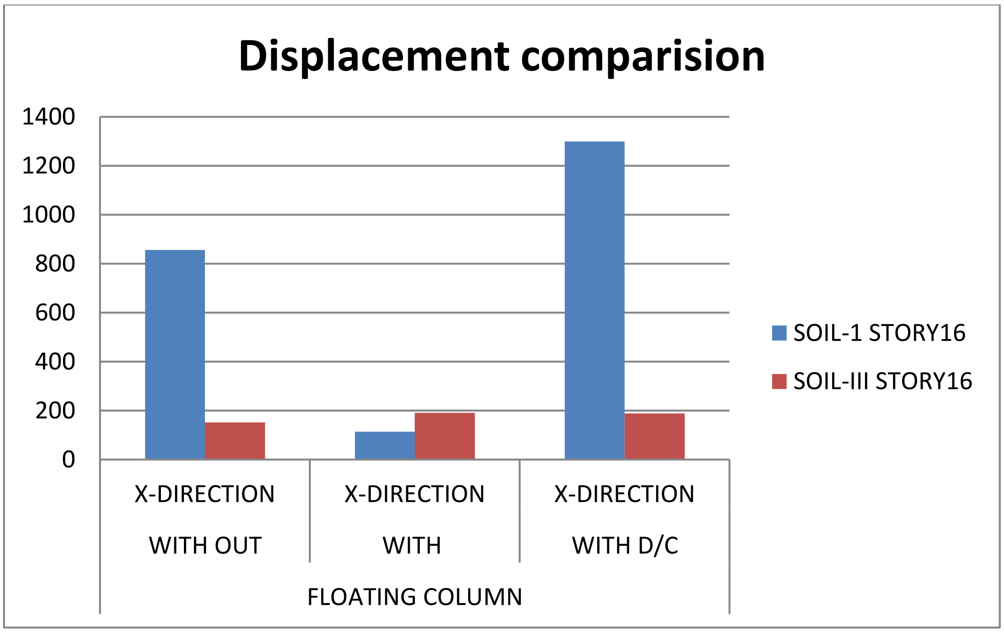


GRAPH 4: RESPONSE SPECTRUM METHOD IN ZONE-V, SOIL-III

TABLE 1. RESPONSE SPECTRUM METHOD IN ZONE-III

DISPLACEMENT COMPARISION

Soil Type	STORY	FLOATING COLUMN		
		WITH OUT	WITH	WITH D/C
		X-DIRECTION	X-DIRECTION	X-DIRECTION
SOIL-1	STORY16	856.7	114.9	1300
SOIL-III	STORY16	152.7	191.3	188.2

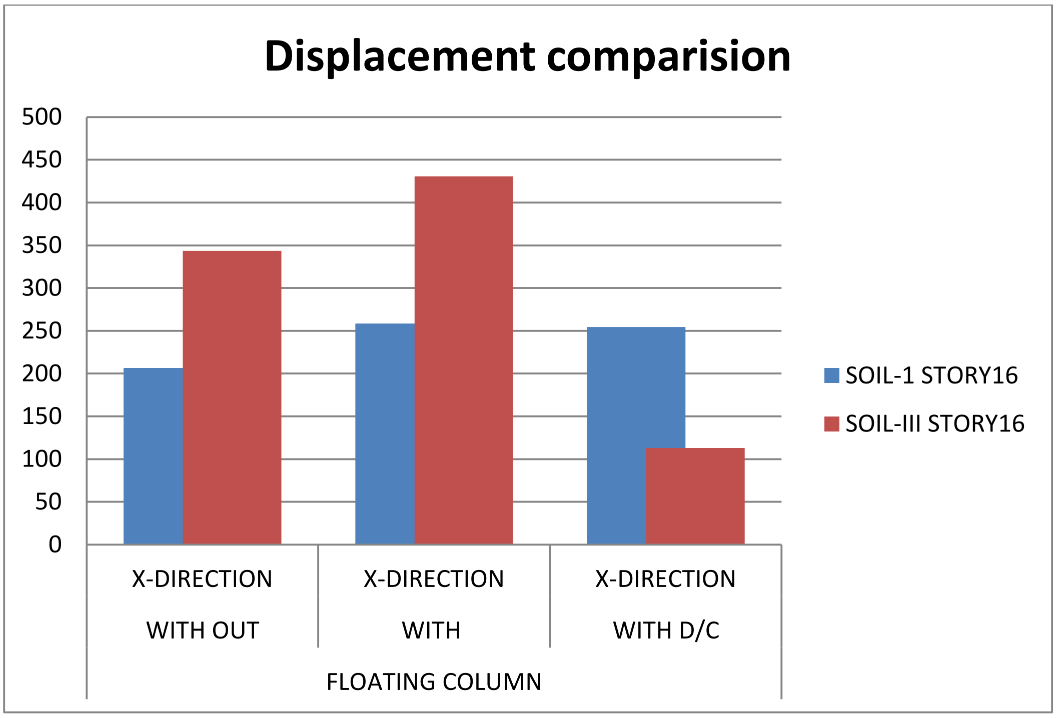


GRAPH 5: RESPONSE SPECTRUM METHOD IN ZONE-III,

TABLE 2: RESPONSE SPECTRUM METHOD IN ZONE-V

DISPLACEMENT COMPARISION

Soil Type	STORY	FLOATING COLUMN		
		WITH OUT	WITH	WITH D/C
		X-DIRECTION	X-DIRECTION	X-DIRECTION
SOIL-1	STORY16	206.7	258.5	254.3
SOIL-III	STORY16	343.5	430.5	113



GRAPH 6: RESPONSE SPECTRUM METHOD IN ZONE-V,

5. DISCUSSIONS ON RESULTS

The results of displacement ,shear, moment are carried out in static analysis for 6 storey building & 12 storey building and results of base shear,base moment are carried out with dynamic analysis.

Case:1 Displacement in static analysis

Displacement is analyzed and compared with normal building, building with floating column, building after change in dimensions for load combinations 1.2(DL+LL+EQX) & 1.2(DL+LL+EQY). It is observed that the displacement is more when the floating column is provided to reduce the displacement the section properties of the building are changed for better performance.

Case:2 Shear in static analysis

SHEAR is analyzed and compared with normal building, building with floating column, building after change in dimensions for load combinations 1.2(DL+LL+EQX) & 1.2(DL+LL+EQY). It is observed that the SHEAR is more when the floating column is provided to reduce the SHEAR the section properties of the building are changed to reduce storey shear.

Case:3 Moment in static analysis

MOMENT is analyzed and compared with normal building, building with floating column, building after change in dimensions for load combinations 1.2(DL+LL+EQX) & 1.2(DL+LL+EQY). It is observed that the MOMENT is more when the floating column is provided to reduce the MOMENT the section properties of the building are changed to reduce moment.

Case 4: Base Shear & Base Moment in dynamic analysis

Results are also taken from the dynamic analysis with respect to time history method. In the dynamic analysis the earth quake motion of "**BHUJ**" earth quake is introduced to the cases and the curves of base shear & base moment are plotted with respect to thr BHUJ earth quake motion.

CASE 1 : Normal Building Without Floating Column

CASE 2 : Building With Floating Column

CASE 3 : Building With Floating Column & with changed dimensions in Frames

6. CONCLUSIONS

1. By the application of lateral loads in X and Y direction at each floor, the displacements of Case 2 and Case 3 building in X and Y directions are less than the case 1 building but displacement of Case 2 and Case 3 building in Z-direction is more compared to that of a Case 1 building. So the Floating column buildings are unsafe for construction when compared to a Normal building.
2. By the calculation of lateral stiffness at each floor for the buildings it is observed that Case 3 (Floating column) building will suffer extreme soft storey effect. So the Floating column building is unsafe.
3. From the time history analysis it is noticed that the Case 2 and Case 3 (Floating column) building is having more displacements than Case 1 (Normal) building. So Floating column building is unsafe than a Normal building.
4. After the analysis of buildings, comparison of quantity of steel and concrete are calculated, From which it is to be identified that Case 3 (Floating column) building has 40 % more quantity of rebar steel and 42 % more concrete quantity than Case 1(Normal) building. So the Floating column building is uneconomical to that of a Normal building

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