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Comparison Of Rcc Building With And Without Floating Column Under Seismic Behavior

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Abstract: ***A column is a vertical structural member which transfers the load of beam and slab to the footing. Due to parking space, drive way, large park, column from ground floor happens to be omitted. In such case column is allowed to float, supported by beam from first floor to fulfill the frame requirement. Frame is made in such a way that beam transfers the load of column to the supporting column. Existing residential building comprising of G+ 11 Storey has been selected for carrying out the work. The above building models will be generated using software ETABS 9.5V and are analyzed using equivalent static method. This project will aim to investigate the effect of a floating column under earthquake excitation for zone factor of 0.16 and as there is no provisions of magnification factor specified in I.S. Code, hence the determination of such factors for safe and economical design of a building having floating column will be useful. It also aims at cost comparison in the quantity of steel and concrete for both the models.***

Keywords: ***Floating Column, Necessity of Floating Column, Effect of Floating Column on Building Analysis, Equivalent Static Analysis, Steel Cost Comparison***

I. INTRODUCTION

A. GENERAL

Many urban multi-Storey buildings in India today have open ground Storey as an unavoidable feature. This is primarily being adopted to accommodate parking or reception lobbies in the ground Storey. For the purpose of parking, usually the ground Storey is kept free without any constructions, except the columns which transfer the building weight to the ground. For a hotel or commercial building, where the lower floors contain banquet halls, conference rooms, lobbies, show rooms or parking areas, large interrupted space required for the movement of people or vehicles. Closely spaced columns based on the layout of upper floors are not desirable in the lower floors. So to avoid that problem floating column concept has come into existence. As buildings with floating column are getting multistoried there is indeed requirement of analyzing and checking the same under seismic excitation. 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 out to the ground. The earthquake forces developed at the 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 having vertical impediment (for ex: hotel buildings with a few Storey extensive than the other) lead to a hasty upsurge in earthquake forces at the plane of disruption. Buildings with fewer Columns or walls in a peculiar Storey or with remarkably tall Storey tend to impairment or failure which is initiated in that Storey.

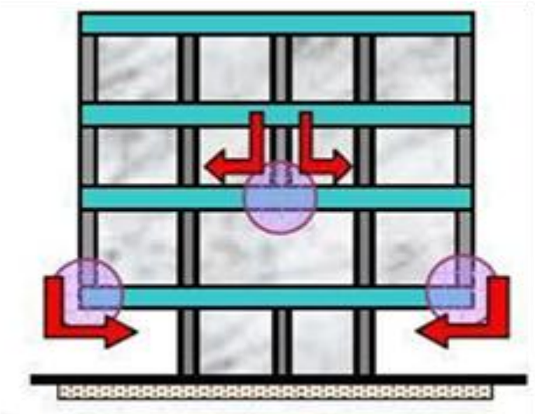

Figure 1: Floating column

B. PROCEDURE OF ANALYSIS

a. WHAT IS FLOATING COLUMN?

A column is a plumb component starting from foundation level and deliver the load to the ground. The term floating column also denotes plumb component which (due to design/ site situation) at its lower level rests on a beam which is a horizontal component. The beams deliver the load to other columns below it

b. SUBSISTING TREND

All round are assorted projects in which buoyant columns are adopted, especially above the ground floor, where release girders are employed, so that more straight from the shoulder space is available in the ground floor. These open spaces may be required for assembly hall or parking purpose. The ceding girders have to be designed and detailed properly, especially in earth quake prone zones. The column acts as a potent load on the beam which supports it. To the extent examination is concerned, the column is often assumed pinned at the base and is therefore taken as a point load on the transfer beam. STAAD Pro, ETABS and SAP2000can be utilized to do the investigation of this sort of structure. Floating columns are capable to convey gravity stacking however exchange brace must be of satisfactory measurements (Stiffness) with exceptionally negligible avoidance. For Floating segments, the Transfer Girder and segments supporting Transfer Girder needs exceptional consideration. On the off chance that heap factor should be enlarged (for Transfer Girder and its segments) to have extra wellbeing of structure, might be received. In the given framework, drifting segments require not be dealt with to convey any Earthquake powers. In this manner whole Earthquake of the framework is shared by the sections/shear dividers without considering any commitment from Float segments. However in outline and subtle elements of Floating segments, least 25% Earth Quake must be provided food notwithstanding full gravity strengths

This way the overall system as some breathing safety during Earth Quake. However, Floating columns are competent enough to carry gravity loading but Transfer Girder must be of adequate dimensions (Stiffness) with very minimal deflection.

Though floating columns need to be discouraged, there are several instances during which they're adopted, particularly on top of the bottom floor, wherever transfer girders are used, in order that a lot of open area is obtainable within the Ground Floor. The transfer girders need to be designed and elaborate properly, particularly in Earth Quake zones. If there aren't any lateral masses, the planning and particularization isn't tough

There may not be paper particularization the diff. of adopting floating columns. You have to do a 3 dimensional analysis and be terribly careful at the joints wherever the floating columns meet the transfer girders.

C. IS CODE

Floating columns don't seem to be lined in codes, to an awfully very little extent, bridge column/pier on a well cap of enormous diameter could also be treated as floating column with well cap acting as Transfer beam but the well staining supporting the well cap, being circular in form, is extremely robust supporting arrangement.

II. LITERATURE REVIEW

A. A P MUNDADA AND S G SAWATKAR (2014)

In this paper the study is carried out on a building with and without floating columns. The building considered is a

Residential building having G+7. Total building consists of 2 phases. 1st phase consists of lower two Storey provided for parking purpose.2nd phase is of residential flats from 1st floor to 7th floor.

Three cases were considered:

Case 1 -It is the model in which all the columns are rested on the ground. All the columns rise up to the top floor of the building and no column is floated or terminated at any level .it refers to normal frame building.

Case 2a-In this all the column are not rested on the ground level. Certain columns are floated from the first floor to upper floors. Also some columns are terminated at 1st floor from which the columns are floated. In this case, the plan covers more area than as compared to case1. Cantilever projections are also provided at certain points.

Case 2b-It is same as case 2.a except that struts are provided below the floating columns in order to balance the moments and provide stability. Certain columns i.e. in all the three models are considered and checked for moments, deflections and shear at each floor in X and Z directions. The results are presented in the form of graphs using STAAD pro.

B. ER. ASHFI RAHMAN (2015)

In this paper a multi- Storey building with and without floating columns by using response spectrum analysis. Different cases of the building are studied by varying the location of floating columns floor wise and within the floor. In this study first a normal building (NB) without any floating columns is modeled. Then, two types of models, namely 1 and 2 are modeled. In model 1, the floating columns are located at ground floor and in model 2 they are located at first floor. For each model three different cases are studied by varying the location of floating columns.

C. ROHILLA1 & GUPTA2, (2015)

In this paper, the critical position of floating column in vertically irregular buildings has been discussed for G+5 and G+7 RC buildings for zone II and zone V. Also the effect of size of beams and columns carrying the load of floating column has been assessed. Also for each model 2 cases of irregularities have been taken. Each model consists of two bays at the spacing of 5 m each and 1 bay at 6m spacing in X direction. However in Y-direction each bay is at spacing of 5m. The importance factor and response reduction factor have been used as 1 and 5 respectively in the analysis. Earthquake has been considered in X direction only. The response of building such as Storey drift, Storey displacement and Storey shear has been used to evaluate the results obtained using ETABS software.

D. GARCIA ET AL [10] (2010):

In this paper a full-scale two-Storey RC building with floating column and poor detailing in the beam column joints on a shake table as part of the European research project ECOLEADER was tested. After the initial tests which damaged the structure, the frame was strengthened using carbon fiber reinforced materials (CFRPs) and re-tested. The paper views at analytically checking the efficiency of strengthening technique for improving the seismic behavior of this frame structures. The experimental data from the earlier shake table tests are used to calibrate analytical models. To simulate deficient beam column joints, models of steel concrete bond slip and bond-strength degradation under cyclic loading were considered. The analytical models were used to assess the efficiency of the CFRP rehabilitation using a set of medium to strong seismic records. The CFRP strengthening intervention enhanced the behavior of the substandard beam column joints, and resulted in substantial improvement of the seismic performance of the damaged RC frame. It was shown that, after the CFRP intervention, the damaged building would experience on an average 65% less global damage compared to the original structure if it was subjected to real earthquake excitations.

E. S.S KADAM, S.V.LALE AND S.B.WAYKULE (2016)

In this paper static analysis is done for a multi-Storey G+5 building with and without floating columns. Multiple cases of the building were studied by shifting the location of floating columns at different floors. The structural response of the building models with respect to Time period, Base shear, Storey drift and Storey displacements were compared for both the building .The analysis was carried out using software SAP 2000.

III. OBJECTIVES

The basic and primary aim of this work is the comparative study of building with and without floating column under seismic behavior.

Determination of seismic response of the models by using equivalent static analysis in ETABS 9.5.

To study the effect of internal and external floating columns on the building under seismic excitation in zone III.

Cost evaluation of both the models is done if designed as earthquake resistant.

Checking out various parameters like base shear, Storey drift, Storey shear and displacement of the both the models.

IV. METHODOLOGY

In this work two model of G +11 Storey are compared with on another using linear static analysis. The first model being without floating column and the second being with floating column is checked for seismic excitation.

METHODOLOGY OF WORK

- ✓ Extensive literature survey by referring books, technical papers carried out to understand basic concept of topic.
- ✓ Identification of need of research.
- ✓ Formulation of stages in analytical work which is to be carried out.
- ✓ Data collection.
- ✓ Analytical work is to be carried out
- ✓ Interpretation of results & conclusion

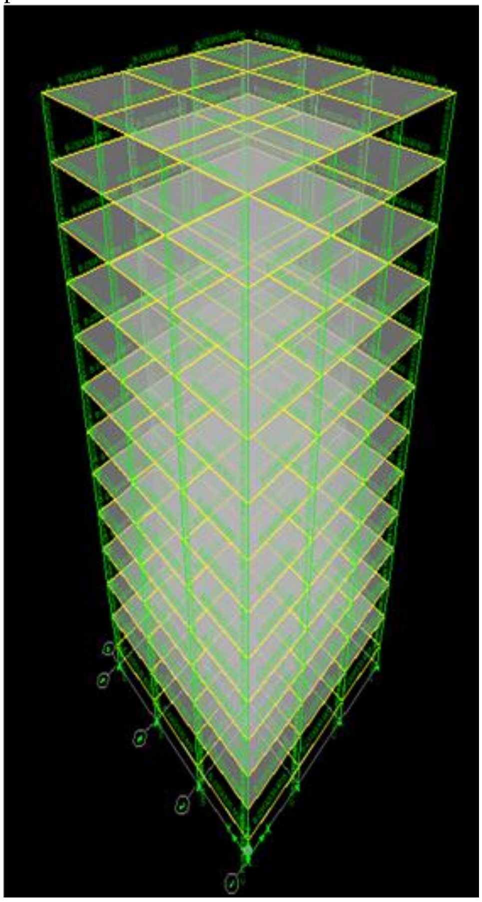

Figure 2: ETABS model

A. ETABS MODEL

Above figure shows the G + 11 Storey building modeled by default grid method. Each Storey has 3.2 m height. 12th slab is roof slab. Only parapet and floor load considered for the top slab. Foundation depth is 2 meter considered to finish the modeling.

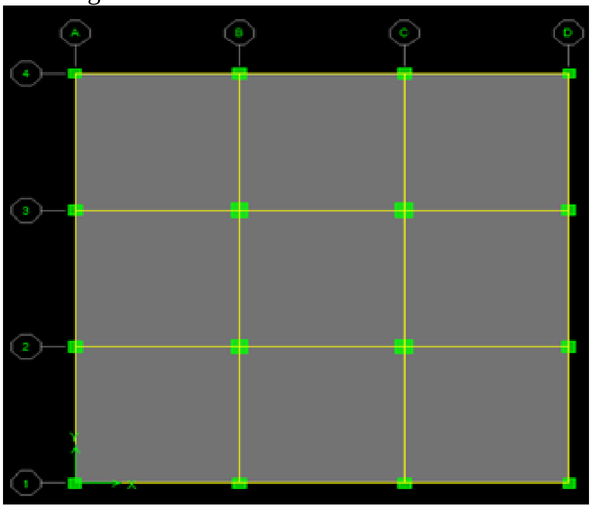

Figure 3: Plan

B. PLAN OF THE MODEL

There is 7m x 7m grid considered to make model. Each column has 7 meter center to center distance. Column sizes are divided in 3 category as explained above in basic data. All beam sizes are 230 mm x 530 mm. All beam contain load as per wall load of basic data. Only top floor beam contain parapet wall load (Assumed Height of parapet is 1.2m).

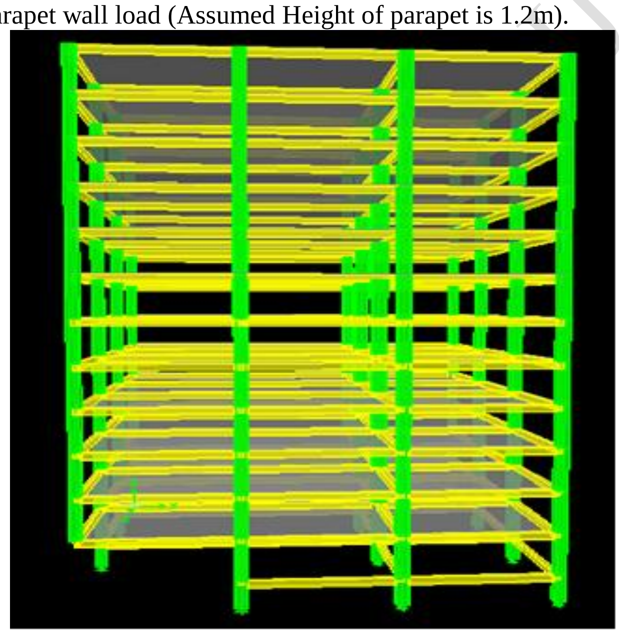

Figure 4: Floating column

C. BASIC DATA OF THE STRUCTURE

- ✓ Ground + 11 Storey structure
- ✓ Concrete Grade : M35
- ✓ Steel Grade : Fe500
- ✓ Size of the exterior corners columns : 500 mm x 500 mm
- ✓ Size of the exterior intermediate columns : 550 mm x 550 mm
- ✓ Size of the interior columns : 700 mm x 700 mm
- ✓ Size of the beams : 230 mm x 530 mm
- ✓ Floor height : 3.2 m
- ✓ Wall thickness : 230mm
- ✓ Loads (as per IS 875)
- ✓ Live Load : 4 kN/sq.m
- ✓ Floor Finished Load : 1.5 kN/ sq.m
- ✓ Wall load : 12.3 kN/m
- ✓ Parapet wall Load : 5.52 kN/m
- ✓ Other Parameters
- ✓ Earth quake zone factor : 0.16
- ✓ Importance factor : 1.5
- ✓ Wind speed : 39 m/sec
- ✓ Response reduction factor : 5

D. LOAD COMBINATIONS

Load Combinations are done using IS 456-2000, IS 1893-2002, IS 875-1987 (PART I, II, III) and they are as follows

a. EARTHQUAKE LOADING

- ✓ 1.5DL+LL
- ✓ 1.5EQX+1.5DL
- ✓ -1.5EQX+1.5DL
- ✓ -1.5EQZ+1.5DL
- ✓ 1.5EQZ+1.5DL
- ✓ 1.2EQX+1.2DL+0.3LL
- ✓ -1.2EQX+1.2DL+0.3LL
- ✓ 1.2EQZ+1.2DL+0.3LL
- ✓ -1.2EQZ+1.2DL+0.3LL
- ✓ 0.9DL+1.5EQX
- ✓ 0.9DL-1.5EQX
- ✓ 0.9DL+1.5EQZ
- ✓ 0.9DL-1.5EQZ

b. WIND LOADING

- ✓ 1.5DL+LL
- ✓ 1.5WLX+1.5DL
- ✓ -1.5WLX+1.5DL
- ✓ -1.5WLZ+1.5DL
- ✓ 1.5WLZ+1.5DL
- ✓ 1.2WLX+1.2DL+0.3LL
- ✓ -1.2WLX+1.2DL+0.3LL
- ✓ 1.2WLZ+1.2DL+0.3LL
- ✓ -1.2WLZ+1.2DL+0.3LL

V. RESULTS AND DISCUSSION

A. STOREY DRIFT

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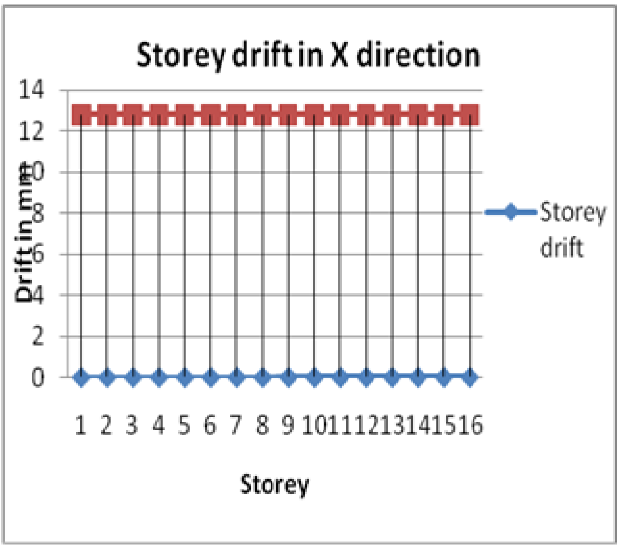

Figure 5: Storey drift in X direction

Maximum story drift witnessed at point 16 on top floor. It is about 0.014098 mm and 0.00828 mm in X and Y direction respectively. Permissible Storey drift as per IS1893:2002 (Part 1) is 0.004 time height. Height of each floor is 3.2 m. Hence, Maximum permissible Storey drift for each Storey is 12.8 mm. Occurring Storey drift is less than permissible limit. Hence model is safe for Storey drift in both the directions.

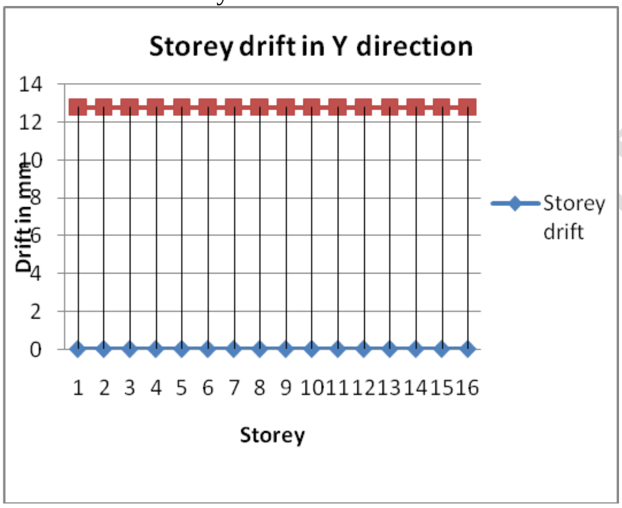

Figure 6: Storey drift in Y direction

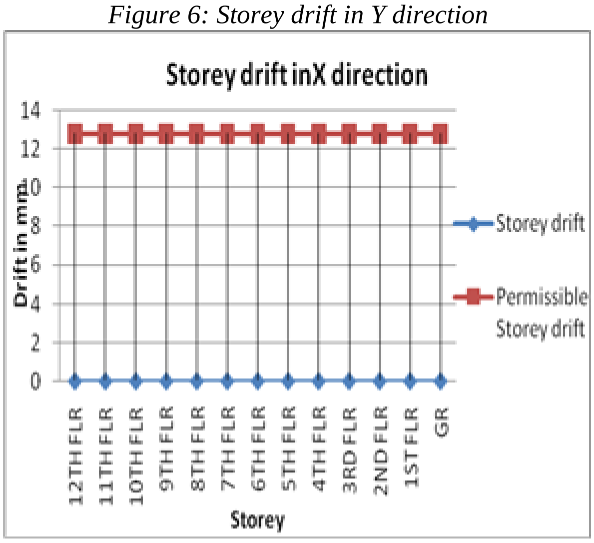

Figure 7: Storey drift in X direction for floating column building

Maximum story drift witnessed at point 16 at first floor. It is about 0.0107mm and 0.0089 mm in X and Y direction respectively. Allowable drift being 12.8 mm hence building is same in both the directions

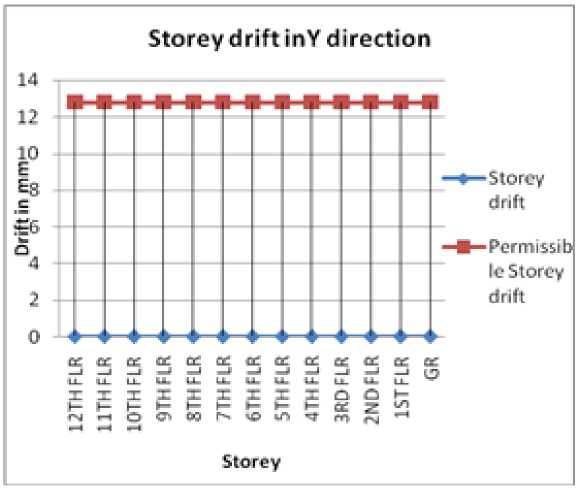

Figure 8: Storey drift in Y direction for floating column building

B. STOREY SHEAR

Maximum Storey shear occurs in X direction at ground floor having value 11,100KN and is due to 1.5 (DL+EQ X) load combination. Graph below showing the occurrence of Storey shear respective to each floor. As building is symmetrical Storey shear is same in Y direction as that in X direction.

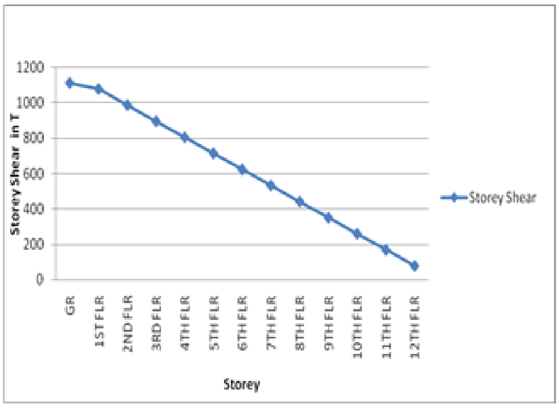

Figure 9: Storey Shear in X direction

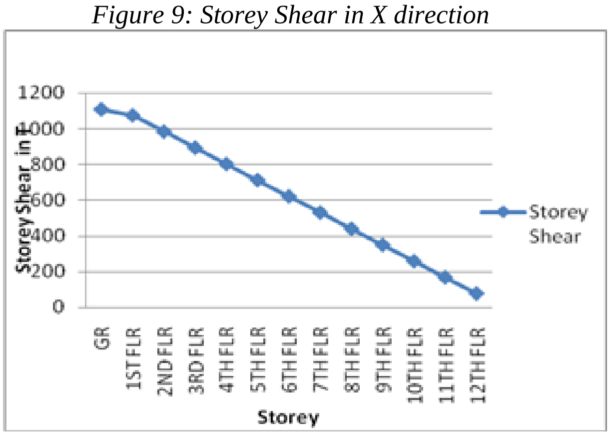

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Figure 10: Storey Shear in Y direction

Maximum Storey shear is due to 1.5 (DL+EQ X) and (DL +EQY) load combination in X and Y direction respectively with the highest value of 11100.52KN at ground floor. Graph above showing the occurrence of Storey shear respective to each floor.

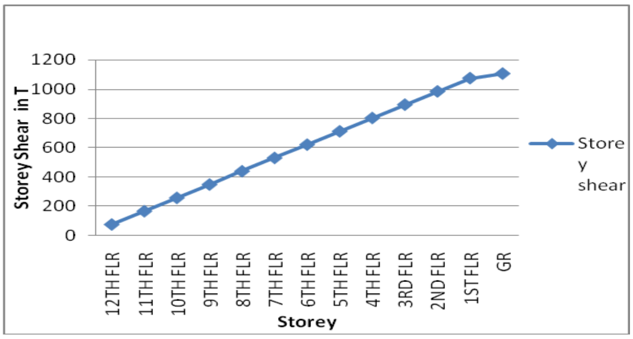

Figure 11: Storey Shear in X direction for floating column building

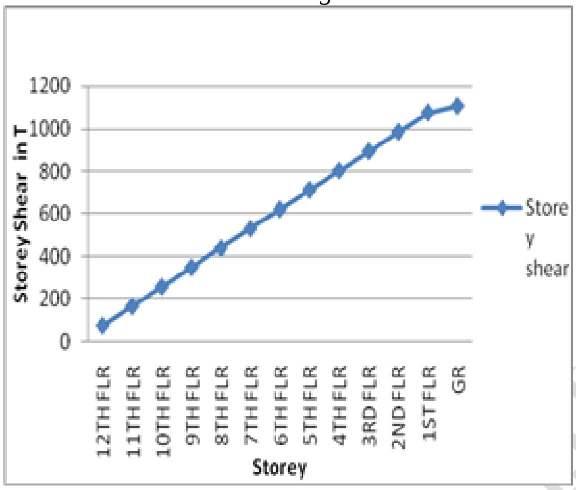

Figure 12: Storey Shear in Y direction for floating column building

Maximum Storey shear is due to 1.5 (DL+EQ X) and (DL +EQY) load combination in X and Y direction respectively with the highest value of 11,070 KN at ground floor. Graph above showing the occurrence of Storey shear respective to each floor.

A. LATERAL FORCE

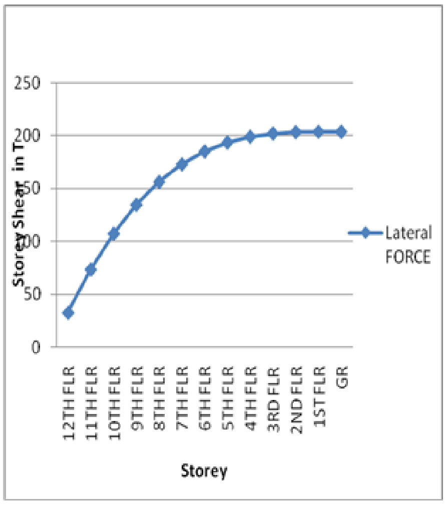

Figure 13: Lateral force in X and Y direction

Maximum lateral force happens to be in load combination of earthquake. Following results showing critical lateral forces of the structure.

STOREY	LOAD TYPE	FORCE (T)
12TH FLR	EQY	32.62
11TH FLR	EQY	73.41
10TH FLR	EQY	107.13
9TH FLR	EQY	134.44
8TH FLR	EQY	156.02
7TH FLR	EQY	172.54
6TH FLR	EQY	184.68
5TH FLR	EQY	193.1
4TH FLR	EQY	198.5
3RD FLR	EQY	201.53
2ND FLR	EQY	202.88
1ST FLR	EQY	203.22
GL	EQY	203.22

Table 1: lateral forces in X and Y direction for building with floating column

B. STOREY DISPLACEMENT

STOREY	POINT	LOAD	UX	UY
12th FLR	1	DLEQX15	52.87	-
12th FLR	16	DLEQY15	-	49.75

Table 2: Storey displacement for the topmost floor in both the directions for non-floating column building.

As per IS456:2000, maximum permissible deflection of the building is height of the building /250 or 20 mm whichever is less.

STOREY	POINT	LOAD	UX	UY
12th FLR	13	DLEQX15	300.43	-
12th FLR	4	DLEQY15	-	201.5

Table 3: Storey displacement for the topmost floor in both the directions for floating column building

Maximum permissible limit for the building is 40400/250 i.e. 161.6mm. Thus the building is unsafe in the same criteria in both the directions.

C. CORRECTED STRUCTURE

Size of above (highlighted) floating column adjoining beam has increased from

230 x 530 → 300 x 750

And column sizes at first floor to ground floor increased by

550 x 550 → 600 x 600

STOREY	POINT	LOAD	UX	UY
12th FLR	1	DLEQX15	92.55	-
12th FLR	16	DLEQY15	-	71.22

Table 4: Check for deflection in the corrected structure

Above results are well within the permissible limits hence making it safe in the deflection criteria.

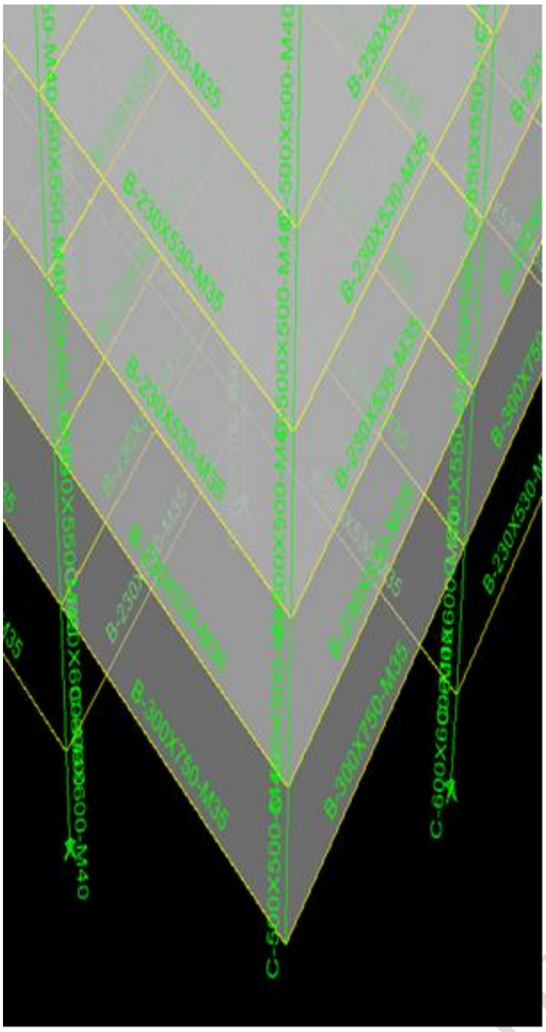

Figure 14: Corrected structure

VI. CONCLUSIONS

Building with floating column gives the worst case in terms of structural behavior as compared to building without floating column

From the analysis in ETABS software it can be concluded that if column floats from 1st floor to last floor, building goes under failure zone with same steel and concrete of structural member. To make it stable and safe for seismic load, structure has to be stiffened in the area of failure zone. But it increases the consumption of steel and concrete.

Deflection of the beam was 300mm and 201.5 mm in X and Y direction respectively if we float the column, which is more than permissible limit. As per IS 456:2000 and IS 1893 it is limited to 161 mm for the given structure

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