Comparative Parametric Study of Seismic Behaviour of RC Framed Building With & Without Floating Column In Different Configuration

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Abstract *- With the increasing demand for residential and commercial space, people preferring vertical system i.e. high rise buildings. And for large uninterrupted space required for the movement of people or vehicles concept of floating columns is often used. The load transfer takes place from horizontal members to vertical members and finally transferred to foundation level, hence, there should be a clear load path available for the load to reach the foundation level. But Floating columns are discontinued at its lower level and rest on a horizontal member, usually beams. This discontinuity of columns at any floor changes the load path and transfers load of the floating column through horizontal beams supporting it. This altered path causes large vertical earthquake forces due to overturning effect. Therefore, where floating columns are provided, special care should be given to the transfer girders and column below the floating column. In the present work, variation in seismic behaviour due to presence of floating columns is studied. Also the effect of configuration of floating column is noted. For the purpose three different models of G+20 RC framed building are prepared and analysed using STAAD.Pro V8i software by Equivalent Static Method and a comparative study based on parameters such as axial force, shear, moment, base shear and displacement has been done. The study reveals that floating columns should be avoided in severe seismic zones and if not avoidable then corner columns should not be floated as the magnitude of design parameters are more severe in such configuration.*

Key Words: Floating Column, STAAD.Pro V8i, Equivalent Static Method, Average Storey Displacement, Storey Drift, Base Shear.

1. INTRODUCTION

Floating Column is a column which does not reaches to foundation level and hence also does not transfer the load carried by it to the ground. It rests on a beam which acts as a transfer girder and transfers the loads to other column(s) on which the beam rests. The floating column in this way discontinued at that beam level. This is done due to may be architectural design or site situation. A primary objective of doing this is to create an interrupted space below the columns which can be utilised as banquet halls, conference rooms, reception lobbies, show rooms or parking areas, etc. Now-a-days, this feature is very common in high rise buildings. Most of the time, architect demands for the aesthetic view of the building, in such cases also many of the columns are terminated at certain floors and floating columns are introduced and hence such buildings are planned and constructed with architectural complexities. This discontinuation of columns introduces vertical irregularities in the structure and elongates the load transfer path which may prove to be detrimental, especially, in seismic conditions, if not taken care properly. So when irregular features such as above are included in buildings, a considerably higher level of engineering effort is required in the structural planning and design. Therefore, where provision of floating column is necessary, special care should be given to the transfer girders and columns below the transfer girders. These beams and columns should have sufficient strength to receive the load from floating column and convey it to the lower level.

2. OBJECTIVE OF THE PRESENT STUDY

The main objective of the present work is to study the effect of presence of floating columns in different configurations on seismic response of a G+20 RC Framed building under the provisions of different IS codes and with the help of STAAD.Pro software. Parameters to be compared are Column & Beam Forces, Average Displacement and Storey Drift.

3. METHODOLOGY

To achieve the objective, three Models of a G+20 RC framed building which differs in configuration of floating columns, introduced above ground floor, are prepared & analysed using STAAD.Pro V8i and results are compared. All the models are assumed to be situated in Seismic Zone IV.

3.1 Modelling

All the three models are 18mx18m in plan, with 6 bays of 3m each in both ways. 21 floors (G+20) of height 3m each (total 63m height above GL) are considered with foundations at level -3m on medium soil. Sizes of beams and columns are kept same for all the models. One normal model (Model 0) is prepared with no floating column which provides the basic data to compare the models with floating columns (Fig.1). In other two models 12 columns in outer periphery are removed at ground floor level i.e. columns above GF are made floating columns. A model with 12 floating columns in alternate including Corner columns named here as Model A, is prepared (Fig.2). And the third model is one which also has 12 floating columns in alternate but excluding corners named Model B (Fig.3). (Empty column represents Floating column and filled column represents normal columns.)

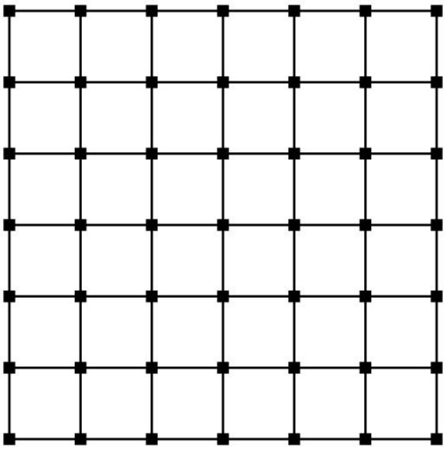

Fig 1: Plan of Model 0

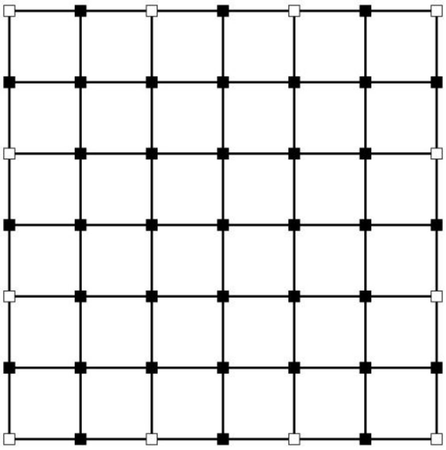

Fig 2: Plan of Model A

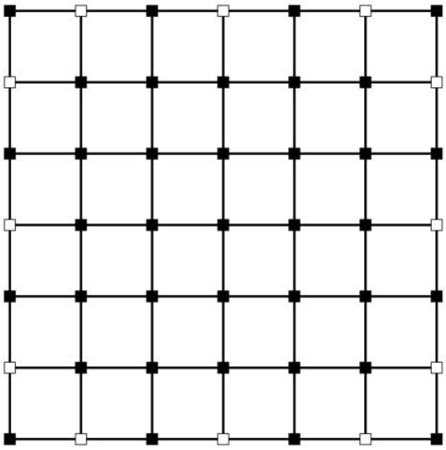

Fig 3: Plan of Model B

3.2 Method of Analysis

The IS Code 1893 (Part 1):2002 recommends two methods for seismic analysis viz. Seismic coefficient method popularly known as Equivalent Static method, and Dynamic method. In the present work former method is adopted. Equivalent Static Analysis approach defines a sequence of lateral forces acting on a building to represent the forces generated due to earthquake ground motion, typically defined by a seismic design response spectrum. The basic assumption is that the building responds in its fundamental mode. Given the natural frequency of the building, the response is examined from a design response spectrum. The lateral equivalent forces are calculated and then distributed along the height of the building using empirical equations as per the clause 6.4 and 7.5 of IS Code 1893 (Part 1): 2002.

(i) Design lateral force or seismic base shear:

The total design seismic base shear (V_B) shall be determined along any principal direction by the following expression:

$$V_B = A_h W$$

Where,

A_h = Design horizontal seismic coefficient by using fundamental natural period (T_a) $= \frac{ZIS_a}{2Rg}$

W = Seismic weight of the whole building as per clause 7.4.2

Z = Zone factor.

I = Importance factor

R = Response reduction factor

S_a/g = Average response acceleration coefficient for rock and soil sites.

T_a = Approximate fundamental natural period of vibration for moment resisting frame building in seconds =

h = Height of the building, in m.

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d = Base dimension of the building, in m, along the considered principal direction of the lateral force.

(ii) Distribution of Base Shear and Design Force:

The computed design base shear (V_B) shall be distributed along the building height by following expression:

$$Q_i = V_B \frac{W_i h_i^2}{\sum_{j=1}^{n} W_j h_j^2}$$

Where,

Q_i = Design lateral force at floor i.

W_i = Seismic weight of floor i.

h_i = Height of floor i measured from base.

n = Number of storey in the building (number of levels at which the masses are located)

STAAD.Pro V8i software calculates and applies the static seismic forces to analyse the structure in accordance with the procedures as recommended by the relevant IS Codes.

3.3 Design Loads

Various loads and load combinations in accordance with IS Codes 875 (Part I):1987, 875 (Part II): 1987, IS 456: 2000 and IS 1893 (Part 1): 2002 are taken into consideration, acting on the building models.

4. RESULTS AND DISCUSSION

Results for all the models are obtained, summarised by taking maximum absolute values of each parameter and compared as follows:

Table - 1: Results (Maximum Absolute Values)

Models			Model 0	Model A	Model B
COLUMN FORCES	Axial Force	(Fx) kN	3969	5955	5768
	Location of Col.		BGF	GF	GF
	Shear-Y	(Fy) kN	94.632	206.246	142.334
	Location of Col.		6th Flr.	1st Flr.	1st Flr.
	Moment-Z	(Mz) kNm	148.516	382.340	253.216
	Location of Col.		BGF	1st Flr.	1st Flr.
BEAM FORCES	Shear-Y	(Fy) kN	137.250	395.080	381.991
	Location of Beam		7th Flr.	1st Flr.	1st Flr.
	Moment-Z	(Mz) kNm	169.749	592.049	550.702
	Location of Beam		7th Flr.	1st Flr.	1st Flr.
Base Shear			2328.67	2321.21	2321.21
Avg. Disp. Of Top Storey (mm)			35.329	41.598	39.911
Storey Drift (mm)	At GF		1.487	1.936	1.899
	At 8th Flr.		1.908	2.198	2.116

Table - 2: Comparison of Results (Model A v/s Model 0)

Models			Model 0	Model A	Difference (%)
COLUMN FORCES	Axial Force	(Fx) kN	3968.662	5954.885	1986.223
	Location of Col.		BGF	GF	**50.0%**
	Shear-Y	(Fy) kN	94.632	206.246	111.614
	Location of Col.		6th Flr.	1st Flr.	**117.9%**
	Moment-Z	(Mz) kNm	148.516	382.340	233.824
	Location of Col.		BGF	1st Flr.	**157.4%**
BEAM FORCES	Shear-Y	(Fy) kN	137.250	395.080	257.830
	Location of Beam		7th Flr.	1st Flr.	**187.9%**
	Moment-Z	(Mz) kNm	169.749	592.049	422.300
	Location of Beam		7th Flr.	1st Flr.	**248.8%**
Base Shear			2328.67	2321.21	-7.461
					-0.3%
Avg. Disp. of Top Storey (mm)			35.329	41.598	6.269
					17.7%
Storey Drift (mm)	At GF		1.487	1.936	0.449
					30.2%
	At 8th Flr.		1.908	2.198	0.290
					15.2%

Table - 3: Comparison of Results (Model B v/s Model 0)

Models			Model 0	Model B	Difference (%)
COLUMN FORCES	Axial Force	(Fx) kN	3968.662	5767.905	1799.243
	Location of Col.		BGF	GF	**45.3%**
	Shear-Y	(Fy) kN	94.632	142.334	47.702
	Location of Col.		6th Flr.	1st Flr.	**50.4%**
	Moment-Z	(Mz) kNm	148.516	253.216	104.700
	Location of Col.		BGF	1st Flr.	**70.5%**
BEAM FORCES	Shear-Y	(Fy) kN	137.250	381.991	244.741
	Location of Beam		7th Flr.	1st Flr.	**178.3%**
	Moment-Z	(Mz) kNm	169.749	550.702	380.953
	Location of Beam		7th Flr.	1st Flr.	**224.4%**
Base Shear			2328.67	2321.21	-7.461
					-0.3%
Avg. Disp. of Top Storey (mm)			35.329	39.911	4.582
					13.0%
Storey Drift (mm)	At GF		1.487	1.899	0.412
					27.7%
	At 8th Flr.		1.908	2.116	0.208
					10.9%

Table - 4: Comparison of Results (Model B v/s Model A)

Models			Model A	Model B	Difference (%)
COLUMN FORCES	Axial Force	(Fx) kN	5954.885	5767.905	-186.980
	Location of Col.		GF	GF	**-3.1%**
	Shear-Y	(Fy) kN	206.246	142.334	-63.912
	Location of Col.		1st Flr.	1st Flr.	**-31.0%**
	Moment-Z	(Mz) kNm	382.340	253.216	-129.124
	Location of Col.		1st Flr.	1st Flr.	**-33.8%**
BEAM FORCES	Shear-Y	(Fy) kN	395.080	381.991	-13.089
	Location of Beam		1st Flr.	1st Flr.	**-3.3%**
	Moment-Z	(Mz) kNm	592.049	550.702	-41.347
	Location of Beam		1st Flr.	1st Flr.	**-7.0%**
Base Shear			2321.21	2321.21	0.000
					0.0%
Avg. Disp. of Top Storey (mm)			41.598	39.91	-1.687
					-4.1%
Storey Drift (mm)	At GF		1.936	1.899	-0.037
					-1.9%
	At 8th Flr.		2.198	2.116	-0.082
					-3.7%

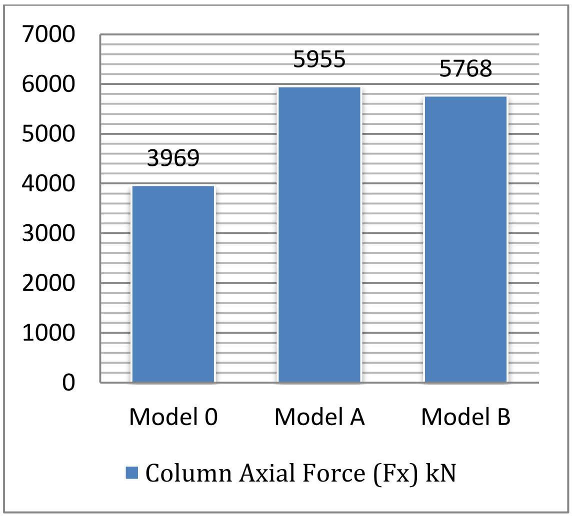

Chart-1: Column Axial Force (Fx) kN

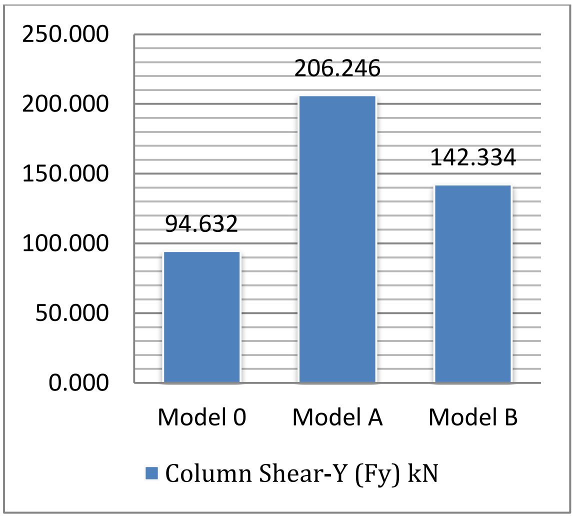

Chart-2: Column Shear Force (Fy) kN

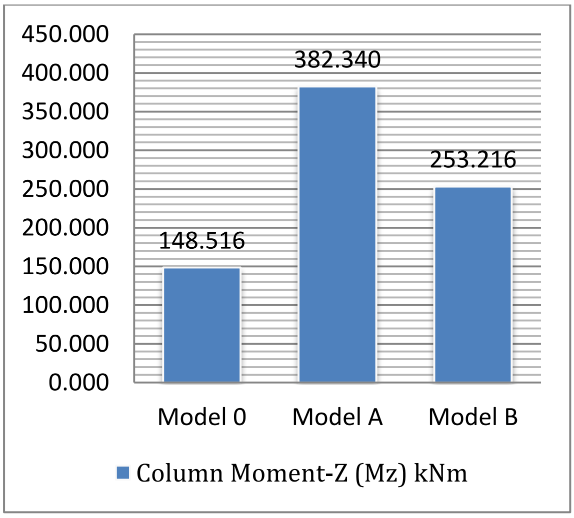

Chart-3: Column Moment (Mz) kNm

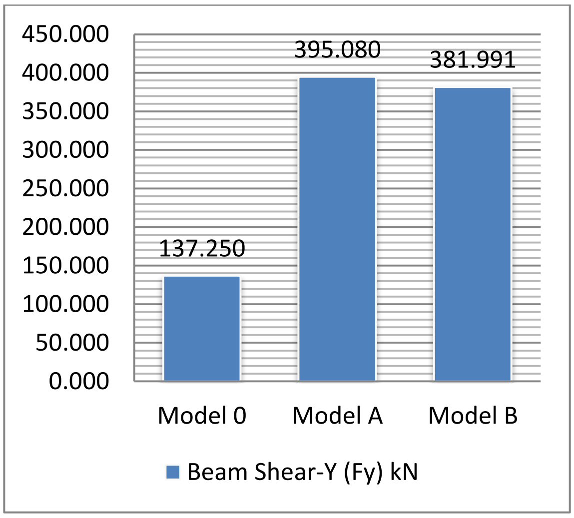

Chart-4: Beam Shear Force (Fy) kN

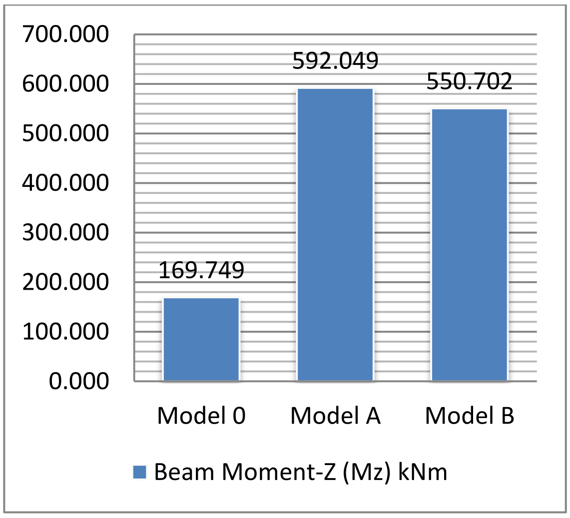

Chart-5: Beam Moment (Mz) kNm

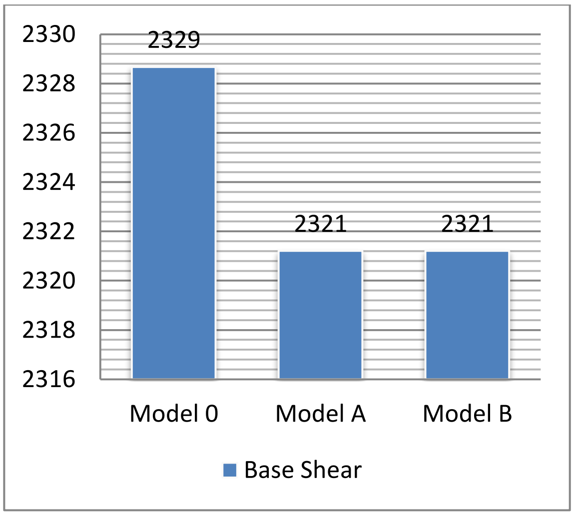

Chart-6: Base Shear (Vb) kN

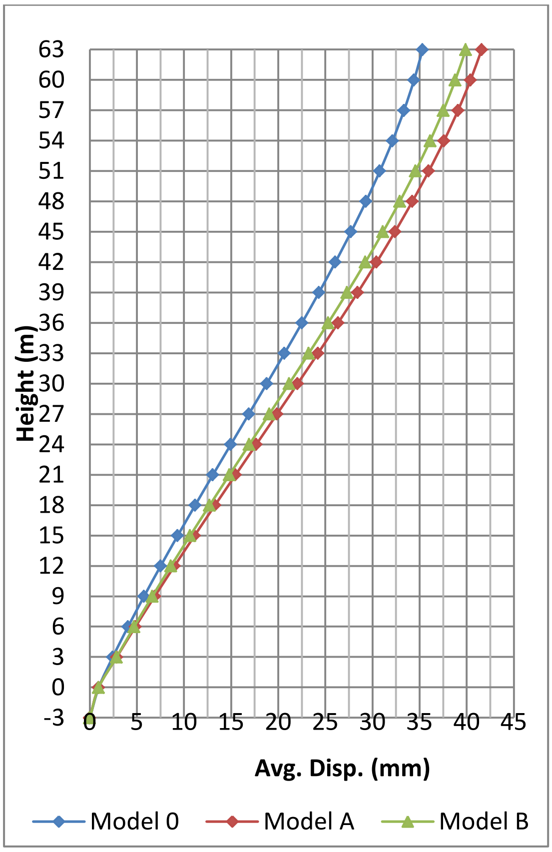

Chart-7: Average Displacement (mm)

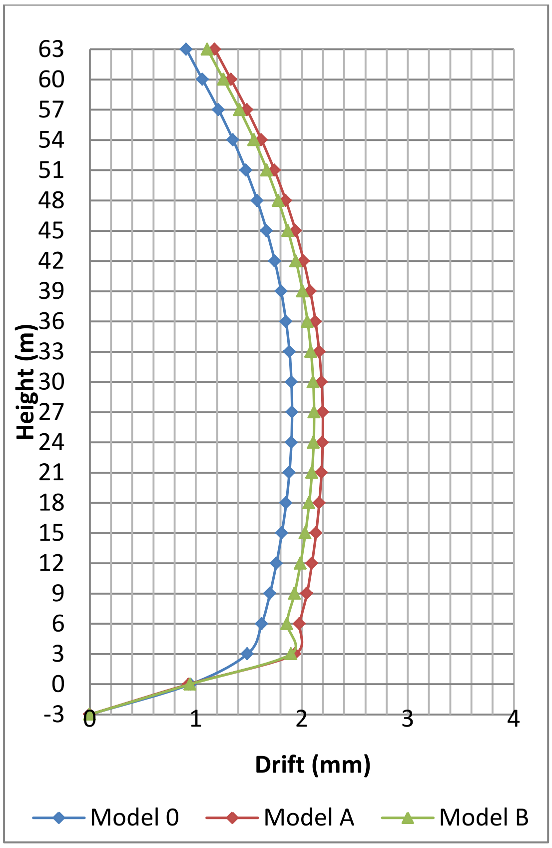

Chart-7: Storey Drift (mm)

It can be seen from above that when the floating columns are introduced the values various parameters increase. In Model A the magnitude of maximum Axial Force, Shear Force and Moment in Column is increased by 50%, 118% and 157% respectively, as compared to Model 0 while these increments are limited to 45%, 50% and 71% respectively in case of Model B. Similarly, the Beam forces viz. Shear Force and Moment are hiked to 188% and 249% for Model A whereas 178% and 224% for Model B respectively. Value of Base Shear is reduced for both the models as Seismic weight of building is reduced due to removal of columns at ground floor level. Average Displacement of top storey is enhanced by 18% and 13% for Model A & B respectively. The magnitude of Storey Drift at GF level & at 8th floor level are increased respectively by 30% & 15% for Model A and 28% & 11% for Model B.

While comparing the models with floating columns with model without floating column, it is also observed that the magnitudes of all the parameters for Model B are lesser than that for Model A. Axial Force, Shear Force and Moment in Column are reduced by 3%, 31% and 34%. Shear Force and Moment in Beam are lowered by 3% and 7%. Also the values of Average Top Storey Displacement, Storey Drift at GF & 8th Floor level are lesser by 4%, 2% & 3.7%. Base Shear remains unchanged as the Seismic weight is same in both the cases.

The occurrences of maximum magnitude of Beam & Column Forces are shifted to ground & first floor from below ground floor and 7th floor.

5. CONCLUSION & FUTURE SCOPE

From above study, it is clear that maximum values of the important design parameters are increased as the floating columns are introduced but the increment is comparatively lesser in case when floating columns are not at corner and appear at ground & first floor levels. It can be concluded that:

i) Presence of floating columns is detrimental;
ii) If introduction of floating columns are unavoidable, then provision of floating columns at corner must be avoided;
iii) Designer should give more attention while designing the floor having lesser columns and the floor above and below it.

Research can be further extended by keeping in view the following points:

a) Adopting Dynamic analysis method;
b) Applying other configurations of Floating Columns;
c) Assuming Unsymmetrical building;
d) Analysing taller structure;

e) Using other tools for analysing such as ETABS, SAP, etc.

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