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Comparative Study on Seismic Analysis of RC Structure with and Without Floating Column Including Lateral Load Resisting Systems

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ABSTRACT: Soft storey, vertical or plan irregularity, floating column, and high loads are all common features of modern multi-story structures. In metropolitan India, these kinds of buildings are becoming increasingly popular. According to the findings of previous earthquake research, most RC buildings with such flaws are extremely undesirable in seismically active locations. These effects occurred as a result of a variety of factors, including non-uniform mass distribution, stiffness, and strength. This study uses the software STAAD PRO V8i to discuss the seismic analysis of a multi-storey G+7 building with floating column built in seismically active area, observing its responses to external lateral force generated on the building in seismic zone 5, including different lateral load resisting systems. The structure is represented in ten different model cases. Model 2 contains a floating column structure, Model 3 includes increased column size on the ground floor. Models 4, 5, 6 and 10 contain different types of bracing (type 1, type 2, type 3 and type 4) which are installed one after another from the ground floor to the top floor and modelled separately. Shear core/shear tube is introduced in model 7 and 9 with thickness 0.2m running from ground to top. Shearwalls of 4 types are introduced in model 8 with thickness of wall as 0.3m running from ground floor to top. Thus, alternative measures involving improving non uniform distribution in irregular buildings, such as multi storey buildings with floating columns, were highlighted, and the safer design of such buildings in seismically active areas was recommended, taking into account the results observed from base shear, storey drifts, storey displacements, bending moment using Equivalent static method. As a consequence of the results, we determined that the introduction of a single bracing/strut contributes to the maximum reduction in shear force and bending moment compared to all model cases, Shear core structure withstands the highest seismic load of any model, When the columns are completely removed to create a floating column design, the % increase in maximum drift is 67.65%, indicating the minimum lateral resistance compared to all model cases.

KEYWORDS: Base shear, Storey shear, Storey displacement, Equivalent static method.

I. INTRODUCTION

Floating columns are vertical elements supported by girder beams and does not transfer loads to the foundation. Loads are normally transferred from the top column to the bottom column and then to the foundation. However, for floating columns, the load is transferred from the floating column first then to the girder beam, and transfer then to the adjacent column and to the foundation. Floating columns are particularly vulnerable to seismic loads of seismic intensity 2 and above, therefore, transverse strength must be added to the existing floating column design. Some of the lateral resistance systems are described below.

- 1) **Bracing Structural Systems-** Bracings are triangular or diagonal in shape to withstand lateral forces from earthquakes and wind. When braces receive lateral loads, they are transferred to adjacent beams, columns, and then to the foundations.
- 2) **Shear Wall Structural System-** Shear walls resist seismic loads by transferring them to beams, columns, and

foundations. A shear wall is a structure whose presence affects the stiffness and seismic effect on a building. The position and shape of shear walls are critical factors in providing safe lateral resistance to seismic loads.

ShearCore-Shear core is an organization of interconnected walls that form a box like structure. The best spot to insert the shear core into the structure is at its center, as the lateral load resistance should be uniform so that it does not twist or turn. Essentially, the design seems as like a closed tubular structure extending from the base to top. This design makes it more resistant to torsion and lateral forces than other lateral resistance designs. The insertion of shear cores offers great flexibility in both design and construction

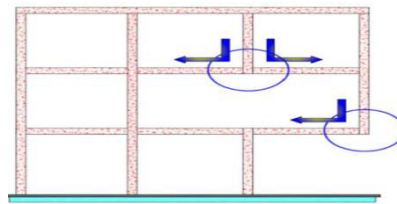


Fig1: Structure with Floating column

II. RELATED WORK

Mohasinkhan N Bargir et al., (2020) studied seismic response of a floating column building. They analysed the structure by equivalent static method and response spectrum method. Parameters considered are time period, storey drift, displacement and shear. It can be seen that as the load increases the storey displacement as well as base shear is also increases for any zone. From the results it was concluded that model having triangular plate shows the maximum reduction in displacement by 7.3 mm. But due to introduction of triangular plate the base shear increases.

Gulchaman Khan et al., (2019) considered lateral displacement and storey drift as parameters to go together with the drift inside the multi-storey buildings having hanging columns with and without shear wall. The main objectives of this work is to observe the impact of shear wall in a floating column building for external earthquake excitations and to evaluate the multi storey homes having floating columns with and without shear wall under earthquake excitations. It is concluded that all the maximum drift values are lying almost in the middle height of the structure, the storey float and displacement is extra-large for floating column homes due to the fact as the columns are eliminated in mass receives accelerated thrust while earthquake excitation is taking place and from the seismic point of view 70% of more strength can be achieved by providing shear wall at all junctions to the floating column building.

RSS Babitha Sri et al., (2018) studied the effect of floating columns on G+9 building. This work is done to study the effect of RC frame building with and without floating columns under seismic loading. Due to discontinuity of stiffness in floating column structure, the flexibility increases with strength reduction resulting in large displacement. It is observed that storey displacement is inversely proportional to storey stiffness, as the storey stiffness is increasing, the storey displacement decreases and vice versa. They have concluded that story drift is more in the model having 18 floating columns in each floor and stiffness is increased from top to bottom of structure for all model cases and building having floating column shows increase in fundamental time period compared to building without floating columns. This is due to decrease of stiffness in the building. Also they have concluded that the structure without floating column has maximum storey shear. The shear force gradually increases from minimum at top floor to maximum at the 1st floor for all the cases considered here.

Kishalay Maitra et al., (2018) highlights the performance of floating column structure compared with normal building under earthquake load. In this study, static and dynamic analyses using response spectrum method have been adopted for multi-story building with and without floating columns. Different cases of the structures have been studied by varying the location of floating column and increasing the column size with varying the floating column location. They had concluded that storey displacement shows a 56.96% increase in floating column structure.



When floating column introduced asymmetrically torsion irregularity exists. Lateral stiffness is increased when loss of cross sectional area of floating column is distributed to ground floor column.

III. METHODOLOGY

In this study, Ten alternative G+7 floor floating column buildings with earthquake resistant models are considered. The floating column model is created by removing the ground floor column from the periphery of the structure having the girder beam size 0.6 x 0.8 m. Then the load combination according to IS1893:2016 is applied. Load types considered for all models correspond to the description in Table 3. The model is analyzed using an equivalent static method with the FEM software STAAD PRO V8i.

Table 1: Specifications of Geometry and member properties

Sl.no	Particulars	Description
1	Zone	5
2	Importance factor	1
3	Response reduction factor	3
4	Soil type	Medium
5	Damping ratio	0.05
6	Software used	STAAD PRO V8i
7	Analysis method	Equivalent Static
8	Node to node distance (X & Z)	5m
9	Node to node distance (Y)	3m
10	Height of building (Y)	24m
11	Length and width of building (X & Z)	25m
12	Number of Storey	7
13	Width of beam	0.30
14	Depth of beam	0.30
15	Slab thickness	0.15
16	square column size	0.40



Table2. Types of loading considered

Sl.no	Particulars
1	EQX
2	EQZ
3	Dead load
4	Liveload
5	1.5X(DL+LL)
6	1.5X (DL +EQX)
7	1.5X (DL+EQZ)
8	1.2X (DL +LL+ EQX)
9	1.2X (DL +LL+EQZ)

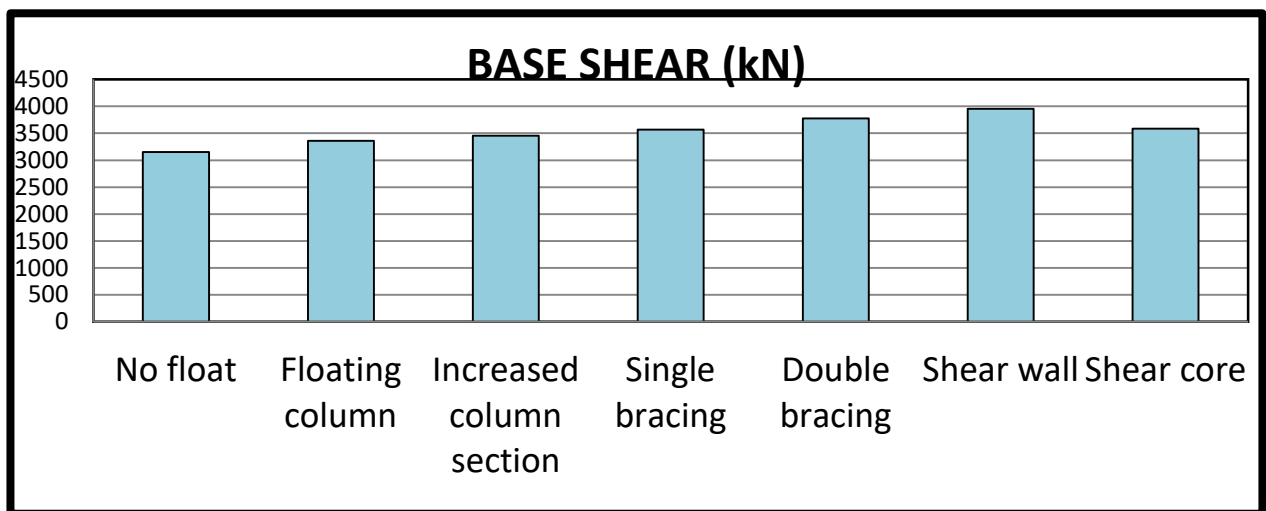
Table 3. Model Description

Sl.no	Model No.	Model Description
1	1	Nofloating Column Structure.
2	2	Floating columns along periphery with girder beam size 0.6 X 0.8m.
3	3a-3j	Increased square column size consecutively from ground floor to top floor
4	4a-4d	Type 1 single bracing around the periphery of size 0.3 X 0.3m consecutively from 1 st upto 2 nd , 3 rd , 4 th and 7 th floor
5	5a-5e	Double bracing around the periphery of size 0.3 X 0.3m consecutively from 1 st upto 2 nd , 3 rd , 4 th and 7 th floor
6	6a-6b	Type 2 single bracing of size 0.3 X 0.3m in Ground floor and with increased ground floor square column size from 0.6 to 0.8 m
7	7a-7e	Shear core at centre of thickness 0.2m, 0.1m, 0.05m,0.025m,0.3m respectively
8	8a-8d	Shear wall on middle of 4 sides,4 corners, adjacent to 4 corners, adjacent to middle of 4 sides with thickness 0.3m respectively.
9	9a-9b	Double shear core at centre of thickness 0.2m (outer) and 0.1m (inner) with Diagonal connection beams and straight connection beams respectively
10	10a-10e	Type 3 single bracing adjacent to periphery of size 0.3 X 0.3m consecutively from 1 st upto 2 nd , 3 rd , 4 th and 7 th floor

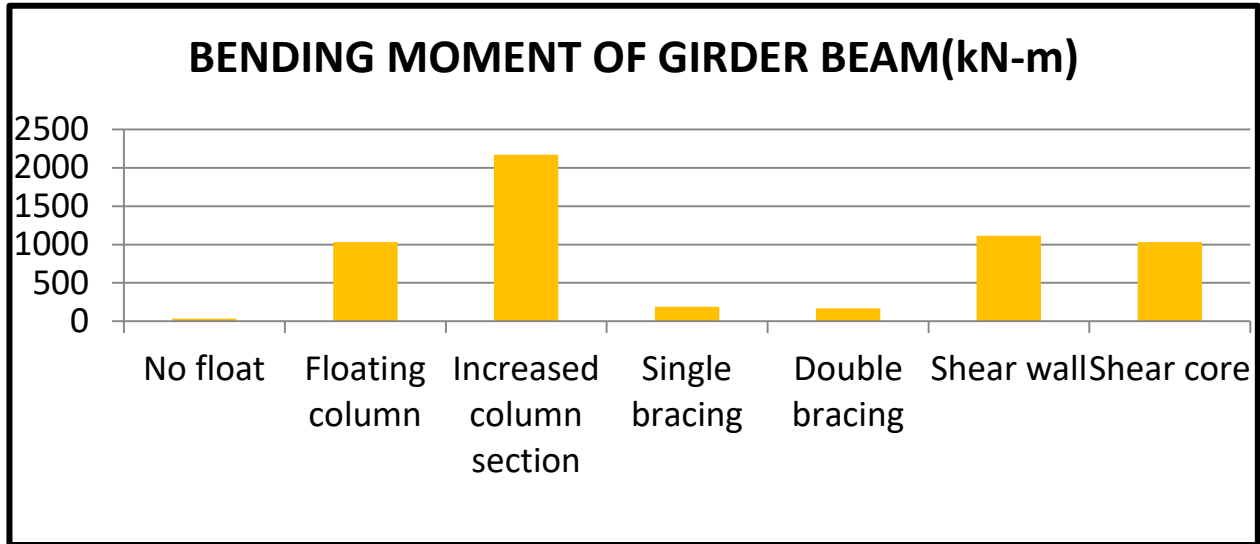


IV. EXPERIMENTAL RESULTS

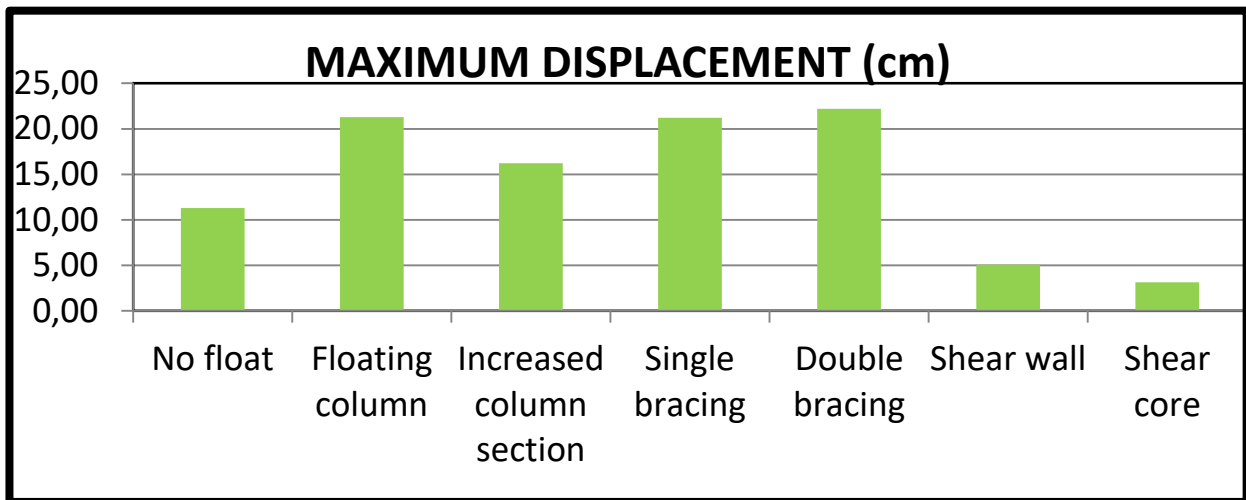
Models	Model description	Bending moment (kNm)	Base shear (kN)	Maximum Displacement (cm)	Maximum Drift (cm)
Model 1	No float	35.83	3151.47	11.29	1.87
Model 2	Floating column	1032.44	3356.79	21.30	3.15
Model 3C	Increased column section	2171.60	3452.10	16.23	2.73
Model 4E	Single bracing	187.35	3565.22	21.24	2.78
Model 5E	Double bracing	166.71	3773.64	22.21	2.96
Model 8C	Shear wall	1114.48	3952.54	5.45	2.24
Model 7E	Shear core	1032.58	3697.22	3.03	0.67



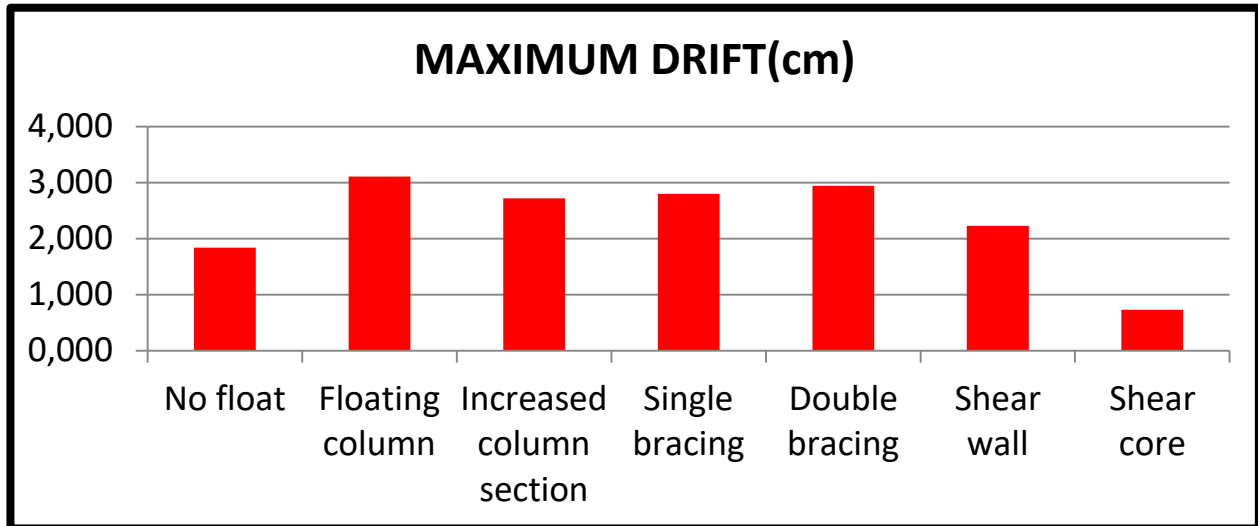
(a)



(b)



(c)



(d)

Fig 2. (a) Results showing the comparison of Base Shear in different Models
 (b) Results showing the comparison of Bending Moment in different Models
 (c) Results showing the comparison of Maximum Displacement in different Models
 (d) Results showing the comparison of Maximum Drift in different Models

V. CONCLUSION

- 1) When the columns are completely removed to create a floating column design, the % increase in maximum drift is 67.65%, indicating the minimum lateral resistance compared to all model cases.
- 2) Using an enlarged column cross section after the 5th floor shows no significant reduction in storey drift.
- 3) The introduction of a single bracing/strut contributes to the maximum reduction in shear force and bending moment compared to all model cases.
- 4) Compared with a single bracing, the introduction of a double bracing does not have much influence on displacement, drift and bending moment.
- 5) Shear core structure withstands the highest seismic load of any model.
- 6) Maximum drift reduction can be achieved with a shearwall on all 4 sides adjacent to center (model case 18d) between shearwall models.
- 7) The dual shear core model with 2 cores shows no significant reduction in maximum drift compared to the single shear core model

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