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COMPARATIVE ANALYSIS OF G+8 STRUCUTRE WITH AND WITHOUT FLOATING COLUMN

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Abstract: In modern times floating columns are typical building feature in multistorey buildings. Floating columns are used to fulfill various aesthetic and functional requirements. This study has been undertaken to investigate the Comparative analysis between the buildings with and without floating columns and to check whether any need of use of lateral load resisting system using two different lateral load resisting systems i.e., Shear wall and X-Bracings. To analyze the models Staad.Pro V8i software is used. For performing the seismic analysis Equivalent Static Analysis method is considered. The study is made with four different cases classified on the basis of system provided. To compare the results, different structural parameters like story drift, story displacements, base shear force, base moments etc. are taken under consideration.

Index Terms **– Floating column, Normal building, Equivalent Static Analysis, Staad.Pro V8i, Lateral Load Resisting System, X-Bracings, Shear Wall**

I. INTRODUCTION

Today many urban multistorey buildings in India have open first story as an unavoidable feature. This is primarily being adopted to accommodate parking or reception lobbies in the first story. Buildings that have fewer columns or walls in a particular story or with unusually tall story tend to damage or collapsed or were severely damaged in Gujrat during 2001 Bhuj earthquake. The behavior of a building during earthquake depends critically on its overall shape, size and geometry, in addition to how 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 columns that hang or float on beams at an intermediate story and do not go all the way to the foundation, have discontinuities in the load transfer path. Buildings with vertical setbacks cause a sudden jump in earthquake forces at the level of discontinuity. 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. A building should possess four main attributes namely simple and regular configuration and adequate lateral strength, stiffness and ductility for well performance in the earthquake.

II. FLOATING COLUMN

The floating column is a vertical member which rest on a beam and doesn't have a foundation. The floating column act as a point load on the beam i.e., Transfer Beam and this beam transfers the load to the columns below it. But such column cannot be implemented easily to construct practically since the true columns below the termination level are not constructed with care and hence finally cause to failure. 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. But Provision of floating columns resting at the tip of taper overhanging beams increases the vulnerability of the lateral load resisting system due to vertical discontinuity. This type of construction does not create any problem under vertical loading conditions. But during an earthquake a clear load path is not available for transferring the lateral forces to the foundation. Lateral forces accumulated at the upper floor during the earthquake have to be transmitted by the projected cantilever beams. Overturning forces thus developed overwhelm the columns of the ground floor. Under this situation the columns begin to deform and buckle, resulting in total collapse. This is because of primary deficiency in the strength of ground floor columns, projecting cantilever beams and ductile detailing of beam column joint. Thus, this project explains the concept of analysis of floating column in residential area. Staad.Pro, ETABS and SAP 2000 can be used to do the analysis of this type of structure. When irregular features are included in buildings, a considerably higher level of engineering effort is required in the structural design and yet the building may not be as good as one with simple architectural features. Hence, the structures already made with these kinds of discontinuous members are endangered in seismic regions. But those structure or come remedial features can be suggested. The columns of the first story can be made stronger, the stiffness of these columns can be increased by retrofitting or these may be provided with bracing to decrease the lateral deformation.

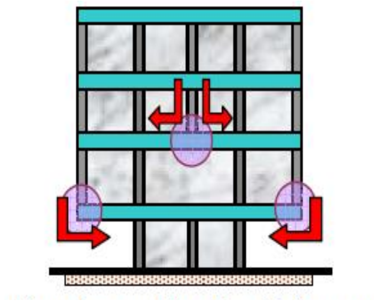


Fig 1: Floating column and transfer beam

III. OBJECTIVE

The objective of the present work is to compare the response of RC frame buildings with floating columns and soft story building under earthquake loading and under normal loading. The major objective of work is listed below:

1. The primary aim of this work is the comparative study of seismic behavior of floating columns and non-floating columns at Midrise R.C. Building.
2. Determination of seismic response of the models by using equivalent static analysis in Staad.Pro V8i software.
3. To study the effect of internal and external floating columns on the building under earthquake loading for seismic zone.
4. Finding out effects on various parameters of RC building under seismic events due to presence of floating column.
5. To check this seismic response of any existing structure with floating columns.
6. To determine which structure is superior to another in higher earthquake zones.

IV. METHODOLOGY

For comparing the seismic response of building when various systems are introduced to the building. These systems are mentioned as following cases:

1. CASE 1: Buildings without floating column i.e., Normal Building.
2. CASE 2: Buildings with floating column (without any lateral load resisting system).
3. CASE 3: Buildings with floating column and X-Bracings (at end bay in both X and Z directions).
4. CASE 4: Buildings with floating column and Shear wall (at end bay and adjacent bay formed by introducing an additional column.

Fig 2: Case 1

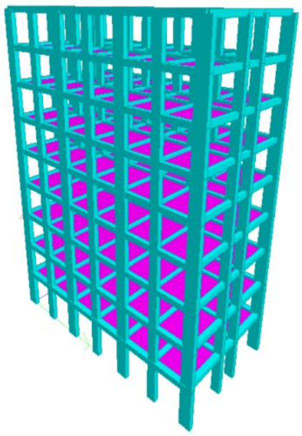


Fig 3: Case 2

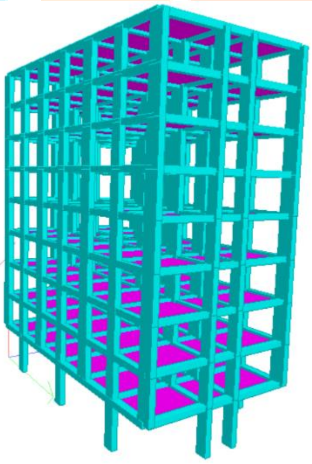


Fig 4: Case 3

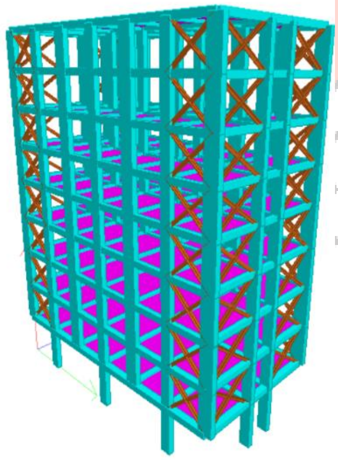
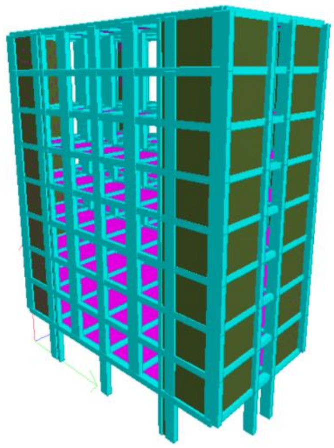


Fig 5: Case 4



Equivalent Static Analysis

The equivalent static method is the simplest method of analysis. Here, force depend upon the fundamental period of structures defined by IS code 1893-2002 with some changes. The equivalent lateral force for an earthquake is a unique concept used in the earthquake engineering. The concept is attractive because it converts dynamic analysis into partial dynamic and partial static analysis to find the maximum displacement induced in the earthquake excitation in the structure. First, design base shear of complete building is calculated, and then distributed along the height of the building, based on formulae provided in code. Also, it is suitable to apply only on the buildings with regular distribution of mass and stiffness. For the seismically resistance construction of structures, only these maximum voltages are of interest, not the time history of stresses. The equivalent side force for an earthquake is defined as a ser of lateral static forces that produces the same peak responses of the structure as obtained by the dynamic analysis of the strictures under the same earthquake. This equivalence is limited only to a single vibration from the structure. Inherently, the equivalent static transverse force analysis is bases on the following assumptions, assume that the structures is rigid. Ensure the perfect fixity between structures and foundation.

Story Drift

Story drift is the difference between displacements of two stories to the story height. Drift is characterized by lateral displacement. Story drift is the drift of a level of multistorey building from the lower level. Thus, greater the drift, greater probabilities of damage. For calculation if story drift as per IS 1893:2002

Story drift ratio= (difference between displacements of two stories) / (height of one story)

Allowable limit = 0.004 x height of each story

Story displacements

Story displacement can be defined as the lateral displacement of the story relative to the base.

As per IS limiting value of story displacement is 5% of height of building.

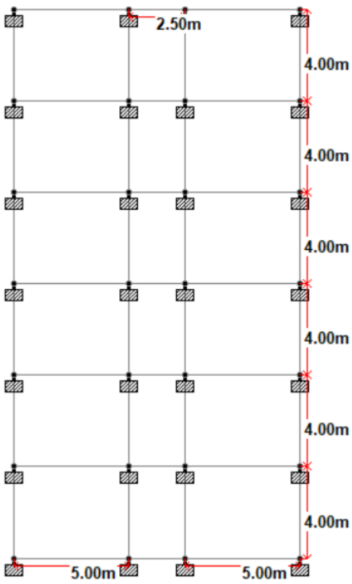
V. PARAMETRIC INVESTIGATION

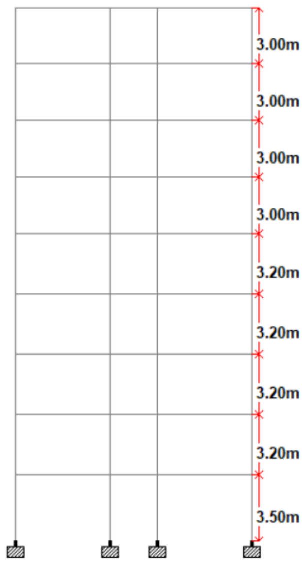
The building considered is a residential building having G+8. The plan dimension is height of each story is kept different as per requirements.

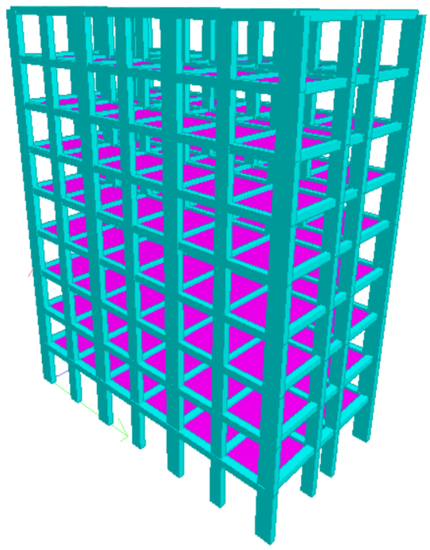
Problem Statement

To study seismic response of floating column structure and regular structure at midrise building i.e., G+8 with respect different terms such as story drift, story displacement and their graphs for these cases have been plotted.

Fig 6: Plan of building Fig 7: Elevation of building Fig 8: 3D model of building







Sr. No.	Member dimensions		
1	Slab thickness		125 mm
2	Beams		450 x 600 mm
			450 x 550 mm
			450 x 500 mm
			450 x 450 mm
			450 x 400 mm
			450 x 350 mm
3	Columns		450 x 1200 mm
			450 x 900 mm
			450 x 750 mm
4	Wall thickness	Outer wall	230 mm
		Inner wall	115 mm
		Parapet wall	115 mm
		Shear wall	150 mm
5	Wall height	Parapet wall	1.2m
Loads			
6	Unit weight of concrete		25 KN/m^2
7	Unit weight of brick infill		20 KN/m^2
8	Floor loads	Dead load	1 KN/m^2
		Live load	1.5 KN/m^2
9	Roof loads	Dead load	1 KN/m^2
		Live load	3.5 KN/m^2
Grade of material			
10	Concrete		M25
11	Steel		Fe500
Seismic load definition			
12	Seismic zone factor	Zone III	0.16
13	Response reduction factor (R)		5
14	Importance factor (I)		1
15	Soil type		Medium soil
16	Structure type		RC Frame building
17	Damping ratio		0.05

Table 1: Member dimensions

VI. RESULTS AND DISCUSSIONS

Story Drift

Story drift is usually interpreted as inter story drift. Following table shows the maximum story drifts of the structures. The story drift of the structure in X and Z direction for different cases is resulted for equivalent static analysis:

All values are in mm								
Story level	CASE 1		CASE 2		CASE 3		CASE 4	
	X	Z	X	Z	X	Z	X	Z
GL	1.897	1.096	3.475	2.119	2.979	1.755	1.094	0.03
I	2.836	2.085	3.421	2.806	1.491	1.562	0.006	0.104
II	3.32	2.64	3.842	3.143	1.473	1.684	0.087	0.133
III	3.498	2.859	4.008	3.266	1.404	1.728	0.164	0.16
IV	3.316	2.774	3.827	3.134	1.419	1.755	0.231	0.179
V	2.697	2.324	3.18	2.643	1.221	1.57	0.272	0.181
VI	2.239	1.963	2.728	2.273	1.097	1.459	0.305	0.181
VII	1.684	1.55	2.181	1.859	0.931	1.311	0.318	0.171
VIII	1.092	1.166	1.594	1.473	0.741	1.133	0.314	0.147

Table 2: Story Drift

From above readings, we can state that the story drift in case 2 is drastically increases as compared with case 1. This increased value of story drift is very risky factor for safety off structure. So, we have to minimize this story drift by using different technique. The values of story drift in case 3 and case 4 is very less as compared with case 2. The case 4 results are more impressive than case 1 also. By analyzing the result, we can say that the x-bracing and shear wall will be very effective in resisting the floating column effect. Comparing in both lateral loads resisting system we used we can say that shear wall is more effective than X-bracings.

Story Displacements

Story displacement is the earthquake parameter in with on the account of an earthquake the relative displacements of each story take place, the story displacement is found to be more on the top most story. Following are the results of story displacement. The story displacement of structure in X and Z direction for different cases are resulted as follows:

All values are in mm								
Story level	CASE 1		CASE 2		CASE 3		CASE 4	
	X	Z	X	Z	X	Z	X	Z
GL	1.897	1.096	3.475	2.119	2.979	1.755	3.475	2.119
I	4.733	3.181	6.896	4.923	4.47	3.317	6.896	4.923
II	8.053	5.821	10.738	8.065	5.943	5.001	10.738	8.065
III	11.551	8.68	14.747	11.331	6.018	5.036	14.747	11.331
IV	14.868	11.454	18.573	14.465	7.422	6.764	18.573	14.465
V	17.565	13.778	21.754	17.107	8.84	8.518	21.754	17.107
VI	19.804	15.74	24.482	19.38	10.061	10.088	24.482	19.38
VII	21.488	17.291	26.662	21.24	11.158	11.548	26.662	21.24
VIII	22.8	18.456	28.256	22.713	12.09	12.859	28.256	22.713

Table 3: Story Displacement

As we know the story displacement is maximum at top story and minimum at lower story. Likewise, all out result shows higher story displacement at top story and lower at bottom story. Form above readings, the story displacement of building in case 1, case 2 and case 4 are maximum than the story displacement in case 3. If taken from story displacement point of view, the X-bracings will be more effective solution than shear wall for floating column effect.

Nodal Displacement

Nodal displacement is the displacement present at different nodes at different level. The result is obtained in X, Y and Z direction for all cases and represented at various no. of nodes.

All values are in mm												
No. of Node	CASE 1			CASE 2			CASE 3			CASE 4		
	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z
37	23.255	0.262	-0.006	29.254	2.088	0.016	14.524	0.357	0	13.891	0.257	0
279	0	0.357	-18.251	0.004	2.58	5.031	-0.009	1.236	9.661	0.012	1.144	7.953
37	-0.001	0.327	18.704	0.005	2.554	23.273	-0.006	1.152	14.228	0.006	1.095	12.329
17	0	0.246	8.717	0	2.579	8.187	-0.006	0.959	6.953	-0.028	-1.646	0.32
237	22.631	0.266	0.005	-28.334	-0.746	-0.015	12.585	-0.915	-0.038	-12.241	-0.609	0.041
93	-7.947	-0.131	0.001	-10.912	-2.1	-0.005	-2.897	0.294	0.159	-2.57	-0.209	0.129

Table 4: Nodal Displacement

By observing the result obtained by analyzing the models with all cases, the nodal displacement is very high in case 2 and low in case 4. The model in case 4 is more favorable and beneficial than case 3 building in nodal displacement to resist the floating column effect.

For comparing the effect of floating column on other adjacent structural element in all cases. We have done the comparative analysis on different structural element like column and beam with respective of their structural function in the structure.

Floating column (column no.: 410)

Column no. 410 is the floating column in case 2, case 3 and case 4 and in case 1 it is normal column. Following are the result in shear force, bending moment and axial force of the column in all the four cases:

Parameters	CASE 1	CASE 2	CASE 3	CASE 4
Shear force (KN)	30.36	29.739	2.666	3.467
Bending moment (KN.m)	58.827	61.119	8.009	7.368
Axial force (KN)	-193.443	-9.716	-6.606	11.12

Table 5: Result of Floating column 410

In floating column, the shear force obtained in case 3 is less among all the other model. The bending moment is less for model in case 4, and for axial force model in case 4 shows positive results. We can say that provision of shear wall will prove best match for the system require to fulfill the floating column effect.

Adjacent column near floating column (column no. 343)

In all the cases, column no 343 is normal column. Here, we are checking the effect of floating column on the column which is adjacent to it. For study we considered parameters like shear force, bending moment and axial force. The results are as follows:

Parameters	CASE 1	CASE 2	CASE 3	CASE 4
Shear force (KN)	28.722	70.638	68.11	65.321
Bending moment (KN.m)	28.722	165.27	147.865	143.729
Axial force (KN)	-174.639	-482.572	-738.2	-521.561

Table 6: Result of Adjacent column near floating column

By observing results in adjoin column of floating column, shear force, bending moment and axial force all are minimum in case 1 and maximum in cases where floating column is present. We can see that provision of only floating column without any lateral load resisting system is worst case. As per the result, provision of shear wall is recommended over provision of X-bracings.

Supporting beam i.e., transfer beam (beam no. 622)

In case 1, beam 622 is normal beam and in other three cases beam 622 is transfer beam which transfer the load of floating column to the adjacent column.

Parameters	CASE 1	CASE 2	CASE 3	CASE 4
Shear force (KN)	-0.064	-31.692	-8.262	-6.211
Bending moment (KN.m)	0.22	-64.086	-18.428	-13.392
Deflection (mm)	1.939	3.497	4.309	4.546

Table 7: Results of Transfer beam

By observing the result of case 1, the shear force, bending moment and deflection in beam is nearly negligible since its near to zero. But in other cases, these values are increased by huge margin. In case 2, shear force and bending moment is maximum than case 3 and case 4 but the value of deflection is more in case 3 and case 4 as compared with other cases. On analyzing the result in transfer beam, the shear wall will be favorable than X-bracings to prevent the lateral load caused by earthquake which is difficult to resist only by using floating column.

Comparison of analysis result

The observations are as follows:

1. There is remarkable increase in story drift and story displacement when floating column is present.
2. The displacement in case 3 is less among all cases.
3. Provision of X-bracings and Shear wall shows drastic change in result for all cases.
4. The shear wall proves better solution to prevent the effect of floating column than X-bracings.

VII. CONCLUSION

The study presented in the paper compares the difference between building with and without floating column. The following conclusions were drawn based on the investigation:

1. This study shows that in building with floating column structure has more story drift as compared to regular structure in both X and Z direction.
2. Both building with floating column and X-bracings and building with floating column and shear wall shows remarkable decrease in story drift compared to building having floating column without any bracings or without any shear wall as well as regular building also.
3. This study shows that story displacement in building with floating column is more as compared to regular building.
4. Building having X-Bracings shows very less story displacement as compared with other models.
5. The probability of failure of model of Case 2 is higher by comparing values of Mx, My and Mz with other cases. Due to the floating columns moments are greatly increase.
6. By comparing all the analysed results, we can say that the Case 4 model is more suitable model for constructing along with floating column for safety precautions.
7. The probabilities of failure of without floating column are less as compared to with floating column.
8. This increased probability of failure when floating column is used can be minimised effectively by introducing the X-Bracing or shear wall to the structure.
9. Moments at every node or every slab level varies significantly. Thus, at every node the moments have to be checked and design for every level separately for the safety and economy purpose.
10. Provision of floating column is advantageous in increasing FSI of the building but is a risky factor and increases the vulnerability of the building.
11. Provision of floating column is recommended when lateral load resitting is being provided along with floating columns.
12. Building with floating column and shear wall and building with floating column and X-bracings performed way better than building with floating column without any lateral load resisting system considering all the structural parameters as well as the increased FSI also.

From the above results it is concluded that floating column building should not be prefer in seismic prone areas without any lateral load resisting system. If there is need of floating column in higher seismic zones then suitable lateral load resisting system should be used along with it for safety purpose.

VIII. ACKNOWLEDGMENT

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