Comparative Study Dynamics Analysis of a Multi-story Building with and without a Floating Column

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Abstract. Parking spaces, lobby areas, terrace gardens, and other amenities are highly sought-after in densely populated urban regions. Although floating columns can be useful and an achievable choice, it is important to research their structural performance and cost-effectiveness in the event of substantial ground motion imposed on by an earthquake. A building's overall dimensions, geometry, and shape all impact how it acts and acts when subjected to seismic loads. For this reason, it is necessary to assess how well floating column buildings perform in seismically vulnerable places in comparison to conventional buildings. In this work, the performance of structures with floating columns for seismic loading is observed using dynamic analytic techniques in accordance with IS 1893 (2005). This study analyses both the floating columns and the conventional building without floating columns. When compared to a regular building, the research reveals that the floating column buildings exhibit a very quick increase in base shear and story displacement. The horizontal displacements experienced by floating column buildings are proportionally larger due to an increase in the fundamental time period. If the lateral displacement exceeds the code-specified maximum limit, damage to structural and non-structural parts may result. Because of the discontinuity in the load distribution path, seismic base shear and overturning moment are also increasing in the case of buildings with floating columns. Additionally, while asymmetrically introducing floating columns, torsional irregularity has been produced but the modal mass participation ratio has decreased. While it is true that the use of floating

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columns in high-rise structures allows for continuous open floor plans, they are also dangerous and susceptible in seismically active locations

1 Introduction

A column is often a vertical element designed to move weights from the foundation to the ground. Both of its lower level, or termination level, resting on a beam that is a horizontal member (either of the architectural design or the limits of the site), this is also known as a floating column. After then, the columns below the beams receive the load. A column that floats above the ground level [1-2]. Floating columns are frequently utilised in construction projects, particularly those that use transfer girders above floor, to enhance the amount of open space on the bottom level. Modern urban multi-story buildings unavoidably feature open first stories [3]. These are frequently used at reception centres and parking lots. The structure's natural period, stiffness, and mass distribution along its height can all affect the overall seismic base shear during an earthquake [4-5]. The shape, size, geometric configuration, and distribution of seismic pressures within a building all have a significant impact on how the building behaves during an earthquake [6]. The quickest route to the ground must be taken when seismic forces are produced in a building at multiple levels. This load transmission path must be straight; any deviation or discontinuity will adversely impair the building's performance [7]. Structures with vertical setbacks, such as hotel buildings that are a few stories broader than the others, have much higher earthquake forces at the discontinuity level. Damage or collapse in a given storey is more likely to occur to columns or walls that are overly tall or improperly supported. Following the 2001 Gujarat earthquake in Bhuj, numerous open-air parking structure structures collapsed and suffered significant damage [8]. The weight transmission path is disrupted by hanging or floating columns, and several studies have been conducted to compare the seismic performance of buildings with and without floating columns [9]. Possibly the most economical option is the framed construction with no floating columns due to the small nodal displacements and the uniform distribution of stresses at all beams and columns. Researchers used software to investigate how multi-story irregular buildings with floating columns responded to earthquakes [10]. They discovered that while the introduction of floating columns in building models increased story drift and displacement, story shear decreased as a result of the columns' decreased mass in the structure [11]. Additionally, they recommended against using floating columns in high-rise buildings located in areas that are very susceptible to earthquakes due to their poor performance [12]. The seismic behaviour of multistory buildings with and without floating columns using STAAD Pro V8i software and comparable static analysis techniques. They concluded that although a floating column raises the building's floor space index, it also makes the structure more vulnerable and dangerous [13-14]. Using STAAD Pro software, the seismic performance and cost-effectiveness of floating column buildings were assessed. It was found that these structures are both dangerous and not cost-effective in seismically active areas [15]. By using bracings, the seismic performance of the multi-story building with floating columns has been increased by 10% to 30% while taking into account various parameters including story drift, story shear, time period, and displacement [16-18]. Studying the seismic response of an RC frame structure with a floating column in different soil conditions, it was discovered that as building height raised the difference in maximum moments for different soil conditions decreased [19]. The floating column's presence in a two-dimensional, multi-story building using Finite Element Methods under various earthquake excitation scenarios with varying frequency content. They also proposed that decreasing the maximum displacement and inter-story drift values during earthquakes [20]. In regions with strong seismic activity, the design of these structures is mostly governed by earthquake forces when the tank is operating at maximum capacity [21-24]. Making ensuring that necessities like the water supply are not harmed during earthquakes is crucial. Tanks should not completely collapse in extreme circumstances [25]. The primary goal of this research is to better understand how various bracing systems behave in order to reinforce traditional staging and improve its performance during earthquakes. Equivalent static analysis done to the elevated circular water tank staging in the seismic zone using various bracing system types [26]. could be achieved by increasing the column. Floating column structures have been built in metropolitan locations recently for a variety of reasons, including practicality, beauty, the assertion of city planning governance, etc . These structures are available in seismically vulnerable places to satisfy customer demands and create unique architectural designs, although they may entail greater shear and torsion than a typical building [27] . Therefore, it makes sense to look into how the floating column buildings perform seismically . With the goal to evaluate the seismic performance and compare various characteristics, such as base shear and story displacements between a conventional building and a floating column (G+7) residential multi-story building, a response spectrum method analysis (using Staad Pro) is carried out in this study [28-31] .

2 Methodology

A column is often a vertical element designed to move weights from the foundation to the earth. both of its lower level, or termination level, resting on a beam that is a horizontal member (either of the architectural design or the limits of the site), this is also known as a floating column [32]. The columns that support the beams below it then receive the loads. a column floating above the surface of the earth. Floating columns are frequently utilised in construction projects, particularly those that use transfer girders above floor, to enhance the amount of open space on the bottom level.

Table 1: Model detailed

Model detailed	
Item of model	**Properties of model**
Number of storey	G+7
Total height of structure	24m
Typical Storey height	3m
Bottom Storey height	3m
Floor diaphragm	Rigid
Bays number along length	5
Number of bays along width	5
Spacing of bays along length	3m
Spacing of bays along width	3m
Beam shape	Rectangular
Beam size	300x450mm
Column shape	Rectangular
Column size	600x600mm
Slab depth	150mm
Slab type	Thin Shell
Concrete grade	M25
Distribution bar (fysec)	Fe415
Main bar (fymain)	Fe415

These open spaces might serve as parking lots or assembly halls [33-36]. This study aims to create awareness about challenges in the design of multi-story facilities to be earthquake-resistant and to give an overview of how multi-story buildings with floating columns behave under seismic excitations [37]. In this study, a response spectrum method analysis (using Staad Pro) is conducted to examine the seismic performance and assess several comparative parameters, including base shear and story displacements between a normal building and a floating column (G+7) residential multi-story building

The table showing that the model specifications outline the detailed characteristics of the structure under consideration. The building comprises a G+7 storeys, with a complete top of 24 meters [38-40]. every storey has a typical height of 3 meters, including the bottom storey. The floor diaphragm is specified to be rigid. The building is divided into 5 bays along both the length and width, with each bay spaced 3 meters apart. Rectangular beams with dimensions of 300x450mm are applied, while the columns are also rectangular with dimensions of 600x600mm. The slab has a depth of 150mm and is classified as a thin shell. The concrete grade used is M25, and the steel reinforcement consists of Fe415 bars for both distribution and main reinforcement. These specifications provide essential details necessary for structural analysis and design considerations [41].

Table 2: Combinations of Load

S.no	Load Combination
1	1.5(DL + LL)
2	1.2(DL + LL + EQ-X DIR.)
3	1.2(DL + LL – EQ-X DIR.)
4	1.2(DL + LL + EQ-Z DIR.)
5	1.2(DL + LL – EQ-Z DIR.)
6	1.5(DL + EQ-X DIR.)
7	1.5(DL – EQ-X DIR.)
8	1.5(DL + EQ-Z DIR.)
9	1.5(DL – EQ-Z DIR.)
10	0.9DL + 1.5EQ-X DIR.
11	0.9DL – 1.5EQ-X DIR
12	0.9DL + 1.5EQ-Z DIR
13	0.9DL – 1.5EQ-Z DIR.

- DL= Dead Load
- LL= Live Load
- EQ-X DIR = Earthquake load in X- Direction
- EQ-Z DIR = Earthquake load in Z- Direction

3 Results and Discussion

Floating columns are frequently utilised in construction projects, particularly those that use transfer girders above floor, to enhance the amount of open space on the bottom level. These open spaces might serve as parking lots or assembly halls [42]. A building's overall dimensions, geometry, and shape all impact how it acts and acts when subjected to seismic loads. For this reason, it is necessary to assess how well floating column buildings perform in seismically vulnerable places in comparison to conventional buildings [43-44]. In this work, the performance of structures with floating columns for seismic loading is observed using dynamic analytic techniques in accordance IS 1893 -2005. Building models' behaviour is examined, and the way floating column structures react to seismic loads is contrasted with that of conventional Structures. A comparison study of a structure with and without a floating column is constructed based on base shear and story displacement.

Table 3: Base Shear Evaluation for floating column

Storey	Height In Meter	Base Shear in KN
8	24.00	105
7	21.00	210
6	18.00	305
5	15.00	386
4	12.00	452
3	9.00	503
2	6.00	536
1	3.00	550
BASE	0.00	550

The table data provided presents in floating column, the storey heights of a building in meters alongside their corresponding base shear values in kilonewtons (KN). as the storey level progresses from the base (BASE) to the 8th storey, the heights decrease at the same time as the base shear tends to increase. For instance, the bottom shear starts at 105 KN on the 8th storey and gradually rises to 550 KN at the first storey. This sample illustrates the distribution of lateral forces in the building, with higher storeys experiencing greater lateral forces as compared to lower storeys. These base shear values are essential in structural engineering as they inform the design of structural factors to withstand lateral loads, such as those resulting from seismic activity.

Table 4: Storey displacement evaluation for floating column

Storey	Height in Meter	Storey displacement in MM
8	24.00	21.9
7	21.00	20.3
6	18.00	18.8
5	15.00	16.4
4	12.00	13.1
3	9.00	9.8
2	6.00	5.7
1	3.00	2.0
BASE	0.00	0.0

The table data provided offers in floating column, the storey heights of a building, measured in meters, along with the corresponding storey displacement values in millimeters (MM). The heights drop as one ascends from the base to the eighth storey, and the corresponding storey displacements likewise decrease. For instance, the displacement starts at 22.9 MM at the 8th storey and gradually decreases to 2.0 MM at the first storey. This trend indicates that higher storeys generally experience less lateral displacement as compared to lower storeys. These displacement values are large in structural engineering as they help evaluate the constructing's response to external forces including seismic activity.

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Table 5: Base Shear Evaluation for without floating column

Storey	Height In Meter	Base Shear in KN
8	24.00	128
7	21.00	271
6	18.00	394
5	15.00	498
4	12.00	585
3	9.00	649
2	6.00	692
1	3.00	708
BASE	0.00	708

The table provided data presents in without floating column, the storey heights of a building in meters alongside their corresponding base shear values in kilonewtons (KN). As the storey level progresses from the base (BASE) to the 8th storey, the heights decrease at the same time as the base shear tends to increase. For instance, the base shear starts at 128 KN at the 8th storey and gradually rises to 708 KN at the first storey. The distribution of lateral forces throughout the building is shown in this pattern, with higher storeys experiencing more lateral forces than lower floors. Engineers utilize this information to ensure the stability and safety of the constructing under various loading conditions.

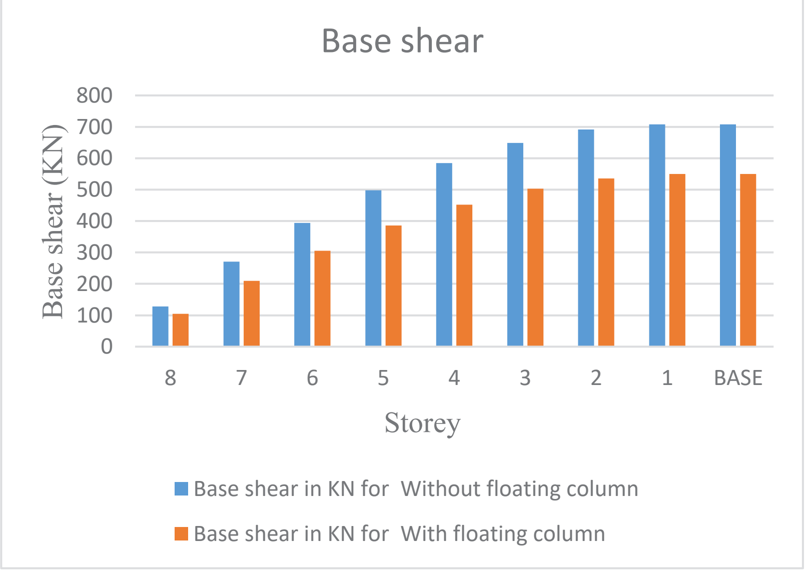

Fig. 1: Comparatively results of base shear with and without floating column

The fig presents a comparison of base shear values, measured in kilonewtons (KN), with and without floating columns for each storey of a building. as the storey level progresses from the base to the 8th storey, the bottom shear values for both eventualities are listed. Notably, the presence of floating columns appears to influence the base shear values across the storeys. For instance, at the base, the base shear with floating columns is 550 KN, even as without floating columns, it increases to 708 KN. This sample continues up the storeys, showing that base shear values are lower when floating columns are present than when they are not. Those versions are critical in structural engineering, as they impact the constructing's overall stability and its capacity to face up to external forces inclusive of seismic activity

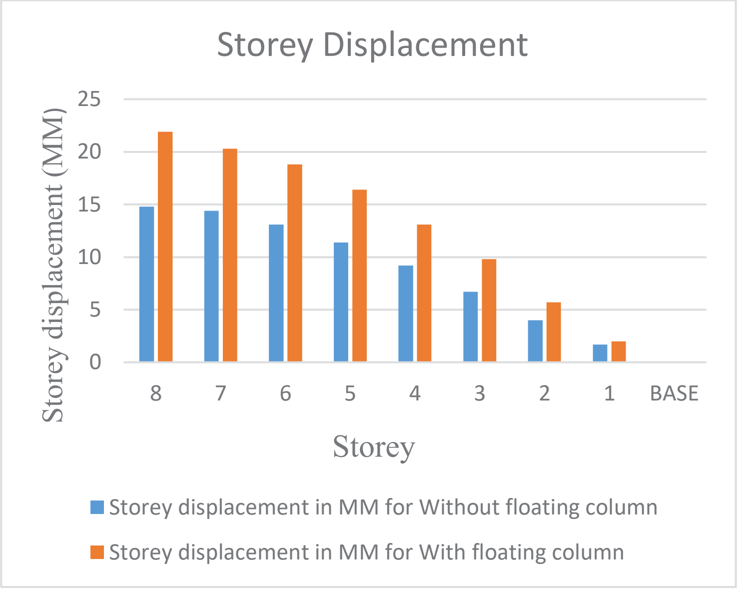

Fig. 2: Comparatively results of storey displacement with and without floating column

The fig showing compares the storey displacements of a building, measured in millimeters (MM), with and without floating columns. as the storey level progresses from the base to the 8th storey, the displacements for both scenarios are listed. Notably, the presence of floating columns tends to have an effect on the storey displacement values. for instance, on the eighth storey, the displacement without floating columns is 14.8 MM, while with floating columns, it will increase to 21.9 MM. This trend continues throughout the storeys, indicating that the inclusion of floating columns results in higher displacement values in comparison to their absence.

4 Conclusion

Floating columns can be useful and an achievable choice, it is important to research their structural performance and cost-effectiveness in the event of substantial ground motion imposed on by an earthquake. This study aims to create awareness about challenges in the design of multi-story facilities to be earthquake-resistant and to give an overview of how multi-story buildings with floating columns behave under seismic excitations. In this study, a response spectrum method analysis (using Staad Pro) is conducted to examine the seismic performance and assess several comparative parameters, including base shear and story displacements between a normal building and a floating column (G+7) residential multi-story building. Analyze behavior of elevated circular water tanks under seismic conditions. Focuses on understanding bracing patterns to enhance conventional staging.

- Examines base shear and storey displacements in a building both with and without floating columns.
- Storey level progression from base to 8th storey. Floating columns significantly affect displacement values. Without floating columns, displacement on 8th storey is 14. 8MM.With floating columns, displacement increases to 21.9 MM.
- Floating columns result in higher displacement values. Base shear values measured in KN, with and without floating columns, for each storey of a building.
- Floating columns significantly influence base shear values across storeys. Base shear with floating columns is 550 KN, without floating it increases to 708 KN. Floating columns decrease base shear values across storeys.
- Floating columns impact the building's stability and resistance to external forces, including seismic activity.

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