Analysis of G+5 Storeys Building With and Without Floating Column

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Abstract. In current period, several structures are being planned and built with structural complicatedness like building with floating columns on different floors and spaces. The buildings accompanying floating columns are extremely detrimental that is constructed in earthquake-prone regions. The current study analyses and compare the buildings with and without floating column. The columns which are directly supported by a beam without any rigid base are known as floating columns. Various buildings have been constructed with floating columns in India. Typically, it is required to provide larger spacing between the columns to entertain the requirements of parking or reception lobbies. Some of the functional requirements of a building might be satisfied by providing the floating columns but the structural behaviour of the building changes abruptly. The beams that supported the floating columns require more flexure and shear demand than the surrounding beams. In addition, it leads to stiffness unevenness at a specific joint. Columns are the main structural elements that resist the lateral load in a rigid frame and have the importance in the performance of the building under earthquake load The storey’s stiffness below the floating column is normally reduced. Therefore, an attempt has been made to analyse the performance of a G+5 storey building with and without floating columns and compare structural parameters such as horizontal displacement, storey drift and storey shear under seismic excitation using (ETABS) Software.

Keywords- Floating column, Normal building, ETABS, Seismic, Excitation

1. Introduction
At the present time, many multi-story buildings in India are constructed for residential, commercial, institutional, and industrial or any other purpose with an open ground storey that has become an inescapable feature. The floating columns are required to provide large space for parking on the ground floor or lobbies, architectural glitter and enhance the floor space index. For the parking purpose, generally [1]–[3], the ground storey is retained free from any structural element other than the columns that transmit the building load to the soil. The buildings, where lower floors have event halls, lobbies, seminar rooms, and malls with large interrupted areas needed for the activity of the human being or movement of the vehicles. Static analysis for high rise buildings with and without columns was conducted by [4], [5].
Buildings with various cases were investigated by changing the position of floating columns floor wise. Performance of building models was investigated related to the displacement of storey and base shear. The study was conducted adopting SAP2000 and found that displacement of the individual storey with the floating column is larger in comparison to no floating column building. Analyzed the effect on a floating column due to earthquake turmoil under different soil conditions. Investigated two buildings consisting of mass irregular and soft storey buildings in seismic zone V for the impact of the floating column [6]–[8].

The response of a building under earthquake excitation depends upon the geometry, shape and size of the building. The earthquake loads produced in a building at various floor heights are required to bring down along the top to soil strata through the shortest way. The load transferring path having any discontinuity causes poor functioning of the building. A specific storey of a building with lesser columns and walls is likely to be detrimental. Hence, the present study analyzes the response of a building with G+5 storey with and without floating columns and compare structural parameters like horizontal displacement, storey drift and storey shear under seismic excitation using (ETABS) Software [9]–[11].

2. Floating Column
The vertical structural member that starts from the base level and transmits the force to soil strata is known as a column. It is an upright structural component that at its termination plane place on a horizontal member i.e. beam [12]–[14]. The floating column transfers the load to the beams and these beams transmit the force to other columns as shown in figure 1.

3. Objective and Scope
The number of areas in units is lessening progressively due to the population growth. Just a few years back people were less so they lived in a horizontally expanded large area available per person but in recent times people are adopting vertical expansion due to scarcity of land area. Therefore, those structures which have already been constructed with these types of discontinuous members are at risk in earthquake prone areas. In addition, they cannot be dismantled but some remedial measures can be implemented to strengthen the structures.
1) To investigate the performance of RC buildings consisting of floating columns and without floating columns under earthquake loading.
2) To correlate the performance of RC buildings consisting of floating columns inward and at the corners of the building.
3) To compute the lateral displacement, storey drift and storey shear by using ETABS [15]–[17].

4. Modeling of Building

Considered the standard G + 5 RC building of plan with 15mx15m dimensions, this structure is considered to be in Zone IV as per IS 1893-2016 as shown in Table 1.

Table1: As shown below gives detailed information about the model.

| Sr. No. | Case for building                  | Nomenclature |
|---------|------------------------------------|--------------|
| 1       | With no floating column            | Model 1      |
| 2       | With floating column               | Model 2      |
|         |                                    | Model 3      |

4.1. Model Description

The three models are developed for structural investigation adopting ETABS software. Assigned geometric particulars of the structure are given in table -2 below. The height of each floor remains constant in all buildings.

Table-2: Geometric details of structures

| Material data         |                  |
|-----------------------|------------------|
| Concrete Mix          | M25              |
| Grade of steel        | Fe415            |
| RCC /Unit weight      | 25kN/m³          |

| Geometry              |                  |
|-----------------------|------------------|
| Classification of structure | SMRF              |
| Soil Classification   | Medium soil      |
| Size of beam          | 230mmx450mm      |
| Size of deep beam     | 450mmx800mm      |
| Size of column        | 450mmx450mm      |
| Depth of slab         | 150mm            |

| Architectural data    |                  |
|-----------------------|------------------|
| NOS.of stories        | G+5              |
| Floor to Floor height | 3m               |
| Dimension of plan     | 9mx9m            |

| Seismic data          |                  |
|-----------------------|------------------|
| Seismic zone          | IV               |
| Response reduction factor | 5               |
| Importance factor     | 1                |
| Damping ratio         | 5%               |

| Loads                 |                  |
|-----------------------|------------------|
Model 1: RC building with no floating column.
Model 2: RC building consisting of floating column, Corner of frame having no column.
Model 3: RC building consisting of floating column, Middle interior frame having no column.

### 4.2. Model Overview

Three cases of buildings with plan and elevation are shown in the Figures.

**Figure 2**- Plan of 1st floor model 1

(a) Elevation of model 1
5. Comparison
5.1. Lateral displacement

The movement of a structure laterally due to the lateral forces is called lateral displacement. It has been observed that lateral displacement of the building becomes larger by introducing the floating column, see Table 3 and 4.

Maximum displacement at the individual floor for the considered load combinations is observed in X and Y direction are represented graphically as shown in Figure 5.

**Table-3**: Displacement values of building with G+5 storeys undergone to earthquake load in the X direction

| Story  | Model 1       | Model 2       | Model 3       |
|--------|---------------|---------------|---------------|
| Story6 | 10.9448       | 17.1819       | 11.2864       |
| Story5 | 9.6651        | 14.6463       | 10.0367       |
| Story4 | 7.7329        | 11.6834       | 8.1498        |
| Story3 | 5.3538        | 8.4129        | 5.8249        |
| Story2 | 2.8568        | 5.0514        | 3.3801        |
| Story1 | 0.9742        | 2.0888        | 1.4899        |
| Base   | 0             | 0             | 0             |

![Figure 5: Displacement values of building with G+5 storeys undergone to earthquake load along X direction](image)

**Table-4**: Displacement values of building with G+5 storeys undergone to earthquake load in the Y direction

| Storey  | Model 1       | Model 2       | Model 3       |
|---------|---------------|---------------|---------------|
| Storey6 | 10.9448       | 17.1819       | 11.2864       |
| Storey5 | 9.6651        | 14.6463       | 10.0367       |
Figure 6: Displacement values of building with G+5 storeys undergone to earthquake load along the Y direction

It is observed from the graphs as shown in Fig.5 and Fig-6, the model-2 and model-3 of buildings show larger displacement in comparison of a model-1 building in both X and Y directions. Note- the values are the same along X and Y direction due to the symmetry of the building (Building is in plus shape).

5.2. Storey drift
The difference between displacements of the respective floors is called storey drift. The drift of floors is directly proportional to the displacement of the floor. At the time we introduce a floating column into the building, the floors drift increases as the floors displacement increases. Floor drift decreases as we move towards top stories, see Table 5 and 6.

For given load combinations, the maximum drift of the floors in each X and Y direction is represented in graphical form as shown in fig.7 and fig.8.

Table-5: Drift values of building with G+5 storeys undergone to earthquake load in the X direction

| Story   | Model 1     | Model 2     | Model 3     |
|---------|-------------|-------------|-------------|
| Storey6 | 0.000427    | 0.000845    | 0.000417    |
| Storey5 | 0.000644    | 0.000988    | 0.000629    |
| Storey4 | 0.000794    | 0.001090    | 0.000776    |
| Storey3 | 0.000837    | 0.001124    | 0.000821    |
| Storey2 | 0.000628    | 0.000997    | 0.000640    |
Figure 7: Drift values of building with G+5 storeys undergone to earthquake load along the X direction

Table 6: Drift values of building with G+5 storeys undergone to earthquake load in the Y direction

| Storey | Model 1  | Model 2  | Model 3  |
|--------|----------|----------|----------|
| Storey6| 0.000427 | 0.000845 | 0.000417 |
| Storey5| 0.000644 | 0.000988 | 0.000629 |
| Storey4| 0.000794 | 0.001090 | 0.000776 |
| Storey3| 0.000837 | 0.001124 | 0.000821 |
| Storey2| 0.000628 | 0.000997 | 0.000640 |
| Storey1| 0.000325 | 0.000687 | 0.000495 |
Figure 8: Drift values of building with G+5 storeys undergone to earthquake load along the Y direction. Model-2 shows a larger displacement in comparison to model 1 in both directions X and Y (From the above graph). The model-3 also shows larger displacement than model 1 till storey 2 and from storey 3 it is almost similar to model-1. Note- the values are the same the along X and Y direction due to the symmetry of the building (Building is in plus shape).

5.3. Storey shear

The forces that occur on each floor during the seismic activity are defined as floor forces. The induced forces on floors in an ordinary building will be greater than in a building with a floating column. For a building, the forces of the floors continue to increase for the lower floors and the lower floors will be maximum, see Table 7.

For given load combinations, the maximum floor shear on every floor is recorded in the X direction that is represented in graph form in fig.9.

Table 7: Storey shear values of building with G+5 storeys undergone to earthquake load along the X direction.

| Storey | Model 1 | Model 2 | Model 3 |
|--------|---------|---------|---------|
| Storey6 | 107.72  | 71.03  | 105.14  |
| Storey5 | 189.37  | 124.87 | 184.83  |
| Storey4 | 241.62  | 159.33 | 235.83  |
| Storey3 | 271.02  | 178.71 | 264.52  |
| Storey2 | 284.08  | 187.33 | 277.27  |
| Storey1 | 287.59  | 189.79 | 281.04  |
It is observed in the above graph, the model-1 building shows more storey shear when examined to a model-2 and model-3 building.

6. Conclusion

In this work, the variation in different parameters between a building with and without a floating column undergone to lateral loading is investigated. The study was conducted based on three essential criteria, namely lateral displacement, storey drift, and storey shear. Based on the result obtained with the ETABS program, it can be concluded that the probability of failure of the build with a float column may be more than the probability of not having a float column. Building performance may vary depending on the position and orientation of the floating column.

Based on the investigation, we can identify the following emerging points.

- Loads applied laterally in the X and Y direction on every floor, the lateral displacements of the building with floating columns in the X and Y directions are larger in a comparison to the normal building. Therefore, a building consisting of floating columns is not safe for construction as comparison to the normal building. The displacement of the floors rises with the increase in the elevation of the building. The offset value of the model for buildings with floating column is especially increased for corner floating columns of the building. Increasing or decreasing the displacement in the floors depends on the mass of the floors.

- By calculating the floor drift in each building floor, it has been analyzed that the building with a floating column will suffer from severe floor drift compared to the normal building. The maximum drift floor is the first floor level in both cases.

- Lower floors will experience more shear than upper floors considering lower weight from lower floors to upper floors. The magnitude of base shear reduces as a result of the addition of the floating column.

- It is concluded that it is not preferable to provide floating columns in buildings expecting that there is an appropriate objective and functional requirements for it. Though it is to be provided, proper care must be taken while planning and designing the structure.
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