IARJSET

ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁘ Peer-reviewed & Refereed journal ⁘ Vol. 11, Issue 7, July 2024

DOI: 10.17148/IARJSET.2024.11713

COMPARATIVE RESPONSE SPECTRUM ANALYSIS OF G+14 MULTI-STORY STRUCTURE WITH AND WITHOUT FLOATING COLUMN IN SEISMIC ZONE V USING ETABS

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Abstract: Nowadays lots of multistory buildings are constructed with floating columns for aesthetic point of view and for getting more space in parking areas for movement. However, such buildings are highly damaged during earthquakes in highly seismic zones as compared to normal buildings. In urban areas, multi-story buildings are constructed by providing floating columns on the ground floor for the various purposes which are stated above. The motive is to compare the response of RC frame buildings with and without floating columns under earthquake loading and under normal loading. The effect of earthquake forces on various building models for various parameters is proposed to be carried out with the help of response spectrum analysis. In this study, it was found that the story displacement, story drift, and story shear of a building without a floating column was more efficient than that of a building with a floating column. On comparing it has been concluded that the maximum story displacement obtained for Cases 1 & 15 with a minimum value of 11.158 mm & 14.8 mm respectively. Comparing the Story drift for all cases, Cases 1, 5, 7 & 15 are observed as most efficient. On analyzing story shear values, Cases 1, 5, and 10 are found to be optimum for both X & Z direction among all cases.

Keywords: Floating column, Story Drift, Base shear, Story Displacement.

I. INTRODUCTION

Many urban multistory buildings in India today have an open first story as an unavoidable feature. This is primarily being adopted to accommodate parking or reception lobbies in the first story. 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. The behavior of a building during earthquakes depends critically on its overall shape, size, and geometry, in addition to how the 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 vertical setbacks (like the hotel buildings a few stories wider than the rest) cause a sudden jump in earthquake forces at the level of discontinuity. Buildings that have fewer columns or walls in a particular story or with unusually tall stories tend to damage or collapse which is initiated in that story. 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.

II. BACKGROUND

A floating column is a column member that is constructed over the beam or slabs of any intermediate floors of a structure. Unlike normal columns, these columns are not attached to any footings or pedestal. The floating column construction is a new development made to serve a certain architectural purpose in the building construction.

- **Load Transfer in Floating Columns and Non-floating Columns:** The load transfer is directly done by the non-floating column where it is safely transferred to the foundation. In the case of a floating column, the load is taken by the below beam. The column is arranged as a point load over the beam. The load is equally distributed to the beam.

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The next important need is that the load from the beam must reach the below floor or foundation by following the shortest path. In the case of floating column construction, the shortest path is through the columns supporting the beams, the column at any level of structure changes the load transfer path and the load of this floating column is transferred through the horizontal beams below it, known as transfer girders.

Objective of the Study

- To study the behavior of multi-story buildings with floating columns under earthquake excitations.
- To find whether the structure is safe or unsafe with floating column when built in seismic zone V.
- To find the most critical and best position of floating column in G+14 building.
- To compare the Nodal displacement and Story drift for all the models with or without floating column.

To find out the optimum location of floating column in a building frame

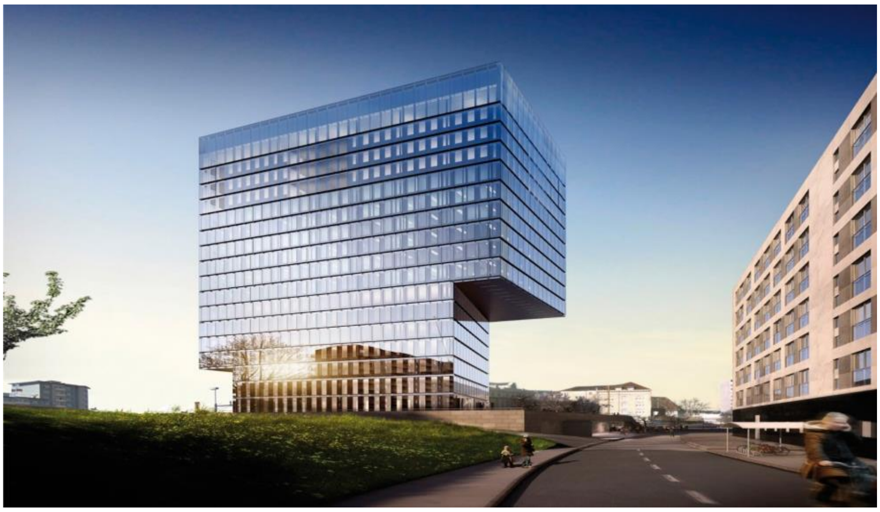

Fig 1 : Tour De esplanade Fribourg (rdrarchitect et.al)

Fig 2**:** Hanoi Museum Vietnam (archidaily et.al)

Effect of Earthquake on Tall Building

The Effect of Earthquakes on Tall Buildings Earthquakes is a destructive natural calamity, which does not predict previously. In the real world earthquake-proof buildings do not exist. Earthquake resistance structure we have. 'Mass' of a building in seismic design is related to building 'stiffness'.

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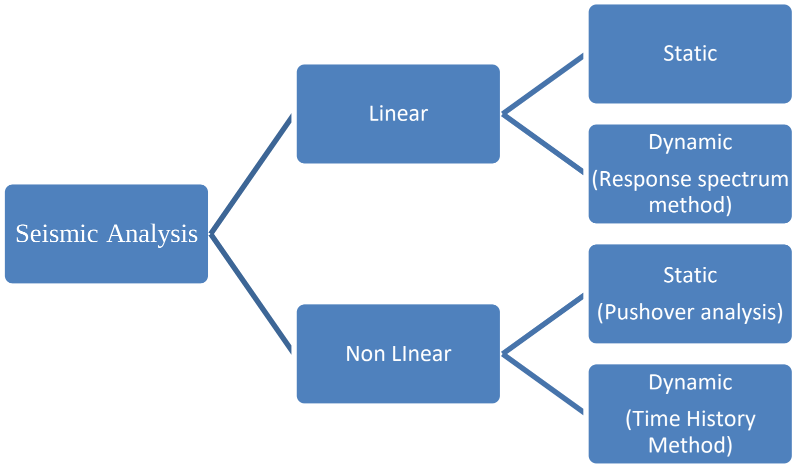
Earthquake induces 'inertia forces' which are proportional to the 'Mass' of the building. Earthquake forces increase directly proportional to ground acceleration and mass of the building. This implies that Newton's law, (F = ma); 'F' represents force, 'm' represents mass, and 'a' represents acceleration. Small buildings are affected by high-frequency waves (short and frequent waves). Tall buildings are affected by long periods or slow shaking. (F=1/T; F represents frequency; T represents time). Increasing the column height decreases the stiffness and decreases the oscillation or frequency.

Different Types of Seismic Analysis

To determine seismic responses, it is necessary to perform a seismic analysis of the structure. The analysis can be done based on some factors like external action, the behaviors of structural materials, and the type of model selected.
Analysis can be classified as –



Response Spectrum Method

Dynamic evaluation ought to be completed with a view to obtaining the design seismic force and its distribution to different levels along height of the structure and to distinctive lateral load resisting components. There are theoretical benefits in the use of the seismic analysis response spectrum approach to predict.

This approach includes the measurement of only the maximal values of the displacements and of the component forces in each mode of vibration using a smooth design spectrum that is the sum of many earthquake movements. Code used for analysis of multi-story building IS:1893

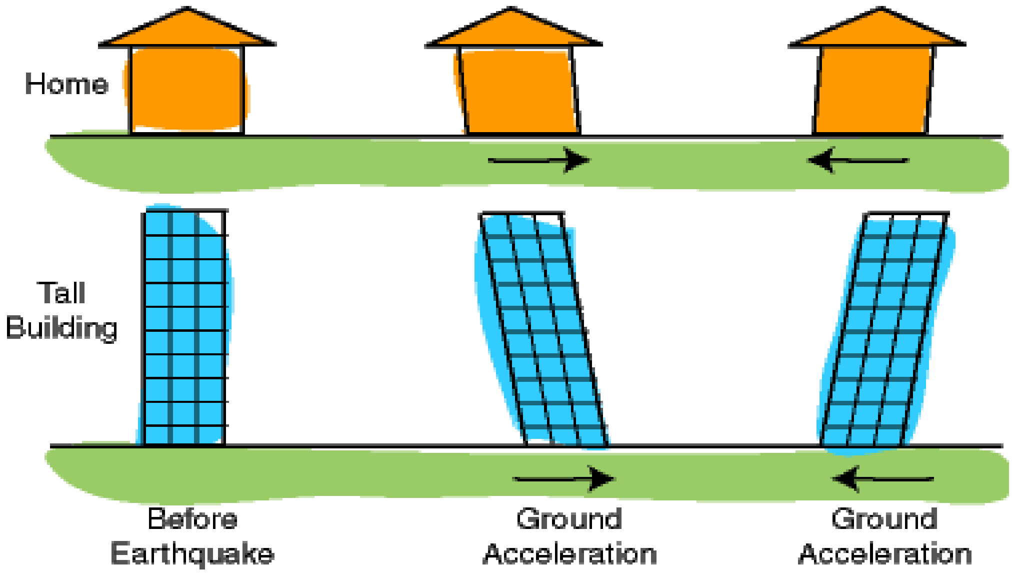


Fig 3: Effect of the earthquake on a building (sematicsholar et al)

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Design Concept

- A G+14 storied model of the building is analyzed having 7 bays in x direction and 4 bays in z direction for a total of 13 cases with and without floating columns at various locations within the floor level and in different stories.

- Using Indian Standard Code IS 1893 (part 1): 2002 various parameters are analyzed for various conditions under seismic zone V by response spectrum method.

- For examining the below cases "ETABS" is used for analysis and the following data is used for analyzing various parameters under various conditions.

Response Spectrum Analysis in ETABS:

- Obtaining the architectural and structural design of the building.
- Geological information of the area; inputting material and section properties.
- Defining material property; member section definitions; and creating the model of the structure.
- Loading arrangement, assigning loadings.
- Response spectrum definitions.
- Load case for response spectrum analysis.
- Perform dynamic linear analysis and check the results.

Structural Configuration

- The overall configuration considered for the design and analysis model has been listed below.

Table 1: Seismic Specification for Design

PARAMETERS	CONFIGURATION
Structure type	RCC Structure
Plan Dimension	22m x 13m
Height of Story	3m
No of Story	15
Slab Thickness	200mm
Column size	800mm x 400mm
Beam size	600mm x 400mm
Grade of Steel	Fe500
Grade of Concrete	M30
Zone Factor	0.15
Response reduction factor	5
Type of soil	Medium Soil
Response Spectra	As per IS 1893(Part-1):2002
RCC Design	As per IS456:2000

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Table 2: Loading Specification for Design

LOADS	VALUE
Dead Load for slab	3.75 KN/m
Dead Load for beam	6KN/m
Dead Load for column	8KN/m
Live Load	3KN/m
Floor Finish Load	1.5KN/m
Wind load	As per IS 875 2015
Wind speed	50 m/s
Terrain category	2

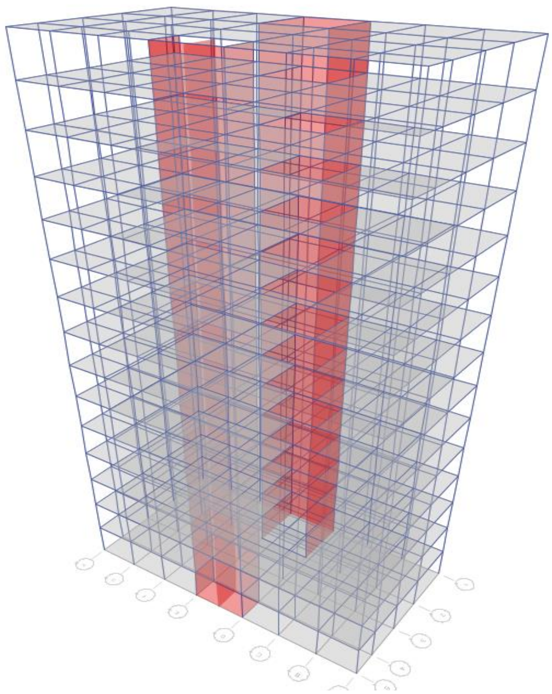

Fig 4: View of Building with floating column

Procedure for Response Spectrum Analysis in ETABS:

- Obtaining the architectural and structural design of the building.
- Geological information of the area; inputting material and section properties.
- Defining material property; member section definitions; creating the model of the structure.
- Loading arrangement, assigning loadings.
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S.NO	BUILDING CONFIGURATION CASES	ABBR
1	Modelling and analysis of G+14 building without floating column.	1
2	Modelling and analysis of G+14 building with floating column at all four corners and middle in ground floor only.	2
3	Modelling and analysis of G+14 building with floating columns at all four corners and middle in G+2 only.	3
4	Modelling and analysis of G+14 building with floating columns at all four corners and middle in G+4 only.	4
5	Modelling and analysis of G+14 building with floating columns at all four corners and middle in G+6 only.	5
6	Modelling and analysis of G+14 building with floating columns at all four corners and middle in G+8 only.	6
7	Modeling and analysis of G+14 building with floating columns at all corners and middle in top floor.	7
8	Modelling and analysis of G+14 building with floating column at two corners and bay 4 at x direction in G+1 only.	8
9	Modelling and analysis of G+14 building with floating column at all corners in Ground floor only.	9
10	Modelling and analysis of G+14 building with floating columns at corners in G+2 only.	10
11	Modelling and analysis of G+14 building with floating column at all corners in G+4 only	11
12	Modelling and analysis of G+14 building with floating columns at all corners in G+6 only.	12
13	Modelling and analysis of G+14 building with floating column at two corners and bay 4 at x direction in G+3 only.	13
14	Modelling and analysis of G+14 building with floating column at two corners and bay 4 at x direction in G+9 only.	14
15	Modelling and analysis of G+14 building with floating column at two corners and bay 4 at x direction in G+5 only.	15

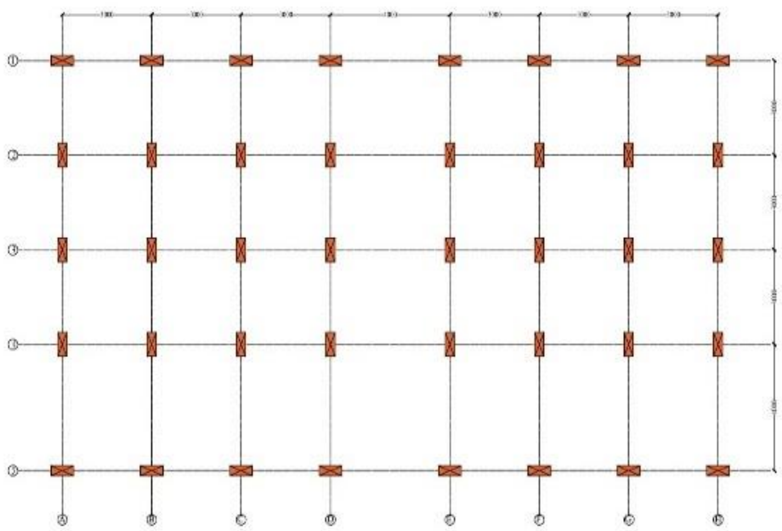

Fig 5: Column grid layout

IARJSET

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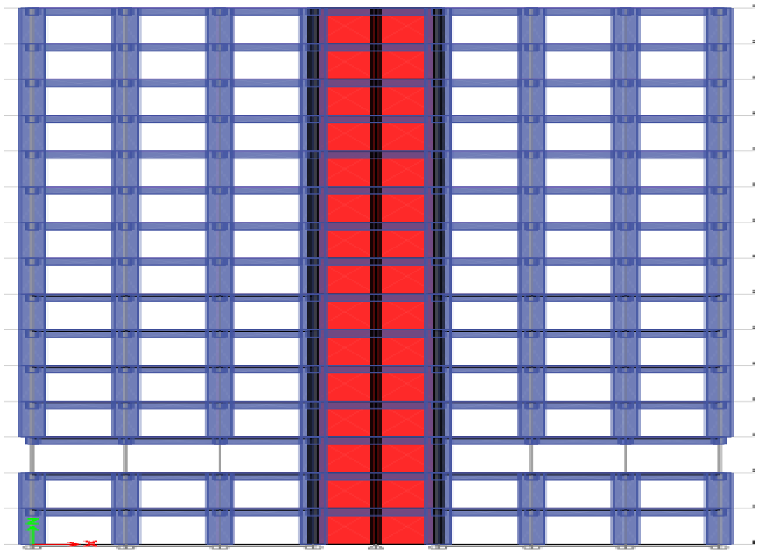

Fig 6: Elevation of buildings with different case

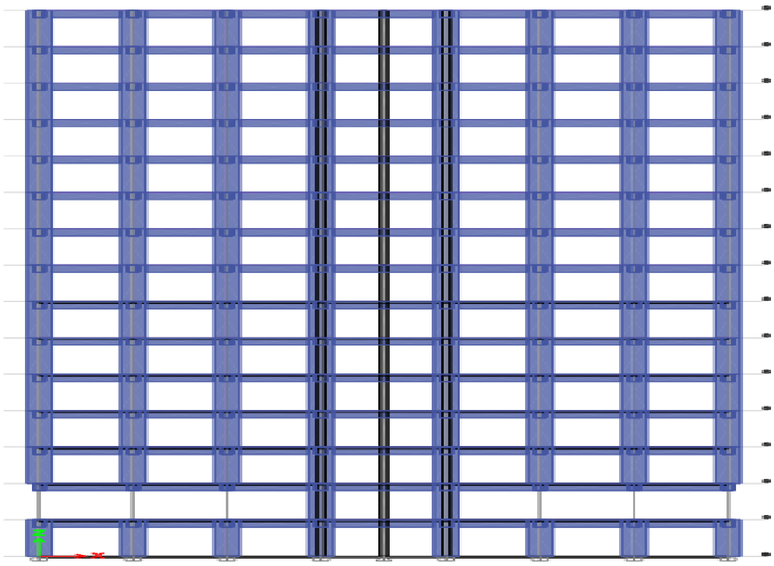

Table 4: Load Cases

Load cases	Load cases type	Type
Dead	linear static	dead
Live	linear static	live
FL	linear static	roofs live
Eqx	linear static	seismic
Eqy	linear static	seismic
Rsax	response spectrum	seismic
Rsay	response spectrum	seismic

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III. RESULTS AND DISCUSSION

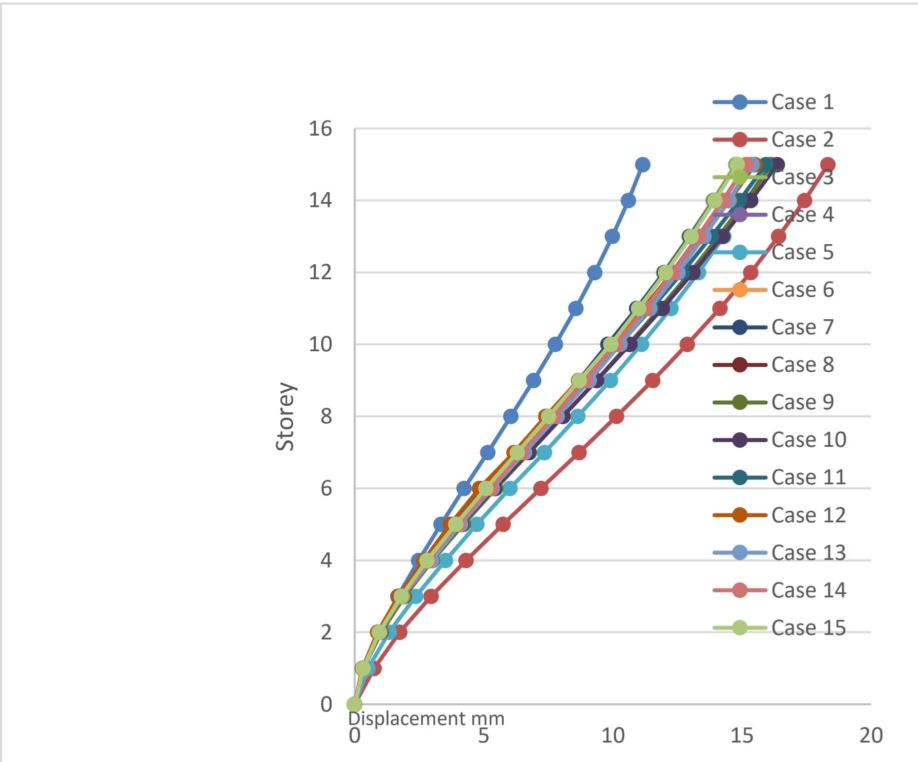
STORY DISPLACEMENT

This chapter presents results of Response spectrum analysis of all the models considered as per the model analysis which was discussed in chapter 1. The result and discussions given are considered in detail with reference to figures.The story displacement parameter which has been considered in this section to study the behavior of multi-story building having floating column at various levels. The story displacement values are obtained for Response spectrum analysis (RSA) in y direction. Plots of the story displacement versus story level are made for the six models all are values on a similar diagram.

Figure 7 shows the relationship between the story height and the maximum story displacement. It could be seen that; the maximum displacement value was recorded case (2) with 18.34mm in which there were floating columns in all four corners and middle at G+3, had the maximum displacement value by an increase of about 60.84% compared to case (1). In floating column buildings Cases 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 and 15 respectively are 32.2%, 36%, 43.8%, 32.7%, 32.6%, 37%, 44.8%, 50%, 42.7%, 38.8%, 37.8%, 35.84% and 32.75%% increasing value in percentage compared to model 1 without floating column building. From case (2) to case (7), it could be noticed that the higher the location of the floating columns, the less lateral displacement was obtained. It was noticed that increasing the height of the location of the floating columns led to increasing the maximum displacement.

STOREY DRIFT: - The story drift parameter which has been considered in this section to study the behavior of multi-story buildings having floating columns at various levels. The story drift values obtained for both Equilateral Static analysis (ESA) and Response spectrum analysis (RSA) in y directions. Plots of the story drift versus story are made for various models.

Figure 8 shows the relationship between the maximum stories drift and the story height for all cases. It could be noticed that cases (2) have maximum story where the floating columns were introduced in the second story. It could be seen that the maximum story drift was located at story 8 over which the floating columns were introduced. Compared to case (1), increasing the number of floating columns led to increasing the story drift by about 0.35%, 9.35%, 0.5%, 4.67%, 10.5%, 8.86%, 4.6% and 3.6% for case 3, 5, 8, 10, 11 and 14 respectively as compared to case 1. Case 4, 9, 12, 13 and 15 have a lower drift ratio than case 1.



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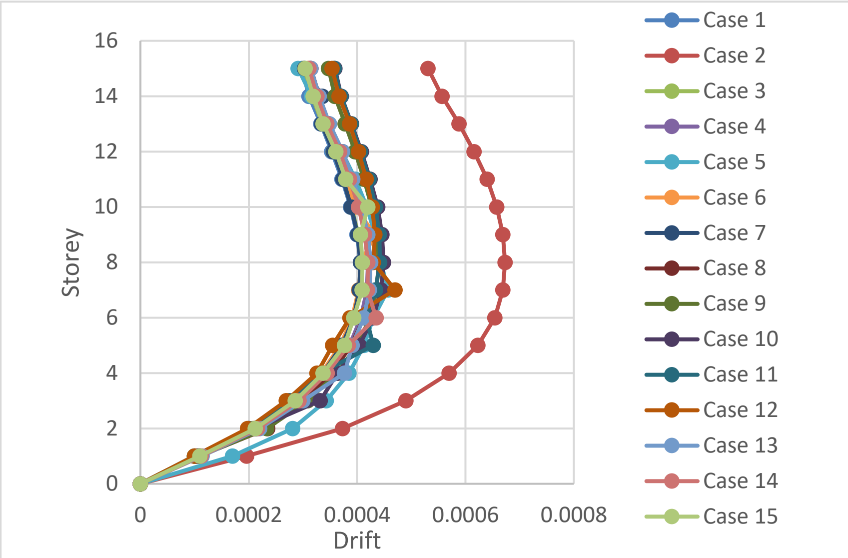

Fig 8: Story Drift in y Direction

SHEAR STORY

Approximate calculation of maximum anticipated lateral force at the base against quake load is called base shear. Wherever structure is fixed base shear will act. The results are taken for zone 5 with medium soil condition. Base shear is calculated from the highest lateral force that will happen due to earthquake ground action at the base of the structure. Hence the weight of the building structure is directly proportional to the base shear values; the regular building structure has minimum loads compared to the other building structures. Base shear calculation depends on soil conditions at the site and seismic activities.

It was observed from the figure 9 the base shear values for case 1 was found 4516.05 kN and 4712.99 kN and in floating column building model 2, 3 and 4 having a lesser value compared to model 1 building and model 5 and 6 getting a same value as compared to model 1 building.

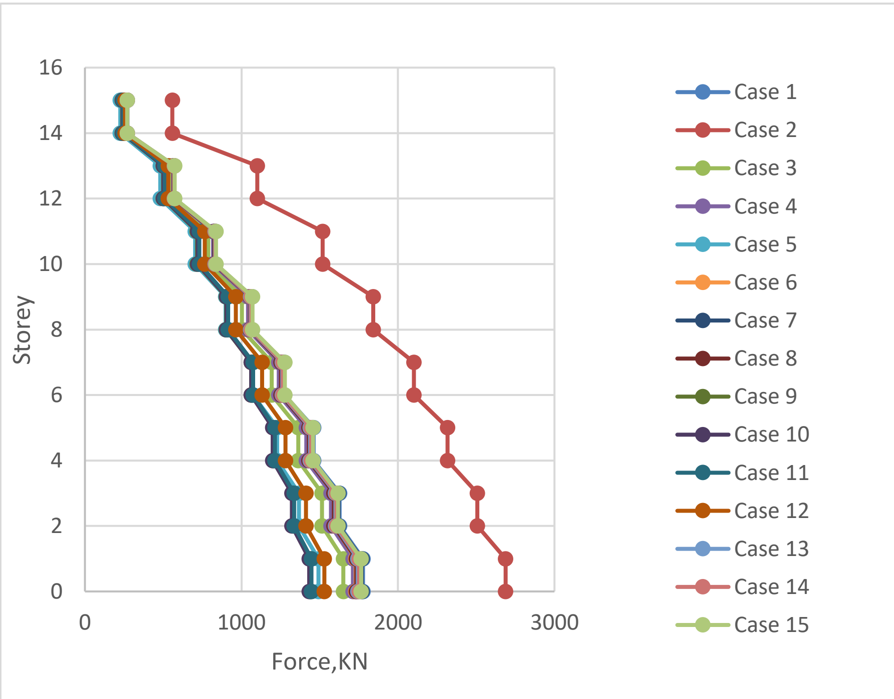

Fig 9: Graph of Base shear

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IV. CONCLUSION OF STUDY

- It has been concluded in this study, when columns as a floating column are eliminated in G + 14 story building at various location within the floors at various levels for seismic zone V that Cases 1, 5, 7 & 15 are seeming to be most efficient case among all 15 cases.
- On comparing it has been concluded that the maximum story displacement obtained for Cases 1, 3, 7 & 15 with a minimum value of 11.8, 14.31, 14.81 mm & 14.8 mm respectively.
- Comparing the Story drift for all cases, Cases 1, 3, 7 &15 are observed as most efficient.
- On analyzing story shear values, Case 5, 10, 11 and 12 are found to be optimum for all cases.
- As per comparative results, Cases 5 was found to be stiffer than among all the models.
- Checking the drift ratios helps us state the deflections and story drifts are forcefully changed due to the increase in the height of the building.
- It is observed that displacement in buildings is greater in the top stories and lesser in the bottom stories.

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