# Seismic Analysis of Floating Columns in Composite Structures

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**Abstract** - Floating columns are constructed for aesthetic point of view and for getting more space in parking areas for movement in lots of multi-storey buildings. Floating columns are not inherently more damaged than normal buildings due to their design. However, their presence in a building can introduce certain design challenges that need to be carefully addressed to ensure their structural integrity and overall stability. This study examines the adverse effect ofthe floating columns in buildings at different positions. In this study models of the frame structure are analysed using STAAD PRO software of the floating columns at different positions such as at the center and at the edge for multi-story composite buildings using structural response of the building with respect to response spectrum method for different zones to find results such as storey displacement, time period and mode shapes. The composite structure with floating columns at the edges of the structure showed better performance than the floating columns placed at the centre of the structure.

**Keywords:** Floating Columns, Composite Structure, STAAD Pro, Response Spectrum, Seismic Analysis

## I. Introduction

Modern construction technology plays a great role on architectural and other features, as most buildings requires an open ground floor to accommodate parking lots, lobbies and other architectural aesthetics. A floating column also known as hanging column or stub column, which is likely to be supported on either joints or rest over the beam eccentrically without any support below it. Usually, columns start from the foundation and it transfers the load to the ground from slabs and beams, but the floating column rests on the beam. This means that the supporting beam act as a foundation for the column. That beam is called as a transfer beam, in this case transfer beam transfers load up to foundation. Composite structures, consisting of a combination of different materials like concrete and steel, have gained significant popularity in the construction industry due to their superior mechanical properties and economic advantages. These structures are used in various applications, including high-rise buildings, bridges, and industrial facilities. There are few drawbacks to be considered in floating columns and composite structure. The purpose of this research study is to investigate and analyze the behaviour of composite structures incorporating floating columns. To study the structural performance, safety, and efficiency of such systems compared to conventional designs. By understanding into the mechanics of composite materials, understanding the interaction between different components, and exploring the influence of varying column heights and locations. and exploring the influence of varying column heights and locations.

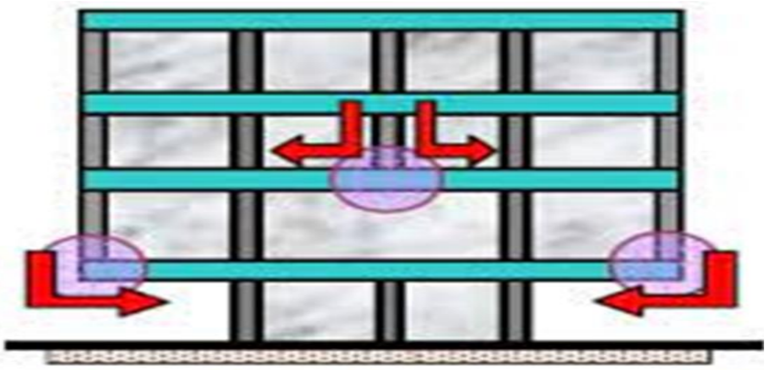


Fig 1: Load Path in Floating Column Structure

## II. Literature review

**N Lingeshwaran et.al (2021),** it says the importance of floating column and also the presence of shear wall in community building. Of all the techniques Time history investigation is taken as essential for primary Seismic Examination. The dynamic analysis of G + 9 multi-storeyed RCC building is completed by time history investigation. The storey displacement, Base shear, inter storey drift are measured fora review on both the building with presence of floating column and building with absence of floating column in ETABS. Here, in this analysis they have considered 3 different cases and have compared the obtained outcome.

**Dinesh Chand et.al (2021),** they have done a comparative analysis of regular column structure and a structure with floating column using ETABS software. Twomodels were modeled and 3 different cases were considered in each model. Some columns were floated at the corner and in another model of the structure it was floated at the edge. Maximum Reactions, maximum Storey Displacement, maximum base shear and maximum storey Drift using Response Spectrum Analysis. Maximum storey displacement in the lateral direction was maximum in the case of the model which had floating columns on their edges. Also, the value of vertical reaction was increased with an increase in storey height.

**Summary:** The software used for the modelling of the structure are ETABS andSTAAD PRO. The analysis of the structure has been done for the different seismic zones. Time history method and response spectrum method are used for the analysis of the structure. The analysis of the structure has been done by placing floating columns at various positions such as different stories and at interiors of the structure.

## III. Methodology

Seismic codes are different for a particular region or a country. In India, Indian standard criterion for earthquake resistant design of structures IS: 1893(part-1)2002 is the main code that provides outline for calculating seismic design forces. STAAD Pro is a powerful and widely used software application for structural analysis and design. Developed by Bentley Systems, it is one of the leading structural engineering software tools available in the market. STAAD Pro stands for "Structural Analysis and Design Professional," and it offers a comprehensive set of tools to analyze and design a wide range of structures, including buildings, bridges, towers, and other civil engineering projects. Response Spectrum method allows the multiple modes of response of a structure to be taken into account. This is required in building code for all except very simple or very complex structures. The response of a structure can be defined as a combination of many modes.

Model 1 is analysed for the floating columns which are placed at the edges of the structure. Model 2 is analysed for the floating columns which are placed at the centre of the structure. Model 1 and Model 2 is analysed for the earthquake zones such as Zone 2, Zone 3, Zone 4 and Zone 5.

Table 1: Parameters Considered for the analysis of the Models

| BUILDING DESCRIPTION | |
|---|---|
| Plan Dimension | 12mx12m |
| Each bay dimension | 3m |
| Response Reduction Factor [R] | 5 |
| Damping Ratio | 0.05 |
| Structure Type | SMRF |
| Importance Factor | 1 |
| Soil type | Medium (type-II) |
| Number of Storey | G+6 Storey |
| Height of typical floor | 3.2m |
| Height of Building | 22.4 m |
| Column size | 800mm x 800mm, ISHB 450, ISHB 400H |

| | |
|---|---|
| Beam size | 450mm x 530mm, ISHB 400H, ISHB 400 |
| Live load | 3kN/m$^2$ |
| Floor Finish | 1.5kN/m$^2$ |
| Live load on roof | 1.5kN/m$^2$ |
| Self-weight | 3.75kN/m$^2$ |
| Wall load | 8.4kN/m$^2$ and 8kN/m$^2$ |

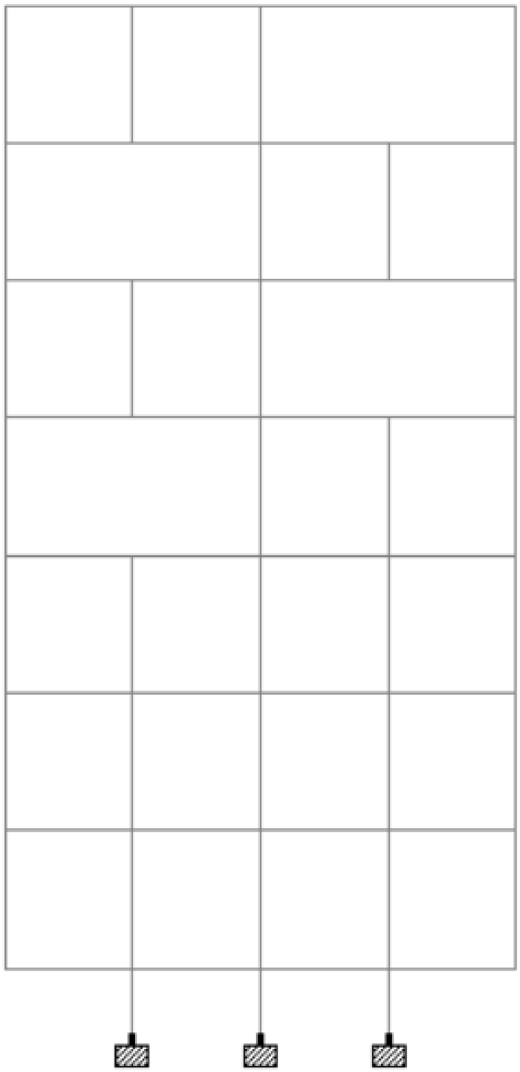


Fig 2: Front View of Model 1

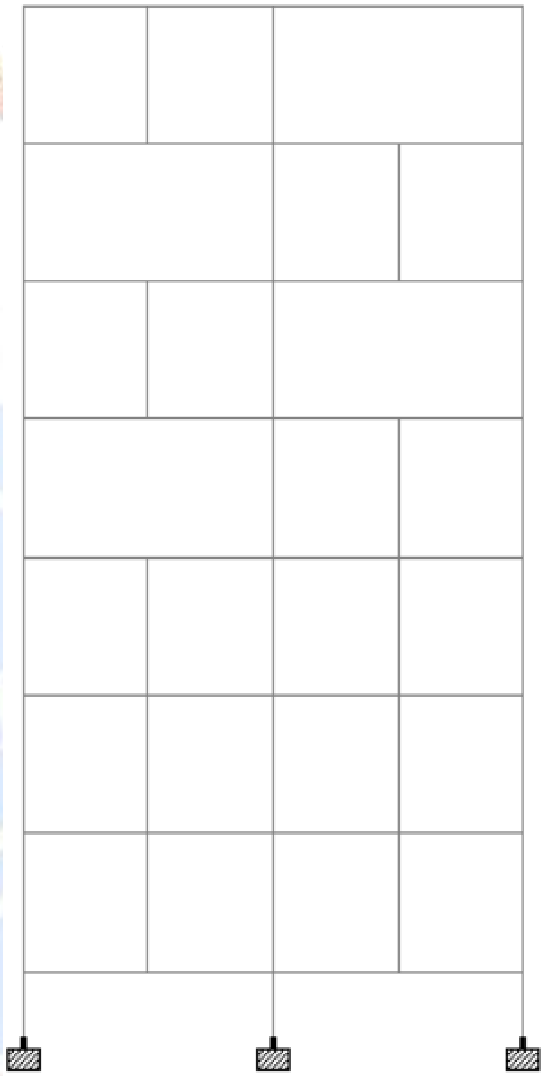


Fig 3: Front View of Model 2

## IV. RESULTS AND DISCUSSION

**1. Storey Displacement:** Storey displacement to the horizontal displacement or lateral movement of a specific storey (floor level) relative to the adjacent storeys in a building or structure. It is a critical parameter in structural engineering, especially in the analysis and design of tall buildings and structures subjected to lateral loads such as wind and seismic forces.

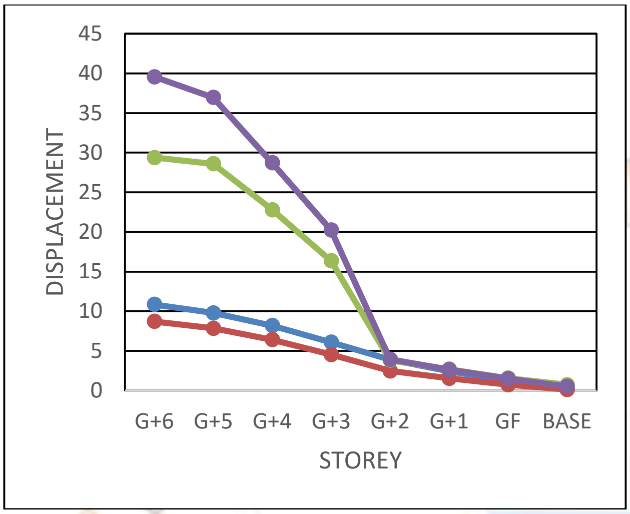



Fig 4: Storey Displacement in Zone 2

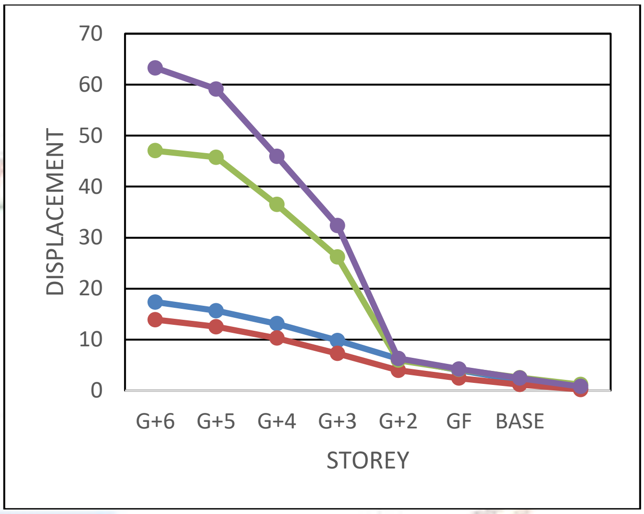



Fig 5: Storey Displacement in Zone 3

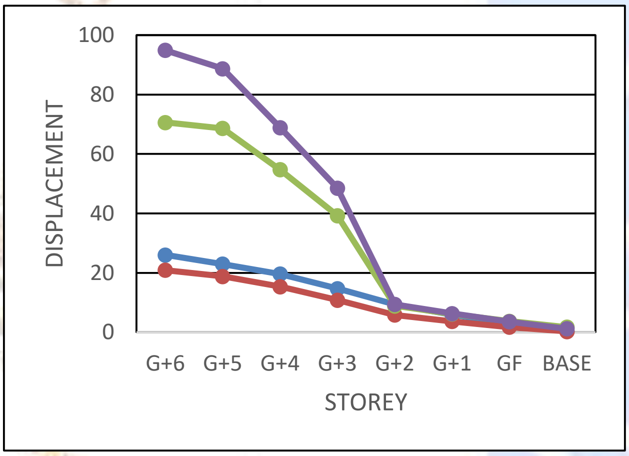



Fig 6: Storey Displacement in Zone 4

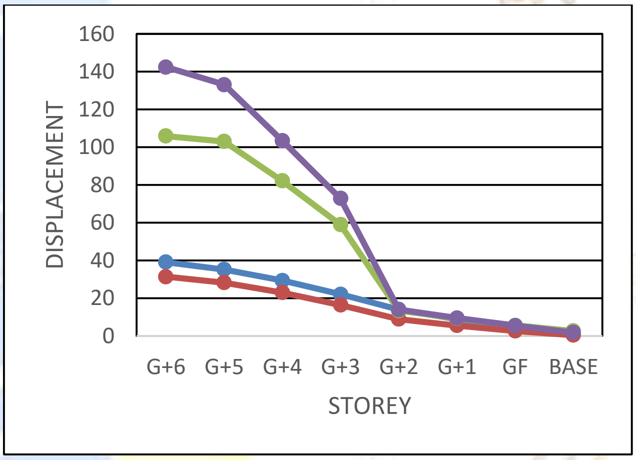



Fig 7: Storey Displacement in Zone 5

Maximum storey displacement for the model according to IS:1893(2016) is 89.6mm. For Model 1 the storey displacement is safe for the zones such as Zone 2, Zone 3 and Zone 4 and for Model 2 it is safe for Zone 2 and Zone 3. Since the storey displacement exceeds the maximum storey displacement by 18.17% in Zone 5 for Model 1 and by 5.96% in Zone 4 and by 59.02% in Zone 5 for Model 2. Since it exceeds the maximum storey displacement there will wide cracks formed in the structure and the ground floor will sink below the ground level. According to the results obtained for storey displacement, the floating columns placed at the edges is better than the floating columns placed at the centre of the structure.

**2. Time Period:** Time period is a fundamental concept in structural engineering. The concept of time period is closely related to the dynamic behaviour of structures under various loading conditions such as earthquakes, wind, and vibrations. The time period of a structure refers to the duration it takes for the structure to complete one full cycle of oscillation or vibration in response to an external force.

Table 2: Time Period of Model 1

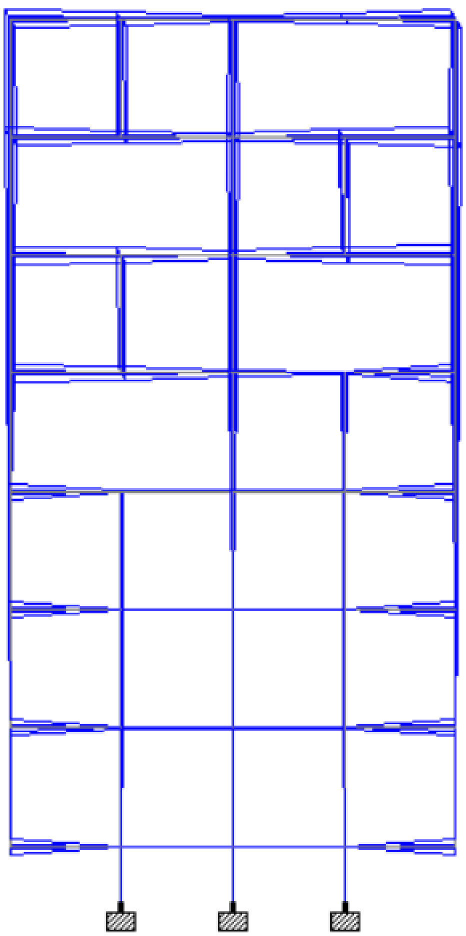
| MODE SHAPES | TIME PERIOD(SEC) |
|---|---|
| 1 | 1.386 |
| 2 | 0.920 |
| 3 | 0.828 |
| 4 | 0.511 |
| 5 | 0.464 |
| 6 | 0.374 |
| 7 | 0.360 |
| 8 | 0.332 |
| 9 | 0.300 |
| 10 | 0.291 |
| 11 | 0.273 |
| 12 | 0.264 |

Table 3: Time Period of Model 2

| MODE SHAPES | TIME PERIOD(SEC) |
|---|---|
| 1 | 1.529 |
| 2 | 0.897 |
| 3 | 0.762 |
| 4 | 0.557 |
| 5 | 0.479 |
| 6 | 0.429 |
| 7 | 0.399 |
| 8 | 0.369 |
| 9 | 0.326 |
| 10 | 0.299 |
| 11 | 0.290 |
| 12 | 0.286 |

Tables show the time period for Model 1 and Model 2. Time period goes on decreasing for higher mode shape number. The time period is 10.3% more for Model 2 than the Model 1 for Mode shape 1. The time period for the last Mode Shape of the models is 2.74% more for Model 2 than the Model 1. Time period is inversely proportional to the stiffness of the structure hence Model 1 is more flexible than the Model 2.

**3. Mode Shapes:** Mode shapes are a fundamental concept in the field of structural engineering. They play a crucial role in understanding the dynamic behaviour and response of mechanical and structural systems and provide insights into how a system oscillates at different natural frequencies. The no of Mode Shapes considered for Model 1 is 69 and for Model 2 is 67. The first two Mode Shapes for the Models is shown below.



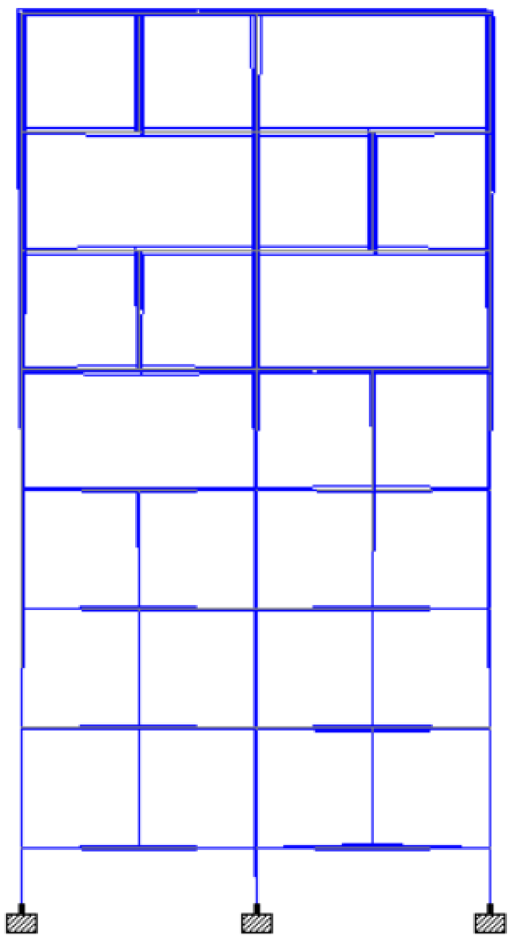


Fig 8: Mode shape 1 of Model 1

Fig 9: Mode shape 1 of Model 2

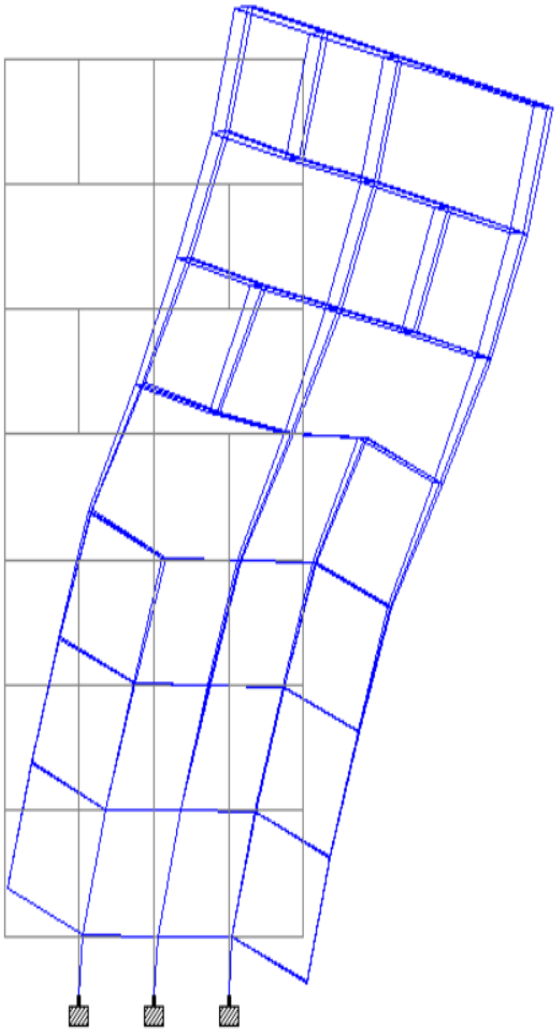


Fig 10: Mode shape 2 of Model 1

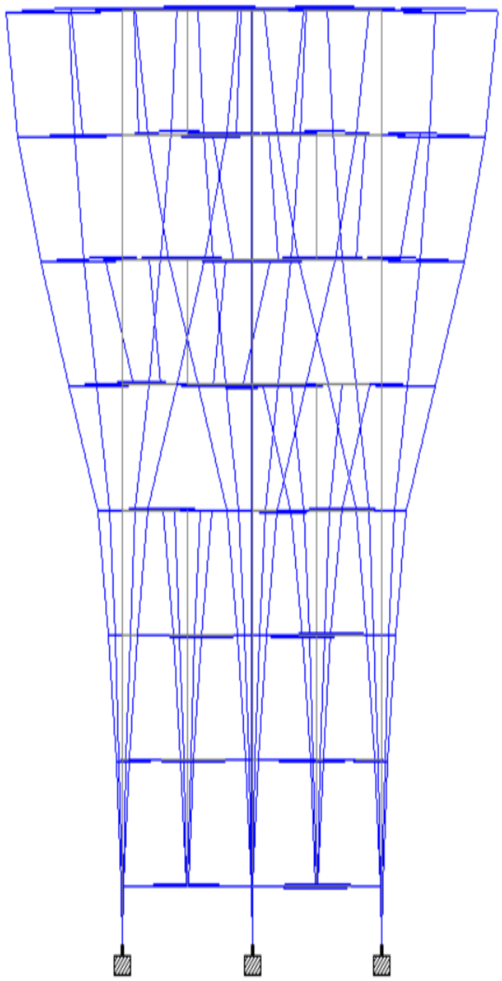


Fig 11: Mode shape 2 of Model 2

Table 4: Participation Factor of Model 1

| MODE | MODAL PARTICIPATION FACTOR (%) | |
|---|---|---|
| | X-DIRECTION | Y-DIRECTION |
| 1 | 0 | 39.422 |
| 2 | 0 | 39.439 |
| 3 | 55.562 | 39.439 |
| 4 | 55.562 | 46.196 |
| 5 | 55.562 | 46.276 |

Table 5: Participation Factor of Model 2

| MODE | MODAL PARTICIPATION FACTOR (%) | |
|---|---|---|
| | X-DIRECTION | Y-DIRECTION |
| 1 | 0 | 38.293 |
| 2 | 59.403 | 38.293 |
| 3 | 59.403 | 38.308 |
| 4 | 59.403 | 44.822 |
| 5 | 59.403 | 44.847 |

Table 6: Maximum Modal Displacement for Model 1

| MODE | MAXIMUM DISPLACEMENT (mm) | | | |
|---|---|---|---|---|
| | ZONE 2 | ZONE 3 | ZONE 4 | ZONE 5 |
| 1 | 2.335 | 3.737 | 5.609 | 8.414 |
| 2 | 1.815 | 3.358 | 5.039 | 7.580 |
| 3 | 1.509 | 2.677 | 4.185 | 6.026 |
| 4 | 1.224 | 2.300 | 3.409 | 5.238 |
| 5 | 0.971 | 1.805 | 2.683 | 4.234 |

Table 7: Maximum Modal Displacement for Model 2

| MODE | MAXIMUM DISPLACEMENT (mm) | | | |
|---|---|---|---|---|
| | ZONE 2 | ZONE 3 | ZONE 4 | ZONE 5 |
| 1 | 3.039 | 4.862 | 7.293 | 10.945 |
| 2 | 2.766 | 3.870 | 6.490 | 9.740 |
| 3 | 2.349 | 3.110 | 5.147 | 8.461 |
| 4 | 1.944 | 2.106 | 4.054 | 7.725 |
| 5 | 1.606 | 1.795 | 3.413 | 5.933 |

The above tables show the modal participation factor in percentage and maximum modal displacement for Model 1 and Model 2. For modal participation factor we can say that 50% of the modal participation factor is obtained within the first few modes and modal participation factor for X-direction receives more percentage than the Y-Direction in both models. In maximum modal displacement it keeps increasing for the higher seismic zone. The maximum modal displacement is more for Model 2 in all the zones by 30.14% in Zone 2, 30.10% in Zone 3, 30.02% in Zone 4 and 30.08% in Zone 5 than Model 1.

## V. CONCLUSIONS

In the present research, floating column in composite structures are analysed at two different positions one model where the floating columns are placed at the edges of the structure and another model where the floating columns are placed at the center of the structure. The analysis is carried out by response spectrum method using STAAD Pro software and the models are compared for the parameters such as Storey displacement, Storey drift, mode shapes, Storey shear and time period.

Storey displacement is safe for model with floating columns at the edges in zone 2, zone 3 and zone 4 but fails in the zone 5. Storey displacement for model with floating columns at centre of the structure is safe for zone 2 and zone 3 but fails in zone 4 and zone 5. The time period is greater by 10.3% for the model with floating columns at the centre than floating column at the edges of the structure. The maximum modal displacement is more for the model with floating columns at the centre of the structure by 30.085% than model with floating columns at the edges of the structure. Therefore, from the results obtained from the time period, mode shapes and storey displacement, we can say that floating columns placed at edges of the structure is safest compared to the floating columns placed at the centre of the structure.

## VI. REFERENCES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