COMPARATIVE SEISMIC ANALYSIS OF A MULTI-STOREY RCC STRUCTURE WITH & WITHOUT FLOATING COLUMN IN ZONE IV USING ETABS.

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Abstract- *A column that has been implemented upon the beam and does not originate from the foundation is said to be the Floating column. It best opts for multi-storied sites for fulfilling the space necessary and to attain a decent architectural view also they're used generally in multi-storey structures designed with the intention of giving parking space on the bottom floor or creating open halls on the higher floors. Since this column is set on the beam the discontinuance of load transfer happens, it is often designed only for the gravity load and not for the seismic uncertainty. Such that it makes a negative impact on the structure during earthquakes. This research paper provides a comprehensive explanation of the process used to analyze the seismic behavior of a multi-storey building (G+10) with and without floating columns in Zone IV. Various building cases are analyzed by maneuvering the floating columns on the ground floor. The equivalent static analysis is carried out in each case and a comparison of these cases is presented, using IS 1893(Part-1):2016 code and computer-aided software ETABS-2020. The current review researches the impact of drifting segments on storey drift, storey shear, and displacement. This will facilitate us in determining the structure's various analytical properties.*

Key Words: Equivalent static analysis, Floating column, Storey drift, Storey displacement, Storey shear, ETABS-2020.

1. INTRODUCTION

India is an emerging nation, where urbanization is occurring nationally most quickly adopting the methods and types of developing structures that have undergone enormous improvements in the past couple of years[1]. Multi-storey structures are a crucial part of human civilization and are built using complex architectural designs[2]. Sometimes, it becomes necessary to terminate the column at certain floors due to the architect's unique way to give the aesthetic approach to the building. Figure 1 shows the building with floating column at different floors. This is generally embraced to oblige vehicle leaves or gathering entryways in the main storey. Therefore, the provision of the Floating column comes in a way that it ascends from the horizontal member beam and goes up to the demanding floor or height[3].Because it emerges from the beam and functions as a concentrated point load, it is capable of carrying only the gravitational load that it passes to the underlying beam. Under vertical loading conditions, this type of construction does not pose any major problems. But during the time of any seismic activity, these floating columns become a major drawback to the vertical load stability of the building. The way in which mass and stiffness are spread out at different levels affects the distribution of seismic force. The size, shape, and structural design of a building, along with the approach employed to transfer lateral forces to the foundation, are among the primary factors that affect its seismic performance. The storey shears at various stories in the structure need to be moved to the ground in the briefest way, any break in the primary individuals brings about the adjustment of the heap way[2]. Structures with floating columns have load path interruptions at the bottom level or middle storey but not throughout the entire foundation[1].

Since earthquakes can cause significant damage, it is critical to account for the seismic load when constructing tall buildings. This is particularly important as the current population continues to urbanize and build more high-rise structures. Several projects have been approved for the use of floating columns, specifically for those situated above the ground floor. This allows for the creation of more open space on the ground floor, providing greater flexibility in design and use.

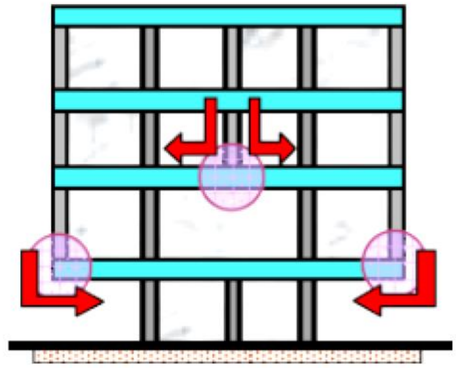

Fig-1: Building featuring the floating column[4]

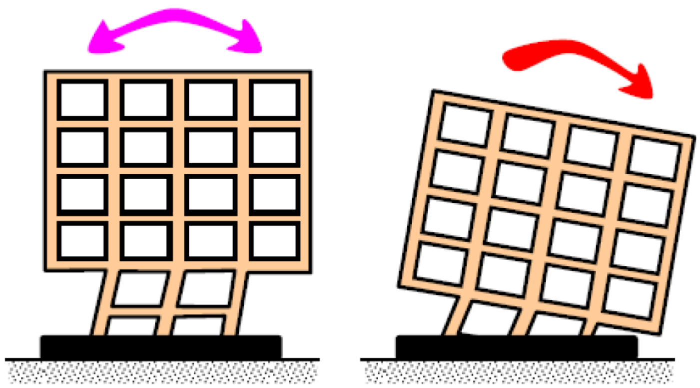

Fig-2: Building featuring the failure of floating column.

1.1 OBJECTIVE

The following are the key objectives of this comparative analysis:

- **Seismic Performance Assessment:** Evaluate the seismic performance of the multi-storey structure with the floating column against others without, in terms of structural integrity, stability, and deformation characteristics, under seismic loads representative of Zone IV[5].
- **Reduction in storey displacements:** Assess whether the inclusion of a floating column reduces lateral displacements and drifts during a seismic event, which can be crucial for occupant safety and structural integrity.
- **Storey Drifts:** Analyze and compare the storey drift ratios to understand how the presence of a floating column affects the relative movement between floors during seismic shaking.
- **Storey shear:** Compare the base shear and storey forces in both structural configurations to determine the impact of the floating column on load distribution within the building.
- **Response Comparison**: Compare the dynamic responses of all four structural models, including displacements, storey drifts and storey shear to determine how the presence of a floating column affects the building's response to seismic forces.[5]

1.2 LITERATURE REVIEW

a) Fahimi M, Sreejith R (2015)[6]

This study emphasizes how crucial it is to explicitly acknowledge the presence of the floating column in building analysis. For this dynamic analysis of a RCC building with G+14 floors considering Sumatra earthquake is done by both time history analysis and response spectrum analysis. By using ETABS three cases are analyzed under which case 1 is meant to be a regular building with no floating column and case 2 has a floating column inside the building and case 3 has floating column at the corners. Further this case is subdivided into five more cases where the positions of the floating columns are altered at various floor level and positions. Conclusions are made upon the results obtained from time analysis and response spectrum by comparing the parameters inter-storey drift storey displacement and base shear. Where, case 1 shows the maximum displacement when compared with case 2 and 3 due to the lesser dimensions of beam and column. When compared to a structure with floating columns on the 14th and 15th storeys, the inter-story drift for the building with a floating column provided on the inner side of the 8th level is reduced. Due to the building's floating column and the fact that its mass is lower, story shear is reduced.

b) Sasidhar T, P. Sai Avinash, N. Janardan (2017)[7]

In this study a multi-storey residential building with G+5 floors lying in seismic zone II are chosen for the analysis and design using static analysis. The work was completed while taking into account various scenarios of removing columns from various locations and building storeys. The goal of the current study is to evaluate the outcomes of buildings with and without floating columns in order to determine the best location for the floating column to achieve the desired outcomes in each situation. Displacements, bending moment, shear force, and reinforcement area are the criteria utilized for comparison. On the building's mathematical 3-D model, an equivalent static analysis is conducted, and the outcomes have been compared. The analysis is done by using the computer aided software ETABS. The moment, shear and storey displacement in case shows the maximum increment when compared with the regular building and other cases. Hence, they concluded that the floating column in a building can be used to increase the floor area index but there are also disadvantages in opting such. The overall requirement of steel in each member of the building will increase which directly affects the cost estimation. Also, in seismic prone area it might be a risky factor to use floating columns as a concern of safety.

c) Kirankumar gaddad, Vinayak vijapur (2018) [8]

This paper studies the effect of seismic response in a multi-storey building (G+20) in the presence of a floating column and shear wall with varying scenarios. The whole analysis is carried around the situation where the building lies in the seismic zone V and four models have been analyzed using computer aided software ETABS as per the Indian standard code IS 1893(part 1):2000 and IS 456: 2000. First model is set to be a regular building, second model is considered to have a floating column at varying positions, third model will have a shear wall and fourth model will have both floating column and shear wall structure. The seismic analysis of the building is analyzed by both Equivalent static analysis and Response spectrum analysis. On analysis all the models are compared on the basis of parameters like base shear, Storey displacement, Time period and Storey drift. Storey displacement of Model 2 shows increment of 6%, decrement of 45% in model 3 and 40 % in model 4 when compared with model 1. Storey drift of Model 2 shows increment of 9%, decrement of 40% in model 3 and 31 % in model 4 when compared with model 1. Storey shear of Model 2 shows decrement of 4.5%, increases by 25% in model 3 and 24 % in model 4 when compared with model 1. When comparing the four models, the floating column building model II has a greater time period than the other three buildings. Comparing all, Model III offers greater performances with lower displacements and more strength.

d) Ms. Payal K. Jayswal, Amey R. Khedikar (2018)[9]

An examination of a multi-storey building with and without floating columns is conducted in this paper utilising the response spectrum method. This paper analyzes the seismic behavior of the structure by modelling four cases, Case 1 is a regular RCC structure with no floating column, case 2 has interior floating columns, case 3 has exterior columns as floating columns and case 4 has floating columns at both interior and exterior. All four cases are analyzed at seismic zone II and zone III by using STAAD pro software. Conclusions are made on the basis of comparison of storey displacement, axial force, shear force and moment at both axis. Where case 4 shows the maximum moment at all floors for both zone II and III. Also, the shear force and axial force of case 3 and case 4 are greater than case 1 and 2. The storey displacement of case 2 and case 4 are larger than the other cases.

e) Shashank. R, Dr. R. Subhash Chandra Bose, Shivashankar K M (2020)[10]

This paper discusses the seismic response of a building and analyzes the building in such a way that it causes less or no damage to the structure that have floating column at any floors. For this, a RCC structure building (G+12) is modelled in 8 different cases in such a way that the positions of floating columns are different in each case. Also, the analysis is carried out for both zone IV and V, using ETABS. The seismic analysis is done by time history analysis and various seismic parameter such as storey displacement, inter-storey drift, overturning moment and base shear are compared to get the best optimizing solutions. Alternative strategies are suggested, such as preserving the stiffness balance between the main story and the story above, to lessen the negative effects of seismic forces. By using the proper methods and techniques, these approaches seek to lessen the irregularity brought on by the floating columns. According to the study, floating column-free building frames perform better in terms of seismic characteristics. The location of the floating column is critical, with interior sites improving stiffness and reducing displacement whereas corner or extreme locations result in worse performance. Furthermore, the addition of Y-shaped columns below particular beams can improve rigidity and reduce storey displacement.

2. METHODS

a) BUILDING CONFIGURATIONS.

For the investigation, a few models have been created, in such a way that a multi-storey building (G+10) measuring 19.2m x 26.37m with a special moment resisting frame is selected as the main reference case and further modeled in three more cases. The details of the model types are discussed below. The whole modeling and analysis part of this study is done using the computer-aided designing software ETABS-2020, as per IS 1893(Part 1):2016 and IS 456:2000(Part 1 & 2) codes[11]. The building has a one-brick-thick outside wall (230mm) around the perimeter, half-brick-thick inner walls and parapet wall at the perimeter of top storey (230mm)[12]. The presumption is that the floor slabs function as diaphragms, effectively integrating all vertical load-bearing components. The load of the wall is distributed throughout the beam uniformly and is rigidly connected to the beam and column. The building comes under the earthquake zone IV, having a category of soil type III. All the structural members and load details are summarized in Table 1, Table 2 and Table 3. The initial phase of this study involves modeling a regular building that does not include any floating columns (Case 1). Figure 3 & Figure 4 illustrates the building's floor plan and elevation. Further, the structure is investigated when floating columns are applied at various locations. Four cases have been considered for analysis of the building and Figures 5, 6, 7, 8, 9, and 10 show each case's floating column positions and elevation.

CASE 1: In this case, the building without any floating column is analyzed in Zone IV (Fig. 3)

CASE 2: The columns situated at the corners and every other column on the outer frame along the two longer sides are floating columns[12] (Fig. 5).

CASE 3: The columns located at the corners and all columns in the central frame along the shorter edge are floating columns (Fig. 7).

CASE 4: Floating columns on the outer frame alternate along the two longer sides, except for the ones situated at the corners and in the central frame along the shorter edge (Fig. 9)[12].

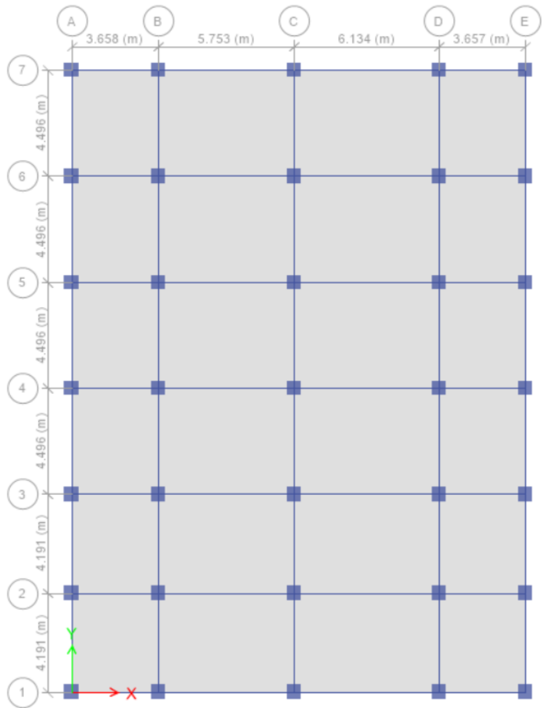

Fig- 3: Column positions as per CASE 1

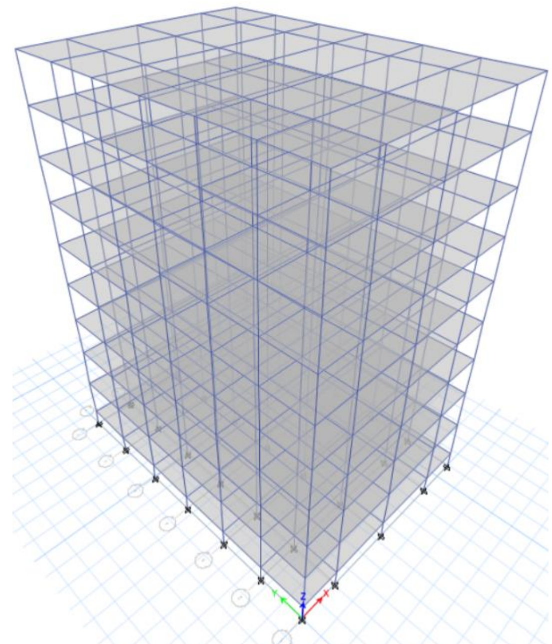

Fig- 4: Elevation of case 1

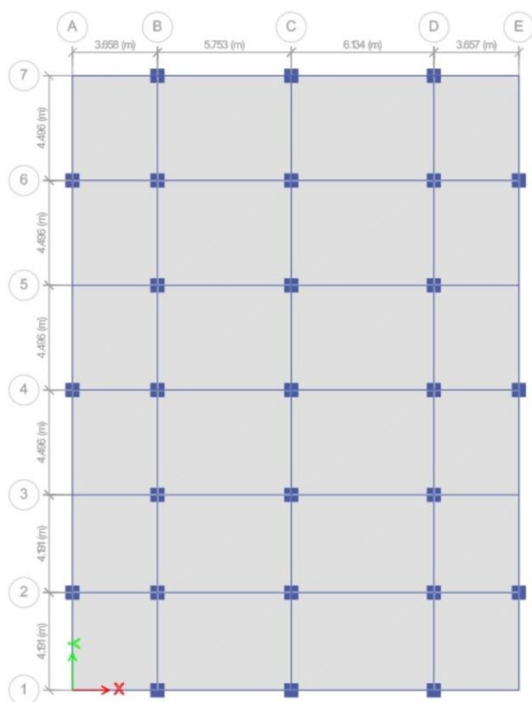

Fig-5: Column positions as per CASE 2

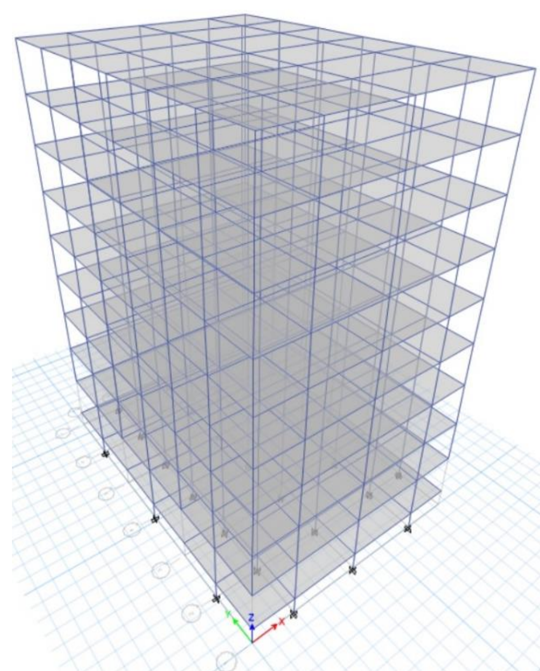

Fig-6: Elevation of CASE 2

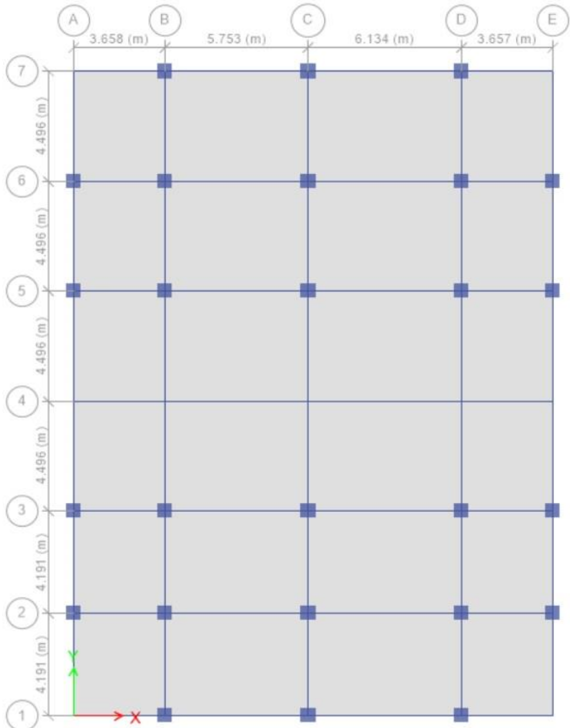

Fig-7: Column positions as per CASE 3

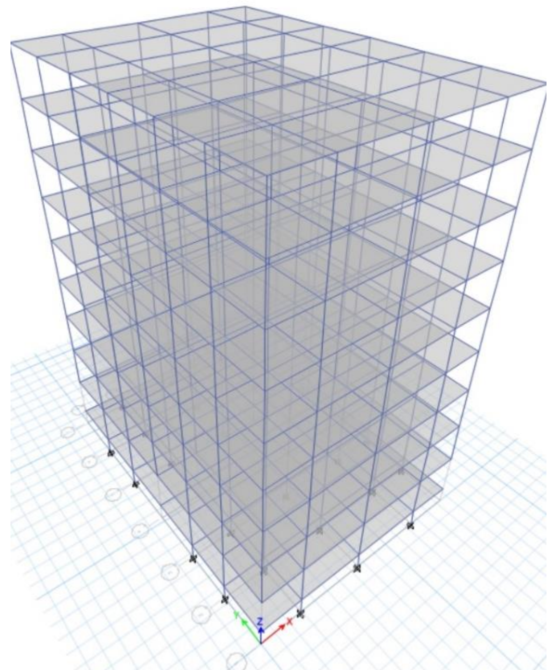

Fig-8: Elevation of CASE 3

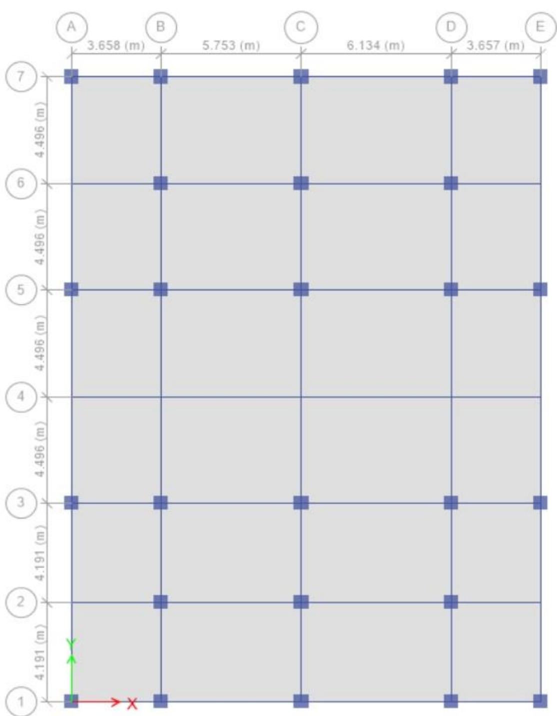

Fig-9: Column positions as per CASE 4

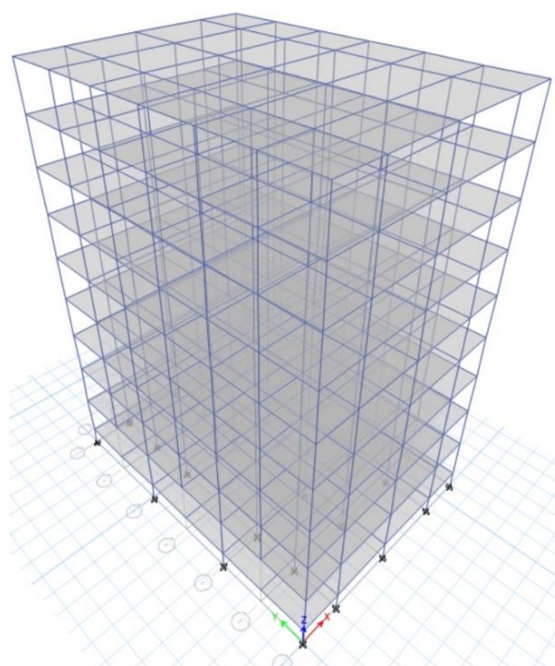

Fig-10: Elevation of CASE 4

b) **PROPERTIES OF THE MATERIAL**

Table-1: Properties of material

PROPERTIES	VALUES
Yield stress for steel (Fy)	500 Mpa
Steel Young's modulus (Es)	20,000 Mpa
Compressive strength of concrete (Fck)	25 Mpa
Concrete Young's modulus (Ec)	25000 Mpa

c) **SECTION PROPERTIES**

Table 2: BUILDING DATA

SPECIFICATION	ALL CASES
Length in X direction (m)	19.20
Length in y direction(m)	26.37
Storey height(m)	3.65
No. of stories	10
Column size (mm)	600 X 600
Beam at exterior (mm)	450 X 300
Beam at interior (mm)	450 X 300
Slab thickness (mm)	150
Exterior wall thickness(mm)	230
Interior wall thickness(mm)	100
Dead load (KN/m^2)	4.75
Live load (KN/m^2)	3.0
Floor finish (KN/m^2)	1
Roof live load (KN/m^2)	1.5
Interior Wall load (KN/m^2)	7.4
Exterior Wall load (KN/m^2)	16.8
Parapet Wall load (KN/m^2)	4.6

d) **SEISMIC PARAMETERS**[13]

Table 3: Specifics on seismic parameters.

Parameter	Standards
Soil	Type-III
Seismic Zone	IV
Damping in the building	5%
Zone factor	0.24
Time period	1
Response reduction factor (R)	5
Importance factor	1

2.1 SEISMIC ANALYSIS

For a certain area or country, there are several seismic codes. For estimating seismic design forces in India, the basic code is Indian Standard Criteria for Earthquake Resistant Design of Structures IS 1893(part 1): 2016[14]. The following approach of analysis is suggested by the code[15]:

a) Equivalent static analysis.
b) Dynamic analysis.
- Response spectrum method.
- Pushover analysis.
- Time history.

Here, only equivalent static analysis techniques are used to demonstrate the analysis of a 3D building model. This method is discussed briefly in the section below.

a)<u>EQUIVALENT STATIC ANALYSIS:</u>

Equivalent static analysis is a streamlined technique used to calculate the forces and moments acting on a structure during a seismic event. The dynamic impacts of the earthquake are not taken into account, and it is predicated on the premise that the structure behaves as a linear elastic system[16]. The dynamic forces are instead referred to as a collection of static forces acting on the structure[17]. The findings of equivalent static analysis reveal the forces and moments that are exerted on the structure during the seismic event. These findings are used to assess the building's safety and determine whether any design modifications are possible to enhance its seismic performance.

The method of equivalent static lateral force is an efficient technique for replacing the dynamic loading of the anticipated earthquake with a static force applied laterally to a structure for design reasons. Typically, the sum of the imposed seismic force is assessed in two horizontal directions that are parallel to the building's principal axis[18].

The following steps make up the equivalent static analysis process:

- To calculate the whole lateral seismic forces, which relies on the earthquake zone, condition of the soil, the time period, importance factor, and the actual seismic weight (Dead load and live load partially or complete).
- To calculate the distribution of vertical seismic forces throughout the building's height, where the height 'h' times the classified mass 'm' at that height determines the force at any specific level.
- Assuming that the diaphragm is rigid, the horizontal distribution of level forces to the different components of the vertical lateral force-resisting system is proportional to their respective rigidities[18].
- To calculate the additional forces that need to be added in the resulting forces from the horizontal distribution of level forces, which are caused by both natural and incidental displacement.

- To determine the direct consequences of the lateral seismic forces, such as storey drift, P-delta effect and overturning moment.

In general, the equivalent static analysis is an easy approach, that is frequently applied to the initial design of buildings. Engineers can rapidly predict the seismic loads that a structure will encounter without having to perform a difficult dynamic study as a result of this.

3. RESULTS

STATIC ANALYSIS

Following the modeling and analysis of models with a regular building (i.e, building with no floating column) and building with floating columns at various locations on ETABS, as per IS 1893(Part 1):2016, the following conclusion is taken into account for the modeling system[19]. With the modeling system, different earthquake responses are concluded that the storey displacement, storey shear force, storey drift and storey stiffness of case 2, 3 and 4 are relatively high when compared with case 1[20]. The tables and figures are used to assess the results. The following analysis will consider the highest parameter for the top storey level, considering different load combinations.

a)STOREY DISPLACEMENT

The deviation of a particular floor from the foundation or ground level of a building is known as storey displacement. As we ascend the structure, we can expect an increase in overall displacement values. When we plot the storey displacement against the height of the building, the resulting graph shows a similar pattern to the deflected shape of the building.

Table 4: Comparison of Max storey displacement among all cases in X-Axis.

MAX STOREY DISPLACEMENT (X-AXIS)				
STOREY	**CASE1 (mm)**	**CASE 2 (mm)**	**CASE 3 (mm)**	**CASE 4 (mm)**
BASE	0	0	0	0
STOREY 1	2.092	2.731	2.754	2.693
STOREY 2	18.941	24.249	24.192	23.661
STOREY 3	42.261	52.602	51.646	50.366
STOREY 4	67.352	82.496	80.51	78.459
STOREY 5	92.318	112.128	109.085	106.27
STOREY 6	115.996	140.374	136.278	132.711
STOREY 7	137.339	166.213	161.074	156.769
STOREY 8	155.29	188.608	182.437	177.403
STOREY 9	168.92	206.65	199.455	193.699
STOREY 10	178.084	220.218	212	205.527

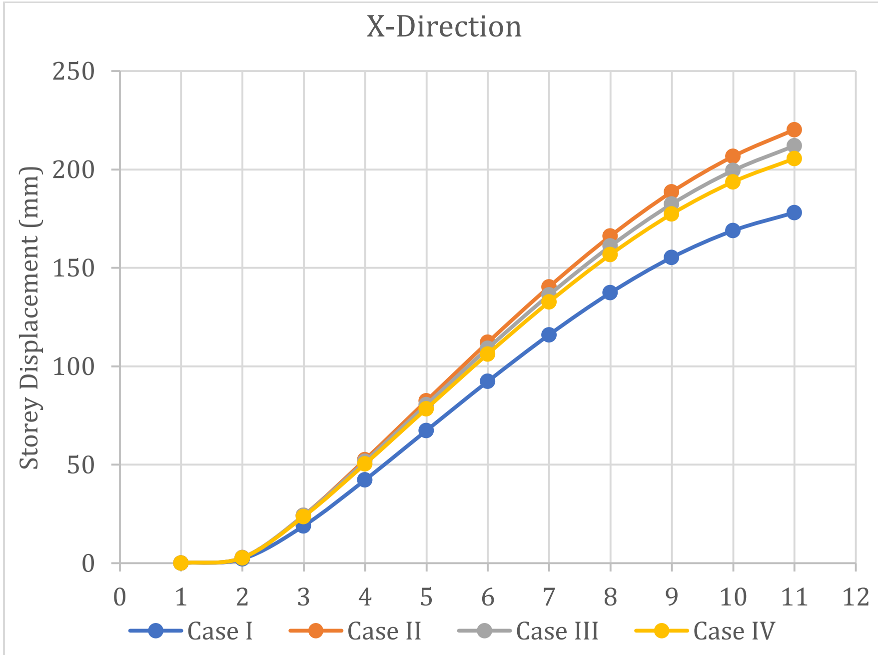

Fig - 11: Comparison of Max storey displacement among all cases in X-Axis.

Table 5: Comparison of Max storey displacement among all cases in Y-Axis.

MAX STOREY DISPLACEMENT (Y- AXIS)				
STOREY	**CASE1 (mm)**	**CASE 2 (mm)**	**CASE 3 (mm)**	**CASE 4 (mm)**
BASE	0	0	0	0
STOREY 1	0.019	0.038	0.035	0.024
STOREY 2	0.176	0.327	0.296	0.215
STOREY 3	0.395	0.708	0.639	0.49
STOREY 4	0.634	1.108	1.007	0.793
STOREY 5	0.878	1.509	1.384	1.107
STOREY 6	1.115	1.9	1.76	1.42
STOREY 7	1.336	2.273	2.122	1.721
STOREY 8	1.531	2.617	2.461	1.999
STOREY 9	1.69	2.925	2.766	2.243
STOREY 10	1.809	3.191	3.03	2.444

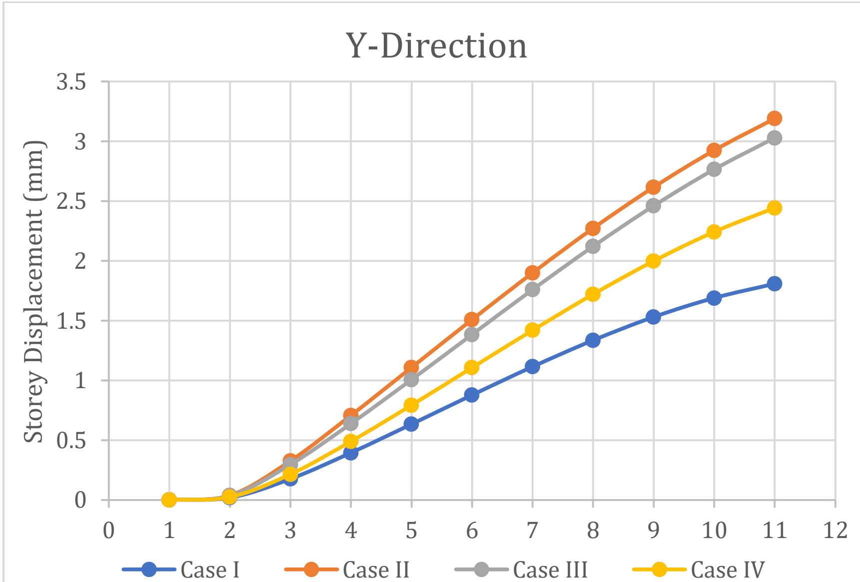

Fig - 12: Comparison of Max storey displacement among all cases in Y-Axis.

- Comparative analysis result discussion of storey displacement

The table 4 and figure 11 above represent the comparison of maximum storey displacement of all cases obtained from the equivalent static analysis method in X- axis and the table 5 and figure 12 represent the comparison of maximum storey displacement of all cases in Y- axis. Load combination 1.5*(DL + EQ+X) shows the maximum displacement in both X and Y direction. It is observed that the building with no floating column shows the minimum displacement and the maximum storey displacement at the top storey is 57.361 mm in X-direction for case 2 where the corner and interior columns are floating columns. An increment of about 15%-25% of the storey displacement can be seen in the building when floating columns are added at ground floor or storey 1. It can be said that the floating column's location and floor level affects the storey displacement of the building.

b) STOREY DRIFT

The analysis of seismic loads can be greatly aided by referring to graphs depicting storey shear and storey drift, which provide critical insights about a multi-storey building under lateral loading conditions. When a floor undergoes horizontal displacement, it is referred to as storey drift. By the division of storey drift by its height, we can easily calculate the ratio of the storey drift. Due to the fact that seismic loading regulations often impose restrictions on the storey drift as a proportion of the storey height, the storey drift ratio serves as a helpful metric that can be readily compared against the code requirement[14]. A graph of the storey drift ratio will indicate which floors are drifting more than others and will identify the potential need for strengthening.

Table 6: Comparison of Max storey drift among all cases in X-Axis.

MAX STOREY DRIFT (X- AXIS)				
STOREY	**CASE1 (mm)**	**CASE 2 (mm)**	**CASE 3 (mm)**	**CASE 4 (mm)**
BASE	0	0	0	0
STOREY 1	0.001394	0.001821	0.001836	0.001795
STOREY 2	0.004616	0.005895	0.005873	0.005744
STOREY 3	0.00639	0.007767	0.00752	0.007315
STOREY 4	0.006875	0.008192	0.007906	0.007695
STOREY 5	0.006842	0.008122	0.007827	0.007618
STOREY 6	0.006489	0.007744	0.007449	0.007243
STOREY 7	0.00585	0.007086	0.006793	0.00659
STOREY 8	0.00492	0.006143	0.005852	0.005652
STOREY 9	0.003737	0.004951	0.004662	0.004464
STOREY 10	0.002513	0.003725	0.003436	0.00324

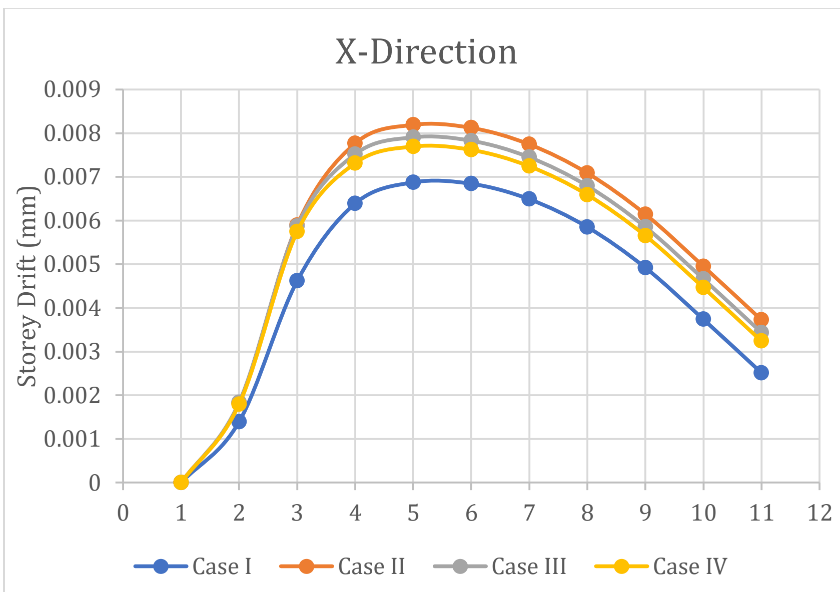

Fig - 13: The comparison of Max storey drift among all cases in X-Axis.

Table 7: Comparison of Max storey drift among all cases in Y-Axis

MAX STOREY DRIFT (Y-AXIS)				
STOREY	**CASE1 (mm)**	**CASE 2 (mm)**	**CASE 3 (mm)**	**CASE 4 (mm)**
BASE	0	0	0	0
STOREY 1	0.000013	0.000024	0.000022	0.000016
STOREY 2	0.000043	0.000075	0.00007	0.000052
STOREY 3	0.000059	0.000095	0.000092	0.000073
STOREY 4	0.000064	0.000099	0.000098	0.000079
STOREY 5	0.000064	0.000098	0.000098	0.00008
STOREY 6	0.000062	0.000095	0.000096	0.000078
STOREY 7	0.000057	0.000089	0.000091	0.000074
STOREY 8	0.000049	0.000081	0.000084	0.000067
STOREY 9	0.000039	0.000071	0.000074	0.000057
STOREY 10	0.000028	0.00006	0.000063	0.000046

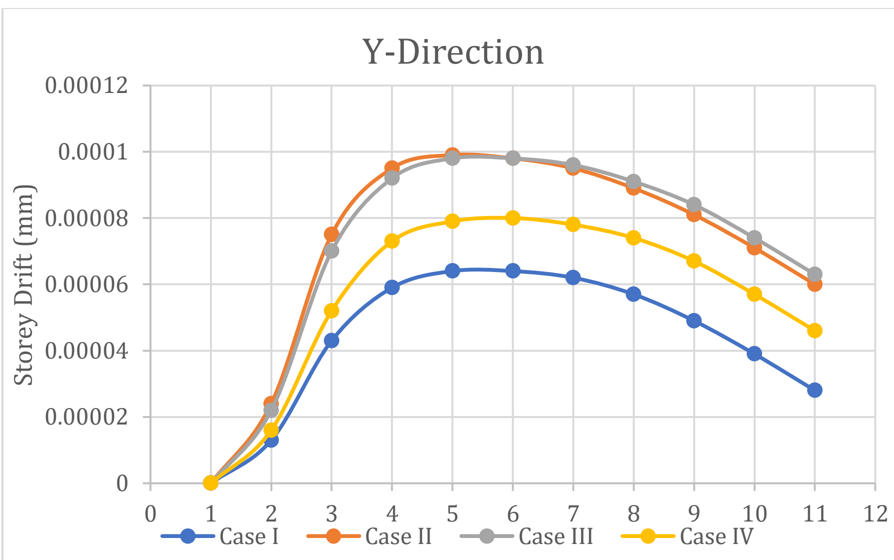

Fig - 14: Comparison of Max storey drift among all cases in Y-Axis

- Comparative analysis result discussion of storey drift

The table 6 and figure 13 above represent the comparison of maximum storey displacement of all cases obtained from the equivalent static analysis method in X- axis and the table 7 and figure 14 represent the comparison of maximum storey displacement of all cases in Y- axis. Load combination 0.9*DL + 1.5*EQ(-X) shows the maximum drift in both X and Y direction. It is observed that the building with no floating column shows the minimum drift and the maximum storey drift at the storey 4 is 0.008192 mm in X-direction for case 2 where the corner and interior columns are floating columns. An increment of about 10%-20% of the storey drift can be seen in the building when floating columns are added at ground floor or storey 1.

c) STOREY SHEAR:

The storey shear force results from the building's lateral deflection, which causes deformation and horizontal movement between the floors or stories. Due to this displacement, there is a transfer of force from one storey to the next, which in turn generates shear forces along the structure's height. The shear force experienced by each storey varies according to its height and the size of the lateral stresses operating on the structure[21]. To evaluate the distribution of shear forces over the height of the structure, engineers consider elements including the building's design, material qualities, load distribution, and lateral load patterns. This can help engineers in designing structures that can survive the dynamic stresses they may experience over their lifetime by knowing and accounting for narrative shear forces.

Table 8: The comparison of the storey shear among all cases in X-Axis

MAX STOREY SHEAR (X-axis)				
STOREY	**CASE 1 (KN)**	**CASE 2 (KN)**	**CASE 3 (KN)**	**CASE 4 (KN)**
BASE	0	0	0	0
STOREY 1	6401.08	6496.79	6628.29	6766.46
STOREY 2	6401.08	6496.79	6628.29	6766.46
STOREY 3	6376.24	6471.89	6602.91	6740.54
STOREY 4	6276.91	6371.06	6500	6635.53
STOREY 5	6053.41	6144.21	6268.6	6399.26
STOREY 6	5656.07	5740.91	5857.14	5979.22
STOREY 7	5035.24	5110.76	5214.23	5322.91
STOREY 8	4141.23	4203.35	4288.45	4377.83
STOREY 9	2924.39	2968.26	3028.35	3091.47
STOREY 10	1335.05	1355.07	1382.51	1411.32

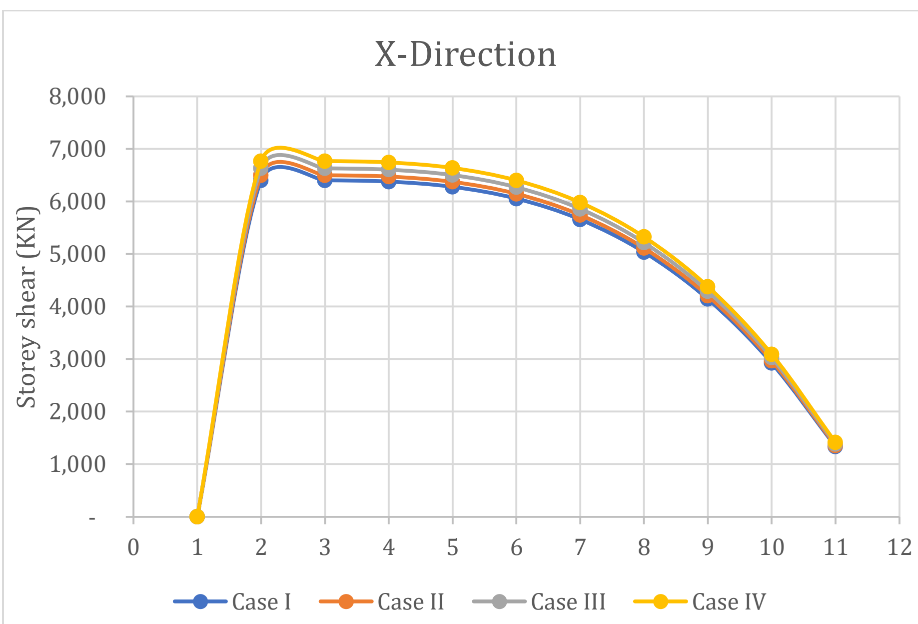

Fig - 15: The comparison of the Storey shear among all cases in X-Axis

Table 9: Comparison of the Max Storey shear among all cases in Y-Axis

MAX STOREY SHEAR (Y-axis)				
STOREY	CASE 1 (KN)	CASE 2 (KN)	CASE 3 (KN)	CASE 4 (KN)
BASE	0	0	0	0
STOREY 1	6401.08	6496.79	6628.29	6766.46
STOREY 2	6401.08	6496.79	6628.29	6766.46
STOREY 3	6376.24	6471.89	6602.91	6740.54
STOREY 4	6276.91	6371.06	6500	6635.53
STOREY 5	6053.41	6144.21	6268.6	6399.26
STOREY 6	5656.07	5740.91	5857.14	5979.22
STOREY 7	5035.24	5110.76	5214.23	5322.91
STOREY 8	4141.23	4203.35	4288.45	4377.83
STOREY 9	2924.39	2968.26	3028.35	3091.47
STOREY 10	1335.05	1355.07	1382.51	1411.32

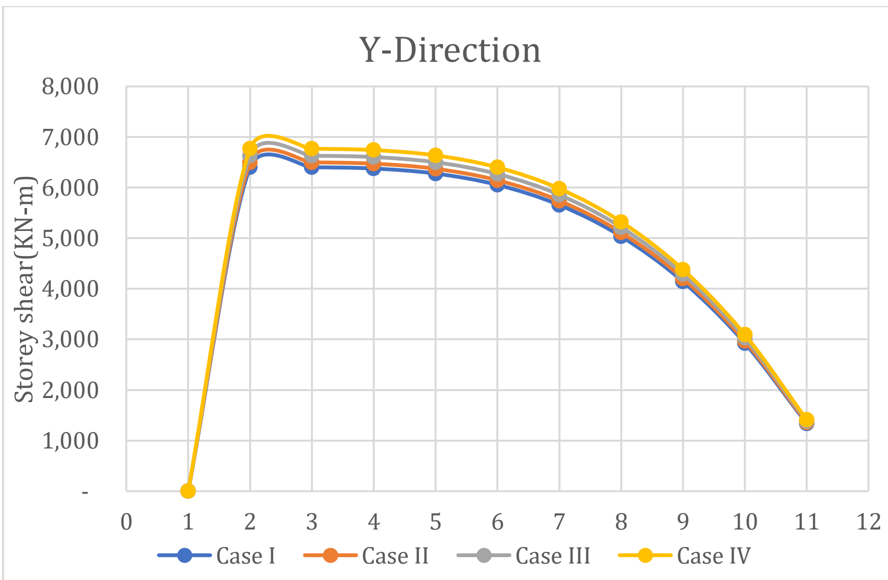

Fig - 16: Comparison of the Max Storey shear among all cases in Y-Axis

- Comparative analysis result discussion of storey shear

The table 8 and figure 15 above represent the comparison of maximum storey displacement of all cases obtained from the equivalent static analysis method in X- axis and the table 9 and figure 16 represent the comparison of maximum storey displacement of all cases in Y- axis. Load combination 1.5*(DL + EQ+Y) shows the maximum shear force in both X and Y direction. It is observed that the building with floating column at the outer frame alternate along the two longer sides, except for the ones situated at the corners and in the central frame along the shorter edge shows the maximum shear force at the base storey of about 6766.46 KN in X-direction. An increment of about 3%-5% of the storey shear can be seen in the building when floating columns are added at ground floor. Removal of column at any level of the building obstructs the lateral-resisting system which thereby increases the storey shear force.

4. DISCUSSION AND LIMITATIONS

4.1. DISCUSSION

A. The analysis above indicates that case 2 exhibited maximum storey displacement in both the X-axes and Y-axes[12]. Considering comparison with case 1, storey displacement increases about 23.7% in case 2, 19% in case 3 and 15.4% in case 4. Thereby, inclusion of floating column increases the storey displacement of the building.
B. It is noticeable that Case-1 has reported experiencing the least storey drift. Whereas case 2 shows an increment of about 19%, case 3 about 15% and case 4 shows about 12% when compared with case 1. Hence, floating column also increases the storey drift of the building.
C. The storey shear shows an increment of 2.35% in case 2, 5% in case 3 and 6.88% in case 4 when compared with case 1 along both axes. The maximum storey shear has been observed in case 4. The floating column affects the lateral-resisting system, which causes the increase in the storey shear of the building.
D. For Case 1, the columns enlarged from the footing level to the top floor without interruption, resulting in greater stability and resilience against seismic forces.
E. The maximum storey displacement is limited by Indian standard code IS456:2000 to H/500, where H is the building height. From the analysis result, it can be said that storey displacement values are within the permissible limit for each case.
F. Similarly, the maximum storey drift is limited by Indian standard code IS456:2000 to 0.004 times the storey height. From the analysis result, it can be said that storey drift values are within the permissible limit for each case.
G. Cases where floating column are present shows the higher storey displacement and storey drift values because the mass gets increases due to the removal of the column.
H. In increasing the dimensions of the beam and column, the stiffness of the building can be increased to a much concern level.

4.2 LIMITATIONS

A. Structural stability: When the parameters like storey displacement, storey drift and storey shear of the building with floating columns are compared with the regular building with no floating columns it can be said that the overall stability of the building are affected. The obstruction in the lateral-resisting system is the main cause of the structural stability of the building.
B. Vertical load stability: Due to the presence of the floating column, there is a break in the vertical load transfer of the upper floor columns to the underlying columns. This blockage affects the vertical load stability of the structure.
C. Cost analysis: The inclusion of floating columns in a structure will necessitate a major increase in the size of the structural parts in order to enhance stiffness, which will in turn result in a significant rise in the cost of construction. Also, the long-term maintenance cost and the operational expense of each design affects the overall estimation of the building.

5. CONCLUSION AND FUTURE WORK

5.1 CONCLUSION

The study's overall goal is to evaluate the impact of floating columns in RCC buildings in terms of dynamic properties and influencing factors that can control the effect on storey displacement, the neighboring storey drifts, storey shear, etc. Using the static equivalent analysis method, we compare each case that involves the moment acting along the X-axis and Y-axis. As a result of the analysis, the following conclusions are drawn.

- It is noticeable that the maximum stiffness has occurred in Case-1, i.e the building with no floating columns.
- Using floating columns in RCC-framed structures, results in a reduction of the stiffness which in turn leads to an increase in the time period of the building.
- The cases where floating columns are at the exterior or corner frames, shows the poor seismic performance as compared to the other cases. The chances of failure of case 2 is quite higher than the other cases.
- The best location of the floating column in a multi-storey building obtained from the results is in Case-4 & then in Case-3.
- In seismic prone areas like zone IV, building with floating columns should be avoided as there can be a chance of structural failure during the time of seismic activity.

- The maximum storey-displacement occurred with the load combination at 1.5*(DL + EQ+X), maximum storey drift at 0.9*DL + 1.5*EQ(-X) and maximum storey shear at 1.5*(DL + EQ+Y) among both the axes, these are the critical load combinations vary depending on the placement of floating columns.

So, it may be concluded that the inclusion of the floating columns can be beneficial in increasing the "Carpet area" of the building. However, a critical highlight emerges as our analysis demonstrates that the results for storey drift remain well within acceptable limits. This reassuring observation underscores the structural integrity of the building concerning sway during seismic events. While the elevated displacement and shear values may raise concerns, our research underscores the potential for effective precautionary measures. These include structural reinforcement and the strategic placement of floating columns, serving as viable strategies to optimize their installation and enhance the building's seismic resilience and overall safety.

5.2 FUTURE WORK

The current study compares moments, deflection, and column shear to determine failure in four cases, and limits its scope to only G+10 storey buildings with floating columns. So, there is a considerable amount of space for further research.

- To effectively forecast how the building would react to earthquakes, use sophisticated analytical models and simulation methodologies. This involves looking into the effects of several design elements, like column height, size, and spacing.
- Assemble information on the functionality of structures after an earthquake, as well as damage patterns. Share best practices with the engineering community and incorporate learnt lessons into future designs[22].
- Construct advanced foundation technologies that can efficiently disperse seismic forces and reduce the danger of column-foundation separation. Take into factors like the effects of dynamic soil-structure interaction and soil-structure interaction.
- A small-size model on a shaking table can be used for an experimental study and verification with simulated motions.
- The design and estimation of the building are necessary to ascertain whether the techniques used to enhance the structure's seismic performance are financially viable.

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