MULTIPLE-STORY BUILDING WITH AND WITHOUT A FLOATING COLUMN: A COMPARATIVE STUDY

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ABSTRACT:

Buildings with Floating Columns are a common element in contemporary multi-story architecture in metropolitan India. Such characteristics are very undesirable in buildings constructed in seismically active zones. The significance of clearly noting the existence of the Floating Column in the examination of building. Alternative methods involving stiffness balancing of the first and second storeys are offered decrease the irregularity caused by Floating Columns FEM analysis was performed on 2D multi-story frames using & without a floating column to investigate the structure's reactions to various seismic excitations varying frequency content while maintaining the PGA and time duration factor constant Roof's historical timeline For both frames, displacement, inter-storey drift, base shear, and column axial force are estimated Column that floats. The load distribution on the floating columns and the various effects due to it is also been studied in the paper. The importance and effects due to line of action of force is also studied. In this paper we are dealing with the comparative study of seismic analysis of multi-storied building with and without floating columns. The equivalent static analysis is carried out on the entire project mathematical 3D model using the software STAAD Pro V8i and the comparison of these models are been presented. This will help us to find the various analytical properties of the structure and we may also have a very systematic and economical design for the structure.

Keywords: Floating column, Response spectrum, Staad Pro, earthquake excitation.

I. INTRODUCTION

General:

Many urban multistory buildings in India today have open first storey as an unavoidable feature. This is primarily being adopted to accommodate parking or reception lobbies in the first storey. 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 with a few storey 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 storey or with unusually tall storey tend to damage or collapse which is initiated in that storey. Many buildings with an open ground storey intended for parking collapsed or were severely damaged in Gujarat during the 2001 Bhuj earthquake. Buildings with columns that hang or float on beams at an intermediate storey and do not go all the way to the foundation, have discontinuities in the load transfer path.

The Response of a structure to the ground vibration is a function of the nature of foundation soil; materials, form, size and mode of construction of structure; and the duration and characteristics of ground motion. IS 1893 (part I):2002 specifies the various criteria for design of structure considering earthquake zones, type of structure, soil type, importance factor of structure, response reduction factor etc. The basic criteria of earthquake resistant design should be based on lateral strength as well as deformability and ductility capacity of structure with limited damage, but no collapse. The floating columns or hanging columns are also vertical members similar to normal RC columns. The hanging columns are normally constructed above the ground storey, so that the ground storey can be utilized for the parking, playground, and function halls. These floating columns disturb the uniformity of distribution of loads in the buildings, thus leading to more flexibility and there by weakening the seismic resistance of building shown in figure1. Building with floating columns is constructed to take advantage of urban bylaws. As per urban bylaws, a prespecified space should be left open between all sides of the building and the plot boundary. The building with floating columns have both inplane and out-of-plane irregularities in strength and stiffness and hence are seismically vulnerable.

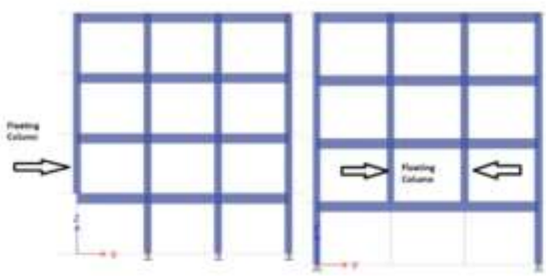

Fig.1: Building with floating column

Floating Column

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.

Floating columns are also called as stub column, or hanging columns.

In floating column transfer of load to the column below it by the beam. The transfer of load in floating column changes from vertical to horizontal within the intermittent frame. In many cases these columns are choosen specially above bottom floor. Thus more open spaces is offered within ground floor which can be used for auditorium or parking intention[6].Thus floating column is additionally used in construction practice and it is avoided due to excess of beams. To maintain the stability of building the joint among beam and floating column are treated as critical. Main cause of collapse of this type of structure is the failure of large beam column specimens occurs in the joint in concrete moment resisting frame.

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 case of 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.
The next important need is that the load from beam have to reach the below floor or foundation by following the shortest path. In case of floating column construction, the shortest path is through the columns supporting the beams.

Benefits of floating column

Floating Column or Hanging Columns: The floating column belongs to a vertical member that is laid on a beam and it doesn?t deliver the load directly to the foundation. The floating column operates as a point load on the beam and this beam transmits the load to the columns situated under it.
The column may set out on the first or second or any other midmost floor as resting on a beam. Generally, columns are laid the foundation to deliver load from slabs and beams. But the floating column is laid on the beam.
It signifies that the beam providing support to the column performs as a foundation. That beam is known as a transfer beam. This is extensively applied in high storied buildings for both commercial and residential purpose. It facilitates to customize and rectify the plan of the top floors. The transfer beam that provides support to the floating column, reassigns the loads up to foundation. For this reason, it should have been designed with more reinforcement.
Floating Column in Buildings: In recent times, multi-storey buildings are developed for the purpose of residential, commercial, industrial etc., containing an open ground storey. To provide space for parking, the ground storey is reserved free devoid of any constructions, exclusive of the columns which move the building weight to the ground.

1.1 OBJECTIVES

From the earlier studies it is observed that the optimum location of floating column in a building is not studied which may not cause any harm even in highly seismic prone areas. The prime objective of this work are:

1. To compare the Nodal displacement for all the models with or without floating column.
2. To compare the maximum shear force among all the models.
3. To find out the optimum location of floating column in a building frame.

II. LITERATURE REVIEW

A Survey of work done in the research area and need for more research

1 A.P. MundadaÅ and S.G. Sawdatkar, "Comparative Seismic Analysis of Multistorey Building with and without Floating Column" Oct 2014:

Civil engineering is a professional engineering discipline that deals with the design, construction, and maintenance of the physical and naturally built environment, including works like roads, bridges, canals, dams, and buildings. Structural engineering is a part of civil engineering dealing with the analysis and design of structures that support or resist loads. This paper deals with the study of architectural drawing and the framing drawing of the building having floating columns. Existing residential building comprising of G+ 7 structures has been selected for carrying out the project work. The load distribution on the floating columns and the various effects due to it is also been studied in the paper. The importance and effects due to line of action of force is also studied. In this paper we are dealing with the comparative study of seismic analysis of multi-storied building with and without floating columns. The equivalent static analysis is carried out on the entire project mathematical 3D model using the software STAAD Pro V8i and the comparison of these models are been presented. This will help us to find the various analytical properties of the structure and we may also have a very systematic and economical design for the structure.

In this paper entitled comparative seismic analysis of multistoried building with and without floating column analytical study is carried out on floating column and other columns affected due to floating column. Preliminary study is carried out on a building model comparing three cases. Following are some conclusions based on work done in the present study. In the model floating columns and struts are provided on the specified locations in different cases. The 3- D analysis of building is carried out for all three cases i.e. normal framed building without floating columns, with floating columns and with struts supporting floating columns and comparative study is done. The main objective of the study is to improve the seismic performance of building with floating columns and proper design of building with floating columns.

2 Ms.Waykule.S.B, Prof. Kadam.S.S, Prof.Lale.S.V, "REVIEW ON STUDY OF BEHAVIOR OF FLOATING COLUMN FOR SEISMIC ANALYSIS OF MULTISTOREY BUILDING" 2016:

Floating columns are a typical feature in the modern multi-storey construction in urban India and are highly undesirable in buildings built in seismically active areas. In this paper static analysis is done for a multi-storey building with and without floating columns. Different cases of the building are studied by varying the location of floating columns floor wise. The structural response of the building models with respect to time period, Base shear, Storey drift and Storey displacements are compared for both building. The analysis is carried out using software sap2000v17.

3 Meghana B .S.1, T.H. Sadashiva Murthy, "EFFECT OF FLOATING COLUMN ON THE BEHAVIOUR OF COMPOSITE MULTISTORIED BUILDING SUBJECTED TO SEISMIC LOAD" 06 | June-2016:

In recent times, many buildings are planned and constructed with architectural complexities. The complexities include various types of irregularities like floating columns at various level and locations. These floating columns are highly disadvantageous in building built in seismically active areas. The earthquake forces that are developed at different floor levels in building need to be carried down along the height to ground by shortest path, but due to floating column there is discontinuity in the load transfer path which results in poor performance of building. In this paper we focus on steel concrete composite structure with floating column in different positions in plan, in buildings of various heights such as G+3, G+10 and G+15 in lower and higher earthquake prone zones. Linear static analysis is carried using ETABS software, Comparison of various parameters such as storey shear, storey drift and storey displacement is done.

4 Gaurav Pandey, Mr. Sagar Jamle, "OPTIMUM LOCATION OF FLOATING COLUMN IN MULTISTOREY BUILDING WITH SEISMIC LOADING" | Oct-2018:

In the present scenario various multistory building are constructed with floating column at various locations for appealing view, for getting more space in parking area for movement and for planning of different plan at different stories. This paper present comparative study about analysis of G+ 14 story building with and without floating column at various location within the floors for periphery columns at various levels for seismic zone V. The motive of this paper 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. A comparative study of the results obtained is carried out for all models. The building with floating columns at top stories will provide optimum results for four cases.

5 Sabari S, Mr.Praveen J.V, "Seismic Analysis of Multistorey Building with Floating Column" | Oct-2014:

In present scenario buildings with Floating Column is a typical feature in the modern multi-storey construction in urban India. Such features are highly undesirable in building built in seismically active areas. This study highlights the importance of explicitly recognizing the presence of the Floating Column in the analysis of building. Alternate measures, involving stiffness balance of the first storey and the storey above, are proposed to reduce the irregularity introduced by the Floating Columns. FEM analysis carried for 2D multistorey frames with and without floating column to study the responses of the structure under different earthquake excitation having different frequency content keeping the PGA and time duration factor constant. The time history of roof displacement, inter storey drift, base shear, column axial force are computed for both the frames with and without Floating Column.

III. METHODOLOGY

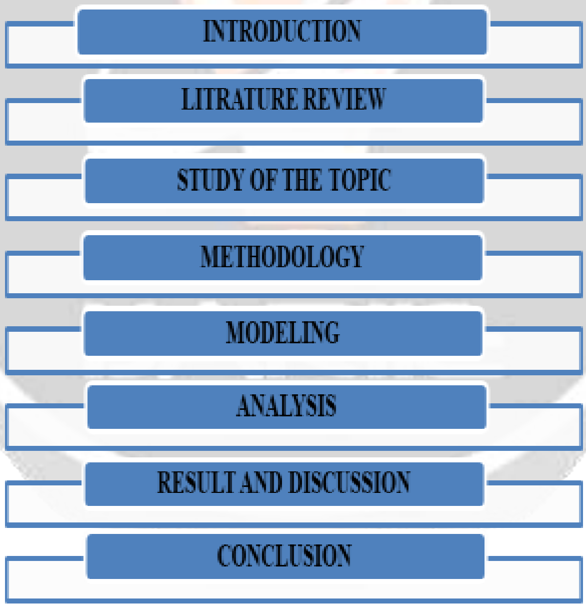

Fig. 2: Methodology Process

Earthquake analysis:

When earthquakes occur, a building undergoes dynamic motion. This is because the building is subjected to inertia forces that act in opposite direction to the acceleration of earthquake excitations. These inertia forces, called seismic loads, are usually dealt with by assuming forces external to the building. Since earthquake motions vary with time and inertia forces vary with time and direction, seismic loads are not constant in terms of time and space. In designing buildings, the maximum story shear force is considered to be the most influential, therefore in this chapter seismic loads are the static loads to give the maximum story shear force for each story, i.e. equivalent static seismic loads. Time histories of earthquake motions are also used to analyze high-rise buildings, and their elements and contents for seismic design. The earthquake motions for dynamic design are called design earthquake motions

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Earthquake Behaviour of Floating Column:

During earthquake, the behavior of building depends on its geometrical shape, size and how the earthquake force carried to the ground. Usually in every building load is transferred from horizontal members (beams and slabs) to vertical members (walls and columns) and then to the foundation. A structure having floating column can be classified as vertically irregular as it causes irregular distribution of mass, strength and stiffness along the building height. Absence of any column at any level of structure changes the load transfer path and load of this floating column is transferred through the horizontal beams below it, known as transfer girders.

IV. MODELING AND PROBLEM STATEMENT

Problem Statement

The building considered is regular G+13 normal RC building of dimension of plan with 14mX12m, the building is considered to be located in Zone V as pre IS 1893- 2002.Th e Table 1 shows structural data of the building.

I) Material Data	
Grade of concrete	M30
Grade of Steel	Fe500
Unit weight of RCC	25kN/m2
II) Structural Data	
Type of structure	SMRF
Type of soil	Medium soil
Size of beam	650mm X750mm
Size of column	650mmX650mm
Depth of slab	200mm
III) Architectural Data	
Number of stories	G+13
Floor height	3mt
Dimension of plan	14mX12m
IV) Seismic Data	
Seismic Zone	V
Response reduction factor	5
Importance factor	1
Damping ratio	5%
V) Loads	
Live load	3kN/m2
Floor finish	1.5kN/m2
Wall load on exterior frame	12kN/m
Wall load on interior frame	6kN/m

MODEL DETAILS

MODEL 1	RC structure without Floating column i.e., Normal (G+13) storey building
MODEL 2	RC structure with floating column, Columns removed in corner of exterior frame **(floating column at first floor)**
MODEL 3	RC structure with floating column, Columns removed in corner of exterior frame **(floating column at 5th and 6th floor)**
MODEL 4	RC structure with floating column, Columns removed in corner of exterior frame **(floating column at 11th and 12Sth floor)**

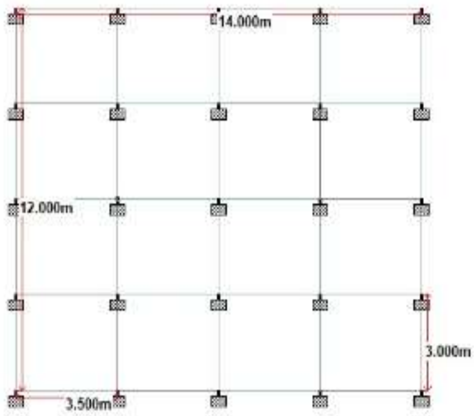


Fig.4.1: top view

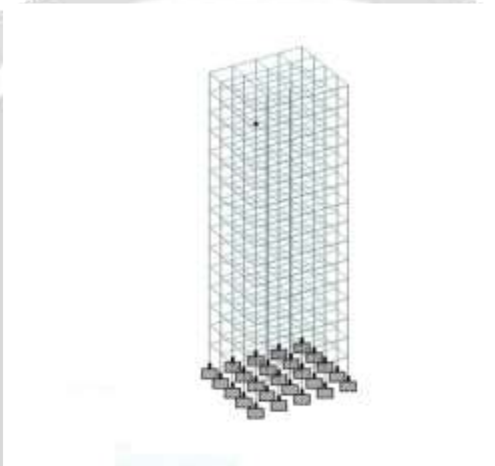


Fig.4.2: 3D view

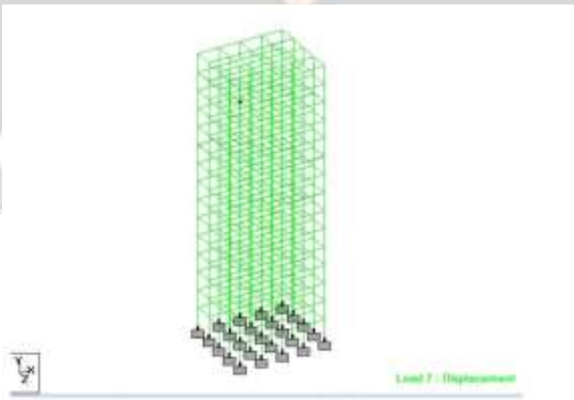


Fig.4:4 Displacement

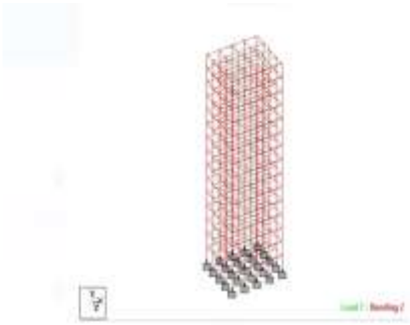


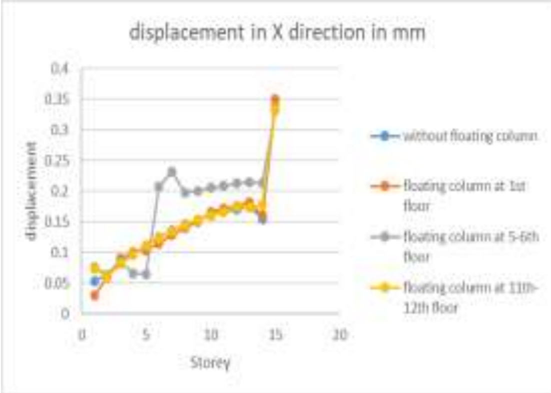
Fig4.6: bending moment in Z direction

Fig4.7: bending moment in Y direction

V. RESULTS

Table 5.1: displacement in X direction in mm

displacement in X direction in mm				
Storey	without floating column	floating column at 1st floor	floating column at 5-6th floor	floating column at 11th-12th floor
GL	0.054	0.03	0.076	0.074
1	0.064	0.061	0.064	0.061
2	0.082	0.09	0.087	0.082
3	0.098	0.101	0.066	0.097
4	0.112	0.104	0.065	0.112
5	0.125	0.115	0.207	0.124
6	0.136	0.129	0.232	0.135
7	0.146	0.14	0.198	0.145
8	0.154	0.151	0.201	0.153
9	0.161	0.166	0.206	0.161
10	0.167	0.172	0.209	0.166
11	0.17	0.176	0.213	0.175
12	0.176	0.182	0.215	0.173
13	0.155	0.16	0.213	0.179
14	0.339	0.35	0.332	0.335

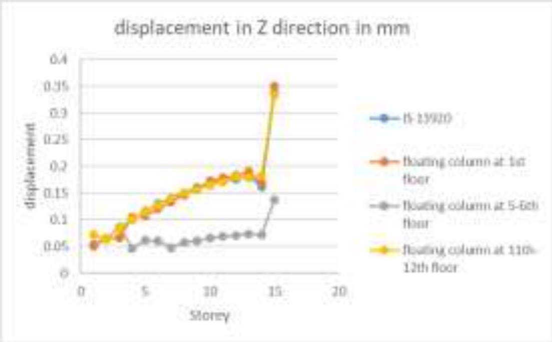


Graph5.1: displacement in X direction in mm

above graph shows displacement in x direction in mm for without floating column, floating column at 1st floor, floating column at 5th, 6th floor and floating column at 11-12th floor. As we can see that floating column at 1st floor has the higher deformation than the without floating column by 3.14285714%, and without floating column has the higher deformation than the floating column at 5-6th floor by 2.06489676%. as well as without floating column has the higher deformation than the floating column at 11th-12th floor by 1.179941%.

Table 5.2: displacement in Z direction in mm

displacement in Z direction in mm				
Storey	IS 13920	floating column at 1st floor	floating column at 5-6th floor	floating column at 11th-12th floor
GL	0.053	0.051	0.072	0.072
1	0.065	0.065	0.064	0.064
2	0.085	0.066	0.087	0.084
3	0.101	0.105	0.047	0.1
4	0.116	0.108	0.062	0.115
5	0.13	0.12	0.06	0.128
6	0.141	0.134	0.048	0.14
7	0.151	0.147	0.058	0.15
8	0.16	0.157	0.06	0.157
9	0.167	0.173	0.066	0.165
10	0.173	0.179	0.069	0.171
11	0.176	0.183	0.071	0.18
12	0.182	0.19	0.074	0.179
13	0.162	0.169	0.072	0.184
14	0.338	0.351	0.138	0.334

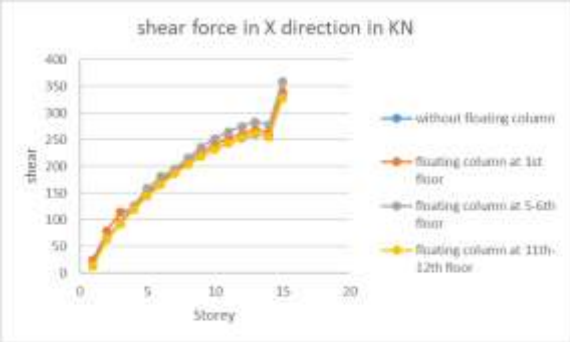


Graph5.2: displacement in Z direction in mm

above graph shows displacement in Z direction in mm for IS 13920, floating column at 1st floor, floating column at 5-6th floor, floating column at 11th-12th floor As we can see that floating column at 1st floor has the higher deformation than the IS 13920 by 3.7037037%, and IS 13920 has the higher deformation than the floating column at 5-6th floor by 59.1715976%. as well as IS 13920 has the higher deformation than the floating column at 11th-12th floor 1.18343195%.

Table 5.5: shear force in X direction in KN

shear force in X direction in KN				
Storey	without floating column	floating column at 1st floor	floating column at 5-6th floor	floating column at 11th-12th floor
GL	23.841	25.638	14.162	13.839
1	62.899	78.9204	65.767	63.884
2	92.833	114.433	95.952	92.009
3	120.67	121.259	126.39	119.818
4	145.588	150.052	158.977	144.473
5	167.904	172.673	181.474	166.592
6	187.729	193.276	194.436	186.27
7	205.181	211.391	215.548	203.668
8	220.351	227.179	236.639	218.916
9	233.307	240.683	252.564	232.279
10	244.141	251.985	265.306	243.455
11	252.651	260.862	274.926	254.558
12	260.563	269.083	283.568	262.185
13	255.508	263.899	278.154	254.816
14	330.06	340.569	358.538	328.113



Graph5.5: shear force in X direction in KN

above graph shows displacement in Z direction in mm for without floating column, floating column at 1st floor, floating column at 5-6th floor, floating column at 11th-12th floor As we can see that floating column at 1st floor has the higher deformation than the without floating column by 3.08571831%, and floating column at 5-6th floor has the higher deformation than the without floating column by 7.9428122%. as well as without floating column has the higher deformation than the floating column at 11th-12th floor 0.589892747%.

Table 5.6: shear force in Z direction in KN

shear force in Z direction in KN				
Storey	without floating column	floating column at 1st floor	floating column at 5-6th floor	floating column at 11th-12th floor
GL	23.293	24.831	13.486	13.468
1	63.075	77.0568	64.214	63.88
2	95.019	116.729	95.628	94.019
3	124.245	125.794	126.915	123.089
4	150.348	155.736	160.941	148.797
5	173.644	179.558	186.031	171.723
6	194.294	201.164	201.354	192.007
7	212.441	220.157	224.287	209.83
8	228.196	236.694	247.032	225.342
9	241.643	250.828	263.653	238.835
10	252.874	262.641	276.644	250.039
11	261.736	271.959	286.347	261.157
12	269.737	280.335	294.799	269.528
13	265.639	276.112	290.105	263.639
14	337.462	350.462	367.808	334.132

Graph5.6: shear force in Z direction in KN

above graph shows displacement in Z direction in mm for without floating column, floating column at 1st floor, floating column at 5-6th floor, floating column at 11th-12th floor As we can see that floating column at 1st floor has the higher deformation than the without floating column by 3.70938932%, and floating column at 5-6th floor has the higher deformation than the without floating column by 8.25050026%. as well as without floating column has the higher deformation than the floating column at 11th-12th floor 0.986777771%.

VIII. CONCLUSION

In the research, a standard building and a building with floating columns at various floor levels are contrasted and compared to one another.

- There is a correlation between the height of the building and the amount of storey displacement. Every single model displacement value goes up for the floating column structures, but most noticeably for the corner floating column building. The mass of the storey may either raise or reduce the amount of storey displacement.
- Storey shear will be greater for lower floors than it will be for higher levels as a result of the gradual decrease in weight from lower to higher floors.

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