Comparative Analysis of Multistorey Building With & Without Floating Column

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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.

A typical Column is a vertical structural member which support to horizontal structural members by means of their weights, moments, shear force, axial load etc., to keep the structure in safe condition and transfer these loads to the ground. But now a day's some columns are designed in such a manner that it does not reach to the ground, because of various architectural aspects. In those cases, the columns transfer above loads as a point load on a beam. This type of column is termed as Floating column. This Point load increases to much bending moment on beam so that area of steel required will be more in such cases. While earthquake occurs, the building with floating columns damages more as compared to the building without any floating columns because of discontinuity of structure & 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, play ground, 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.

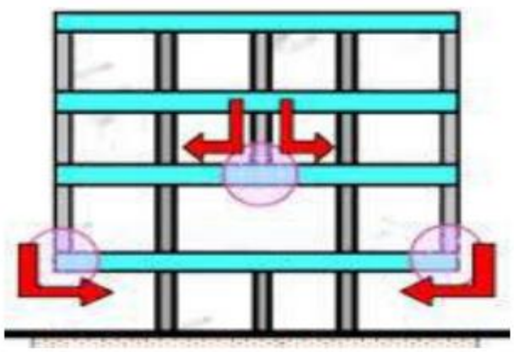


Fig.1: Building with floating column

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 maximum bending moment in each story.
3. To compare the maximum shear force among all the models.
4. 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

2.1 Suneelakumar Hattarakihal1, Dr. S. S. Dyavanal, (2016).

The floating columns are given the priority in the multi-storey structures, as to cope up with the problems with continuing the columns from a lower storey, due to the disturbance caused by them to usable area and aesthetics. In the present study, performance based seismic evaluation of 3D G+6 storeys RC building with and without floating columns is carried out. The building models located on medium soil in seismic zone III, are considered. Brick masonry and solid concrete block infill walls aremodelled as equivalent diagonal strut. Two distinct analyses are carried out namely, equivalent static and response spectrum as per the load combinations given in IS 1893 (Part I) 2002 using ETABS 2013 V13.2. All the building models are designed as per IS: 456-2000 and their performance based seismic investigation is assessed by pushover analysis considering FEMA 440 parameters. The pushover results like hinge status, ductility ratio, safety ratio and global stiffness are compared for different models.

2.2 Sharma R. K, Dr. Shelke N. L, (2016).

In urban India floating column building is a typical feature in the modern multistorey construction. Floating columns buildings are adopted either for architectural aspect or when more free space is required in the ground floor. Such features are highly undesirable in seismically active area. In the project studies the analysis of G+5, G+7, G+9, G+11 and G+13 storey building with floating column and without floating is carried out. The analysis is done by using Staad Pro V8i software by using Response spectrum analysis.

The paper deals with the results variation in displacement of structure, base shear, Seismic weight calculation of building from manual calculation and Staad pro V8i. For building with floating column and building without floating column, finding the variation between the response parameters of earthquake and describe what happens when variation may be high or low. The study is carried out to find whether the floating column structures are safe or unsafe when built in seismically prone areas, and also find out commercial aspects of floating column building either it is economical or uneconomical.

2.3 Sukumar Behera, (2012).

In present scenario buildings with floating column is a typical feature in the modern multistory 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 codes are developed for 2D multi storey 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 floor displacement, inter storey drift, base shear, overturning moment are computed for both the frames with and without floating column. The behavior of multistory building with and without floating column is studied under different earthquake excitation. The compatible time history and Elcentro earthquake data has been considered. The PGA of both the earthquake has been scaled to 0.2g and duration of excitation are kept same. A finite element model has been developed to study the dynamic behavior of multistory frame. The static and free vibration results obtained using present finite element code are validated. The dynamic analysis of frame is studied by varying the column dimension. It is concluded that with increase in ground floor column the maximum displacement, inter storey drift values are reducing. The base shear and overturning moment vary with the change in column dimension.

2.4 Kandukuri Sunitha, Mr. Kiran Kumar Reddy, (2017).

In present scenario buildings with floating columns are of typical feature in the modern multi storey construction practices in urban India. Such types of constructions are highly undesirable in building built in seismically active areas. This paper studies the analysis of a G+4,G+9,G+14 storey normal building and a G+4,G+9,G+14 storey floating column building for external lateral forces. The analysis is done by the use of ETABS. The intensities of the past earthquakes i.e., applying the ground motions to the structures,from that displacement time history values are compared.This study is to find whether the structure is safe or unsafe with floating column when built in seismically active areas and also to find floating column building is economical or uneconomical.

III. METHODOLOGY

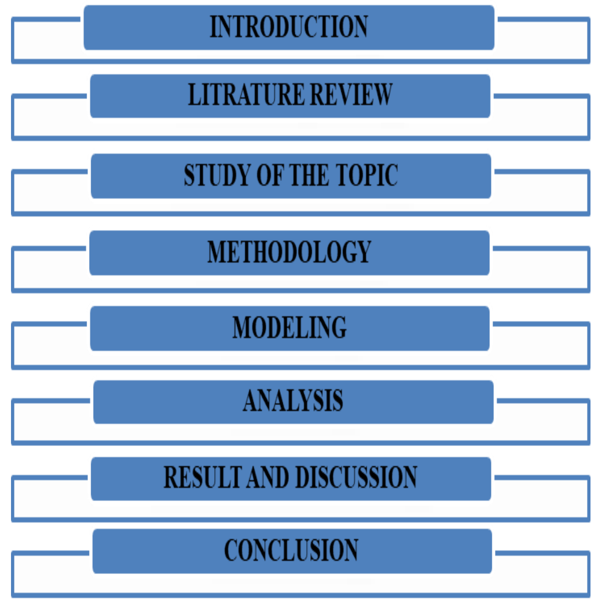


Fig. 2: Methodology Process

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

List of Indian Standards on Earthquake Engineering: -

1. IS 1893 (Part I), 2002: Indian Standard Criteria for Earthquake Resistant Design of Structures
2. IS 4326, 1993: Indian Standard Code of Practice for Earthquake Resistant Design & Construction of Buildings.
3. IS 13827, 1993: Indian Standard Guidelines for improving Earthquake Resistance of Earthen Buildings
4. IS 13828, 1993: Indian Standard Guidelines for Improving Earthquake Resistance of Low Strength Masonry Buildings
5. IS 13920, 1993 Indian Standard Code of Practice for Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces.

6. IS13935, 1993: Indian Standard Guidelines for Repair and Seismic Strengthening of Buildings

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.The

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)**

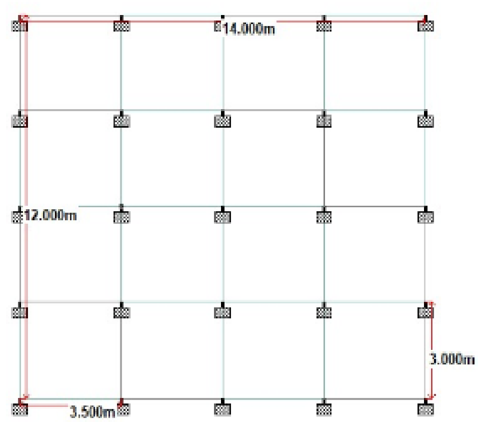


Fig.4.1: top view

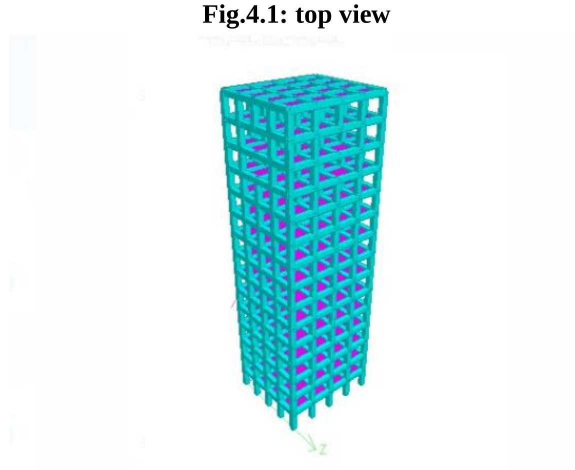


Fig.4:3D rendered view

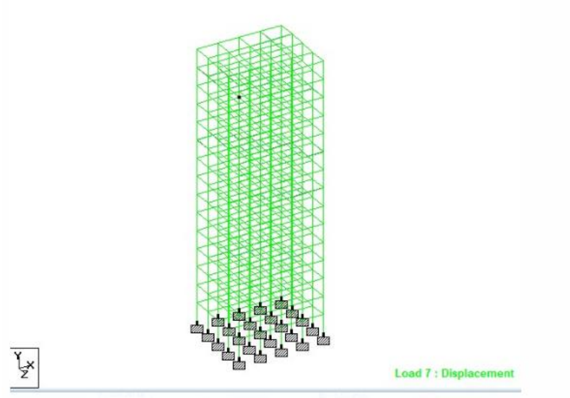


Fig.4:4 Displacement

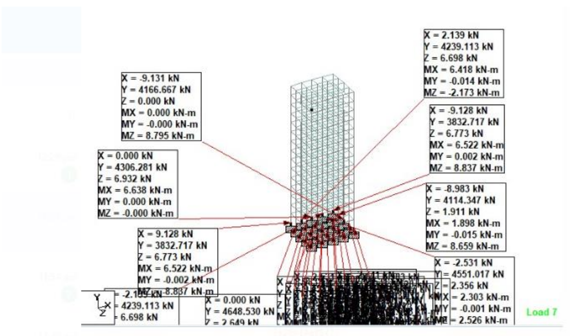


Fig.4:5 Reactions

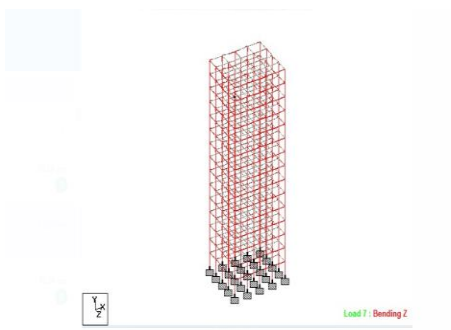


Fig4.6: bending moment in Z direction

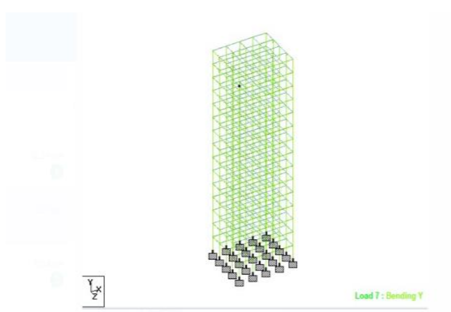
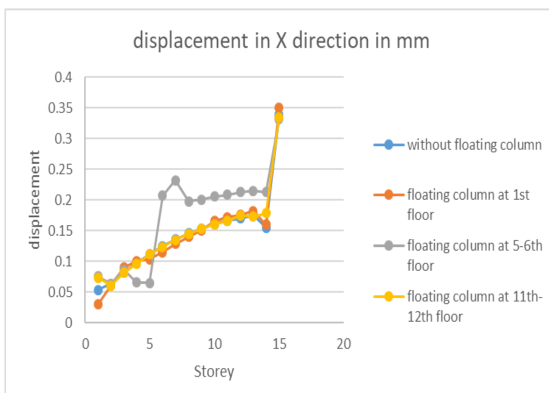


Fig4.7: bending moment in Y direction

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

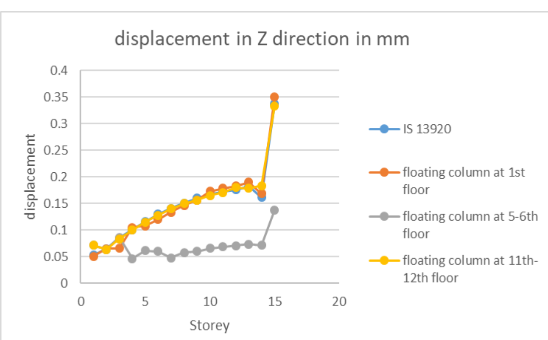


Graph5.1: displacement in X direction in mm

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

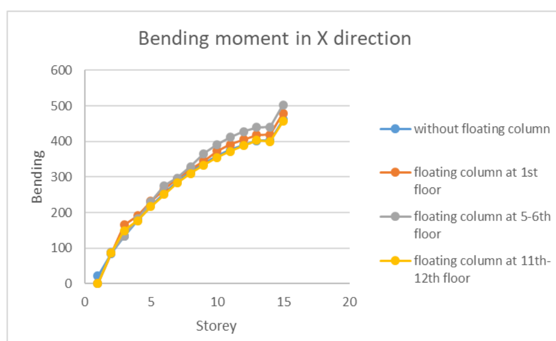


Graph5.2: displacement in Z direction in mm

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 5.3: Bending moment in X direction

Bending moment in X direction				
Storey	without floating column	floating column at 1st floor	floating column at 5-6th floor	floating column at 11th-12th floor
GL	21.788	0	0	0
1	85.303	86.15603	87.908	87.559
2	133.803	165.83	134.119	149.785
3	178.591	191.561	182.03	176.976
4	218.561	231.662	230.543	216.337
5	254.274	265.197	275.75	251.499
6	285.974	295.359	296.676	282.644
7	313.884	321.869	328.837	310.048
8	338.177	344.9	365.299	333.95
9	358.989	372.588	391.344	354.696
10	376.445	390.947	411.767	372.288
11	390.467	405.693	427.242	388.229
12	402.225	418.02	439.705	403.073
13	403.153	419.036	440.3	400.002
14	460.947	478.846	502.696	456.852



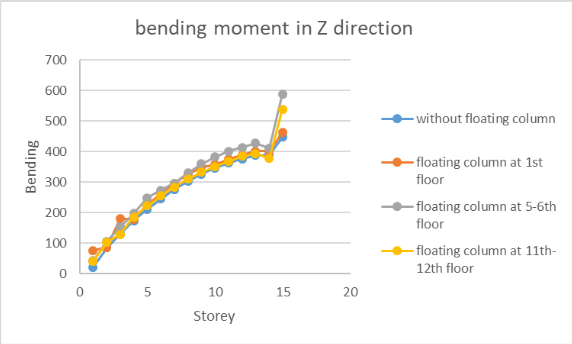
Graph5.3: Bending moment in X direction

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 3.73794498%, and floating column at 5-6th floor has the higher deformation than the without floating column by

8.30501934%. as well as without floating column has the higher deformation than the floating column at 11th-12th floor 0.88838847%.

Table5.4: bending moment in Z direction

bending moment in Z direction				
Storey	without floating column	floating column at 1st floor	floating column at 5-6th floor	floating column at 11th-12th floor
GL	22.3	76.915	42.486	41.516
1	85.757	86.61457	106.545	103.324
2	130.941	179.919	153.076	129.632
3	173.597	178.748	197.622	187.046
4	211.722	226.642	248.828	223.311
5	245.916	262.85	274.551	255.776
6	276.339	296.035	296.632	284.628
7	303.173	325.224	330.264	310.103
8	326.56	350.715	359.925	332.384
9	346.612	357.532	382.871	351.953
10	363.444	375.089	401.129	367.957
11	376.94	389.169	414.65	385.331
12	388.413	401.107	427.97	394.09
13	388.547	401.293	411.556	377.25
14	447.711	462.12	588.867	538.528

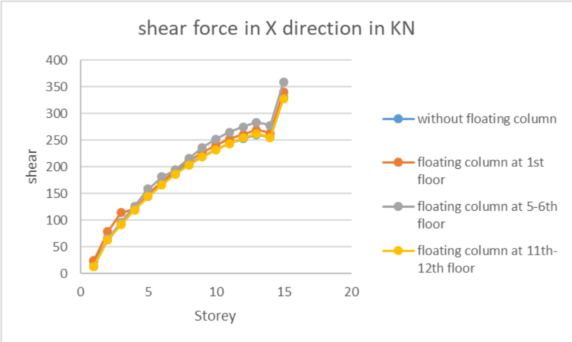


Graph5.4: bending moment in Z direction

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 3.11802129%, and floating column at 5-6th floor has the higher deformation than the without floating column by 23.9707778%. as well as floating column at 11th-12th floor has the higher deformation than the without floating column 16.8639328%.

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

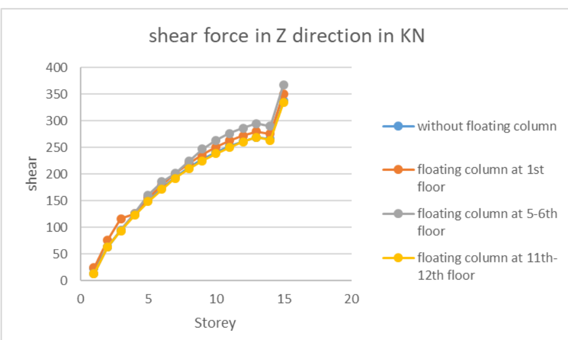


Graph5.5: shear force in X direction in KN

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.
- As a result of the incorporation of the floating column, the base shear value is reduced.
- As the floor rises, the amount of shear force also rises.

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