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Comparison of Response Spectrum and Equivalent Static Analysis for Identifying the Safest Location of Floating Columns Using ETABS in Zone IV

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Abstract. Many of the high-rise buildings and tall structures are currently designed with floating columns for aesthetic intentions and to deliver additional space for mobility in parking spaces and effective utilization of working areas in a building. However, when compared to typical buildings, some of the structures are more likely to be damaged or collapse during earthquakes in high seismic zones. The soft-story, vertical or plan irregularity, Floating Column (FC), and large loads are all common features of modern multi-story buildings, whereas modern technology in the construction industry returns out to be an increasingly common practice in India's cities. Most RC structures were found to be constructed with these flaws were particularly unfavorable seismically active zones based on the findings of previous earthquake research. These outcomes occurred because of a variety of considerations, including a non-uniform distribution of mass, stiffness, and strength are all factors to consider. In this investigation, it has been compared for the analysis of multi-story buildings with and without Floating Columns (FC) at various levels in regular plans, to build a safe placement for floating columns in seismic designs. Using the software ETABS 2017, Equivalent Static Analysis (ESA) and Response Spectrum Analysis (RSA) have been performed on the Mathematical 3D model of G+10 building of a regular plan, and these models were compared, and it will assist in determining the structures numerous analytical properties as well as providing a very systematic and cost-effective design.
Keywords. Floating Column, Soft story, Base Shear, Story Displacement, Story Drift, Equivalent Static method, Response Spectrum method.

INTRODUCTION

Earthquake disasters have long been a natural hazard that causes structural damage or collapse. The Indian subcontinent had witnessed a significant number of powerful earthquakes on the continent. As a reason, a seismic analysis must be considered while designing multi-story buildings. The purpose of seismic research is to have a better understanding of earthquakes. The investigation was started with the assumption that the structure should withstand the RC elements. Mild tremors can occur without causing any damage. The high-rise building has been the most complex constructed structure since the discovery of the wheel. Various standards are still in conflict, and the problem is confusing, as the construction seems to be interconnected. Numerous modern multistorey structures have the distinct feature of leaving the ground floor accessible for recreational and functional uses, such as retailing, parking, shops, and reception are just a few of the services offered. Buildings with a "soft first story" or an "open ground story" are commonly referred to as "soft first storey" or "open ground storey" constructions. Soft stories (SS) at various structural levels are designed for the function of utility services as well as the service narrative as a weak soft storey to meet a functional requirement and to serve several functions. Because the story's stiffness is lower than the stiffness of the stories above it.

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Concept of Floating Column

"Columns are vertical element that stretches from the base of the structure to the point in which the weight is distributed" to the stack's very bottom. The lower level (termination level) rests on a FC, which is a vertical component that concludes at its end on a beam. In a logical sequence, the rafters are transferring the load to other columns. Theoretically, columns like these, where the stress is evenly distributed, are considered a single point of load. The load is subsequently shifted beneath the beams to additional columns. Even though they are placed above the beam and have no structural continuity, the loads in that columns have been evaluated as a point load. Vertical elements that are comparable to ordinary RC columns are floating columns, often referred as hanging columns, typically constructed above the bottom floor, permitting the lower storey to be used for parking, a play area, and event spaces. These FC cause the uniform distribution of loads in buildings to be disrupted, causing in higher flexibility and, as a result, a reduction in seismic vulnerability. FC buildings are constructed to take advantage of local ordinances. City regulations require that a predetermined area among all buildings and the plot boundaries be left open.

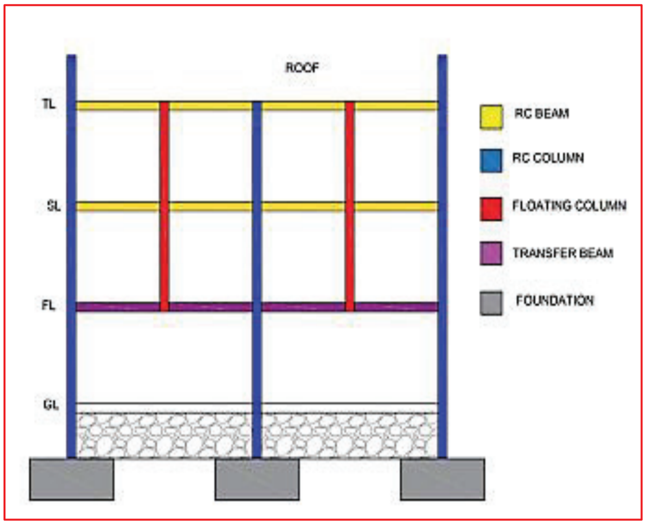

FIGURE 1 Floating column (Lingeshwaran,2021[9])

Due to various in-plane and out-of-plane irregularities in strength and stiffness, the building with floating columns is seismically vulnerable. Consequently, there is no apparent load mechanism for distributing lateral stresses to the foundations during earthquakes. In seismic activity, the recommended cantilever beams should transfer lateral loads collected in the upper floors. As a result, it's crucial to understand how such structures behave during earthquakes and to retrofit existing structures with floating columns so that they would withstand greater seismic forces. A soft story is described as "one in which the lateral stiffness is less than 70% of that in the story above" (IS 1893 (Part 1), 2016). The overall stiffness above has been made up of 80% of the average lateral stiffness of the three stories. The FC was ideal for a variety of projects, especially those involving the ground level and the use of transferring girders to create more open space. At EQ-prone regions, the transfer girders should be appropriately planned and detailed. The design and detailed work will be straightforward if there are no lateral loads. A floating column's primary objective is to disrupt the flow of EQ force transfer.

SIGNIFICANCE OF THE STUDY

Earthquake-induced study of multi-story structures with floating and non-floating columns" was the focus of (Sawai et al., 2021). They chose the SMRF (Special Moment-Resisting Frame) for this study because it is positioned in zones II and V on medium soil conditions created three distinct model setups for Base+GF+3 (Duduskar, R., Yerudkar, D. S., & Sharma, 2021). considered a (GF+20) structure in accordance with IS 1893-2016, four separate models are built, and seismic analysis is performed using ETABS-2018 software to overcome limitations like storey displacement, shear, drift, and time. (Deepak Maheshkar, 2021)., 2021 created six models for a (G+12) structure with five bays in the X and Z directions with a height of 45 metres, concluding that the floating column's arrangement on the upper floor seems to be the best option.(Sharma, S., & Pastariya, 2020),(KeerthiGowda, B. S., & Tajoddeen, 2014) investigated a G+10 building with SMRF, analysed for Zone V, and situated on Type 2 soil carried out a response analysis to determine the BM, SF, storey drift, node displacement, and seismic weight of the structural system created 16 models with a damping ratio of 5% for the structure with regularities and irregularities on the inner and outer periphery. The seismic weight is less when comparing to the seismic weight lacking vertical irregularities, according to the analysis. The BS values are

5654.27 KN, which is about equal to all models, but drops as the model becomes more irregular. When floating supports are present on the outside margin of both regular and irregular structures, the displacements are greater. The influence of shear wall placement together in seismically loaded G+10-story structure with a floating column was explored by (Nayel et al., 2018), (Andwal et al., 2014). The maximum storey drift was determined using four models and ETABS analysis. Displacement levels are fluctuating and increasing, according to the results, as the shear wall design performed better than other building types.(Goud, 2017) investigated the structure's response under earthquake circumstances. The WFC and FC structure and isolation design were compared in three examples in this study to determine base isolation affected earthquake loading. The displacement on the top floor for models 2 and 3 is 40 mm and 13 mm, correspondingly, based on the results obtained. In Time History Analysis (THA), the inter-story drift is higher than in the other two models. For WFC, the inter-story drift (SD) is more in the third storey, whereas in the case of FC, it is more in the first level (Pradeep & Ashwini, 2017). modelled a (G+6) building in Zone V using various soil conditions as per IS 1893-2002 and found that a structure without FC has 35% lesser displacement than a building with FC. (Kumbhar, G., & Banhatti, 2016) calculated the (G+5) commercial building with SS and FC for seismic retrofitting and stated that shear wall retrofitting is the efficient strategy to mitigate the structure's displacement. According to Sarita et al. (2015), time period (TP) is more in floating columns than in typical buildings. When FC are present in a building, the storey displacement increases. As a result, in seismic zones, this type of situation should be avoided as much as possible, and if that is not possible, the building must be retrofitted. Push over-analysis of RC frame structure with FC and SS in different seismic zones was studied by (Bhensdadia, H., & Shah, 2015)(Mundada, 2014) perform a comparative seismic behavior of multi-story buildings with and without FC and concluded providing FC is a risk element that enhances the structural damage during earthquakes. The implication of the current study into the behaviour of multi-storey buildings with and without FC is to investigate the behaviour of storey displacement (SD), base shear (BS), and storey drift (SD) in multi-storey buildings with and without FC under seismic conditions, as well as the effect of FC location.

METHODOLOGY AND MODELLING OF STRUCTURE

ETABS 17 software used to create a G+10 storey RC building with and without an FC. When the FC is present on the same floor and in various locations across the building, comparable study is undertaken to compare a multi-story building with and without an FC in various zones. For this present study, SMRF is being used to model a 25 m x 22.5 m for the multi-storey (G+10) building over Type 2 soil, it was assessed to be in seismic zones IV. Structures were remodelled in ten different cases to assess the impact of seismic loading, yielding a total of ten models with the location for FC orientation in each cases.

1. **Model 1 -** Building without FC located in Zone IV.
2. **Model 2**: Building with FC @ FF Zone IV. Case 2(a) CB2, CB5, CE2, CE5, Case 2(b) CA1, CA6, CF1, CF6, Case 2(c) CA5, CF5, CA2, CF2.where floating column are located.
3. **Model 3 -** Building with FC @ 3F Zone IV. Case 3(a) CB2, CB5, CE2, CE5, Case 3(b) CA1, CA6, CF1, CF6, Case 3(c) CA5, CF5, CA2, CF2.where floating column are located.
4. **Model 4 -** Building with FC @ 6F Zone IV. Case 4(a) CB2, CB5, CE2, CE5, Case 4(b) CA1, CA6, CF1, CF6, Case 4(c) CA5, CF5, CA2, CF2.where floating column are located.
5. **Model 5:** Building with FC @ 10F Zone IV. Case 5(a) CB2, CB5, CE2, CE5, Case 5(b) CA1, CA6, CF1, CF6, Case 5(c) CA5, CF5, CA2, CF2.where floating column are located.

The study's primary objective is to provide a cost-effective and safe design of a building with a floating column in seismically prone zones, along with acceptable design guidelines, because there is no specific provision or magnification factors for this type of irregularity in IS standards to compare and contrast various analysis methodologies.

Story drift: "Displacement of one-story relative to other story is called story drift. The story shall not exceed 0.004 times the story height", according to IS 1893(part1): 2016 (cl 7.11.1). X axis indicates the No. of Models and Y axis indicates Story Drift as shown in Table 2 and 3.

Story displacement: The lateral displacement of the building, also known as joint displacement, is a crucial characteristic to consider while designing a multi-story structure. In the case of wind load, the maximum displacement of the building should be within 1/500 times the building height, and in the case of earthquake load, it should be 1/250 times the building height, according to Indian Codes. For comparable static analysis, the displacement of the structure in the X and Y directions for various models is calculated as shown in the Table 4-5. (Shashikumar et al., 2018).

Base shear: "Base shear is a calculation of the greatest predicted lateral force on the structure's base as a result of seismic activity". X axis indicates the No.of Models and Y axis indicates Base Shear in kN in Fig.20 and Fig.21.

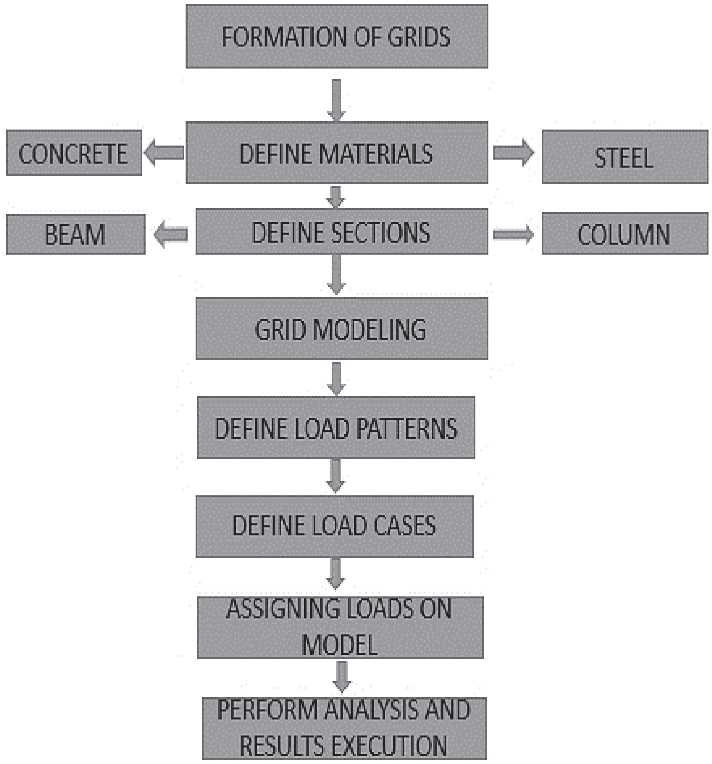

FIGURE 2 Methodology

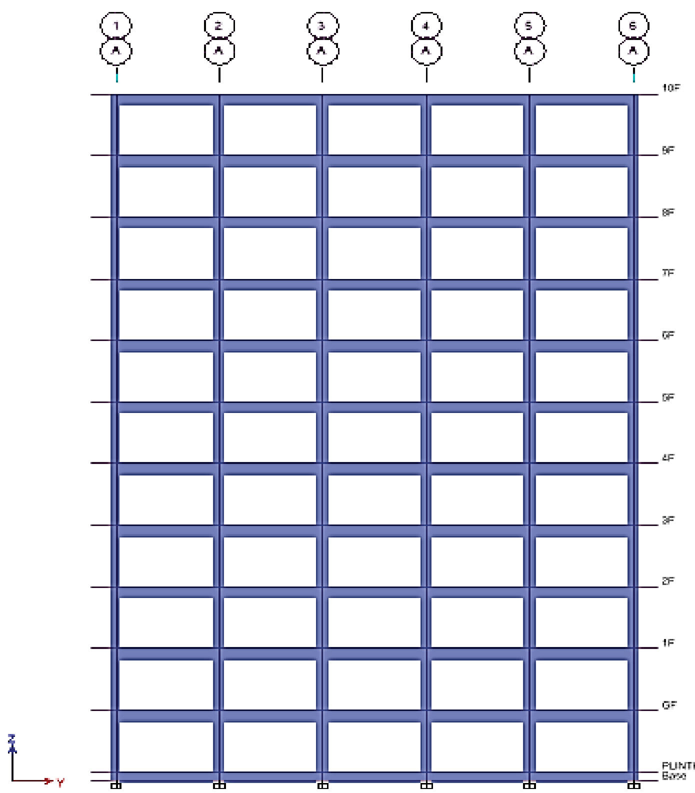

FIGURE 3 Model Without FC

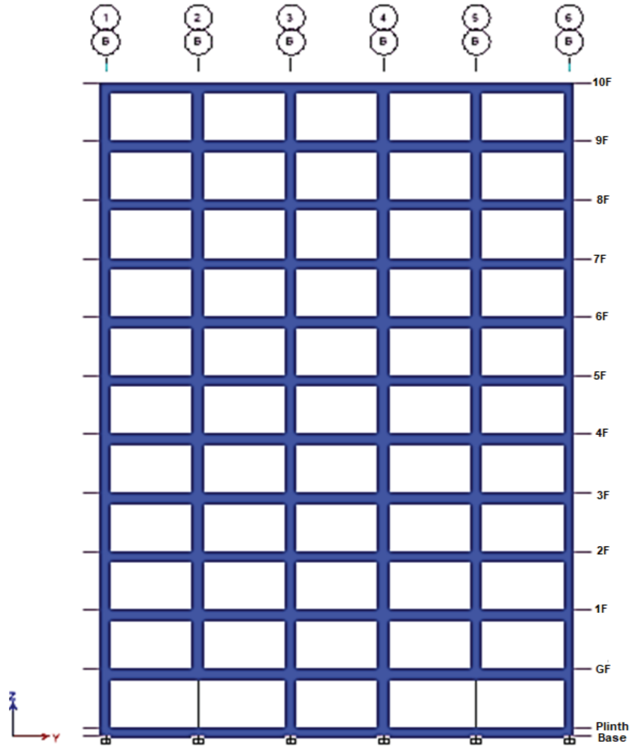

FIGURE 4 FC located in CB2, CB5, CE2, CE5 in FF

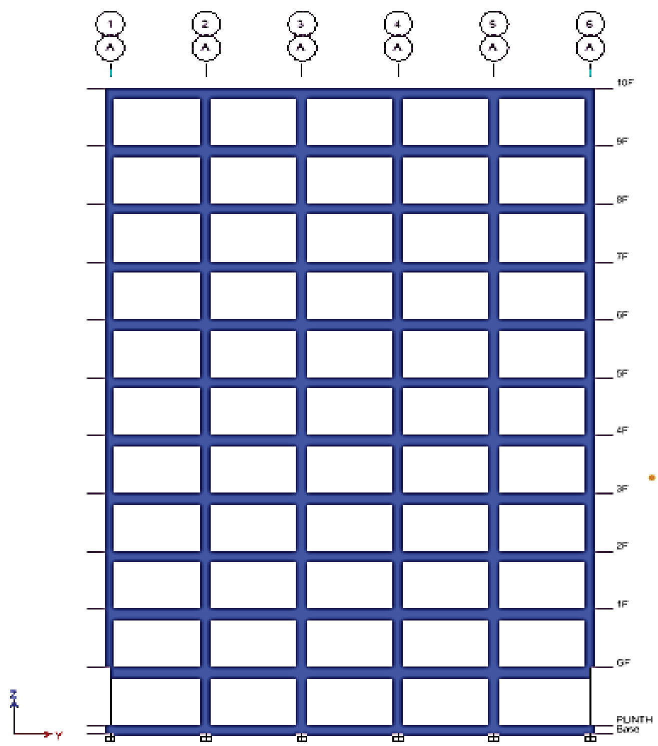

FIGURE 5 FC located in CA1, CA6, CF1, CF6 in FF

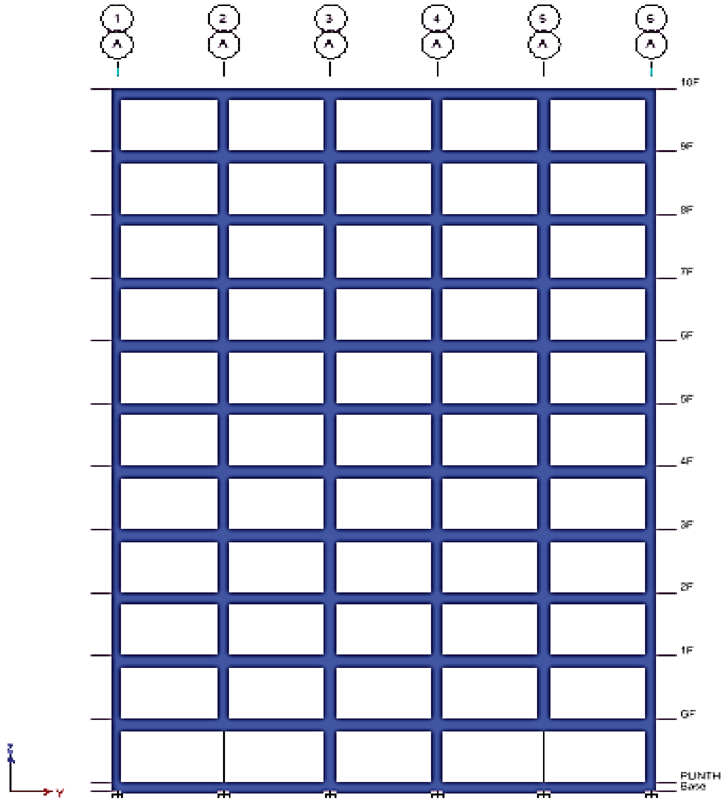

FIGURE 6 FC located in CA5, CF5, CA2, CF2 in FF

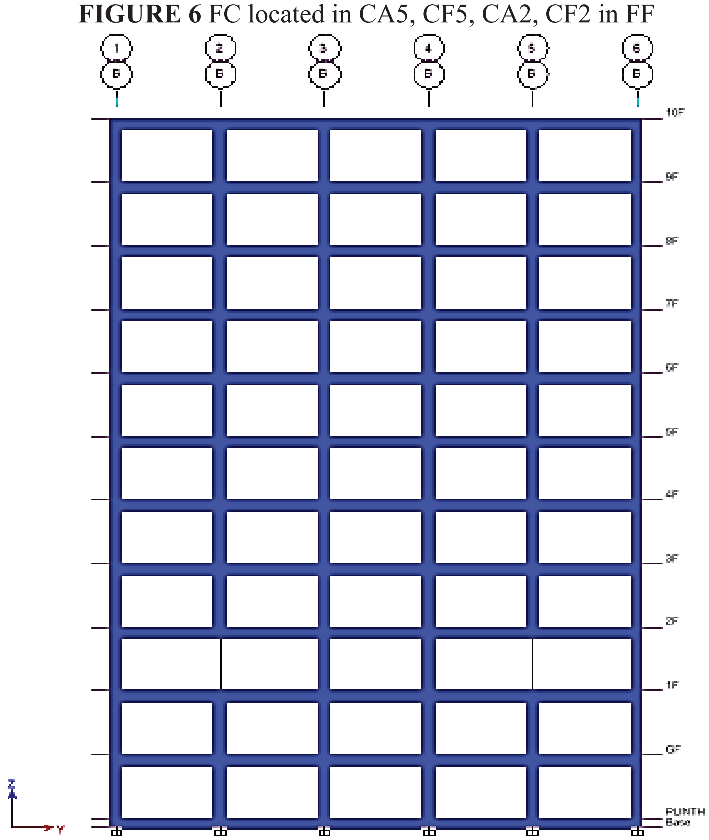

FIGURE 7 FC located in CB2, CB5, CE2, CE5 in 3F

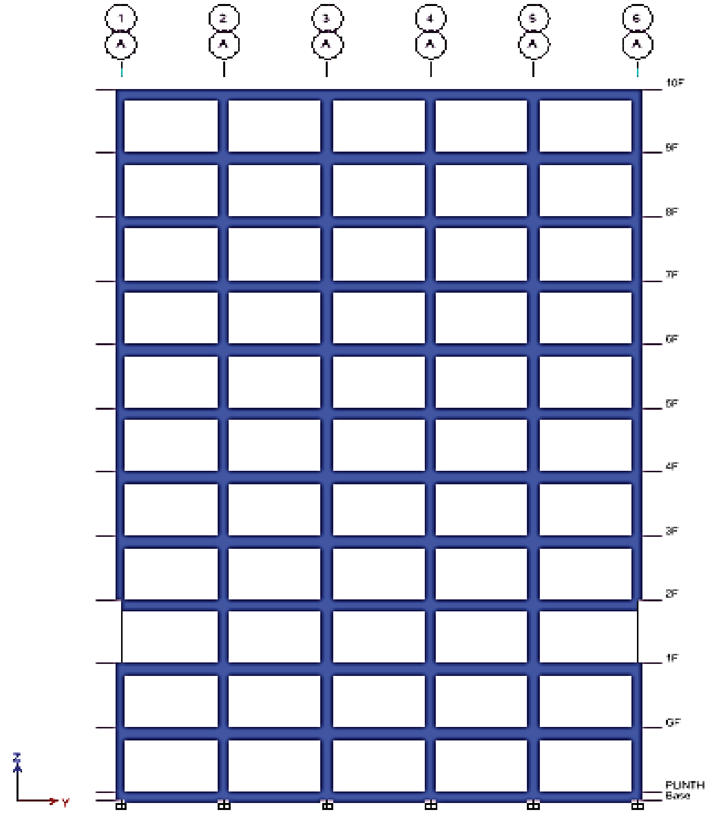

FIGURE 8 FC located in CA1, CA6, CF1, CF6 in 3F

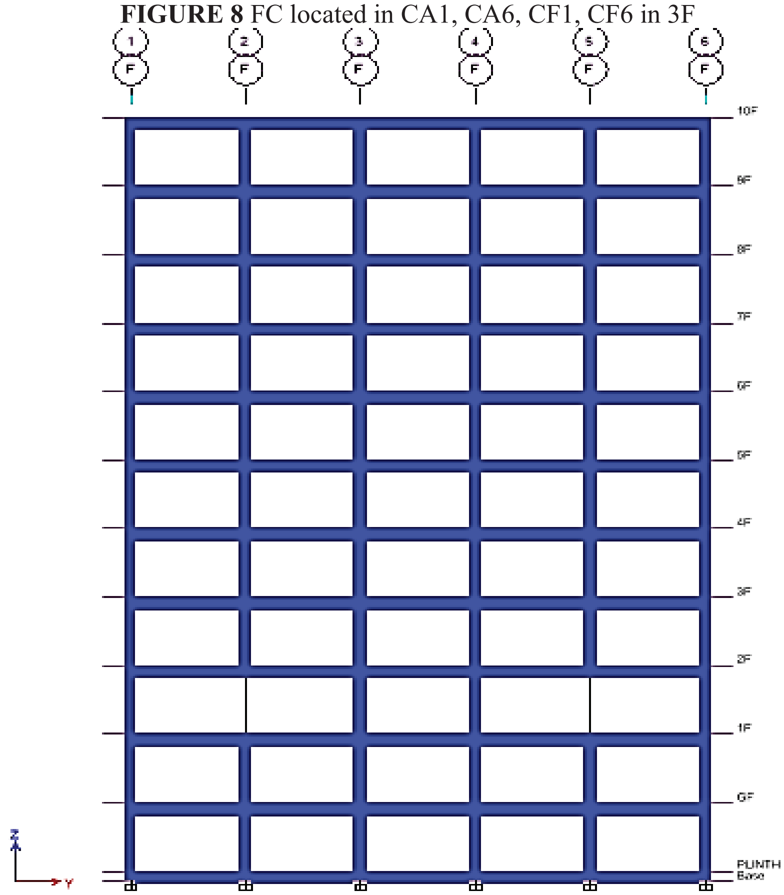

FIGURE 9 FC located in CA5, CF5, CA2, CF2 in 3F

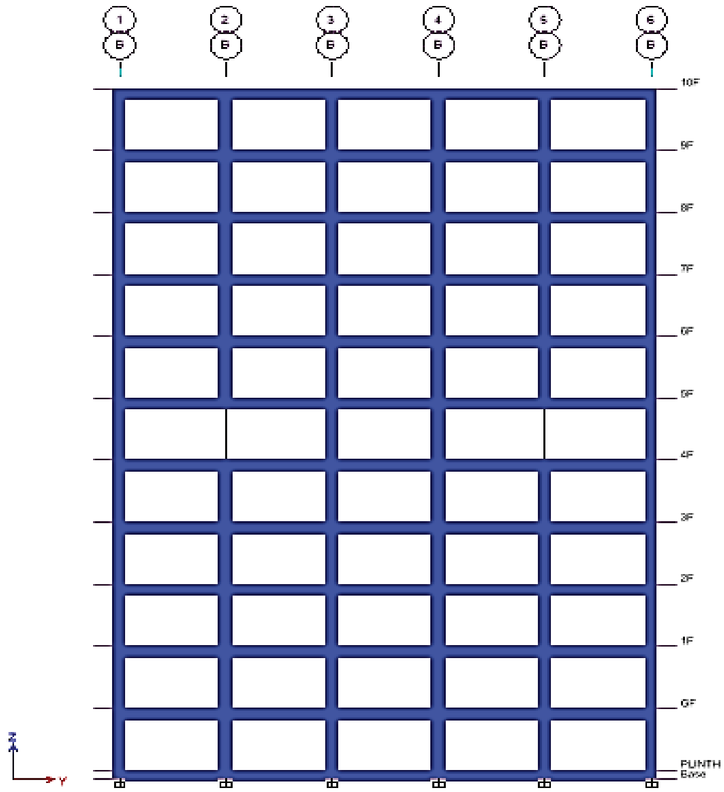

FIGURE 10 FC located in CB2, CB5, CE2, CE5 in 6F

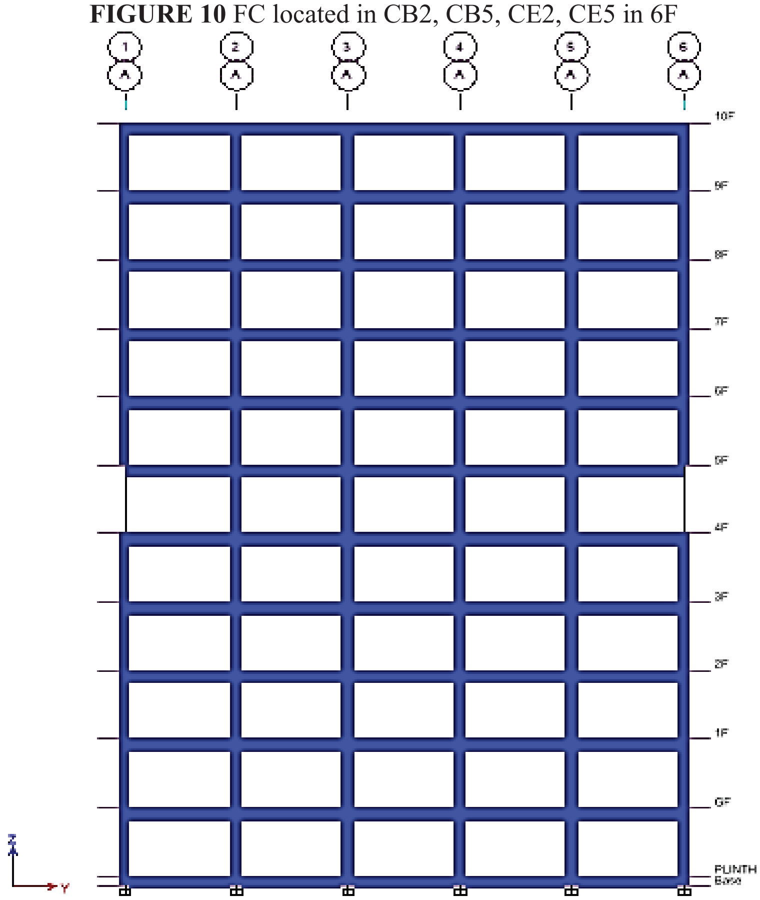

FIGURE 11 FC located in CA1, CA6, CF1, CF6 in 6F

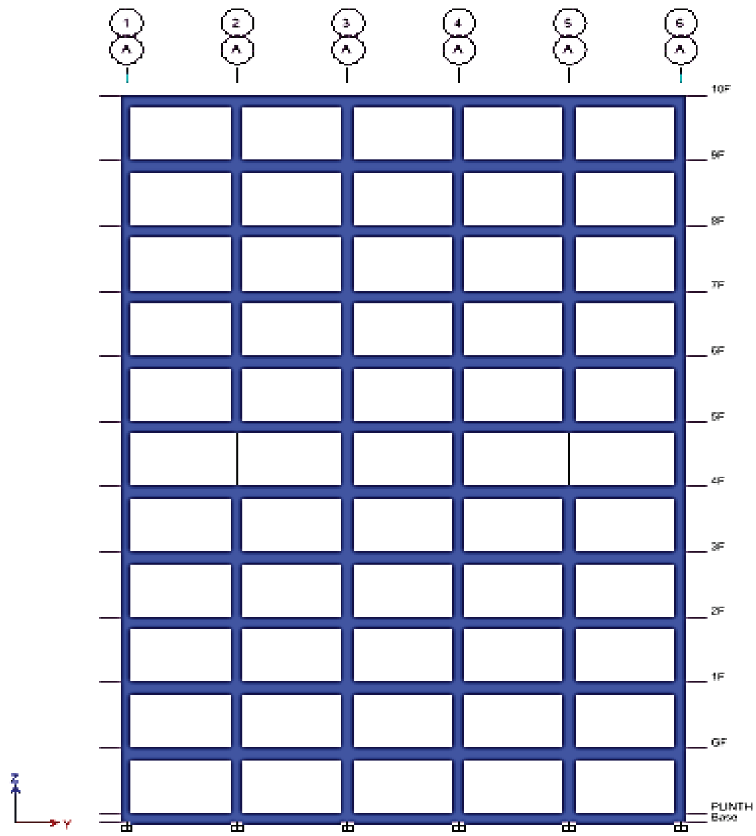

FIGURE 12 FC located in CA5, CF5, CA2, CF2in 6F

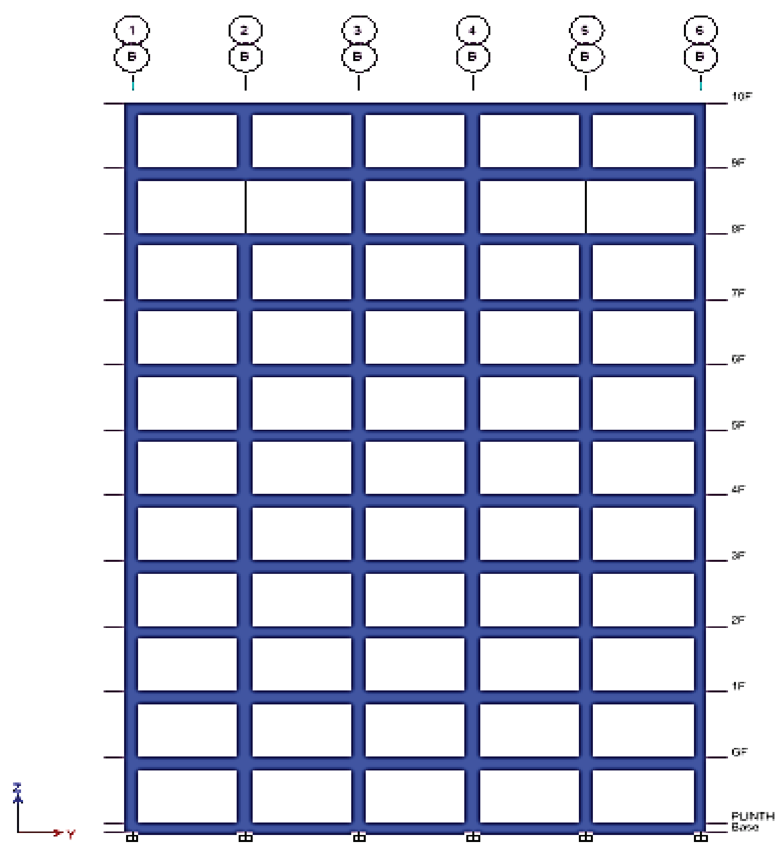

FIGURE 13 FC located in CB2, CB5, CE2, CE5 in 10F

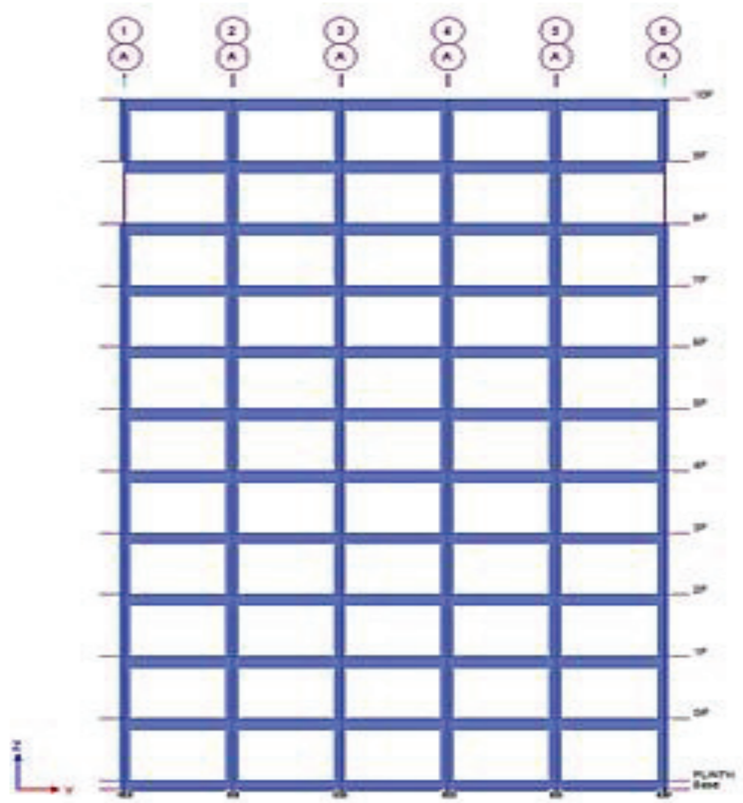

FIGURE 14 FC located in CA1, CA6, CF1, CF6 in 10F

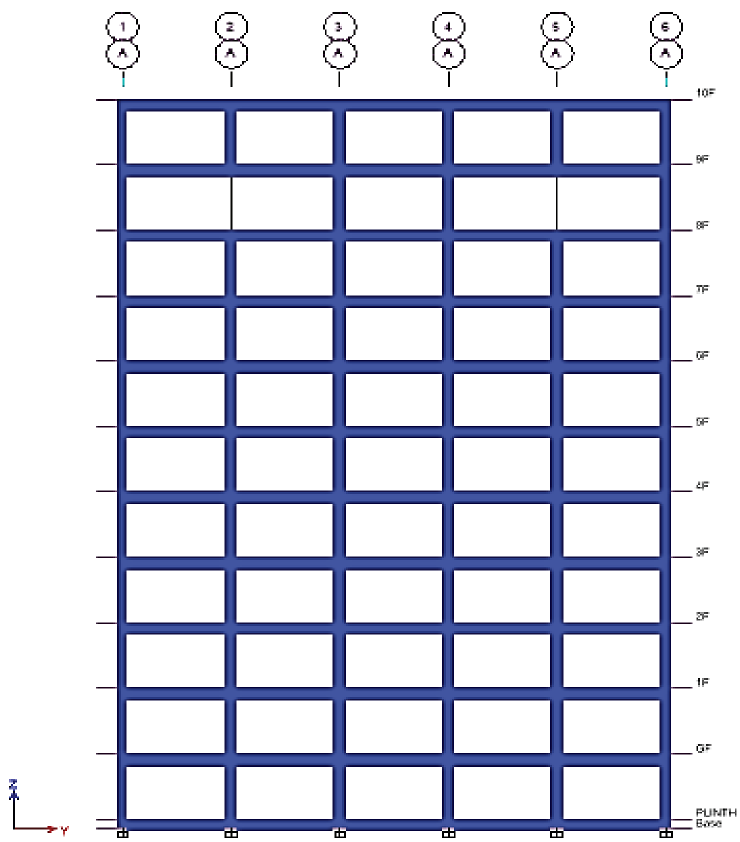

FIGURE 15 FC located in CA5, CF5, CA2, CF2 in 10F

Method of Analysis

"The effects of design earthquake load on structures can be analysed using two methods".

a) Equivalent static approach
b) Dynamic analysis method

Equivalent Static Method: Most seismic analyses are still performed on the assumption that the lateral (horizontal) force is identical to the real (dynamic) loading. Based on structural mass, fundamental period of vibration, and corresponding mode shape, the base shear, which is the total horizontal force on the structure, is computed. "According to the Code formula, the base shear is distributed along with the height of structures in terms of lateral forces". For low to medium height buildings with a regular conformation, this strategy is usually conservative . (Pankaj Agarwal & Shrikhande, 2007)

Dynamic analysis Method *:* Dynamic analysis on the other hand, can be done in three different ways Response spectrum approach, Modal time history method, Time history method(IS 1893 (Part 1), 2016).

Response Spectrum Method: "A response spectrum is a graph of the peak or steady-state response of a sequence of oscillators with different natural frequencies that are all triggered by the same base vibration or shock". The resulting graphic can then be used to isolate the response of any linear system based on its natural oscillation frequency. X axis indicates the No.of Models and Y axis indicates Storey Drift as well as Storey Displacement in mm for this study.

TABLE 1 SPECIFICATIONS OF BUILDING MODELS

Type of Property	***Specifications***	***Type of Property***	***Specifications***
Type of structure and No of storey	SMRF and G+10	*Seismic Zone and Zone factor*	IV and 0.24
Height of each story	3 m	*Type of soil*	Medium
Dimensions of plan	25 m x 22.5 m	*Response reduction factor*	5
Damping ratio	5%	*Importance factor*	1.5
Grade of concrete	Columns M_{40}, Beams M_{30}, Slab M_{30}	*Thickness of Main wall and Parapet*	0.23 m and 0.10 m
Grade of steel	Fe 500 & Fe 415	*Thickness of Slab*	0.12 m
Size of column	C1 = 0.6 m x 0.6 m	*Beams in X – directions*	B1 = 0.45 m x 0.6 m
	C2 = 0.525 m x 0.6 m	*Beams in Y – directions*	B2 = 0.375 m x 0.6 m
	C3 = 0.45 m x 0.6 m	*Plinth beam*	PB = 0.45 m x 0.6 m

TABLE 2 STOREY DRIFT FOR EQ_X AND EQ_Y

	EQx				**EQy**			
Story Level	**10F**	**6F**	**3F**	**FF**	**10F**	**6F**	**3F**	**FF**
NB	0.000524	0.001817	0.002226	0.002058	0.000547	0.001906	0.002336	0.002173
C2A	0.000521	0.001804	0.002212	0.002069	0.000543	0.001891	0.00232	0.002186
C3A	0.000521	0.001807	0.002216	0.002047	0.000544	0.001895	0.002323	0.002158
C4A	0.000523	0.001812	0.002218	0.00205	0.000546	0.001897	0.002328	0.002165
C5A	0.000522	0.001832	0.002246	0.002077	0.000542	0.001921	0.002357	0.002193
C2B	0.000621	0.001879	0.002281	0.002126	0.000652	0.001975	0.002399	0.00224
C3B	0.000621	0.00189	0.002281	0.002024	0.000651	0.001985	0.002398	0.00214
C4B	0.000602	0.001874	0.00221	0.002043	0.00063	0.001972	0.002319	0.002156
C5B	0.000538	0.001815	0.002224	0.002057	0.000566	0.001903	0.002334	0.002172
C2C	0.000594	0.001859	0.002262	0.002112	0.000545	0.001897	0.002326	0.002184
C3C	0.000595	0.001869	0.002261	0.002029	0.000544	0.001894	0.00233	0.002166
C4C	0.00058	0.001855	0.002214	0.002046	0.000546	0.001905	0.002328	0.002164
C5C	0.00053	0.001815	0.002224	0.002057	0.000544	0.001903	0.002334	0.002172

TABLE 3 STOREY DRIFT FOR RS_X AND RS_Y

Story Level	RSx				RSy			
	10F	6F	3F	FF	10F	6F	3F	FF
NB	0.000361	0.001474	0.002061	0.002015	0.000497	0.001525	0.001846	0.002018
C2A	0.000361	0.001476	0.002068	0.002048	0.000493	0.001517	0.001975	0.002035
C3A	0.00036	0.001473	0.002064	0.002018	0.000494	0.001516	0.001972	0.002006
C4A	0.000361	0.001471	0.002055	0.002007	0.000496	0.001519	0.001973	0.002009
C5A	0.000355	0.001469	0.002056	0.002011	0.000492	0.001523	0.001982	0.002018
C2B	0.000461	0.001581	0.00217	0.002133	0.000566	0.001584	0.002026	0.002062
C3B	0.000452	0.001567	0.002136	0.00201	0.000567	0.001586	0.002016	0.001983
C4B	0.000424	0.001523	0.002051	0.002002	0.000559	0.001569	0.001961	0.001995
C5B	0.000368	0.001468	0.002055	0.002009	0.000519	0.001521	0.001981	0.002016
C2C	0.000433	0.001551	0.00214	0.002109	0.000494	0.001519	0.001977	0.00203
C3C	0.000427	0.001541	0.002112	0.002009	0.000494	0.001515	0.001979	0.002011
C4C	0.000406	0.001506	0.002052	0.002004	0.000496	0.001525	0.001973	0.002008
C5C	0.000363	0.001467	0.002054	0.002009	0.000495	0.001521	0.001981	0.002016

TABLE 4 STOREY DISPLACEMENT FOR EQ_X AND EQ_Y

Story Level	EQX				EQY			
	10F	6F	3F	FF	10F	6F	3F	FF
NB	54.187	41.539	23.622	10.257	56.929	43.671	24.885	10.845
C2A	54.189	41.632	23.842	10.544	56.954	43.797	25.154	11.192
C3A	54.218	41.645	23.832	10.199	56.963	43.779	25.101	10.774
C4A	54.322	41.704	23.537	10.218	57.067	43.84	24.795	10.805
C5A	54.778	41.907	23.838	10.352	57.547	44.057	25.111	10.945
C2B	56.418	42.791	24.353	10.648	59.349	45.005	25.623	11.203
C3B	55.999	42.313	23.772	10.079	58.923	44.534	25.062	10.666
C4B	55.235	41.705	23.451	10.182	58.083	43.863	24.698	10.762
C5B	54.277	41.504	23.608	10.252	57.028	43.634	24.871	10.84
C2C	55.813	42.472	24.209	10.614	57.016	43.816	25.115	11.12
C3C	55.483	42.087	23.737	10.111	56.987	43.807	25.13	10.8
C4C	54.948	41.667	23.488	10.197	57.098	43.866	24.794	10.802
C5C	54.25	41.505	23.609	10.252	57.008	43.635	24.87	10.839

TABLE 5 STORY DISPLACEMENT RS_X AND RS_Y

Story Level	RSX				RSY			
	10F	6F	3F	FF	10F	6F	3F	FF
NB	46.905	37.816	22.658	10.093	45.012	36.138	22.169	10.197
C2A	47.404	38.309	23.123	10.495	45.202	36.386	22.492	10.56
C3A	47.243	38.163	23.005	10.101	45.075	36.259	22.361	10.132
C4A	47.049	37.968	22.581	10.056	45.048	36.2	22.064	10.151
C5A	46.846	37.718	22.61	10.076	45.049	36.116	22.165	10.201
C2B	50.448	40.101	23.975	10.745	46.938	37.124	22.684	10.462
C3B	49.274	39.06	23.091	10.062	46.362	36.581	22.17	10.013
C4B	47.819	37.991	22.525	10.03	45.619	36.069	21.913	10.082
C5B	46.828	37.696	22.595	10.066	45.044	36.1	22.15	10.188
C2C	49.564	39.568	23.714	10.662	45.163	36.329	22.415	10.474
C3C	48.631	38.727	22.991	10.061	45.091	36.28	22.383	10.149
C4C	47.559	37.94	22.545	10.039	45.065	36.213	22.059	10.15
C5C	46.806	37.691	22.592	10.065	45.032	36.096	22.148	10.187

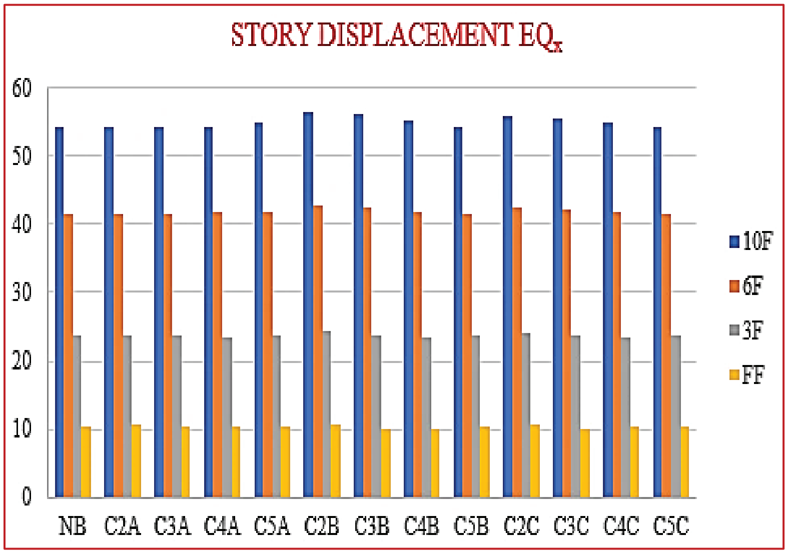

FIGURE 16. Story displacement EQ_x

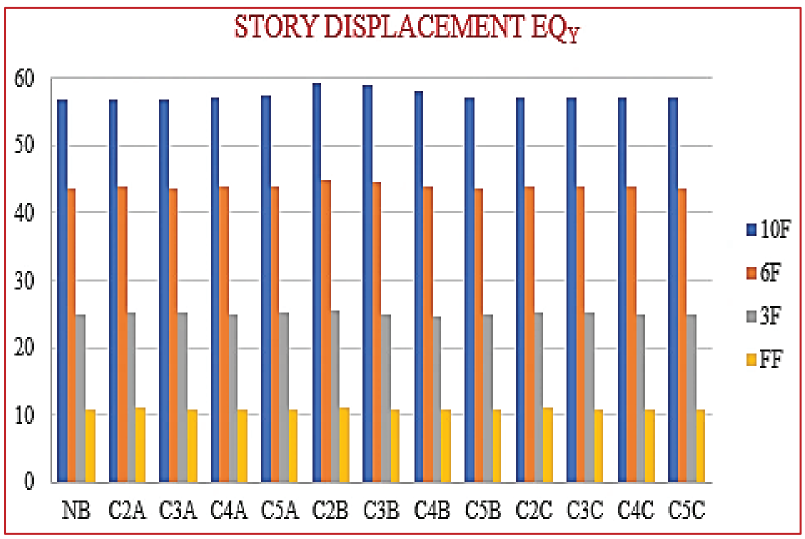

FIGURE 17. Story displacement EQ_y

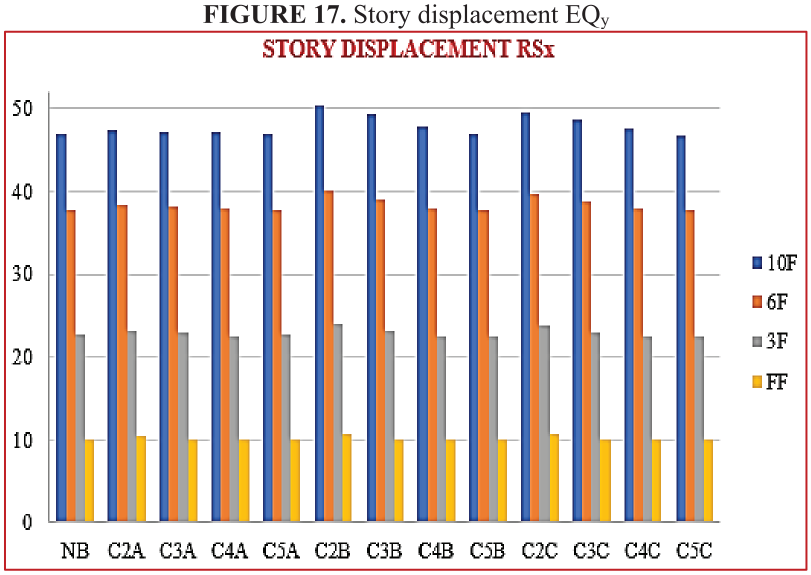

FIGURE 18. Story displacement RS_x

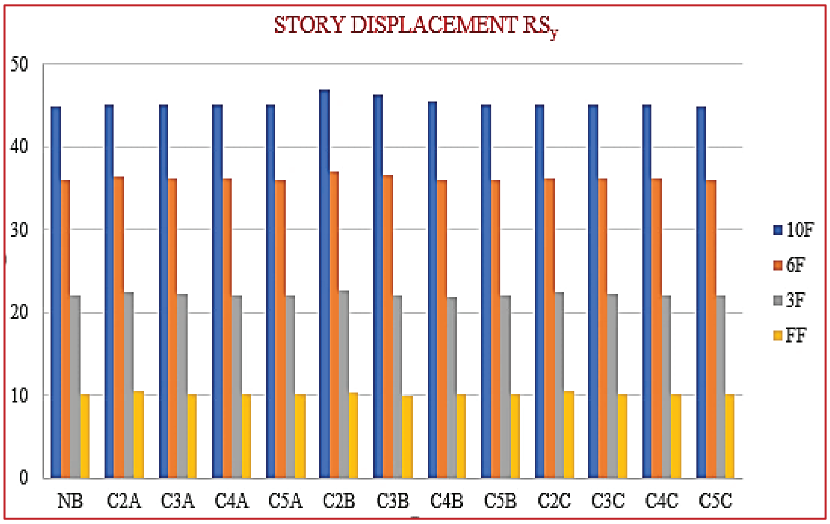

FIGURE 19. Story displacement RSy

TABLE 6 BASE SHEAR FOR ESA AND RSA

Model	Equivalent Static Analysis		Response Spectrum Analysis	
	EQ_x	EQ_y	RS_x	RS_y
NB	3630.74	3480.72	3635.86	3437.56
C2A	3607.17	3456.46	3654.115	3422.523
C3A	3608.3	3459.57	3634.348	3412.405
C4A	3616.7	3467.51	3621.964	3423.22
C5A	3665.81	3514.38	3633.136	3451.394
C2B	3533.13	3387.91	3647.439	3364.163
C3B	3560.1	3410.65	3615.37	3370.463
C4B	3605.62	3455.68	3613.623	3401.376
C5B	3629.27	3479.39	3626.463	3434.035
C2C	3555.93	3466.72	3648.783	3428.213
C3C	3576.01	3458.35	3619.268	3410.859
C4C	3610.13	3466.69	3616.365	3422.714
C5C	3629.21	3478.92	3625.992	3433.776

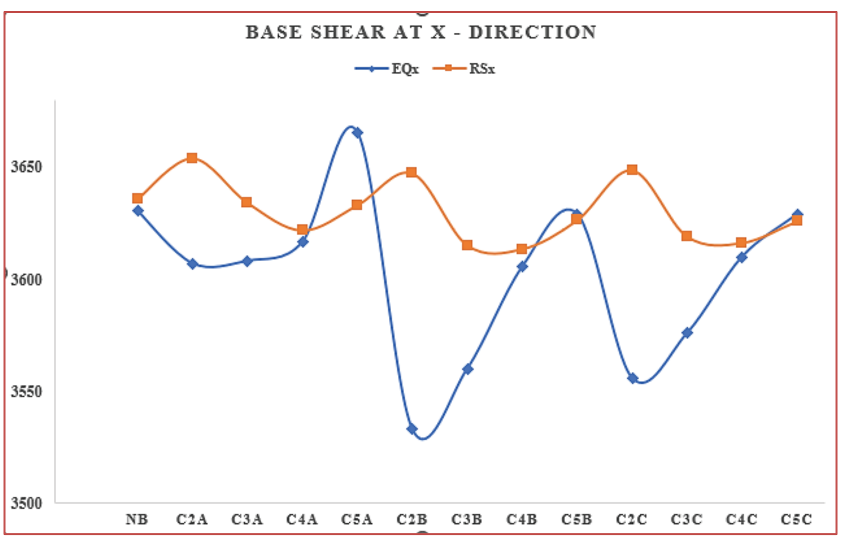

FIGURE 20. Comparison of base shear in EQ_x and RS_x

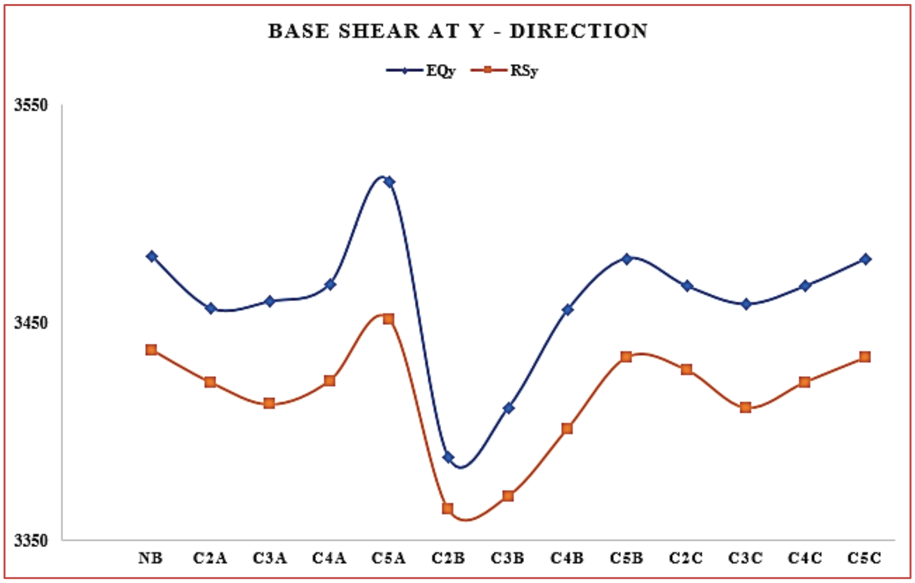

FIGURE 21. Comparison of base shear in EQ_y and RS_y

DISCUSSIONS

Based on the modeling and analysis of the different models (Cases 1 to 5) in which the location of the floating column is changed at different positions and the introduction of a floating column on the 1, 3, 6,10 floor occurs. The following findings are generated from a linear static and dynamic analysis of a building subjected to normal building and floating column. The outcomes are compared to those in this paper. The following inferences are drawn from these findings.

- There is an increment in the story drift value of 18.51%, 18.01%, 14.9%, 2.67%, 13.35%, 13.6%,10.7%,11.27% in model C2b, C3b, C4b, C5b, C2c, C3c, C4c, C5c, respectively in EQx and EQy direction with respect to NB1, (Normal building) with the data that the inclusion of a floating column higher values can be obtained if floating column located in CA1, CA6, CF1, CF6 building.
- There is an increment in the story drift value of 27.70%, 25.20%, 17.45%, 1.93%, 19.94%, 18.28%,12.46%,0.55% in model C2b, C3b, C4b, C5b, C2c, C3c, C4c, C5c, respectively in RSx and RSy direction with respect to NB1, (Normal building). Similarly decrement of 0.63%, 0.51%, 0.13%, 1.39% in model C2a, C3a, C4a, C5a, respectively in RSx & RSy direction with respect to NB1, we can learn from the data that the inclusion of a floating column higher values can be obtained if floating column located in CA1, CA6, CF1, CF6 building.
- For base shear, the decrement value is observed in floating column models. The decrease can be seen as 0.6%, 0.61%, 0.38%, 2.68%, 1.94%, 0.69%,0.04%, 2.06%,1.50%, 0.57%, and 0.04% in model C2a, C3a, C4a, C2b, C3b, C4b, C5ba, C2c, C3c, C4c, C5c with respect to NB1 models in EQx and EQy directions. In RSx and RSy direction the decrement value is 0.04%, 0.38%, 0.07%, 0.56%, 0.6%, and 0.25% ,0.455%,0.53%,0.27% in model C3a, C4a, C5a, C3b, C4b, C5b, C3c, C4c, C5c with respect to NB1.There is an increment value of base shear seen as 0.96 % in EQx and EQy directions in model C5a.In RSx and RSy directions the value is increase as 0.5%, 0.32%, 0.35%, in C2a, C2b, C2c respectively.
- There is an increment in the story displacement value from bottom story to top story of 0.3%, 0.5%, 0.24%, 1.09%, 4.11%, 3.346%,1.93.7%,0.16% ,3%,2.39%, 1.40 %, 0.11 %, in model C 2a, C3a, C4a, C5a, C2b, C3b, C4b, C5b, C2c, C3c, C4c, C5c respectively in EQx and EQy direction with respect to NB1, (Normal building).
- In RSx and RSy directions the displacement is increase in 1.06%,0.72%,0.30%,7.55%,5.05%, 1.94%, 5.68%, 3.67%,1.39%, in model C 2a, C3a, C4a, C2b, C3b, C4b, C2c, C3c, C4c, and the displacement values are decrease in 0.12%,0.14%,0.21% in model C5a, C5b, C5c respectively. It can be concluded that from the data that the inclusion of a floating column from bottom story to top story higher values can be obtained if floating column located in CA1, CA6, CF1, CF6 building.

CONCLUSION

- To derive the parameters story displacements, story shear, and story drift for seismic zones IV, seismic analysis of G+10 story buildings is performed using both equivalent static and response spectrum methods.
- The results of the analysis show that the drift values for all of the cases analyses follow a similar pattern along with story height, The inter-story drift is maximum at 3rd floor in all cases and linearly decreased at the top story.
- The story drift is larger in structures with floating columns (CA1, CA6, CF1, CF6,) located in corner of the building than other models.
- Inter story drift at each floor for the building it is seen that building with a floating column in all cases will experience extreme inter-story drift than the normal building in zone IV.
- The base shear value will not vary much compared to static and dynamic analysis, since these values are dependent on building parameter not on earthquake behaviour.
- By the introduction of floating columns in a building base shear value decreases in C2b, in EQx & EQy directions in all the cases. In RSx &RSy the value is less in Base shear value is more in C2a, compare to all other models.
- The story displacements increase when floating columns are introduced in the building. The deflections were more in C2b, C3b, C4b, as compared to all other models. which proves that buildings with floating columns located in corner of the building at ground floor are more vulnerable during earthquake.
- Whether the floating columns on GF or 10F the displacement values increases when a floating column is provided in (CA1, CA6, CF1, CF6,) corner of the structure than floating column located in (CB2, CB5, CE2, CE5, CA5, CF5, CA2, CF2) in Zone IV.
- It is observed that displacement in building is greater in the top stories and lesser in the bottom stories for all the cases.
- From the analysis, it is observed that the floating column at different locations of a building results in to variation in response to earthquake forces and most critical case is providing the floating column at the corner of the structure.
- The dynamic analysis shows much practical result compared to static analysis. The Model C2b, C3b, C4b, being highest in both static, dynamic, and lowest being C5a.
- The best location of floating column is top story it is acceptable in all the conditions.
- Hence, floating columns should be avoided as far as possible in seismic regions and if they are unavoidable. To develop the design methodology for safe and economical design of floating column the structure should be strengthened by adopting some remedial features. like providing a shear wall, bracings, dampers etc.

REFERENCES

1. Andwal, N. I. B., Ande, A. N. P., Endhe, V. A. M., & Adav, A. M. Y. (2014). To Study Seismic Behaviour of RC Building with Floating Columns. *International Journal of Science Engineering & Technology Research*, *03*(08), 1593–1596.
2. Bhensdadia, H., & Shah, S. (2015). (2015). Pushover Analysis of Rc Frame Structure With Floating Column and Soft Story in Different Earthquake Zones. *International Journal of Research in Engineering and Technology*, *04*(04), 114–121. https://doi.org/10.15623/ijret.2015.0404020
3. Deepak Maheshkar, K. G. (2021). IRJET- Analysis of G+12 Building with Floating Column under Seismic Loading. *Irjet*, *8*(3), 1520–1529.
4. Duduskar, R., Yerudkar, D. S., & Sharma, M. R. (2021). IJERT-Seismic Analysis of Multi- Storey Building with and without Floating Column and Shear Wall Seismic Analysis of Multi-Storey Building with and without Floating Column and Shear Wall. *Seismic Analysis of Multi-Storey Building with and without Floating Column and Shear Wall*, *10*(07), 668–675.
5. Goud, R. (2017). Study of Floating and Non-Floating Columns with and Without Earthquake. *International Journal of Science Technology & Engineering*, *4*(1), 152–157.
6. IS 1893 (Part 1). (2016). IS 1893 (Criteria for Earthquake resistant design of structures,Part 1:General Provisions and buildings). *Bureau of Indian Standards, New Delhi*, *1893*(December), 1–44.
7. KeerthiGowda, B. S., & Tajoddeen, S. (2014). (2014). Seismic analysis of multistorey building with floating columns. *Seismic Analysis of Multi-Storey Building with Floating Columns*, 356–365. https://doi.org/10.22214/ijraset.2019.3028
8. Kumbhar, G., & Banhatti, A. (2016). Seismic Retrofitting of Building with So Storey and Floating Column.

Irjet, *03*(07), 1917–1921.
9. Lingeshwaran, N., Kranthinadimpalli, S., Kollasailaja, Sameeruddin, S., Kumar, Y. H., & Madavarapu, S. B. (2021). A study on seismic analysis of high-rise building with and without floating columns and shear wall. *Materials Today: Proceedings*, *47*(xxxx), 5451–5456. https://doi.org/10.1016/j.matpr.2021.07.120
10. Mundada, A. (2014). Comparative Seismic Analysis of Multistorey Building with and without Floating Column Comparative Seismic Analysis of Multistorey Building with and without Floating Column. *International Journal of Current Engineering and Technology*, *4*(October 2014), 3395–3400.
11. Nayel, I. H., Abdulridha, S. Q., & Kadhum, Z. M. (2018). The effect of shear wall locations in rc multistorey building with floating column subjected to seismic load. *International Journal of Civil Engineering and Technology*, *9*(7), 642–651.
12. Pankaj Agarwal, & Shrikhande, M. (2007). Seismic Retrofitting Strategies of Reinforced Concrete Buildings. In *Earthquake Resistant Design of Structures* (pp. 524–555).
13. Pradeep, D., & Ashwini, B. T. (2017). Seismic Analysis of Multi-Storey Building. *IJSDR*, *2*(9), 110–116.
14. Sawai, G., Atif, M., & Khan, Y. (2021). Seismic Analysis of Multi-Storey Building with Floating and Non Floating Column. *IJECS*, *4*(7), 16–19.
15. SHARMA, S., & Pastariya, S. (2020). (2020). Effect of Floating Columns on Seismic Response of Multistory Building. *International Journal of Advance Scientific Research And Engineering Trends*, *5*(12), 795–800.
16. Shashikumar, N. S., Gowda, M. R., Ashwini, B. T., & Kumar, Y. M. V. (2018). Seismic Performance of Braced Framed Structure With Floating Column. *International Journal of Scientific Development and Research*, *3*(6), 388–405.
17. C. Vivek Kumar, A. Ganesh, J. Bommisetty, L. Maithri Varun, A. Naga Saibaba and R. Ravinder(2022), "Evaluation of Response Spectartrum and Equivalent Static Analysis for recognizing the safest position of Floating Columns by ETABS in Zone V,"*IEEE Xplore*, pp. 209-216, doi: 10.1109/CISES54857.2022.9844329.
18. Chandra Kumar, Vivek Kumar, Manisha, Patam, Sadula, Pooja. (2020). Behavior of Monotonic Loading for Glass Fibre based High Performance Concrete in External Beam-Column Joint using ANSYS. Analysis. *E3S Web of Conferences.* 184. 01088. 10.1051/e3sconf/202018401088.
19. K Ajay Kumar, A Venkat Sai Krishna, S Shrihari, V Srinivasa Reddy (2021), Studies on stress-strain behaviour of concrete mixes confined with BFRP rebars, E3S Web Conf. 309 01049, DOI: 10.1051/e3sconf/202130901049