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Effect of Floating Column on RCC Building With and Without Infill Wall Subjected Seismic Force

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Abstract — *In recent times, multi-storey buildings in urban cities are required to have column free space due to shortage of space, population and also for aesthetic and functional requirements. For this buildings are provided with floating columns at one or more storey. These floating columns are highly disadvantageous in a building built in seismically active areas. The earthquake forces that are developed at different floor levels in a building need to be carried down along the height to the ground by the shortest path. Deviation or discontinuity in this load transfer path results in poor performance of the building. The object of the present work is to study the behaviour of G+3 buildings having floating columns. However recent studies based on floating columns, which mostly concentrated on higher seismic zones and very few works is available for lower seismic zones Also to obtain the effects of mass variations and infill walls on behaviour of normal and floating column building*

Keywords- *floating column, hanging column, performance point*, Seismic Behavior, Lateral Displacement, Storey Drift

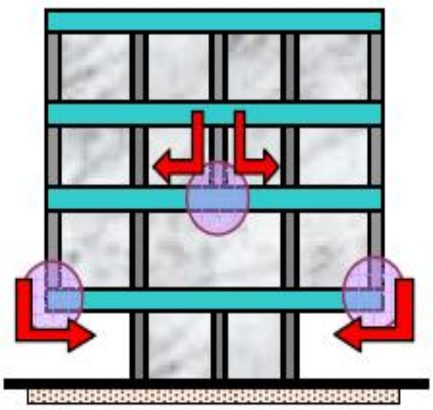
I. INTRODUCTION

Many multi-storey 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's 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.

1.1 Floating Column

A column is supposed to be a vertical member starting from foundation level and transferring the load to the ground. The term floating column is also a vertical element which (due to architectural design/ site situation) at its lower level (termination Level) rests on a beam which is a horizontal member. The beams in turn transfer the load to other columns below it. [1]



Hanging or Floating Columns

II. LITERATURE REVIEW

Seismic response on building due to floating column

In recent times, multi-storey buildings in urban cities are required to have column free space due to shortage of space, population and also for aesthetic and functional requirements. For this buildings are provided with floating columns at one or more storey. These floating columns are highly disadvantageous in a building built in seismically active areas. The earthquake forces that are developed at different floor levels in a building need to be carried down along the height to the ground by the shortest path.

Suchita Hirde et al (2016) author had compared seismic performance of building conventional floating columns building for various seismic zones in case of medium soil. For this purpose they adopt Pushover to get performance point and hinge pattern in a multi-storey buildings. To achieve this objective, they create model of G+7 storey normal building and building with different locations of floating columns

1	Type of Structure	SMRF
2	Grade of concrete	M30
4	Size of building	12.5 X 24m
5	Grade of steel	Fe 415
6	Floor to floor height	3.5 m
7	Plinth height above GL	1.2 m
8	Parapet height	1.5 m
9	Slab thickness	0.20 m
10	External wall	0.23 m
11	Internal wall	0.15 m
12	Size of column	C1: 300 x 800mm C2: 300 x 600 mm C3: 500 x 800 mm
13	Size of beams	B1: 300 x 500 mm B2: 500 x 800 mm
14	Live load on floor	$3kN/m^2$
15	Live load on roof	$1.5\ kN/m^2$
16	Floor finishes	$2\ kN/m^2$
17	Roof treatment	$1.5\ kN/m^2$
18	Density of concrete	$25\ kN/m^3$

Figure 1 Building description

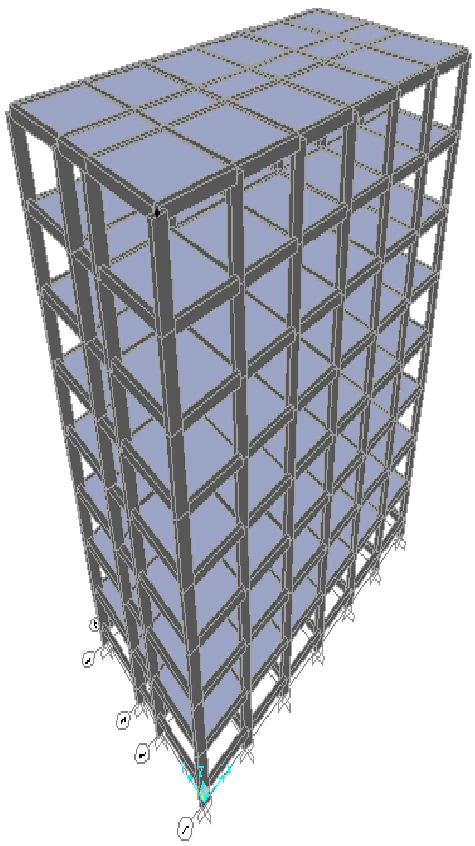


Figure 2 Isometric view of model

The results obtained from non-linear static pushover analysis on all the building models as per different zone are presented in table 2 in the form of base shear, story displacement, performance point and performance level for model without floating columns and with floating columns are shown in table 2.

Building	Earthquake Zone	Performance Point				Seismic Performances level
		X direction		Y direction		
		V (kN)	D (mm)	V (kN)	D (mm)	
Building Without floating columns	III	1420.891	103	1521.638	95	Behind IO
	IV	1523.782	161	1654.791	149	IO-LS
	V	1719.914	467	1932.853	409	Beyond LS
Building with floating columns in which dimension increases at one floor	III	1455.247	90	1571.008	82	Behind IO
	IV	1565.796	133	1765.756	124	Beyond IO
	V	1732.114	376	2020.903	356	LS-CP
Building with floating columns dimension increases at two consecutive floors.	III	1550.752	84	1699.963	79	Behind IO
	IV	1667.635	123	1930.499	116	Behind IO
	V	1807.654	327	2184.424	308	Up to LS

From comparison of above result they had concluded that Due to increase in dimension at two consecutive floors for same building under same loading condition building with floating columns it is observed that the story displacement carried at performance point is decrease (improved) by 8 to 12% in all zone for X and Y direction respectively. There is very much increment in base shear for Building with floating column this is due to increase in seismic weight of building. Because of larger beam and column sizes are provided to resist load of floating columns. And Story displacement decreases with increase in dimension of beam and columns in case of floating columns building. [4]

Poonam et al (2012) studied the response of structurally irregular building frame subjected to seismic excitations. To obtain reliable results they modelled 10-storeyed plane frame in ETABS. Various frames having different irregularities but with the same dimension have been analysed to study their behaviour when subjected to lateral force. Different irregularities provided in this paper were mass irregularity at fourth and seventh level, reduction of stiffness at 4th and 5th storey by 50% compare to others, floating column provisions at second storey. Finally they conclude that, comparing all the cases the floating column frame is the weakest and showing maximum displacement. Also they found that there is maximum storey drift in a floating column frame on a soft storey level. [9]

Floating Column Building with Infill Wall

Previous experimental research on the response of RC frames with masonry infill walls subject to static and dynamic lateral cyclic loads (Fiorato et al., 1970; Broken and Bertero, 1981; Calvi and Bolignini, 2001; Negro and Verzeletti, 1996; Zarnic et al., 2001; Hashemi and Mosalam, 2006) have shown that infill walls lead to significant increases in strength and stiffness in relation to bare RC frames. Within conventional seismic design, which focuses on accelerations and strength, it may be difficult to recognize the benefits of increases in stiffness. However, research and field evidence (Shimazaki and Sozen 1988, Lepage, 1997; Wood, 1991) has shown that increases in stiffness are beneficial because they lead to reductions in the magnitude of the deformations induced by ground motions.

Susanta Banerjee et al (2014) had studied that Buildings with floating column are highly undesirable built in seismically active areas. Many urban multi-storey buildings today have floating column buildings which are adopted to accommodate parking at ground floor or reception lobbies in the first storey. 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. Floating column buildings are severely damaged during earthquake. Damage on this structure can be reducing by taking the effect of infill wall. This paper presents the effect of stiffness of infill wall to the damage occurred in floating column building when ground shakes. Modelling and analysis are carried out by non linear analysis programmed IDARC- 2D. Damage occurred in beams, columns, storey are studied by formulating modified Park & Ang model to evaluate damage indices. Overall structural damage indices in buildings due to shaking of ground are also obtained and concluded that Infill wall provides seismic strengthening of floating column building. It helps to reduce the seismic parameters of this type of building and Base shear is increased due to infill wall as it provides more stiffness on the structure. [7]

A.L. Ramírez-Márquez et al (2012) a large number of reinforced concrete (RC) frame structures built in earthquake-prone areas in developing countries are vulnerable to strong ground motions. In this paper a numerical experiment was conducted in which several idealized prototypes representing RC frame structures of school buildings damaged during the Port-au- Prince earthquake (Haiti, 2010) were hypothetically strengthened by adding elements representing masonry infill walls arranged in different configurations and studied under non-linear dynamic analysis. Each configuration had a different ratio *Rm* of area of walls in the direction of the ground motion (in plan) to the total floor area. The non linear response of the models under three major earthquakes which PGA 0.5*g* was estimated numerically. The results were summarized in tentative relationships between *Rm* and interstory drift, Park&Ang damage indexes, and dissipated energy. For *Rm*_4% computed interstory drift ratios did not exceed 1.5%.and conclude that This work investigated a potential retrofitting alternative for RC frame structures that have been damaged by severe earthquakes. It consists in adding masonry infill panels (preferably with reinforcement). The main advantages of using masonry infill panels instead of other solutions such as dampers or RC walls are the ease of construction, the low cost, and the minimum technology involved. [8]

Different Locations of Floating Columns

Open first story and Floating column are typical features in the modern multi-storey constructions in urban India. Such features are highly undesirable in buildings built in seismically active areas; this has been verified in numerous experiences of strong shaking during the past earthquakes like Bhuj 2001.

Hardik and Siddharth (2015) Undertook pushover analysis of RCC building with floating column with soft storey in different zones to determine the collapse load and ductility capacity of the structure. They had modelled g+4, g+9 and g+15 storey building in sap 2000. They analysed different models with different positions of floating columns like providing on edge, on face and on interior portion of frame. As a result they conclude that whether the floating columns on top floors or on ground floors the performance become poor when floating column is provided in edge and middle than face of the column. [2]

Gourav Sachdeva et al (2016) they had represent a comparative analysis carried out to evaluate the performance of RCC frame building with different position of floating column along with the seismic analysis. Different models were structured up by using the software STAAD Pro V8i., each being sub-divided into various sub-models, showing the different positions of floating column at each storey. Through this analysis, the best position of the floating column is located in each case on the basis of Parameters taken.
Also the equations are formulated such that the Maximum Displacement (in X & Z direction) along with Minimum Reaction (in Y direction) can be calculated up to 6 storey's SMRF (Special moment resisting frame) Building. And finally concluded that when the floating column provided near ground level is most hazardous. Therefore the best position of floating column is the top Storey. [5]

Varying dimension of rcc member

Floating columns building with increase in dimension of beam columns at two consecutive floor for different seismic zone i.e. III, IV, V resp. From this hinges are not formed at both the consecutive floor in any zone. it is much more improvement in formation of hinges after increase in dimension of beam and column of two consecutive floor.

sabari s and mr.praveen (2015) had studied that 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 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 roof displacement, inter storey drift, base shear, column axial force are computed for both the frames with and without Floating Column and the give the conclusion is that The dynamic analysis of frame is studied by varying column size dimension. It is concluded that by increasing the column size the maximum displacement and inter storey drift values are reducing. [6]

suchita hirde and dhananjay rahangdale (2016) had attempt a study to the comparison of seismic performance of building with normal building and floating columns building for various seismic zones in case of medium soil. For this purpose they adopt Pushover to get performance point and hinge pattern in a multi-storey buildings. To achieve this objective, they create model of G+7 storey normal building and building with different locations of floating columns are analyzed and the base shear and displacement of multi-storey RCC buildings have been compared and finally they concluded that Due to increase in dimension at two consecutive floor for same building under same loading condition building with floating columns it is observed that the story displacement carried at performance point is decrease (improved) by 8 to 12% in all zone for X and Y direction respectively. There is very much increment in base shear for

Building with floating column this is due to increase in seismic weight of building. Because of larger beam and column sizes are provided to resist load of floating columns. And Story displacement decreases with increase in dimension of beam and columns in case of floating columns building. [4]

III. SUMMARY OF REVIEW

From the study of all literature review it was observed that whether the floating columns on top floors or on ground floors the performance become poor when floating column is provided in edge and middle than face of the column. When the floating column provided near ground level is most hazardous. Therefore the best position of floating column is the top Storey. Floating column should be avoided in high rise irregular building in higher zone area, Story displacement decreases with increase in dimension of beam and columns in case of floating columns building and increasing in column and beam dimensions only on one floor does not reduce the displacement so dimensions should be increased in two consecutive storey's for better performance of irregular building.

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