A REVIEW ON SEISMIC ANALYSIS AND SUSTAINABILITY OF MULTI STOREY STRUCTURE WITH AND WITHOUT FLOATING COLUMNS

Er. Shashank Kalla[1], Er. Om Prakash Singh[2], Dr. Shailesh Choudhary[3]

[1]*M.E. Scholar, Department of Structural Engineering, M.B.M. College J.N.V.U Jodhpur*
[2]*Ph.D. Scholar, Department of Structural Engineering, M.B.M. College J.N.V.U Jodhpur*
[3]*Associate Professor, Department of Structural Engineering, M.B.M. College J.N.V.U Jodhpur*

Abstract - *With escalating urbanization, demand for greater spaces either in form of parking spaces, or in form of aesthetic view point or for ambiance from architectural verse sometimes let structural designer to plan and act according to it. Construction of multistorey structures with floating columns have been never a choice of preference for any structural engineer rather than being a demand or requirement from either owner or architect. But such structures are highly susceptible to be damaged during earthquakes in highly seismic zone as compared to normal structures. The paper turns out with static analysis done for multistorey structures with and without floating columns along with different cases of building structure are analyzed by varying the location of floating columns floor wise. The structural response of building models with respect to storey drift, storey displacement, base shear and time period for both building. The analysis is carried out using different structural analysis and design software SAP2000v17, STAAD-PRO and ETABS.*

Key Words: Floating column, Earthquake analysis, Multi-storey, Linear static method, Time history method, SAP2000v17, STAAD-PRO, ETABS.

1. INTRODUCTION

Now a day's, multistorey structures in urban cities are required to have column free space due to shortage of space, increasing population and also for aesthetic and functional requirements. To cope with such problems of parking accommodations or reception lobbies most of multistorey structures in India today prefers to have an open first storey as an unavoidable feature or finds it as easiest solution to the problem. Thus, to meet-up with situation use of floating columns starts, now talking about floating columns it's a vertical member without a foundation i.e. it rests on a beam. Being without foundation this floating column comes up as a point load over the beam and further this beam transfers the load to the columns below it. The floating column sometimes also serves purpose of architectural view and site situations. The Provision of floating columns can be stated as most of the buildings in India are covering the maximum possible area on a plot within the available by laws. Thus most times for fulfilling the desires we neglect behaviour of a building structures during earthquakes as it depends critically on geometry, size and overall shape, in addition with how the earthquake forces are carried to the ground. Hence, ultimately not following basics of dynamic of structures that earthquake forces developed at different floor levels need to be brought down along the height to the ground by the shortest path; any deviation or discontinuity here with load transfer path results in poor performance of the building structure. It had been found most of the energy developed during earthquake is dissipated by columns of the soft stories. Further transfer of this energy leads to formation of plastic hinges at the ends of columns, which transform the soft storey into a mechanism finally in such case the collapse is unavoidable. Building structures with vertical setbacks (like the hotel buildings, malls, etc. with a few storey wider than the rest) are most susceptible to cause a sudden jump in earthquake forces at the level of discontinuity. Structures with fewer columns or walls in a particular storey or with unusually tall storey tend to damage or collapse which is initiated in that storey. These are highly undesirable in building built in seismically active areas usually the civil engineering infra structures are subjected to two classes of loads, static and dynamic loads. The static loads such as dead load and live load are independent with respect to time in case of dynamic loads, they are changing with respect to time. Most of the cases the structures are designed with the assumptions that all the loads applied are static. Generally the dynamic loads i.e. earthquake loads are not taking account in the design because the buildings are not regularly subjected to earthquakes, and also it takes more time to solve these parameters in the analysis and also its more difficult to solve the solution.

It has been analyzed by using various designs and structural analysis software that for an open ground storey frame, retrofitting by introducing reinforced concrete wall in the open ground storey, offers the maximum strength and ductility. Building structures with columns that hang or float on beams at intermediate storey and not to go all the way to the foundation, have discontinuities in the load transfer path. These floating columns are highly disadvantageous in a building built in seismically active areas, especially after the desolating Nepal earthquake 25 April 2015 and tragic example of Bhuj earthquake occurred on 26 January, 2001 there have been a mutual effort throughout India to provide more awareness, especially in practice and education, with respect to earthquake resistant design of structures. Sustainability of such building structures could be achieved up-to a certain extent by providing seismic retrofitting, as it can be done in different ways and to various extents. The purpose should be to certify that the building takes all the damage, but does not collapse when severe earthquake occurs.

2. REVIEW OF LITERATURE

(1) Sukumar Bahera* - Their literature comes up with stiffness balance of first storey and above storey are studied with the aim to minimize irregularity occurring with due presence of a floating column. To make sure how structures under different earthquake excitation having a different frequency content responses keeping the time duration factor and PGA constant they develop FEM codes for 2D frames with and without floating column. This behaviour of building structure frames with and without floating columns is studied for cases under static load, free vibration and forced vibration condition. For developing the finite element codes MATLAB is used as primary platform. Various computations including inter storey drift, overturning moment, base shear, time history of floor displacement has been done for both the frames with and without floating column. Furthermore, study for dynamic analysis of frame by varying the column dimension had also been done. It concludes that, with increment in ground floor column values for the maximum displacement and inter storey drift seems to be reduced. The change in column dimension also leads to variation in base shear and overturning moment.

(2) A.P. Mundada*, S.G. Sawadakar - The paper covers up the study for architectural and the framing drawing of the building structure having floating columns. A comparison for a G+7 existing residential building structure with and without floating column are taken to carry out entire project work. The design creation of models and equivalent static analysis of the models both have been done through the use of STAAD ProV8i. Various parameters including moment distribution, importance of line of action of force, axial load and seismic factors are studied for designed models. Thus, finally provides an edge to find various analytical properties of the structure as well as provides criteria for very systematic and economical design for the structure.

(3) Shrikanth M.K*, Yogendra R. Holebu – The literature is about comparison of study for the behavior of a building structure having only floating column and having floating column with complexities. High rise building structures have been analyzed for different intensity of earthquake force. The study consist of creation of four models and analysis for lower and higher seismic zones at medium soil condition. Analysis being carried out with help of extended 3-D analysis of building system ETAB version 9.7.4 software. Result being computed in regarding soft storey, storey drift and displacement for designed four models and finally tabulated on basis of linear seismic analysis.

(4) Hardik Bhensdadia*, Siddarth Shah – Their study is an attempt made to evaluate the effects of floating column & soft story in different earthquake zones by seismic analysis. As the analysis yields performance level of building structure for design capacity (displacement) carried out up to failure and to meet out this requirement methodology of push over analysis is being adopted as it helps in determination of collapse load and ductility capacity of the structure. For fulfillment of this objective three RC bare frame structures constituting of G+4, G+9, G+15 stories respectively have been analysed and compared for base force and displacement of RC bare frame structure with G+4, G+9, G+15 stories. Providing different earthquake zones intensity like Bhuj, Jamnagar and Rajkot using SAP 2000 14 analyses package.

(5) T. Raja Sekhar*, P.V. Prasad – The study provides up with the behavior of building frame structure with and without floating column and is studied for different cases of dynamics under static load, free vibration and forced vibration condition. The results for same is being plotted for both the frames with and without floating column by comparing each other for different parameter of time history of floor displacement, base shear. A 3D model using the software STAAD Pro V8i is created and equivalent static analysis is carried out for the entire project. Comparison of these models are been presented. This will help to find various analytical properties of the structure and we may also have a very systematic and economical design for the structure.

(6) S.S. Kadam*, D.D. Mohite*, Ms. S.V. Lale*, Ms. Waykule S.B*, C.P. Pise, C.M. Deshmukh, Y.P. Pawar - The study comes up with the effect of varying the location of floating columns floor wise of multi storey RC building structure. Attempt to mark out various structural response quantities of the building structure using static analysis has been done. It was being observed that with introduction of floating column at 1st floor base shear of such building decreases as compared to building without floating column. Along with that it was also being found that base shear increases from 1st floor. The final observations lead to mark that displacement of each storey of floating column building is more than compared to without floating column building.

(7) Susanta Banerjee*, Sanjay Kumar Patra – The study point out the effect of stiffness of infill wall to the damage occurred in floating column building for ground shakes. Non linear analysis programme IDARC- 2D has been used to carry out modeling and analysis work. By formulating modified Park & Ang model damages occurred in beams, columns, storey are studied. Due to shaking of ground overall structural damage indices in buildings are also obtained. Various dynamic response parameters including storey drift, lateral floor displacement, base shear and time period of buildings are obtained and results are compared with the ordinary moment resisting frame buildings. Formation of plastic hinge, cracks, yields are also being observed during analysis. The final conclusion was being made that lateral floor displacement, storey drift of floating column building with infill wall are reduced in comparison to that floating column building without infill wall. It was also being concluded that values for fundamental time period, lateral floor displacement of floating column building are higher than ordinary moment resisting frame.

(8) Prerna Nautiyal*, Saleem Aktar, Geeta Batham – For various soil conditions, since there is no provision or magnification factor specified in I.S. Code, hence the determination of such factors for safe and economical design of a building having floating column is difficult there paper investigate about the effect of a floating column under earthquake excitation for different soil conditions. The study is done on bases of Linear Dynamic Analysis for 2D multi storey frame with and without floating column. To meet up the requirements the model of G+4 and G+6 building structures have been created, having changing the position of floating column. Furthermore, the response spectrum analysis is done for both building structures. Different dynamic response parameters including base shear and moment for hard and medium soil condition are obtained for both building models.

(9) Sreekanth Gandla Nanabala*, Pradeep kumar – The literature deals with the fact to find to parameters firstly, whether structure is safe or unsafe with floating column when built in seismically active areas and secondly, are floating column in building economical or uneconomical. The whole analysis is carried by modeling of G+5 storey normal building and one with floating column building. This analysis was done by use of SAP2000 external lateral load were calculated manually using equivalent static method for analysis created 2D 3model, model1, model2, model3. Model1 being a normal building with same dimension of beam and column, model2 being with floating column building without changing dimensions and model3 being a floating column building with changing dimension of beam and column. Finally, comparing them on displacement due to lateral load in terms of model1, model2, model3 and also based on stiffness & time history analysis. To check economy of both building compares steel and concrete quantity in terms of model, model2, model3 and was concluded that one with floating columns requires larger quantity with compare to one that doesn't have a floating columns.

(10) Er. Ashfi Rahman* - The study comes up with response spectrum method for static analysis and dynamic analysis. It's done for multi-storeyed building structures with and without floating columns. By varying the location of floating columns floor wise and within the floor different cases of the building structure is studied. The structural response of different parameters of the building models with respect to Spectral acceleration, Base shear, Fundamental time period, Storey drift and Storey displacements is investigated. STAAD Pro V8i software was used to carry out the analysis.

(11) S.B.Talavara* - It gives a comparative study of seismic analysis of multi-storied building structures consisting of both cases i.e. with and without floating columns. The entire analysis is done by taking up Response Spectrum Analysis, as per IS: 1893-2002. Different features of lateral stiffness strengthening system, including lateral bracing, shear walls, increasing the column size in the soft ground storey. Project modeling is done with ETABS 3D model and the comparison of these models are been presented with their combinations, and are proposed to reduce the stiffness irregularity and discontinuity in the load path incorporated by the soft ground storey and the floating columns respectively. The study consist of two models A & B and each furthermore having five different models (namely 1A, 1B, 1C, 1D, 1E, 2A, 2B, 2C, 2D, 2E) with each one having different structural compositions, comparison and study of these different models have been taken up. Various parameters such as base shear, storey drift and displacement are within the permissible limit except the displacement provided by Time history analysis for normal multistorey building. Provision of floating column could be advantageous in increasing FSI to a certain extent of the building but is a risky factor and increases the vulnerability of the building. Multistorey building with shear walls comes out with the peak value of base shear in time history analysis. It was found that shear wall retrofit is the best method of retrofit the soft storey as it also reduces the displacement of the whole structure and offers the maximum strength (frequency) and ductility. The base shear value shows up increase for buildings with steel braced soft story in comparison to without steel bracing indicating increase in stiffness and ductility of building. As per final outcomes out of all the three methods used to evaluate base shear, Multistorey building with shear walls were found to perform better from the points of view of strength, stiffness, ductility and frequency profile compared to normal multistorey building.

(12) D. Annapurna, Sriram Nadipelli* - The paper deals with the comparison of a G+5 storey building with all columns and a similar structure without edge columns or with floating columns, i.e. from the first story to the top storey all columns are present except for the ones at ground. Thus, mechanism for load transfer goes from edge columns to the interior ones present in the ground storey. Up to the extent applying the static loads both the structures are found be safe but as the dynamic loads like earthquake loads in lateral direction the structure without edge columns is unsafe, that is displacement of this structure is more than the structure with edge columns and stiffness of a structure is also less than the structure with edge columns. For study three models 1 (normal), 2 (with floating column) & 3(with floating column and increased structural components) all having different specifications have been prepared using structural design and analysis software ETABS. Due to application of lateral loads in X and Y directions the displacements of Model 2 and Model 3 building found to be more than displacements of model 1 building. So the Floating column buildings are unsafe for construction when compared to a Normal building. On mitigating the problems of model 2 in model 3 building, it was found that floating column building can be made safe by increasing the size of transfer girder beams and size of columns adjacent to floating columns to which finally load is transferred. Calculating lateral stiffness at each floor for the buildings, it is observed that model 2 and model 3 buildings that are for buildings with floating columns will suffer from extreme soft storey effect, where model 1 being a normal one is free from soft storey effect. So the floating column building is unsafe. Furthermore, after the analysing and comparing the quantity of steel and concrete for model 1 & 3 building, from which it is identified that model 3 building has more quantities of rebar steel and more concrete quantities than model 1 building. So the Floating column building will be uneconomical when compared to normal building. From the time history analysis it is noticed that the model 2 and model 3 building is having more displacements than model 1 building. Hence, floating column building seems out to be unsafe than a normal building.

(13) Shiwli Roy*, Gargi Danda de – The paper presents the floating column and RCC column analysis on multistoried building and analyzed by STAAD PRO V8i. Here G+3, G+5 and G+10 structures are analyzed and compared with parameters shear force and bending moment. The analysis is carried out on a building structure with floating columns. The building considered is a multistorey building having G+3, G+5 and G+10 structures. All three models having different heights from 12 m, 18 m & 36 m are designed and analyzed by creating fixed support on ground storey, by assigning dead load & live load for floating column as well as for proper RCC column. The analysis on floating column for G+3, G+5 and G+10 structures observes that if the height of the structure increases, the shear force and bending moment also increases. Following are some conclusion as done on above study: Along with that it was observed that as the situation and orientation of columns varies the value for column shear also varies. On comparison for shear force for G+3 with normal column, floating column (column removed from G.F.) and floating column 1 (column removed between F.F. & S.F.) the variation shows that the shear force is maximum in floating column (column removed from G.F.) the shear force increases by a value about 57% for G+3 (normal column) to G+3 (floating column) structures and 6.67% for G+3 (floating column) to G+3 (floating column1)structures in column1 (column for G.F.) and in column2 (column for F.F.) it increases by 56% for G+ 3 (normal column) to G+3 (floating column)structures and 3.42% for G+3 (floating column) to G+3 (floating column1) structures. While on comparison for bending moment for G+3 structure in normal column, floating column (column removed from G.F.) and floating column 1 (column removed between F.F. & S.F.) it was found that the variation in bending moment shows that the bending moment is maximum in floating column 1 (column removed between F.F. & S.F.) the bending moment increases by 10.25% for G+3 (normal column) to G+3 (floating column) structures and 12.82% for G+3 (floating column) to G+3 (floating column1) structures in column1 (column for ground floor) and in column2 (column for F.F.) it increases by 5.98% for G+3 (normal column) to G+3 (floating column) structures and 11.96% for G+3 (floating column) to G+3 (floating column1) structures.

(14) Sampath Kumar M.P.*, V.S. Jagadeesh – The literature analyze tall structures with floating column basically includes a preparatory outline, theoretical outline, advancement and clear investigation to securely convey gravity and lateral loads. The outline criteria include serviceability, strength, stability and human comfort. Floating column is a vertical component which closes at its lower load level and lies on beam and exchange the load of the structure through column to beam. The conclusions as per there study were that lateral displacement increases with the height of the building. The displacement parameter is more for the floating column buildings compared with the regular building. Similarly, it was found building structures displacement increases with the height of column. Mass irregularities of building seem to posses higher displacement than that of regular building and soft story building. Inter storey drift increases from top storey, later the storey drift reduces due to stiffness near fixed end at base. As the stiffness and mass parameter increases the base shear also increases. Base shear is observed lesser in the floating column building when compare to regular building due to decrease in column weight. Finally, from the study concludes that as for as possible, the floating columns should be avoided, especially in the seismic prone areas.

(15) Niteen Malu*, Amaresh.S.Patil – As per scope of this literature a G+10 storey building structure is taken for the analysis. Building frame being prepared in ETABS by defining beam, column and slab. Slab was modelled as thin membrane. Frame elements being taken as rigid. Hinges being also assigned to these frame elements. These hinges are default hinges available in ETABS. For seismic analysis structures in earthquake zone II and zone V with soil type II (medium soil) were considered. Four different models were created in ETABS constituting of Regular building (with & without floating columns) and Irregular building (with & without floating columns). Their analysis and outcomes include, as the magnitude of intensity will be more for higher zones, a sudden increase in displacement about 18-23% could be seen from lower zones to higher zones. It was also observed base shear performance of buildings was more for case of structure without floating column in comparison to those with floating columns. The parameters like bending moment and shear force in column where the floating column is provided at storey 5 is found to be more about 45% and 40% in compare to similar storey without floating columns.

3. CONCLUSIONS

After going through all above literature reviews there were certain conclusions to be marked out for longer sustainability of structures some of these marked out points have been discussed below:

1. It was observed that building structures with floating column comes out with less base shear as compared to ones without floating column.

2. Displacement factor for floating column building observes out to be more than compared to without floating column building.

3. Talking about storey drift it was found to be more for building structures with floating column as compared to building without floating column.

4. From dynamic analysis point of view it was observed that floating column at different location results into variation in dynamic response.

5. Buildings with floating column observed out to have more time period as compared to building without floating columns.

6. It was also found that as shift of floating column starts towards top of the building it results out in increasing time period which is majorly because of decreased lateral stiffness of the building.

7. As we increase the number of storey's the inter storey drift also increases. The storey drift is more for the floating column buildings because as the columns are removed the mass gets increased.

8. On calculation analysis of lateral stiffness at each floor for most of the buildings it is observed that floating column building will suffer extreme soft storey effect where normal building is free from soft storey effect. Making the floating column building unsafe.

9. After overall analysis of buildings, it was found on comparing for quantity of steel and concrete it was found there was increase in both physical parameters for building structures with floating column building than a normal building. Ultimately making floating column building uneconomical.

10. From the study of all above literature review it was observed that there is still a lot of study required to make sure that provision of floating column in building to be safe from earthquake point of view. It have been observed from almost all literature review the building structures without floating columns seems to give better results as compared to floating column building so more study required for this. Hence, finally from the study it can be concluded that as far as possible, the floating columns are to be avoided especially, in the seismic prone areas.

REFERENCES

[1]. Sukumar Behera Seismic analysis of multistory building with floating column, Department of Civil Engineering, National Institute of Technology Rourkela (May 2012).

[2]. A.P.Mundada Comparative seismic analysis of multi storey building with and without floating column, International Journal of Current Engineering and Technology, Vol.4, No.5 (Oct 2014)

[3]. Shrikanth M.K. Seismic response of complex building with floating column and without floating column, International journal of Engineering Research-Online. A Peer Reviewed International Journal. Vol. 2, Issue 4, (2014).

[4]. Hardik.Bhensdadia Pushover analysis of RC structure with floating column and soft storey in different earthquake zones, frame International Journal of Research in Engineering and Technology. Vol. 4, Issue 4 (Apr-2015).

[5]. T. Raja. Sekhar Study of behavior of seismic analysis of multistory building with and without floating column, SciTech, Vol 2, pp 697-710, (2014).

[6]. Ms. Waykule S.B et al Comparative Study of floating column of multi storey building by using software, Int. Journal of Engineering Research and Application, Vol. 7, Issue 1, (Part -3), pp.31-38 (January 2017).

[7]. Susanta Banerjee and Dr. Sanjaya K Patro Estimation of park-Ang damage index for floating column building with infill wall, 55th Annual Technical, Journal of Orissa State Centre, Institute of Engineers (India), pp.211-217 (2014).

[8]. Prerna Nautiyal Seismic response evaluation of R.C. frame building with floating column considering different soil conditions , International Journal of Current Engineering and Technology, Vol.4, No.1 (2014).

[9]. Sreekanth Gandla Nanabala Seismic analysis of a normal building and floating column building, International Journal of Engineering Research & Technology (2014).

[10]. Er. Ashfi Rahma Effect of Floating Columns on Seismic Response of Multi-Stored RC Framed Buildings, International Journal of Engineering Research & Technology, Vol. 4 Issue 06, (June-2015).

[11]. Rahul Kapase, Mukund Pawar, M.M. Deshmukh, S.B.Talavara Effect of Seismic Retrofitting on R.C. Building with Soft Storey and Floating Column, International Journal of Engineering Trends and Technology, Vol. 46, No. 7, (April 2017).

[12]. D. Annapurna, Sriram Nadipelli Comparative study of seismic analysis of a normal building and building with floating columns, IJRET, Vol. 04, Special Issue: 13, ICISE-2015, (Dec-2015).

[13]. Shiwli Roy, Gargi Danda de Behavioural studies of floating column on framed structure, IJRET, Vol. 09, Issue: 09, (Sept. -2015).

[14]. Sampath Kumar M.P, V.S. Jagadeesh Effect of floating columns on seismic response of multistory building, International Research Journal of Engineering and Technology, Vol. 03, Issue: 09, (Sep -2016).

[15]. Niteen Malu, Amaresh.S.Patil Performance of RC frame structure with floating column and soft storey in different earthquake zones using pushover analysis, International Research Journal of Engineering and Technology, Vol. 04, Issue 09, (Sep 2017).

[16]. Vijayanarayanan. R, Rupen Goswami and C.V.R.Murty Special class of open ground storey RC buildings built in india unsafe during earthquakes 67Department of Civil Engineering, IIT-Madras. pp. 0147.

[17]. Agarwal Pankaj, Shrikhande Manish Earthquake resistant design of structures PHI learning private limited (2009).

[18]. Criteria for Earthquake Resistant design of structures, Part1: General provisions and buildings, IS 1893:2002, Bureau of Indian Standards, New Delhi.

[19]. IS 875 (Part-I) Bureau of Indian Standards (1987) Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures: Dead Loads-Unit Weights of Building Materials and Stored Materials (Second Revision). UDC 624.042: 006.76.

[20]. IS 875 (Part-II) Bureau of Indian Standards (1987) Code of Practice for Design Loads For Buildings and Structures: Imposed Loads (Second Revision). UDC 624.042.3: 006.76.