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A Review Paper on Seismic Analysis of Multi-Storey Building with Floating Columns at Different Locations of Shear Wall

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Abstract: The purpose of the study of seismic response of a building is to design and build a structure in which the damage to the structure and its structural component by earthquake is minimized. The paper aims towards the review of study of dynamic structural behavior of multi storey building with floating columns conducted by various authors in the past and use of shear walls at different locations to improve strength and stiffness of the buildings. The analysis is done on building models having different numbers of storey with simple and complex floor plans with floating columns at different floors in different zones. Shear walls, infill walls and bracings are provided to increase the lateral load carrying capacity of the building. Various methods such as Response spectrum method and Time history method are used for linear and non-linear dynamic analysis of building using FEM software. Dynamic action is caused on building by both wind and earthquakes. Finite element base software namely ETABs, SAP2000, STAAD.Pro v8i, used for the analysis which can easily determine the parameter such as lateral forces, shear force, axial force, bending moment, storey shear, storey drift, storey displacement. The analysis results of structural response are plotted to compare and discuss.
Keywords: ETABs, SAP2000, STAAD.Pro v8i, Response spectrum method and Time history method

I. INTRODUCTION

Nowadays, multi-storey building construction for residential, industrial or commercial purpose has become a common feature. This multi-storey building needs ample of parking or open spaces below. In multi-storey residential building, to accommodate for the number of parking places and the turning radius, some of the columns from the floors above create a problem. In these cases, these columns are designed as floating columns. Like in any structure, the load from the floors above is transferred to the column. The entire load is then transferred to the beam on which the floating column is going to rest. The floating column is designed as regular column. The beam on which it rests is designed as a beam carrying all the load of the column as a single point load. This beam referred to as girder beam or transfer beam usually has a big cross section with heavy steel. This girder beam is also subjected to torsion. The design and detailing of this girder beam is very crucial in the construction of floating columns.

The lateral forces due to earthquake need to be transferred to the foundation through clear force transfer path. This force transfer path is disrupted in case of floating columns. These floating columns attract a lot of seismic force, which is unfavorable in the high seismic zone. The floating columns act well when only vertical forces are considered. But they are highly undesirable for lateral forces such as earthquake. It is highly discouraged to have floating columns in high seismic zone regions.

But even then, we see a lot of buildings be it residential, commercial or industrial using floating columns in their construction. And the only reason being the flexibility to alter the plan above or below to suit the client requirement. So, in this situation, it is the job of structural engineers like us to ensure that such buildings are not only analyzed properly but the detailing of such buildings is also done properly. Floating columns, though highly discouraged, are still an important part of the construction industry.

II. LITERATURE REVIEW

Israa H.Nayel et al. (2018) studied the effect of shear wall locations in the G+10 storey building with floating column subjected to seismic load. Four models had taken for the analysis. The first model was without shear wall, while the other three models include a shear wall at each corner, centre and side of the building to study the best location of shear wall. Response spectrum analysis is carried out by using ETABS-2015. It was concluded that the maximum storey drift values and shifts are becoming larger for the floating columns. Building with shear wall system worked well in case of corner than in other models of building.

Prof. S. S. Patil et al. (2018) studied a building with open ground storey to bring out the importance of the presence of soft ground storey in the analysis. Usually the most economical way to eliminate the failure of soft storey is by adding shear walls. The shear walls are one of the most efficient lateral force resisting elements in high rise buildings. This paper deals with occurring of soft storey at lower level in high rise building subjected to earthquake. Also it has been tried to investigate on adding of shear wall to structures in order to reduce soft storey on seismic response of building.

Kandukuri Sunitha et al. (2017) studied on the analysis of normal building with five storey, ten storey and fifteen storey. Different positions and different conditions of floating columns, shear walls, bracings are to be taken as same models. Two methods were considered for the analysis of structure as linear static method and time history method. Analysis was done by using ETAB software. They concluded that the maximum displacement and storey drift values are increasing for floating columns. And the building with bracing system worked well in case of smaller height than in high rise building. The deflection and storey drift were drastically changed when the height of the building increased.

Suchita Hirde et al. (2016) studied the comparison of seismic performance of building with and without floating column for various seismic zones in case of medium soil. For this purpose they adopt Pushover analysis 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. The base shear and displacement of multi-storey RCC buildings have been compared and they concluded that due to increase in dimension at two consecutive floors for same building under same loading condition in floating columns building, the story displacement carried at performance point decreases (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 and this is due to increase in seismic weight of building. Story displacement decreases with increase in dimension of beam and columns in case of floating columns building.

Gourav Sachdeva et al. (2016) had represented 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. Finally, he concluded that when the floating column provided near ground level is most hazardous. Therefore the best position of floating column is the top Storey.

Hardik et al. (2015) Undertook pushover analysis of RCC building with floating column and soft storey in different zones to determine the collapse load and ductility capacity of the structure. They had modeled G+4, G+9 and G+15 storey building in sap 2000. They analyzed different models with different positions of floating columns like providing on edge, on face and on interior portion of frame. As a result they concluded that whether the floating columns are 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.

Sabari et al. (2015) has studied the importance of the presence of the Floating Column in the analysis of building. Finite element 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 compatible time history and Bhuj earthquake data has been considered. The dynamic analysis of frame is studied by varying column size dimension. It was concluded that by increasing the column size, the maximum displacement and inter storey drift values are reducing.

Isha Rohilla et al. (2015) studied the seismic response of the multistory irregular building with floating column. The building models were considered as G+5 and G+7 with zone II and zone V. To evaluate the results of the building as storey response, storey shear, storey displacements was obtained by using ETABS software. They concluded that the floating column should be avoided in high rise building in zone V. Storey displacements increases with increase in load on floating column. Storey shear decreases because of reduction of mass of column in structures. Increase the size of the beams and columns to improve the performance of building with floating column to reduce the storey displacements and storey drift.

N. Janardhana Reddy et al. (2015) studied seismic analysis of 14 storied high rise building with different locations of shear walls using ETABS-2013. They studied to determine the ideal location of shear walls in high rise buildings to minimize the effect of torsion. Two different zones- II and V were considered for seismic analysis. The analysis was done by Equivalent static method and Response spectrum method. The authors concluded that the maximum displacement reduces considerably by providing shear walls. The shear force and moments values are also reduced considerably for a building with shear walls. The inclusion of shear wall in buildings increases stiffness and reduces displacements. The shear walls provided from foundation to the top of the building are very effective in resisting lateral loads. For symmetrical buildings, shear walls placed symmetrically on the outer periphery of the building are more effective.

Srikanth et al. (2014) has performed the whole work consisting of four models i.e. FC (floating column provided in particular floor, location), FC+4 (floating column provided by rising height by 4m), FC+HL (floating column provided by applying heavy load), FC+4+HL (floating column provided by applying heavy load and rising the storey height by 4m). The design methodology employs the fully combined process that allows modeling, analyzing, designing. The author concluded that complex building will undergo whiplash effect under earthquake shaking. The models experience less displacement value for lower zone and goes on increase for higher zone.

Prerna Nautiyal et al. (2014) studied the response of RC frame building with floating column considering different soil conditions. Two reference models were used by taking model A and model B with G+3 and G+5 storey respectively. Floating columns were located on different floors for both frames to compare base shear and maximum bending moment at each floor. Linear dynamic analysis was done for 2D multi-storey frame. Also, magnification factor was determined for safe and economical design of building with floating column. It was found that base shear demands for medium soil are higher than that of the hard soil. It was also observed that maximum moment varies at ground floor whereas there is minimum variation at top floor. Also, as the height of the building increases the variation of maximum moments gets reduced for different soil conditions.

Susanta Banerjee et al. (2014) had studied that buildings with floating column are highly undesirable built in seismically active areas. Floating column buildings are severely damaged during earthquake. Damage on this structure can be reduced 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. Modeling and analysis were carried out by non linear analysis programmed IDARC- 2D. Damage occurred in beams, columns, storey were studied by formulating modified Park & Ang model to evaluate damage indices. Overall structural damage indices in buildings due to shaking of ground were 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.

P. P. Chandurkar et al. (2013) summarize that in the seismic design of buildings, reinforced concrete structural walls act as major earthquake resisting members. For this study, all models of 10-storey building with regular in plan were modeled. These buildings were designed in compliance to the Indian Code of Practice for Seismic Resistant Design of Buildings. Models were studied in all four zones comparing lateral displacement, storey drift, percentage of area of steel in column, concrete quantity required, and total cost required in all zones for all models. From the analysis, it was observed that building with shear wall in short span at corner is economical as compared with other models. From this it can be concluded that large dimension of shear wall is not effective in 10-storey or below 10-storey buildings. Changing the position of shear wall will affect the attraction of forces, so that wall must be in proper position. If the dimensions of shear walls are large then major amount of horizontal forces are taken by shear walls. Providing shear walls at adequate locations substantially reduces the lateral displacements due to earthquake.

Sukumar Behera et al. (2012) studied the behavior of multistory building with and without floating column under different earthquake excitations. The PGA of both earthquakes was kept 0.2g and duration of excitation was kept constant. The finite element model was prepared to study dynamic behavior of the building. The static and free vibrations results were validated using finite element code. From the study, he concluded that with increase in ground floor column the maximum displacement, inter storey drift reduces. The base shear and overturning moment varies with change in dimensions of column.

III. CONCLUSIONS

A. Base shear increases in case of core centre Shear wall in building when compared to corner and side shear wall in building.
B. Building with floating column worked well in case of corner shear well than in other location of shear wall in building.
C. Displacement varies as the shear wall location changes. Changing the position of shear wall will affect the attraction of forces, so that wall must be in proper position.
D. Shear wall which are provided from foundation to the roof top, are one of the excellent mean for providing earthquake resistance in high rise building. These are little expensive but desirable for safe structure.
E. The moment resisting frame with shear walls are very good in resisting lateral force such as earthquake and wind force.
F. There is very much increment in Base shear for building with floating column because larger beam and column sizes are provided to resist load of floating column.
G. Base shear obtained from pushover analysis is much more than base shear obtained from the equivalent static analysis.
H. The axial forces are increases in the columns other than floating column due to transfer of loads of the floating column to the conventional column.

I. Whether the floating column is on the ground floor or in eighth floor, the displacement values increases when a floating column is provided in edge or middle than the outer face of the frame.
J. Floating column should be avoided in high rise building in zone V because of its poor performance.
K. Maximum displacement and storey drift increases for building with Floating columns.

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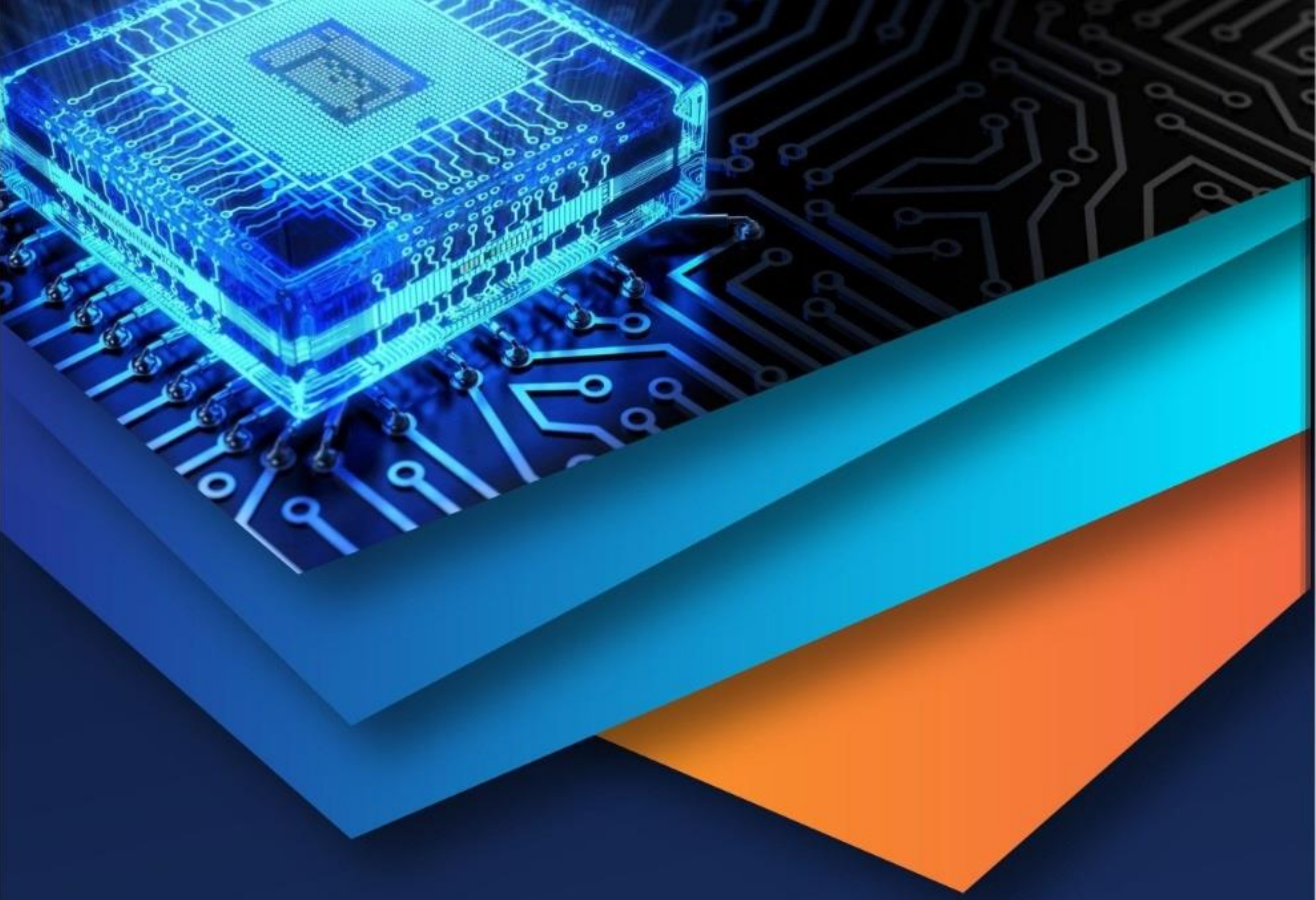

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