Seismic Performance and Retrofitting of Open Ground Storey Buildings with Floating Columns

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Abstract

Floating columns, columns which rests on beams and does not have any foundation, are common in many of the multi storey buildings which are proposed to accommodate parking at ground floor or open halls. An attempt is made here to analyse the seismic performance of open ground storey buildings with floating columns and to suggest the best retrofitting method to strengthen the building. G+15 building models are considered for the study. Effect of position of floating column is also studied. 5 methods of retrofitting are compared to find out the best one among them. Analysis is done by using ETABS-2015 software. The results show that, lower the position of floating column, the worse is the response of building. From the study it has been found that infill walls can be used as the most effective retrofitting method to strengthen the floating column buildings.

Keywords— *Floating column, Open ground storey, Retrofitting, Storey displacement*

I. INTRODUCTION

A column can be defined as a vertical member starting from foundation level and transferring the load to the ground. The term floating column refers to a vertical element, whose lower end is resting on a beam, and does not have a foundation [1]-[3]. Many urban multi storey buildings are provided with floating columns for aesthetic beauty and many other features like large open halls, parking etc. An open ground storey building has only columns and no walls in the ground storey and both partition walls and columns in the upper storeys [4]. Buildings which are proposed to accommodate parking at the ground floor are having an open ground 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 in this load transfer path results in poor performance of the building under earthquake loading [5].

In this study, G+15 models having open ground storey and floating columns are prepared and analysed using ETABS 2015 software, to determine the effect of positioning of floating columns in building performance and also to suggest the best retrofitting method to strengthen the buildings.

II. MODELLING AND ANALYSIS

The entire work consists of 14 different models of G+15 building. Open ground storey models with and without floating columns are prepared. Positions of floating columns are changed from top floor, middle floor and 3rd floor respectively to study the effect of position of floating columns. 5 types of retrofitting methods were adopted for each building models and compared. General details of buildings are given in Table1.

Table 1 General Building details

No. of storeys	G+15
Beam size	230x400mm
Column size	Columns in the periphery of ground floor- 650x650 All other columns-550x550
Slab Thickness	150mm
Storey Height	3m
No. of bays in x direction	4
No. of bays in y direction	7
Bay width in x direction	5m
Bay width in y direction	5m
Dead Load	1kN/m^2
Live Load	3kN/m2
Soil Type	Medium soil
Material Properties	Concrete M25, Steel Fe415
Earthquake zone	Zone V
Zone factor	0.36
Importance Factor	1
Response Reduction Factor	5

A. Model Details

The standard model was named as Model A. Models are created by providing floating columns at 15th floor, 10th floor and 3rd floor, named as Mode A-1, A-2 and A-3 respectively. Further, for each of the models, retrofitting methods are applied and modelled. Various retrofitting methods such as cross bracings, infill walls, intermediate columns, strengthened columns and shear walls are modelled and they are named as Model A-1 Br, A-1 If, A-1 Ic, A-1 Sc and Model A-1 Sw respectively. The detailed descriptions of the various derived models are given in Table.2.

Table.2: Description of Models

Model Name	Description
Model A	Building with no floating columns, but having an open ground storey
Model A-1	Floating columns at the 15th floor
Model A-2	Floating columns at the 10th floor
Model A-3	Floating column at the 3rd floor
Model A-1 Br	Cross bracings in ground and 15th floor (ISMB300 steel section)
Model A-1 If	Infill walls in ground and 15th floor (230mm brick infill)
Model A-1 Ic	Intermediate column in 15th floor
Model A-1 Sc	Strengthened column in ground and 14th floor (750x750mm columns below the floor having floating columns)
Model A-1 Sw	Shear wall along Y axis in 2 corners (230mm thick)
Model A-2 Br	Cross bracings in ground and 10th floor
Model A-2 If	Infill walls in ground and 10th floor
Model A-2 Ic	Intermediate column in 10th floor
Model A-2 Sc	Strengthened column in ground and 9th floor
Model A-2 Sw	Shear wall along Y axis in 2 corners

B. Structural Analysis

Time history analysis is performed in each of the models. The loads and load combinations are selected as per Indian standard codes; IS 875 and IS 1893-Part 1 [6]-[9]. From the analysis results, the models are compared based on the storey displacement and storey drift values.

III. Results and Discussions

Results obtained from the Time history analysis are discussed in this section. For each models, the values of storey displacement and storey drifts are analysed and compared. The load combination 1.5(DL+EQX) is found to be more critical, thus chosen for comparison.

A. Storey Displacement

Displacement profile of a structure represents the interaction of flexibility of its different components i.e. column, beam. But the presence of floating columns reduces the rigidity to the frame against lateral forces, thereby increasing the horizontal displacements.

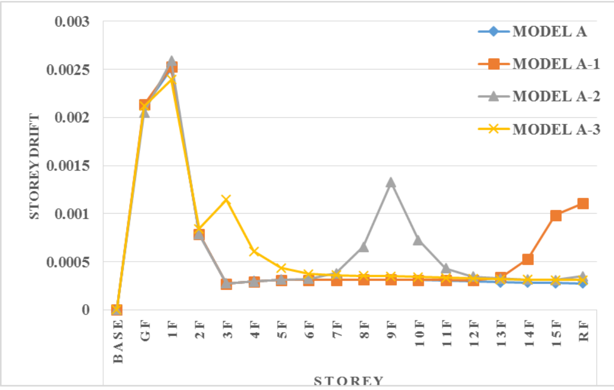


Fig. 1 Storey Displacement - Model A by Varying Position of Floating Column

Comparison of storey displacements for Model A by varying the position of floating columns are shown in Fig.1. From the figure, it is clear that Model A-2 has highest storey displacement compared to other two models, at the level of floating columns. It shows 10% increase from the standard model in the displacement value. The ground floor displacement is almost similar for all the models. While considering the top floor, the maximum value is shown by Model A-3.

Fig.2 shows the storey displacement plot for Model A-1 with varying retrofitting methods. From the figure, it is clear that Model A-1 If, which is provided with infill walls, shows the minimum storey displacement in each storey compared to other methods. It shows 8.2% decrease from the standard model.

Fig.3 shows the storey displacement plot for Model A-2 with varying retrofitting methods. From the graph it is seen that, similar to Model A-1, Model A-2 If shows the minimum value of storey displacement in all the storeys. The model shows 24% decrease in the storey displacement value from the standard model.

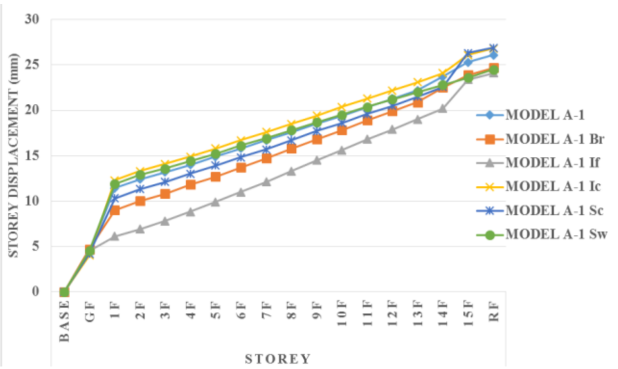


Fig. 2 Storey displacement - Model A-1 by Varying Retrofitting Methods

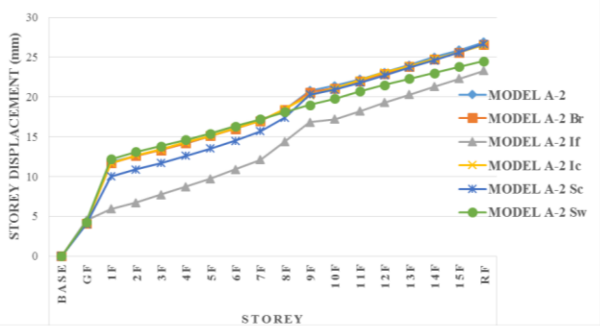


Fig. 3 Storey displacement- Model A-2 by Varying Retrofitting Methods

B. Storey Drift

Storey drift is the displacement of one level relative to the other level above or below. Greater the story drift, greater is the chances of damage. Peak inter storey drift values larger than 0.06 indicate severe damage. While values larger than 0.025 indicate that the damage could be serious enough to pose a serious threat to human safety. As per Clause number 7.11.1 of IS 1893 Part-1: 2002 [9], the storey drift in any storey due to specified design lateral force with partial load factor 1.0, shall not exceed 0.004 times the storey height.

Fig.4 shows the storey drift plot for Model A by varying position of floating columns. Form the graph, it is clear that Model A-2 shows greater variation in storey drift at the storey having floating columns. It shows 76% increase in storey drift from the standard model.

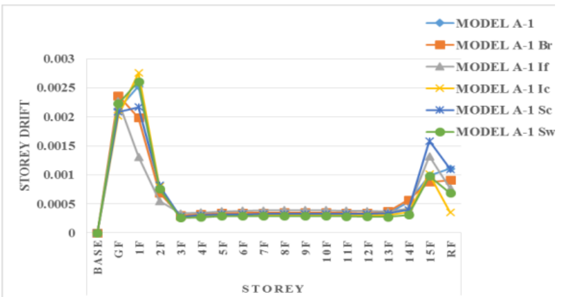
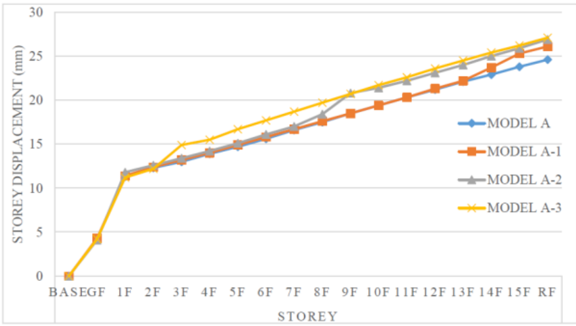


Fig. 4: Storey Drift- Model A by Varying Position of Floating Column

Fig. 5: Storey Drift- Model A-1 by varying retrofitting methods



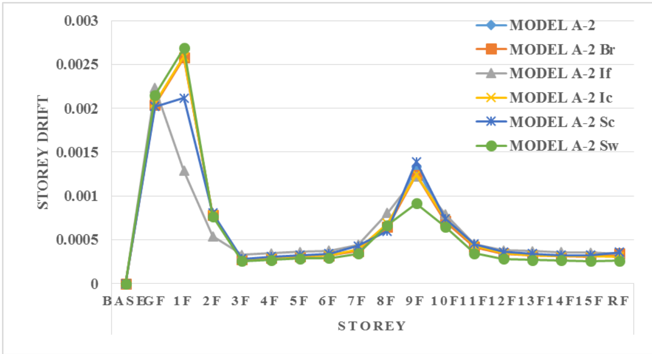


Fig. 6: Storey Drift- Model A-2 by Varying Retrofitting Methods

Fig.5 shows the storey drift plot for model A-1 by varying retrofitting methods. From the figure, it is observed that Model A-1 Ic shows the minimum drift at the level of floating column. But considering the ground storey drift, the model which shows minimum storey drift is Model A-1 If.

Fig.6 shows the storey drift plot for Model A-2 by varying retrofitting methods. Here Model A-2 Sw is seen to be having the minimum value of storey drift at the storey having floating columns. But while considering the ground storey drift, the minimum value is for Model A-2 If.

IV. CONCLUSIONS

In this study, an attempt is made to identify the seismic performance of open ground storey buildings with floating columns and also to suggest the best retrofitting method to strengthen such buildings. All the models are analysed using ETABS software and the results are compared with the standard models.

From the study, it is observed that, the most vulnerable position of floating column is at the middle level. It causes up to 10% increase in storey displacement and 76% increase in storey drift, at the level of floating columns. Providing infill walls reduces the storey drift at the ground floor, but shows maximum drift at the level of floating column wherever the floating columns are. But the storey drifts are found to be in the permissible limits. While considering the storey displacement, models with infill walls show a decrease percentage up to 24 compared to the standard model. Thus, providing infill walls is found to be a better solution among the others to reduce the storey displacement wherever the floating columns are placed.

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REFERENCES

[1] Srikanth.M.K and Yogeendra.R.Holebagilu, Seismic response of complex buildings with floating column for zone II and zone V, International journal of Engineering Research-Online, Vol.2., Issue.4, 2014
[2] A.P Mundada and S.G Sawdatkar, Comparative Seismic Analysis of Multistorey Buildings with and without Floating Column, International Journal of Current Engineering and Technology, Vol.4, No.5 (Oct. 2014)
[3] P.V Prasad and T.Raja Sekhar, Study Of Behaviour Of Seismic Analysis Of Multi Storied Building With And Without Floating Column, Carib.J.SciTech, Vol2, 2014
[4] Hiten L Kheni and Anuj K Chandiwala, Seismic Response of RC Building with Soft Stories, International Journal of Engineering Trends and Technology, Vol.10, April 2015
[5] Prerna Nautiyal, Saleem Akhtar and Geeta Batham, Seismic Response Evaluation of RC frame building with Floating Column considering different Soil Conditions, International Journal of Current Engineering and Technology, Vol.4, No.1 (February 2014)
[6] IS: 875(Part-1)-1987. Code of practice for design loads (other than earthquake) for buildings and structures, Dead loads, unit weights of building materials and stored materials. Bureau of Indian Standard, New Delhi.
[7] IS: 875(Part-2)-1987. Code of practice for design loads (other than earthquake) for buildings and structures, imposed loads. Bureau of Indian Standard, New Delhi.
[8] IS: 875(Part-3)-1987. Code of practice for design loads (other than earthquake) for buildings and structures, wind loads. Bureau of Indian Standard, New Delhi.
[9] IS: 1893(Part-I)-2002. Criteria for Earthquake Resistant Design of Structures. Bureau of Indian Standard, New Delhi.