Seismic Analysis of Multistorey Buildings having Floating Columns

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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. In the seismic regions the construction of these floating columns are highly disadvantageous. 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 multistorey buildings having floating columns under seismic forces and observe the effect of shear wall in the same building. For this purpose three cases of multi-storey buildings are considered having 8 storey, 12 storey and 16 storey. All the three cases are considered having floating columns provided with and without shear wall, and also analysed for zone III, zone IV and zone V by using software Staad.Pro.

Observation shows that the provision of floating columns is advantageous in increasing FSI of the building but is a risky factor and increases the vulnerability of the building. It is observed from the analysis that lateral displacement and storey drift of the building increases from lower to higher zones because the magnitude of intensity will be more for higher zones. By the use of shear wall these parametric values reduces in all the models.

This analysis work provides a beneficial help on the parameters lateral displacement and storey drift in the multistorey buildings having floating columns with and without shear wall.

Keywords — *Shear wall, Floating column, Seismic analysis, Lateral displacement, Storey drift.*

I. INTRODUCTION

A column is said to be a vertical member starting from foundation and transferring the load to the bottom level. When a vertical element ends at its lower level and rests on a beam which is a horizontal member that is known as floating column. So the beams transfer the load to other columns below it. Theoretically these types of structures can be analysed and designed. In reality, the true columns that are below the termination level are not constructed with care and more liable to failure.

A lot of multi-storey buildings in urban India nowadays have open first storey as an unavoidable feature. This is basically being adopted to accommodate parking or reception lobbies in the first storey. Though the seismic base shear acting on the building during an earthquake depends on its natural period, the seismic force distribution is dependent on the distribution of stiffness and mass along the height. In Gujarat during the 2001 Bhuj earthquake so many multi-storey buildings having an open ground storey intended for parking collapsed or was severely damaged.

In a hotel or commercial building, where the lower floors contain banquet halls, conference rooms, lobbies, showrooms or parking areas, large uninterrupted space is required for the movement of people or vehicles. A common method to overcome this problem is the introduction of "transfer girders". Some columns from the upper storeys are terminated at the first floor or higher level. These floating columns are supported on beams called transfer girders. They can also be supported on slabs called transfer slabs. A transfer girder transmits the load from a discontinuous column to the columns in the storey beneath, which support the transfer girder.

Therefore, the structures previously made with these types of discontinuous members are endangered in seismic regions. However those structures cannot be demolished, to a certain extent study can be done to strengthen the structure or some remedial features can be suggested. The columns of the first storey can be made stronger, the stiffness of these columns can be increased by retrofitting or these may be provided with bracing to decrease the lateral deformation.

II. LITERATURE REVIEW

Research on the behaviour of the floating column with different models is described below:

ISHA ROHILLA et. al. [2015], discussed the critical position of floating column in vertically irregular buildings for G+5 and G+7 RC buildings for zone II and zone V. Also the effect of size of beams and columns carrying the load of floating column has been assessed. The response of building such as storey drift, storey displacement and storey shear has been used to evaluate the results obtained using ETABS software. On the basis of analysis and results following conclusions have been made:

1. Floating columns should be avoided in high rise building in zone 5 because of its poor performance.
2. Storey displacement and storey drift increases due to presence of floating column.
3. Storey displacement increases with increase in load on floating column.
4. Storey shear decreases in presence of floating column because of reduction mass of column in structure.
5. Increase in size of beams and columns improve the performance of building with floating column by reducing the values of storey displacement and storey drift.

Increasing dimensions of beams and columns of only one floor does not decreases storey displacement and storey drift in upper floors so dimensions should be increased in two consecutive floors for better performance of building.

KAVYA N et. al. [2015**]**, studied the seismic behavior of the RC multistory buildings with and without floating column is considered. The analysis is carried out for the multi-storey buildings of G+3 situated at zone IV, using ETABS software. To determine seismic behavior of the Buildings with and without floating columns for zone IV the basic components like inter storey drift, lateral displacement, and fundamental time period this analysis has been carried using the software ETABS V 9.7.1. for the analysis purpose Equivalent static method, and Response spectrum methods are adopted. In this building model RC multi storied structures of 4 stories are considered with and without floating columns for the analysis. The typical height of the floors is considered as 3.6m and the height of the ground storey is taken as 4.8m. to avoid the tensional response under the pure lateral forces the buildings are kept symmetric in both the orthogonal directions in plan. On the basis of analysis following conclusions are drawn:

1. The natural time periods obtained from the empirical expressions do not agree with the analytical natural periods. Hence, the dynamic analysis is to be carried out before analyzing these type of structures. And also it can be concluded from the analysis that the natural time period depends on the building configuration.
2. Lateral displacement increases along the height of the building. There is more increase in the displacement for the floating column buildings compared with the regular building.
3. The inter storey drift also increases as the increase in the number of storey. The storey drift is more for the floating column buildings because as the columns are removed the mass gets increased hence the drift.
4. As the mass and stiffness increases the base shear also increases. Therefore, the base shear is more for the floating column buildings compared to the conventional buildings.

Hence, 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.

A.P. MUNDADA et. al. [2014], studied the architectural drawing and the framing drawing of the building having floating columns. Existing residential building comprising of G+ 7 structures has been selected for carrying out the project work. The load distribution on the floating columns and the various effects due to it is also been studied in the paper. The importance and effects due to line of action of force is also studied. In this paper we are dealing with the comparative study of seismic analysis of multi-storied building with and without floating columns. The equivalent static analysis is carried out on the entire project mathematical 3D model using the software STAAD Pro V8i and the comparison of these models are been presented. This will help us to find the various analytical properties of the structure and we may also have a very systematic and economical design for the structure. Also they concluded that provision of floating column is advantageous in increasing FSI of the building but is a risky factor and increases the vulnerability of the building.

KEERTHIGOWDA B. S et. al. [2014], examined the adverse effect of the floating columns in building. Models of the frame are developed for multi-storey RC buildings with and without floating columns to carry out comparative study of structural parameters such as natural period, base shear, and horizontal displacement under seismic excitation. Results obtained depicts that the alternative measure of providing lateral bracing to decrease the lateral deformation, should be taken. The RC building with floating column after providing lateral bracing is analysed. A comparative study of the results obtained is carried out for three models. The building with floating columns after providing bracings showed improved seismic performance. The main purpose of present study was to assess seismic performance of the RC building with floating columns and seismic performance of RC building with floating columns after providing lateral bracings. For this purpose response spectrum analysis (RSA) is performed considering three models (without floating columns, with floating columns and floating columns with bracings). Through the parametric study of storey drift, storey shear, time period and displacement, it was found that the multi-storey buildings with floating columns performed poorly under seismic excitation. Thus to improve seismic performance of the multi-storey RC building, lateral bracings were provided. The bracings improved seismic performance of multi-storey building considerably as different parameters such as storey drift, storey shear, time period and displacement improved up to 10% to 30%.

PRATYUSH MALAVIYA et. al. [2014], studied the effect of floating columns on the cost analysis of a structure designed on STAAD Pro V8i. For this purpose a 2 storied15mt x 20mt regular structure is considered for the study. Modeling, analysis, estimation and design of the structure is done separately on the software. Analysis is performed on the zone II, zone III, zone IV and zone V. It is concluded that in the framed structure with no floating columns the nodal displacements is minimum with uniform distribution of stresses at all beams and columns. As a result it is most economical.

PRERNA NAUTIYAL et. al. [2014**],** investigated the effect of a floating column under earthquake excitation for various soil conditions and as 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. Linear Dynamic Analysis is done for 2D multi storey frame with and without floating column to achieve the above aim i.e. the responses (effect) and factors for safe and economical design of the structure under different earthquake excitation. For the analysis purpose two models have been considered namely as:
Model A: Four storied (G+3) special Moment Resisting Frame (Case 1).
Model B: Six storied (G+5) special Moment Resisting Frame (Case 2).
From the study it is concluded that the base shear demands for medium soil are found higher than that of the hard soil in both cases (i.e. G+3 and G+6 model). As the height of the building increases, variation in base shear from medium to hard soil condition decreases. For different soil conditions (medium to hard) the max moments vary from 22-26% for four storied building model and 16-26% for six storied building model. It has been found that max. variation in values of max moments comes at the ground floor (26%) for both the cases whereas the min. variation comes at the top floor (22% for case 1 and 16% for case 2). It can further been concluded that as the height of the building increases the variation of max. moments gets reduced for different soil conditions.

SABARI S et. al. [2014], highlighted 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. It is concluded that by increasing the column size the maximum displacement and inter storey drift values are reducing.

T.RAJA SEKHAR et. al. [2014], developed FEM codes for 2D multi storey frames with and without floating column to study the responses of the structure at different earthquake conditions having different frequency by keeping the PGA and time duration factor constant. The behaviour of building frame with and without floating column is studied under static load, free vibration and forced vibration condition. The results are plotted for both the frames with and without floating column by comparing each other time history of floor displacement, base shear. The equivalent static analysis is carried out on the entire project mathematical 3D model using the software STAAD Pro V8i and the comparison of these models are been presented. This will help us to find the various analytical properties of the structure and we may also have a very systematic and economical design for the structure. It is concluded that with increase in ground floor column the maximum displacement is reducing and base shear varies with the column dimensions.

III. OBJECTIVES

The objectives of the present work are:
1. To study the behaviour of multistorey buildings having floating columns under earthquake excitations.
2. To study the effect of shear wall in the same building under earthquake loads.
3. To compare the behaviour of multistorey buildings having floating columns with and without shear wall under earthquake loads.

IV. PROBLEM FORMULATION

The object of the present work is to compare the behaviour of multi-storey buildings having floating columns with and without shear walls under seismic forces. For this purpose three cases of multi-storey buildings are considered. To reduce lateral displacement and storey drift shear walls have been provided.
In case-I, total 8 storeys are provided. Building area provided is 28 m x 28 m up to lower 4 storeys and 32 m x 32 m up to upper 4 storeys.
In case-II, total 12 storeys are provided. Building area provided is 28 m x 28 m up to lower 4 storeys and 32 m x 32 m up to upper 8 storeys.

In case-III, total 16 storeys are provided. Building area provided is 28 m x 28 m up to lower 4 storeys and 32 m x 32 m up to upper 12 storeys.

To study the behaviour the response parameters selected are lateral displacement and storey drift. All the cases are assumed to be located in zone III, zone IV and zone V. All the three cases are analysed with and without shear wall.

A. Details of case I

In case-I building area of 28m x 28m is taken in lower 4 storeys and 32m x 32m is taken in upper 4 storeys. The building is of (G + 7) configuration, having storey height of 3.6m. The columns are provided in 4m x 4m grid form. Shear walls are placed at the centre of plan.

The sizes of beams are taken as 300mm x 500mm throughout the height of building.

The thickness of shear wall is taken as 150mm.

B. Details of case II

In case-II building area of 28m x 28m is taken in lower 4 storeys and 32m x 32m is taken in upper 8 storeys. The building is of (G + 11) configuration, having storey height of 3.6m. The columns are provided in 4m x 4m grid form. Shear walls are placed at the centre of plan.

The sizes of beams are taken as 300mm x 500mm throughout the height of building.

The thickness of shear wall is taken as 150mm.

C. Details of case III

In case-III building area of 28m x 28m is taken in lower 4 storeys and 32m x 32m is taken in upper 12 storeys. The building is of (G + 15) configuration, having storey height of 3.6m. The columns are provided in 4m x 4m grid form. Shear walls are placed at the centre of plan.

The sizes of beams are taken as 300mm x 500mm throughout the height of building.

The thickness *of shear wall is taken as 150mm.*

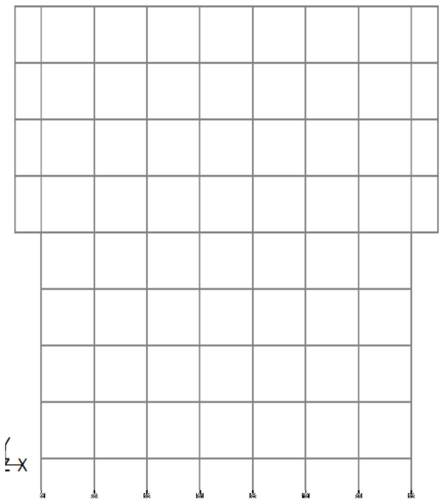

Fig.1 8 Storey Without Shearwall

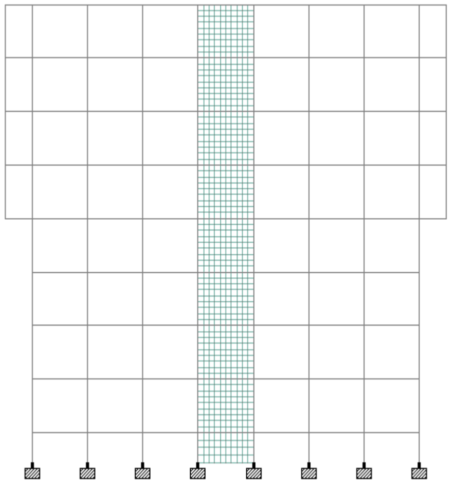

Fig.2 8 Storey With Shearwall

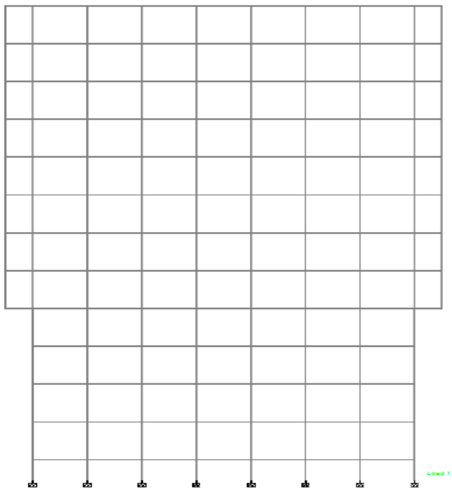

Fig.3 12 Storey Without Shearwall

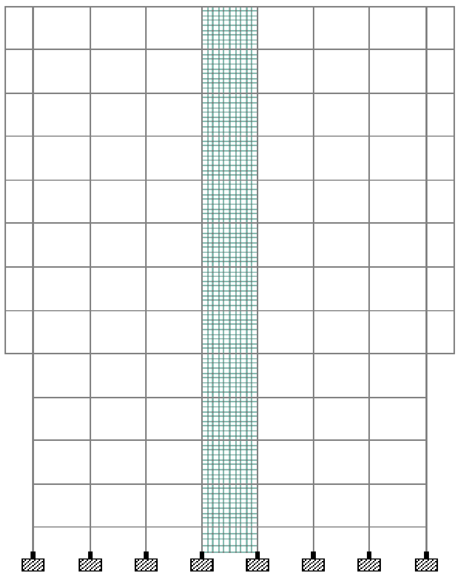

Fig.4 12 Storey With Shearwall

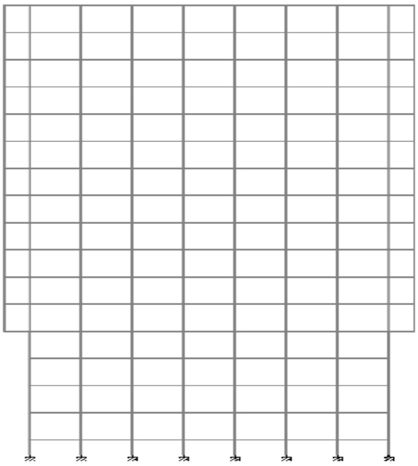

Fig.5 16 Storey Without Shearwall

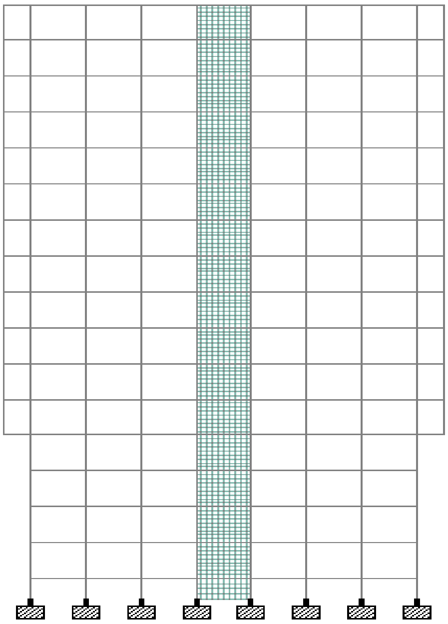

Fig.6 16 Storey With Shearwall

V. RESULTS AND DISCUSSIONS

A. Storey Drift

1. According to IS:1893:2002 (part I), maximum limit for storey drift with partial load factor 1.0 is 0.004 times of storey height. Here, for 3.6m height and load factor of 1.5, though maximum drift will be 21.6mm.
2. It is observed from analysis results that for all the cases considered drift values follow around similar path along storey height with maximum value lying somewhere near about the middle storey.
3. In all the models drift values are less for lower zones and it goes on increases for higher zones because the magnitude of intensity will be the more for higher zones.
4. The storey drift is more for floating column buildings because as the columns are removed the mass gets increased and hence drift also increases.
5. By providing shear wall drift values reduces as compared to without shear wall models for all the zones.
6. For all the models in all the zone drift values are safe within maximum permissible limits in without shear wall models. Hence, it may be said that from drift view point shear wall is not required for buildings having floating columns.

B. Lateral Displacement

1. According to IS:456:2000, maximum limit for lateral displacement is H/500, where H is building height. For 8 storeys building model it is 57.6mm, for 12 storey building model it is 86.4mm, for 16 storey building model it is 115.2mm.
2. It is observed from table nos. 5.1 to 5.18 and figure nos. 5.1 to 5.36 that for all the models considered displacement values follow around similar gradually increasing straight path along storey height.
3. In all the models displacement values are less for lower zones and it goes on increases for higher zones because the magnitude of intensity will be the more for higher zones.
4. The displacement is more for floating column buildings because as the columns are removed the mass gets increased and hence displacement also increases.
5. By providing shear wall displacement values reduces as compared to without shear wall models for all the zones.
6. In zone IV 16 storey building model, zone V 8 storey and 12 storey building models displacement values crosses the maximum permissible limits in case of without shear wall but it becomes safe in case of building models with shear wall.
7. In zone V 16 storey model is not safe for both without and with shear wall. Hence it is advised to increase size of column to reduce the displacement values.

VI. CONCLUSIONS

Within the scope of present work following conclusions are drawn:

1. For all the cases considered drift values follow around similar path along storey height with maximum value lying somewhere near about the middle storey.
2. For all the models considered displacement values follow around similar gradually increasing straight path along storey height.
3. In all the models storey drift and displacement values are less for lower zones and it goes on increases for higher zones because the magnitude of intensity will be the more for higher zones.

4. The storey drift and displacement is more for floating column buildings because as the columns are removed the mass gets increased and hence drift and displacement also increases.
5. By providing shear wall drift and displacement values reduces as compared to without shear wall models for all the zones.
6. As drift values are safe within maximum permissible limits in without shear wall models so there is no necessity of providing shear walls from drift view point.
7. In zone IV 16 storey building model, zone V 8 storey and 12 storey building models displacement values crosses the maximum permissible limits in case of without shear wall but it becomes safe in case of building models with shear wall.
8. In zone V 16 storey model is not safe for both without and with shear wall. Hence it is advised to increase size of column to reduce the displacement values.

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