Static and Dynamic Analysis of Multistorey Buildings Having Floating Columns

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Abstract - *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.*

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 by using static and dynamic analysis. 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 9 storeys are provided. Building area provided is 20 m x 20 m upto lower 4 storeys and 28 m x 28 m upto upper 5 storeys.* ***In case-II****, total 12 storeys are provided. Building area provided is 20 m x 20 m upto lower 4 storeys and 28 m x 28 m upto upper 8 storeys.* ***In case-III****, total 15 storeys are provided. Building area provided is 20 m x 20 m upto lower 4 storeys and 28 m x 28 m upto upper 11 storeys. To study the behavior 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 and analyzed using static and dynamic methods. All the three cases are analyzed with and without shear wall using Staad.Pro software.*

From the analysis result parameters displacement and storey drift of the building models increases from lower to higher zones because the magnitude of intensity will be more for higher zones. In comparison to methods of analysis, dynamic method of analysis gives more appropriate results.
Present work provides good information on the result parameters displacement and storey drift in the multistorey buildings with floating columns.

Key Words**: Seismic, Floating Columns, Shear Wall, Lateral displacement, Storey drift.**

1. INTRODUCTION

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 and 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 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 Columns

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.

There are many projects in which floating columns are adopted, especially above the ground floor, where transfer girders are employed, so that more open space is available in the ground floor. These open spaces may be required for assembly hall or parking purpose. The transfer girders have to be designed and detailed properly, especially in earth quake zones. The column is a concentrated load on the beam which supports it. As far as analysis is concerned, the column is often assumed pinned at the base and is therefore taken as a point load on the transfer beam. STAAD Pro, ETABS and SAP2000 can be used to do the analysis of this type of structure. Floating columns are competent enough to carry gravity loading but transfer girder must be of adequate dimensions (Stiffness) with very minimal deflection.

Looking ahead, of course, one will continue to make buildings interesting rather than monotonous. However, this need not be done at the cost of poor behavior and earthquake safety of buildings. Architectural features that are detrimental to earthquake response of buildings should be avoided. If not, they must be minimized. When irregular features are included in buildings, a considerably higher level of engineering effort is required in the structural design and yet the building may not be as good as one with simple architectural features.

Hence, the structures already made with these kinds of discontinuous members are endangered in seismic regions. But those structures cannot be demolished, rather 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.

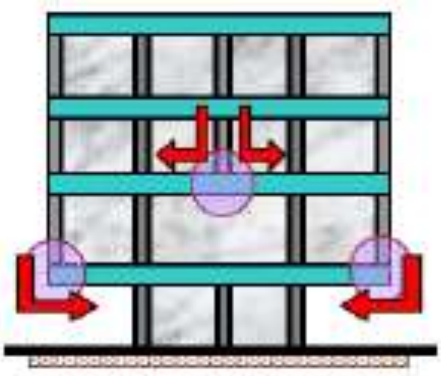

Fig -1: Floating Columns

2. PROBLEM FORMULATION & ANALYSIS

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 by using static and dynamic analysis. 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 9 storeys are provided. Building area provided is 20 m x 20 m upto lower 4 storeys and 28 m x 28 m upto upper 5 storeys.

In case-II, total 12 storeys are provided. Building area provided is 20 m x 20 m upto lower 4 storeys and 28 m x 28 m upto upper 8 storeys.

In case-III, total 15 storeys are provided. Building area provided is 20 m x 20 m upto lower 4 storeys and 28 m x 28 m upto upper 11 storeys.

To study the behavior 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 and analyzed using static and dynamic methods. All the three cases are analyzed with and without shear wall.

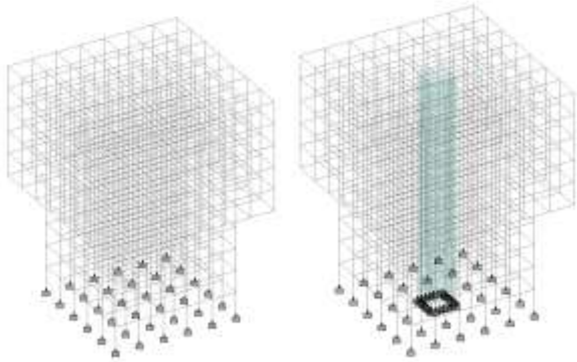

Fig -2: 9 storey model with & without shear wall

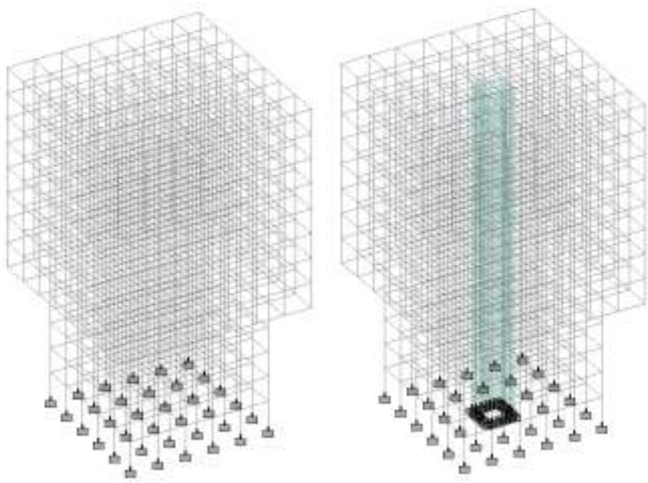

Fig -3: 12 storey model with & without shear wall

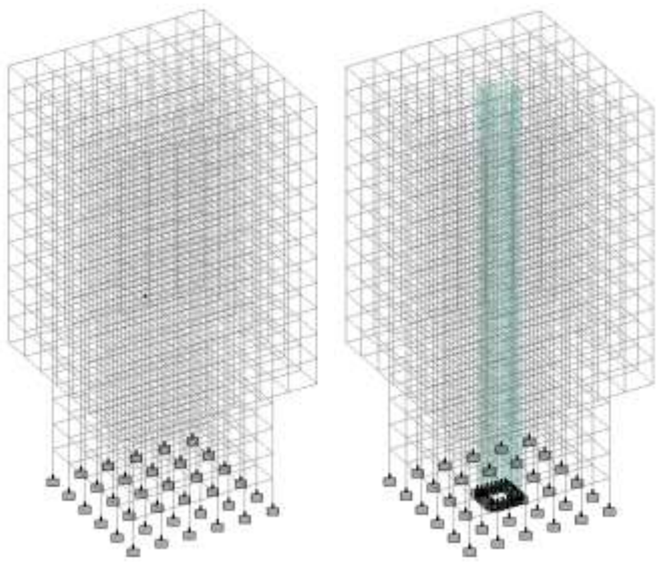

Fig -4: 15 storey model with & without shear wall

3. RESULTS AND DISCUSSIONS

The study examines the performance of floating columns in multi-storey buildings of different heights with shear walls and without shear walls for seismic forces in zone III, IV and V using static and dynamic analysis methods. As it is discussed earlier that use of floating columns in buildings makes the structure more vulnerable under seismic loading, therefore, in present work floating columns are provided in different buildings with shear wall also.

To study the effectiveness of all the models considered, the displacement and storey drift are worked out. The results organized in various tables and figures are discussed in detail.

3.1 Effect of parameters studied on 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.
1. It is observed from results that for all the cases considered drift values follow around similar path along storey height with maximum value lying somewhere near about 4th storey in all the models.
2. It is observed here that 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.
3. In all the models it is observed that by providing shear wall drift values reduces as compared to without shear wall models for all the zones and both the methods of analysis.
4. From the results it is observed that drift values of dynamic analysis are less in comparison to static analysis. Hence it may be preferable to adopt dynamic analysis method in practice.
5. It is observed that with the increase of number of storeys values of storey drift also increases.
6. In the 9 storey models from zone III to zone V for without shear wall models drift values varies from 3.18mm to 19.83mm in static analysis whereas in dynamic analysis it reduces from 2.66mm to 17.68mm. Also in with shear wall models these values varies from 2.15mm to 11.36mm in static analysis and in dynamic analysis from 1.89mm to 10.92mm.
7. In the 12 storey models from zone III to zone V for without shear wall models drift values varies from 3.67mm to 23.40mm in static analysis whereas in dynamic analysis it reduces from 3.00mm to 21.26mm. Also in with shear wall models these values varies from 2.63mm to 12.93mm in static analysis and in dynamic analysis from 2.31mm to 12.52mm.
8. In the 15 storey models from zone III to zone V for without shear wall models drift values varies from 4.15mm to 26.19mm in static analysis whereas in dynamic analysis it reduces from 3.37mm to 24.00mm. Also in with shear wall models these values varies from 3.12mm to 14.33mm in static analysis and in dynamic analysis from 2.56mm to 13.28mm.
9. As limiting values of storey drift is 21.6 mm, according to this all the models in zone III and zone IV are safe within permissible limits. For zone V in 9 storey model it is safe whereas in 12 storey and 15 storey models it fails on 4th storey in both the methods of analysis for without shear wall case but it is safe in case of with shear wall models.
10. For improving these drift conditions of buildings having floating columns in higher seismic zones using static and dynamic analysis, the stiffness of columns should be increased or thickness of shear wall should be increased.

3.2 Effect of parameters studied on displacement

1. According to IS:456:2000, maximum limit for lateral displacement is H/500, where H is building height. For 9 storey building model it is 64.8mm, for 12 storey building model it is 86.4mm, for 15 storey building model it is 108mm.
2. It is observed from results 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. By providing shear wall displacement values reduces as compared to without shear wall models for all the zones in both static and dynamic analysis.
5. The lateral displacement is maximum at the top storey and least at the base of structure.
6. As compared to with and without shear wall building models, values of displacement are more in case of without shear wall.
7. From the results it is observed that displacement values of dynamic analysis are less in comparison to static analysis. Hence it may be preferable to adopt dynamic analysis method in practice.
8. It is observed that with the increase of number of storeys values of displacement also increases.
9. In the 9 storey models from zone III to zone V for without shear wall models displacement values varies from 12.2mm to 127.67mm in static analysis whereas in dynamic analysis it reduces from 11.81mm to 114.05mm. Also in case of with shear wall building models these values varies from 4.83mm to 67.20mm in static analysis and in dynamic analysis from 4.75mm to 62.63mm.
10. In the 12 storey models from zone III to zone V for without shear wall models displacement values varies from 13.75mm to 191.89mm in static analysis whereas in dynamic analysis it reduces from 13.42mm to 167.62mm. Also in case of with shear wall building models these values varies from 5.42mm to 108.36mm in static analysis and in dynamic analysis from 5.33mm to 99.61mm.

11. In the 15 storey models from zone III to zone V for without shear wall models displacement values varies from 14.96mm to 266.49mm in static analysis whereas in dynamic analysis it reduces from 14.68mm to 227.66mm. Also in case of with shear wall building models these values varies from 5.94mm to 161.04mm in static analysis and in dynamic analysis from 5.71mm to 130.93mm.
12. As limiting value of displacement in 9 storey is 64.8mm, in 12 storey is 86.4mm and in 15 storey it is 108.0mm. In all the cases both in static and dynamic analysis methods at the higher zones model fails at higher storeys. To improve this behavior from past researches it is suggested to increase size of column to reduce the displacement values.

4. 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 4th storey in all the building models.
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. By providing shear wall drift and displacement values reduces as compared to without shear wall models for all the zones.
5. It is observed that drift values and displacement values of dynamic analysis are less in comparison to static analysis. Hence it may be preferable to adopt dynamic analysis method in practice.
6. It is observed that with increase of number of storeys values of storey drift and displacement also increases.
7. In all the zones at some storeys displacement values and drift values crosses the maximum permissible limits in case of without shear wall but it becomes safe in case of building models with shear wall.

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