Seismic Analysis of MultiStorey Buildings with Vertical Irregularities Having Floating Columns

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Abstract - *Seismic resistant design of RCC buildings is an enduring area of research while the earthquake engineering has started not only in India but in other developed countries also. The buildings still damage due to some one or the other reason during earthquakes. In spite of all the weaknesses in the structure, either code imperfections or error in analysis and design, the structural configuration system has played a vital role in catastrophe.*

The object of the present work is to compare the behaviour of multi-storey buildings with vertical irregularities having floating columns with and without shear walls under seismic forces. For this purpose a multi-storey building of 15 storeys is considered. To reduce lateral displacement and storey drift shear walls have been provided. Plan size of building is considered 20m x 20m. To study the behavior the response parameters selected are lateral displacement and storey drift. Building is assumed to be located in seismic zone III, zone IV and zone V. All the building models are analysed with and without shear wall. For this purpose 4 models of 15 storeys for zone III, zone IV and zone V are considered: Floating column without shear wall, Floating column with shear wall, Floating column with vertical irregularity without shear wall, Floating column with vertical irregularity with shear wall. In building having floating column area of 12m x 12m is taken in lower 4 storeys and 20m x 20m is taken in upper 11 storeys. For vertical irregularity building plan is reduced to 12m x 20m. From the results it is observed that in comparison to floating column building and floating column with vertical irregularity building, the model with vertical irregularity performs well in all the seismic zones. Also by providing shear wall drift and displacement values reduces as compared to without shear wall models for all the zones. 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.

Present work provides good information on the result parameters lateral displacement and storey drift in the multistorey building having floating columns and vertical irregularity.

Key Words: **Floating column, vertical irregularity, displacement, storey drift, shear wall.**

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 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 analyzed and designed. In reality, the true columns that are below the termination level are not constructed with care and more liable to failure.

Hypothetically, these floating columns are not such required – and the spans of all beams need not be nearly the same and some spans can be larger than others. Thus, the columns supporting beams with larger spans would be designed and constructed with greater care.

On providing floating columns, it is required to pay special attention on the transfer girder and columns supporting transfer girder. If load factor needs to be augmented to have additional safety of structure, shall be adopted. In the given system, floating columns need not be treated to carry any seismic forces. Therefore entire earthquake of the system is shared by the columns/shear walls without considering any contribution from Floating columns. Though for designing and details of floating columns, minimum 25% earthquake must be considered in addition to full gravity forces.

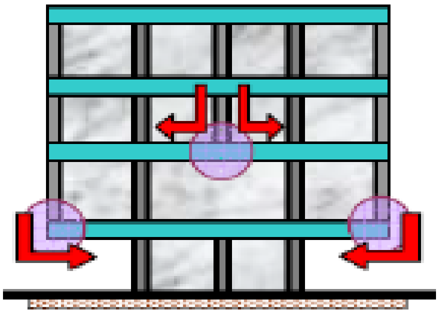

Fig -1: Floating Columns

1.2 Seismic Irregularities

A building is supposed to be a regular when its configurations are nearly symmetrical about the axis and it is said to be the irregular when it lacks symmetry and discontinuity in the geometry, mass or elements which resists load.

At the time of an earthquake, structure starts to fail at the points of weakness. This weakness arises due to discontinuity in mass, stiffness and geometry of the structure. The building structures having this type of discontinuity are termed as Irregular structures. Irregular structures contribute a large portion of urban infrastructure. Vertical irregularities are one of the main reason of failures of building structures during earthquakes. As an example structures with soft storey were the most notable structures which collapsed. So, the effect of vertically irregularities on the seismic evaluation of structures becomes actually important. Height-wise changes in stiffness and mass render the dynamic characteristics of these buildings different from the regular building.

Irregular buildings make up a large portion of the urban infrastructure. The presence of irregularities can be due to architectural, functional, and economical constraints. The main objective of this research is to improve the understanding of the seismic behavior of building structures with vertical irregularities. This is done by quantifying the effects of vertical irregularities in mass, stiffness, or strength on seismic demands.

IS 1893 definition of Vertically Irregular structures:

The vertical irregularity in the structures possibly due to irregular distributions in their mass, strength and stiffness along the height of building. When such buildings are constructed in high seismic zones, the analysis and design becomes more complicated.

2. PROBLEM FORMULATION & ANALYSIS

The object of the present work is to compare the behaviour of multi-storey buildings with vertical irregularities having floating columns with and without shear walls under seismic forces. For this purpose a multi-storey building of 15 storeys is considered. To reduce lateral displacement and storey drift shear walls have been provided. Plan size of building is considered 20m x 20m.

To study the behavior the response parameters selected are lateral displacement and storey drift. Building is assumed to be located in seismic zone III, zone IV and zone V. All the building models are analysed with and without shear wall. For this purpose 4 models of 15 storeys for zone III, zone IV and zone V are considered:

1. Floating column without shear wall
2. Floating column with shear wall
3. Floating column with vertical irregularity without shear wall
4. Floating column with vertical irregularity with shear wall

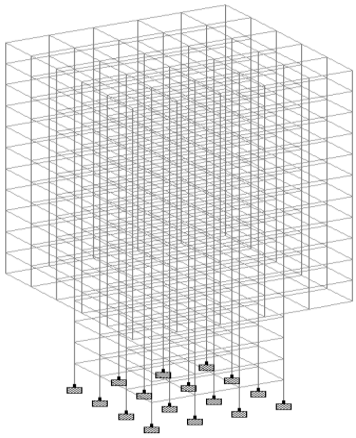

Fig -2: Floating Column Without Shear Wall

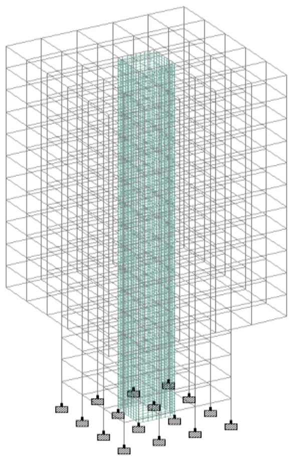

Fig -3: Floating Column With Shear Wall

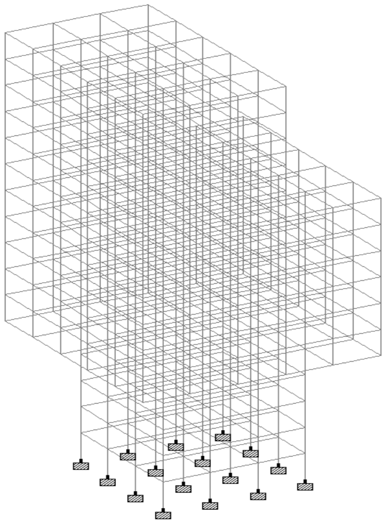

Fig -4: Vertical irregular building with floating column without shear wall

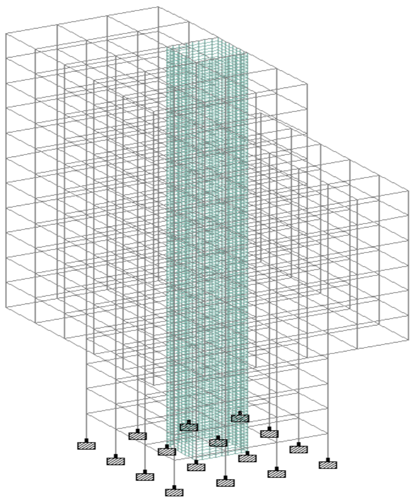

Fig -5: Vertical irregular building with floating column with shear wall

3. RESULTS AND DISCUSSIONS

The study examines the performance of multistorey buildings with vertical irregularities having floating columns with shear wall and without shear wall. 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 15 storey building with vertical irregularity with and without shear wall.

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 3.2m height and load factor of 1.5, though maximum drift will be 19.2mm.
2. It is observed from table nos. 5.4 to 5.6 and figure nos. 5.13 to 5.24 that for all the cases considered drift values follow around similar path along storey height with maximum value lying somewhere near about the fourth 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. By providing shear wall drift values reduces as compared to without shear wall models for all the zones.
5. From the results it is observed that in comparison to floating column building and floating column with vertical irregularity, the model with irregularity performs well in all the seismic zones.
6. For all the models in zone III and zone IV drift values are safe within maximum permissible limits in without shear wall and with shear wall models. But in zone V, in case of floating column building and floating column with vertical irregular building it is fail at 4th storey in without shear wall model but it is safe in case of with shear wall model.

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 15 storey building model it is 96mm.
2. It is observed from table nos. 5.1 to 5.3 and figure nos. 5.1 to 5.12 that for all the models considered displacement values follow around similar gradually increasing straight path along storey height. The value of lateral displacement is maximum at the top storey and least at the base of structure.
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.
5. From the results it is observed that in comparison to floating column building and floating column with vertical irregularity, the model with vertical irregularity performs well in all the seismic zones.
6. In zone III, floating column without shear wall model fails at top 4 storeys but it is safe in case of with shear wall model. Whereas floating column with vertical irregularity model is safe within permissible limit in both without and with shear wall models.
7. In zone IV, floating column without shear wall model fails at top 8 storeys but it is safe in case of with shear wall model. Whereas floating column with vertical

irregularity model fails at top 4 storeys but it is safe within permissible limit in case of with shear wall models.

8. In zone V, floating column without shear wall model fails at from fifth storey to the top and also fails in case of with shear wall model at top 5 storeys. Whereas floating column with vertical irregularity model fails at from seventh storey but it is safe within permissible limit in case of with shear wall models.
9. To improve the performance of models it is advised to increase the stiffness of columns by increasing its sizes, which will cause reduction in values of displacement.

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 the fourth storey.
2. For all the models considered displacement values follow around similar gradually increasing straight path along storey height with maximum value at top storey.
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. In comparison to floating column building and floating column with vertical irregularity building, the model with vertical irregularity performs well in all the seismic zones.
6. On considering storey drift value, models in zone III and zone IV are safe within permissible limit whereas in zone V it fails at 4th storey only in case of without shear wall model but it is safe in case of with shear wall models.
7. On considering lateral displacement, in zone II and zone IV models fail in without shear wall case but are safe in with shear wall models. But in zone it fails in both the cases in without shear wall as well as in with shear wall also. Hence it is advisable to increase the stiffness of columns.

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