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Comparative Study of Seismic Analysis of Multi-Storey Building with and without Floating Column: A Review

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A B S T R A C T

These days floating column is commonly used in most of the multi-storey building. These multi-storey buildings mostly have one storey open (no walls) in the ground level and its purpose is to use as a parking or open auditorium. Such types of structures having discontinuation in the load transfer mechanism, because of columns are in floating condition. Hence, such structure can produce very high risk in terms of damage at the time of earthquake, so these are not desirable in those areas that are coming under seismic active zone. In this project the multi-storey building having floating column in the earthquake prone area is considered to observe its behaviour under the effect of earthquake.

Keywords:Floating Column: STAAD Pro: Seismic Analysis: Base Shear

1.Introduction

In modern building technology, the emphasis is on architecture and other functions, and most multi-storey buildings have an open ground floor as a mandatory function to provide parking, lobbies reception and other architectural requirements. Today, it is common to build multi-storey buildings for residential, industrial or commercial purposes. These tall buildings require more parking space or underground space. This open ground floor concept leads to the rupture of the so-called floating columns, leaving the building undisturbed from the side. The concept of this floating pillar is due to the architectural need to evoke an aesthetic view of the building and to overcome the limitations of the floor space index (FSI). Even a commercial building may require a basement meeting or banquet room. For these purposes, we prefer open spaces between columns. Many tall urban buildings in India today undoubtedly have an open floor in the ground. Mainly used for parking or reception on the first storey. In the event of an earthquake, the main seismic displacement of a building depends on its natural cycle, but the distribution of seismic force depends on its distribution of hardness and mass with altitude.

Recently, all multi-storey structures have been built with the floating column concept. These structures are not included in the regulation as they cannot withstand seismic forces and can be damaged. Many of the buildings in the Gujarat Bhuj area were rebuilt after the first floor collapsed in the 2001 earthquake. It is recommended to use existing structures in seismic areas. These structures are not dynamically reliable. The static reliability of floating column structures should be investigated. In this case, floating columns come into the picture. Floating column allow us to freely change the floor plan above. As with other structures, the load on the upper floors is transferred to the columns. The entire load is then

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transfer to beam on that these columns is on rest. These columns are designed just like any simple column designed as per IS 456 (2000). These columns are designed as beams that support the entire load of the supporting beam as a single point load. These beams are commonly referred to as heavy cross-section steel beams. Torsion is also acting in these beams. The design and details of these beams are very important in the construction of buildings with floating columns. The seismic forces generated by a building must be transmitted to the ground in the shortest way along the height of the building. Any deviation or interruption of this transmitted load will degrade the performance of the building.

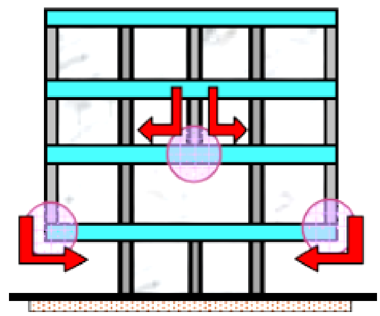

Fig. 1 - Building with floating column

A common type of load line break in torque frames occurs in floating columns. In other words, it occurs when the columns at the top of any structure give way to an underlying floor, mostly at ground floor. In this case, the load on the roof forms a bypass which is transferred to the nearer continuous column to the foundation. This increases the demand for the first floor columns and can cause them to collapse.In general, such high-rise architecturally complex buildings have shown the least useful behavior during past earthquakes. In general, the behavior of such type of structure at the time of earthquake is highly dependent on its geometry, size, overall shape, and how seismic loads are transmitted to the base of the structure through columns. The transport of goods is stopped in buildings where the columns are suspended or floating on the mezzanine and do not reach the foundation. Some buildings have declined vertically, such as hotel buildings that are several floors larger than other buildings, and the seismic force suddenly surges at discontinuous levels.

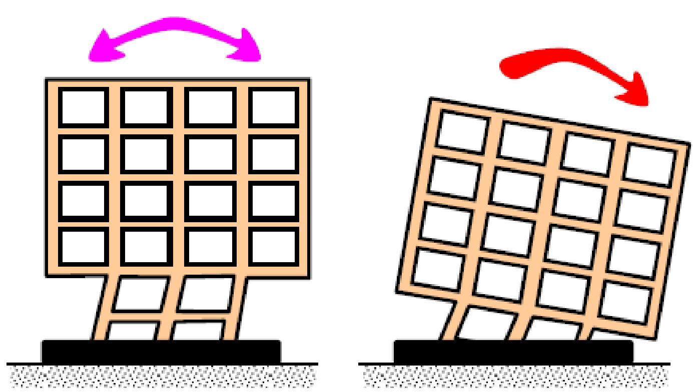

Fig. 2 - Behaviour of structure with floating column during earthquake

There are many projects in India where floating columns have already been used. In particular, the transmitted beam is used above the ground floor, so more open space can be used on the ground floor. In this case, the pillar is a load focused on the beams that support the pillar. Therefore, there is a threat to the structures formed by these fractures in the seismic zone. Hence, floating columns are used for architectural views and site conditions.

1.1. Earthquake Resistant Design

In general, buildings with floating columns are generally designed for gravitational loads and are safe for such types of loads, though it is not safe for seismic loads. Therefore, such buildings are not safe in areas prone to earthquakes. Therefore, the purpose of this work is to aware people regarding such problems in the design of multi-storey building having floating column in seismic prone area. The characteristics of the four virtue of the design of seismic resistant building, the part of the architect and the design engineer, the part of the building, especially the earthquake, the lateral strength, the lateral stiffness, structure configuration due to seismicity, and ductility. By neglecting other aspect such as functionality, aesthetic, and comfort due to building structure, ductility, lateral strength and stiffness of building may be judge by strict implementation of seismic design standards such as IS 1893-2002 (Part 1).

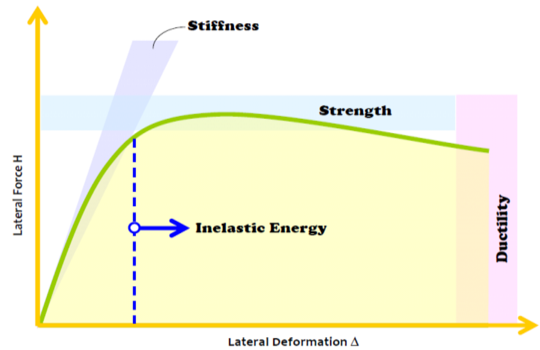

Fig. 3 - Four virtues of Earthquake-Resistant Buildings control earthquake performance of buildings

Fig. 3, explains that strength, ductility, and stiffness is very much dependent on load and deformation characteristics of any building structure, whereas the structural seismic configuration indirectly affect above four features of earthquake resistant building that minimizes the effect of earthquake on the building. Unlike different load effects, such as wind loads, wave loads, explosive loads, live loads, snow loads, and static loads, shaking due to earthquake is the most critical, because it causes movement under the building. It affects over time the lateral deformation of the building between the foundation and the superstructure. In all multi-storey buildings, the concept of floating columns has been developed to avoid this problem, as densely packed columns on the lower floors are not required depending on the location of the upper floors. These buildings are often referred to as one-story open buildings or stacked buildings, and these one-story open systems are adopted because of the advantages of open spaces that can meet economic and architectural requirements.

1.2 Response Spectrum Method of Seismic Design

The overall seismic design of the structure is done using the maximum force induced in the structure under the influence of an earthquake. Force can be defined in two ways: (i) using mass and acceleration i.e. inertial force ($F = ma$) or (ii) using stiffness and displacement i.e. elastic force ($F = kx$). In addition, absolute maximization of these effects is beneficial for design, thus producing maximum response maps across a range of SDOF structures with the same natural period, T, and damping for the same earthquake. This map is called a special spectrum of earthquakes. This response spectrum, which corresponds to the building's acceleration, is called the acceleration response spectrum for throwing 5% of the shock of the 1940 earthquake into the Imperial Valley. It is easier to calculate the actual mass of a building during an earthquake than to estimate the total stiffness of a real building, called the seismic mass (seismic weight divided by gravitational acceleration).

Therefore, after estimating the natural period associated with each vibration region, the value of the acceleration response spectrum is multiplied by the mass associated with each vibration region to obtain the corresponding seismic lateral force. By generating a spectrum of acceleration responses and changing the frame of reference for deformation together, we can easily turn the basic problem of motion in earthquake-prone buildings into an accepted basic problem. Because the action of seismic waves is different in different parts of the country, the response spectrum of the design acceleration is different for each location on the ground. For the design of special buildings, it is necessary to make various designs acceleration responses specific to the location on which the special building will be built.

2.Literature Review

A comparative study of seismic effects on buildings with and without the use of shear wall was conducted (Vaidya and Sayed 2018). This review summarizes the work of several authors on the concept of a multi-storey building having or not having shear walls. The most used seismic resistant structure is none other than shear wall. Multi-storey building having G + 5, 10 and 15 floor were performed by researchers (Sunitha and Reddy 2017). In this research work they considered various situations such as: bracing, shear wall and floating column. For structural analysis, two approaches must be considered: the time history method (THM) and the linear static method (LSM). Seismic analysis performed with ETAB software compares the values of displacement, floor displacement and time history of various models. In the static seismic analysis, it was found that the values of floor displacement and floor drift increased by maintaining the drift ratio for the floating column and that the floor deviation and deviation changed rapidly as the height of the structure increased.

Shear wall structures are seismic systems and are used in masonry and reinforced concrete buildings (EI-Sokkary and Galal 2020). The purpose of this work was to estimate the amount of construction material required for the reinforced masonry (RM) wall in comparison to reinforced concrete (RC) wall. Three buildings with multi-storey shear wall made of RM with different floors and different heights were selected in three different Canadian cities. For the multi-storey building with floating column reliability analysis was done using STAAD Pro software (Ahirwar and Satbhaiya 2020). In contrast to the stability of the rigidity of the entire floor, this study proposes to reduce the irregularities of the floating column in the building. Modeling was performed using FEM commercial tools and detailed analysis using STAAD Pro.

Vishal et al., (2020) worked on the topic analysis of multi-storey building in a seismic zone and considering irregularities in the structures. In that analysis work they analysed 20 numbers of floors of a building having vertical irregularity, modelled as well as analysed it with the help of construction sequence analysis (CSA) and response spectrum method (RSM) in the software ETABS as per the IS Code IS 1893:2016 (Part I). For the safety and economy of the structure, it should be analyzed using the successive tasks of each floor. Finally, the results like: bending moment, shear force, axial forces, and response of storey like: shear, drift and displacement were plotted and then compare it for every structural components. The researchers (Gujar and Jadhav 2019) worked on the construction of the floating column, stating that the building will be subjected to a maximum load after the entire building is constructed. However, in the real world, the construction of the building is completed in stages. Therefore, the effects associated with sequential loading are different from the actual analysis. The aim of this research was to assess the consequences of vertical disturbances in buildings such as floating columns. For the analysis, the structure of the G+10 layer is taken into account for Zone IV. Results such as slip displacement and layer displacement were obtained using ETAB software.

Seismic performance of multi-storey building (made of steel and reinforced concrete) having floating columns as well shear wall was studied (Kini and Rajeeva 2017). These studied models are analyzed by analyzing the response spectra in the assumption that the structure will receive total or partial loads when the structure is completely built. The building samples are analyzed by the CSI ETABS. Rohilla et al., (2015) explain the best location of floating columns in buildings that cannot be vertically adjusted for Zone II and V soil for G + 5 and 7 reinforced concrete building. In their work they used storey shear, drift, and displacement with the help of software (ETABS). Based on the work, and results, below findings were drawn:

a. Floating columns should be avoided, as performance is poor in tall buildings in Zone 5
b. Because of building having floating columns, the displacement of the floor and the drift of the floor increase
c. When there are floating columns the movement of the floors is reduced due to the reduction of the mass of the columns in the structure

The action of a multi-storey floating-column building under the influence of earthquake forces was discussed by Yadav et al., (2016). For this purpose, in the case of a multi-storey building, they considered three cases: 8, 12, and 16-storey and analysis work done using STAAD pro for zone III, IV, and V. The outcome of the work was mentioned in terms of lateral displacement and displacement parameters of the floor of a multi-storey building without shear walls and but with floating columns. After the analysis, they have drawn following conclusions:

a. The storey displacement and drift is higher for those building having floating columns. The storey displacement and drift values are lesser in the lower zone; subsequently it increased for upper zone as the intensity is higher at upper zone.
b. With the inclusion of shear wall will get low value of displacement and shear comparing to those models having no shear walls at every zones. They also conclude that as drift value is for a large range safe in the permissible limit with no shear wall, hence no need of use of shear wall from a point of view of storey drift.

Analysis of RC frame constructed with floating column to know whether it is safe or unsafe in the areas that are seismic prone (Gandla et al., 2014). They also studied the economic impact of floating column. In this regard, the analysis of G+5 building of RC frame having not a single floating column against external lateral forces is performed. All the analysis work was performed using SAP 2000, and external loads are calculated manually using the static equivalent method. For this purpose, three 2D models were modeled in SAP 2000: Model 1, 2, and 3. Model 1 is a model prepared by normal reinforced concrete frame structure. Model 2 is a model prepared by same as model 1 but having floating column, also its dimension is same as of model 1. Model 3 is a model prepared by same as model 1 but having floating column, also its dimension is changed as of model 1. The researcher conclude that they found higher value of displacement in the reinforced concrete frame having floating column compare to buildings without floating column.The performance of reinforced concrete frame with infill wall having different percentage of wall opening was studied (Kulkarni et al., 2013). They conclude that with the increase in percentage opening in these reinforced concrete frame structure a decrease in the lateral stiffness was found. The research and analysis work based on various data collected were done for a reinforced concrete frames in the codal provision of infill wall for masonry structures were done (Jamnekar et al., 2013). The researchers conclude that the utilization of infill wall has a significant impact on the dynamic properties, stiffness, strength, as well as seismic performance of reinforced concrete frame.

3.Conclusions

Although there are many methods for assessing the seismic impact on buildings, these analyzes also have limitations. A study was conducted to apply this analysis to both high and low buildings simultaneously. At this time, special analyzes are performed as appropriate. Buildings with floating columns are considered for analysis. All frames of the building have flat symmetry. Response spectrum analysis and associated floor movement were performed for each building on solid and medium ground. A comparison between the storey drift, displacement, and base shear of each floor was done.

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