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Seismic Analysis of Multistory Building with Floating Column

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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. Ground acceleration and shaking are the main effects of damage to buildings and rigid structures. The severity due to the local influence is related to a composite grouping of the magnitude of the earthquake, the distance from the epicenter and the local geological and topographic conditions. The motion of the earth is measured by the acceleration of the earth.

Keywords:Floating Column: STAAD Pro: Seismic Analysis: Base Shear: Multi-storey

1.Introduction

Traditional engineering structures were designed based on stiffness and strength standards. Stiffness is nothing but serviceability limits that ensure that structural displacements remain within acceptable limits, whereas strength is nothing but which allows the forces arising in the structure to remain at the elastic limit. In case of seismic force, restoring force is required. The seismic intensity of a region indicates the frequency, type and magnitude of earthquakes that occur over a period of time. Buildings are affected by ground movement. Earthquakes are the result of a sudden release of energy from the crust, producing seismic waves. The activity of seismicity of a region indicates the frequency, type and magnitude of earthquakes that have occurred over a period of time. Buildings are affected by motion of ground, frequency, peak ground acceleration (PGA), peak ground velocity (PGV), maximum soil displacement (PGD), frequency content and duration play a dominant role when studying the behavior of buildings under seismic loads.

Ductility is an important feature of structures that must respond to strong earthquakes. Ductility is when a structure is deformed or deformed without being broken or damaged, resulting in energy dissipation. The structure does not fall and has a high capacity for plastic deformation, which increases flexibility and energy consumption. This leads to a decrease in the actual seismic force. Most of the energy generated during an earthquake is transmitted via column of these soft storeys. A plastic hinge is formed at the end of the column and turns these soft storeys into mechanism. In this case, collapse is not avoidable. Recently, all multi-storey structures have been built with the floating column concept. These

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structures are not included in the regulation as they cannot withstand seismic forces and can be damaged.

The design of the transfer girders becomes of prime importance in such structures especially when they are in a place that is prone to seismic activities. Floating columns are especially used for projects on the first floor and above that use carriage beams, allowing maximum space open at the first floor. This space can be used as an auditorium or car park. Especially in seismic prone areas, the transmitted beam needs to be properly designed and detailed. For considering the analysis part of any structure, floating column is mainly used to be fixed to the ground and are therefore considered point loads of transmitted beams. For the analysis of these columns anyone can use STAAD Pro, SAP 2000 and ETABS. These columns are able to withstand gravitational loads, but transmission supports must have the correct size with minimal deflection.

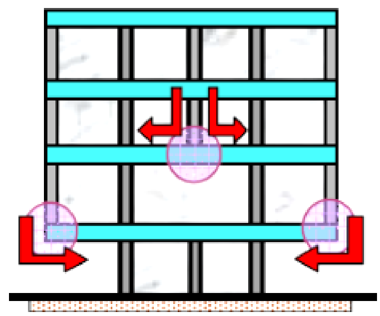

Fig. 1 - Building with floating column

In India floating columns are used in majority of projects. In particular, the transmitted beam is used above the ground floor (GF), hence maximum open space can be used on the GF. 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. This project uses the multi-storey buildings of architectural complexity, i.e. multi-storey buildings with "floating columns" and their behavior in high seismic zones, and considers some recommendations. These columns can be analysed with the help of some of the software like: STAAD Pro, SAP2000, and ETABS. This study used ETABS to model and analyzes the behavior of multi-storey floating-column buildings in high seismic regions.

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).

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.

3.1. Material and Methodology

This research work aims to study the effect of seismic forces on floating columns in various soil conditions and to design it in such a way that the structures can achieve their purpose over their lifetime. To achieve this, in this work the effects of different load types on different structures with and without floating columns were considered, and then compare the results obtained. The analysis is performed using STAAD Pro software using the linear dynamic analysis method, the response spectrum method and the equivalent static method. The project is implemented in the following steps:

a. The building model was created using STAAD Pro software. This requires specifying certain parameters, such as the type of building, the number of floors, the height of the building, the materials used, the dimensions of the columns and beams, the type of floor and the presence or absence of floating columns, etc. Then these parameters were change to monitor and analyse different situations.
b. After the preparation of model then it is carefully looked for the load on the structure. The major load acting on any structures are: dead load (DL), live load (LL), wind load (WL), earthquake load (EL) etc.

Now next step is to study about structural response due to seismic analysis in different situations. The obtained result is analysed in terms of maximum value of storey-drift in horizontal direction, base shear, maximum bending moment, and time period.

3.1.1 Analysis of G+9 building with floating column

In this project work a G+9 stories building in the seismic zone V is considered for analysis using STAAD Pro software. A G+9 storey building having floating column that is in seismic zone V was taken. Analysis was done as per IS 1893 (Part1): 2002. A different position of floating column in first storey of the building is also considered for the study. Modelling and analysis of the building is done by using STAAD Pro software. Seismic analysis is also done to check the structure is safe or not. Response spectrum method is used to find the values of storey drift, displacement and shear. Behaviour of shear wall in floating column building is also considered for the study. The critical and best positions of floating column can be determined from this analysis. Considering seismic zone V having zone factor 0.36.

Table 1 Dimension detailing of building

Sl. No.	Particular	Input value
1	No. of stories	G+9
2	Floor height	3 m
3	Beam (size)	350 mm x 500 mm
4	Column (size)	650 mm x 650 mm
5	Slab (Thickness)	150 mm

Table 2 Load detailing in the building

Sr. No.	**Material**	**UDL**
1	Dead load	2 **kN/m^2**
2	Live load	4 **kN/m^2**
3	Roof load	1.5 **kN/m^2**
4	Earthquake load at	**x -direction**
5	Earthquake load	**z -direction**

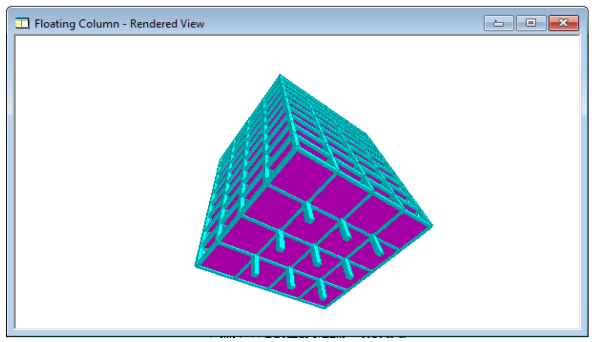

Figure 2: 3D Rendered view (Isometric view) of building

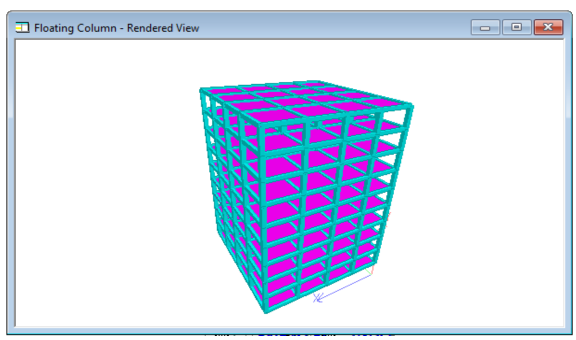

Figure 3: 3D Rendered view (Isometric view) of building by rotating w.r.t x axis

While analyzing and designing of the multi-storied (G+9) framed structure with floating column some manual calculation is carried out for the feeding of data to the STAAD Pro software. As per the Indian standard code of practice data is taken for calculation and result is obtained. After the calculation of seismic parameter these values are entered for the analysis purpose.

4. 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. After analyzing and designing the G+9 building with floating column using STAAD Pro these conclusions were drawn:

- The maximum value of storey shear force was for the first floor
- The location of building is also affecting the structure, as the building located in hard strata shows lesser base shear compared to building at soft strata
- Compared to traditional building the building with floating column is developing larger displacement
- The value of displacement in increased from bottom to top most storey

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