A Review Of The Literature On The Seismic Response Of Floating Column Structures

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Abstract- *Engineers now find floating column construction to be extremely interesting. Buildings with floating columns offer more space and a high-quality product. However, when a floating column is installed in a multi-story building in a high seismic zone, there are significant structural challenges. This paper reviews a number of studies on the actions of floating column buildings under seismic loads. This paper investigates how earthquake-prone areas affect buildings with floating columns. The size and shape of the building structures also affect the risk of damage. The joint surfaces' ductile detailing is a promising protection against such structures failing instantly. Building's structural analysis for various load scenarios by application of design software such as STADD PRO, SAP, ETABS, ANSYS, etc.*

Keywords- Floating Column, multi-story,seismic loads, Response spectrum analysis, Base Shear, Storey Drift, Node Displacement, Shear Force, Bending Moment

I. INTRODUCTION

Buildings are a feat of structural engineering because they represent the modern city. Along with how the earthquake forces are transmitted to the ground, a building's shape, size, and geometry all affect how it will behave seismically during an earthquake. Therefore, the structural engineers must ensure that the unfavourable features are avoided and a good building configuration is chosen from the start. In modern urban cities, multi-story buildings must have column-free space due to population growth, a lack of available land, and a desire for both functionality and aesthetics. Floating columns are a common design element in modern multi-story buildings in urban India, but they are extremely dangerous in structures built in seismically active regions.

Earthquake is movements within the Earth’s crust whichcause stress to build up at points of weaker zone and rocks todeform. Large scale damage occurs during several moderate earthquakes in recent years which indicate, despite such earlygains, earthquake risk in the country has been increasing alarmingly. In high earthquake regions of the country most of the buildings continue to be built without appropriate earthquake resistant features. India is divided into different seismic zones. As per IS 1893:1984 Code India is divided from Zone I to Zone V. But as per IS 1893:2002 Code it has been divided from Zone II to Zone V. Zone I has been discarded.

II. LITERATURE REVIEW

Prabhat dhankad, Aman upadhayay (2022)

Engineers now find floating column construction to be fascinating. Buildings with floating columns offer additional space and a pleasing appearance. However, when a floating column is installed in a multi-story building in a high seismic zone, there are significant structural issues. This study examines a number of studies on the behaviour of floating column buildings under seismic stresses.This paperinvestigates how earthquake-prone areas affect buildings using floating columns. The size and shape of the buildings also affect the likelihood of destruction. The joints' ductile detailing is a promising defense against such structures failing instantly.

Teena Tara Tom, V.P Akhil (2022)

Floating columns are a type of column constructed over beams or slabs of any intermediate floors of a multistoried building. They are not attached to any footings or pedestal and is also called hanging column. The present study investigates the effect of floating column upon the storey shear, displacement and storey drift using ETABS software. Static analysis and dynamic analysis using response spectrum method is done for multi storied building with and without floating columns.

Prajakta Agawane1* , Girish Joshi (2021)

In the modern multi-storey construction in urban India, Floating columns is a classical feature and is highly undesired in buildings built in seismically active areas. Buildings built in seismically active areas do not desire to have buildings built with floating column. From the past events that took place in seismically active areas it can be inferred that the structures constructed without proper design and without proper quality can cause great destruction and can be highly harmful. Thus, the tall structures build in seismically active areas should be built with proper safety against earthquake forces therefore, there is need to determine seismic responses of such building for designing earthquake resistant structures by carrying seismic analysis of the structure.

Jigar J. Solanki, Dr. S. S. Angalekar (2021)

Floating Columns are those which starts from an intermediate floor level instead of foundation level to meet the requirement of open storey. The beam on which floating column rests is called as Transfer Girder. This Assembly of floating column and transfer girder creates many problems in a structure. Hence it should be carefully studied, analyzed and designed. Bracings in concrete structures are used because it can withstand lateral loads due to an earthquake, wind etc. It is one of the best methods for lateral load resisting systems. Concrete-framed high-rise buildings are becoming more common in major cities. Engineers have turned to braced concrete framed structures as a costeffective way to resist seismic loads. In this report, Dynamic Analysis by Response Spectrum Analysis is carried out with G+12 Building having floating columns with different types of bracing systems.

Sushil Sharma, Siddharth Pastariya (2020)

Different parts of the world has seen adverse effects in high rise multi-storey buildings due to earthquakes because of different irregularities present and inadequately designed structures. A structure is regarded as vertically irregular if it has irregular distribution of stiffness, strength and mass along the building height. Irregular building provided with floating column makes it much more irregular with discontinuous load path and are probable to collapse during earthquake. Floating column due to discontinuity in load path makes the performance of building weak. In the present study high rise G+10 building with regular structure and with irregularity are studied and analyzed with and without floating column. The critical position of floating column has been studied for different locations around the periphery columns for both regular and irregular structures for zone V. The study highlights the response of G+10 high rise regular and vertically irregular building with and without presence of floating columns subjected to earthquake forces. The various response parameters such as base shear, storey drift, node displacement, shear forces and bending moments are studied in the various models. The results are compared to determine the effects of presence of floating column in a building.

Aman Gupta , V. K. Verma , Chetan Agari (2019)

Behaviour of multi-storey building with and without floating columns is studied on the basis of displacement, shear, drift, stiffness and overturning moments. A G+10 storey building under the seismic zone V is analyzed using ETABS software. The Response Spectrum Analysis is carried out with 3D model using the software ETABS. This parametric study may be helpful for systematic and economical design for the structure with and without floating column.

Neha Pawar, Dr Kuldeep Dabhekar , Prof Prakash Patil, Dr Isha Khedikar, Dr Santosh Jaju (2018)

In Recent Trends, buildings are planned to fulfill their architectural and functional requirements but sometimes this creates complexity in its structural strength. One such element is the floating column. It is used to boost Floor Space Index. The Earthquake forces developed at different storey need to be carried down by the shortest path. Discontinuity in the load transfer path leads to poor seismic performance of the structure. Hence as per IS: CODE-1893:2016 clause no-7.1, the Construction of Floating Column is restricted. But there is no limit to research work. The purpose of this research is to analyze the structural irregularity occurring due to floating columns and also to find out the optimized solution to decrease the risk due to earthquake excitation. For Simplicity, the focus of this study is limited to symmetrical G+8 Structure. Finite element Based ETabs software has been used for the analysis. Response spectrum analysis was done in the software. Total ten models are considered with different conditions and their results were compared in terms of Storey displacement, Storey drifts, Base Shear and Overturning moments. All results are compared with the conventional building.

N.Elakkiyarajan , G.Iyappan And A Naveen (2018)

The term floating column is a vertical member which ends at its lower level rests on a beam which is a horizontal member. The beams in turns transfer the load to other column below it. In present scenario buildings with floating column is a typical feature in the modern multistory construction in India. Such features are highly undesirable in building built in seismically active areas. In the unavoidable circumstance floating columns are adopted in building. Brief analysis will be made for the structure with and without floating column. Floating columns are placed different story levels and different position in the structure, for different seismic excitation by changing the frequency of vibration using ETABS standard Finite element analysis package. Final results for maximum story displacement, maximum inter-story drift, story base shear, overturning moment are compared with different seismic excitation. The most safer and economical method to reduce the cost of floating column beam is suggested.

Isha Rohilla , S.M. Gupta , Babita Saini (2015)

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. These floating columns are highly disadvantageous in a building built in seismically active areas. 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. In this paper, the critical position of floating column in vertically irregular buildings has been discussed 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.

Banerjee S. and Sanjaya K Patro (2015),

In paper “The approximation of damage catalogue for building with infill wall considering floating column”.This paper concluded as that the infill wall considering the floating columns provides seismic reinforcement of the structure with the floating columns, and the embankment effect has a slightly higher damage index but helps reduce the formation of high-rise cracks. The infill wall increases the rigidity of the structure, resulting in higher base shear.

Sudheer KV (2015),

In paper “The behaviour of G+15 multi storey building with and without floating column”. Performed 3 - D Analysis of Building Systems (ETABS) software was used for designing and analysis purposes. The analysis of the multi-storey buildings with & without hanging columns is completed and various results are compared. This research conclude as the floating column building is going to experience very risky storey displacement or drift when compared with conventional one and storey shear is also high due to the use of additional amount of materials than a conventional building.

Malaviya P, Saurav (2014),

The impacts of floating columns on a building's overall cost are compared in the paper "The Comparative Learning of Effects." created with STADD PROV8i. Different models were developed and examined. This study finds that node displacement is low and stress is equally distributed among all columns and beams in a frame system without floating columns.

Poonam, et al (2012),

in the article "The Response of Structurally Asymmetries Buildings Performed the Seismic Analysis of Building Frames Considering Several Unevennesses Like Mass Unevenness and Stiffness Unevennesses" They came at conclusions regarding how these abnormalities affected storey shear forces, storey drifts, and girder deflection. This article comes to the conclusion that irregularities are disastrous to the structure, but that they must be provided when there occur, and that they must be detailed and well-designed, with ductile joints.

III. PROBLEM STATEMENT

As per review of papers, researchers have done study on floatingcolumns or discontinuity of column in a building and comparing those results with the normal building. Several analysis method both static and dynamic have been used to determine the response of structure due to earthquake loads. Also on the basis of irregularity literatures, some study has been done by researchers on different types of irregularity taken for consideration and comparing the regular and irregular structures.

- stiffness irregularity in open ground
- discontinuity in load path due to fc
- more displacement occurs during earthquake
- increment in storey drift
- torsional irregularity due to horizontal irregularity

IV. STRUCTURAL SYSTEMS FOR SEISMIC RESISTANCE

Alternative structural configurations should be discussed as early as possible in the idea development process to ensure that unwanted geometry is not locked-in to the system before structural design begins. Irregularities, which are almost always unavoidable, add to the complexity of structural activity. They can cause unanticipated damage and even collapse if they go unnoticed. Structural abnormalities can come from a variety of places. Many of these abnormalities, as well as suggestions for remedial methods to avoid or mitigate their unfavorable impacts, rely on a thorough grasp of structural behaviour. Design experience and the ability to seek for unfavorable structural elements are also useful assets. It is possible to quantify the relative importance of various abnormalities. Some codes provide only little assistance in this regard. The basic function of all building constructions is to support gravitational loads. Buildings, on the other hand, may be vulnerable to lateral forces caused by wind or earthquakes. The effects of lateral forces become increasingly substantial as a building rises in height. Buildings are made up of three different sorts of constructions. –

1. **Structural Frame Systems –**Frames are commonly used in multi-story reinforced concrete buildings. In nature, beams, supporting floors, and columns are all continuous. They come together at nodes, which are also known as "stiff" joints. Such structures can easily support gravity loads while also resisting horizontal forces acting in any direction.
2. **Structural Wall Systems –** When functional requirements allow, lateral force resistance can be attributed solely to structural walls made of reinforced concrete or masonry. The effects of gravity loads on such walls are rarely considerable, and they have little bearing on the design. There are usually other elements within such a structure that are only assigned to carry gravity loads. Their, if any, contribution to lateral force resistance is frequently overlooked.
3. **Dual System –** Reinforced concrete frames interact with reinforced concrete or masonry walls to give the required lateral force resistance, while each system bears its fair share of the gravity load. The words dual, hybrid, and wall-frame systems are all used to describe these forms.

STRUCTURAL FRAME SYSTEMS

Frame

A frame is a structure that resists lateral and gravitational loads by combining beams, columns, and slabs. The primary function of a structural frame is to counteract the huge moments created by applied loads. Reinforced concrete or steel can be used to construct structural frames. Frames are commonly used in the construction of multi-story reinforced concrete buildings. In nature, beams, supporting floors, and columns are all continuous. They come together at nodes, which are also known as "stiff" joints. Such structures can easily support gravity loads while also resisting horizontal forces acting in any direction.

Moment-Resisting Frames

As per Indian Standards i.e., IS 1893:2002 RC moment-resisting frames are categorized into –

1. Ordinary Moment Resisting Frames
2. Special Moment Resisting Frames

OMR Frame is a moment resisting frame that does not fulfill the ductile behaviour criteria. A SMRF is a moment-resisting frame designed to produce ductile behaviour and meet the criteria of IS-4326, IS-13920, or SP6. Buildings with non-ductile concrete frames have regularly suffered substantial structural damage in earthquakes. These principles were introduced to the US about 1960. Special moment resistant frames were introduced in India about 1993.

Response Reduction Factor

It is the factor by which we decrease the actual base shear force to achieve the lateral force for design with an assumption that our structure is still behaving as elastic structure during the Design Basis Earthquake (DBE) shaking. To account for non-linear behaviour and deformation limitations, designers might utilize this factor.

Table 1: Difference Between SMRF AND OMRF

Special Moment Resisting Frames (SMRF)	Ordinary Moment Resisting Frames (OMRF)
It is a moment-resisting frame specially detailed to provide ductile behavior and comply with the requirements given in IS 13920.	It is a moment-resisting frame not meeting the special detailing requirements for ductile behavior.
Response Reduction Factor, R=5	Response Reduction Factor, R=3
Used under moderate or high earthquakes.	Used in low earthquakes.
High design base shear.	Low design base shear.
It is safe to design a structure with ductile detailing.	It is not safe to design a structure without ductile detailing.

V. CONCLUSIONS

The following points are concluded from the literature review –

1) The building with floating column has more time period as compared to building without floating columns.

2) The building with floating column has less base shear as compared to building without floating column
3) Floating column building has more displacement as compared to without floating column building.
4) Building with floating column has more storey drift as compared to building without floating column.
5) Floating column at different location results into variation in dynamic response.
6) Building with floating column are more vulnerable in high seismic zone than buildings without floating column.
7) Building without floating column are more economical than building with floating column.
8) Hard soil type is more feasible to construct buildings with floating column.

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