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Experimental Study on the Seismic Analysis of Multistoried Building With Floating Column

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Abstract*: - Modern multi-storey buildings are constructed with irregularities such as soft storey, vertical or plan irregularity, floating column and heavy loads. These type of structures have become a very common construction practice in urban India. It is observed that most of the RC structures with such irregularities constructed are highly undesirable in seismically active areas from the results of past earthquake studies. These effects occurred due to various reasons, such as non-uniform distribution of mass, stiffness and strength. This study explains the seismic analysis of a multi-storey building with floating column constructed in seismically active areas observing its reactions to the external lateral forces exerted on the building in various seismic zones using the software ETABS. Thus highlighting the alternative measures involving in improvising the non-uniform distribution in the irregular building such as multi-storied building with floating column, and recommended the safer design of such building in seismically active areas considering the results observed from storey drifts, story displacements, when compared to Response Spectrum method shows best results.*

KEYWORDS: - *multi-storey buildings, earthquake, seismic, software ETABS, floating column*

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I. INTRODUCTION

GENERAL

India is a developing country, where urbanization is at the faster rate in the country including adopting the methods and type of constructing buildings which is under vast development in the past few decades. As a part of urbanisation multi-storey buildings with architectural complexities are constructed. These complexities are nothing but soft storey, floating column, heavy load, the reduction in stiffness, etc. Now a day's most of the urban multi-storey buildings have open first storey as an unavoidable feature. Accommodation of parking or reception lobbies is the primary use of these open first story in the multi-storey buildings constructed. But Conventional Civil Engineering structures are designed on the basis of strength and stiffness criteria. Usually the ground storey is kept free without any constructions, except the columns which transfer the building weight to the ground. This thesis adopt the multi-storey building with a architectural complexity i.e. the complexity of a multi-storey building with "Floating column" and the behaviour of the building in higher seismic zones is observed and considered some recommendations. Floating column

"A column is supposed to be a vertical member starting from foundation level and transferring the load to the ground, and the term "Floating Column" is also a vertical element which at its lower level rests on a beam which is a horizontal member

A common form of discontinuity in load path in moment frames arises with a floating columns, i.e., when a column coming from top of the building is discontinued at a lower level, usually at the ground storey. In such cases, loads from the overhanging portions take a detour and travel to the nearest column that is continuous till the foundation. This leads to increased demand on the columns in the ground story and can cause failure of these columns.

Usually these high-rise and architectural complex buildings showed a least serviceable behavior during past earthquakes. Generally the behaviour of a building during earthquakes depends mainly on its overall shape, size and geometry, in addition to the how earthquake forces are carried to the ground by the columns. 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. There are some 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. There are many projects in India in which floating column are already adopted, especially above the ground floor, where the transfer girders are employed, so that more open space is available on the ground floor, and these open spaces may be required for assembly hall or parking purpose. The column is a concentrated load on the beam which supports it

in this condition. Hence the structures already made with these kinds of discontinuous members are endangered in seismic regions. Thus the floating column is used for the purpose of architectural view and site situations. It can be analyzed by using STAAD Pro, ETABS and SAP2000. In the study the behaviour or the multi-storey buildings with floating columns at higher seismic zones using ETABS are modeled and analysed. Earthquake Resistant Design Generally these buildings with floating columns are usually designed for gravity loads and are safe under gravity loads but are not designed for earthquake loads. So these buildings are unsafe in seismic prone areas. Hence this study aims to create awareness about these issues in earthquake resistant design of multi-storeyed buildings with floating column. There are four virtues of Earthquake Resistant Design, and the characteristics of the building are like the aspects for architects and design engineers to work with to create the earthquake resistant design of a building, namely seismic structural configuration, lateral stiffness, lateral strength and ductility. In addition to other aspects like form, aesthetics, functionality and comfort of building, lateral stiffness, lateral strength and ductility of buildings can be ensured by strictly following most seismic design codes like IS 1893-2002(Part-1). But, good seismic structural configuration can be ensured by following coherent architectural features that result in good structural behavior. The virtues are achieved by inputs provided at all stages of the development likely in its Planning, Design, Construction, and Maintenance.

Objectives and scope of the work

In this present project, the following aspects are attempted to study.

1) Modelling of the multi-storey building with and without floating column using ETABS,

2) Comparative study is done between the multi-storey building with and without floating column in different zones, when the floating column are present at the same floor and different location in the building,

3) Comparative study on variations in the structural response in the structure due to seismic excitation is also performed,

4) The building with floating column are tend to fail at seismic excitations, hence the recommendations for the earthquake resistant design of the considered buildings are modelled and analyzed.

5) The main objective of the study is to provide a economical and safe design of a building with floating column at seismic zones with recommending some design recommendations as there is no specified provision or magnification factor provided in I.S codes for this type of irregularities.

OBJECTIVE OF THE STUDY

Now having a look over history of SCC, question arises that what is needed to go for SCC? So, here are some of the important aspects to go with SCC:

Foundry sand and red mud has pozzolanic properties hence increasing the binding properties and gives the better strength at the same time it reduces the cost problems. And also reduces the following problems.

1. Foundry waste dumping
2. Red mud dumping.

In dumping land become useless. It starts polluting the groundwater. So it should be used in some constructive fashion.

II. LITERATURE REVIEW

In the present study, the research articles and journals that are studied for understanding of the work to be carried out are discussed and these papers are presented as per the reference of this study in this chapter. Sabari. S, Mr. Praveen J.V [1],(2014), this paper refers to the "SEISMIC ANALYSIS OF MULTI-STOREY BUILDING WITH FLOATING COLUMN" in which the FEM analysis is carried out for 2D and 3D multistory frames with and without floating columns studying the responses of the structure with different seismic excitations where the RC frames are of with different stiffness on floor wise and height of the building, that are considered in the analysis keeping PGA and time duration factors as constants having different frequency and highlighting with alternative measures involving stiffness balance to reduce the irregularity in the first and storey above which is introduced by the floating columns. The time history analysis is done by considering the whole system of frames of the building to Bhuj earthquake excitations, and are provided to compare the results obtained from the analysis of all types of frames using the SAP2000 software. This paper thus concluded as results obtained using present finite element code for the static and free vibration are validated and the dynamic analysis of frame is studied by varying column size dimension and is concluded that by increasing the column size the maximum displacement and inter storey drift values are reducing.

Sreekanth Gandla Nanabala, Pradeep Kumar Ramancharla, Arunakanthi E[2],(2014), This paper refers as "SEISMIC ANALYSIS OF A NORMAL BUILDING AND FLOATING COLUMN BUILDING" in which the analysis of a G+5 storey normal building and G+5 storey floating column building for external lateral forces using SAP2000, is done. This paper study the variations of both buildings such as time history values by applying the intensities such as ground motions of the past earthquakes. Such that the study highlights whether the structure with

floating columns are safe or unsafe in seismically active areas and also observe the structure is economical or uneconomical. This paper studies the G+5 storey building with all columns that is a normal building and the other building without edge columns in the ground floor that is a floating column building's behaviour when excited to the lateral loads. After the comparison of the buildings it is found that the G+5 without edge columns is not safe in seismic zone as the lateral displacement in a floating column building is higher than a normal building, so the floating column building is unsafe in seismic areas. When the lateral stiffness of both the buildings are compared then it is observed that the building with floating columns will suffer extreme soft storey effect where on the other side the normal building is free from soft storey effect completely. In the analysis carried out between the buildings the quantity of steel and concrete are 40% and 42% more in floating column building than the normal building. Hence it is concluded that the floating column building is unsafe and uneconomical and not preferable for construction when compared with the normal column building.

Srikanth.M.K, Yogeendra.R.Holebagilu [3](2014), This paper refers to "SEISMIC RESPONSE OF COMPLEX BUILDINGS WITH FLOATING COLUMN FOR ZONE II AND ZONE V" in which the analysis of the building with floating column and also other complexities are considered for ten storey building at alternative location and also for low to higher zones. This study providing alternative measures involving stiffness balance of the storey where floating column provided and the storey above when other irregularities are also introduced in the stories. Finally analysis results such as storey drifts, storey displacements, storey shears of the high rise building are compared in the study using the software ETABS. The main objective of the study in this paper is to compare the seismic behavior of the building having only floating column and floating column with other complexities in it where the location of the floating column are also varied to find the optimum position comparing the results obtained from zone II to V, thus the study is observed between the four types of models that is a floating column model, a floating column model with raised floor heights, a floating column model with heavy load at the floating column floor, and the last is a floating column with raised floor height provided with heavy load in that floor. The results obtained are in terms of lateral displacements, storey shears, storey drifts. It is concluded that, the displacement of the building increases from lower zones to higher zones, because the magnitude of intensity will be more for higher zones, similarly for drift, because it is correlated with the displacement. Storey shear will be more for lower floors, then the higher floors due to the reduction in weight when we go from bottom to top floors, and with this if we reduce the stiffness of upper floors automatically there will be a reduction in weight on those floors so in the top floors the storey shear will be less compared to bottom stories. The response of the building which is having only floating column will be less when compared to other. The multi-storey building with complexities will undergo large displacement then the model having only floating column. In all models the displacement values are less for lower zones and it goes on increases for higher zone. Prerna Nautiyal, Saleem Akhtara And Geeta Batham[4],(2014) titled as "SEISMIC RESPONSE EVALUATION OF RC FRAME BUILDING WITH FLOATING COLUMN CONSIDERING DIFFERENT SOIL CONDITIONS". This paper investigated the effect of the floating column under earthquake excitation for different soil conditions and a linear dynamic analysis is done for the 2D frame of the multi-storey building with and without floating column to achieve the response of the frame for safer and economical design of the structure under such excitations.

This paper study the effect of a floating column under earthquake excitation for various soil conditions where for the purpose of analysis two different models are considered. They are G+3 and G+5 moment resisting frames. The result verified are the response spectrum analysis for varying soil conditions and the magnification factor which is evaluated for base shear and moments for both G+3 and G+5 models including the exterior and interior columns and beams. From the results thus obtained are concluded as, the base shear observed for medium soil are higher than the hard soil in both the cases as the height of the building increases the variation in the base shear from medium to hard soil condition decreases, and further it can be concluded that, as the height of the building increases the variation of maximum moments gets reduced for different soil conditions. Hence from the results of the response spectrum analysis obtained for both the moment resistance frames shows that the location of floating columns at corners as of modelled in the cases considered are more critical than others in the present study.

III. METHODOLOGY, MODELLING AND ANALYSIS OF FRAMES

This chapter explains the methodology adopted in the modelling and analysis of the frames in the study.

• The modelling of the buildings are done using ETABS software,
following the codes IS 456-2000 and IS 1893-2002(part1),

• As per IS 1893-2002, "clause 6.2 assumptions" for "Earthquake
Resistant design of structures" are followed, and as per clause
6.3.1.2 the load combinations are accounted, i.e.

a) 1.5(DL±IL)
b) 1.2(DL±IL±EL)
c) 1.5(DL±EL)

d) 0.9DL±1.5EL
• Shear walls are designed as per IS 13920-1993 Clause 9.1.2 and their thickness is not less than 150mm.
• As per IS 1893-2002, the moment resisting frames are designed independently to resist at least 25% of the design base shear. The modelling details of the buildings are as discussed below.
• For analysis and study purpose there are few models developed in this study such that a multi-storey building that is Stilt+G+4 building is considered and modelled into two types mainly.
They are a multi-storey building without floating column that is a normal building and the other type is multi-storey building with floating columns at different positions in it.
• Among these two types of models, the multi-storey building without floating column is considered constant comparing it with the models developed as multi-storey building with floating column where these floating column are present at different portions of the building analysing it at different zones as zone 5 to zone 2 as per codal provisions.
• And the analytical models of the building include all the component that influence the mass, strength, stiffness and deformability of the structure.
• ETABS is a standalone finite element based structural program for the analysis and design of civil structures and which is a fully integrated program that allows model creation, modification, execution of analysis, design optimization, and results review from within a single interface and thus used for the analysis of all structural systems by linear static method for zones II and V.
• Hence the results are tabulated by focusing the parameters like lateral displacements, base shear and story drift.
• From the "Response Spectrum Analysis" when compared shows the best results. This is explained as, The earthquake response spectrum analysis is the most popular method in the seismic analysis of the structures.
• There are computational advantage for prediction of displacements and member forces in the structural systems using the response spectrum method. This method involves in the calculation of the maximum values of the displacements and member forces in each mode of vibrating using smooth design spectra that are the average of several earthquake motions.
• This paper studies with the response spectrum analysis of the multi- storey building with floating column at different positions of the building. As per the code IS 1893-2002(part 1) the response spectrum analysis of multi-storey building is summarized.
The models details are,
Model 1: Stilt+G+4 building without floating column i.e. normal building analysed from zone 5 to zone 2,
Model 2: Stilt+G+4 building with floating column at Edge column position, analysed from zone 5 to zone 2,
Model 3: Stilt+G+4 building with floating column at Centre portion, analysed from zone 5 to zone 2,
Model 4: Stilt+G+4 building with floating column at parallel positions, analysed from zone 5 to zone 2,
Model 5: Stilt+G+4 building with floating column with recommendations, analysed from zone 5 to 2, Comparison of the results observed in the three models that is Maximum displacements, Story drifts, Response spectrum analysis, of the normal building, floating column building and floating column building with shear walls.

IV. RESULTS AND DISCUSSIONS

A comparative study and analysis is performed between a normal column building that is the building with all regular columns and other structural and non-structural members in it and on the other hand a floating column building at various zones as per the specifications in IS- 1893(2002)part 1. A detail study is carried out on the floating column building to find out the variations in the structural response of the building with floating columns at "parallel positions, at one edge column position and at the centre portion", observed from the parameters like maximum displacements in the building at each floor, story drifts and the results obtained are beyond the deformation limits.

Then such a floating column building tend to fail in extreme earthquake zones, thus some recommendations are performed to analyse the building response in that case. The recommendations followed are shear walls, infill walls, Steel bracings and the designed frame is a moment resisting frame for the analysis of the building in these conditions. Hence the results are discussed and are as shown below. In the analysis of the models with recommendations, the following are the assumptions made. In consideration of shear walls, following the provisions in the code IS 1893-2002(part 1), and in the consideration of infill walls, the masonry infill walls are considered. As, it is observed that the masonry infill walls tend to reduce the displacements, time periods when compared with the other type. And also that, the steel bracings are considered in the study, by observing that steel bracings are more efficient compared to the concrete bracings in resisting the forces exerting on it, and the "x" shape are used as this shape of bracing system proves to have less torsion effect on the structure when external forces are exerted on it. Thus, from these considerations, the models are analysed as discussed below,

Model 1: Stilt+G+4 building without floating column i.e. normal building analysed from zone 5 to zone 2 In this model, Normal building frame is designed and analysed considering the parameters like maximum displacements

and story drifts in X and Y directions, Column P-M-M interaction rations are observed and response spectrum analysis is also observed. Thus, the results obtained are discussed below. The figures shown below are plan and elevation view of the normal building.

V. CONCLUSION

General

The study in this paper mainly comprises the difference between a normal column building and a floating column building and then followed with the recommendations that can be recommended for a safe and economical design of a floating column building which can be defined as an earthquake resistant design, and following conclusions are drawn from the analysis,

1) Generally, a building becomes expensive if it is designed to sustain any damage during a strong earthquake shaking.

2) In the present study, it is observed that the normal column building is more efficient when compared with other models i.e. floating column buildings.

3) From the results it is observed that the building with floating column at Zone 2 and Zone 3 can be safe designed by increasing the dimensions of the beams and columns, whereas in Zone 4 and Zone 5 the Recommendations are ultimately to be followed in the design.

4) Hence the recommendations such as shear walls, infill walls, bracings are considered in the modelling and analysis and observed that they can also be designed as an earthquake resistant up to an extent, such that on introduction of floating columns in the RC frames increases the time period of bare frames due to decrease in the stiffness.

5) On comparison of the results obtained for each model, it is observed that the building with normal column building have lesser displacements and story drifts when compared with the floating column models.

6) Similarly, when the floating column models are compared with each other, it is observed that the floating column building at one Edge column position have higher displacements and story drifts followed by floating column at parallel positions and finally the floating column at the centre portion.

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