STUDY THE BEHAVIOR OF FLOATING COLUMN IN MULTI STOREY BUILDINGS UNDER THE SEISMIC IMPACT

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Abstract

In current scenario buildings with floating column is a usual feature in the recent multi-storey structure in urban India. Such features are vastly undesirable in building constructed in seismically active areas. This study highpoints the importance of explicitly distinguishing the presence of the floating column in the analysis of building. Alternate measures, encompassing stiffness balance of the first storey and the storey above, are suggested to reduce the irregularity presented by the floating columns.

FEM codes are established for 2D multi storey frames with and without floating column to revise the responses of the structure in different earthquake excitation having different frequency content keeping the PGA and time duration factor constant. The time antiquity of floor displacement, inter storey drift, base shear, overturning moment are calculated for both the frames with and without floating column.

KEY WORDS: floating column, multi storey, seismically active areas, stiffness, FEM, time duration factor, inter storey drift, base shear.

I. INTRODUCTION

In current time, multi-storey buildings in metropolitan cities are required to have column open space due to shortage of space, population and also for aesthetic and serviceable requirements. For this, buildings are delivered with floating columns at one or more floors. These floating columns are extremely disadvantageous in a building built in seismically active zones. The earthquake forces that are settled at different floor levels in a building need to be passed down along the height to the ground by the shortest path. Deviation or discontinuity in this load transfer path result in reduced performance of the building. The performance of a building during earthquakes depends unfavourably on its overall shape, size and geometry, in addition to how the earthquake forces are passed to the ground. Many buildings with an open ground storey anticipated for parking collapsed or were severely damaged in Gujarat in the 2001 Bhuj earthquake. Column: The column is a vertical participant which transfers it's self-weight and burden of corresponding beams to the foundation beneath it. Floating Column: The floating column is a vertical participant which rests on a beam and doesn't have a footing.

Many urban multi-storey buildings in India, nowadays have open first storey as an obligatory feature. This is predominantly being accepted to accommodate parking or reception lobbies in the first storey. Whereas the total seismic base shear as experienced by a building during an earthquake is reliant on its natural period, the seismic force distribution is dependent on the dissemination of stiffness and mass along the height.

The behaviour of a building during earthquakes depends disapprovingly on its overall shape, size and geometry, in addition to how the earthquake forces are passed to the ground. The earthquake forces established at different floor levels in a building need to be conveyed down along the height to the ground by the smallest path; any deviation or discontinuity in this weight transfer path results in reduced 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 certain storey or with remarkably tall storey tend to damage or collapse, which is initiated in that storey. Many buildings with an open ground storey anticipated for parking collapsed or were severely damaged in Gujarat in the 2001 Bhuj earthquake. Buildings with columns that hang or float on beams at a transitional storey and do not go all the way to the foundation, have incoherence in the load transfer path.

A column is thought to be a vertical member starting from foundation level and shifting the load to the ground. The beams consecutively transfer the load to other columns below it. There are countless projects in which floating columns are implemented, especially above the ground floor, where transfer girders are engaged, so that additional open space is available in the ground floor.

These open spaces may be requisite for assembly hall or parking purpose. The transfer girders have to be planned and detailed properly, especially in earth quake regions. The column is a concentrated load on the beam which maintenances it. As far as examination is concerned, the column is frequently assumed pinioned at the base and is hence taken as a point load on the transfer beam. STAAD Pro, ETABS and SAP2000 can be used to do the analysis of such type of structure. Floating columns are competent enough to carry gravity loading but transfer girder must be of adequate dimensions (Stiffness) with very minimal deflection.

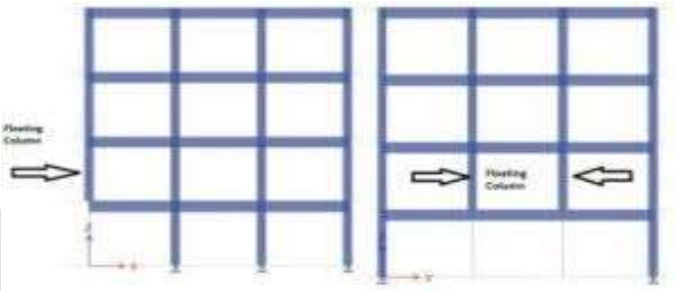


Fig. 1: A multi-storey with floating column

II. OVERVIEW OF WORK

The salient objectives of the present study have been identified as follows:

- The objective of the present work is to study the behaviour of floating columns in multi-storey buildings under earthquake excitations.
- To compare the behaviour of floating columns and non-floating columns with seismic Behaviour
- To study flow of forces and variations in column forces in a building by varying locations of floating column floor wise.
- Finite element method is used to solve the dynamic governing equation. Linear time history analysis is carried out for the multi-storey buildings under different earthquake loading of varying frequency content. The base of the building frame is presumed to be fixed. Newark's direct integration scheme is used to advance the solution in time.

III. NEED FOR THE PROPOSED WORK

Now a day's multi-storey building construction for residential, industrial or commercial purpose has become a common feature. These multi-storey building need ample of parking or open spaces below.

In multi-storey residential building to accommodate for the number of parking places and the turning radius, some of the columns from the floors above create a problem. In these cases, these columns are designed as floating columns. Even in commercial building there might be a need for seminar hall or banquet hall on the lower floors. For these purposes we desire to have a clear open space instead of having columns in between. This is where floating columns come into the depiction. Floating columns gives the freedom to alter the floor plans above.

- To fulfil the architecture requirements of a structure.
- Useful when the lower floor has a large span hall
- Useful in the construction of soft storeys
- Useful to varied the plan on each floor

IV. LITERATURE REVIEW

Literature review allied to the seismic analysis of multi-storey building was carried out. The objective was to discern the strength of different multi-storey buildings for different seismic zones. It was observed that many researchers, scholars and consultants have worked extensively on seismic zones, seismic design, importance of seismic analysis, modern design methods, design formulae etc.

Fig. 2: A multi-story at site with floating column

Sasidhar T (2017) performed the analysis of buildings using program ETABS. They considered a housing building G+5 and different cases of elimination of columns in dissimilar positions and in various floors of the housing building. Equivalent analysis is done on a mathematical model and results are related or compared with the existing model. It was concluded that, the use of floating columns results in increased shear, increased bending moments and increased steel requirements of the buildings.

Mohamed Aqeeb Ulla (2016) studied earthquake behaviour of reinforced concrete buildings by means of non-linear static analysis by considering presence of floating columns. Linear analysis practices of structures give a decent suggestion of elastic ability of the structures and designate where first yielding will occur. Using nonlinear analysis procedure, the model integrates directly the force-deformation characteristics of individual parts of structures and fundamentals due to in-elastic physical behaviour and response. Several models were prepared and analysed for non-linear responses. They concluded that overall strength capacity of the building totally depends on the applied forces and the base-shear capacity. It was considered that, shear of the storey depends on
The mass of the structural model.

Rahman A. (2015) in “Effect of floating columns on seismic response of multi-storeyed RC framed buildings” discovers the effects of the anomaly which is formed by Disjuncture or cut-offs of a column in a building open to seismic forces. Dynamic and static analysis using response-spectrum method were performed for a high-rise G+6 Storey building by fluctuating the location of floating columns floor-wise. It has been noted that by presenting a floating column in RC building the time period rises and this is generally due to the reduction in the stiffness. It also decreases the base reaction and spectral acceleration.

Udhav B (2015) in their paper study of multi-storey building with floating column deliberated the behaviour of a present structure which was a G+10 residential building. Various building models were created using STAAD Pro software and analysis was done using static method. The systematic building models comprises of all the modules which effect the mass, deformability, stiffness and finally the strength of structure. The structural building system consists of a column, block, wall, beam, elevator, staircase, slab, footing and retaining wall. The results shows that the column shear Changes in accordance with the condition and location of column, also the curvature at every single floor or storey rises and shear force gradually rises but it is almost equivalent at every floor for respective columns.

This project contracts with the revision of architectural drawing and the encompassing drawing of the building having floating columns. The load dispersal of the floating columns and the various effects due to it, is also being studied. The significance and effects due to the line of action of force are studied as well. In this we are dealing with the relative study of seismic analysis of multi-storeyed building with and without floating columns. The corresponding static analysis is carried out on the entire project with mathematical 3D model using the software STAAD Pro V8i and the evaluation of these models are being done. This will help us to find the various methodical properties of the structure and we may also have a very systematic and economical design of the structure. The floating column is a vertical participant which at its lower level rests on the beam which is a horizontal member. These beams carry this surplus load to neighbour columns or the columns below it, which ultimately rises the load on remaining columns. There are many buildings in which floating columns are practiced, especially above the ground floor, so as to provide more open space for parking and other needs.

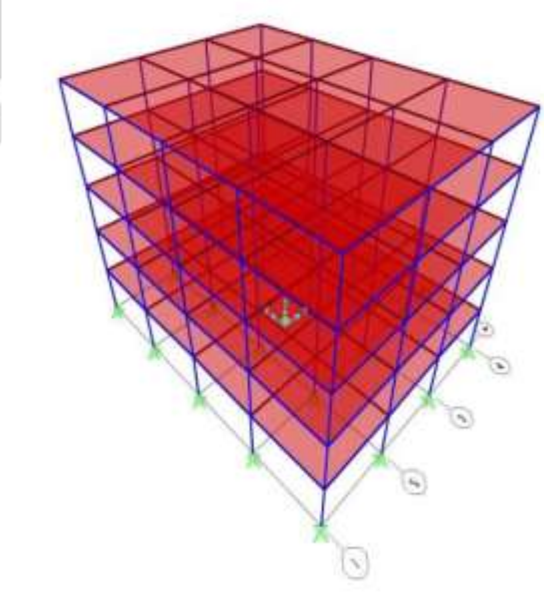
V. DESCRIPTION OF STRUCTURAL MODEL

The description of the structure and other important parameters are given below:
Geometry: The building has five bays in X direction and four bays in Y direction with the plan dimension 22.5 m × 14.4 m and a storey height of 3.5 m each in all the floors and depth of foundation taken as 1.5 m.
Material properties: M-25 grade of concrete and Fe-415 grade of reinforcing steel are used for all the frame models, the unit weights of concrete and masonry are taken as 25.0 kN/m3 and 20.0 kN/m3, the poison ratio of concrete is 0.2 and of masonry is 0.15.

Details of Structure

- This is a typical low rise RCC building. All principal necessities for gravity, wind, and seismic design have been considered. It was designed for a typical live load of 3 KN/m2.
- The floor finish load (dead load) is assumed to be of 1 KN/m2.
- This is a five-storey RCC building which consists of 4-bays @ 5m along x-axis and 3-bays @ 5m along y - axis.
- The storey height is 3.10 meters.
- Slab thickness is taken as 0.150 meters.
- Density of concrete - 25 KN/m3
- Floor to Floor height – 3.10 m
- Size of the beams- 300x 500 mm
- Size of the columns – 500 x 600mm
- Concrete of grade M30.
- Steel of grade Fe415.
- Support condition – Rigid

Fig 3: 3D view of model



It is basically a procedure which governs the vibrational characteristics of a structure.

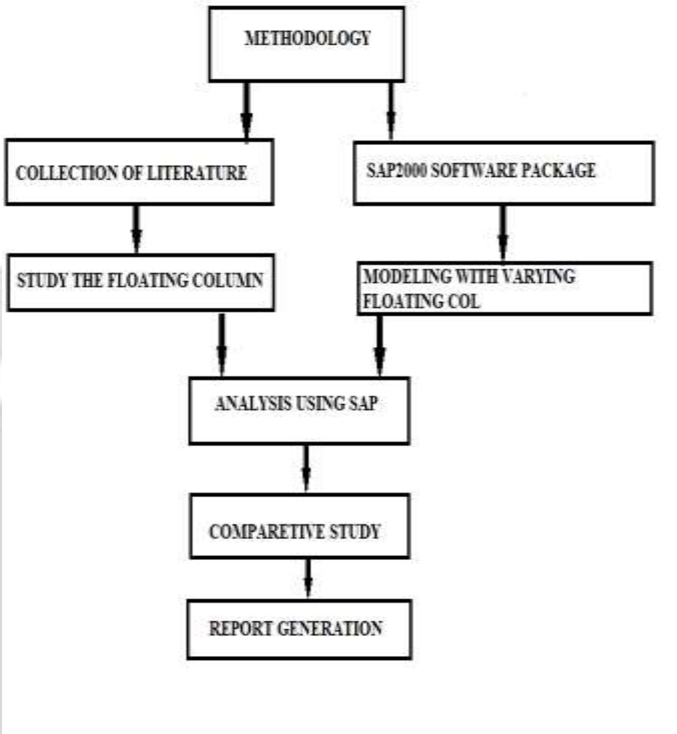
- Natural fundamental frequencies
- Mode shapes
- Mode participation factors i.e. how much a given mode contributes in a particular direction.
- Most vital of all the dynamic analysis types.

Procedure: -

Step by step procedure to carry out modal analysis:
- Creation of model.
- Assigning materials properties to the model.

• Create step (procedure type – linear perturbation)
• Application of various boundary conditions.
• Define meshing size and finding results.

VI. WORKING FLOW CHART



VII. RESULT

In present study, evaluation and comparison of seismic response parameter like time period, storey displacements, base shear, and dynamic response are done by changing the position of floating column level wise or floor wise by using linear static analysis. Result are associated in tabular form and also graphs are prepared for the analysis of building models with and without floating column. Time period founded for building with floating column and building without floating column for various models are given in the Table

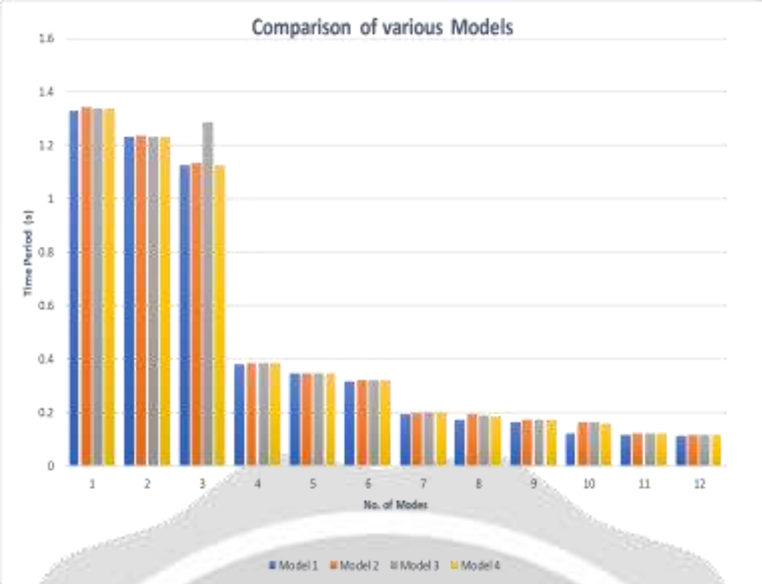


Fig. 4: Comparison of time period for no. of modes and for various models

Base shear defined as horizontal reaction at the base in contrast to horizontal quake load. This base shear acts at base or at the support level of the structure or at the fixed ends of structures.
The distinction in base shear due to the different position of floating or hanging column floor wise are tabulated in diagram

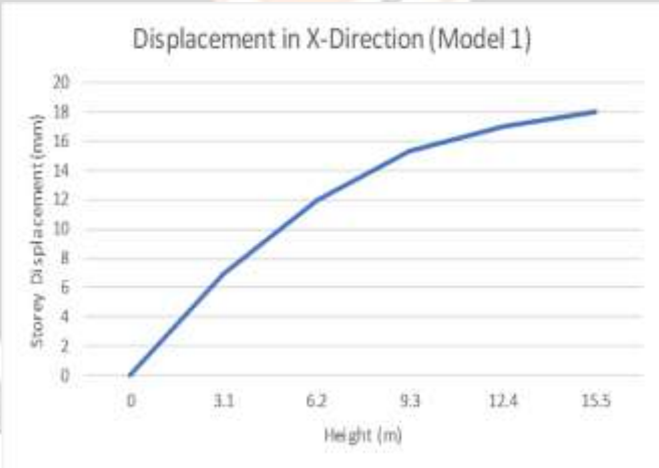


Fig 5: - Model-1, Storey Displacement in X-direction

The time of occurrence of earthquake on structure, the output we get from the building is similar to that of input. The topmost displacement of building is found to be 0.174 m.

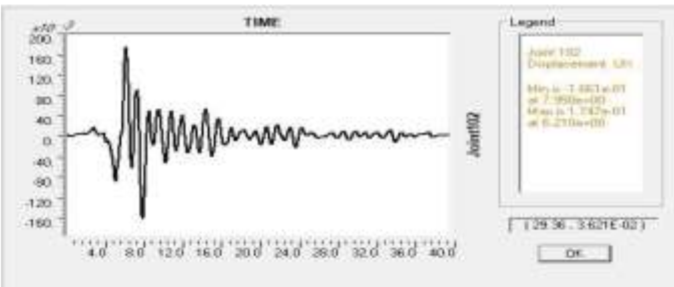


Fig 6: - Displacement v/s Time (Plot) for Model-1 (without Floating Column)

VIII. CONCLUSION

The following are the main findings of the present study –

- Time period of the building without floating column is less and is maximum when floating column is near the basement. It tends to decrease when hanging column is present in the upward floors.
- Displacements of various floors in longitudinal direction i.e. x-direction is determined and it has been seen that when floating column is provided storey displacement is slightly higher than the normally constructed building without considering any discontinuity.
- From the response spectrum analysis, base reaction of the building rises when we move floating column to the upper floors being lowest for the first floor and maximum when there is no such floating column.
- Drift of a particular storey increases due to the existence of floating column in the structure.
- It has been seen that chances of failure of buildings with floating column are much higher as compared to the buildings without floating column.

IX. SCOPE FOR FUTURE WORK

The present study depends upon few approximations and assumptions which can be improved through advanced research. Few technical aspects might be considered for the future study to be presented, as given below;

1. Effect of strut supports in various location on the building with floating column can be studied as it can be helpful in minimization of deflection.

2. Non-linear properties can be considered in analysis for assessing the behaviour of building with irregularities when subjected to various quake excitations.

3. Provision of floating column with strut support in buildings.

4. Computation of dynamic response parameters on a high and low-rise multi-storey building with floating column in various seismic zones and different soil state using software.

5. Modelling and analysis of floating column building in software SAP2000.

6. Study of variation in the dimensions of floating column and its effects on the response parameters.

7. Response Spectrum and Time History analysis in SAP2000.

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