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Research Paper

EFFECT OF MASS IRREGULARITY AND FLOATING COLUMN ON HIGH-RISE STEEL FRAMED STRUCTURE

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***Abstract**: Numerous studies are being conducted daily to discover new ways and strategies in the current world. Improvements in structural design are now a perfect part of life. Any structural designer's primary goal is to make the construction both safe and economical. Buildings are typically designed and built in a very basic manner, but experts are now concentrating on irregular structural elements to create complex structures that are both safe and cost-effective. Since it provides a hazy picture of column failure, numerous scholars have been studying loating column analysis with seismic and wind forces as well. Because steel framed structures have so many advantages over RCC structures, they have become a significant component of infrastructure. Therefore, an examination of these buildings under wind and seismic pressures will be crucial to the development of infrastructure design. Thus, the impact of mass irregularity and the floating column on steel-framed structures has been reviewed in this study.*

In the present study seismic analysis and design of multi story steel building with floating was carried out by using ETABS 2018. The results like story drift, Shear force, Bending moment, Building torsion are studied for G+25 story floating column building and detailing is done in CSI detailing software.

***Key words:** floating columns, Earthquakes, story drift, Shear force, Bending moment, Building torsion.*

1. INTRODUCTION

Many urban multi storey buildings in India today have open first storey as an unavoidable feature. This is primarily being adopted 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 dependent on its natural period, the seismic force distribution is dependent on the distribution of stiffness and mass along the height.

The behavior of a building during earthquakes depends critically on its overall shape, size and geometry, in addition to how the earthquake forces are carried to the ground. The earthquake forces developed at different floor levels in a building need to be brought down along the height to the ground by the shortest path; any deviation or discontinuity in this load transfer path results in poor 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 particular storey or with unusually tall storey tend to damage or collapse which is initiated in that storey. Many buildings with an open ground storey intended for parking collapsed or were severely damaged in Gujarat during the 2001 Bhuj earthquake. 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.

Steel as a Structural Material

Structural steel is a material used for steel construction, which is formed with a specific shape following certain standards of chemical composition and strength. They can also be defined as hot rolled products, with a cross section of special form like angles, channels and beams/joints. There has been an increasing demand for structural steel for construction purposes in the India. Measures are been taken by the structural steel authority for ready availability of structural steel on time for the various projects. The people at every level are working hard to realize the purpose of producing steel on time, like, service centers, producers, fabricators and erectors along with the general contractors, engineers and architects are all working hand in hand. Steel has always been more preferred to concrete because steel offers better tension and compression thus resulting in lighter construction. Usually structural steel uses three dimensional trusses hence making it larger than its concrete counterpart. There are different new techniques which enable the production of a wide range of structures and shapes, the procedures being the following

1. High-precision stress analysis
2. Computerized stress analysis
3. Innovative jointing

WHAT IS FLOATING COLUMN

A column is supposed to be a vertical member starting from foundation level and transferring the load to the ground. The term floating column is also a vertical element which (due to architectural design/ site situation) at its lower level (termination Level) rests on a beam which is a horizontal member. The beams in turn transfer the load to other columns below it.

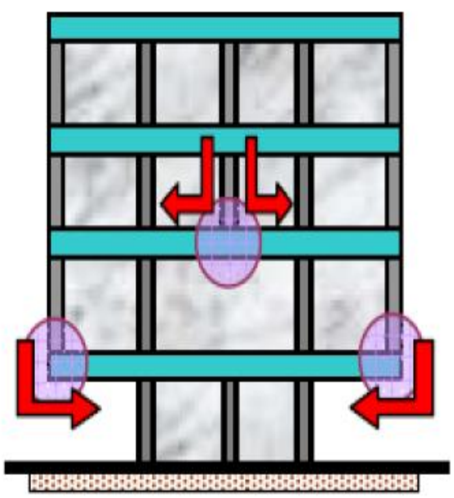


Fig 1: Hanging or floating columns

There are many projects in which floating columns are adopted, especially above the ground floor, where transfer girders are employed, so that more open space is available in the ground floor. These open spaces may be required for assembly hall or parking purpose. The transfer girders have to be designed and detailed properly, especially in earth quake zones. The column is a concentrated load on the beam which supports it. As far as analysis is concerned, the column is often assumed pinned at the base and is therefore taken as a point load on the transfer beam. STAAD Pro, ETABS and SAP2000 can be used to do the analysis of this 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.

Looking ahead, of course, one will continue to make buildings interesting rather than monotonous. However, this need not be done at the cost of poor behavior and earthquake safety of buildings. Architectural features that are detrimental to earthquake response of buildings should be avoided. If not, they must be minimized. When irregular features are included in buildings, a considerably higher level of engineering effort is required in the structural design and yet the building may not be as good as one with simple architectural features.

Hence, the structures already made with these kinds of discontinuous members are endangered in seismic regions. But those structures cannot be demolished, rather study can be done to strengthen the structure or some remedial features can be suggested. The columns of the first storey can be made stronger, the stiffness of these columns can be increased by retrofitting or these may be provided with bracing to decrease the lateral deformation.

Objective of the study

1. To study the mass irregular floating column steel building by using IS1893 code
2. To calculate the design lateral forces for floating column building by using ETABS.
3. To study the Story drift, Shear force, Bending moment, Building Torsion for floating column building.
4. To study the steel column building with response spectrum analysis.

2. LITERATURE STUDIES

T.raja sekhar[1] ,Mr.P.V.Prasad[2], et al.,(2014) The behavior of building frame with and without floating column is studied under static load, free vibration and forced vibration condition. The results are plotted for both the frames with and without floating column by comparing each other time history of floor displacement, base shear. The equivalent static analysis is carried out on the entire project mathematical 3D model using the software STAAD Pro V8i and the comparison of these models are been presented. This will help us to find the various analytical properties of the structure and we may also have a very systematic and economical design for the structure.

A.p.mundada[1] ,S.G.Sawadakar[2], et al., (2014) In this paper study is done for architectural drawing and the framing drawing of the building having floating columns. For comparision G+7 existing residential building with and without floating column are taken for carry out entire project work. by using STAAD ProV8i 3D 3 model are created .equivalent static analysis of these model are done by using STAAD Pro V8i .Different parameters such as axial load ,moment distribution, importance of line of action of force and seismic factors are studied for models. This will help them to find the various analytical properties of the structure and also have a very systematic and economical design for the structure.

Hardik Bhensdadia ,Siddarth shah, et al.,(2015) In this study an attempt is made to reveal the effects of floating column & soft story in different earthquake zones by seismic analysis. For this purpose Push over analysis is adopted because this analysis will yield performance level of building for design capacity (displacement) carried out up to failure, it helps determination of collapse load and ductility capacity of the structure.

To achieve this objective, three RC bare frame structures with G+4, G+9, G+15 stories respectively will be analysed and compared the base force and displacement of RC bare frame structure with G+4, G+9, G+15 stories in different earthquake zones like Rajkot, Jamnagar and Bhuj using SAP 2000 14 analysis package.

3. METHODOLOGY USED

RESPONSE SPECTRUM ANALYSIS

The representation of maximum response of idealized single degree freedom system having certain period and damping, during earthquake ground motions. This analysis is carried out according to the code IS 1893-2002 (part1). Here type of soil, seismic zone factor should be entered from IS 1893-2002 (part1). The standard response spectra for type of soil considered is applied to building for the analysis in ETABS 2013 software. Following diagram shows the standard response spectrum for medium soil type and that can be given in the form of time period versus spectral acceleration coefficient (Sa/g).

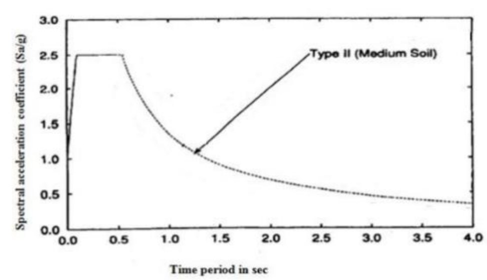


Fig 2: Response spectrum for medium soil type for 5% damping

This approach permits the multiple modes of response of a building to be taken in to account (in the frequency domain). This is required in many building codes for all except very simple or very complex structures. The response of a structure can be defined as a combination of many special shapes (modes) that in a vibrating string correspond to the "harmonic" computer analysis can be used to determine these modes for a structure. For each mode, a response is read from the design spectrum, based on the modal frequency and the modal mass, and they are then combined to provide an estimate of the total response of the structure. In this we have to calculate the magnitude of forces in all directions i.e. X, Y & Z and then see the effects on the building. Combination methods include the following:

- absolute - peak values are added together

- square root of the sum of the squares (SRSS)
- complete quadratic combination (CQC) - a method that is an improvement on SRSS for closely spaced modes

The result of a response spectrum analysis using the response spectrum from a ground motion is typically different from that which would be calculated directly from a linear dynamic analysis using that ground motion directly, since phase information is lost in the process of generating the response spectrum.

In cases where structures are either too irregular, too tall or of significance to a community in disaster response, the response spectrum approach is no longer appropriate, and more complex analysis is often required, such as non-linear static analysis or dynamic analysis.

4. DESIGN CONSIDERATIONS AND MODELING OF BUILDING

Problem statement:

In the present study, analysis of G+ 19 stories building in Zone V seismic zones is carried out in ETABS.

Basic parameters considered for the analysis are

1. Grade of concrete : M40
2. Grade of Reinforcing steel : HYSD Fe500
3. Grade of steel :Fe250
   (Beams and Columns)
4. Thickness of slab : 150mm
5. Height of bottom story : 3.3m
6. Height of Remaining story : 3m
7. Live load :3 KN/m^2
8. Dead load : 2 KN/m^2
9. Density of concrete : 25 KN/m^3
10. Seismic Zones : Zone 5
11. Site type : II
12. Importance factor : 1.3
13. Response reduction factor : 5
14. Damping Ratio : 5%
15. Structure class : C
16. Basic wind speed : 44m/s
17. Risk coefficient (K1) : 1.08
18. Terrain size coefficient (K2): 1.14
19. Topography factor (K3) : 1.36
20. Wind design code : IS 875: 1987 (Part 3)
21. RCC design code : IS 456:2000
22. Steel design code : IS 800: 2007
23. Earth quake design code : IS 1893 : 2002 (Part 1)

5. MODEL IN ETABS

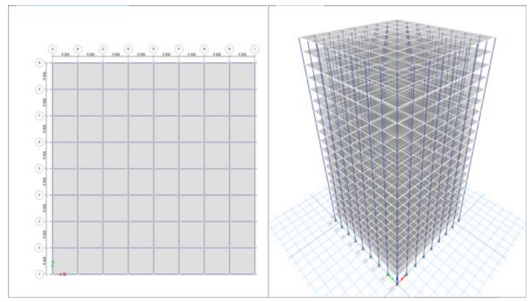


Fig 3: Regular building without floating column

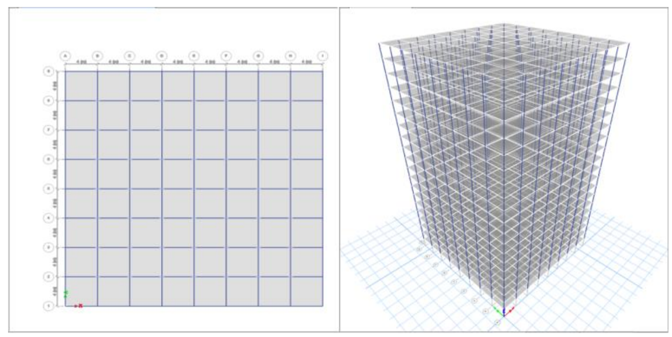


Fig 4: Regular building with external floating column

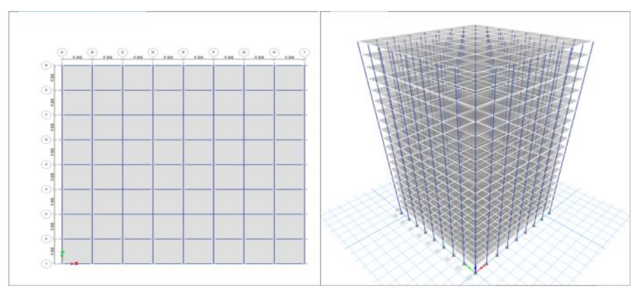


Fig 5: Regular building with internal floating column

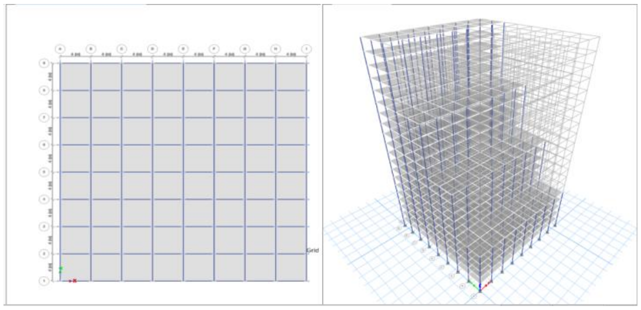


Fig 6: Mass irregular building without floating column

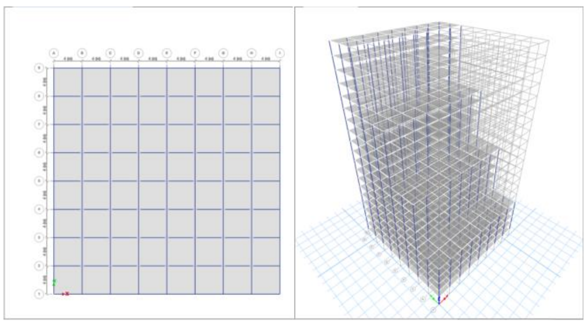


Fig 7: Mass irregular building with external floating column

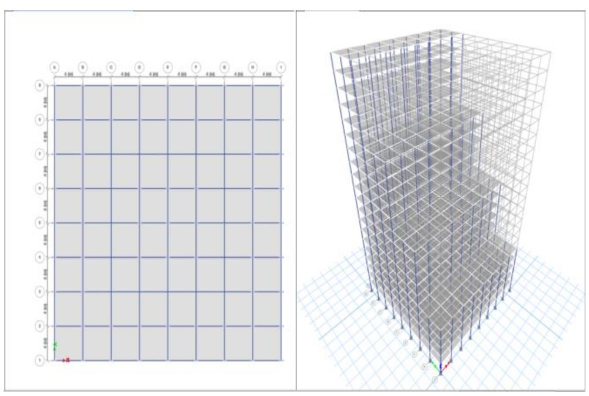
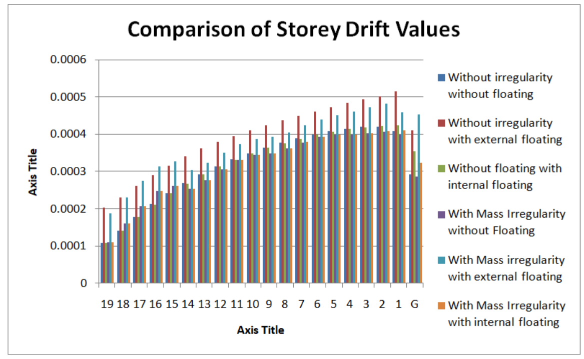


Fig 8: Mass irregular building with internal floating column

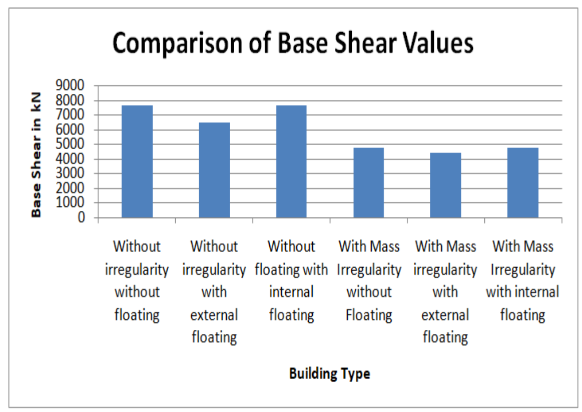
6. RESULTS AND ANALYSIS

Storey drift



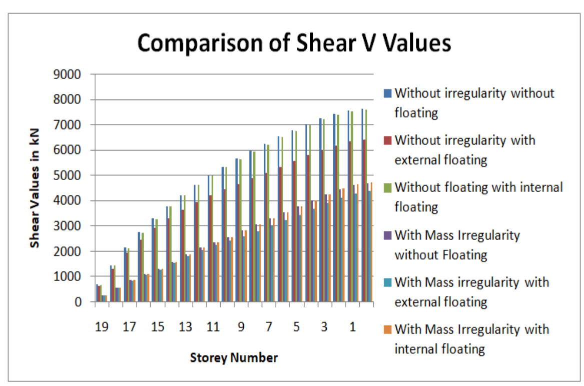
Graph 1: Comparison of Storey Drift Values

Base shear



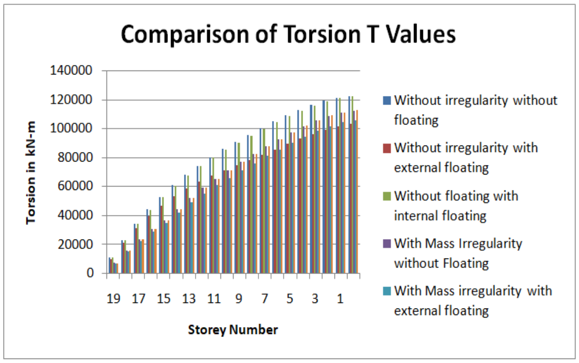
Graph 2: Comparison of Base Shear Values

Shear V Values



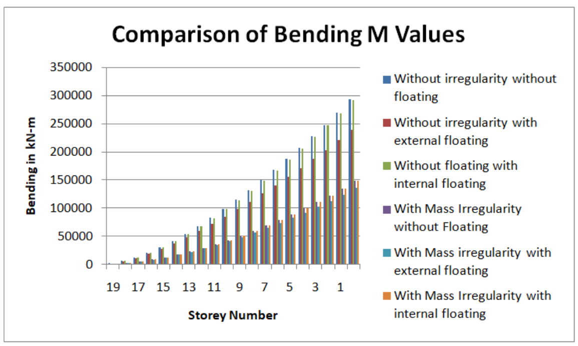
Graph 3: Comparison of Shear V Values

Torsion T Values



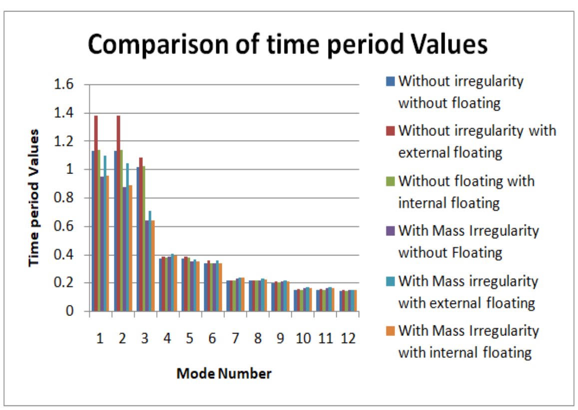
Graph 4: Comparison of Torsion T Values

Bending M Values



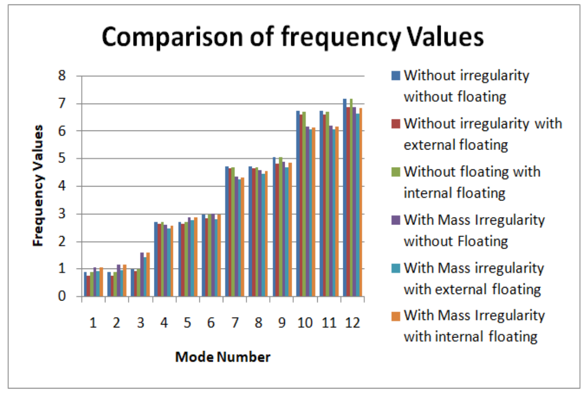
Graph 5: Comparison of Bending M Values

Time period Values



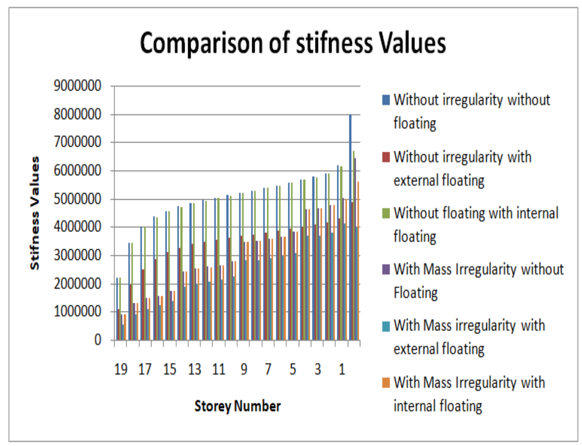
Graph 6: Comparison of time period values

Frequency Values



Graph 7: Comparison of frequency Values

Storey stiffness Values



Graph 8: Comparison of storey stiffness Values

7. CONCLUSIONS

From the above study the following conclusions were made

1. The term floating column is also a vertical element which (due to architectural design/ site situation) at its lower level (termination Level) rests on a beam which is a horizontal member. The beams in turn transfer the load to other columns below it.
2. The storey drift values decreasing from top storey to bottom storey and higher values are obtained for floating column sections than remaining models namely without floating column buildings.

3. The base shear values are compared from the analysis results the less intensity of base shear values were obtained for the external floating column building models than internal floating columns and buildings without floating columns.
4. The values of shear force, bending moment and torsion values were observed less intensities for the external floating column building than remaining buildings namely without floating and internal floating column.
5. The values of storey stiffness were obtained less intensities for the building model made with external floating columns than remaining cases for both without irregularity and with mass irregularity buildings.
6. As the structural response depends on the type, location and degree of irregularity, these factors need to be taken care while designing any structure.
7. This would help in incorporating irregularities in structures without compromising their performance.
8. The seismic response of the regular structure is better in comparison with that of irregular structure because of the discontinuities along the height of building.

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