Research Paper on Comparative Study of Floating & Non Floating Column

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Abstract- *In urban India floating column building is a typical feature in the modern multi-storey construction. Floating columns buildings are adopted either for architectural aspect or when more free space is required in the ground floor. Such features are highly undesirable in seismically active area. In the project studies the analysis of G+14 storey building with floating column and without floating is carried out. The analysis is done by using Etabs software. The paper deals with the results variation in displacement of structure, base shear, Seismic weight calculation of building from Etabs. For building with floating column and building without floating column, finding the variation between the response parameters of earthquake and describe what happens when variation may be high or low. The study is carried out to find whether the floating column structures are safe or unsafe when built in seismically prone areas, and also find out commercial aspects of floating column building either it is economical or uneconomical.*

Keywords- Floating column building, Normal building, ETABS

I. INTRODUCTION

Many urban multi-storey buildings in India today have an open storey as an unavoidable feature. This is primarily being adapted to accommodate parking or reception lobbies in the first storey. 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‘s 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.

Most of the buildings in India are covering the maximum possible area on a plot within the available bylaws. Since balconies are not counted in floor space index (FSI), buildings have balconies overhanging in the upper stories beyond the column foot print areas at the ground storey, overhangs up to 1.2 m to 1.5 m in plan are usually provided on each side of the building. In such cases, floating columns are provided along the overhanging perimeter of the building. Most of the times Architect demands for the aesthetic view of the building, in such cases also many of the columns are terminated at certain floors and floating columns are introduced.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

A.OBJECTIVES

The objective of the present work is to study the behavior of multi-storey buildings with and without floating columns under earthquake excitations. Seismic Coefficient Method is carried out for the multi-storey buildings under different load combination. The base of the building frame is assumed to be fixed.

In this project, a plan of G+ 14 story building is selected with introduction of floating column, The following 4 cases are taken,

1) Case 1: RC Building without floating columns
2) Case 2: RC Building with Internal floating columns
3) Case 3: RC Building with External floating columns
4) Case 4: RC Building with Alternate floor floating columns

B. 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. Such columns where the load is considered as point load. Theoretically such structures can be analyzed and designed. In practice, the true columns below the termination level are not constructed with care and more liable to failure.Hypothetically there is no need of such columns. The span of all beams need not be nearly same and some span can be larger than others, this way, the columnsupporting beams with larger spans would be designed and constructed with greater care.

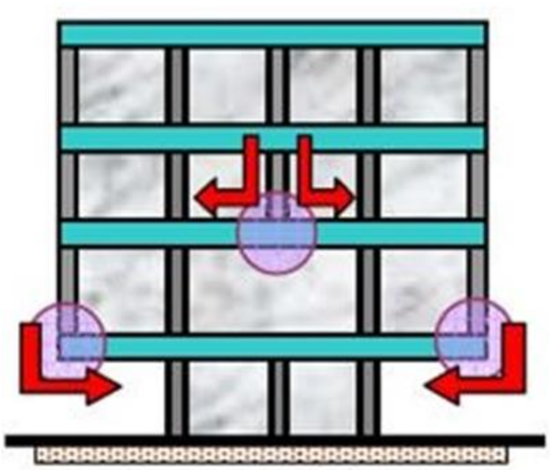


Fig 1 Floating column

II. STATE OF DEVELOPMENT

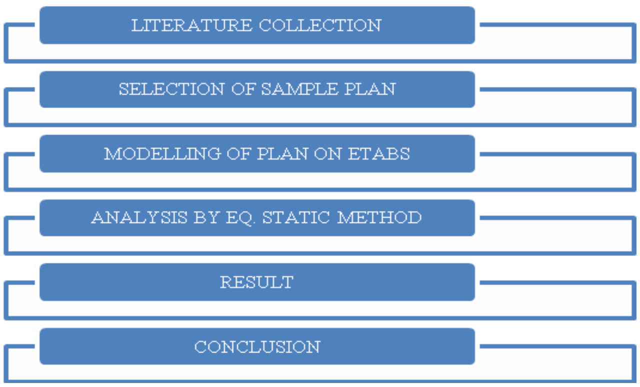
Literature survey related to the behaviour of structures with earthquake exitation acquainted with the latest measures and techniques adopted for the same. Technical articles published in the proceedings and other journals have been referred to determine the further scope of work and to understand the status of each project undertaken. It has been noted that many researches and academicians have worked on seismic analysis of structures with floating columns.

Shaikh Abdul Aijaj et.al investigated the proportional distribution of lateral forces evolved through seismic action in each storey level due to changes in stiffness of frame on vertically irregular frame. A proportionate amount of stiffness is advantageous to control over the storey and base shearRavikumar C M et.al studied two kinds of irregularities in the building models namely plan irregularity with geometric and diaphragm discontinuity and vertical irregularity with setback and sloping ground.

Sadashiva et.al studied a simple and efficient method of determining structural irregularity limits for structures designed using different analysis procedure as an example the methodology is applied to simple models of shear type structure with different amounts of mass irregularity located at different locations within the structure all designed in accordance with the Equivalent Static Method of NZS 1170.5, including P-Delta effects .these models were then analyzed using inelastic dynamic time history analysis for the 20 SAC 10 in 50 earthquake records for Los Angeles. Dubey et.al the main objective of this study is to understand different irregularity and torsional response due to plan and vertical irregularity, and to analyze T-shaped building while earthquake forces acts and to calculate additional shear due to torsion in the columns. From the studied results of the analysis of four frames, it is observed that in the regular frame, there is no torsional effect in the frame because of symmetry.
The static and dynamic analysis has done on computer with the help of STAAD-Pro software using the parameters for the design as per the IS-1893- 2002- Part-1 for the zones- 2 and 3 and the post processing result obtained has summarized and It can be concluded that the results as obtained for the Dynamic Analysis are higher than the values as obtained by Static Analysis for the same points and conditions.

et.al Futain Shangri – La project provides an excellent example of the structural design under challenging condition including the lateral force-resisting system, sloping outer concrete columns, long span post-tensioned transfer girder and other design challenges The design team achieved economical structural solutions without compromising aesthetic design integrity. It is found that the mass and stiffness criteria of UBC result in moderate increases in response quantities of irregular structures compared to regular structures. It is found that the mass and stiffness criteria of the IS code results in moderate increase in response quantities of irregular structures compared to regular structures. The seismic response behaviors are computed using the response spectrum (Newmark and ATC spectra) and equivalent static load methodsMaison and Ventura Members of ASCE computed dynamic properties and response behaviors of thirteen-story building and this result are compared to the true values as determined from the recorded motions in the building during two actual earthquakes and shown that state-of-practice design type analytical models can predict the actual dynamic properties.

III. METHODOLOGY



A. PROBLEM STATEMENT

A RCC medium rise building of G+14 stories with floor height 3m subjected to earthquake loading in Zone II, III, IV, V has been considered .In this regard, ETAB software have been considered as tool to perform. Hence in this chapter we will discuss the parameters defining the computational models, the basic assumptions and the geometry of the selected building considered for this study. Displacements, axial forces, shear force, bending moment. have been calculated for different columns and beams to find out the effect in the building.

a) Description of structure

1. Length of building -26 m
2. Width of building-26 m
3. Storey Height of building – 3m
4. Total height of building – 45 m
5. Dimension of column - 0.8x0.5 m for zone v
6. Dimension of beam - 0.5x 0.3 m for zone v
7. Thickness of slab – 150 mm
8. Dead load on building for 0.23m thick wall - 14 kN/m
9. Dead load on building for 0.15m thick wall – 9kN/m
10. Live load on building -3 kN/m^2
11. Response Spectra - As per IS 1893 (Part-1): 2002
12. Damping - 5%
13. Importance Factor - 1.5
14. Response reduction factor
    i. For SMRF - 5
15. Seismic load as per zone factor and Response Reduction Factor
    a. Earthquake load in X –Direction
16. Earthquake load in Z –Direction

b) Assumption

1. The material is homogeneous and isotropic.
2. All columns supports are considered as fixed at the foundation.
3. Tensile strength of concrete is ignored in sections subjected to bending.
4. The maximum target displacement of the structure is calculated in accordance with the guidelines given by IS Code for maximum roof level lateral drift and displacement.
5. The building is designed by according to I.S. 456:2000 for Dead Load and Live load.

IV. SYSTEM DEVELOPMENT

In the Present work three building models of G+14 has been developed for RCC, for different position of shear wall situated in zone V with subsoil Type medium -II were analyzed in ETAB software. All the buildings are subjected to same earthquake loading to check their seismic behavior for same storey and storey height. For the analysis of these models various methods of seismic analysis are available but for present work both linear static and non-linear static method is used.

A. METHOD OF ANALYSIS

a) Equivalent Static Method: The design lateral force due to earthquake is calculated as follow

- **Design horizontal seismic coefficient** :

The design horizontal seismic coefficient Ah for a structure shall be determined by the following expressions:-
Ah = (Z/2) X (I/R) X (Sa/g)

Provided that for any structure with T≤0.1 s, the value of Ah will not be less than Z/2 whatever the value of I/R.

Where,

Z= Zone factor
I = Importance factor depending upon the functional use of the structure.
R=Response reduction factor, depending upon the perceived seismic damage performance of the structure
Sa /g = Average response acceleration coefficient

- **Design Seismic Base Shear** :

The total design lateral force or seismic base shear (Vh) along any principal direction is determined by the following expression:-

$V_b = A_h . W$

Where, W is the seismic weight of the building.

- **Distribution of design force** :

The design base shear (V_b) computed is distributed along the height of the building as below:

$Q_i = V_b (w_i h_i^2 / \sum w_i h_i^2)$

Where,

Q_i = Design lateral force at each floor level i
W_i = Seismic weight of floor i.
h_i = Height of floor i measured from the base.

B. SOFTWARE INFORMATION (ETABS)

ETABS is a sophisticated, yet easy to use, special purpose analysis and design program developed specifically for building systems. ETABS 2016 features an intuitive and powerful graphical interface coupled with unmatched modeling, analytical, design, and detailing procedures, all integrated using a common database. Although quick and easy for simple structures, ETABS can also handle the largest and most complex building models, including a wide range of nonlinear behaviors necessary for performance based design, making it the tool of choice for structural engineers in the building industry.

Dating back more than 40 years to the original development of TABS, the predecessor of ETABS, it was clearly recognized that buildings constituted a very special class of structures. Early releases of ETABS provided input, output and numerical solution techniques that took into consideration the characteristics unique to building type structures, providing a tool that offered significant savings in time and increased accuracy over general purpose programs. As computers and computer interfaces evolved, ETABS added computationally complex analytical options such as dynamic nonlinear behavior, and powerful CAD-like drawing tools in a graphical and object-based interface. Although ETABS 2016 looks radically different from its predecessors of 40 years ago, its mission remains the same: to provide the profession with the most efficient and comprehensive software for the analysis and design of buildings. To that end, the current release follows the same philosophical approach put forward by the original programs, namely Most buildings are of straightforward geometry with horizontal beams and vertical columns. Although any building configuration is possible with ETABS, in most cases, a simple grid system defined by horizontal floors and vertical column lines can establish building geometry with minimal effort.

- Many of the floor levels in buildings are similar. This commonality can be used to dramatically reduce modeling and design time.
- The input and output conventions used correspond to common building terminology. With ETABS, the models are defined logically floor-by-floor, column-by-column, bay-by-bay and wall by-wall and not as a stream of non-descript nodes and elements as in general purpose programs. Thus the structural definition is simple, concise and meaningful.
- In most buildings, the dimensions of the members are large in relation to the bay widths and story heights. Those dimensions have a significant effect on the stiffness of the frame. ETABS corrects for such effects in the formulation of the member stiffness, unlike most general-purpose programs that work on centerline-to-centerline dimensions.

The results produced by the programs should be in a form directly usable by the engineer. General-purpose computer programs produce results in a general form that may need additional processing before they are usable in structural design.

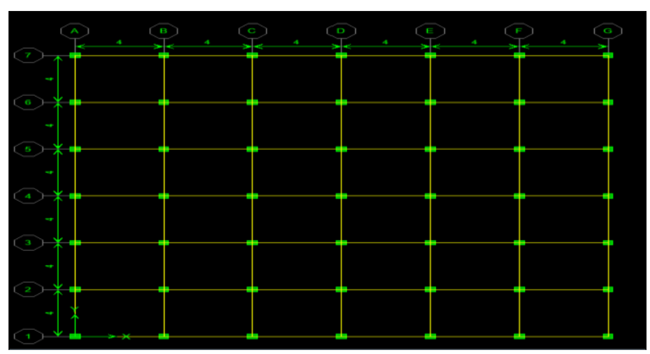


Fig 2 Plan of structure

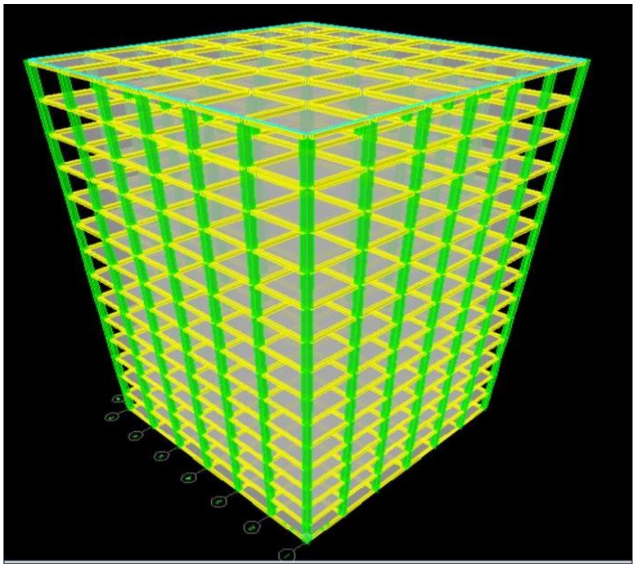


Fig 33-D View of the Structure

V. THEORETICAL CONTAIN

A. BASE SHEAR

Base shear is an estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure. Calculations of base shear (V) depend on:

- soil conditions at the site
- proximity to potential sources of seismic activity (such as geological faults)
- probability of significant seismic ground motion
- the level of ductility and over strength associated with various structural configurations and the total weight of the structure
- the fundamental (natural) period of vibration of the structure when subjected to dynamic loading

B. DRIFT IN HIGH RISE BUILDING

Drift of a building in simple terms can be defined as the horizontal displacement undergone by the building with respect to its base when subjected to horizontal forces such as wind and earthquake loads. Thus story drift can be defined as the displacement of one floor level of the building with respect to its adjacent level above or below the considered floor level. The above figure (Fig 1) shows the displacement undergone by the structure with respect to its base due to the horizontal load Ex. In Fig 2, drifts at each floor level such as ground, first, second and third floor are denoted as D1, D2, D3 and D4 respectively and d1, d2, d3, d4 are the story drifts of each floor of the building.

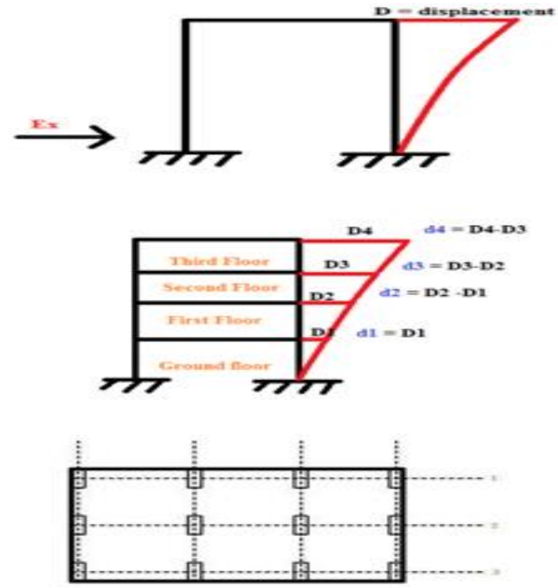


Fig 2 Displacement

In Fig 2, plan of the building is shown where the columns with same sizes are aligned in same direction and the spacing between them is equal in both x and y directions. So here the lateral stiffness on grids A, B, C, D, 1, 2 and 3 are same. So when Base shear or seismic load is applied to the building as Ex or Ey in x and y directions, load is distributed equally along the grid lines, thus resulting in equal drift values along each grid line. For Example, if the base shear (Ey,i.e along y direction) calculated is 1000 KN, the load carried by columns along each grid line will be 250 KN as the lateral stiffness along each grid line are equal. But this scenario is quite rare or can be referred to as an “ideal condition”. In most of the cases, buildings are designed with different column sizes and with irregular column spacing which results in variation in lateral stiffness along each column line as shown in Fig 3.2.

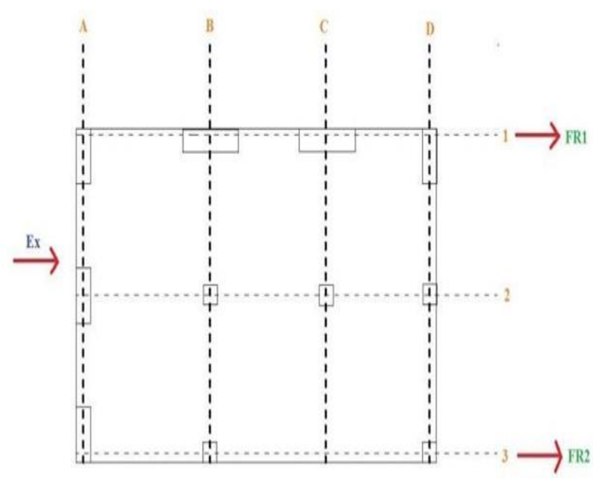


Fig 3 lateral stiffness along each column

Since the number of columns and its size are less along the grid line 3, it is quite evident that lateral stiffness along grid line 3 is quite less compared to grid line 1.This difference in lateral stiffness will give rise to twisting or torsion in building when subjected to horizontal loads. The drift along a column grid line can be calculated by
Drift = Lateral Load/Lateral stiffness

C. DEMAND OF DISPLACEMENT IN HIGH RISE BUILDINGS

A change of frame of reference of deformation facilitates converting the moving base problem of earthquake shaking of buildings into a fixed base problem. The latter is easy to handle, since design practice is conversant with analysis and design of structures subjected to forces, and not subjected to displacements or accelerations. Therefore, now the acceleration response spectrum allows quick, back- of-the-envelope type calculations by senior engineers to check the ball park values of force generated in a building during earthquake shaking. In early days of designing buildings to resist earthquakes, an earthquake-induced lateral force was thought to be the root cause of the earthquake problem. Designers observed that buildings performed well, if they were designed for lateral forces; mostly, this lateral force was due to wind effects. Hence, as a first measure of consciously designing for earthquake effects, designers took 10% of the weight of the building and applied it as a lateral force on the building (distributed along the height). But, the 10% force was too penalizing for taller buildings. Around that time, understanding grew on the ground motions, and it was learnt that different buildings respond differently to the same ground shaking. Thus, the design lateral force was now taken as a function of the fundamental natural period of the building. This was not sufficient either. Many buildings showed brittle performance, i.e., collapsed suddenly in low seismic regions. This was the beginning of understanding the importance of introducing ductility in buildings. But, the method of introducing ductility was prescriptive; it was based on limited laboratory tests performed on structural elements and sub-assemblages. The above also was found insufficient, when buildings did not collapse, but were rendered not-usable after many strong earthquakes.

Performance of buildings during and after the earthquake came into focus. And, this was the beginning of a new direction of designing buildings to resist earthquake effects. Fresh thinking began towards displacement-based design of buildings. Then, it was clear that imposed lateral displacement was the root cause of the earthquake problem and not any lateral force. Thus, the present effort in the research community is to arrive at a displacement based design with capability to quantitatively assess the ultimate deformation capacity of buildings at the design stage itself. In the following chapters, earthquake DEMAND on the building and earthquake CAPACITY of the building are discussed. While doing so, the associated basic concepts are elaborated and demonstrated with appropriate numerical work. Acceleration time history at the base of a building: Converted to a force time history at the mass of the building with the base fixed … ag (t) Mass m – mag

D. DEFLECTION IN HIGH RISE BUILDINGS

Serviceability criteria in the form of lateral deflection and acceleration limits under wind loading are often the governing structural issues for tall buildings. Whilst the basis for acceleration criteria has been the subject of research, rational refinement and consensus over recent years, deflection limits are still rather arbitrary. Current guidance on deflection limits in international design codes is very limited and is based primarily on experience with typical low and medium -rise buildings. The issues with lateral deflection in very tall buildings are different to those of low-rise buildings, and depend on structural form. Rational choice of deflection criteria for tall buildings therefore requires further consideration of the nature of the deformations and the effects they have on the functional aspects of the building.

Lateral loading effects from wind and seismic sources usually dominates the structural design of tall buildings. As well as strength considerations, stiffness and its' effect on deflection is usually the governing criteria which determines structural element size and cost. Structural design codes are generally written with conventional types of low-rise and medium-rise buildings in mind. High-rise buildings often have different structural forms such as outrigger systems, bundled tubes, mega bracing etc. The nature of the deflection with these structural types often differs to that in low-rise buildings. At the time of writing there are a large number of buildings around the world being designed above 300m in height, with a few significantly higher than that. In order to justify the performance of these buildings, it is essential to understand the nature of lateral deflections.

VI. CONCLUSION

In India many existing structure design as per Indian standard code 456:2000 but to make building earthquake resistant IS 1893-2002 should be used to avoid future building vulnerable in earthquake. Although quick and easy for simple structures, ETABS can also handle the largest and most complex building models, including a wide range of nonlinear behaviors necessary for performance based design, making it the tool of choice for structural engineers in the building industry. Hence, as a first measure of consciously designing for earthquake effects, designers took 10% of the weight of the building and applied it as a lateral force on the building (distributed along the height).

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