

# Analysis of Tall Building Structure Subjected to Wind and Earthquake Loads in Different Seismic Zones

Mr. Jaiprakash C<sup>1</sup>, Ms. Ramya B V<sup>2</sup>

<sup>1</sup>Post Graduate in Structural Engineering, BIET College, Davangere, Karnataka, India

<sup>2</sup>Assistant Professor, M-Tech Structural Engineering, BIET College, Davangere, Karnataka, India

\*\*\*

**Abstract** - Consideration of site specific lateral loading due to wind or earthquake loads together with vertical gravity loads is important for finding the behavior of the tall buildings. As the height of a building becomes taller, the quantity of structural material required to resist lateral loads increases considerably. The design of tall buildings essentially involves a conceptual design, approximate evaluation, preliminary design and optimization, to safely convey gravity and lateral loads. The design criteria are strength, serviceability and human consolation. The goal of the structural engineer is to arrive at appropriate structural schemes, to meet these criteria. In the present research, the Response Spectrum Method of analysis of a G+30-storey reinforced concrete high rise building under wind and seismic loads as per IS codes of exercise is described. The comparison was made for base shear, storey drift, storey displacement, storey acceleration, storey forces and storey stiffness.

**Key Words:** Tall Building<sup>1</sup>, ETABS<sup>2</sup>, Response Spectrum<sup>3</sup>, Seismic Loads<sup>4</sup>, Wind Loads<sup>5</sup>

## 1. INTRODUCTION

Tall buildings, which are usually designed for office or commercial use, are among the most distinguished space definitions in the Structural Engineers history of Indian urbanism in the twentieth century. They are primarily a reaction to the rapid growth of the urban population and the demand by business activities to be as close to each other as possible. Structural Engineers reinterpretations of the building type, the high cost of land in urban areas, the desire to prevent the disorganized expansion, the need to preserve agricultural production, the concept of skyscraper, influence of cultural significance and prestige, have all contributed to force buildings upward. Today, it is virtually impossible to imagine a major city without tall buildings. The importance of tall buildings in the contemporary urban development is without doubt ever increasing despite their several undeniable negative effects on the quality of urban life.

### 1.1 Wind Effects on Tall Buildings

The wind is the most powerful and unpredictable force affecting tall buildings. Tall building can be defined as a mast anchored in the ground, bending and swaying in the wind. This movement, known as *wind drift*, should be kept within acceptable limits. Moreover, for a well-designed tall building,

the wind drift should not surpass the height of the building divided by 500. Wind loads on buildings increase considerably with the increase in building heights. Furthermore, the speed of wind increases with height, and the wind pressures increase as the square of the wind speed. Thus, wind effects on a tall building are compounded as its height increases.

Besides this, with innovations in architectural treatment, increase in the strengths of materials, and advances in methods of analysis, tall building have become more efficient and lighter, and so, more vulnerable to deflection, and even to swaying under wind loading. Despite all the engineering sophistication performed with computers, wind is still a complex phenomenon, mainly owing to two major problems. Unlike dead loads and live loads, wind loads change rapidly and even abruptly, creating effects much larger than when the same loads were applied gradually, and that they limit building accelerations below human perception. Although the true complexity of the wind and the acceptable human tolerance to it have just begun to be understood, there is still a need to understand more the nature of wind and its interaction with a tall building, with particular reference to allowable deflections and comfort of occupants.

### 1.2 Earthquake Effects on Tall Buildings

As earthquakes can happen almost anywhere, some measure of earthquake resistance in the form of reserve ductility and redundancy should be built into the design of all structures to prevent catastrophic failures. Moreover, during the life of a building in a seismically active zone, it is usually expected that the building will be subjected to many small earthquakes, including some moderate ones, one or more large ones, and possibly a very severe one. Building massing, shape and proportion, ground acceleration, and the dynamic response of the structure, influences the magnitude and distribution of earthquake forces. On the other hand, if irregular forms are inevitable, special design considerations are necessary to account for load transfer at abrupt changes in structural resistance. Therefore, two general approaches are utilized to determine the seismic loading, which take into consideration the properties of the structure, and the past record of earthquakes in the region. When compared to the wind loads, earthquake loads have stronger intensity and shorter duration.

## 2. OBJECTIVES

- How the seismic evaluation of a building should be carried out.
- To study the behavior of a building under the action of seismic loads and wind loads.
- The building model in the study has thirty storey's with constant storey height of 3m. Model is analyzed with constant bay lengths and the bay width along two horizontal directions are kept constant in model for convenience.
- Different analysis like Response Spectrum method is carried for the analysis and corresponding effects are interpreted in the results.
- Wind speeds are taken for wind analysis and their corresponding effects of building structure are interpreted in the results.

## 3. METHODOLOGY

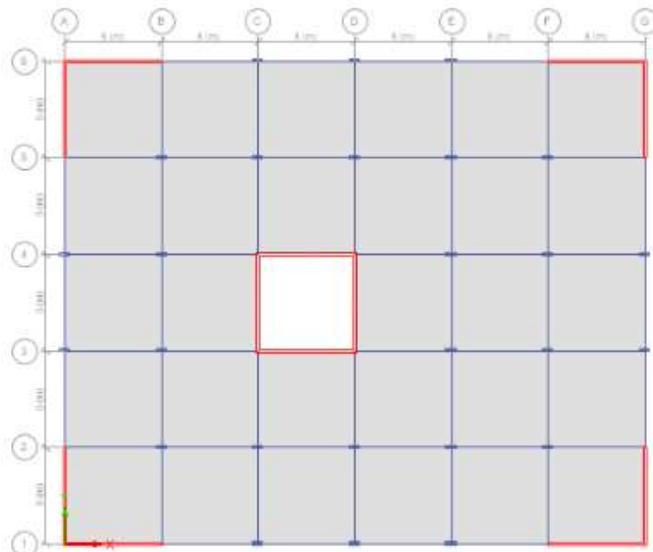
- An extensive literature review is carried out to establish the above objectives for the project work.
- G+30 storey structure is chosen for the present investigation.
- ETABS software is chosen for modelling and analysis of the selected structure.
- To understand the behaviour of structure, the analysis is carried in Response spectrum method are considered.

### 3.1 Modelling

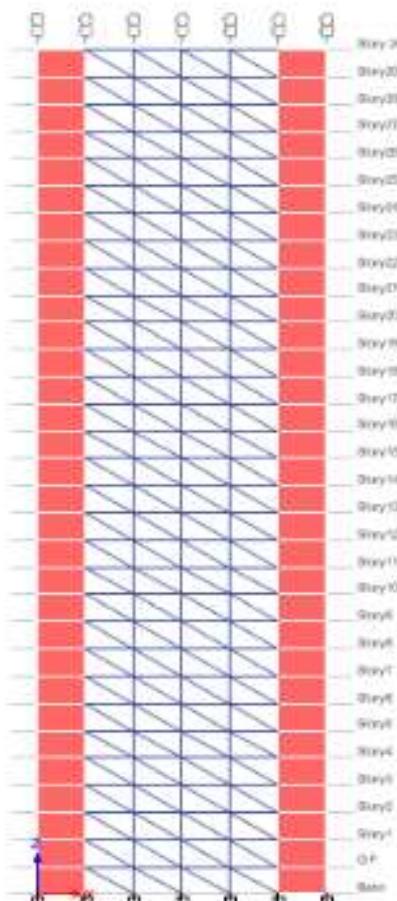
**Table-1:** Structure Details

|   |                       |
|---|-----------------------|
| Number of stories                           | G+30                  |
| C/C distance between columns in X-direction | 5 m                   |
| C/C distance between columns in Y-direction | 5 m                   |
| Foundation level to ground level            | 3 m                   |
| Floor to floor height                       | 3 m                   |
| Live load on all floors                     | 3 kN/m <sup>2</sup>   |
| Live Load on Roof                           | 1.5 kN/m <sup>2</sup> |
| Floor Finish                                | 1.5 kN/m <sup>2</sup> |
| Concrete                                    | M25 and M30           |
| Steel                                       | Fe 415 and Fe 500     |
| Size of column                              | 800 x 800 mm          |
| Size of beam                                | 400 x 650 mm          |
| Depth of slab                               | 150 mm                |

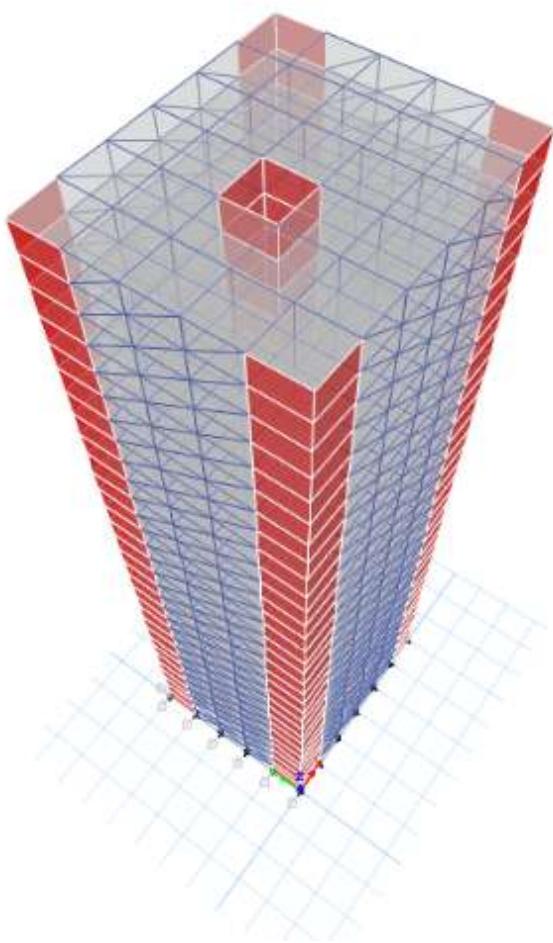
|                 |      |
|-----------------|------|
| Seismic zone II | 0.10 |
| Seismic zone IV | 0.24 |
| Soil Type       | II   |



**Fig-1:** Structural Plan of Model



**Fig-2:** 2D Elevation of Model



**Fig-3:** 3D Elevation of Model

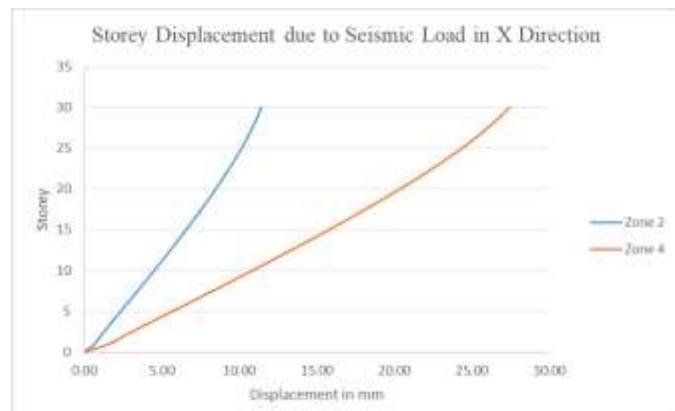
#### 4. Analysis Results

This chapter deals with results and discussion of RC building with bracings and shear walls in Zone II and Zone IV

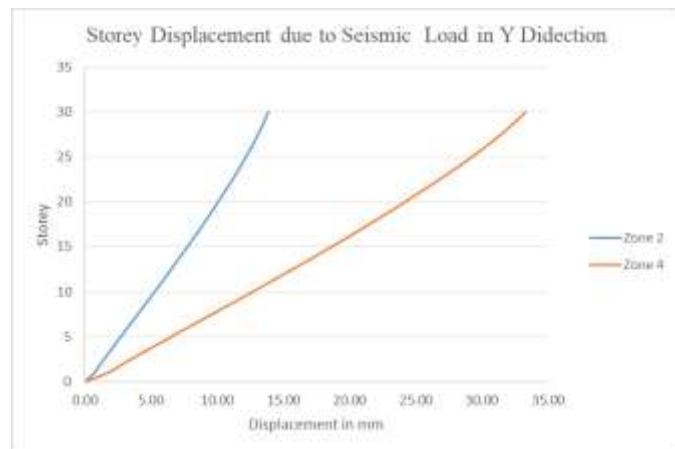
- Model 1- RC building with bracings and shear wall in Zone II
- Model 2- RC building with bracings and shear wall in Zone IV

Discussions are made based on following parameters

- Storey Displacement
- Storey drift
- Storey acceleration
- Storey forces
- Storey Stiffness
- Base Shear



**Chart-1:** Storey Displacement due to Seismic Load in X Direction



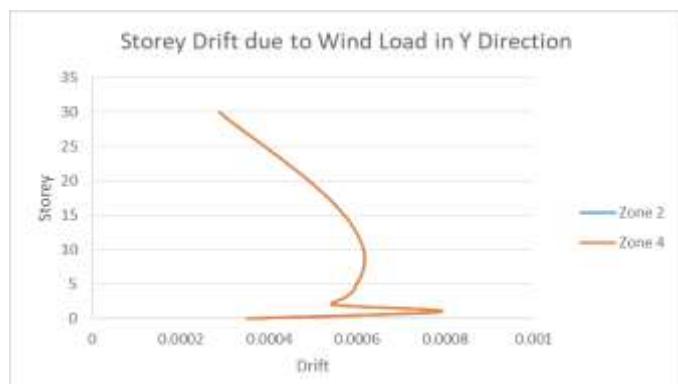
**Chart-2:** Storey Displacement due to Seismic Load in Y Direction



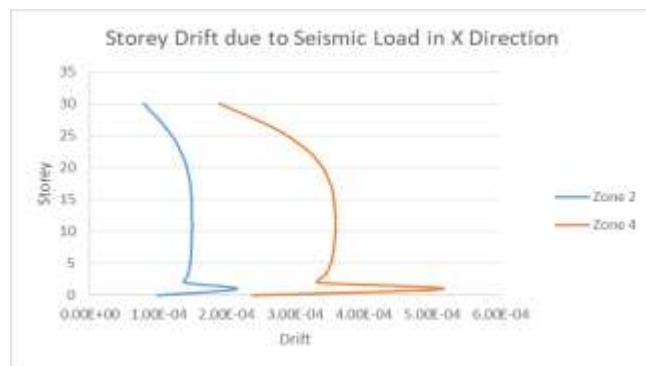
**Chart-3:** Storey Displacement due to Wind Load in X Direction



**Chart-4:** Storey Displacement due to Wind Load in Y Direction



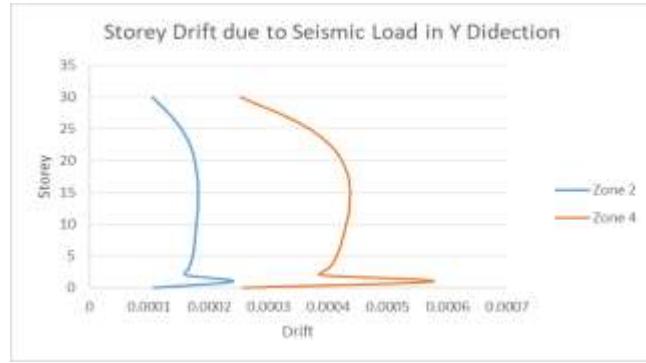
**Chart-8:** Storey Drift due to Wind Load in Y Direction



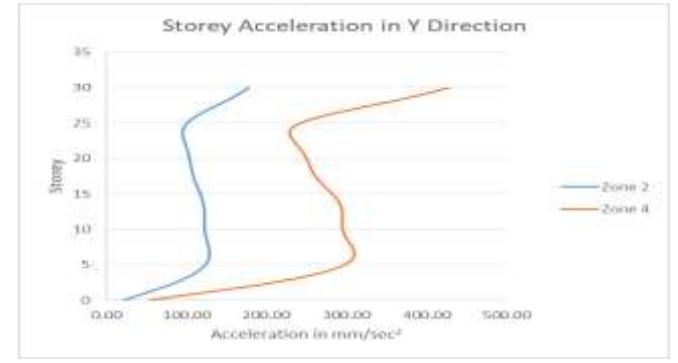
**Chart-5:** Storey Drift due to Seismic Load in X Direction



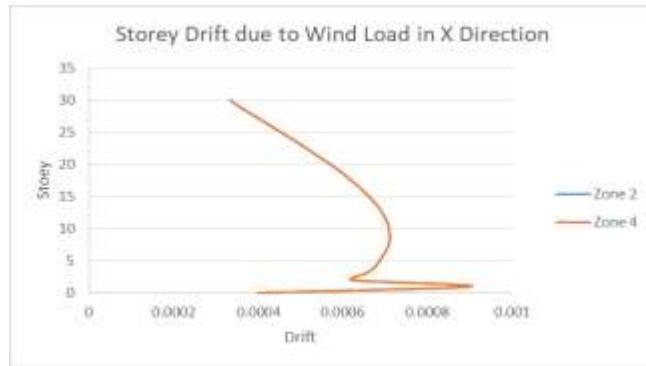
**Chart-9:** Storey Acceleration in X Direction



**Chart-6:** Storey Drift due to Seismic Load in Y Direction



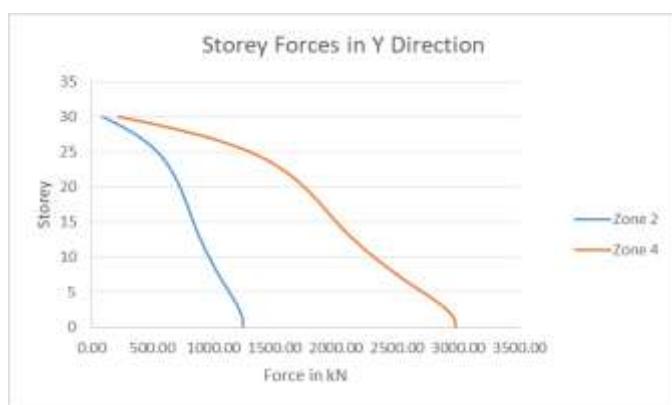
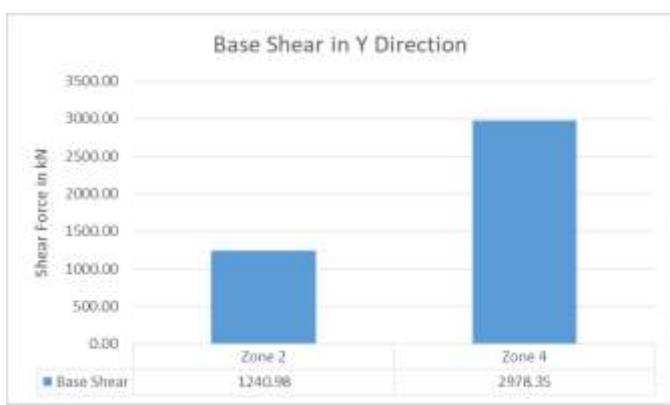
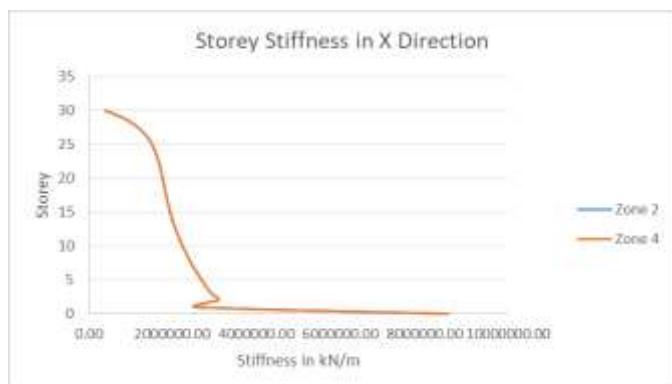
**Chart-10:** Storey Acceleration in Y Direction

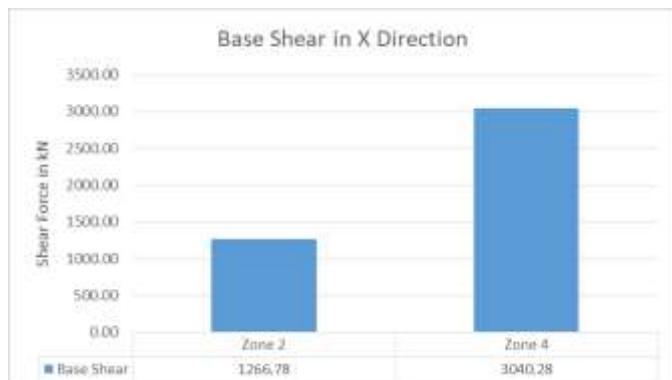


**Chart-7:** Storey Drift due to Wind Load in X Direction



**Chart-11:** Storey Force in X Direction


**Chart-12:** Storey Force in Y Direction

**Chart-16:** Base Shear in Y Direction

**Chart-13:** Storey Stiffness in X Direction

**Chart-14:** Storey Stiffness in Y Direction

**Chart-15:** Base Shear in X Direction

## 5. CONCLUSIONS

Effects on models have been shown in the form of graph in successive part of results by comparing various parameters such as displacements, storey drifts, storey acceleration, storey force, storey stiffness, and base shear. Hence from the obtained results the following conclusions are made,

1. The maximum lateral storey displacement was observed at the top storey, as the height increases the lateral stiffness offered by the building decreases thus intern result in max storey displacement at the top stories.
2. It was observed that for the storey drift the max values was noted at the at mid height level and goes on decreasing from mid height towards roof level
3. As the height of the building increases storey acceleration also increases and is also directly proportional to the seismic intensity.
4. In multi-storey buildings, provision of shear walls and the bracings were found to be effective in increasing the overall seismic response and characteristics of the structure.
5. Shear wall and bracing system combinely increases the stiffness and strength of the structure and affect the seismic behavior of the structure.
6. The seismicity/ the resistive force of the building against the seismic force are directly proportional to the intensity of the quake, i.e., as the intensity increases seismicity of the building increases proportionally.
7. From the analytical result, it is observed that base shear increases in the model with higher seismic intensity, i.e., as the intensity increases the seismicity of the building increases proportionally.
8. For better seismic performance, a building should have proper lateral stiffness. Low lateral stiffness leads to large deformation and strains, damage to non-structural members.
9. Hence, Shear walls and Bracing system combinely offer a good resistance to buildings against lateral force that significantly increases the strength of

overall frame and thus decrease the possibility of failure of the structure.

## REFERENCES

- [1] Anupam Rajmani, Prof Priyabrata Guha, "Analysis of Wind & Earthquake Load for Different Shapes of High Rise Building" IAEME Volume 6, Issue 2, February (2015), pp. 38-45.
- [2] Baldev D. Prajapati & D. R. Panchal, "Study of Seismic and Wind Effect on Multi Storey R.C.C., Steel and Composite Building" IJAET Vol. 6, Issue 4, pp. 1836-1847.
- [3] K. Rama Raju, M.I. Shereef, Nagesh R Iyer, S. Gopalakrishnan, "Analysis and Design of Rc Tall Building Subjected to Wind and Earthquake Loads" APCWE December 10-14, 2013.
- [4] Narla Mohan, A.Mounika Vardhan, "Analysis of G+20 Rc Building in Different Zones Using Etabs" IJPRES Volume VIII /Issue 3 / Mar 2017.
- [5] Naga Sai,G. Radha Devi, "Seismic and Wind Effects on High Rise Structure Using ETABS" IJRASET Volume 6 Issue II, February 2018.
- [6] Shruti Badami, M. R. Suresh, "A Study on Behavior of Structural Systems for Tall Buildings Subjected To Lateral Loads" IJERT Vol. 3 Issue 7, July – 2014.
- [7] Susheel S M, Sanjith J, Vidyashree B S3, Ranjith A, "Analysis of Tall Building in Chikkamagaluru Region" IRJET Volume: 03 Issue: 06 | June-2016.
- [8] Vikrant Trivedi, Sumit Pahwa, "Wind Analysis and Design of G+11 Storied Building Using STAAD-Pro" IRJET Volume: 05 Issue: 03 | Mar-2018.

## BIOGRAPHIES



Mr. Jaiprakash C  
Post Graduate Student,  
Department of Civil Engineering,  
BIET College, Davangere.



Ms. Ramya B V  
Assistant Professor,  
Department of Civil Engineering,  
BIET College, Davangere.