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Comparison of Influence of Earthquake and Wind Forces on High-Rise Multi Story Structures

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Abstract: This study offers a comparison of the impact of earthquake forces and wind forces on a multi-storey structure. The performance of the structures under seismic and wind loads plays a significant role, influencing not only structural integrity but also the safety of individuals residing within the structure. Studying the effects and behaviour of multi-storey buildings during seismic loading is a significant challenge. It is crucial to take into account the impacts of lateral loads when designing reinforced concrete structures. It establishes the essential design loading for multi-storey structures exposed to earthquake zones (II, III, IV, and V) and varying wind speeds. This study analyses the behaviour of high-rise multi-storey buildings under earthquake loads according to IS 1893:2016 and wind loads as per IS 875 part-3:2015. When a structure is located in a specific earthquake zone, the primary design loads for that building can be determined utilizing these findings. Following an in-depth analysis, the structures experience greater impact from earthquake forces in zone V and a lesser impact in zone II.

I. INTRODUCTION

As the elevation of the structure rises, the forces impacting it, including those from earthquakes and wind, also escalate with the building's height. With increasing height, the rigidity and stability of the structure are influenced, making it essential to design it mainly for lateral forces, moments, story drift, and overall horizontal deflection at the highest story level. Earthquakes and wind forces are unforeseen occurrences that cannot be anticipated in advance. Surviving this disaster requires thorough thought in the planning and design of structures in urban settings. A structure's height makes it susceptible to lateral forces from earthquakes and wind, which significantly influence the structural design. Tall buildings must withstand overturning moments and lateral deflection from lateral forces such as wind and earthquakes, alongside the gravitational loads impacting the structure. Lateral loads can generate significant stresses, induce swaying, or lead to vibrations; thus, it is crucial for the structure to possess enough strength for vertical loads and sufficient stiffness to counter lateral forces. Seismic and wind loads are crucial design factors in civil engineering, significantly influencing the structural design of tall buildings. Consequently, understanding the dynamic properties of a high-rise building subjected to seismic or wind forces is essential in engineering design and academic research.

In high- risk seismic zone, the seismic performance of structures is considered as the primary importance on the other hand which influence seismic performance, may be the effect of impact forces resulting from earth movement greater than the forces caused by wind loads and consequently, Seismic loading determines form and final design of the structure. Every year, natural disasters such as earthquakes, droughts, floods, and cyclones result in a large number of deaths and property losses. Earthquakes and cyclones are the most dangerous natural disaster. As a result, it is important to learn to cope with these occurrences. Property loss can be restored to some degree after a disaster, but life loss cannot. The collapse of buildings is the leading cause of death. It is said that earthquakes/ wind does not destroy people; it is buildings that are poorly built that do. As a result, it's critical to properly assess the structure for earthquake/wind load impacts. The primary goal of this project is to compare the responses of a tall building in different seismic zones as well as different wind speed in order to determine specific design parameters.

The main objective of our project is:

1) To make a study to calculate and comparing different parameters like story shear, lateral deflections, story drift, Reinforcement of Beams etc.at different seismic zones and with different wind speed in India.
2) Analyzing and design of the structure with the particular software named **ETABS**.
3) To study the structural response of forces acting on the structure as the height of the building increases.
4) To observe variation of response of the forces between different seismic zones in India.

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5) To examine how the forces respond differently at various wind speeds in India.
6) To compare the variation of response of the forces of the structure between different seismic zone with different wind speed in India.

II. WORK METHODOLOGY

A. *Introduction*

The critical factors for seismic analysis of structures are selected using appropriate methodology and structural modelling that accurately represents the system's actual behavior. A brief introduction and literature survey relevant to the nature of this study are presented in the previous section of this chapter.

We are conducting a comparative review of the following systems for modelling and analysis:

1) A mixed-use building featuring shear wall (G+ Podium+ Club +33 story) located in seismic zone IV and V.
2) A commercial cum Residential building with shear wall (G+ Podium+ Club +33 story) in seismic zone III and IV.
3) A mixed used building comprising shear wall (G+ Podium+ Club +33 story) considering wind velocity 50 m/sec.
4) A commercial cum Residential building featuring shear wall (G+ Podium+ Club +33 story) considering wind velocity 55 m/sec.

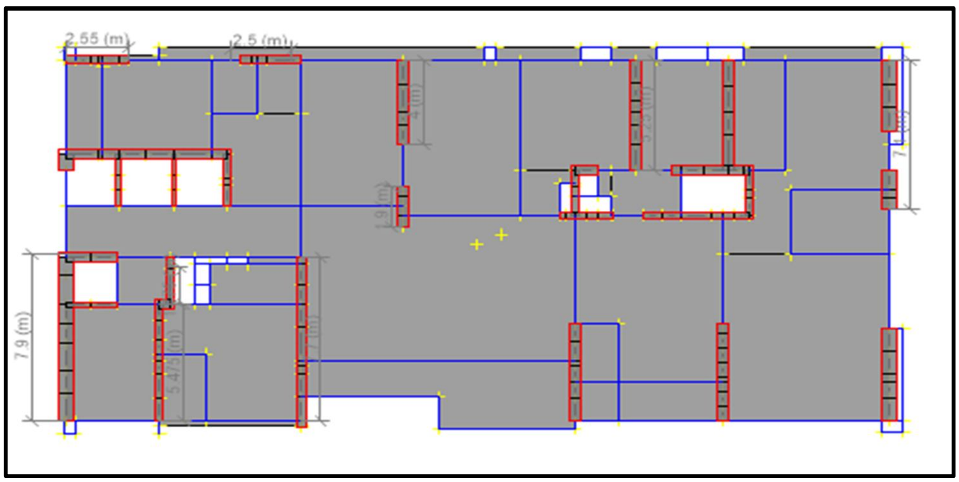

Fig. 3. Typical Floor Plan For Analysis

B. *Dynamic Analysis (Seismic)*

A dynamic analysis will be performed on the specified buildings to establish the design seismic force and its distribution across different heights of the building, along with various lateral load-resisting components: Regular and Irregular

The dynamic analysis of the model for building configurations can precisely represent the kinds of irregularities found in the structure. The dynamic analysis can be conducted using either the TIME HISTORY METHOD or the RESPONSE SPECTRUM METHOD.

C. *Calculation of Base Shear*

The Indian code categorizes the nation into four different seismic zones to evaluate design seismic forces (II, III, IV, and V). Originally, there were five zones, but in the fifth version of the I.S. code, Zones I and II merged into Zone II. The horizontal seismic force co-efficient A_h for a building needs to be determined using the formula provided below:.

$$A_h = \frac{Z I S_a}{2 R g}$$

Z = zone factor, It is the value of peak ground acceleration considered by the I.S. code 1893-2016 for the design of structures located in each seismic zone. Factor 2 in denominator is used to reduce the ground acceleration to design basis earthquake .

I = importance factor, used to estimate design seismic forces depending on the functional use of the structure, characterized by hazardous consequences of its failure, post-earthquake functional needs, historical value or economic importance.

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R = response reduction factor, it is a factor by which the base shear induced in a structure if it were to remain elastic in nature, is reduced to obtain the design base shear.it depends upon the perceived seismic damage performance of the structure, characterized by ductile or brittle deformations, redundancy in the structure, or overstrength inherent in the process of design. However the ratio *I/R* shall not be greater than1.

$\frac{Sa}{g}$ = average response acceleration coefficient. **(Fig 3.1)**

D. Design Lateral Force

The following expression determines the total design lateral force or design seismic base shear (Vb) in every principal direction of the building.

$$V_b = A_h \times W$$

Where, A_h is the horizontal seismic forces coefficient and W is the seismic weight of building.

Distribution of Design Force

"The design base shear, V_b computed above shall be distributed along the height of the building as per the following expression",

$$Q_i = \frac{W_i h_i^2}{\sum_{-1}^{n} W_j h_{jj}^2}$$

Where,

Qi = design lateral force at ith. floor

Wi= seismic weight of ith floor

hi = height of ith floor measured from base, and

n = numbers of story in the building is the number of the levels at which the masses are located.

For buildings with floors that can offer rigid horizontal diaphragm action, the overall shear in any horizontal plane will be allocated to the different vertical components of the lateral force resisting system, considering the floors as infinitely rigid in the horizontal plane.

E. Seismic Zones in India

Based on scientific inputs relating to seismicity, past earthquakes, and tectonic setup of the area, the Indian subcontinent is divided into four seismic zones (II, III, IV, and V). The country was previously divided into five seismic zones based on the intensity of the earthquakes, but the Bureau of Indian Standards [IS 1893 (Part I):2016] grouped the country into four seismic zones; the first and second seismic zones were merged".

F. Wind Analysis

Wind loading on a tall building not only acts over a larger surface area but also with greater intensity at greater height and with a large moment arm about the base than on a low rise building. Wind pressure on a low-rise building has a minimal impact on the structural design calculations of the structure, while wind on a very tall building can significantly affect its structural configuration and design.

The assessment of the wind pressure force acting on the building has been conducted in accordance with IS **875.3:2016.**

Wind is complicated phenomenon, a random time-dependent load composed of a mean plus a fluctuating component. Due to this fluctuating component, all structures experiences dynamic oscillations. Movement of wind is so unpredictable that need to be compute the statistical distribution of velocity rather than just simple averages. The mean component of wind speed produces a static force on a structure. The time-varying component that is the fluctuating component too, which is created by the gusty nature of the wind, is overlaid on the static component and has many frequencies distributed across a large band. Turbulence intensity, which is the ratio of the standard deviation to the average wind speed and is given in percentages, is a common way to quantify variable velocity.

When a wind load impacts a structure, it generates a positive pressure on the side facing the wind and a negative suction pressure on the opposite side (leeward side). The net wind force is computed as the summation of windward pressure and leeward suction but each of these two have their own local impact. Due to the roughness of earth surface, there acts a drag force on wind flow near the ground.

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This effect gradually decreases as the height increases and at a certain gradient level (around 400m), this drag-force becomes negligible. The degree of surface roughness and drag caused by surrounding projections that oppose wind flow determines the vertical profile of wind speed. Gradient height is the height at which the drag effects become zero, while gradient velocity is the corresponding velocity that do not show variation above this height. The atmospheric boundary layer is the height up to which terrain and topography influences the wind speed.

In low rise buildings, only static effects are sufficient to be considered whereas in tall buildings, the aerodynamic and dynamic effects are to be analyzed along with the static effects. High Rise structures are subjected to along with as well as across wind effects. The along wind effect are caused primarily due to buffeting phenomenon caused due to gust effects whereas across wind induced effects are due to vortex shedding.

Other dynamic wind induced phenomenon need to be evaluated that are due to increase in amplitude of oscillation with increase in wind speed. Galloping phenomenon are more susceptible to structural elements that are not circular, which is due to transverse oscillations of structures due to wind response that are in phase with motion due to the development of aerodynamic forces. Flutter is another unsteady oscillatory motion induced by the interaction of aerodynamic force and structural elastic deformation.

The most critical design considerations for tall buildings are the lateral stability and gravity system of the superstructure, along with the foundation design. The primary aim of designing tall buildings is to provide sufficient rigidity to withstand lateral or vertical loads.

To calculate the design pressure coefficients and force coefficients for such structures subjected to wind generated loads, the designers consult applicable wind load standards such as (AS/NZS: 1170.2-2002, ASCE: 7-02-2002, BS: 63699-1995, IS: 875 (Part-3) 2005). These standards, on the other hand, give information for simple cross-sectional shapes with a small number of wind incidence angles. These codes do not include information on wind loadings for buildings with unconventional shapes or for varying angles of wind attack. To determine these wind response coefficients, wind tunnel testing and CFD techniques are commonly used on models of such buildings.

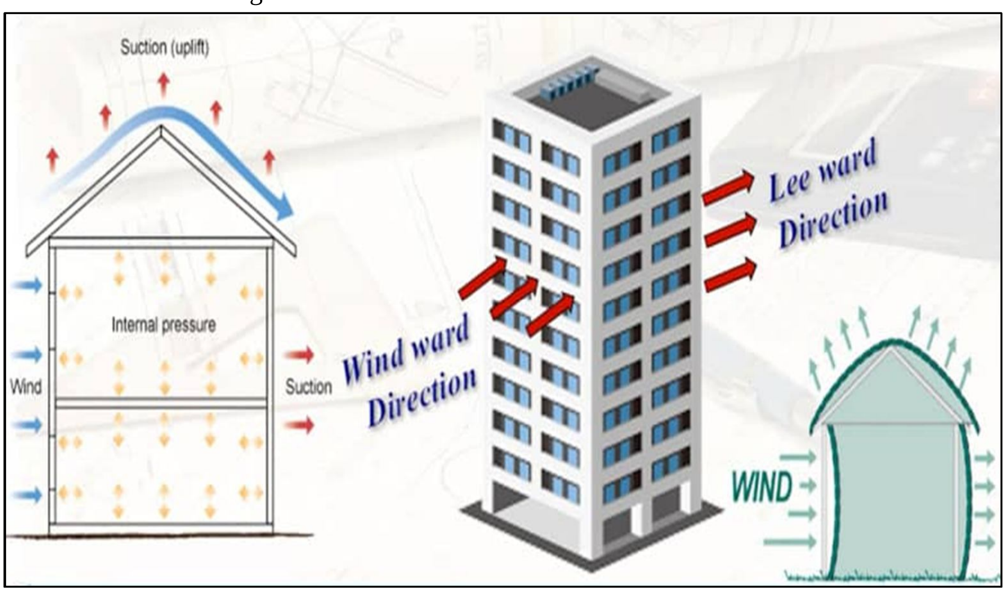

Fig- 12

III. WIND LOAD ON BUILDINGS

The following load combinations are considered as per IS 456:

FOR WIND LOAD

1. Load Case 1 = 1.5 [D.L + L.L]
2. Load Case 2 = 1.2 [D.L + L.L + W.L]
3. Load Case 3 = 1.5 [D.L + L.L - W.L]
4. Load Case 4 = 1.5 [D.L + W.L]
5. Load Case 5 = 1.5 [D.L - W.L]

FOR SEISMIC LOAD

1. Load Case 1 = 1.5 [D.L + L.L]
2. Load Case 2 = 1.2 [D.L + L.L + S.L]
3. Load Case 3 = 1.5 [D.L + L.L - S.L]
4. Load Case 4 = 1.5 [D.L + S.L]
5. Load Case 5 = 1.5 [D.L - S.L]

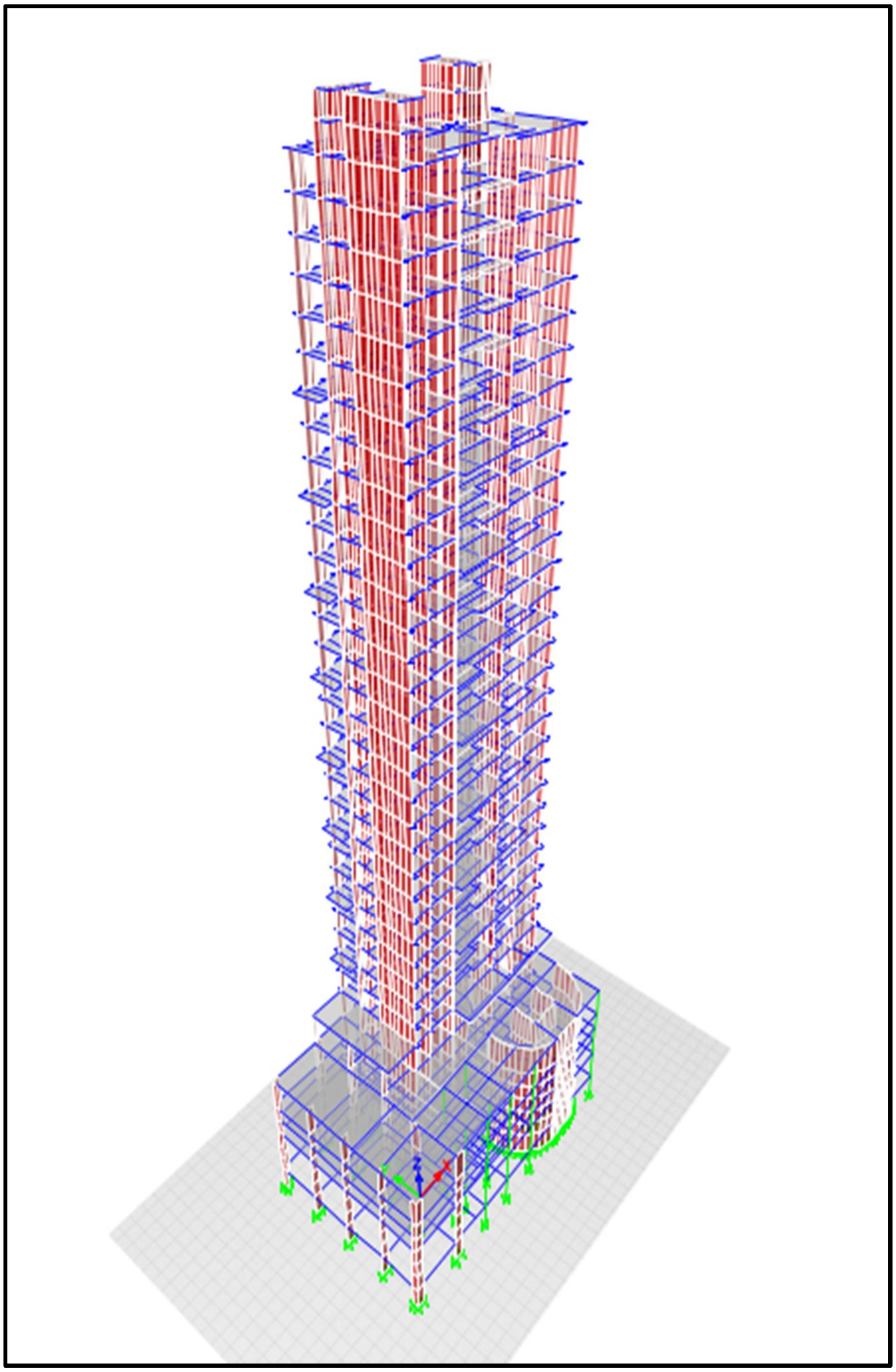

Fig.-20

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Volume 13 Issue VI June 2025- Available at www.ijraset.com

IV. ISOMETRIC VIEW

A. Comparison of Structure with basement (G+Podium+Club+33 story) at zone IV and a Structure with Basement (G+Podium+Club+33 story) at seismic zone V.

1) Story Shear (KN) :

It is the lateral force acting on a story as a result of forces such as earthquakes at zone IV and V. It is measured for each story, with the lowest value at the top and the highest value at the bottom of the house.

Table 5.1 Story Shear (X- DIRECTION)

Story	At zone IV (KNx10^3)	At zone V (KNx10^3)	Quantitative Increment (%)
Base	19.0	23.0	21.0%
Podium- 3rd	14.0	17.0	21.42%
Club- 6th	9.0	11.0	22.00%
10th Floor	8.0	9.0	12.5%
12th Floor	7.5	8.0	6.7%
14th Floor	7.0	7.5	7.2%
21st Floor	6.0	7.0	16.66%
25th Floor	5.5	6.0	9.1%
27th Floor	5.0	5.5	10.0%
29th Floor	4.0	4.5	12.5%
33rd Floor	2.0	2.5	25.0%
Roof Level	0.9	1.0	11.11%

2) Lateral Deflections (mm)

The elastic displacement is the absolute lateral displacement of any point in the structure relative to its base under strength-level design earthquake forces .

Table 5.3 Lateral Deflections (X- DIRECTION)

Story	At Zone IV (mmx10^3)	At Zone V (mmx10^3)	Quantitative Increment (%)
Base	0	0.0	0
Podium-3rd	0	0	0
Club-6th	0.025	0.05	100%
10th Floor	0.08	0.10	25.0%
14th Floor	0.18	0.20	11.11%
18th Floor	0.3	0.35	16.67%
21st Floor	0.4	0.45	12.5%
25th Floor	0.46	0.55	19.6%
27th Floor	0.55	0.60	9.1%
29th Floor	0.59	0.70	18.6%
33rd Floor	0.73	0.80	9.6%
Roof Level	0.78	0.85	8.97%

3) Story Drifts (mm)

Story Drift is characterized as the ratio of the displacement between two adjacent floors to the height of that particular floor. It is a crucial term employed for research purposes in the field of earthquake engineering. A key factor for indicating the structure's performance according to IS 1893: 2016 Part 1 is that the story drift must be under 0.004 times the height of the relevant story under consideration.

Table 5.5 Story Drifts (X- DIRECTION)

Story	At Zone IV	At Zone V	Quantitative Increment (%)
Base	0.0	0.0	0.0
Podium-3rd	0.8	1.0	25.0%
Club-6th	3.2	4.0	25.0%
10th Floor	4.4	6.7	52.27%
14th Floor	6.0	8.1	35.0%
18th Floor	6.22	9.0	44.7%
21st Floor	6.45	9.2	42.64%
25th Floor	6.25	8.8	40.8%
27th Floor	6.22	8.5	36.65%
29th Floor	6.2	8.1	30.65%
33rd Floor	5.0	7.6	52.0%
Roof Level	4.95	6.5	31.31%

B. Comparison of Structure with basement (G+Podium+Club+33 story) with wind speed 50m. per second and a Structure with Basement (G+Podium+Club+33 story) with wind speed 55 m per second.

1) Story Shear (KN)

It is the lateral force acting on a story as a result of forces such as wind load with a speed of 50m/sec. and 55 m/sec. It is measured for each story, with the lowest value at the top and the highest value at the bottom of the building.

Table 5.13 Story Shear (Perpendicular To X-Axis)

Story	Wind Speed 50m/sec. (KNx10^3)	Wind Speed 55m./sec. (KNx10^3)	Quantitative Increment (%)
Base	20.0	24.0	20.0%
Podium- 3rd	18.0	23.0	27.78%
Club- 6th	17.0	21.0	23.52%
10th Floor	15.0	18.0	20.0%
12th Floor	13.0	16.0	23.1%
14th Floor	9.0	12.5	38.89%
21st Floor	7.0	11.0	57.14%
25th Floor	5.0	7.5	50%
27th Floor	4.0	5.5	37.5%
.29th Floor	3.0	5.0	66.67%
33rd Floor	1.0	1.5	50.0%
Roof Level	0.0	0.0	0.0%

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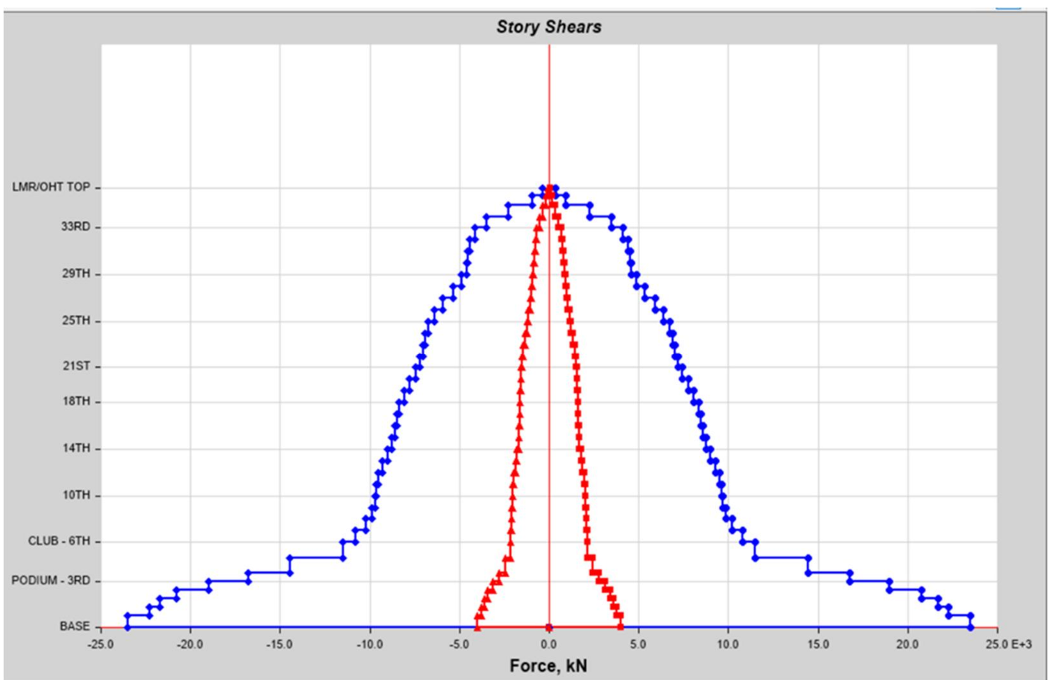
2) Lateral Deflections (mm)

The elastic displacement is the absolute lateral displacement of any point in the structure relative to its base under strength-level design wind forces.

Table 5.14 Lateral Deflections (Wind Perpendicular To X-Axis)

Story	Wind Speed 50m./sec. (mmx10^3)	Wind Speed 55m./sec. (mmx10^3)	Quantitative Increment (%)
Base	0	0.0	0
Podium-3rd	0.02	.03	50.0%
Club-6th	.06	.07	16.67%
10^{th} Floor	0.1	0.12	20.0%
14^{th} Floor	0.2	0.25	25.0%
18^{th} Floor	0.3	0.37	23.33%
21^{st} Floor	0.38	0.45	18.42%
25^{th} Floor	0.48	0.55	14.6%
27^{th} Floor	0.52	0.62	19.23%
29^{th} Floor	0.58	0.70	20.68%
33^{rd} Floor	0.68	0.88	29.4%
Roof Level	0.72	0.89	23.6%

FIG- 22



STOREY SHEAR (ZONE V)

INDIATES X DIRECTION

INDIATES Y DIRECTION

V. OBSERVATIONS

In this project, a tall Hi-rise building has been analyzed with the E-Tabs software considering different seismic zones in India and with different wind speed and their **Story Response** plots also are studied. From the modeling and analysis of these building, the following results are extracted for discussions.

1) The story shears of high rise building increases as the earthquake zone increases at a rate of 30%, 35%, 45%.
2) The displacements of high rise building increases as the earthquake zone increases at a rate of 30%, 40%, 50%.
3) The story drifts of high rise building increases as the earthquake zone increases at a rate of 20%, 32%, 42%.
4) The story shears of high rise building increases as the wind zone increases at a rate of 36%, 40%, 57%.
5) The story displacement of high rise building increases as the wind zone increases at a rate of 20%, 30%, 40%.

VI. CONCLUSION

In this study, the multistoried building excited to earthquake and wind forces for different seismic zone and varying wind forces are studied. From the modelling and analysis of these building, the following conclusion are drawn out.

1) The wind forces are found equally dominating for the high rise building.
2) As the earthquake zone increases, the displacements and story shears rise. The tall structures are similarly affected by wind and seismic forces, and the impact of the wind grows as their height increases further.
3) It is noted that the lateral forces acting on the structure have exhibited greater intensity with a rise in wind speed and earthquake zone factor.
4) It is observed that, the lateral forces excited on the structure have shown increasing severity with increase in the wind speed and earthquake zone factor.
5) When earthquake force effects observed on the buildings, the low rise buildings shows higher influence to earthquake forces when compared to high rise building.
6) When wind force effects observed on the buildings, the low rise buildings shows lesser influence to wind forces when compared to high rise building.
7) When evaluating response parameters influenced by wind and earthquake forces for structures of identical height, it has been noted that seismic zone V largely resembles the impact of a wind speed of 50 m/sec.
8) From this, it can also be concluded that, for tall building design ,both earthquake and wind forces need to be taken into account with great attention considering appropriate design loads.

REFERENCES

[1] Behavior of reinforced concrete walls under the impact of Earthquake force by Dr.Sudhir Kumar Jain.
[2] Earthquake resistant design of structure by Shrikhande, Manish Agarwal, Pankaj.
[3] Earthquake Dynamics of Structures by Anil. K. Chopra.
[4] Reinforced design of Tall Building by S. Taranath.
[5] Earthquake Tips authored by Prof. C V R Murty, IIT Kanpur and sponsored by Building Materials and Technology Promotion Council, New Delhi, India. (Source: www. www.iitk.ac.in)
[6] Earthquake Engineering Practice, Volume 1, Issue 1, March 2007, published by National Information Center of Earthquake Engineering, IIT Kanpur, Kanpur 208016.
[7] Earthquake resistance design of structure by Duggal- Oxford University Press.
[8] Zynamics of structure by Clough R.W. and Penzin J. McGraw Hill Civil Engineering Series
[9] Dynamics of structure by Mario Paz, CBSPD Publication
[10] Earthquake Resistant Design by David J. Downik, John Wiley and Sons Publication
[11] Earthquake Tips NICEE, IIT, Kanpur
[12] Elements of Earthquake Engineering by Jaikrishna and Chandarsekaran.
[13] Geo-technical Earthquake Engineering by Kramer S. L. Prentice Hall India Publication
[14] Introduction to Structural Dynamics by John M. Biggs
[15] Mechanical Vibrations by V. P. Singh

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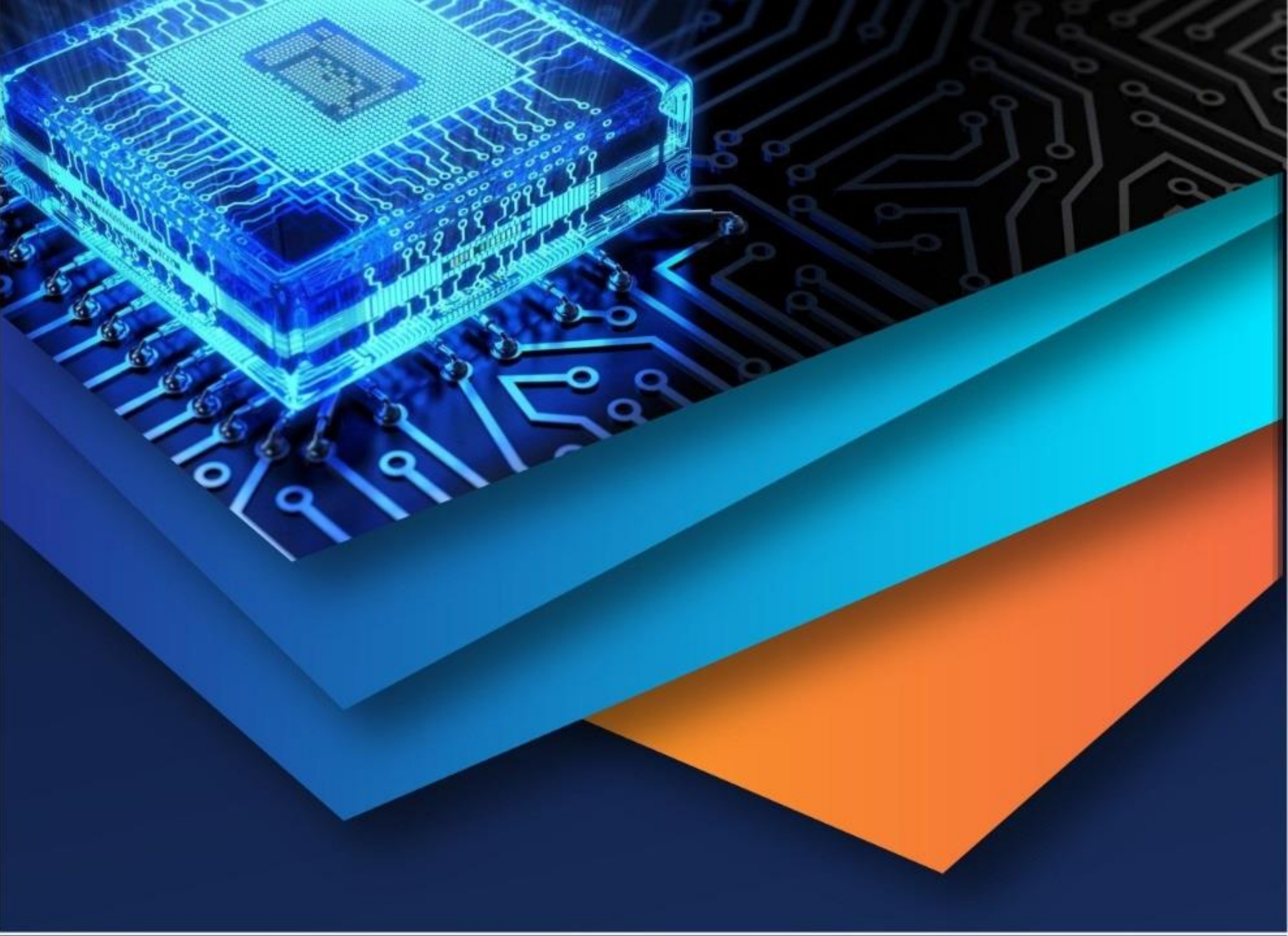
Table 6 – I.S Codes used in Building Design.

S. No	Code	Description
1.	IS:875(Part-1)-1987	Code of Practice for Design Loads (other than earthquake) for buildings and structures – Unit weights of buildings materials and stored material.
2.	IS:875(Part-2)-1987	Code of Practice for Design Loads (other than earthquake) for Buildings and structures – Imposed loads.
3.	IS:456-2000	Code of Practice for Design Loads (other than earthquake) for Buildings and structures – Wind loads.
4.	IS:1893(Part-1)-2016	Criteria for Earthquake Resistant Design of Structures-General Provisions and Buildings
5.	IS:13920-2016	Ductile Design and Detailing of Reinforced Concrete Structure Subjected to Seismic Forces.
6.	SP-16	Design Aids for Reinforced Concrete to IS: 456:1978



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