International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 10 Issue: 06 | Jun 2023 www.irjet.net p-ISSN: 2395-0072

Analysis of Wind Load Effects on R.C Structure Resting on Flat and Sloping Ground by Using E-tabs

Ms. Khan Shaima Khan Iftekhar Khan[1], Mr. Aakash Suthar [2]

[1]Student, Master's in Structural Engineering, L.J.I.E.T, Gujarat, India
[2]Assistant Professor, Structural Engineering Department, L.J.I.E.T, Gujarat, India

---***---

Abstract - *In this study, 36 models are prepared the interaction between tall buildings and wind on flat and sloping ground, specifically focusing on the northern part of India with high wind flow. Reinforced concrete structures of different heights (G+5, G+10, and G+15) are analysed on both flat terrain and slopes (0°,10°,20°, and 30°) for various wind zones. Wind load analyses using the e-tabs software are performed in this paper there are 3 types of models has been done for the different zones. The story displacement, story drift, mode period has been also checked and result is satisfactory. Results from software and manual calculations are compared, and design considerations are based on maximum obtained values.*

Key Words: **Wind analysis, building tower, Sloping Ground, wind load, wind analysis, high-rise structure, deflections, wind pressure.**

1. INTRODUCTION

Wind load is a critical factor in the design of structures and requires thorough investigation to understand its effects on buildings. Particularly, buildings constructed on hill slopes often possess unsymmetrical characteristics. This project focuses on conducting a comprehensive study of wind load behavior on building frames, analysing the structural response to wind, and assessing the impact of slope on the structures. Structural designs aim to withstand earthquakes, and wind loads, maintain stability, and prevent damage.

Wind load acts as a lateral force on buildings, exerting pressure along and across the wind direction. In [IS 875 – (Part 3) – 2015], the basic wind speeds are specified and categorized by zones on a map. The shape and size of a building play a crucial role in wind analysis since wind pressure depends primarily on the exposed area of the building facing the wind speed.

The analysis of structures becomes particularly critical when located on steep or sloping ground, especially in areas with higher wind flow intensity and hilly regions. Buildings constructed on hills using masonry with mud mortar or cement mortar, without conforming to seismic codal provisions, have proven to be unsafe and resulted in the loss of life and property during earthquake ground motions.

1.1 A Building Resting on A Flat Surface

. In today's world, the expansion of cities and human colonies is causing our agricultural fields and villages to vanish. High-rise buildings play an important role in minimizing wasteful land use. A tall building or structure built for residential or commercial purposes is referred to as a high-rise building, apartment tower, office tower, apartment block, or block of flats.

Fig -1 Resting on A Flat Ground

1.2 An indicative R.C. Structure Resting on Inclined Ground

Buildings resting on sloping ground present a unique set of challenges for structural engineers. The slope of the ground can cause uneven column heights, different soil conditions, and increased seismic risk. These challenges must be carefully considered in the design and construction of the building to ensure its safety and stability.

Fig -2 Resting on Inclined Sloping Ground

1.3 Objectives

The objectives of the analysis of wind load effects on an R.C. structure resting on flat and sloping ground using E-tabs are as follows:

Evaluate wind load distribution: Determine the distribution of wind loads on the structure considering both flat and sloping ground conditions.

Compare effects on the flat and sloping ground: Analyse and compare the effects of wind loads on the structure when it is resting on flat ground versus sloping ground.

Study structural behaviour: Investigate the structural behaviour of the R.C. structure under wind loads, including deflections, bending moments, shear forces, and support reactions.

Assess structural stability: Evaluate the stability of the structure under wind loads, considering both overall stability and individual member stability.

Optimize design: Identify areas of improvement in the structural design to enhance the resistance against wind loads.

Validate design codes: Compare the results obtained from the analysis with the provisions specified in relevant design codes and standards.

Provide recommendations: Based on the analysis results, offer recommendations for improving the structural design, construction techniques, or site selection to enhance the wind resistance of the R.C. structure on both flat and sloping ground.

Overall, the study aims to provide valuable insights into the analysis of wind load effects on buildings resting on both flat and sloping ground, with a focus on wind zones and the use of ETABS software for design purposes.

2. LITERATURE REVIEW

BD Yadav1 *, Nilesh Choudhary1, Jaydev Kumar Mahato2 and Nitin Kumar2, "study the effects of various wind loadings in high rise rc-framed structures in zone –v" In brief it is found that: Wind loading, and seismic loading are two crucial factors in the design of high-rise buildings to ensure their stability and structural integrity. Let us deeper into each aspect and discuss the relevant provisions suggested in the Indian Standards (IS).

Prof. D.N. Kakde1, Shaikh Mohd. Kasheef, "influence of slope angle variation on the structures resting on sloping ground subjected to heavy winds." The research study focused on evaluating the structural performance of high-rise structures in the northern part of India, where wind flow is significantly higher. These structures were further complicated by being constructed on inclined portions of hilly regions. The study aimed to specifically examine the effects of heavy wind loads on such structures.

Naveen Suthar, Pradeep K. Goyal, "comparison of the response of building against wind load as per wind codes [is 875 – (part 3) – 1987] and [is 875 – (part 3) – 2015]." In brief it is found that: The research paper presented a comparison of wind loads for a G+11 building using two different wind loading codes: the old code [IS: 875 – (Part 3) – 1987] and the new code [IS: 875 – (Part 3) – 2015]. The comparison focused on the wind loads calculated using the static method for zone 4 with terrain category 3. This comparison allowed them to assess the differences in the wind load calculations and understand how the changes in the code provisions affected the structural response.

B. Shobha1, Dr.H. SudarsanaRao2, Dr. Vaishali.G. Ghorpade, "effect of wind load on low, medium, high-rise buildings in different terrain categories." In this study, the focus is on assessing the response of tall buildings to wind loads, specifically considering both "along wind" and "across wind" vibrations caused by wind flow. While modern tall buildings are designed to meet lateral drift requirements, excessive oscillations can still occur during windstorms, which can pose threats to the structure's integrity and cause discomfort to occupants. Therefore, accurately assessing the motion of tall buildings under wind loads is crucial to ensure their serviceability.

K. Surender Kumar a, N. Lingeshwaran b Syed Hamim Jeelani, "ANALYSIS OF RESIDENTIAL BUILDING WITH STAAD. PRO & ETABS." This paper focuses on the design and analysis of a multi-story building with the aim of achieving efficiency and long-term durability. Multi-story buildings offer the advantage of increased floor area without the need for expanding the land area, resulting in cost savings and optimized land utilization. The primary objective of the study is to develop an effective design analysis methodology that encompasses various aspects such as load cases, load combinations, support reactions, and the reinforcement of columns and beams.

3. METHODOLOGY

The analysis and design of an RCC structure resting on flat or sloping ground using ETABS software typically involve the 3 different types of story building is possible for Analysis of Wind Load Effects on R.C Structure Resting on at 0°,10°,20°,30° Sloping Ground. These steps require a good understanding of IS codes (Indian Standard codes) and fundamental structural concepts. To validate and compare the results, a total of 36 models were created.

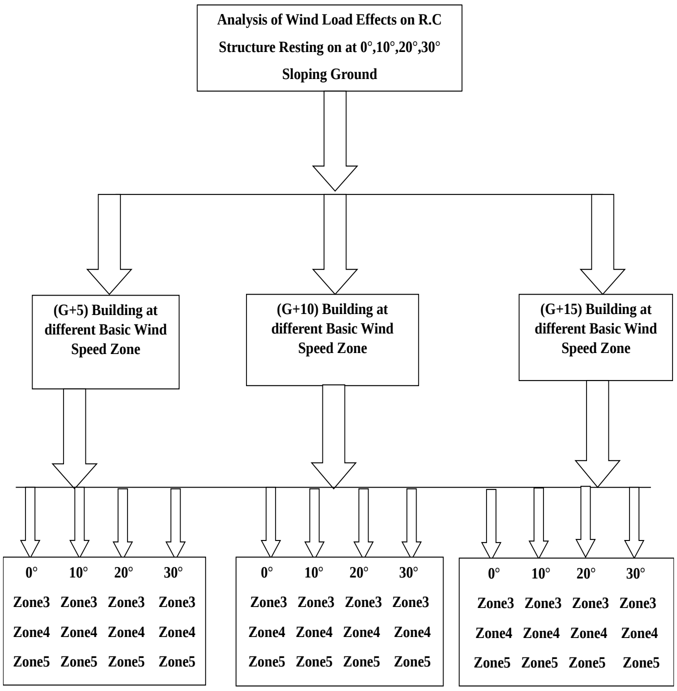

Fig -3 Flow Chart of models

3.1 Software of analysis

ETABS is a powerful and versatile software that can be used to accurately calculate wind loads on buildings according to Indian standards. The software's features make it well-suited for a variety of wind load analysis applications, including the design of new buildings and the evaluation of existing buildings for wind safety.

These features include the ability to:

- Calculate wind loads based on the terrain category and height of the building.
- Account for the effects of wind gusts and vortex shedding.
- Calculate wind-induced uplift forces.
- Generate a variety of reports that can be used to document wind load calculations.
- ETABS is a commercial software, so there is a cost associated with using it.
- The software can be complex to learn and use, so it is important to have some training before using it for wind load analysis.

3.2 Modelling

To study the seismic behavior of RCC structure, different cases have been defined and their comparative graphs for these cases have been plotted. A typical RCC building will be designed and analysed for dead load, live load, wind load.

i. Seismic zone, Z (IS 1893: 2002, clause 6.4.2, table 2)

ii. Response reduction factor, R (IS 1893: 2002, clause 6.4.2, table 7)

iii. Importance factor, I (IS 1893: 2002, clause 6.4.2, table 6)

iv. Soil type (IS 1893: 2002, clause 6.4.5, page 16)

Table -1: Modelling Details for RCC Structure

PARAMETERS	DETAILS
Number of stories	(G+5), (G+10), (G+15)
Type of structure	R.C. Structure
Story to Story height	3m
Ground story height	3m
Grade of concrete	M30 for Column and Slab & M30 for Beam
Thickness of slab	150mm
Thickness of slab	230mm
Beam size	400mmX400mm
Column size	450mmX600mm
Density	For concrete 25KN/m For Brick wall 19 KN/m
Basic wind Speed Zone	Zone3, Zone4, Zone5
Degree of Slope	0°,10°,20°,30°

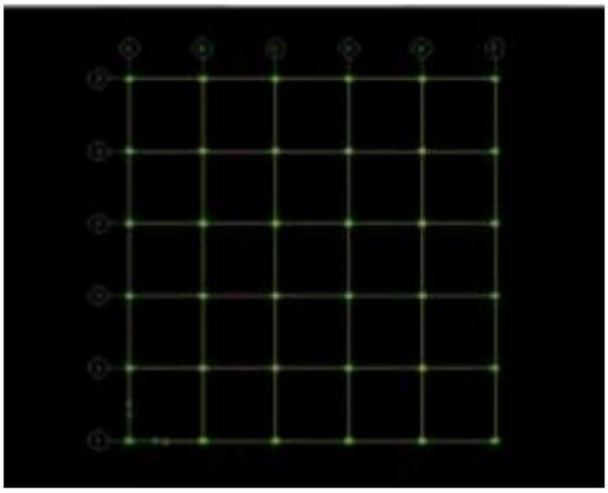

Fig - 4 Top View of Typical Structure

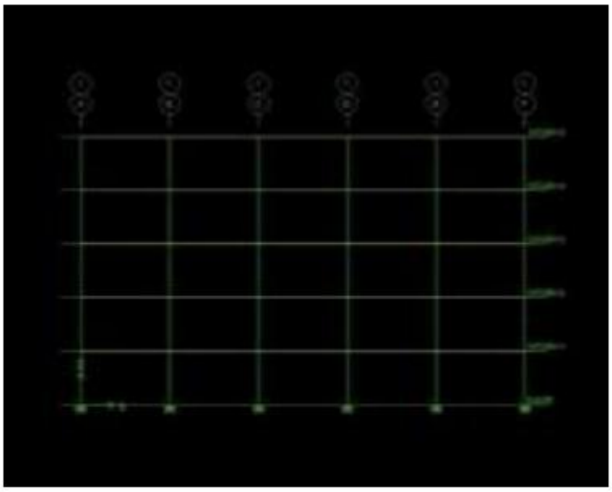

Fig – 5 Plain Ground Structure

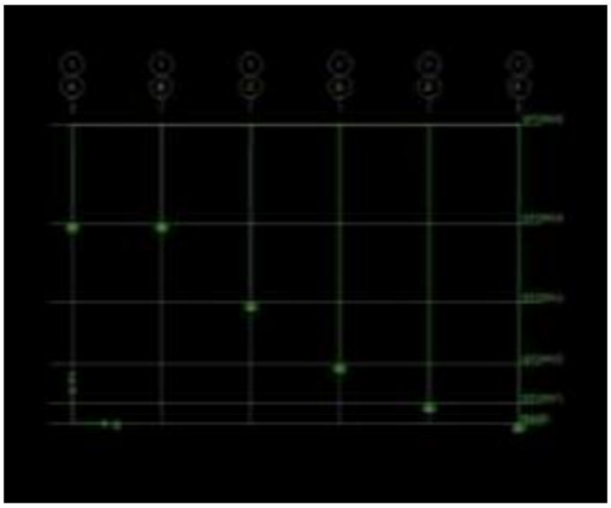

Fig - 6 Story G+10º Sloping Ground

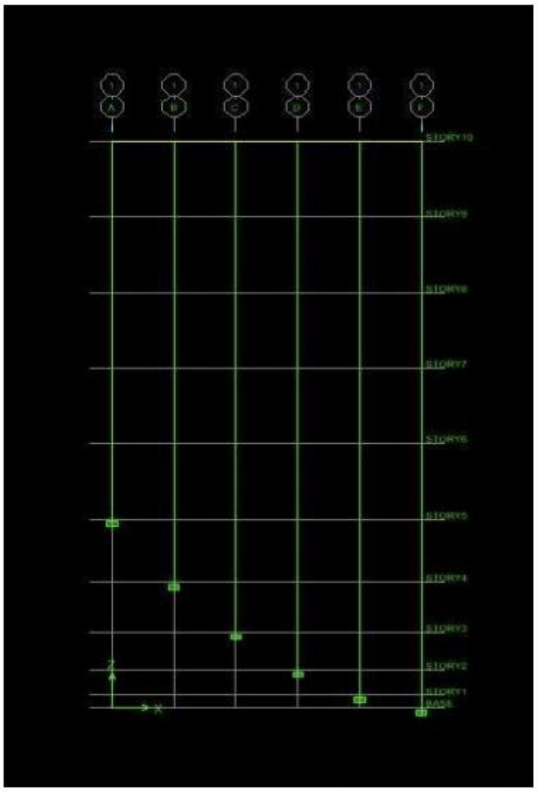

Fig – 7 G+10 Story 10º Sloping Ground

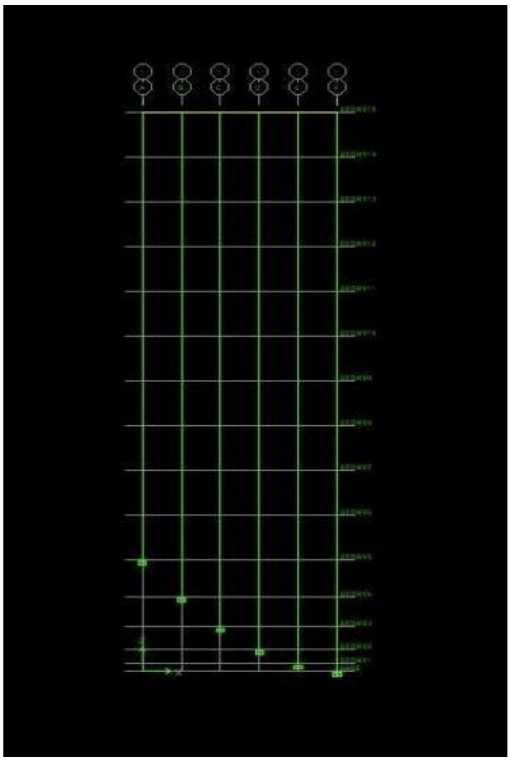

Fig – 8 G+15 Story 10º Sloping Ground

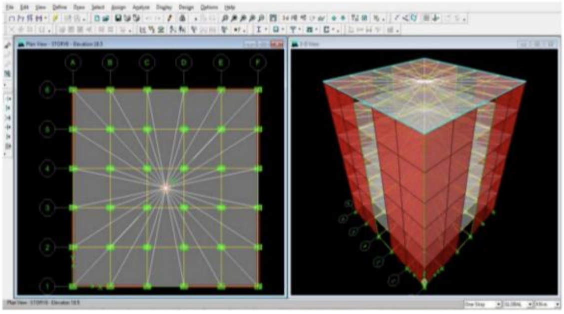

Fig – 9 G+5 Story At 0º

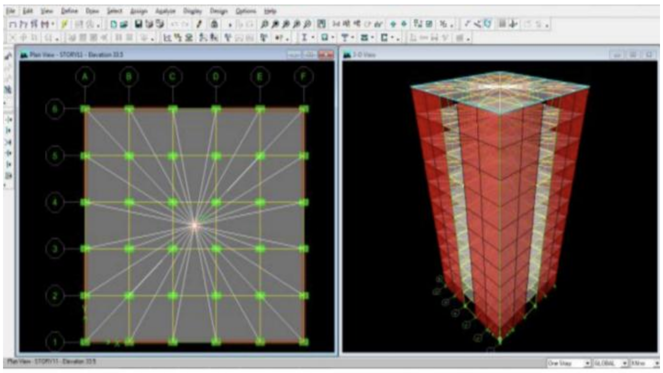

Fig – 10 G+10 Story At 0º

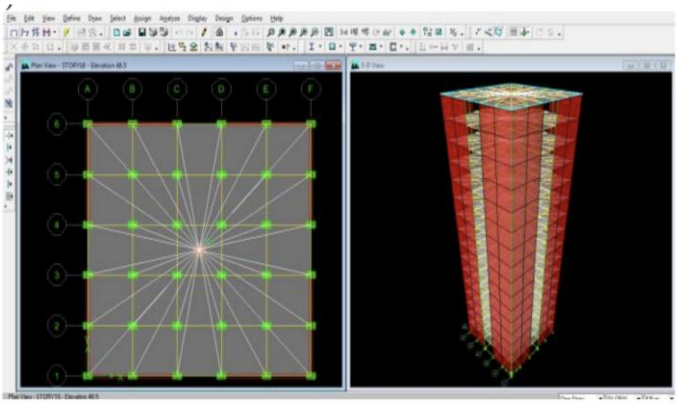

Fig – 11 G+15 Story At 0º

4. OBSERVATIONS

There are 3 major types of models is analysed of different heights (G+5, G+10, and G+15) on both flat terrain and slopes (0°,10°,20°, and 30°) with different wind zones.

4.1 Story Displacement: - The permissible limit for story displacement is 0.004 times the story height. Therefore, the story displacement values in the table are within the permissible limit.

The X and Y direction values are the same in the table because the building is assumed to be symmetrical in both directions. This means that the wind load is applied equally in both directions, and the stiffness of the building is the same in both directions.

4.1 Story Displacement: - The permissible limit for story displacement is 0.004 times the story height.

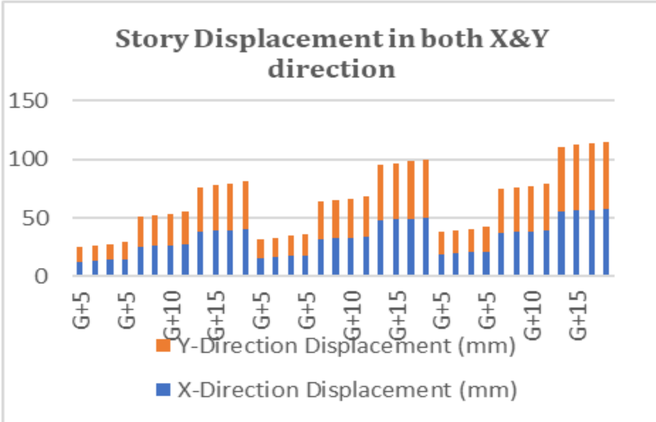

Chart 1: -Story Displacement for three Models

4.2 Story Drift: - The permissible limit of story drift depends on the type of structure and the applicable building code. In India, the permissible limit of story drift for RC structures is 0.004 times the story height. The values given in the table are within the permissible limit.

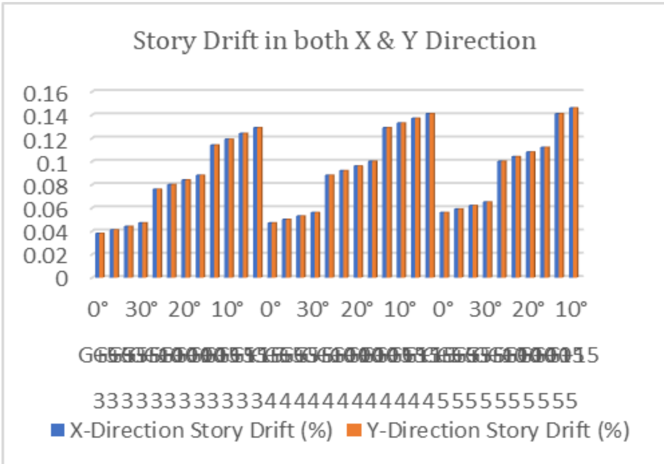

Chart 2: -Story Drift for three Models

4.3 Mode Period: - The permissible limit of mode period depends on the type of structure and the applicable building code. In India, the permissible limit of mode period for RC structures is 0.15 seconds. The values given in the table are within the permissible limit.

The values in both X and Y directions are the same because the building is assumed to be symmetrical in both directions. This means that the wind load is applied equally in both directions, and the stiffness of the building is the same in both directions.

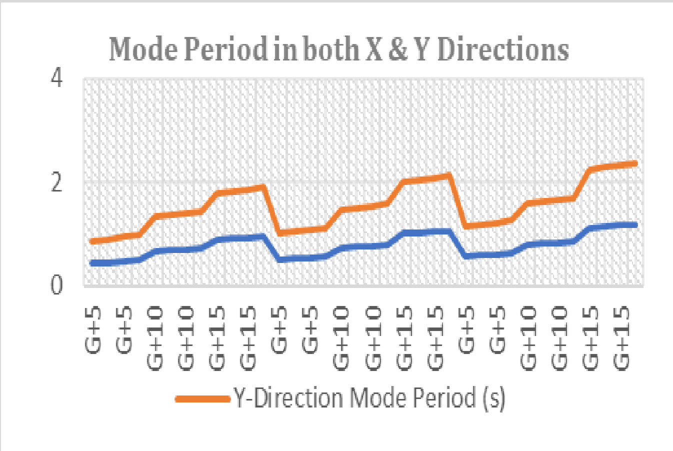

Chart 3: -Mode Period for three Models

5. CONCLUSIONS

Table -2: A table that summarizes wind characteristics in various zones: -

Wind Zone	Table 1	Table 2
Zone 3	Story drift increases with number of stories and slope. Story displacement increases with number of stories and slope. Mode period increases with number of stories and slope.	Story drift increases with number of stories. Story displacement increases with number of stories. Mode period decreases with number of stories.
Zone 4	Story drift increases with number of stories and slope. Story displacement increases with number of stories and slope. Mode period increases with number of stories and slope.	Story drift increases with number of stories. Story displacement increases with number of stories. Mode period decreases with number of stories.
Zone 5	Story drift increases with number of stories and slope. Story displacement increases with number of stories and slope. Mode period increases with number of stories and slope.	Story drift increases with number of stories. Story displacement increases with number of stories. Mode period decreases with number of stories.

In all three wind zones, story drift and story displacement increase with the number of stories and slope. This is because the taller the building, the more it will sway in the wind or under seismic loading. The slope of the ground also has an effect, as a sloping ground will cause the building to sway more than a level ground.

In Zone 3 and Zone 4, mode period increases with the number of stories and slope. This is because a taller building has more mass, which will tend to dampen the swaying motion. However, in Zone 5, mode period decreases with the number of stories. This is because the higher wind speeds in Zone 5 require a shorter mode period to prevent the building from oscillating too much.

1. The structure on sloping ground exhibits a higher maximum displacement, which can lead to critical situations compared to structures on flat ground.

2. The mode shape analysis reveals that the 15-storey structure has the longest period at both the top and bottom stories.

3. The tables show that story drift, story displacement, and mode period all increase with the number of stories and slope. However, mode period decreases with the number of stories. This is because a taller building has more mass, which will tend to dampen the swaying motion.

4. The base shear is greater in the X-direction than in the Y-direction for structures on sloping ground.

5. The mode period decreases as the slope angle increases.

6. The maximum story displacement is observed in the structure with a 10º slope.

7. The displacement is higher at the top story compared to the bottom story in all other models, both in the X-direction and Y-direction.

8. The maximum story drift occurs in the structure with a 10º slope in all models.

REFERENCES

[1] Yadav, B. D., Choudhary, N., Mahato, J. K., & Kumar, N. (2023). Study The Effects of Various Wind Loadings in High Rise Rc-Framed Structures In Zone–V. Journal of Civil Engineering Research & Technology. SRC/JCERT-140. DOI: org/10.47363/JCERT/2023 (5), 139, 2-6.

[2] Kakde, D. N., & Kasheef, S. M. (2020). INFLUENCE OF SLOPE ANGLE VARIATION ON THE STRUCTURES RESTING ON SLOPING GROUND SUBJECTED TO

HEAVY WINDS. Solid State Technology, 63(1s), 2352-2364.

[3] Suthar, N., & Goyal, P. K. (2021, June). Comparison of response of building against wind load as per wind codes [IS 875– (Part 3)–1987] and [IS 875–(Part 3)–2015]. In IOP Conference Series: Earth and Environmental Science (Vol. 796, No. 1, p. 012007). IOP Publishing.

[4] Shobha, B., Rao, D. H. S., Vaishali, D., & Ghorpade, G. (2018). Effect of wind load on low, medium, high rise buildings in different terrain category. International Journal Of Technical Innovation In Modern Engineering & Science (IJTIMES).

[5] Kumar, K. S., Lingeshwaran, N., & Jeelani, S. H. (2020). Analysis of residential building with STAAD. Pro & ETABS. Materials Today: Proceedings, 33, 1221-1228.

[6] S. Yogeshwaran, L. Natrayan, G. Udhayakumar, G. Godwin, L. Yuvraj, Effect of waste tyre particles reinforcement on mechanical properties of jute and abaca fiber-epoxy hybrid composites with pre-treatment, Mater. Today: Proc. (2020),

[7] IS: 875(Part 1, Part 2, Part 3)- 2015, bureau of Indian standard code of training for configuration loads.

[8] B. Shobha, H Sudarshan Rao, Vaishali G Ghorpade (2018) Effect of wind load on low, medium, High rise buildings in different terrain category IJTIMES-2018.

[9] Al Agha W, Umamaheswari N (2021) Analytical study of irregular reinforced concrete building with shear wall and dual Framed-Shear wall system by using Equivalent Static and Response Spectrum Method. Mater. Today Proc., International Conference on Advanced Materials Behaviour and Characterization (ICAMBC 2020) 43: 2232-2241.

[10] A.S. Patil, P.D. Kumbhar. Time history examination of multistorey RCC structures for various seismic powers, Int. J. Auxiliary Struct. Designing Explore. (IJSCER), Vol. 2(3), 2013.