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(Review Article)

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Effect of wind on RC structure resting on sloping ground and analysis done using ETABS software

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Abstract

Wind load is one of the common loads for civil engineering structures viz. for long span bridges, tall buildings, towers and mast structures also. Wind load is acting on such structure throughout its life span. Therefore it is most important phenomenon to be taken into consideration for a structural engineer. Due to scarcity of land or due to mountainous terrains in North and North-East part of India most of the time structures are constructed on sloping grounds which is a challenge for structural engineer for analysis and design. These structures are also directly subjected to wind loads. India is also having large records of earthquake which left behind loss of many lives and heavy destruction to property and economy. Analysis of buildings in hilly regions with sloping grounds is somewhat different than the building located over a levelled ground. In present study 3D building frames of 25 storied building resting on flat terrain and sloping ground are taken into consideration. For sloping ground slopes of 20^0,30^0, and 40^0 are considered. They are to be analyzed for wind speeds 39 m/s, 47 m/s and 55 m/s respectively. The modelling and analysis can be done using ETABS software which stands for extended three dimensional analysis of building system.

Keyword: Wind load; Sloping ground; Wind speeds; Slopes; ETABS software

1. Introduction

India has a track record of wind in various regions which left behind the loss of many lives and heavy destruction to property and economy. Analysis of buildings in the hilly region is somewhat different than the buildings on leveled ground, since the column of the hill building rests at different levels on the slope. Such buildings have mass and stiffness varying along the vertical and horizontal planes resulting in the center of mass and center of rigidity coinciding on various floors; hence they demand torsional analysis, in addition to lateral forces under the action of wind force. Structures resting on sloping ground are highly vulnerable to earthquakes due to irregularities in plan and elevation. The unsymmetrical buildings require great attention in the analysis and design under the action of seismic excitation. Past earthquakes in which buildings located near the edge of a stretch of hills or on sloping ground suffered serious damages. The shorter column attracts more forces and undergoes damage, when subjected to earthquakes. The other problems associated with hill buildings are, additional lateral earth pressure at various levels, slope instability, different soil profiles yielding unequal settlement of foundation.

Wind load is an external pressure or force which is acting on structure throughout its life. Therefore, it is most important phenomenon to be taken in consideration for a structural engineer. The effect of wind speed on building frame resting on sloping ground have been considered because of scarcity of land. In this study 3D building frames of 25 story resting on flat terrain as well as three slopes 20°, 30° and 40° are to be modelled and analyzed for wind zones 39 m/s, 47 m/s and 55 m/s respectively. The modeling and the analysis can be appropriately done using software ETABS. ETABS means

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extended three dimensional analysis of building system. The parameters considered for the post analysis are maximum storey displacement and maximum storey drift. Both the parameters are to be compared for wind speeds and ground slopes and results will be obtained the after analysis and tabulated to represent graphically.

Figure 1 Sloping ground with unequal storey height

Figure 2 Buildings resting on steep sloping ground

2. Problem statement

Wind analysis of regular shape building having different location will be considered in project. It should be kept in mind that the various design parameters such as earthquake parameters, wind parameters and all regular and irregular shape building data such as number of floors, plan dimension, type of structure and other building data remain the same for all building. After analysis of all the structures; the results of analysis should be compared and conclusion will be drawn for the suitability of the structures.

Table 1 Detailed features of the building model

Type of structure	**Frame structure**
Moment-Resisting frame	Special Moment Resisting Frame(SMRF)
Location	Pune
Basic wind speed	39,47,55 m/sec
Slope angles	20^0, 30^0, 40^0
No. of Stories	G+25
Height of each story	3m

Height of ground story	1.2m
Thickness of slab	125mm
Thickness of outer wall	150mm
Thickness of inner wall	100mm
Grade of reinforcing steel	Fe 415
Density of concrete	25 KN/m3
Density of Brick wall	20 KN/m3
Grade of concrete in slab	M30
Grade of concrete in beam	M30
Grade of concrete in column	M40
Analysis method	Response spectrum method

Table 2 Details of building model cases to be taken-a) for sloping angle

Condition	Basic wind speed
20 degree	39 m/s
20 degree	47 m/s
20 degree	55 m/s
30 degree	39 m/s
30 degree	47 m/s
30 degree	55 m/s
40 degree	39 m/s
40 degree	47 m/s
40 degree	55 m/s

Table 3 Building model cases to be taken- b) for flat ground

Condition	Basic Wind speed m/s
Flat ground	39
Flat ground	47
Flat ground	55

3. Modeling

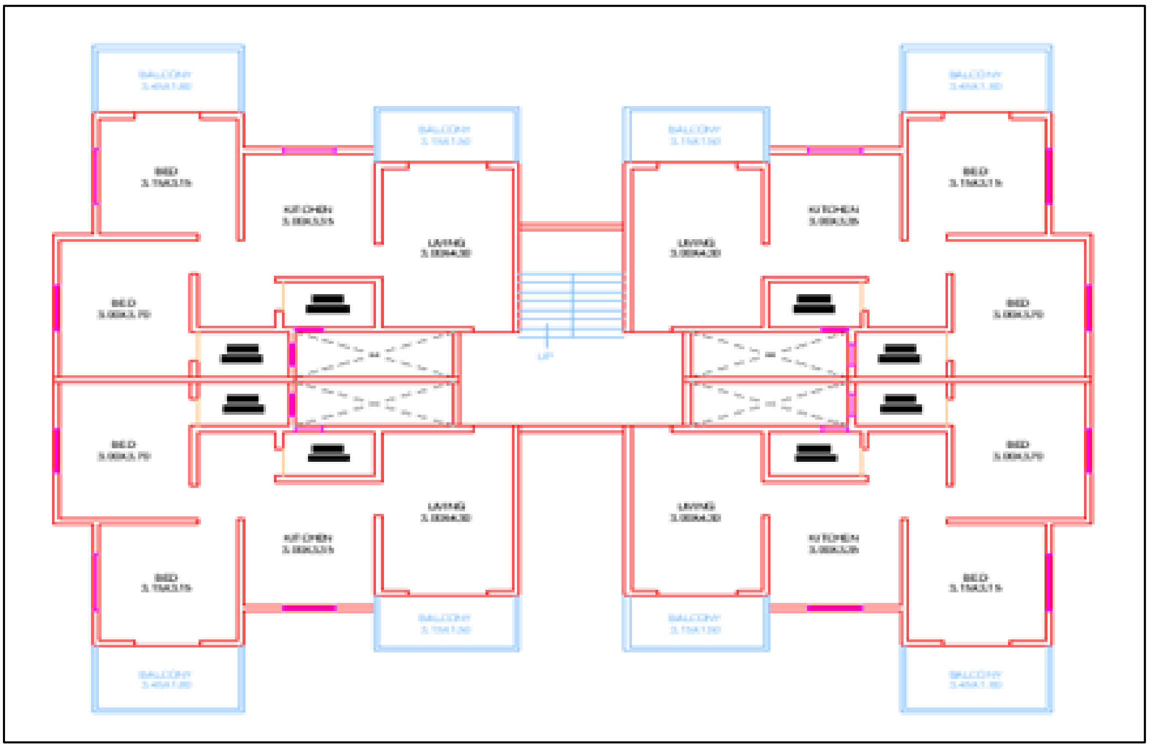


Figure 3 Plan of the building

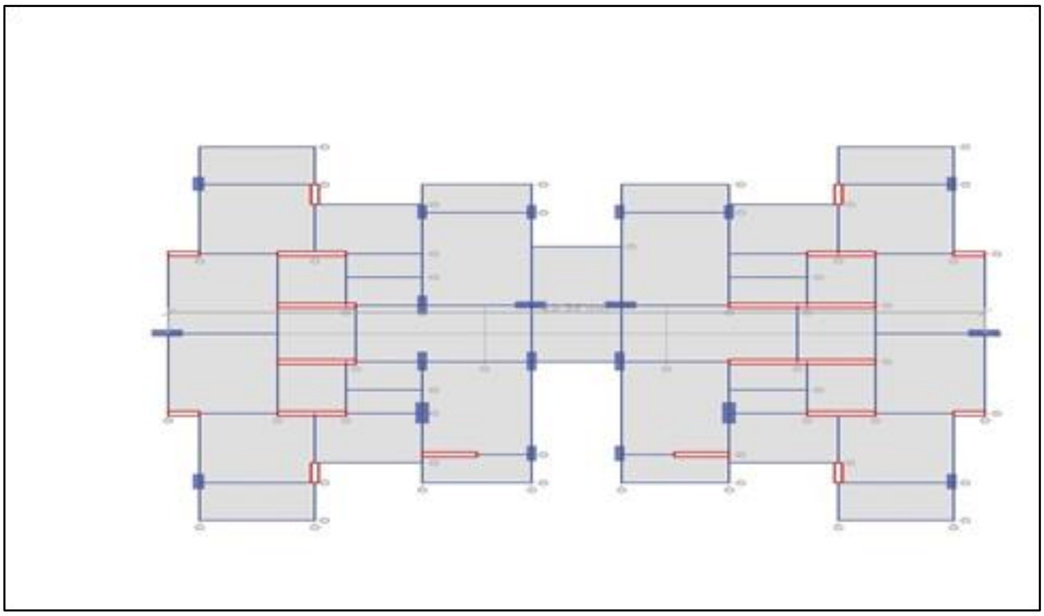


Figure 4 Plan view of building in ETABS software

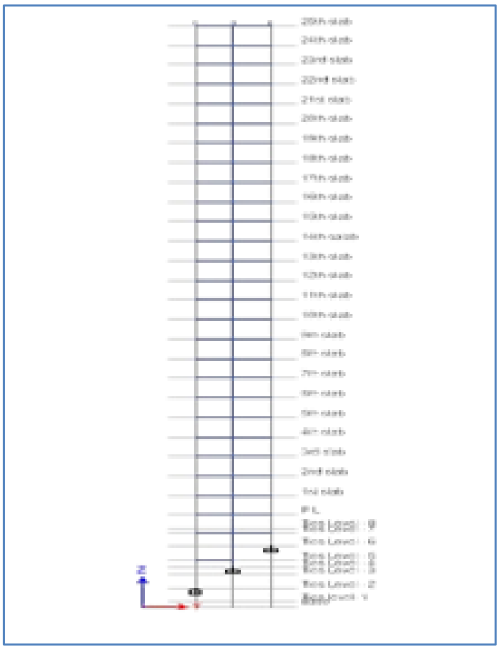


Figure 5 Elevation of building model resting on sloping ground

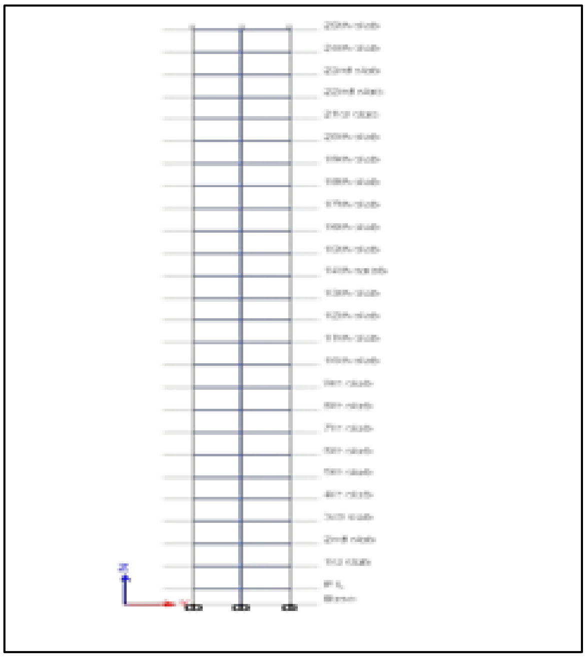


Figure 6 Elevation of building model resting on flat ground

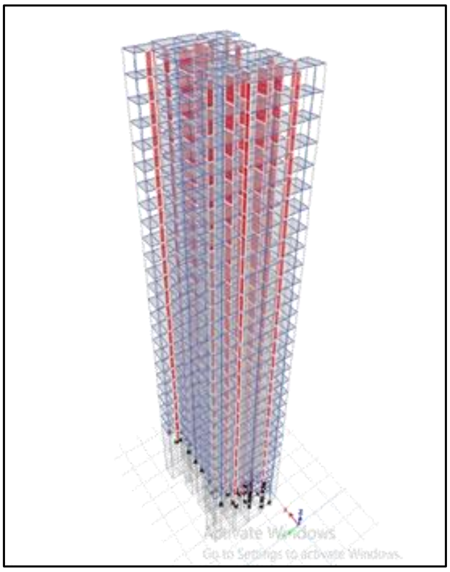


Figure 7 3-D view of building resting on the sloping ground

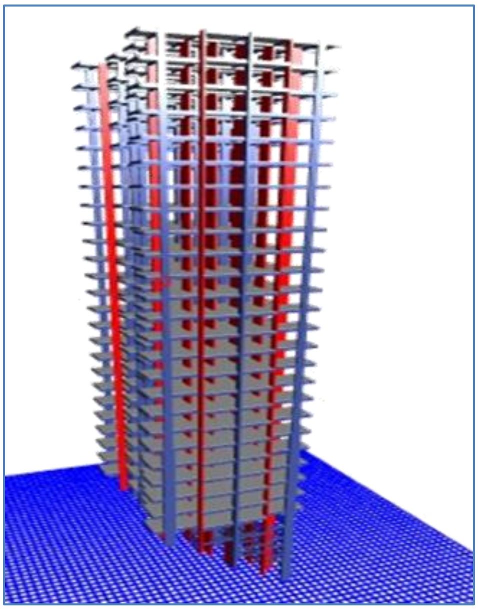


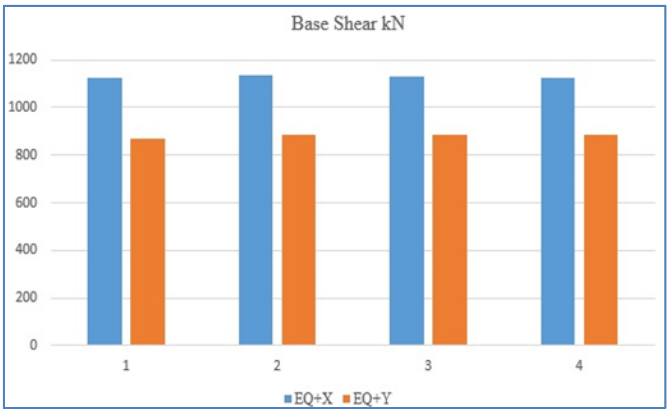
Figure 8 3-D rendering model resting on sloping ground

4. Results and discussion

Results are obtained in terms of base shear, earthquake displacement, wind displacement, and storey drift. For G+25 storey building which is located on flat and sloping ground of slopes 20, 30, and 40 degree in seismic zone III with soil type II i.e. medium soil with varying wind speeds 39, 47 and 55 m/s following results are formed

4.1. Base shear results-

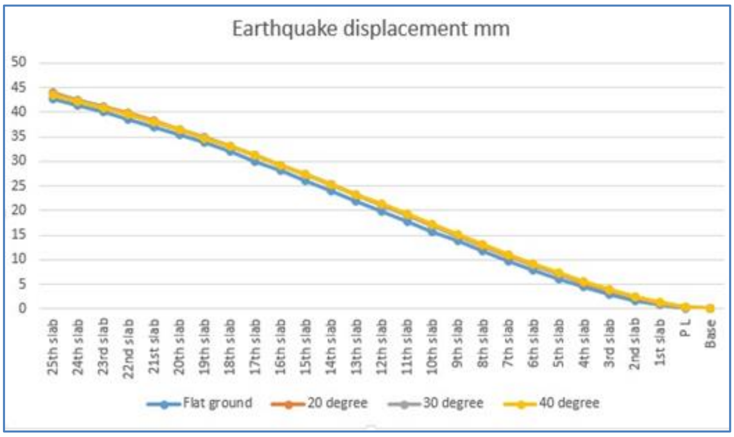
Following graph shows results for base shear for building resting on flat and sloping grounds of slope 20 degree, 30 degree and 40 degree respectively-



Graph 1 For base shear results on flat, 20, 30 and 40 degree sloping ground

4.2. Earthquake displacement results

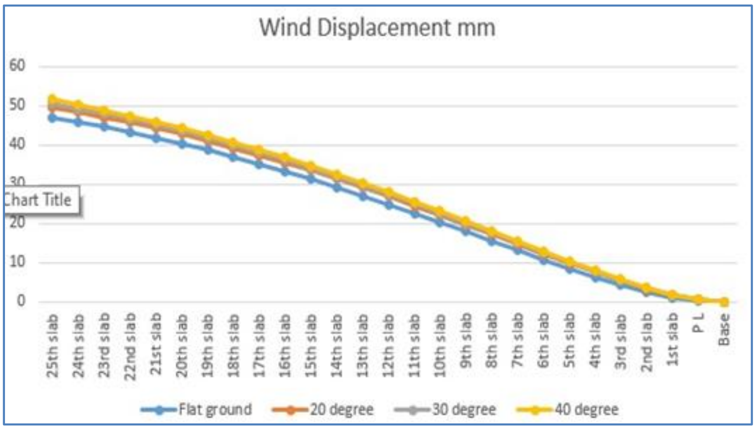
Earthquake displacement results are obtained for a building resting on flat and sloping ground. Following graph shows results for earthquake displacement.



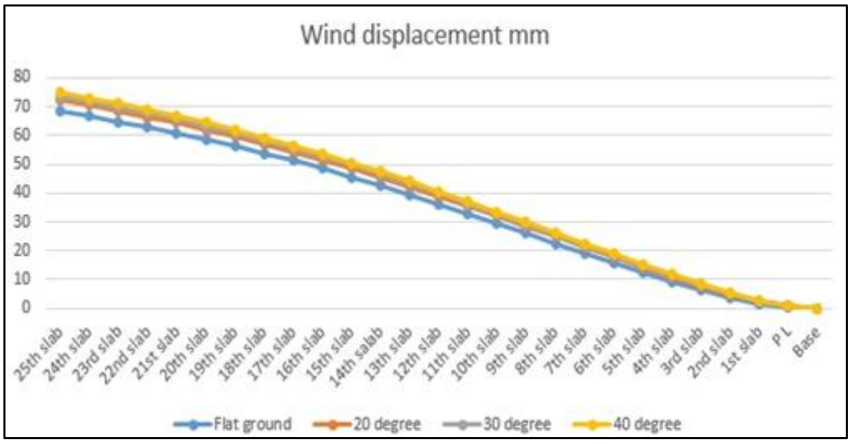
Graph 2 For earthquake displacement results on flat, 20, 30 and 40 degree sloping ground

4.3. Wind displacement

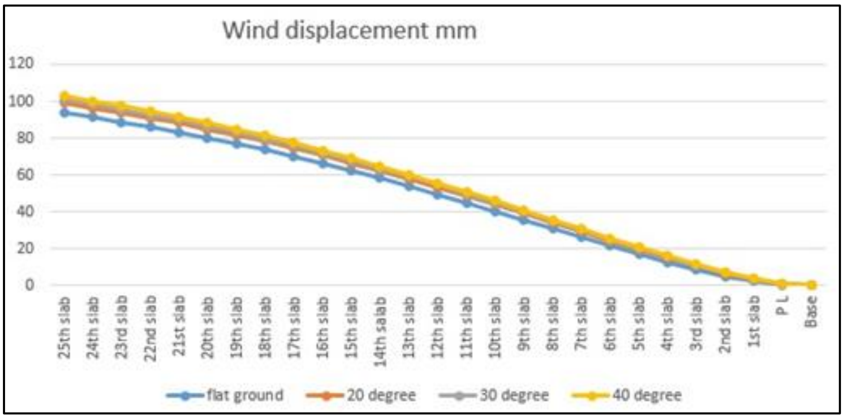
Wind displacement results are obtained by varying wind speeds of 39, 47 and 55 m/s for all conditions of sloping and flat ground. Graphs for wind displacement are as follows-



Graph 3 For wind displacement results on flat, 20, 30 and 40 degree sloping ground with wind speed 39 m/s



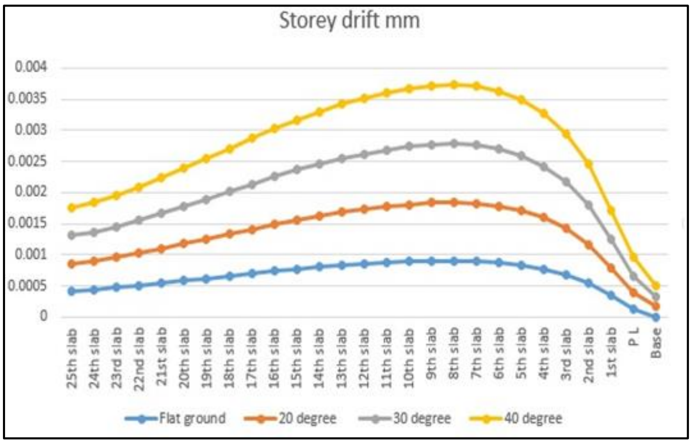
Graph 4 For wind displacement results on flat, 20, 30 and 40 degree sloping ground with wind speed 47 m/s



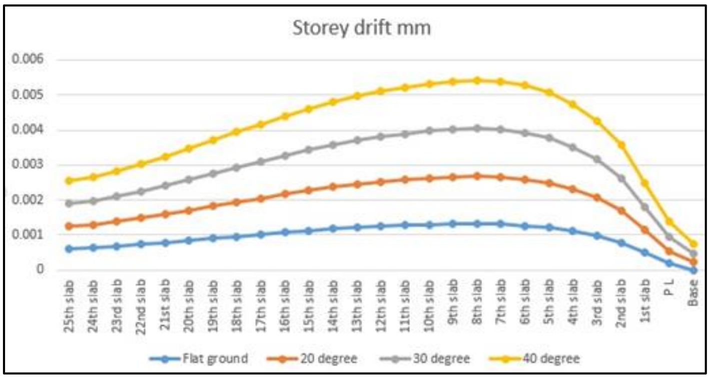
Graph 5 For wind displacement results on flat, 20, 30 and 40 degree sloping ground with wind speed 55 m/s

4.4. Storey drift

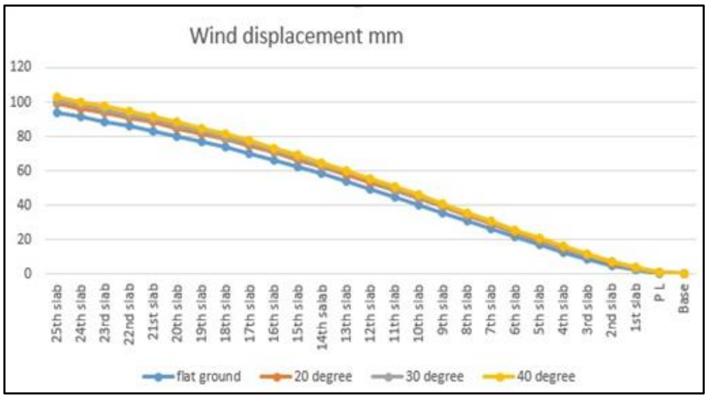
Storey drift results are obtained for all conditions of sloping ground and flat ground by varying all three wind speeds. Graphs for storey drift results are as follows-



Graph 6 For storey drift results on flat, 20, 30 and 40 degree sloping ground with wind speed 39 m/s



Graph 7 For storey drift results on flat, 20, 30 and 40 degree sloping ground with wind speed 47 m/s



Graph 8 For storey drift results on flat, 20, 30 and 40 degree sloping ground with wind speed 55 m/s

5. Conclusion

Following conclusions are drawn from these results-

- Analysis of RCC structure with different slope angles i.e. resting on flat ground, 20 degree, 30 degree and 40 degree sloping ground with different basic wind speed i.e., 39m/sec, 47m/sec and 55m/sec with medium soil condition in zone III has been done and significant variations are observed in different slope angles with different basic wind speeds.
- Base shear results for all the sloping angles and flat ground are obtained. They are almost equal in all sloping angles.
- Earthquake displacement results are obtained in different sloping ground building i.e. flat ground, 20 degree, 30 degree and 40 degree sloping ground which is almost equal in all sloping angle building.
- Wind displacement results for 39m/sec basic wind speed with different slopes are obtained i.e. flat ground, 20 degree, 30 degree and 40 degree sloping ground. Wind displacement increases with respect to slope angle, hence when ground slope increases wind displacement also increases. Here for 20 degree slope displacement increases by 5.6%, for 30 degree slope it increases by 7.5% and for 40 degree slope it increases by 9.7% when compared with building resting on the flat ground.
- Wind displacement results are obtained for 47m/sec basic wind speed with different slopes i.e. for flat ground, 20 degree, 30 degree and 40 degree sloping ground. Wind displacement increases with respect to slope angle, hence when ground slope increases then there is increase in the displacement; for 20 degree slope it increases by 5.6%, for 30 degree slope it increases by 7.55% and for 40 degree slope it increases by 9.72% with respect to building resting on the flat ground. We can conclude that when slope angle changes with every 10 degree then results variations are constant for different basic wind speeds.
- The storey drift results for building with different basic wind speed structure varies from building resting on flat ground and resting on sloping grounds of 20 degree, 30 degree and 40 degree. When compared with flat

ground building storey drift increases by 3.55%, 5.45% and 7.5825% for sloping angles of 20 degree,30 degree and 40 degree respectively.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that there is no conflict of interest in publishing the paper

References

[1] Diksha Gawai, Sarita Harne (2022), "Effect of wind on building frame resting on sloping ground and analysis done using ETABS", Journal of Emerging Technologies and Innovative Research (JETIR) May 2022, Volume 09, Issue 05.

[2] Jiss Treesa Gijo, Gokul P.V. (2022), "Effect of wind on RC structure resting on sloping ground and analysis done using ETABS", International Journal of Engineering Research and Technology (IJERT) , Volume 10, Issue 06.

[3] Dikshanki Anil Sukhdeve, Prof Girish Sawai, Prof. Sanjay Dange (2021),"Wind effect on multi-storied building resting on sloping ground and analysis done in various zones using ETABS software", International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET), Volume 10, Issue 07.

[4] Umakant Arya, Aslam Hussain, Waseem Khan (2014), "Wind analysis of building frames on sloping ground", International Journal of Scientific and Research Publications, Volume 04, Issue 05.

[5] Anupam Rajmani, Prof. Priyabarta Guha (2015), "Analysis of wind and earthquake load for different shapes of high rise building", International Journal of Civil Engineering and Technology (IJCIET), Volume 06 , Issue 2.

[6] Okafor C. Vincent, Kevin C. Okolie, Mbanusi C. Echefuna, Okafor C.Pamela (2017), "Analysis of wind effect on high rise building for different terrain category", European Journal of Engineering Research and Science (EJERS), Volume 02, No. 12.

[7] Ravindra Navale, Dr. Sandeep Hake, Pramod Kharmale (2017), "Analysis of unsymmetrical building resting on sloping ground by dividing in 2D frame", International Journal of Engineering and Technology (IRJET), Volume 04 , Issue 07.

[8] P. Chaitanya Kishore, R. Sumathi (2018), "Design and analysis of multi Storey building on sloping ground and flat ground by using ETABS", International Journal in Advent Technology (IRJAT), special issue ICADMMES 2018.

[9] D. Haritha, P. Anuf Kumar, K. Nagraju, P. Sai Gopi, S. Nagaragu, M. Rajesh (2021), "Analysis of multi-storey building using ETABS software", Journal of Engineering and Sciences (JES), Volume 12, Issue 7.

[10] Numan Sahu, Swati Agrawal, Akshit Lamba (2021), "Study and dynamic analysis of sloped building" International Journal of Innovations In Engineering Research and Technology (IJIERT), Volume 8, Issue 5.

[11] IS 13920," Ductile detailing of reinforced concrete structure subjected to seismic forces code of practice", 1993.

[12] IS 875(part 1-5)-code of practice for structural safety of Building loading standards.

[13] IS 875, "Code of practice for design loads (other than earthquake) for building and structures - Part 2: Imposed loads", Bureau of Indian Standards, New Delhi, 1987.

[14] IS 456, "Indian Standard Code of Practice for Plain and Reinforced Concrete", Bureau of Indian Standards, New Delhi, 2000.

[15] IS 1893 (Part I), "Criteria for Earthquake Resistant Design of Structures", Bureau of Indian Standards, New Delhi, 2002.

[16] IS 1893 (Part I), "Criteria for Earthquake Resistant Design of Structures", Bureau of Indian Standards, New Delhi, 2016.