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Comparative study of wind analysis of 3-D framed structure on sloping ground

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Abstract - *The objective of this project is to analyse and design the framed structure which is placed at different footing levels on an inclined surface (slope).The RC framed structure is subjected to self-weight, live load and wind load. The structure is analysed using ETAB 2016 .Here 12models of framed structure are drawn and analysed. Of these 3 models are of 8 stories with 0°,5°,10° slope with ground and 3 models are of 12 stories with 0°,5°,10° slope with ground and of wind speed 33 m/s.Similiarly 6 more models with another wind speed of 39 m/s are drawn. A 3-d RCC frame with the dimensions of 5 bays @ 3m in x-axis and 4 bays @ 3m in y-axis is taken. The 3D frame is analysed and the results are compared for maximum story displacement, storey stiffness and storey drifts. The research gap in my project is that I studied change in maximum storey drift, maximum storey displacement, maximum storey drift with change in slope, change storey height, and change in velocities. And also the analysis is done for 2-D structures in the journals I have extended it to 3-D framed structures.*

***Key Words*: framed structures, self-weight, live load, wind load.**

1. INTRODUCTION

The project involves analysis and design of multi-storied building using a very popular designing software ETABS. We have chosen ETAB because of its advantages such as easy to use interface, conformation with the Indian Standard Codes, versatile nature of solving any type of problem, accuracy of the solution.

ETAB is the professional's choice for steel, concrete, timber, aluminium and cold-formed steel design of low and high-rise buildings, culverts, petrochemical plants, tunnels, bridges, piles and much more.

Multi-storied building frames on sloping ground will be coming up in large number in future times. In this regard realistic analysis and design of these building frames on sloping ground are of paramount importance. In the modern time, such multi storied building frames are designed using ETAB software. This motivation has led to this study on effect of different sloping angle in multi storied building frames .The building with 8 and 12 stories are considered for analysis with 0°,5° and 10° sloping with ground.

1.1 Objective

- To study the effect of wind velocity on building with zero degree inclined footing level.
- To study the effect of wind velocity on building with 5°, 10° inclined footing level.
- Comparative study of effect of wind on building rests on plane and slopping ground.
- Approach for professional practice in the field of structural engineering

1.2 Loads Considered

Dead loads are considered for the design of structure as per the Indian standard recommended guidelines for dead loads contained in the Hand book of

IS 875:1987(part 1) published by the Indian standards Institution. All permanent constructions of the structure form the dead loads.

Live loads are considered for the design of structure as per the Indian standard recommended guidelines for dead loads contained in the Hand book of IS 875:1987(part 2) published by the Indian standards Institution

Knowledge of the dynamic characteristics of a structure under wind loading becomes a requirement in engineering design and in academic study. To address this need, comparison of wind loads and their effects on sloping ground buildings is conducted as per the Indian standard recommended guidelines for dead loads contained in the Hand book of IS 875:1987(part 3) published by the Indian standards Institution.

2. MODELLING

Three dimensional reinforced concrete frame is considered. 3 building consists of 8 stories and 3 building consists of 12 stories. The columns in all models are assumed to be fixed at the base. The height of each floor is considered as 3 m. Slab is with 0.125 m thickness. Live load is taken as 3kN/m^2. Floor finish on floor is 1kN/m^2. The unit weights of concrete and masonry is taken as 25kN/m^3 and 20kN/m^3 respectively. The grade of the concrete for column and beam is considered as M25.

Structural modelling

Beam size: 350mm X 350mm

Column size: 350 mm X 350mm

Slab size: 125mm thick

Cover to beam: 25mm

Cover to column: 40mm

3. RESULTS AND DISCUSSION

As mentioned in the objective of the study, the behavior of multi-storey building frames under the different winds velocity and different ground slope are studied. Considered static load and wind load on different height of building frame have been analyzed. The results obtained from the analysis are represented by tables and graphs and also plane ground and sloping ground in degree are also compared in Tables and Graphs as follows.

3.1 Maximum Storey displacement

Table 1 variation of max storey displacement with slope for 8 storeys

Model	Maximum storey displacement	
	Along X	Along Y
0°	5.996591	8.412819
5°	5.497357	8.060742
10	5.00519	7.475338

From the plot it can be identified that the maximum storey displacement occurs along y direction as compared to x axis. The storey displacement value also decreases with increase in slope.

Similarly the following table shows the variation of maximum storey displacement with changing slope for 12 storey building with wind velocity of 33 m/s.

Table 2 variation of max storey displacement with slope for 12 storeys

model	Maximum storey displacement	
	X direction	Y direction
0°	6.236967	8.888552
5°	5.723711	8.510425
10°	5.216424	7.897482

From the above it can be drawn that there is not much change in value of maximum storey displacement when we changed the building height or number of stories. Also from the plot it can be identified that the maximum storey displacement occurs along y axis as compared to x axis. The storey displacement value also decreases with increase in slope.

Similarly the following table shows the variation of maximum storey displacement with changing slope for 8 storey building with wind velocity of 39 m/s.

Table 3variation of max storey displacement with slope for 8 storey

model	Maximum storey displacement	
	Along x	Along y
0˚	8.3755404	11.750136
5˚	7.678127	11.2583
10˚	6.99072	10.440762

From the plot it can be identified that the maximum storey displacement occurs along y direction as compared to x axis. The storey displacement value also decreases with increase in slope.

Similarly the following table shows the variation of maximum storey displacement with changing slope for 12 storey building with wind velocity of 39 m/s.

Table 4. Variation of maximum storey displacement with slope for 12 storeys.

model	Maximum storey displacement	
	Along x direction	Along y direction
0˚	8.71136	12.414
5˚	7.994274	11.886461
10˚	7.285763	11.030368

From the above it can be drawn that there is not much change in value of maximum storey displacement when we changed the building height or number of stories. Also from the plot it can be identified that the maximum storey displacement occurs along y axis as compared to x axis. The storey displacement value also decreases with increase in slope

3.2 Maximum Storey Drift

The following table shows the variation of maximum storey drift with changing slope for 8 storey building with wind velocity of 33 m/s.

Table 5 variation of max storey drift with slope for 8 storey

model	Maximum storey drift	
	Along x	Along y
0˚	0.000339	0.000552
5˚	0.0003579	0.000541
10˚	0.000498	0.000718

It is observed that by changing slope maximum storey drift has only a small change .It does not show a gradual increase or decrease. Also maximum drift take place along y direction.

Similarly, the following table shows the variation of maximum storey drift with changing slope for 12 storey building with wind velocity of 33 m/s.

Table 6 variation of max storey drift with slope for 12 storey.

Model	`Maximum Storey drift.	
	Along x	Along y
0°	0.00039	0.000552
5°	0.000383	0.000541
10°	0.000357	0.000514

From the above it can be concluded that changing height of the building also have only little change in maximum storey drift values. Next we can look whether increasing wind velocity make any change in maximum storey drift values.

The following table shows the variation of maximum storey drift with changing slope for 8 storey building with wind velocity of 39 m/s.

Table 7 variation of max storey drift with slope for 8 storey

model	Maximum storey drift	
	Along x	Along y
0°	0.000558	0.000772
5°	0.000536	0.000755
10°	0.000498	0.000718

From the above it can be drawn that on increasing the wind velocity to 39 m/s the maximum storey drift values also increases than that of 33m/s. Also maximum drift take place along y direction.

Similarly, the following table shows the variation of maximum storey drift with changing slope for 12 storey building with wind velocity of 33 m/s.

Table 8 Variation of max storey drift with slope for 12 storey

Model	Maximum storey drift	
	Along x	Along y
0°	0.000557	0.000771
5°	0.000535	0.000755
10°	0.000498	0.000718

From the above it can be concluded that changing height of the building also have only little change in maximum storey drift values.

3.3 Maximum storey stiffness

The following table shows the variation of maximum storey stiffness with changing slope for 8 storey building with wind velocity of 33 m/s.

Table 9variation of max storey stiffness with slope for 8 storey

Model	Maximum storey stiffness	
	Along x	Along y
0°	180536	176780
5°	133777	128794
10°	143819	137233

From the above it can be observed that the storey stiffness first increases when changing slope to 5° from 0°.but when slope is increased to 10° the storey stiffness decreases. Maximum stress in a building generally increases with increase in stiffness. While low stiffness has the advantages decreasing stiffness usually comes with penalties of increasing shear strain and decreasing yield strength

Similarly, the following table shows the variation of maximum storey stiffness with changing slope for 12 storey building with wind velocity of 33 m/s.

Table 10 variation of max storey stiffness with slope for 12 storey

Model	Max storey stiffness	
	Along x	Along y
0°	180536	176780
5°	133777	128839
10°	143889	137278

From the above table, it is observed that on increasing number of storeys the storey stiffness also increases. Next we can look whether change in wind speed affect storey stiffness.

The following table shows the variation of maximum storey stiffness with changing slope for 8 storey building with wind velocity of 39 m/s.

Table 11 variation of max storey stiffness with slope for 8 storey

Model	Maximum storey stiffness	
	Along x	Along y
0°	180536	176780
5°	133777	128794
10°	143819	137233

From the above, it can be concluded that storey stiffness is not affected by increase or decrease in wind speed.

The following table shows the variation of maximum storey stiffness with changing slope for 12 storey building with wind velocity of 39 m/s.

Table 12 Variation of max storey stiffness with slope for 12 storey.

Model	Max storey stiffness	
	Along x	Along y
0°	180579	176807
5°	133848	128839
10°	143889	137278

From the above table, it is observed that on increasing number of storeys the storey stiffness also increases.

4. CONCLUSION

- The maximum storey displacement occurs along y direction as compared to x axis. The storey displacement value also decreases with increase in slope.
- There is not much change in value of maximum storey displacement when we changed the building height or number of stories
- When we increase the wind velocity to 39 m/s it is observed that the max storey displacement value increase with that of wind speed 33 m/s.
- It is observed that by changing slope maximum storey drift has only a small change .It does not show a gradual increase or decrease. Also maximum drift take place along y direction.
- On increasing the wind velocity to 39 m/s the the maximum storey drift values also increases than that of 33m/s.
- On increasing number of storeys the storey stiffness also increases
- Maximum stress in a building generally increases with increase in stiffness. While low stiffness has the advantages decreasing stiffness usually come with penalties of increasing shear strain and decreasing yield strength.

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