EFFECT OF WIND ON BUILDING FRAME RESTING ON SLOPING GROUND AND ANALYSIS USING ETABS

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Abstract - 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. In this research paper, the effect of wind speed on building frame has been studied. For the study the building resting on sloping ground have been considered because of scarcity of land. The 3D building frames of 8 storey, 10 storey and 12 storey resting on flat terrain as well as three slopes 5°, 10° and 15° are modeled and analysed. for wind zones 33 m/s, 39 m/s, 44 m/s, 47 m/s and 55 m/s respectively. The modeling and the analysis is appropriately done using software ETABS.. The parameters considered for the post analysis are maximum storey displacement and maximum storey drift. Both the parameters have been compared for wind speeds and ground slopes and results obtained the after analysis have been tabulated and represent graphically.

Keyword: sloping ground, displacement, drift, wind zones, ETABS

1 INTRODUCTION

In past few decades urbanization is increased because of modernization, industrialization and social rationalization. More than half of the world population lives in urban areas. In modern days urbanization is considered as a sign of economic progress but at the same time urban areas becoming more populated and dense. On the other hand land scarce and ever growing demand of accommodation also increasing. Therefore Owing to scarce land resources, urbanization and ever-growing demand of accommodation is leading developers into sloping grounds. To overcome this problem the only solution is that to prefer multi-storeyed structural buildings in the current scenario of this world. In this regard realistic analysis and design of these building frames on sloping ground are of paramount importance.

Wind is the major factor which affects the building resting on sloping ground. Wind load is one of the important design load in civil engineering. Static wind load creates elastic bending and twisting of building and load affects the structural design of the structure. Therefore knowledge of the

characteristics of structure under wind loading becomes a requirement in engineering design. Structural engineers want strong structural components to withstand excess loads during the building's life cycle and serviceability of the building, despite expected wind deflections

This project based on the study of wind and behavior of multi-storey building. Normally the building constructed on hill slopes is unsymmetrical in nature. The detail study of wind load acting on building frames, the structural response to wind and effect of slope is carried out in this project. In this project, three different height of building frames resting on four different slopes of ground for five different wind speeds are analysed. The study is carried out on software ETABS for effect of wind on building frame resisting on sloping ground. The influence of slope and wind on the building frame will be investigated and analyzed using ETABS software.

1.1 Objective

1 To study the effect of wind velocity on building with zero degree slope and different inclined slope.
2 To study the effect of wind velocity on different height of building
3 Comparative study of effect of wind on building rests on plane and slopping ground.
4 To study the approach in field of structural engineering.

2 PROPOSED METHODOLOGY

This section of research paper explains the detail of methodology used while this study. There are few stages in which whole study from modelling to analysis and result is carried out which are as following.

Step 1: selecting the building frame
In this study, the 8 storey, 10 storey, 12 storey building frame is considered for modeling purpose. Each storey has a height of 3m. There are five numbers of bays in x direction as well as 5 numbers of bays in y direction also.

Step 2: selecting slope.
The flat terrain and three different ground slope is taken into account of analysis. The 0°, 5°, 10° and 15° are the slopes on which building are resting. From this way up to this step 12 model have been made.

Step 3: selecting wind zones.
As per IS 875:1987 part 3 the wind velocities of 33m\s, 39 m\s, 44m\s, 47m\s and 55m\s are considered. Up to this step the total model becomes 60.

Step 5: selecting properties and assigning load.
Various material properties and section properties are defined. Wind load and dead load calculated and assigned to the model. Wind load in both x and y direction is assigned as per Indian Standard Code.

Step 5: Analysis of all cases
Models are analysed and results are compared, tabulated and graphically represented.

3 MODELLING

The various material and section properties which have to define during modelling in ETABS are tabulated as following:

3.1 Section Properties

There are three different storey or three different height buildings have to modelled. The length and width taken while modelling is 15m. Each storey height is 3m. The size of beam and column is 350 mm x 350 mm. The thickness of slab which we taken is 150mm. The thickness of interior and exterior walls of building is taken as 150mm and 230mm respectively. All the support are fixed

3.2 Material Properties

For the structure component like column, beam and slab M30 grade of concrete and Fe415 steel grade are considered. Mild steel is used for confinement bars. The cover considered is 25mm. The dead load is calculated using 25kN/m³ unit weight of concrete

and 20 kN/m³ density of brick masonry. Mild steel is used for confinement bars.

4 LOADING

4.1 Dead Load

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.

- Exterior wall load = (unit weight of brick masonry X wall thickness X wall height)

=20*0.230*

= 13.8kN/m

- Interior wall load = (unit weight of brick masonry X wall thickness X wall height)

=20*0150*3

=9kN/m

- Floor load = (density of concrete X slab thickness)+ floor finish

= (25*0.150) +1

= 4.75kN/m²

4.2 Live Load

Live loads of 3kN is 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.

4.3 Wind Load

Calculation and assigning of wind load is done as per is-code 875 (part-III):1987

$$V_z = V_b \, k_1 \, k_2 \, k_3$$

- V_b = design wind speed at any height z in m/s = (39 m/s, 44 m/s, 49 m/s)

- kl= risk coefficient (see 5.3.2.2)= 0.83 (for 24m)

=0.93 (for 30m)

=1 (for 36m)

- k2 = terrain, height and structure size factor (see 5.3.2) = 1

- k3 = topography factor (see 5.3.3) = 1

- Terrain category = 4

- Structure class = B

Wind load is assigned as per clause 6.2.2.1 , table number 4 of IS875:1987 (Part 3). This table gives the value for external pressure due to wind for wind angle of 90° and 0°. Here we have to calculate the ratio of height to width as well as the ratio of length to width. According to that the external pressure coefficient values have to apply to the buildings.

5 RESULTS AND DISCUSSION

Maximum storey displacement and maximum storey drift of 8 storey, 10 storey and 12 storey building frames on four different slopes are evaluated and compared. Here the results are tabulated and represented graphically keeping the eye on wind loads WLx, WLy and load combination 1.2(DL+LL+WL) as per Indian Standard Code of 875: 1987 Part III on software ETABS

5.1 Maximum Storey Displacement

Table 1.1: Maximum Storey Displacement in 8 Storey Building Frame due to Wind Load WLx

Slope of ground	Wind Speed				
	33 m/s	39 m/s	44 m/s	47m/s	55 m/s
0°	1.96864	2.749588	3.281017	3.74368	5.46845
5°	1.87824	2.62332	3.339084	3.80994	5.21732
10°	1.65321	2.309029	2.93904	3.35348	4.59225
15°	1.51385	2.114381	2.691283	3.07079	4.20513

Table 1.2: Maximum storey displacement in 8 storey building frame due to wind load WLy

Slope of ground	Wind Speed				
	33 m/s	39 m/s	44 m/s	47m/s	55 m/s
0°	1.98563	2.773312	3.530001	4.027775	5.515627
5°	1.94281	2.713511	3.453884	3.940924	5.396693
10°	1.654256	2.31049	2.937799	3.352065	4.595157
15°	1.632664	2.28033	2.691283	3.311805	4.535178

Table 1.3: Maximum storey displacement in 8 storey building frame due to Load Combination 1.2(DL+LL+WL)

Slope of ground	Wind Speed				
	33 m/s	39 m/s	44 m/s	47m/s	55 m/s
0°	2.95296	4.12438	4.92153	5.61552	8.20267
5°	2.28589	3.40352	4.47717	5.18345	7.29452
10°	1.39839	2.34576	3.26149	3.87483	5.73299
15°	0.89647	1.71452	2.55163	3.10207	4.75561

Table 1.4: Maximum storey displacement in 10 storey building frame due to wind load WLx

Slope of ground	Wind Speed				
	33 m/s	39 m/s	44 m/s	47m/s	55 m/s
0°	4.29938	6.00491	7.64334	8.72114	11.94271
5°	4.16298	5.81441	7.40086	8.44469	11.56384
10°	3.74238	5.22697	6.65313	7.5913	10.39551
15°	3.4987	4.88661	6.2199	7.09685	9.718597

Table 1.5 : Maximum storey displacement in 10 storey building frame due to wind load WLy

Slope of ground	Wind Speed				
	33 m/s	39 m/s	44 m/s	47m/s	55 m/s
0°	3.520365	4.916874	6.258428	7.140943	9.778793
5°	3.501377	4.890353	6.22467	7.102426	9.726047
10°	3.148745	4.397834	5.597769	6.387124	8.746514
15°	3.039044	4.244615	5.402744	6.164598	8.441788

Table 1.6: Maximum storey displacement in 10 storey building frame due to load combination 1.2(DL+LL+WL)

Slope of ground	Wind Speed				
	33 m/s	39 m/s	44 m/s	47m/s	55 m/s
0°	6.456942	9.01477	11.471943	13.0885	17.920337
5°	5.369653	6.225643	10.226289	11.79165	16.470535
10°	4.009813	4.937834	8.364884	9.772144	13.97846
15°	2.89165	4.913104	6.860103	8.175399	12.107656

Table 1.7: Maximum storey displacement in 12 storey building frame due to wind load WLx

Slope of ground	Wind Speed				
	33 m/s	39 m/s	44 m/s	47m/s	55 m/s
0°	7.9312	11.07747	14.09992	16.08818	22.03112
5°	7.72917	10.79529	13.74074	15.67836	21.46991
10°	7.07353	9.879555	12.57516	14.34841	19.64869
15°	6.69032	9.344327	11.8939	13.57108	18.58422

Table 1.8: Maximum storey displacement in 12 storey building frame due to wind load WLy

Slope of ground	Wind Speed				
	33 m/s	39 m/s	44 m/s	47m/s	55 m/s
0°	6.48952	9.06388	11.53693	13.16378	18.06451
5°	6.46611	9.03117	11.4953	13.11628	17.96141
10°	5.91554	8.2622	10.51652	11.99948	16.43206
15°	5.69778	7.95806	10.12939	11.55776	15.82717

Table 1.9: Maximum storey displacement in 12 storey building frame due to load combination 1.2(DL+ LL+ WL)

Slope of ground	Wind Speed				
	33 m/s	39 m/s	44 m/s	47m/s	55 m/s
0°	11.89542	16.6147	21.14826	24.13058	33.04477
5°	10.33788	14.93696	19.35506	22.56142	30.94858
10°	8.278043	12.487	16.53032	19.19014	27.14039
15°	6.456971	10.36206	14.18642	16.7022	24.2219

5.2 Maximum Storey Drift

Table 1.10: Maximum storey drift in 8 storey building frame due to wind load WLx

Slope of ground	Wind Speed				
	33 m/s	39 m/s	44 m/s	47m/s	55 m/s
0°	0.000117	0.000164	0.000198	0.000226	0.000326
5°	0.000116	0.000162	0.000206	0.000225	0.000322
10°	0.000106	0.000148	0.000188	0.000214	0.000293
15°	0.000102	0.000143	0.000182	0.000207	0.000284

Table 1.11: Maximum storey drift in 8 storey building frame due to wind load WLy

Slope of ground	Wind Speed				
	33 m/s	39 m/s	44 m/s	47m/s	55 m/s
0°	0.000118	0.000165	0.000210	0.000240	0.000329
5°	0.000117	0.000167	0.000210	0.000239	0.000328
10°	0.000107	0.000149	0.000189	0.000216	0.000296
15°	0.000104	0.000146	0.000186	0.000212	0.000290

Table 1.12: Maximum storey drift in 8 storey building frame due to load combination 1.2(DL+LL+WL)

Slope of ground	Wind Speed				
	33 m/s	39 m/s	44 m/s	47m/s	55 m/s
0°	0.000176	0.000246	0.000297	0.000339	0.000489
5°	0.000154	0.000223	0.000290	0.000333	0.000463
10°	0.000116	0.000177	0.000236	0.000275	0.000394
15°	0.000089	0.000150	0.000209	0.000247	0.000362

Table 1.13: Maximum storey drift in 10 storey building frame due to wind load WLx

Slope of ground	Wind Speed				
	33 m/s	39 m/s	44 m/s	47m/s	55 m/s
0°	0.000202	0.000231	0.000296	0.000335	0.000561
5°	0.000202	0.000232	0.000295	0.000336	0.000560
10°	0.000187	0.000215	0.000274	0.000312	0.000521
15°	0.000185	0.000212	0.000270	0.000309	0.000513

Table 1.14: Maximum storey drift in 10 storey building frame due to wind load WLy

Slope of ground	Wind Speed				
	33 m/s	39 m/s	44 m/s	47m/s	55 m/s
0°	0.000165	0.000282	0.000359	0.000409	0.000459
5°	0.000166	0.000283	0.000358	0.000409	0.000461
10°	0.000154	0.000262	0.000333	0.000380	0.000427
15°	0.000152	0.000258	0.000328	0.000374	0.000423

Table 1.15: Maximum storey drift in 10 storey building frame due to load combination 1.2(DL+LL+WL)

Slope of ground	Wind Speed				
	33 m/s	39 m/s	44 m/s	47m/s	55 m/s
0°	0.000303	0.000423	0.000538	0.000614	0.000841
5°	0.000276	0.000396	0.000511	0.000587	0.000813
10°	0.000231	0.000342	0.000449	0.000520	0.000731
15°	0.000195	0.000304	0.000410	0.000479	0.000687

Table 1.16 : Maximum storey drift in 12 storey building frame due to wind load WLx

Slope of ground	Wind Speed				
	33 m/s	39 m/s	44 m/s	47m/s	55 m/s
0°	0.000305	0.000426	0.000543	0.000619	0.000848
5°	0.000304	0.000425	0.000541	0.000617	0.000845
10°	0.000290	0.000405	0.000516	0.000588	0.000806
15°	0.000285	0.000399	0.000508	0.000579	0.000793

Table 1.17: Maximum storey drift in 12 storey building frame due to wind load WLy

Slope of ground	Wind Speed				
	33 m/s	39 m/s	44 m/s	47m/s	55 m/s
0°	0.000250	0.000349	0.000445	0.000507	0.000695
5°	0.000250	0.000349	0.000444	0.000507	0.000694
10°	0.000238	0.000332	0.000423	0.000483	0.000661
15°	0.000233	0.000325	0.000414	0.000472	0.000646

Table 4.18: Maximum storey drift in 12 storey building frame due to load combination 1.2(DL+LL+WL)

Slope of ground	Wind Speed				
	33 m/s	39 m/s	44 m/s	47m/s	55 m/s
0°	0.000458	0.000640	0.000814	0.000929	0.001272
5°	0.000424	0.000605	0.000778	0.000893	0.001235
10°	0.000373	0.000546	0.000711	0.000820	0.001146
15°	0.000328	0.000498	0.000661	0.000768	0.001089

5 CONCLUSIONS

In the previous chapter all the results are tabulated and graphically represent. Tables shows the effect of wind velocity and slope on the maximum displacement and maximum drift value. It is proved and represented by graphs. All the tables and graphs are studied and find out conclusions. In this chapter we are discussing the conclusion after the analysis of all the 60 cases.

- The wind speed has more effect on the structure. It is observed that when we increased the wind velocity, the maximum storey displacement values increased with that of wind speed for wind load WLx, WLy. It is also increased with load combination 1.2(DL+LL+WL).

- It is observed that the maximum storey displacement value is less for 0° sloped ground as compare to other three slopes. It is decreased with increase in slope. There is not much difference in the value of 0° and 5°.

- Maximum displacement value increased more for considered load combination as compare to wind loads.

- Storey displacement is more for 10storey and 12 storey building frames. So it is concluded that maximum storey displacement increased with increase in height of building due to wind load WLx, WLy and load combination 1.2(DL+LL+WL) for 8 storey, 10 storey and 12 storey building frames.

- Like maximum storey displacement, maximum storey drift also have similar observations. It is observed that when we increased the wind velocity, maximum storey drift values increased with that of wind speed for wind load WLx, WLy and load combination 1.2(DL+LL+WL).

- It is observed for some cases that the values of maximum storey drift for 0° and 5° are same or differ very less. Therefore it can be said that by changing slope maximum storey drift has only a small change. It did not show a gradual increase or decrease.

- Maximum storey drift increases with increase in height of building due to wind load WLx, WLy and load combination 1.2(DL+LL+WL) for 8 storey, 10 storey and 12 storey building frames.

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