A Comparative Study on Effect of Wind Load For Low Rise And High Rise Building Using ETABS

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Abstract- *Wind is a perceptible natural movement of the air, especially in the form of current air blowing from a particular direction. This paper presents a comparative study on wind loads to decide the design loads of a multistorey building.Two models are analysed using E-TABS software with different wind speeds as per IS 875(Part-III):1987.A comparison in terms of maximum displacements and story shears has been carried out for both high rise and low rise buildings. After a detailed study, finally it is found that high rise buildings are more effected by wind forces when compared to low rise buildings.*

Keywords- Wind speeds, Design loads, High rise buildings, Low rise buildings, E-TABS software.

I. INTRODUCTION

Wind has two aspects- the first beneficial one is that its energy can be utilized to generate power, sail boats and cool down the temperature on a hot day and on the other hand, the parasitic one is that it loads any and every object that comes in its way. The importance of wind energy is emerging in India ever since the need of taller buildings due to scarcity of land. Recently there has been a considerable increase in number of taller buildings both residential and commercial. As the height of the structure increases, the forces acting on the structure also increases along with the height of the building and affects the rigidity and stability of the structure so it becomes necessary to design the structure preferably for lateral forces, story drift, moments. Therefore, it is very important for the structure to have sufficient strength against vertical loads along with adequate stiffness to resist the lateral loads.

II. LITERATURE REVIEW

John D. Holmes (et.al)(2009) The paper describes a comparison of wind load calculations on three buildings with different wind loading codes and standards from the Asia-Pacific Region. He performed an analysis on the low, medium, and high rise structures. The tall building has a significant amount of resonant dynamic response to wind which complicates the evaluation of base shear, bending moments and acceleration at the top of the building. The coefficients of variation for both along- wind and cross- wind responses were relatively small in the range of 14% to 18%.

Hemil M .Chauhan (et.al.,)(2011) The paper presented a study on the comparative study of wind forces on high rise buildings. For analysis he used E- TABS software with four terrain categories and six different wind speeds. He performed the analysis on 60m and 120m building. In static analysis, both buildings give almost same values of shear forces & bending moments. IS present code gives increased values of base shear compared to IS Draft code. IS Draft code gives more accurate and more direct than present code for estimating response parameters such as acceleration and forces.

Valsson Varghese (et.al.,)(2013) The paper presents the comparative study of special moment reinforced building over ordinary moment reinforced building with seismic and wind effect. The forces on OMRF structure are comparatively much higher than that of SMRF structure. It is more safe to design a ductile detailing structure than the non – ductile detailing structure. The quantity of steel is found to be more in case of SMRF than that of OMRF.

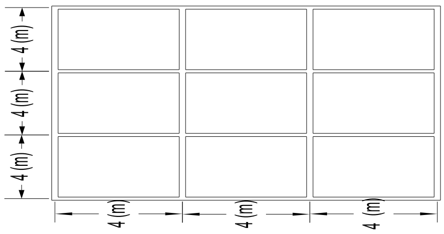
Athanase Ndikokubwayo (et.al.,)(2014) The paper presented a study on the extensive study lateral and base shear forces acting on 20 stories building in Bujumbura city during the seismic Activity using the E-TABS software for analysis. He observed that the seismic shear forces and lateral forces can reach 2000 kN and 230 kN respectively.

Juliya Mironova(et.al.,)(2020) The paper presented a study on the Wind impact on low-rise buildings when placing high-rises into the existing development. The purpose of the study is to model wind flows to determine maximum aerodynamic wind effects on multi-storey buildings and their surroundings. It also aims at improving the expression for defining maximum wind load depending on the building height and the distance to it. In this study numerical experiments on modelling the distribution of wind flows in a virtual wind tunnel for an existing low-rise building have been carried out. Based on their results, an increasing coefficient in the expression for determining the wind load depending on the height of a multi-storey building and the distance to it is proposed. The results obtained can be used in determining wind loads during the reconstruction of low-rise buildings and their verification calculations when placing multi-storey and high-rise buildings in existing buildings.

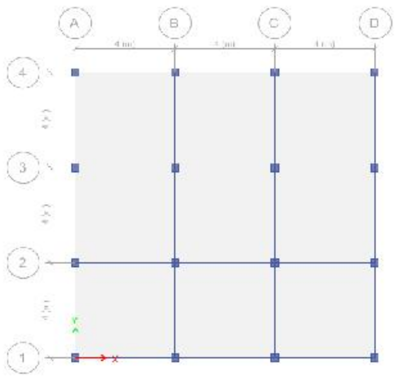
III. METHODOLOGY

A symmetric building plan is considered for the study. For a low-rise building (G+4) is considered and for high-rise multi-story structure (G+12) is considered. The analysis is carried out using the software E-tabs.

1. PLAN AND 3D MODELLING :



(a)



(b)

Figure.1.(a)&(b).Plan of low rise and high rise building

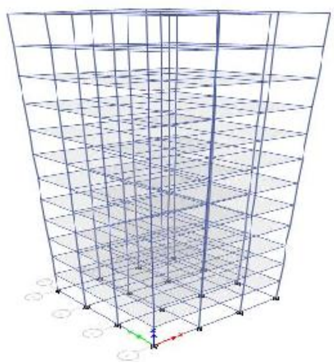


Figure. 2. 3D view of High Rise multistorey building

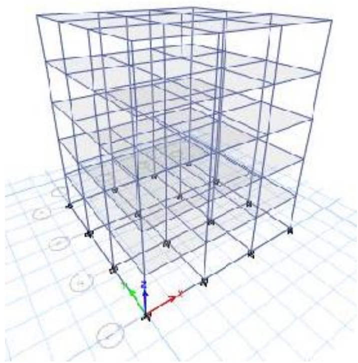


Figure.3. 3D view of Low Rise multistorey building

2. BUILDING DETAILS:

A symmetric building plan is considered for the study. For a low-rise building (G+4) is considered and for high-rise multi-story structure (G+12) is considered. The analysis is carried out using the software E-tabs.

Model 1 : Structural details

No. of Stories	G+12
Storey Height	3.0 m
Grade of Concrete	M30
Grade of Steel	Fe415
Thickness of Slab	0.150 m
Beam size	0.23 x 0.45 m
Column size	0.40 x 0.40 m
Exterior wall load	12 kN/m
Interior wall load	6 kN/m
Parapet wall load	4 kN/m
Live load on slab	2 kN/m2
Live load on roof slab	1 kN/m2

Model 2: Structural details

No. of Stories	G+4
Storey Height	3.0 m
Grade of Concrete	M30
Grade of Steel	Fe415
Thickness of Slab	0.150 m
Beam size	0.23 x 0.45 m
Column size	0.40 x 0.40 m
Exterior wall load	12 kN/m
Interior wall load	6 kN/m
Parapet wall load	4 kN/m
Live load on slab	2 kN/m2
Live load on roof slab	1 kN/m2

3.WIND ANALYSIS:

Wind response for a building is considered based on the wind forces generating from wind speeds. Wind loading on a tall building not only acts over a large 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.

The calculation of the wind pressure force on the building is applied according to IS 875:1987. The basic wind speed is applicable at 10 m height above mean ground level for different zones of the country.

The Design wind pressure (PZ) in N/mm2 at height Z can be determined by,

$$P_Z = 0.6\, V_Z^2$$

Design wind speed (VZ) in m/s at height Z,

$V_Z = V_b k_1 k_2 k_3$

Where,

V_b=Basic wind speed

k_1=Probability factor(Risk coefficient)

k_2=Terrain, height and structure size

k_3=Topography factor

Table 1: Values taken from IS 875:1987

Terrain Category		2
Risk Coefficient (k_1)		1
Terrain, height and structure size (k_2)	Low rise	1.05
	High rise	1.18
Topography Factor(k_3)		1.40
Windward pressure coefficient		0.8

IV. RESULTS AND DISCUSSION

The effect is studied based on the comparison of lateral displacements and storey shears in terms of the forces and a graphical representation is made to explain the impact of these forces.

Table 2: Displacement for different wind speeds for high rise story building:

High rise story displacements with different wind speeds in X direction						
Story	elevation	39 m/s	44 m/s	47m/s	50 m/s	55 m/s
Base	0	0	0	0	0	0
Story1	3	2	2	2	3	3
Story2	6	4	5	5	7	7
Story3	9	6	8	8	10	12
Story4	12	9	11	11	14	16
Story5	15	10	13	13	17	20
Story6	18	12	16	16	20	24
Story7	21	14	18	18	23	27
Story8	24	15	19	20	25	30
Story9	27	16	21	21	27	32
Story10	30	17	22	23	28	33
Story11	33	18	23	24	29	35
Story12	36	18	23	24	30	35

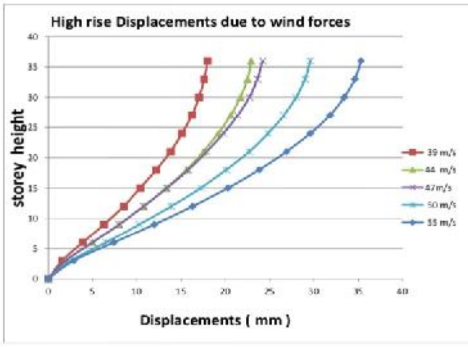


Figure.4.1.Graph showing displacements for different wind speeds for high rise story building.

Table 3: Displacement for different wind speeds for low rise story building:

G + 4 Low rise story displacements with different wind speeds in X direction						
Story	elevation	39 m/s	44 m/s	47m/s	50 m/s	55 m/s
Base	0	0	0	0	0	0
Story1	3	1	1	1	1	1
Story2	6	1	2	2	2	2
Story3	9	2	3	3	3	3
Story4	12	2	3	3	4	4
Story5	15	2	3	4	4	4

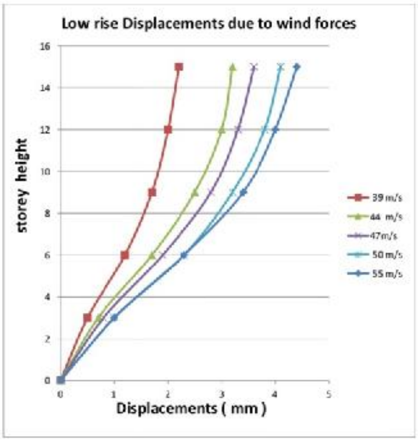


Figure.4.2. Graph showing displacements for different wind speeds for low rise story building.

Table 4: Story displacement for high rise structure for different wind speeds

High rise Story base Shears forces with different wind speeds						
Story	elevation	Wind speed 39	Wind speed 44	Wind speed 47	Wind speed 50	Wind speed 55
Story1	3	316	402	458	519	627
Story2	6	303	386	440	498	602
Story3	9	278	353	403	456	552
Story4	12	252	321	367	415	502
Story5	15	226	288	329	372	450
Story6	18	199	253	289	327	396
Story7	21	171	217	248	281	339
Story8	24	141	180	205	232	281
Story9	27	111	142	162	183	221
Story10	30	80	102	117	132	160
Story11	33	49	62	71	80	97
Story12	36	16	21	24	27	32

Table 5: Displacement for low rise and high rise building for maximum wind speeds:

comparison of displacements low rise and for high rise building from maximum wind speed			
Story	elevation	High rise wind	Low rise wind
Base	0	0	0
Story1	3	3	1
Story2	6	7	2
Story3	9	12	3
Story4	12	16	4
Story5	15	20	4
Story6	18	24	
Story7	21	27	
Story8	24	30	
Story9	27	32	
Story10	30	33	
Story11	33	35	
Story12	36	35	

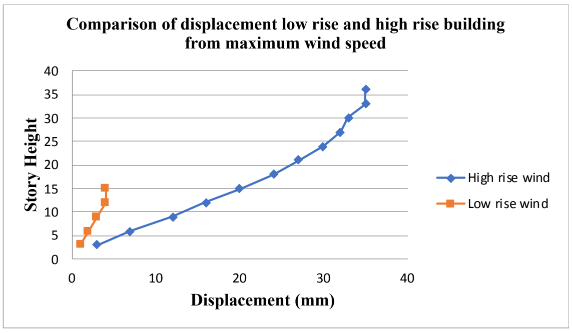


Figure 4.3. Graph showing displacement for low rise and high rise building for maximum wind speeds.

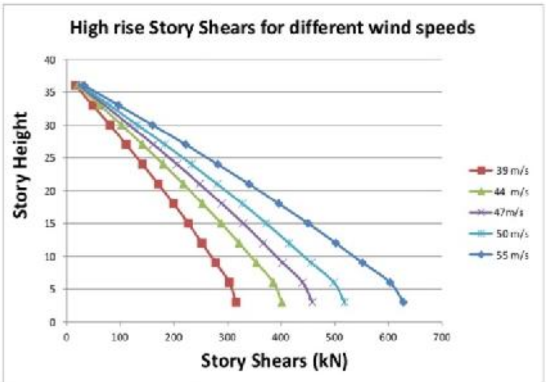


Figure 4.4.Graph showing story shear for different wind speeds for high rise building.

Table 7:Story shears for different wind speed for low rise building:

G + 4 Low rise Story base Shears forces with different wind speeds						
Story	elevation	Wind speed 39	Wind speed 44	Wind speed 47	Wind speed 50	Wind speed 55
Base	0	0	0	0	0	0
Story1	3	103	131	149	169	205
Story2	6	90	115	131	148	179
Story3	9	65	83	94	107	129
Story4	12	40	51	58	65	79
Story5	15	14	17	20	22	27

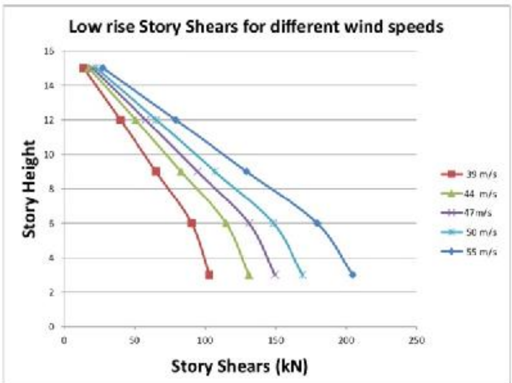


Figure.4.5. Graph showing story shears for different wind speeds for low rise building.

Table 8: Story shear for low rise and high rise building for the maximum wind speeds:

Story	elevation	high rise wind shear	low rise wind shear
Base	0	0	0
Story1	3	627	205
Story2	6	602	179
Story3	9	552	129
Story4	12	502	79
Story5	15	450	27
Story6	18	396	
Story7	21	339	
Story8	24	281	
Story9	27	221	
Story10	30	160	
Story11	33	97	
Story12	36	32	

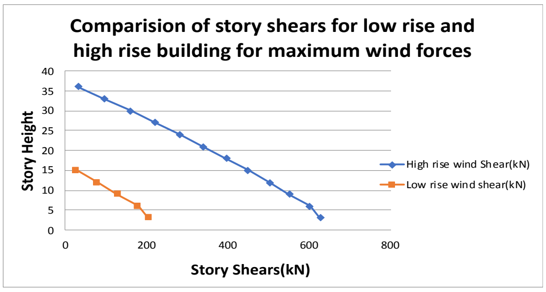


Figure 4.7. Graph showing story shears for low rise and high rise for the maximum wind speeds.

V. CONCLUSION

In this study, the multi-storied building excited to different wind forces are studied. From the modelling and analysis of these building, the following conclusions are carried out.

- The displacements, story shears increases as the wind speed increases. The high rise stories are more effected by the wind forces and the wind influence increases if the height of the structure increases further.
- It is observed that, the lateral forces excited on the structure have shown increasing severity with increase in the wind speed.
- When the lateral forces exerted on high rise buildings, the observed order of the effects are wind speed 55, wind speed 50,wind speed 47,wind speed 44, wind speed 39.
- From this, it can also be concluded that the high rise buildings are more effected by the wind forces when compared to low rise buildings.

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