Influence of Wind Load on Multi-Storey Tall RCC Building of Different Shapes

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Abstract - *The behavior of the Structures during wind loads definitely has a major role, not only from structural Engineering point of view, but also safety of humans living in the structure. It is a major challenge to study the impact and performance of tall structures of different shape under wind loading. In this dissertation, the influence of wind load on R.C.C. tall buildings of different shape as per IS: 875-1987 (part-3) codes of practice are studied most and lesser structurally stable shape of building. Wind load analysis with force coefficient method is used for analysis of a 40-storey RCC high rise building as per IS 875(Part3):1987 codes respectively. The building is modelled in 3D using STAAD.ProV8i software. The geometrical configuration of a high rise building is a vital parameter that affects the wind response of the structure. In this study, seven different geometrical configurations having 40 floors with a total height of 120m built with RCC were modelled using STAAD.ProV8i. All the models are loaded with the Dead load, Live load and Wind Load as per IS: 875 (part I to III).*

Key Words: Shapes, Load, Force Coefficient Method, STAAD.PRO V8i, Shear force, Bending Moment, Rotation, Displacement.

1. INTRODUCTION

Over the last two decades, wind engineering has increasingly focused on the high rise structures. As some of these IS Code and full scale wind engineering into the design codes and standards, one may expect to see reduced hurricane/cyclonic damage. However, when one combines the more rapid increase in population along the world's tropical coasts with a generally unacceptably low standard of new building construction inspection, it seems quite likely that loss of life, as well as insured and uninsured property losses will continue to be the norm in the foreseeable future. The wind engineering community needs to be more responsible in forcefully transferring our technical knowledge to the designer and builder. It is observed that, the rapid growth of population and industrial activity has resulted in the increase in horizontal construction, reduce forest area and cultivable land has resulted of environmental deterioration, with such rapid urbanization and the use of new materials and building configurations there is a need to understand the effect of wind not only for the buildings but also for the surroundings. There is increase in the shortage of land for buildings and therefore the vertical construction is given importance. Structural engineers face this major challenge and are concerned about the wind loads on the buildings from the safety standpoint, both of structural and of cladding systems. The need is to construct high rise building which are structurally safe.

1.1 Objective of the study

- To understand and analyses the wind effect on tall structures.
- To study and analyses the effect of wind load on different shape of the building and asses the most & lesser structurally stable shape of a multi-story tall R.C.C structure.
- The present study deals with the buildings of different shapes: Rectangular; L; U; T; I; Plus and Non-uniform.

2. Parameter of building

Various parameter of the building which are kept constants as follows:

- Height : 120 m
- Total number story : 40
- Storey height : 3m
- Bay size : 4m *4m
- Length : 24 m

- Width : 20 m
- Column size : 600 mm*600 mm
- Beam size : 450 mm* 450 mm
- Wall thickness : 230 mm
- Support: Fixed
- Material use: Concrete: M-40, Steel: Fe-500
- Type of structure: Ordinary Moment Resisting Frame (OMRF)
- Type of system : Moment frame system
- Location : Gwalior (M.P.), India

2.1 Load Considered:

Dead load: The loads of beam, column and slab have been taken in account by STAAD.PRO V8i, Using the command of self-weight.

Considering unit weight of RCC: 25kN/m^3,

Unit Weight of brick: 20kN/m^3

Deal load due to wall =.23*3*20 =13.8kN/m.

Live load: Live load has been taken as on floors: 4.5kN/m^2

Wind load: Wind pressure and forces on multi story building (*force coefficient method)*

$V_Z=V_B*k_1*k_2*k_3$

Where: k_1=Probability factor, k_2=terrain, height, and structure Size factor, & k_3= topography factor.

For Gwalior City:

G+39 story building @ 3.0m height of each floor=120 m total height of building. Basic Wind Speed for Gwalior city = 47m/s. k_1=1.07, k_2= Varies with each story height of building

For class –C and Categories-3 of building k_3=1

Then, $V_Z=50.3*K_2$ m/s

Design Wind Pressure (P_Z) = $0.6*V_z^2$ =$1518.054*(K_2)^2$ N/m^2,

Wind force in a Building = C_F*Ae*P_Z

Wind intensity (P_I) = C_F*P_Z kN/m^2, C_F =force coefficient

2.2 Load Combination

Loads & Load combination under consideration:-

1. DL, 2.LL, 3.WL: +X,

4. WL: -X, 5.WL: +Z, 6.WL: -Z

7. 1.5(DL+LL)

8. 1.5(DL+ WL: +X)

9. 1.5(DL+ WL: +Z)
10. 1.5(DL+ WL: -X)
11. 1.5(DL+ WL: -Z)
12. 1.2(DL+LL+WL: +X)
13. 1.2(DL+LL+WL: +Z)
14. 1.2(DL+LL+WL: -X)
15. 1.2(DL+LL+WL: -Z)
16. 0.9(DL) +1.5(WL: +X)
17. 0.9(DL) +1.5(WL: +Z)
18. 0.9(DL) +1.5(WL: -X)
19. 0.9(DL) +1.5(WL: -Z)

Different shape of buildings under consideration:

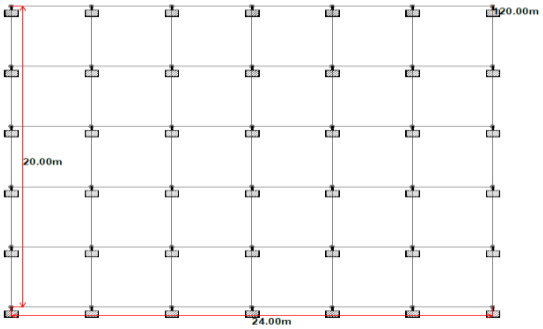


Fig-1.1 Rectangular Shape

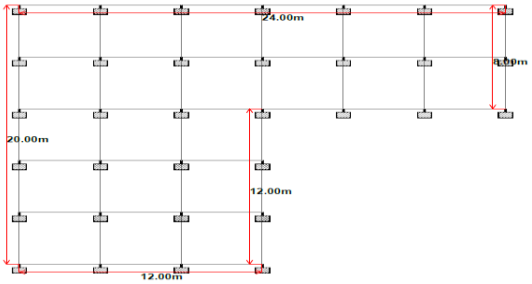


Fig-1.2 L Shape

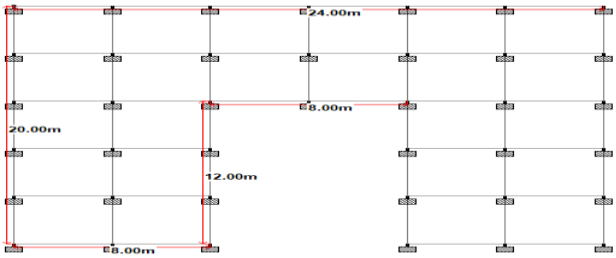


Fig-1.3 U Shape

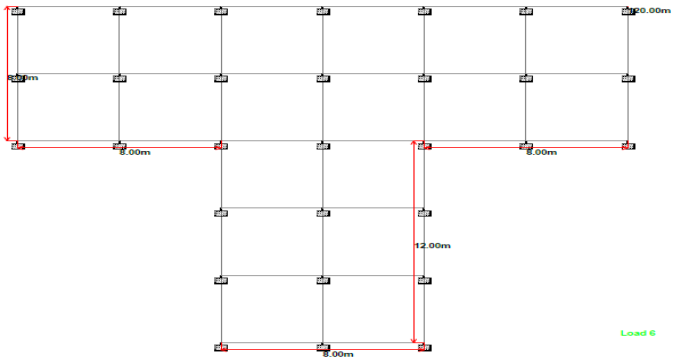


Fig-1.4 T Shape

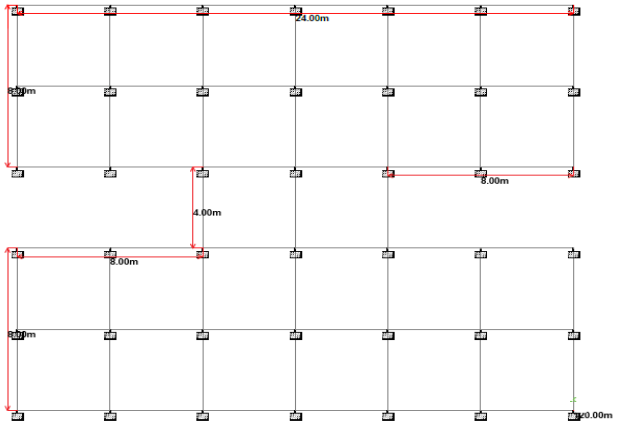


Fig-1.5 I Shape

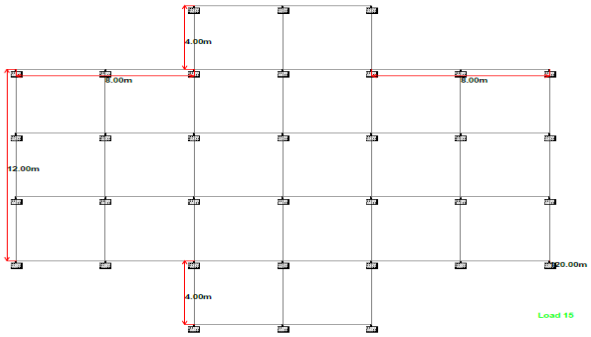


Fig-1.6 + Shape

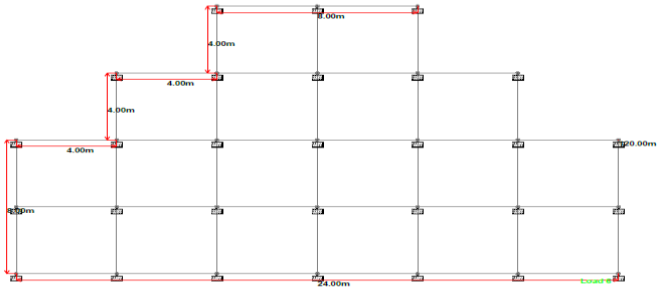


Fig-1.7 Irregular Shape

Table-1 C_F Value for each shape

Shape	C_F
Rectangular	1.34
L	1.85
U	2.00
T	1.45
I	1.55
+	1.70
Non uniform	1.95

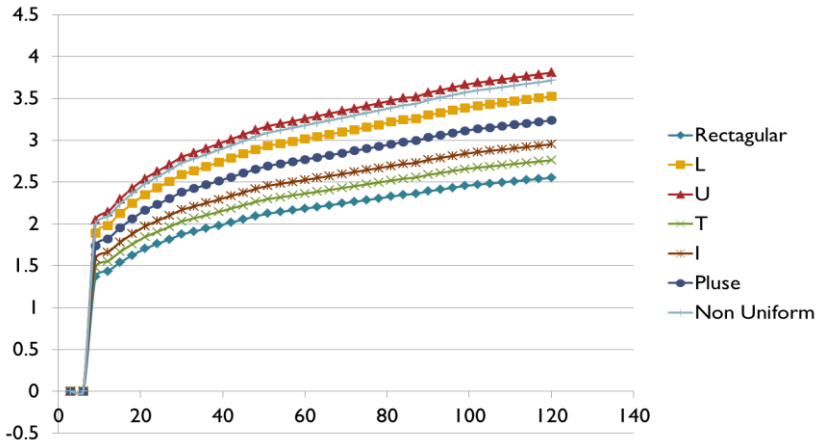


Fig-2: Variation of wind intensity (kN/m²) v/s Height (m.)

2.2 Wind intensity of shapes of building:

Shapes / H (m.)	Rectangular	L shape	U shape	T shape	I shape	+ shape	Non uniform
	Wind Intensity in kN/m²						
9	1.368	1.888	2.041	1.48	1.582	1.735	1.99
12	1.435	1.982	2.142	1.553	1.66	1.821	2.089
15	1.54	2.126	2.298	1.666	1.781	1.953	2.241
18	1.626	2.245	2.427	1.759	1.881	2.063	2.367
21	1.703	2.351	2.542	1.843	1.97	2.161	2.478
24	1.76	2.429	2.626	1.904	2.035	2.232	2.56
27	1.816	2.508	2.711	1.966	2.101	2.305	2.644
30	1.875	2.588	2.798	2.029	2.168	2.378	2.728
33	1.91	2.637	2.851	2.067	2.209	2.423	2.779

36	1.945	2.686	2.904	2.106	2.251	2.468	2.831
39	1.981	2.736	2.958	2.144	2.292	2.514	2.884
42	2.017	2.786	3.012	2.184	2.334	2.56	2.936
45	2.054	2.837	3.067	2.223	2.376	2.607	2.989
48	2.091	2.888	3.122	2.263	2.419	2.653	3.044
51	2.123	2.931	3.169	2.297	2.456	2.693	3.089
54	2.143	2.959	3.198	2.319	2.479	2.719	3.118
57	2.163	2.986	3.228	2.341	2.502	2.744	3.148
60	2.183	3.014	3.258	2.363	2.525	2.77	3.177

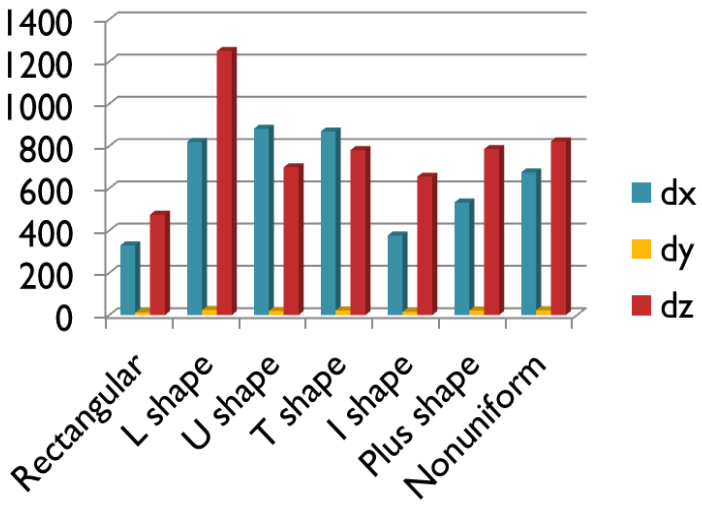
Shapes / **H (m.)**	**Rectangular**	**L shape**	**U shape**	**T shape**	**I shape**	**+ shape**	**Non uniform**
	Wind Intensity in kN/m²						
63	2.203	3.042	3.289	2.384	2.549	2.796	3.207
66	2.223	3.07	3.319	2.406	2.572	2.821	3.236
69	2.244	3.098	3.35	2.429	2.596	2.847	3.266
72	2.265	3.127	3.381	2.451	2.62	2.873	3.296
75	2.285	3.156	3.411	2.473	2.644	2.9	3.326
78	2.306	3.184	3.442	2.496	2.668	2.926	3.356
81	2.327	3.218	3.473	2.518	2.692	2.952	3.387
84	2.348	3.242	3.505	2.541	2.716	2.979	3.417
87	2.361	3.26	3.52	2.555	2.731	2.995	3.436
90	2.39	3.3	3.568	2.587	2.765	3.032	3.478
93	2.411	3.329	3.599	2.609	2.789	3.059	3.509
96	2.433	3.359	3.631	2.633	2.814	3.086	3.54
99	2.454	3.388	3.663	2.656	2.839	3.114	3.571
102	2.47	3.411	3.687	2.673	2.857	3.134	3.596
105	2.483	3.429	3.707	2.687	2.873	3.151	3.614
108	2.497	3.448	3.727	2.702	2.889	3.168	3.634
111	2.51	3.466	3.748	2.717	2.904	3.185	3.654
114	2.524	3.485	3.768	2.732	2.92	3.203	3.674
117	2.538	3.504	3.788	2.746	2.936	3.22	3.693
120	2.551	3.523	3.808	2.761	2.952	3.237	3.713

3.0 Discussions on Result:

Comparison of maximum displacement value of different shapes.

Table-3.1: Max. +Ve nodal displacement (in mm.)

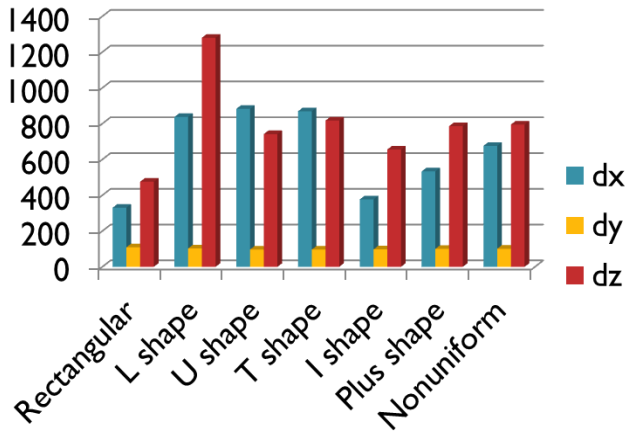
	dx	dy	dz
Rectangular	330.168	12.116	475.318
L shape	820.11	24.3	1250
U shape	882.373	19.46	699.852
T shape	869.207	21.999	781.178
I shape	376.856	15.404	655.433
Plus shape	533.082	22.234	785.994
Non uniform	675.752	23.648	822.516



Graph 3.1: Max. +Ve nodal displacement (in mm.)

Table-3.2: Max. -Ve nodal displacement (in m.m.)

	dx	dy	dz
Rectangular	330.168	108.833	475.318
L shape	837.339	102.846	1280
U shape	882.373	96.395	741.429
T shape	869.207	96.003	817.385
I shape	376.856	97.22	655.433
Plus shape	533.082	100.144	785.944
Non uniform	675.752	100.761	794.823

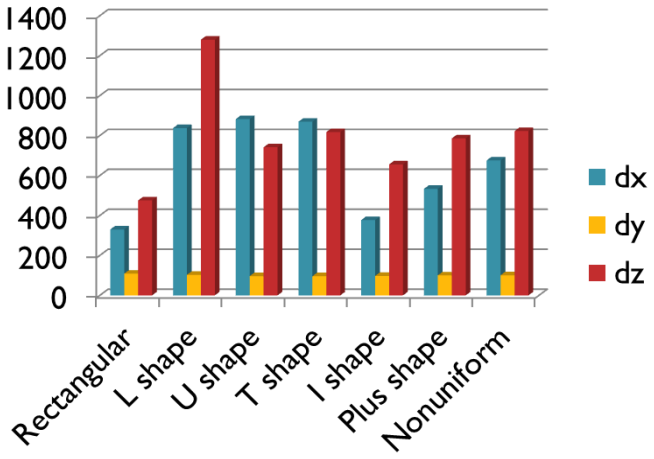


Graph-3.2: Max. -Ve nodal displacement (in m.m.)

3.1: Comparison of abs. max. Nodal displacement & joint rotation value of different shapes of building:

Table-3.3: Absolute maximum nodal displacement (in m.m.)

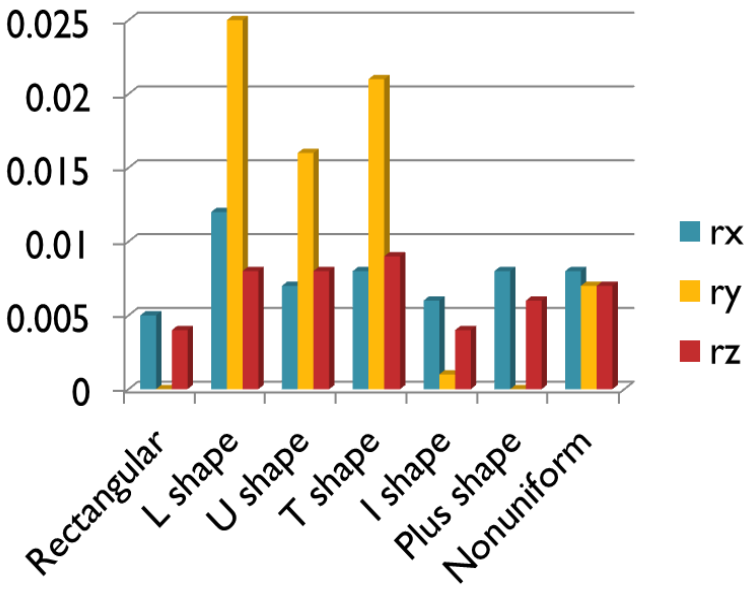
	dx	dy	dz
Rectangular	330.168	108.833	475.318
L shape	837.339	102.842	1280
U shape	882.373	96.395	741.429
T shape	869.207	96.003	817.385
I shape	376.856	97.22	655.433
Plus shape	533.082	100.144	785.944
Non uniform	675.752	100.761	822.516



Graph-3.3: Absolute max. nodal displacement (in m.m.)

Table-3.4: Max. nodal rotation (in rad.) of shapes

	rx	ry	rz
Rectangular	0.005	0	0.004
L shape	0.012	0.025	0.008
U shape	0.007	0.016	0.008
T shape	0.008	0.021	0.009
I shape	0.006	0.001	0.004
Plus shape	0.008	0	0.006
Non uniform	0.008	0.007	0.007

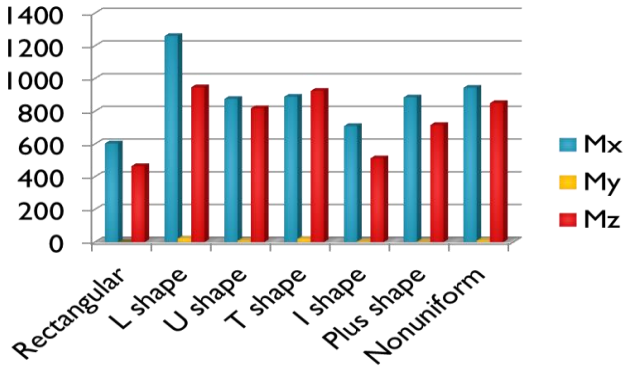


Graph-3.4: Max. nodal rotation (in rad.) of shapes

3.2: Comparison of max. B.M. & S.F. value of shapes

Table-3.5: Maximum bending Moment (in kN.m)

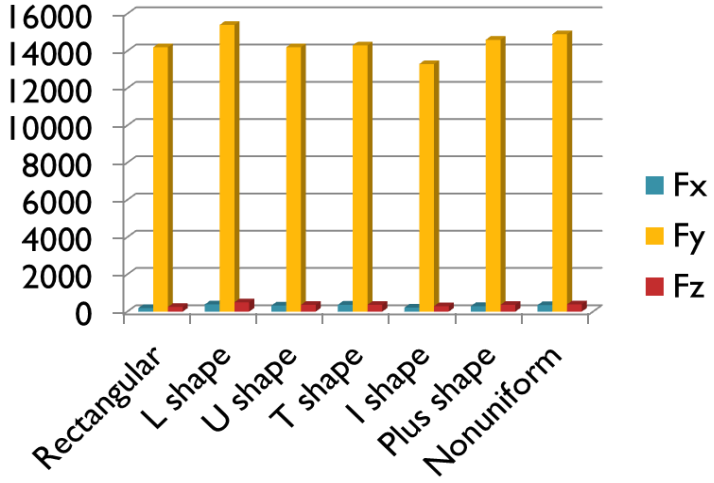
	Mx	My	Mz
Rectangular	602.618	0.361	464.411
L shape	1260	22.25	946.487
U shape	875.372	8.77	818.059
T shape	888.671	19.788	924.284
I shape	709.05	4.337	512.26
Plus shape	884.696	2.959	715.526
Non uniform	943.595	10.175	850.08



Graph-3.5: Maximum bending Moment (in kN.m)

Table-3.6: Max. Shear Force (in kN)

	Fx	Fy	Fz
Rectangular	189.688	14200	249.806
L shape	388.195	15400	503.353
U shape	325.785	14200	361.797
T shape	371.192	14300	366.865
I shape	214.039	13300	293.307
Plus shape	297.741	14600	365.2
Non uniform	347.367	14900	390.465



Graph-3.6: Max. Shear Force (in kN)

4. CONCLUSIONS

- It can be concluded that for 40 storied building with height of 120 m, with their varying shape.
- The increasing order of the wind intensity of shapes of building:

  Rectangular < T shape < I shape < + shape < L shape < Non uniform shape.
- The Increasing order of the maximum node displacement:

  Rectangular < I shape < + shape < U shape < T shape < Non uniform shape < L shape.
- The decreasing order of stability of structure:

  Rectangular > I shape > + shape > U shape > T shape > Non uniform shape > L shape.
- Similar order in the case for the joint (Node) rotation also.
- It can be concluded that L- shape and Non uniform shape are the least stable of all the shapes.
- Rectangular shape is the most structurally stable shape as compared to the other shapes.
- By increasing the number of beam and column without changing the dimensions of the building, the stiffness can be increased thereby increasing the stability of other shapes.

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