Effect of Bracing Pattern on the L Shape of RCC Tall Building Due to Wind Load

Dharm Singh[1], Dr. Sanjay Tiwari[2]

[1]M.E. Scholar, Structural Engineering, MITS, Gwalior (M.P.), India
[2]Professor, Dept. of Civil Engineering, MITS, Gwalior (M.P), India

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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 RCC structures of L shape under wind load. In this paper, the influence of wind load on R.C.C. tall buildings of L shape as per IS: 875-1987 (part-3) codes of practice are studied effect of bracing pattern on building of L shape. 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, Rectangular shape geometrical configurations having 40 floors with a total height of 120m built with RCC and bracing pattern 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: Shape, Load, Force Coefficient Method, STAAD.PRO V8i, Brace, 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 RCC structures.
- To study and analyses the effect of wind load on L shape of the tall RCC building.
- The present study deals with the buildings of L shape with varying bracing pattern, like X, V, inverted V bracing.

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
- Bracing member : ISA 110*110*16
- 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

For L shape Building

C_F = 1.85

Rectangular shape of buildings under consideration:

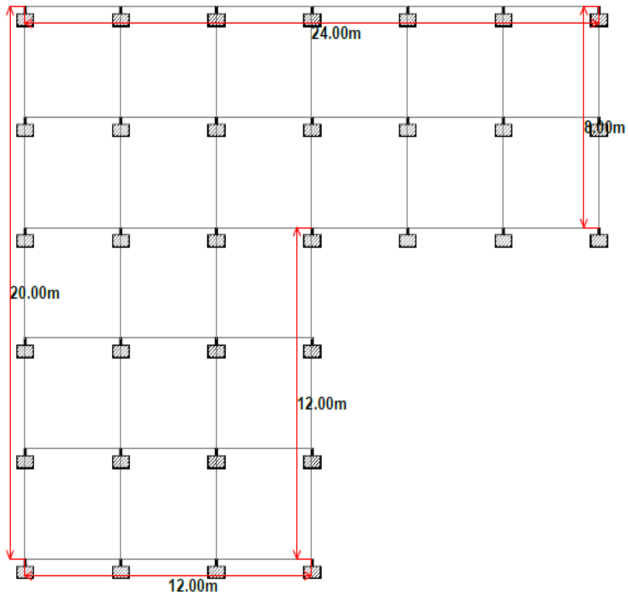


Fig-1.1 L Shape

2.2 Load Combination

Loads & Load combination under consideration as per

IS 875:1987 (part-3)

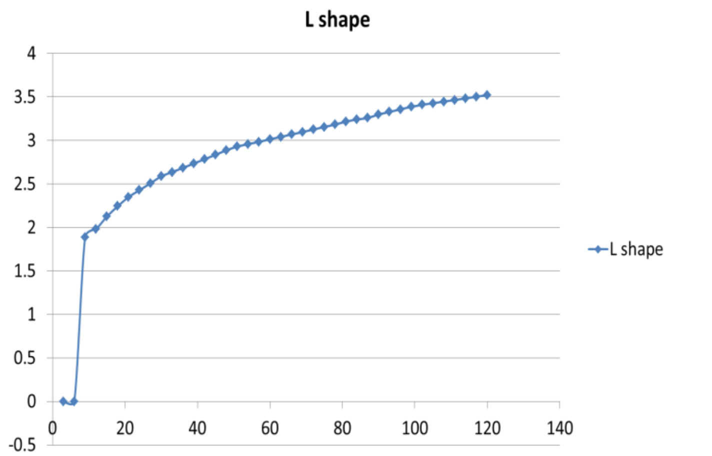
1. DL, 2.LL, 3.WL: +X,

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)

Table-1.1: Wind intensity of L shape building

Shapes / H (m.)	L shape	H (m.)	L shape
	Wind Intensity in kN/m²		
3	0	**63**	3.042
6	0	**66**	3.07
9	1.888	**69**	3.098
12	1.982	**72**	3.127
15	2.126	**75**	3.156
18	2.245	**78**	3.184
21	2.351	**81**	3.218
24	2.429	**84**	3.242
27	2.508	**87**	3.26
30	2.588	**90**	3.3
33	2.637	**93**	3.329
36	2.686	**96**	3.359
39	2.736	**99**	3.388
42	2.786	**102**	3.411
45	2.837	**105**	3.429
48	2.888	**108**	3.448
51	2.931	**111**	3.466
54	2.959	**114**	3.485
57	2.986	**117**	3.504
60	3.014	**120**	3.523

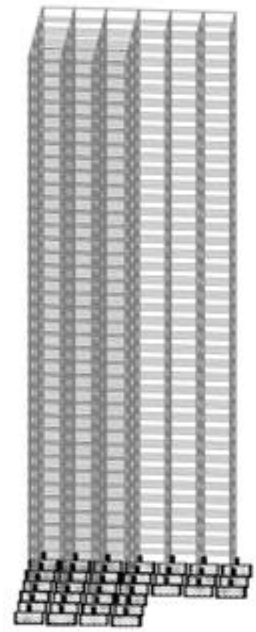


Graph-1: Variation of wind intensity (kN/m²) v/s Height (m)

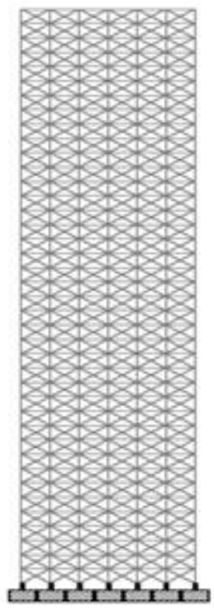
3. Bracing Pattern use in Rectangular shape:

The following type of L shape of model use with bracing pattern:

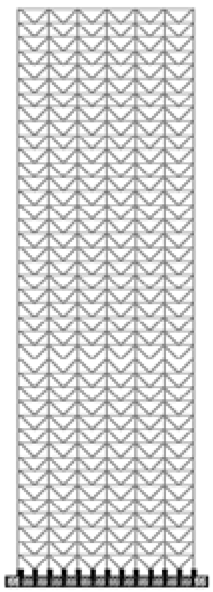
- OMRF L shape – Model: 5
- X bracing in L shape – Model: 6
- V bracing in L shape – Model: 7
- Inverted V bracing in L shape - Model: 8



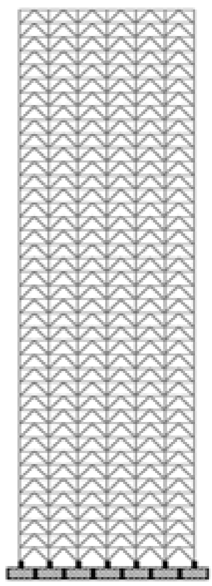
Model: 5



Model: 6



Model: 7



Model: 8

Loading diagram for bracing pattern in L shape

(X bracing):

Similarly for other bracing pattern also-

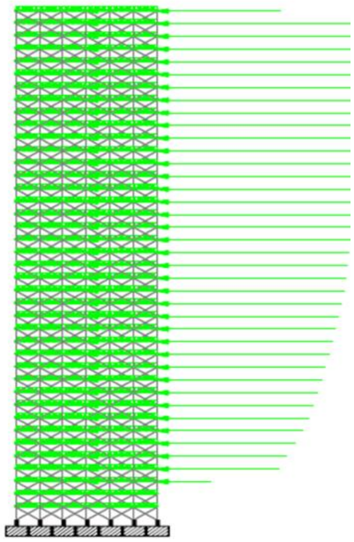


Fig-1.2: Loading of X bracing L shape of

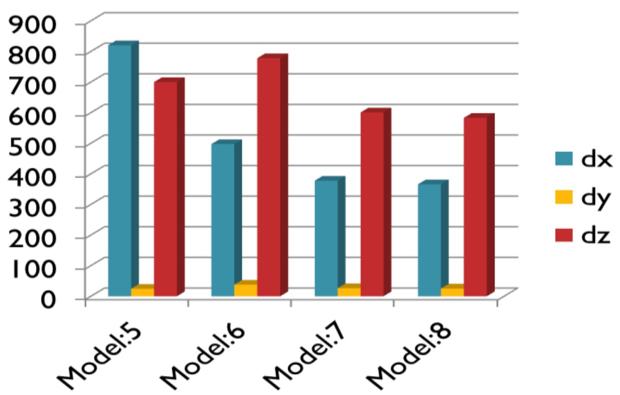
Load combination-14

4. Discussions on Result:

Maximum displacement in L shape of building:

Table-1.2: Max. +Ve nodal displacement (in mm.)

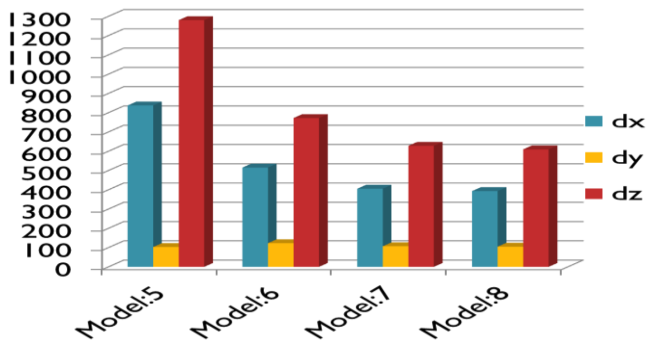
	dx	dy	dz
Model:5	820.11	24.3	699.852
Model:6	497.144	37.763	777.871
Model:7	377.575	26.186	600.544
Model:8	365.806	25.122	582.909



Graph-1.2: Max. +Ve nodal displacement (in mm.)

Table-1.3: Max. -Ve nodal displacement (in mm.)

	dx	dy	dz
Model:5	837.339	102.846	1280
Model:6	515.292	122.962	772.084
Model:7	405.502	106.848	627.975
Model:8	393.218	104.704	609.442

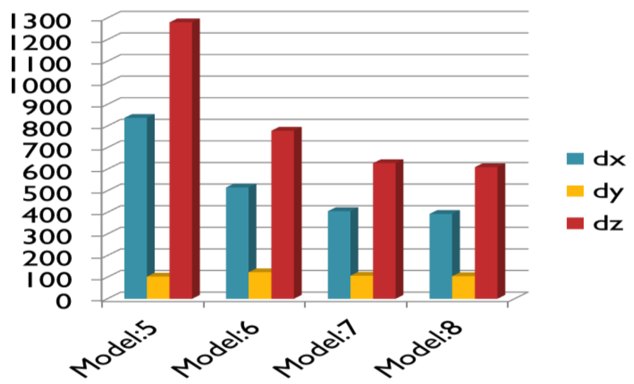


Graph-1.3: Max. -Ve nodal displacement (in mm.)

4.1 Comparison of maximum absolute nodal displacement and joint rotation:

Table-1.4: Absolute max nodal displacement (in mm.)

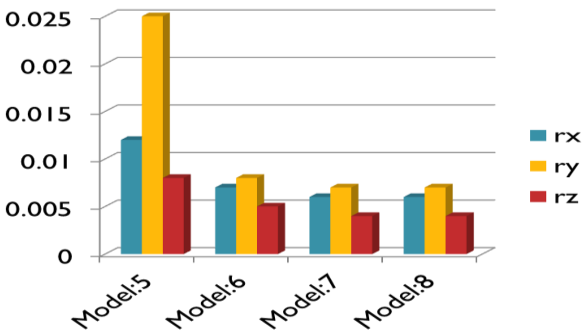
	dx	dy	dz
Model:5	837.339	102.846	1280
Model:6	515.292	122.962	777.871
Model:7	405.502	106.848	627.945
Model:8	393.218	104.704	609.442



Graph-1.4: Absolute max. nodal displacement (mm.)

Table-1.5: Maximum nodal Rotation (in rad.)

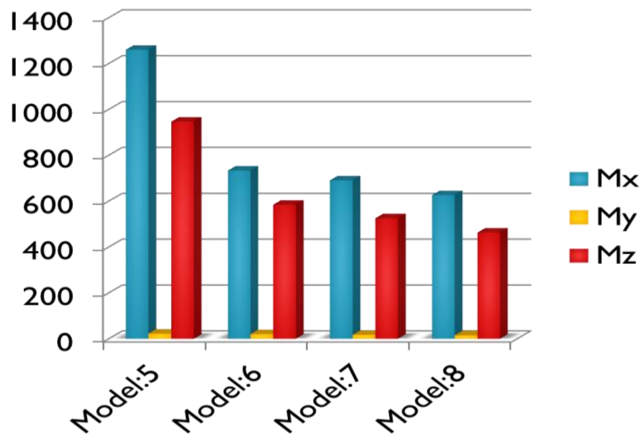
	rx	ry	rz
Model:5	0.012	0.025	0.008
Model:6	0.007	0.008	0.005
Model:7	0.006	0.007	0.004
Model:8	0.006	0.007	0.004



Graph-1.5: Maximum nodal Rotation (in rad.)

Table-1.6: Max. Bending Moment (in kN.m)

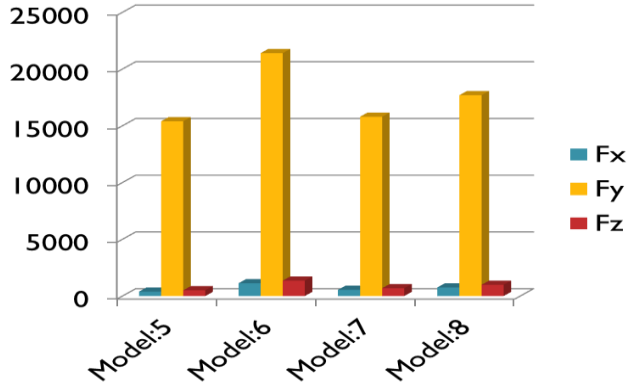
	Mx	My	Mz
Model:5	1260	22.25	946.487
Model:6	733.348	19.936	584.549
Model:7	690.685	16.755	525.339
Model:8	626.117	14.961	462.886



Graph-1.6: Max. Bending Moment (in kN.m)

Table-1.7: Max. Shear Force (in kN)

	Fx	Fy	Fz
Model:5	388.195	15400	503.353
Model:6	1120	21400	1350
Model:7	542.83	15800	686.469
Model:8	757.326	17700	987.568



Graph-1.7: Max. Shear Force (in kN)

5. CONCLUSIONS

- It can be concluded that for 40 storied building of L shape with height of 120 m, with their varying in bracing pattern.
- The Increasing order of the maximum node displacement in L shape of bracing pattern of building :
- inverted V bracing building < V bracing building < X bracing building < OMRF L shape building.
- The increasing order of stability of structure:
- OMRF L shape building < X bracing building < V bracing building < inverted V bracing building.
- Similar in the case for the joint (Node) rotation & max. B.M.
- It can be concluded that OMRF L shape and X bracing shape of building are the least stable of all the bracing pattern in the L shape building.

  Inverted V bracing and V bracing pattern in L shape of RCC tall building is the most structurally stable shape as compared to the other bracing pattern in L shape building.

6. REFERENCES

[1] IS: 875, "code of practice for design load (other than earthquake) for buildings and structures" Bureau of Indian Standards, New Delhi,2002..

[2] STAAD PRO V8i user guide.

[3] Advanced Reinforcement concrete by B.C.Punmia.

[4] Abhay Guleria, "Structural Analysis of a Multi-Storeyed Building using ETABS for different Plan Configurations" International Journal For Engineering Research And Technology, Vol. 3 Issue 5, May – 2014.

[5] IS: 456, Code of practice for plain and reinforced concrete code of practice, Bureau of Indian Standards, New Delhi, 2000.

[6] STAAD PRO V8i; Structural analysis and design software.

[7] Comparative Study of Wind Analysis with Horizontal Irregularities in Multi-Storied Buildings using STAAD Pro, International Journal of Science Technology & Engineering Volume 2 | Issue 01 | July 2015.

[8] SATISHKUMAR ET AL (2011): "Importance of wind load in design of tall buildings" Indian Institute of Technology Madras, Design of Steel structures.

[9] IS: 16700:2017 Criteria for structural safety of tall structural buildings.

[10] High rise building: Structure system and services by Abhinav, Sandeep Verma, Vishal, Shrivan BARC research.

[11] ANALYSIS AND DESIGN OF RC TALL BUILDING SUBJECTED TO WIND AND EARTHQUAKE LOADS K. Rama Raju*,[1], M.I. Shereef[3], Nagesh R Iyer[2], S. Gopalakrishnan[4] [1]Chief Scientist, [2]Director, [3]Project Student, CSIR-Structural Engineering Research Centre, Chennai-600113, *krraju@serc.res.in, [4]Professor, K S Rangasamy College of Technology, Tiruchengode-637215.

[12] COMPARATIVE ANALYSIS OF TWO DIFFERENT WIND SPEEDS FOR A MULTISTOREY BUILDING P.Sirisha*, E.V.Raghava Rao, V.Bhargavi.

[13] COMPUTATIONAL TOOL FOR WIND PRESSURE AND FORCES ON A MULTISTORY COMMERCIAL COMPLEX [1]N G Shilu, [2]Dr. H S Patel.

[14] The AUST Journal of Science and Technology, Volume 5, Issue 2, Page 84-94, January 2013(Published in January 2014), ISSN 2072-0149, (DRAFT COPY)

[15] Analysis on the Structural Systems for Drift Control of Tall Buildings due to Wind Load: Critical Investigation on Building Heights by Shafiqul Islam1 and Md. Mashfiqul Islam

[16] ANALYSIS AND DESIGN OF RC TALL BUILDING SUBJECTED TOWIND AND EARTHQUAKE LOADS

K. Rama Raju,1, M.I. Shereef, Nagesh R Iyer, S. Gopalakrishnan

[17] Chief Scientist, Director, Project Student, CSIR-Structural Engineering Research Centre, Chennai-600113, *krraju@serc.res.in, 4Professor, K S Rangasamy College of Technology, Tiruchengode-637215.