Effect of Bracing Pattern on the Most Structurally Stable Rectangular Shape of Building

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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 Rectangular shape under wind load. In this paper, the influence of wind load on R.C.C. tall buildings of Rectangular shape as per IS: 875-1987 (part-3) codes of practice are studied effect of bracing pattern on building of Rectangular 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 Rectangular shape of the tall RCC building.
- The present study deals with the buildings of Rectangular 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 Rectangular Building

L/B = 24/20 = 1.2, H/B =120/20 = 6, C_F = 1.34,

C_F value taken form fig-4 of IS: 875-1987 (part-3)

Rectangular shape of buildings under consideration:

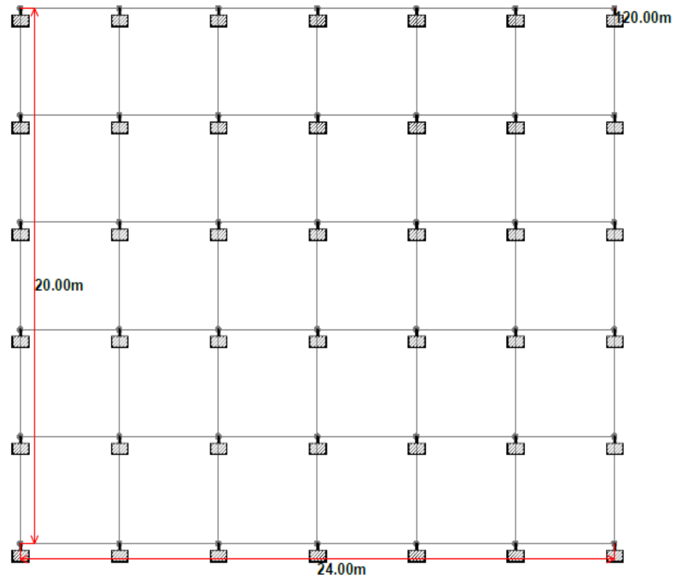


Fig-1.1 Rectangular Shape

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)

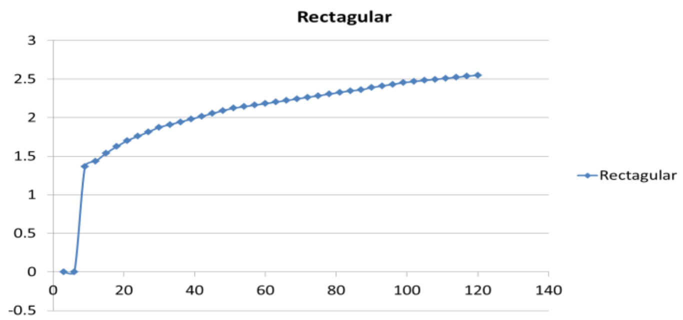
17. 0.9(DL) +1.5(WL: +Z)

18. 0.9(DL) +1.5(WL: -X)

19. 0.9(DL) +1.5(WL: -Z)

Table-1.1: Wind intensity of rectangular shape

Shapes / H (m.)	Rectangular	H (m.)	Rectangular
	Wind Intensity in kN/m²		
3	0	**63**	2.203
6	0	**66**	2.223
9	1.368	**69**	2.244
12	1.435	**72**	2.265
15	1.54	**75**	2.285
18	1.626	**78**	2.306
21	1.703	**81**	2.327
24	1.76	**84**	2.348
27	1.816	**87**	2.361
30	1.875	**90**	2.39
33	1.91	**93**	2.411
36	1.945	**96**	2.433
39	1.981	**99**	2.454
42	2.017	**102**	2.47
45	2.054	**105**	2.483
48	2.091	**108**	2.497
51	2.123	**111**	2.51
54	2.143	**114**	2.524
57	2.163	**117**	2.538
60	2.183	**120**	2.551

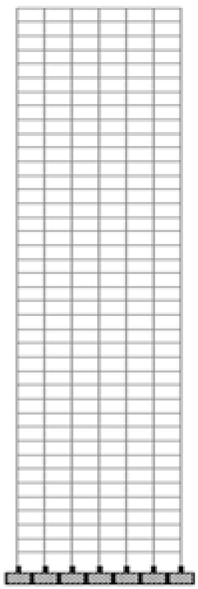


Graph-1: Variation of wind intensity (kN/m²) v/s Height (m)

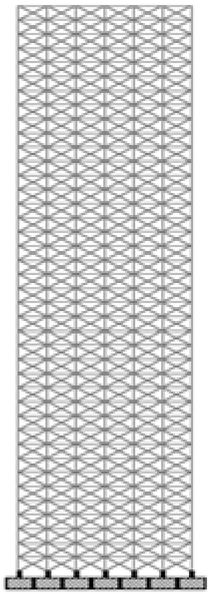
3. Bracing Pattern use in Rectangular shape:

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

- OMRF rectangular shape – Model :1
- X bracing in rectangular shape – Model :2
- V bracing in rectangular shape – Model :3
- Inverted V bracing in rectangular shape - Model :4



Model: 1



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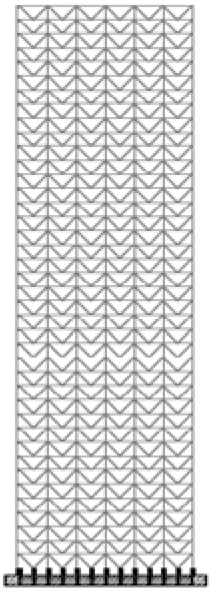
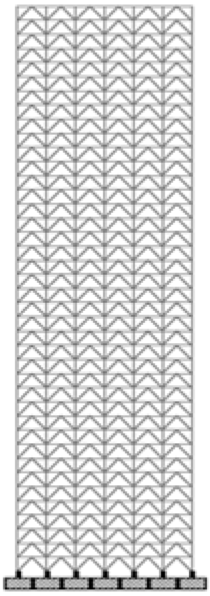


Model: 3



Model: 4

Loading diagram for bracing pattern in Rectangular shape (inverted V bracing):

Similarly for other bracing pattern also-

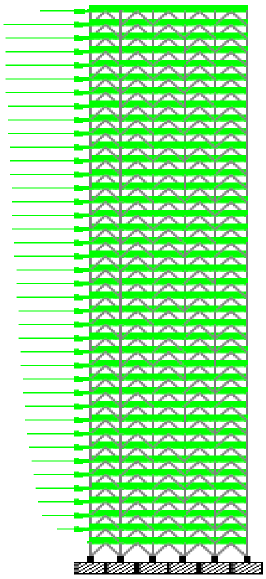


Fig-1.2: Loading of X bracing rectangular shape of

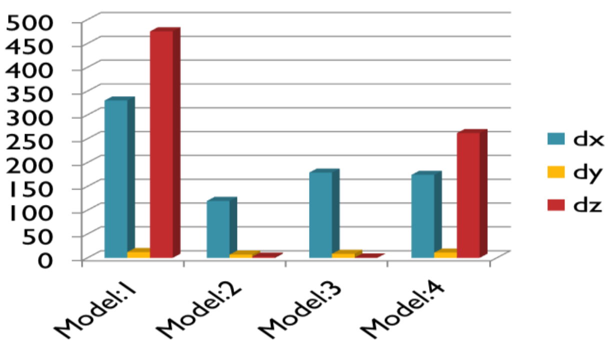
Load combination-13

4 Discussions on Result:

Maximum displacement in rectangular shape of building:

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

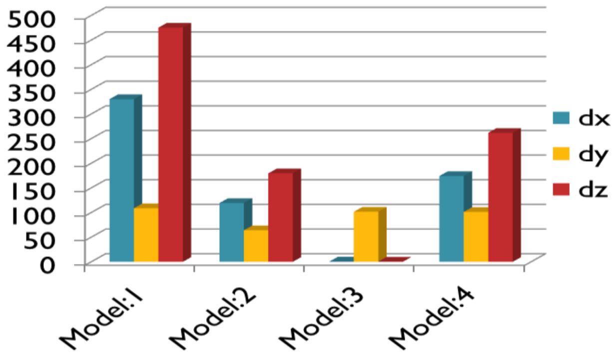
	dx	dy	dz
Model:1	330.168	12.116	475.318
Model:2	119.365	6.766	2.44
Model:3	178.87	8.322	0.551
Model:4	174.138	10.995	261.886



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

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

	dx	dy	dz
Model:1	330.168	108.833	475.318
Model:2	119.365	64.067	179.619
Model:3	0.606	101.63	0.511
Model:4	174.138	101.368	261.886

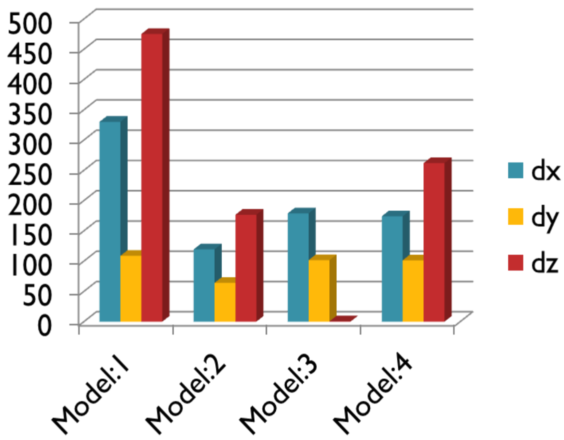


Graph-1.3: Max. -Ve nodal displacement (in mm.)

4.1 Comparison of maximum absolute nodal displacement and joint rotation:

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

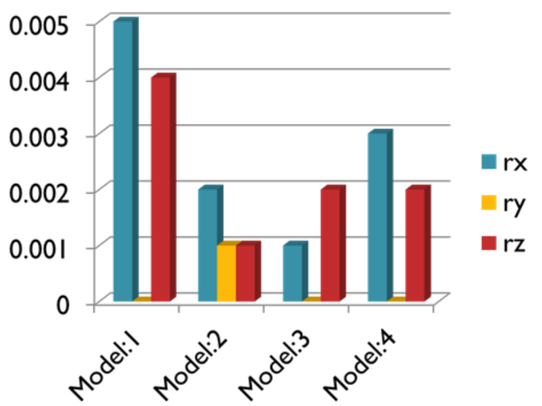
	dx	dy	dz
Model:1	330.168	108.833	475.318
Model:2	119.365	64.067	176.619
Model:3	178.87	101.63	0.551
Model:4	174.138	101.368	261.886



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

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

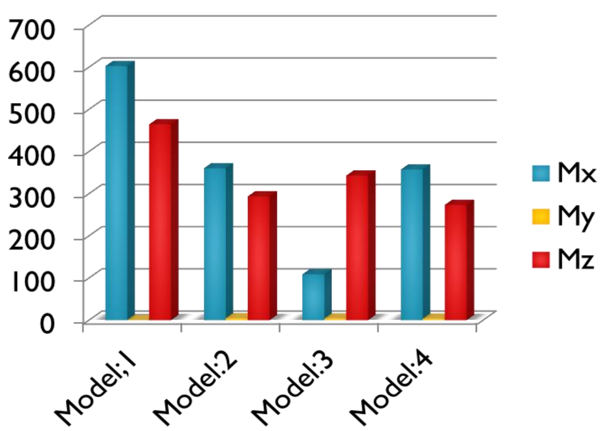
	rx	ry	rz
Model:1	0.005	0	0.004
Model:2	0.002	0.001	0.001
Model:3	0.001	0	0.002
Model:4	0.003	0	0.002



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

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

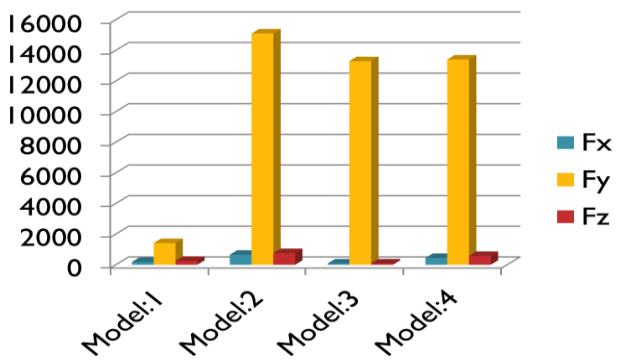
	Mx	My	Mz
Model:1	602.618	0.361	464.411
Model:2	360.31	4.648	293.525
Model:3	108.853	3.885	342.938
Model:4	357.558	3.413	273.395



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

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

	Fx	Fy	Fz
Model:1	189.688	1420	249.806
Model:2	656.574	15100	759.937
Model:3	87.962	13300	84.828
Model:4	444.662	13400	577.572



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

5. CONCLUSIONS

- It can be concluded that for 40 storied building of rectangular shape with height of 120 m, with their varying in bracing pattern.

- The Increasing order of the maximum node displacement in rectangular shape of bracing pattern of building :

  X brace building < V bracing building < inverted V bracing building < OMRF rectangular building.

- The increasing order of stability of structure:

- OMRF rectangular building < inverted V bracing building < V bracing building< X bracing.

- Similarly in the case for the joint (Node) rotation & max. B.M.

- It can be concluded that OMRF rectangular building and inverted V bracing shape building are the least stable of the entire bracing pattern in the rectangular shape building.

- X bracing pattern and V bracing in Rectangular shape of building is the most structurally stable.

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. Shereef3, Nagesh R Iyer2, S. Gopalakrishnan4 1Chief Scientist, 2Director, 3Project Student, CSIR-Structural Engineering Research Centre, Chennai-600113, *krraju@serc.res.in, 4Professor, 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 1N G Shilu, 2Dr. 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

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