EFFECTS OF WIND LOAD ON RC BUILDINGS BY USING GUST FACTOR APPROACH

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***Abstract*:** The development of new architectural forms of buildings and flexible structural systems are vulnerable to wind action. For desirable performance of these building, we required better understanding of interaction between building and wind. The objective of this study is to understand provisions of international standards and compare them with Indian standard. Hence A wind load effects on RC buildings is conducted utilizing major codes and standards: IS 875 (Part-3):1987, IS 875 (Part-3):2015, ASCE 7-05. In this study also focuses on Indian code i.e. IS 875 (Part-3):2015 and point out the advantages over IS 875 (Part-3):1987.The present study deals with the buildings of different shape such as regular plans and irregular plans. IS: 875 (Part-3):2015 is the standard code of practice for design load of buildings and structures which was used to calculate the along wind load effect i.e. gust factor. To determine along wind load effect on different shapes of building using Indian standard, spread sheets are prepared. Further, all these shapes were analysed using finite element software package ETAB-2016. Each building is a 20 storied building with story height as 4m summing upto a total height of 80m. For, the purpose of analysis the plan area of regular shape like Square, Rectangular, Elliptical, Circular and Rectangle with two semicircle shapes kept same as well as the frame properties also kept equal.

Keywords: IS:875(Part-3):1987/2015, ASCE 7-05, Gust factor, Storey shear, Storey drift, Displacement.

I. INTRODUCTION

Wind is the term used for air in motion and is usually applied to the natural horizontal motion of the atmosphere. Motion in a vertical or nearly vertical direction is called a current. Movement of air near the surface of the earth is three-dimensional, with horizontal motion much greater than the vertical motion. Vertical air motion is of importance in meteorology but is of less importance near the ground surface. On the other hand, the horizontal motion of air, particularly the gradual retardation of wind speed and the high turbulence that occurs near the ground surface, are of importance in building engineering.

If the height of structures today and the height of structures planned to be built are inspected, it is clear that the structures in the future will be higher and higher. The height of the tallest building changes year by year because skyscrapers are constructed constantly worldwide. With this development that buildings are rising, there will be a larger awareness of occupants comfort due to wind induced acceleration in the top floors of a high rise structure. So when the height of structure increases then the consideration of lateral load and other factors are very much important. For that the lateral load resisting system becomes more important thanthe structural system that only resists the gravitational loads. Therefore the study of response of different types of structural elements used and the different shape of building adopted to choose the perfect combination and shape of structural element which minimize the lateral displacement.

II. OBJECTIVES

Following are the objectives:

- To critically study the provisions of IS:875 (Part3):2015 and compare with IS:875 (Part3):1987. To understand international codes related to Gust Loading Factor, Pressure coefficients, wind load and study variations in results.
- To study the behaviour of tall structures when subjected to along wind load .
- To study the effect of shape of the building in plan on the behaviour of the structure.
- To determine the effect of wind load on various parameters like storey drift,lateral displacements in the building.

III. METHODOLOGY

A study involving dynamic effect of wind load on RC buildings and study the behavior of the buildings. The gust factor method is used to determining along wind load effect. The methodology worked out to achieve the above-mentioned objectives is as follows:

1) As a part of research the international standards and their provisions were critically studies. For this purpose following codes were considered:
   Indian Standard -IS 875(Part-3):1987
   Indian Standard -IS 875(Part-3):2015
   American Standard ASCEC 7-O5

2) Critically understand comparison between them.
3) The E-TABS software is used to develop 3D model and to carry out the analysis. The lateral loads to be applied on the buildings are based on the Indian standard IS-875-Part 3: 1987 and IS-875-Part 3: 2015.
4) Comparative study on the result obtained from the above analysis.
5) Result and discussions.

Comparison of building codes with respect to wind force determination :

1) IS 875 (Part-III) :1987 :-

Wind Velocity : ($V_z = V_b\, k_1 k_2\, k_3$)
V_z = design wind speed at any height z in m/s
V_b = basic wind speed in m/s.
k_1 = probability factor (risk coefficient)
k_2= terrain, height and structure size factor
k_3 = topography factor
Pressure: ($P_z = 0.6\, V_z^2$)
P_z = design wind pressure in N/m^2 at height z,
V_z - design wind speed at any height z in m/s.
Gust Factor: $G = 1 + g_f r\sqrt{[B(1+\emptyset)^2 + \frac{SE}{\beta}}$

2) IS 875 (Part-III) :2015 :-

Wind Velocity:($V_z = V_b\, k_1 k_2\, k_3$)
V_z = design wind speed at any height z in m/s
V_b = basic wind speed in m/s.
k_1 = probability factor (risk coefficient)
k_2= terrain, height and structure size factor
k_3 = topography factor
Pressure : ($P_z = 0.6\, V_z^2$)
P_z = design wind pressure in N/m^2 at height z,
V_z - design wind speed at any height z in m/s.
Gust Factor: $G = 1 + r\sqrt{[g_v^2 B_s (1+\emptyset)^2 + \frac{H_s g_R^2 SE}{\beta}}$

3) ASCEC 7-05 :-

Wind Velocity : ($q_z = 0.613 K_z K_{zt}\, K_d V_2 I$)
q_z = velocity pressure at heightz, KN/m2
K_d= wind directionality factor
K_z= velocity pressure exposure coefficient
K_{zt} = topographic factor
I= structural importance factor
V= basic wind speed in m/s
Pressure : (p = qGCp− qi (GCpi))
p= design wind pressure
G = gust effect factor
C_p = external pressure coefficient
(GC_{pi})= internal pressure coefficient
Gust Factor:

$$G = 0.925\left(\frac{(1+1.7 g_Q I_z Q)}{1+1.7 g_v I_z}\right)$$

Table -1 Parameters considered for the study

No of storey	20
Total height of building	80.0 M
Typical storey height	4.0 M
Bottom story height	4.0 M
Height of parapet	1.0 M
Material Properties :	
Grade of concrete	M30
Grade of steel	Fe500
Dead load intensity :	
Floor finish	1.5 KN/m^2
Live load intensity :	
i) Roof	4 KN/m^2
ii) Floor	4 KN/m^2

BUILDING MODELS: (Plan and 3D View)

Regular shape models:

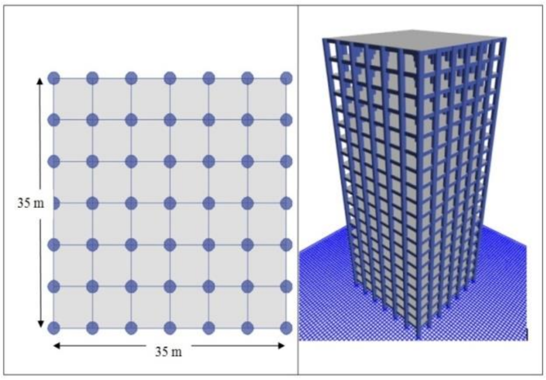


Fig-1 : Square Shape

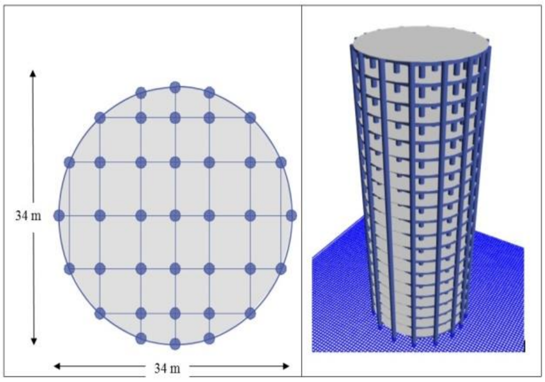


Fig-2 : Circular Shape

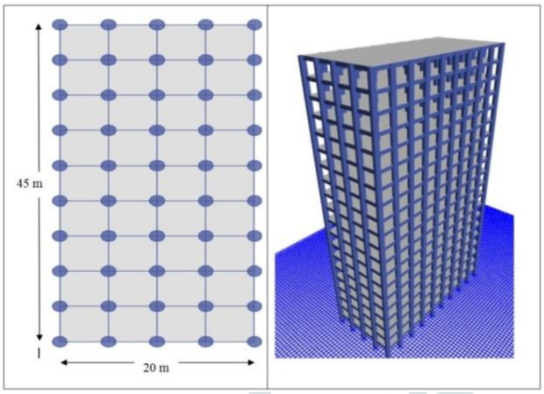


Fig-3 : Rectangular Shape

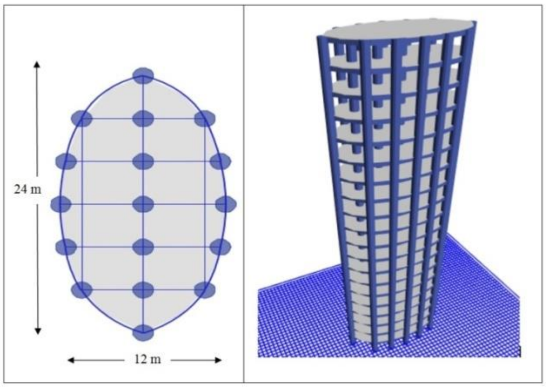


Fig-4 : Elliptical shape

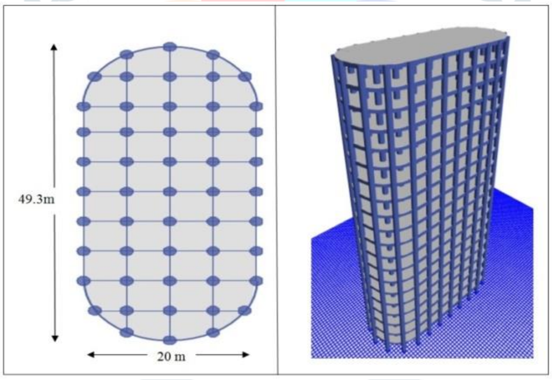


Fig-5 : Rectangular with two semi circle shape

IV. ANALYSIS AND RESULTS

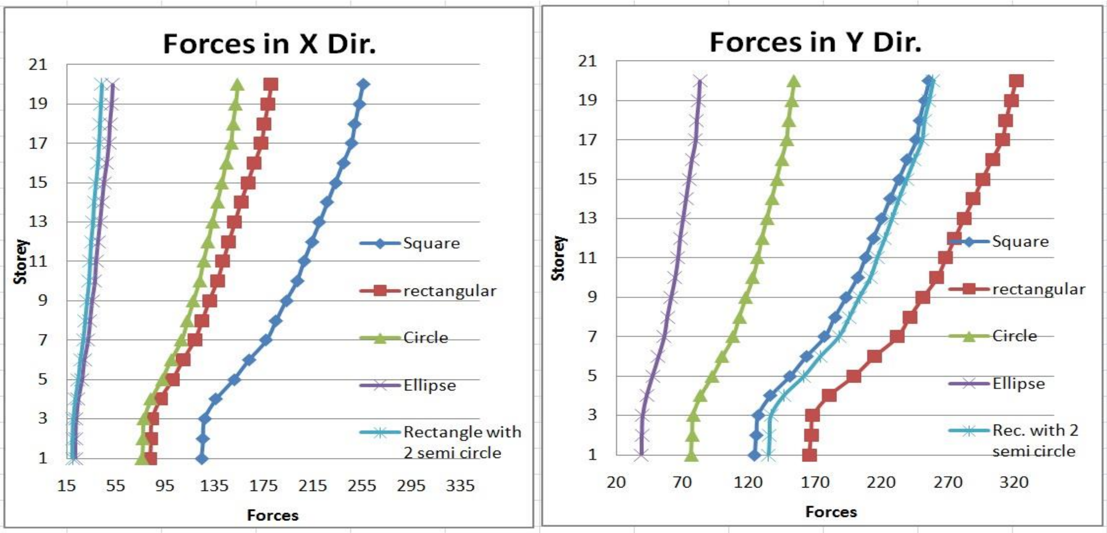
Results for regular shape building:

Table-2 Storey wise distribution of Forces for each model along X- direction

Storey	Forces (KN)				
	Square Shape	Rectangular Shape	Rectangle with two half circle	Elliptical Shape	Circular Shape
1	124.396	82.52491	19.80598	22.20633	76.35824
2	125.5914	83.39743	20.01538	22.43861	77.05269
3	126.8521	84.33627	20.2407	22.69452	77.77994
4	136.3424	90.86665	21.808	24.51724	83.53147
5	151.0605	101	24.24001	27.36069	92.45802
6	163.1053	109.3839	26.25213	29.73054	99.73319
7	177.0599	119.1537	28.59688	32.50819	108.1467
8	184.8893	124.7927	29.95026	34.13677	112.815
9	193.2031	130.8392	31.4014	35.89779	117.7576
10	201.9478	137.2687	32.94449	37.78895	122.9398
11	207.798	141.7766	34.02638	39.15725	126.3489
12	213.8793	146.534	35.16816	40.62568	129.8805
13	220.1497	151.5169	36.36407	42.19496	133.5105
14	226.5612	156.6905	37.60571	43.8637	137.2134
15	232.9877	161.9525	38.86859	45.6106	140.9186
16	239.5113	167.3316	40.15957	47.44792	144.6835
17	246.0724	172.7354	41.45651	49.34099	148.4816
18	248.7113	175.2493	42.05983	50.39739	149.9494
19	252.323	178.3001	42.79202	51.56189	152.0343
20	255.5387	180.8507	43.40416	52.46025	153.9209

Table-3 Storey wise distribution of Forces for each model along Y- direction

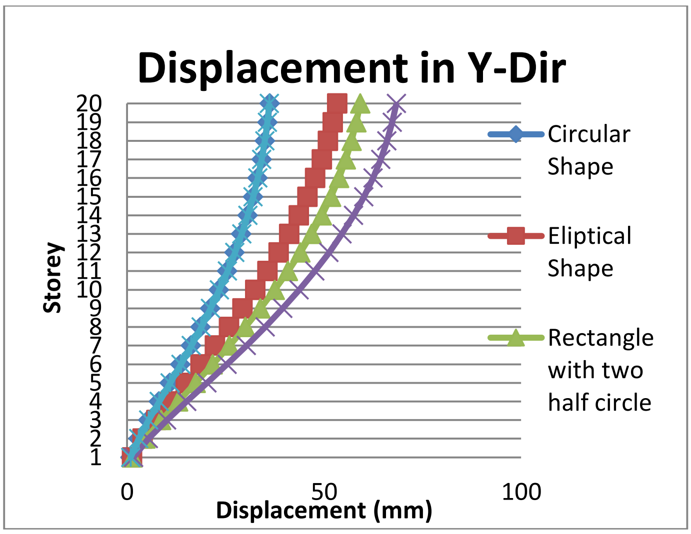
Storey	Forces (KN)				
	Square Shape	Rectangular Shape	Rectangle with two half circle	Elliptical Shape	Circular Shape
1	124.396	165.6074	134.665	39.00517	76.35824
2	125.5914	166.8679	135.615	39.40584	77.05269
3	126.8521	168.1655	136.5873	39.83325	77.77994
4	136.3424	180.2717	146.337	42.87234	83.53147
5	151.0605	199.1237	161.5425	47.58454	92.45802
6	163.1053	214.3417	173.7802	51.46617	99.73319
7	177.0599	231.8772	187.8676	55.978	108.1467
8	184.8893	241.3569	195.4217	58.55363	112.815
9	193.2031	251.3379	203.3646	61.30371	117.7576
10	201.9478	261.7442	211.6351	64.21397	122.9398
11	207.798	268.3431	216.8234	66.21582	126.3489
12	213.8793	275.1481	222.171	68.3133	129.8805
13	220.1497	282.1205	227.6494	70.49312	133.5105
14	226.5612	289.223	233.2325	72.73809	137.2134
15	232.9877	296.3307	238.8239	75.00269	140.9186
16	239.5113	303.5896	244.5459	77.30553	144.6835
17	246.0724	310.9739	250.3821	79.61522	148.4816
18	248.7113	313.6239	252.4381	80.61982	149.9494
19	252.323	317.6723	255.64	81.9043	152.0343
20	255.5387	321.4445	258.6453	83.01068	153.9209



Graph-1: Storey wise distribution of Forces for each model along X and Y- direction

Table-4 Displacement for each model along X-direction

Storey	Displacement (mm)				
	Square Shape	Rectangular Shape	Rectangle with two half circle	Elliptical Shape	Circular Shape
1	0.927	0.413	0.094	0.356	0.687
2	2.957	1.32	0.3	1.128	2.176
3	5.485	2.453	0.555	2.086	4.013
4	8.209	3.677	0.83	3.123	5.974
5	10.973	4.921	1.11	4.186	7.948
6	13.694	6.148	1.386	5.246	9.875
7	16.324	7.337	1.653	6.286	11.725
8	18.836	8.474	1.91	7.295	13.481
9	21.211	9.552	2.153	8.267	15.131
10	23.437	10.563	2.382	9.194	16.67
11	25.503	11.505	2.596	10.073	18.09
12	27.402	12.371	2.793	10.898	19.388
13	29.127	13.16	2.973	11.666	20.562
14	30.672	13.869	3.136	12.373	21.609
15	32.031	14.494	3.28	13.016	22.526
16	33.203	15.034	3.405	13.593	23.31
17	34.185	15.487	3.51	14.101	23.963
18	34.984	15.857	3.598	14.541	24.487
19	35.614	16.15	3.667	14.919	24.895
20	36.112	16.381	3.723	15.246	25.21



Graph-3:Comparison of Displacement Vs Storey for each model along Y- direction

VI. CONCLUSION

1. From the comparison between IS 875 part3 1987 and IS 875 part3 2015 it is conclude thatIS 875 part 3- 2015 gives mathematical equations instead of graphs. Hence new IS code is more precise than old one.
2. Building having Circular, Elliptical and Rectangle with two half circle plan forms a smaller surface perpendicular to the wind direction, Hence the wind presser is less than the buildings having Square and Rectangular plan.
3. Square shape and rectangular shape buildings are subjected to maximum wind forces in X direction and Y direction respectively, Related to this in X-direction percentage reduction in Circular, Rectangular, Rectangle with two semi circle and Elliptical shape buildings are 39.28%, 31.35%, 83.52% and 80.85% respectively. While in Y-direction percentage reduction in Square, Circular, Rec tangle with two semi circle and Elliptical shape buildings are 22.37%, 52.85%, 19.21%, and 75.19% respective. Hence it is conclude that in case of regular shape wind load is reduced by maximum percentage with an elliptical and rectangle with two semi circular in its longitudinal face.
4. The gust factor decreases with the height, because as the height of the frame increases the fundamental frequency decreases.

REFERENCES

1. A. J. Bowen, “Engineering aspects of the wind” Department of Mechanical Engineering, University of Canterbury, Christchurch.
2. [2] Dr. B.Dean Kumar, “Critical Gust Pressures on Tall Building Frames-Review of Codal Provisions” Dept. of Civil Engineering JNTUH College of Engineering Hyderabad, INDIA international Journal of Advanced Technology in Civil Engineering, ISSN: 2231 –5721, Volume-1, Issue-2, 2012.
3. Dr. K. R. C. Reddy and Sandip A. Tupat, “ The effect of zone factors on wind and earthquake loads of high-rise structures” Department of
Civil Engineering, Kavikul guru Institute of Technology and Science. Ramtek-441106, Dist. Nagpur, India IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X PP 53-58.

4 Jean-Paul Pinelli and Emil Simiu “Hurricane Damage Prediction Model for Residential Structures” Journal of Structural Engineering © Asce/ November 2004 / 1691.

5 Kiran Kamath, N. Divya, Asha U Rao, “A Study on Static and Dynamic Behaviour of Outrigger Structural System for Tall Buildings” Bonfring International Journal of Industrial Engineering and Management Science, Vol. 2, No. 4, December 2012.

6 K. Suresh Kumar, “Commentary on the Indian Standard for Wind Loads” RWDI India, T5 Thejaswini, Technopark, Trivandrum, Kerala, India 13th International Conference on Wind Engineering, Amsterdam, The Netherlands,July 10-15, 2011.

7 Khaled M. Heiza and Magdy A. Tayel ,”comparative study of the effects of windand earthquake loads on high-rise buildings” CivilEngineering Department, Faculty of Engineering, Menoufiya University, EGYPT.

8 Muhammad AzharSaleem, “wind load calculations: is simplification possible” Department of Civil Engineering, University of Engineering and Technology Lahore, Pakistan Pak. J. Statist.2012 Vol. 28(4), 485-493.

9 M.R Suresh,PradeepK.M,“Influence of Outrigger System in RC Structures for Different Seismic Zones”International Journal for Scientific Research & Development Vol. 3, Issue 05, 2015 ISSN (online): 2321-0613.

10 R. M. FAYSAL,” Comparison of Wind Load among BNBC and other Codes in different type of areas.” Faculty of Civil Engineering, Bangladesh University of Engineering and Technology, Bangladesh, International Journal of Advanced Structures and Geotechnical
Engineering ISSN 2319-5347, Vol. 03, No. 03, July 2014.

11 Yin Zhou, Tracy Kijewski, and Ahsan Kareem,” along-wind load effects on tall buildings: comparative study of major international codes and standards” M.ASCE3Journal Of Structural Engineering / June 2002 / 789.

12 American Standard ASCE 05-7, “Minimum Design Loads for Buildings and Other Structures”.

13 A Commentary on Indian Standard Code of practice for design loads (other than earthquake) For buildings and structures Part 3 Wind Loads (Second Revision)by Dr.PremKrishna,Dr. Krishan Kumar,Dr. N.M.BhandariDepartment of Civil EngineeringIndian Institute of Technology
Roorkee.

14 An Explanatory handbook on “Indian Standard Code Practice for Design Loads” (other than earthquake) for buildings and structures part 3 wind loads [IS 875 (Part 3): 1987]” , Bureau of Indian standards, New Delhi.

15 An Explanatory handbook on “Proposed IS 875 (Part 3) wind loads on buildings and structures” by Dr. N. M. Bhandari, Dr. Prem Krishna, Dr.Krishen Kumar, Department of Civil engineering, Indian Institute of Technology, Roorkee and Dr.Abhay Gupta, Department of Civil engineering, Shri. G. S. Institute of Technology and Science, Indore.

16 Indian Standard IS 875 (Part-3):1987, Code of practice for design loads (Other than earthquake) for buildings and structures”

17 Taranath, B. S, Wind and earthquake resistant buildings; structural analysis and design.(Second Edition, Mc Graw – Hill Publications, 1988).

18 Taranath, B. S, “Reinforced Concrete Design of Tall Buildings”.