# 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:**

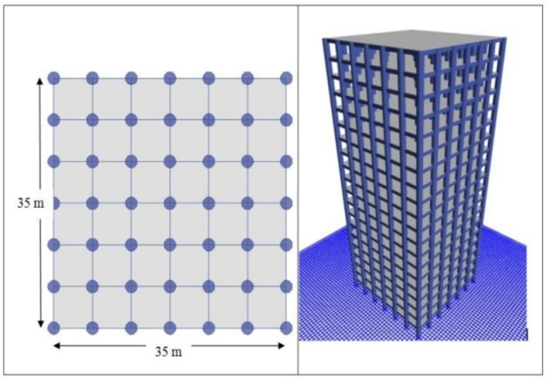



Fig-1 : Square Shape

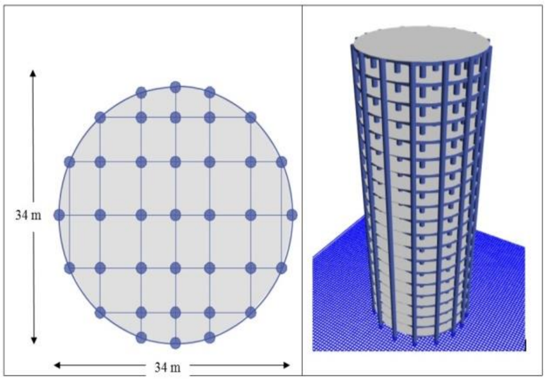



Fig-2 : Circular Shape

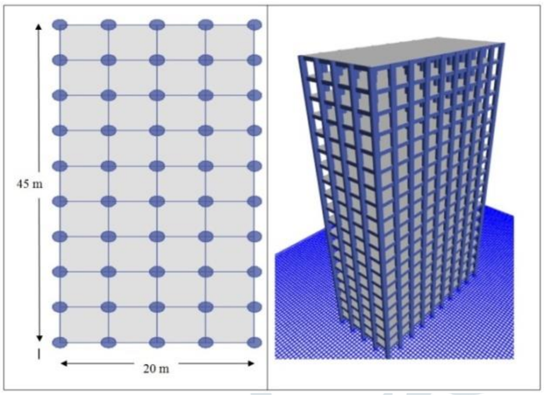



Fig-3 : Rectangular Shape

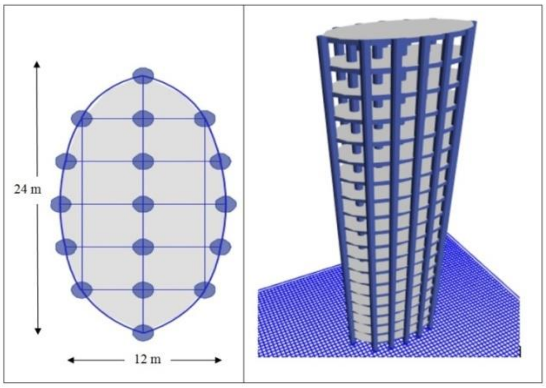



Fig-4 : Elliptical shape

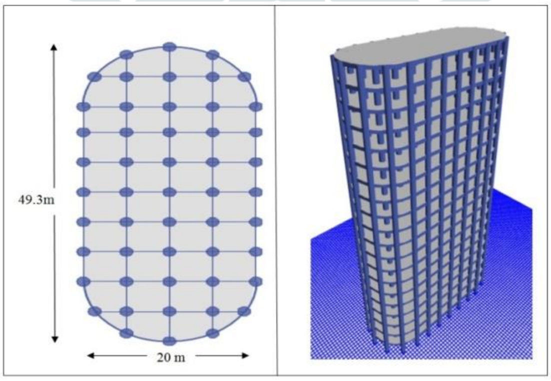



Fig-5 : Rectangular with two semi circle shape

## IV. ANALYSIS AND RESULTS

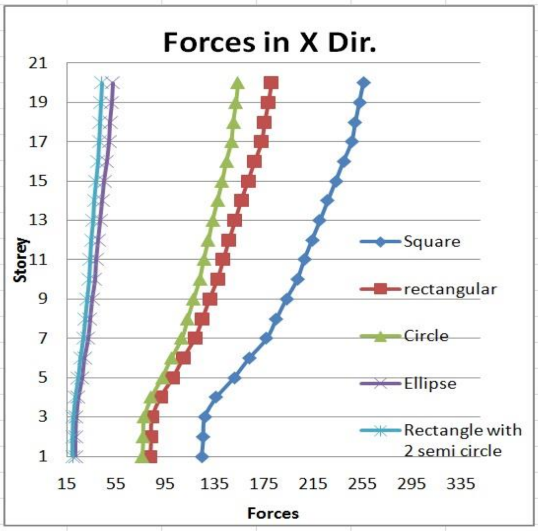
**Results for regular shape building:**

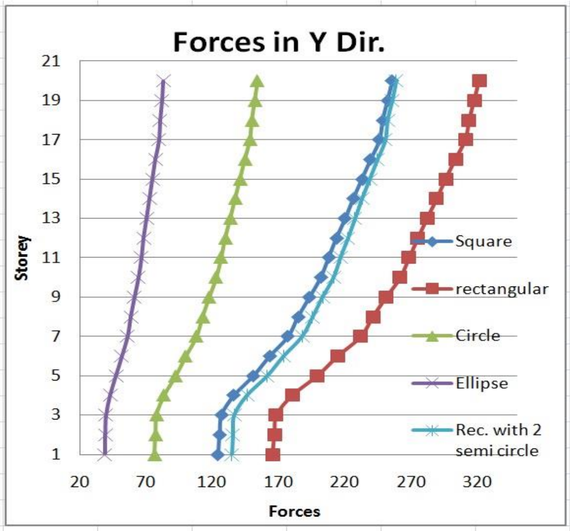
**Table-2 Storey wise distribution of Forces for each model along X- direction**

| 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 |

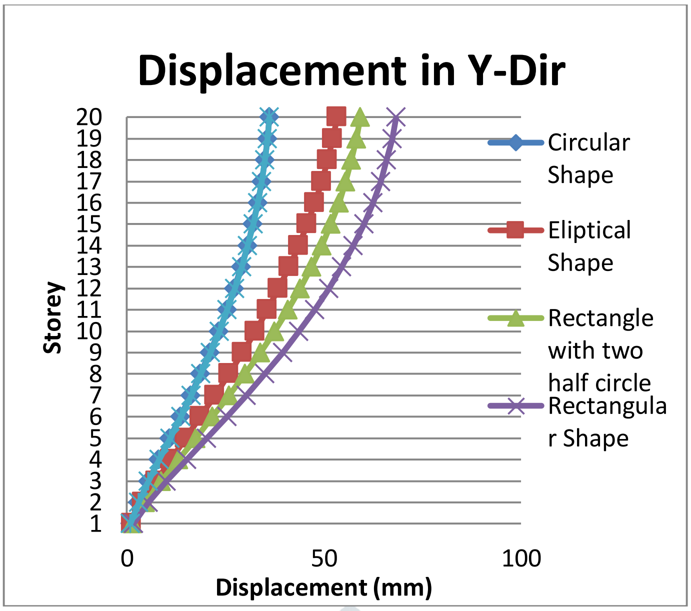



**Graph-1: Storey wise distribution of Forces for each model along X and Y- direction**

**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.

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