Multistory Building Along And Across Wind Analysis

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Abstract- *Wind is a perceptible natural motion of air relative to earth surface especially in the form of air current blowing in a particular direction .The major harmful aspect which concern to civil engineering structures is that, it will load any and every object that comes in its way. Wind blows with less speed in rough terrain and higher speed in smooth terrain present study is based an to determine .Wind load is really the result of wind pressures acting on the building surfaces during a wind event.*

This wind pressure is primarily a function of the wind speed because the pressure or load increases with the square of the wind velocity. Structural walls, or shear walls, are elements used to resist lateral loads, such as those generated by wind and earthquakes .The effect of gust factor method multistory building along wind and across wind analysis of IS 875 part 3 (2015) on difference H/B ratio and different terrain category for along and across wind analysis. There are several model analysis using ETAB-2016.

Keywords- wind, terrain category, along wind , across wind , ETAB 2016

I. INTRODUCTION

T Movement of air with respect to the earth surface is known as wind. Earths‟‟ rotation and terrestrial radiation differences are the major causes of wind. The effects of the radiation are mainly accountable for either upward or downward convection. Generally at high wind speeds, the wind blows to the ground horizontally.

Vertical components of atmospheric motion are comparatively small. Thus the term wind almost exclusively means the horizontal wind. The capability of a structure to withstand enormous pressure of the wind depends on geography, nearness of other hindrances to the flow of air and also depends on the characteristics of the structure. The combined action of internal and external pressure acting on the structure as whole determines the effect of wind on it. In all cases, the computed wind load acts normally to the surface to which they apply.

Combined and separate effects of wind loads and imposed loads on vertical Mean plus a fluctuating component constitutes Wind velocity. Gust will be created if the momentary deviation of the fluctuating component occurs from the mean value. Both of these components of wind velocity depends upon the approach terrain and varies with the height. The irregular shapes and square RC 3-

1) D bare frame structures are studied for dynamic wind load cases. Wind analysis has been conducted as per IS: 875(part 3)-2015. The FEM software package ETABS 16 has been used for the modeling and analysis of the RC bare frames. Storey drift, Storey displacement and their variations are analyzed for dynamic wind load cases.

II. DESIGN PROCEDURE

Design Wind Speed

Speed of the wind in the atmospheric boundary layer increases with increase in height from ground level to top level at a height called as the gradient height. The variation with height depends mainly on the terrain conditions. However, the speed of the wind at any height never remains constant. It has also been found easier to determine its instantaneous magnitude to an average value and a fluctuating component near this average value. Peak gust velocity remains constant over a short period of time, of about 3 seconds for basic wind speed and corresponds to mean heights in an open terrain above ground level. As mentioned in the code, our country is divided into six different regions. As far as the basic wind speed is concerned, the basic wind speeds in six regions are 33, 39, 44, 47, 50 and 55 m/s respectively. The basic wind speed shall be modified to include risk level, terrain roughness, height of the structure and local topography to get the design wind velocity,

Vz given as:

Vz= Vb. K1. K2. K3 (of IS: 875 (Part 3) - 2015**)**

Where,
VZ = Design wind speed at any height z in m/s

Vb = Basic wind speed for different zones
K1 = Probability factor (risk coefficient)
K2 = Terrain roughness and height factor
K3 = Topography factor

1) Risk coefficient (K1):

The suggested life period to be assumed and the corresponding K1 factor for different class of structures as per IS: 875 (Part 3)

2) Terrain and height factor (K2):

Terrain categories shall be selected with due regard given to the effect of obstruction, which constitute the ground surface. The terrain category used in the design of structure varies depending on the direction of wind under consideration. Terrain in which a specific structure stands shall be considered as being one of the following terrain categories.

a) Category 1

Exposed open terrain with few or no obstructions in which the mean height of any object that surrounds the structure is less than 1.5 m. Open sea-coasts and flat treeless plains are included in this category.

b) Category 2

Open terrain having well scattered obstructions with heights usually between 1.5 to 10m. This is the criterion for measuring regional basic wind speeds and includes open parklands, airfields and undeveloped sparsely built outskirts of suburbs and towns. Open land adjacent to sea coast also comes under Category 2, because of the roughness of large sea waves at high wind speeds.

c) Category 3

Terrain with many closely spaced obstructions having the size of building structures this category includes well wooded areas and shrubs, towns and industrial areas full or partially developed.

d) Category 4

Terrain with plenty of large high closely spaced obstructions . This category includes large city centers, generally with obstructions above 25m and well developed industrial complexes.

3) Topography Factor (K3):

The basic wind speed Vb, considers general level of site above the sea level. This does not allow for local topographic features such as valleys, hills, cliffs, ridges or escarpments, which can significantly affect wind speed in their vicinity. The effect of topography is to accelerate wind near the summits of hills or crests of cliffs, escarpments or ridges and decelerate the wind in valleys or near the foot of cliffs, steep escarpments or ridges.

The effect of topography is of significant importance at a site when the required slope is greater than about 3°, and below that, the value of K3 may be taken as equal to 1.0. The value of K3 is confined in the range of 1.0 to 1.36 for slopes greater than 3°.

Design Wind Pressure

The design wind pressure at any height above mean level can be obtained by the following relationship between wind pressure and wind velocity:|

$$PZ=0.6\ Vz^2$$

Where,

PZ = Design wind pressure in N/m2 at height z m
VZ **=** design wind velocity in m/s at height z m

Wind Load on Individual Members: (IS: 875 (Part 3)

$$F = (Cpe - Cpi)\ APz$$

Where, Cpe = external pressure coefficient,
Cpi = internal pressure- coefficient,
A = surface area of structural or cladding unit and
Pz = design wind pressure.

Parameters considered for the study

Number of Storey 30
Bottom Storey height 3m
Storey height 3m
Type of building use residential buildings
Foundation type Isolated footing
Soil type Medium
Wind zone III
Shape of buildings rectangular shape and square shape
Material Properties
Grade of concrete M30

Young’s modulus of concrete, Ec

$25.0*10^6 kN/m^2$

Grade of steel Fe 415

Density of reinforced Concrete

25 kN/m^3

Poisson’s Ratio of reinforced concrete

0.25

Member Properties

Thickness of slab 0.125m
Beam size 0.45*0.75m
Column size 0.85*0.85m
Dead load (DL) intensities
Floor finish on floors 1.5 kN/m2
Floor finish on roof 2 kN/m2
Live load (LL) intensities
Live load on floors 3 kN/m2
Live load on roof 2 kN/m2

Linear Analysis

Bottom Storey height= 3m,
Each Storey height= 3m

The maximum dimension of the building is above 50m, hence it is classified in to “Class C”, and Terrain Category 1-4 has been considered for the bare frame models, k1=1 Slope below 30, k3=1, Where k2 value (IS: 875(part 3)-2015).

GUST FACTOR

A gust factor is defined as the ratio between a peak gust and mean speed over a period of time. It can be used to examine the structure of the wind along with other statistics. The magnitude of fluctuating component of the wind speed, called gust, depends on the averaging time. Gust factors are heavily dependent on upstream terrain conditions (roughness), and are also affected by transitional flow regimes (specifically, changes in terrain and the distance from the upstream terrain change to the measuring device), Anemometer height, stability of the boundary layer, and potentially, the presence of deep convection.

Wind load calculation as per IS: 875 (part – 3) – 1987 with gust factor method for 20 floors in zone-1 (33 m/s)

Time Period Calculation:

h = 60m (height of structure)
dx = 40m (dx = plan dimension in X- direction)
dy = 40m (dy = plan dimension in Y-direction)
Tx = 0.09h / d …… **(From page – 48)**
Tx = 0.853 sec Ty = 0.853 sec

*** Along wind**

1.F_z=$\mathbf{C_f A_e P_d G}$
F_z= design peak along wind load on the building! structure at any height z

2. $\mathbf{P_d}$=design hourly mean wind pressure corresponding to $\mathbf{P_z=0.6V_z^2}$ (N/m^2)

$\mathbf{C_f}$ = the drag force coefficient of the building! structure corresponding to the area Az

3.V z,H = $K_2 v_b$

K_2= hourly mean wind speed factor for terrain category

$$K_2=\mathbf{0.1423[\ln(z / z_{0i})]\,(z_{0i})^{0.0706}}$$

4. r = roughness factor which is twice the longitudinal turbulence intensity, $I_{h,i}$

5. B_s= background factor indicating the measure of slowly varying component of fluctuating wind load caused by the lower frequency wind speed variations

$$\frac{1}{1+\frac{\sqrt{0.26(h-s)^{\wedge}2*0.46bs}}{Lh}}$$

6. $L_{h=}$ measure of effective turbulence length scale at the height, h, in m

$85*(h/10)^{0.25}$ for terrain category 1 to 3
$70*(h/10)^{0.25}$for terrain category 4

7. Φ = factor to account for the second order turbulence intensity

$$(g_h I_{h,I}\sqrt{b_s})/2$$

8. H_s=height factor for resonance response

$$H_s=1+(s/h)^2$$

9. S=size reduction factor given by:

$$\frac{1}{[1+\frac{3.5\,fah}{vh}][1+\frac{4\,fbh}{vh}]}$$

10. E =spectrum of turbulence in the approaching wind stream

$$\boldsymbol{\Pi N/(1+70.8N^2)^{0.833}}$$

11. β= damping coefficient of to be building/structure
Bolted steel/RCC structures β : 0.020

12. N= effective reduced frequency

$$\boldsymbol{F_a L_h/V_{hd}}$$

13. G_R=peak factor for resonant response

$$\sqrt{[2\ell n3600\,fa]}$$

14.G= Gust Factor and is given by

$$\boldsymbol{G= 1+r\sqrt{[g_v^2 B_s(1+g)^2+H_s g_R^2\, SE/\beta]}}$$

*** Across wind**

1.g_{h} =a peak factor

$$\sqrt{[2\ell n3600\,fa]}$$

2. **P_d**=design hourly mean wind pressure corresponding to

$$\boldsymbol{P_z=0.6V_z^2}\ (\mathrm{N/m^2})$$

3. V z,H = $K_2 v_b$

K_2= hourly mean wind speed factor for terrain category

$$K_2=\boldsymbol{0.1423[\ln(z/z_{0i})](z_{0i})^{0.0706}}$$

4. b =the breadth of the structure normal to the wind, in m;
h = the height of the structure, in m;

5. f_a = first mode natural frequency of the building! structure in across wind direction, in Hz.

6. k = a mode shape power exponent for representation of the fundamental mode shape as represented by:

$$\boldsymbol{(z/h)^k}$$

7. C_{fs} = across wind force spectrum coefficientgeneralized for a linear mode

Is 875 -2015 page no. (49,50)

8.across wind design peak base bending moment=M_c

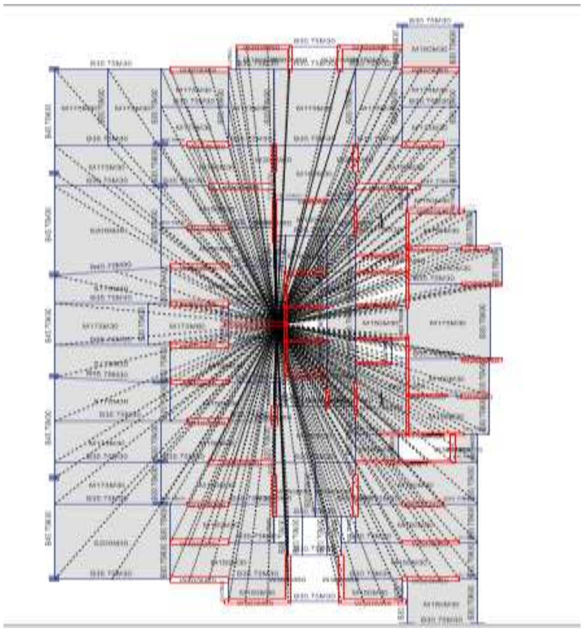
$$\boldsymbol{M_c=0.5g_h\,p_h bh^2(1.06-0.06k)(\Pi C_f)^{0.5}}$$

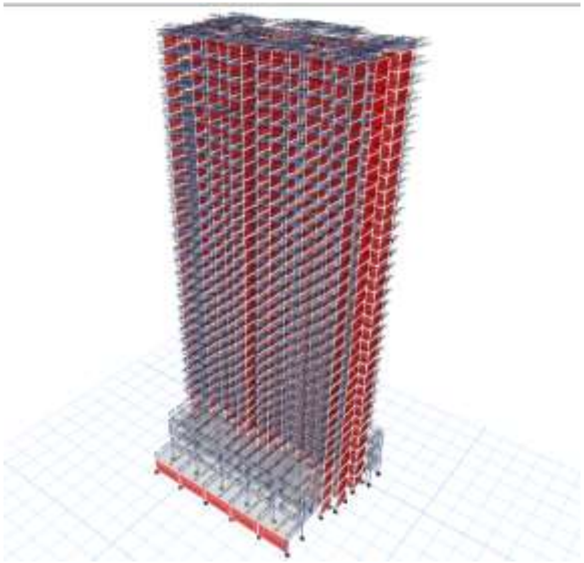
9. The across wind load distribution on the building structure can be obtained from M_c using linear distribution of loads as given below

$$\boldsymbol{F_{z,c}=(3M_c/h^2)(z/h)}$$

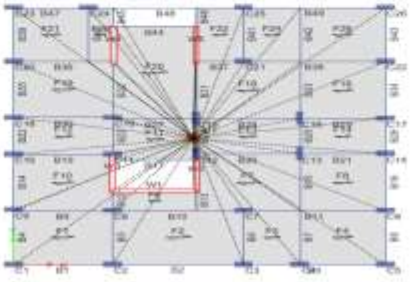
Modeling in ETABS 16

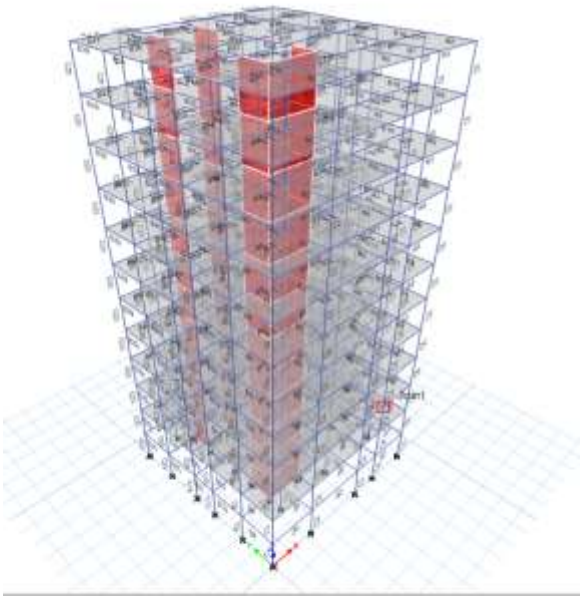
Rectangular model



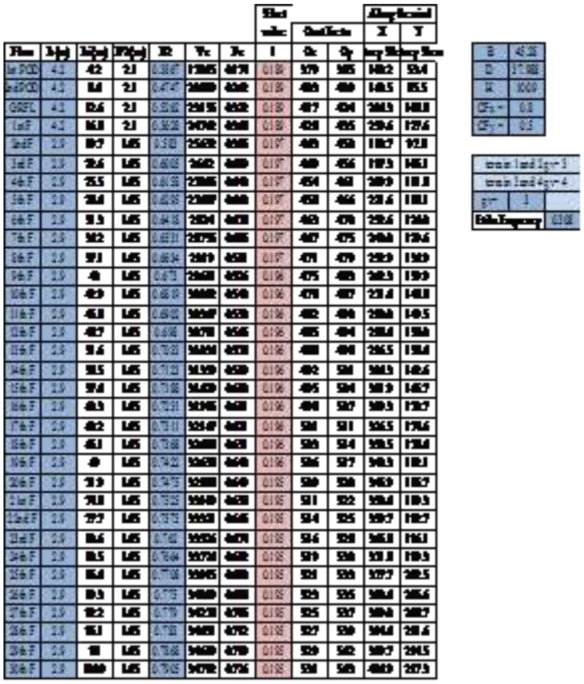


Square model

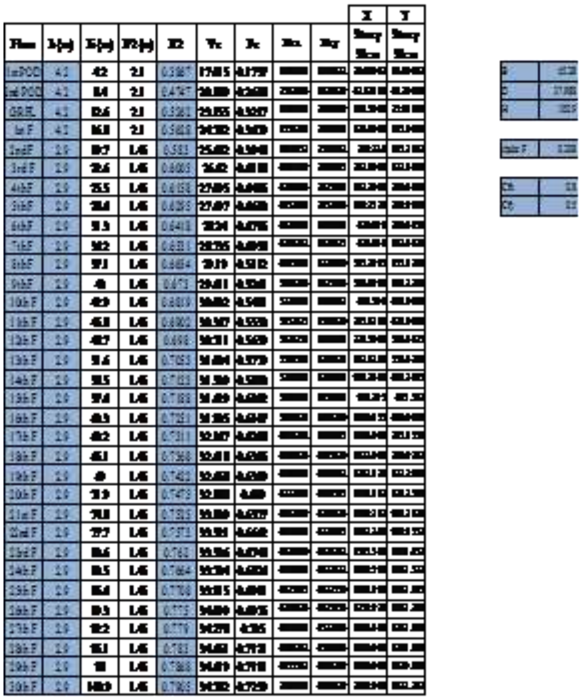




Wind load calculation with gust factor for 30 floors rectangular shape in as per IS: 875 (part-3) – 2015 terrain category 1 (along wind)

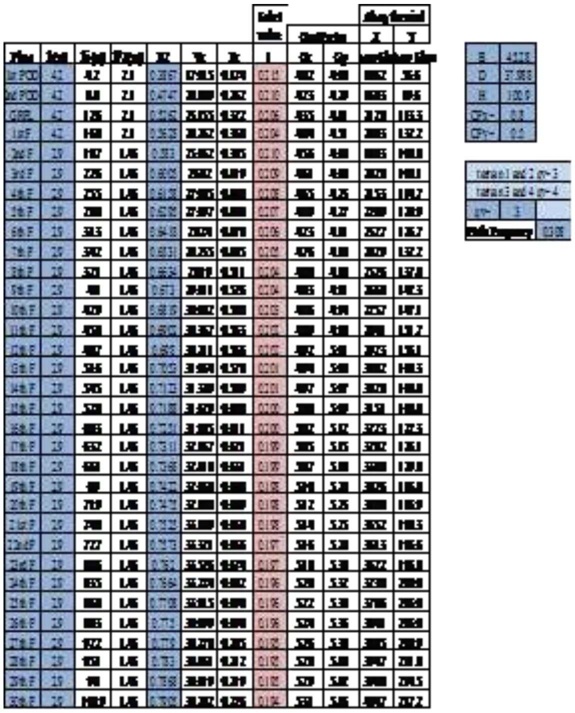


Wind load calculation with gust factor for 30 floors rectangular shape in as per IS: 875 (part-3) – 2015 terrain category 1 (across wind)

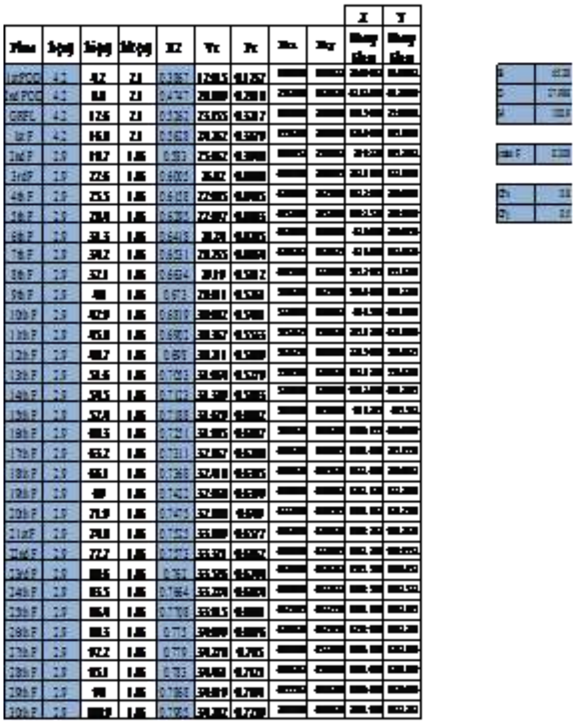


Dynamic analysis

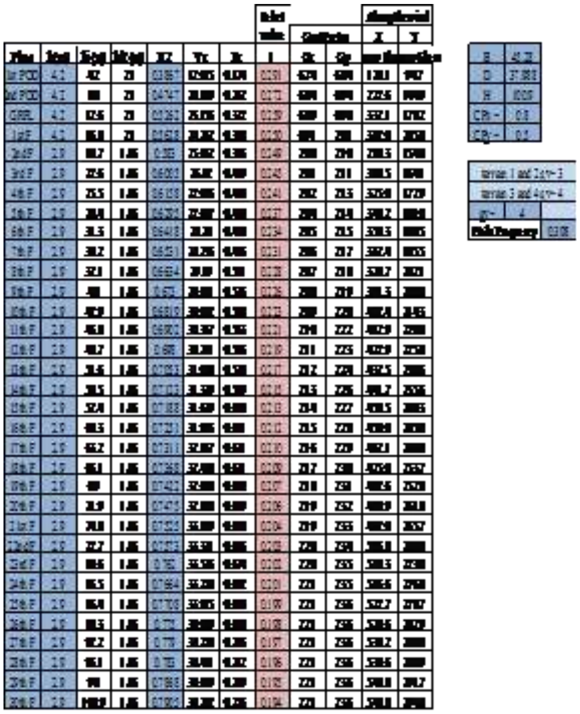
Wind load calculation with gust factor for 30 floors rectangular shape in as per IS: 875 (part-3) – 2015 terrain category 2 (along wind)



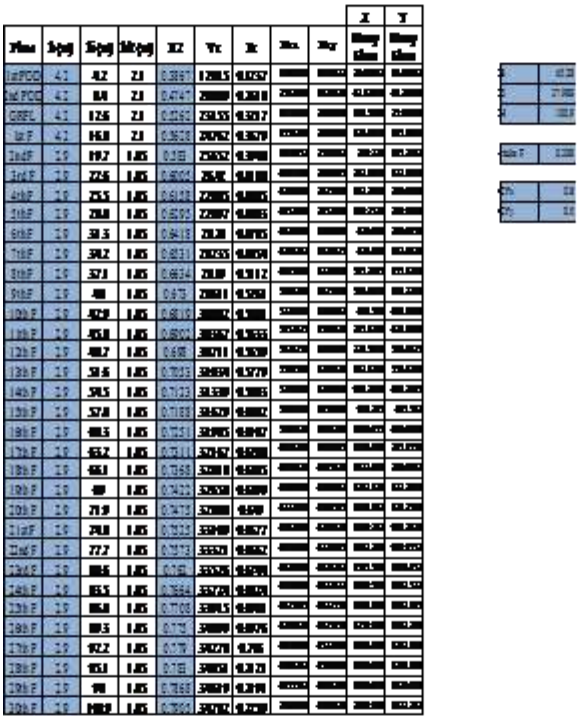
Wind load calculation with gust factor for 30 floors rectangular shape in as per IS: 875 (part-3) – 2015 terrain category 2 (across wind)



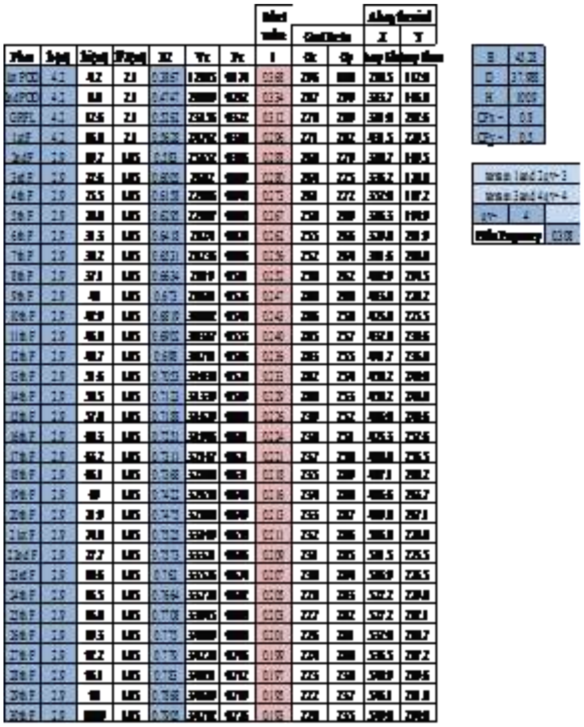
Wind load calculation with gust factor for 30 floors rectangular shape in as per IS: 875 (part-3) – 2015 terrain category 3(along wind)



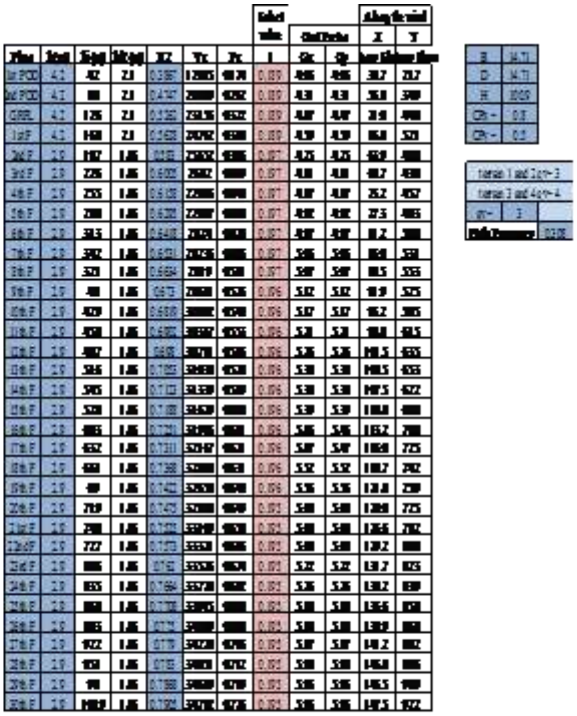
Wind load calculation with gust factor for 30 floors rectangular shape in as per IS: 875 (part-3) – 2015 terrain category 3(across wind)



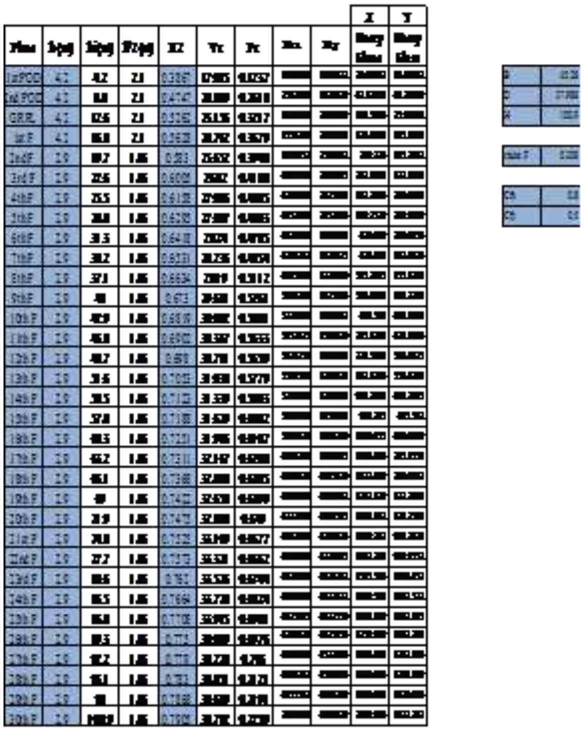
Wind load calculation with gust factor for 30 floors rectangular shape in as per IS: 875 (part-3) – 2015 terrain category 4(along wind)



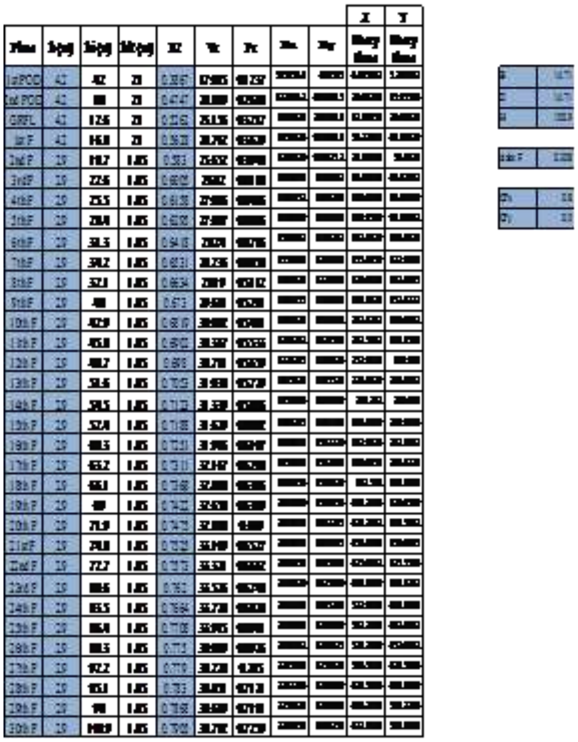
Wind load calculation with gust factor for 30 floors square shape in as per IS: 875 (part-3) – 2015 terrain category 1(along wind)



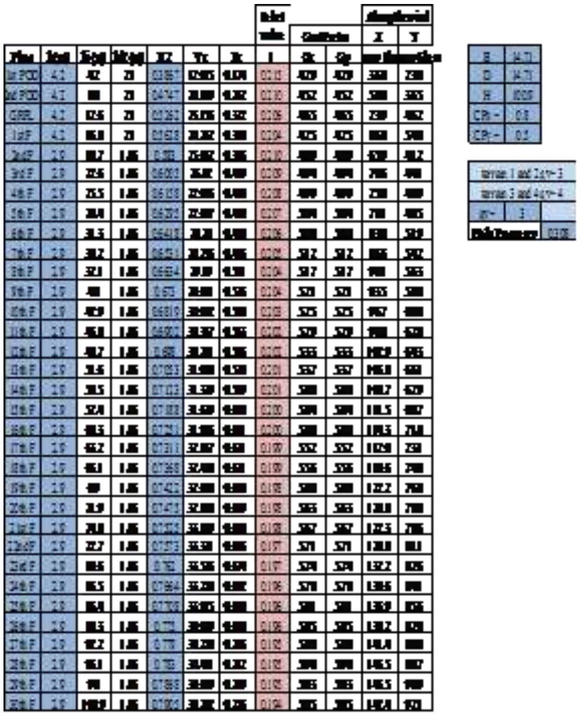
Wind load calculation with gust factor for 30 floors rectangular shape in as per IS: 875 (part-3) – 2015 terrain category 4(across wind)



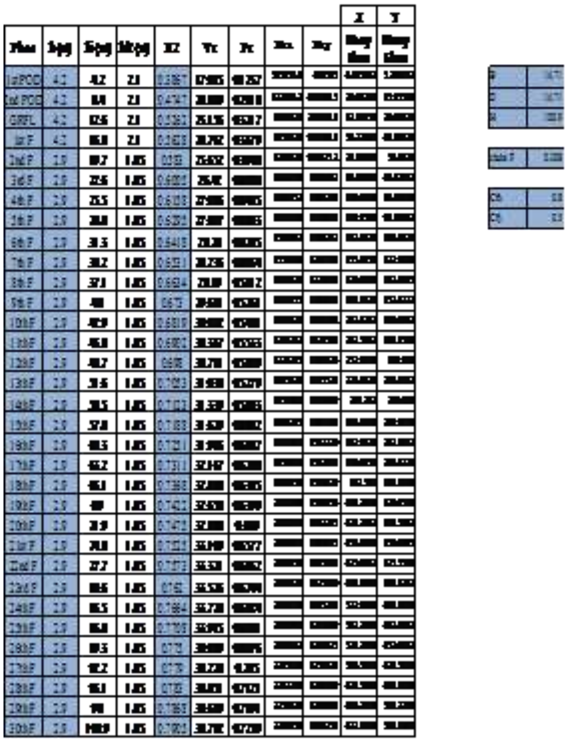
Wind load calculation with gust factor for 30 floors square shape in as per IS: 875 (part-3) – 2015 terrain category 1(across wind)



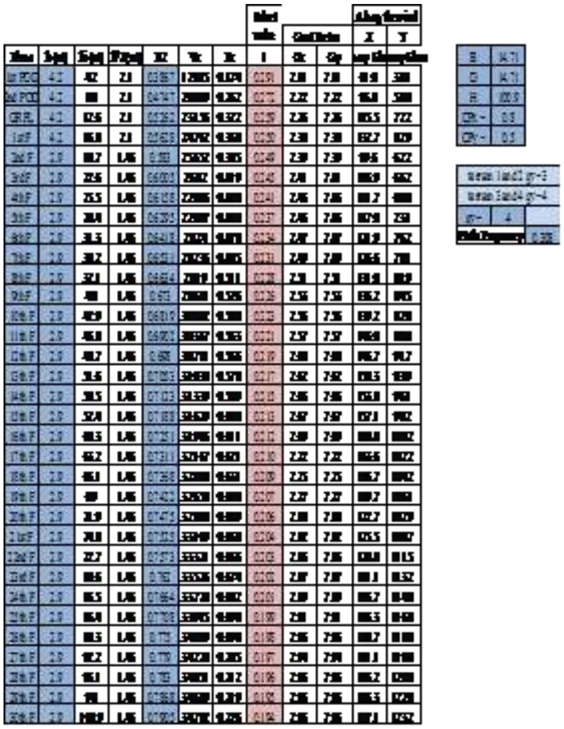
Wind load calculation with gust factor for 30 floors square shape in as per IS: 875 (part-3) – 2015 terrain category 2(along wind)



Wind load calculation with gust factor for 30 floors square shape in as per IS: 875 (part-3) – 2015 terrain category 2(across wind)



Wind load calculation with gust factor for 30 floors square shape in as per IS: 875 (part-3) – 2015 terrain category 3(along wind)



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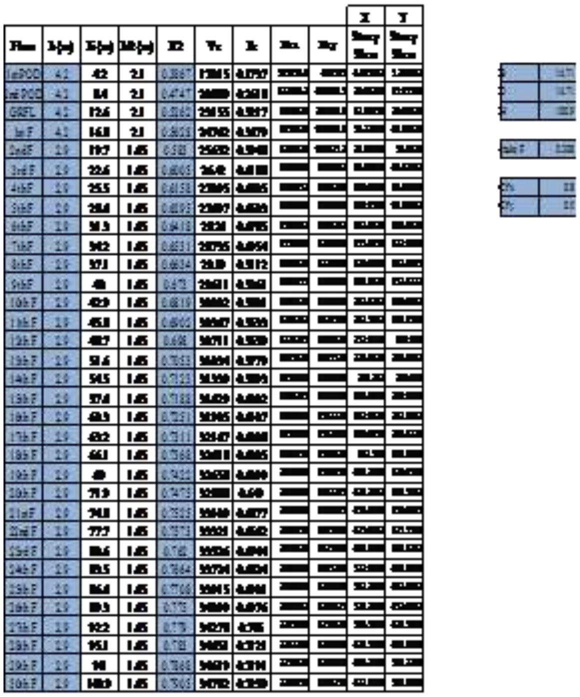

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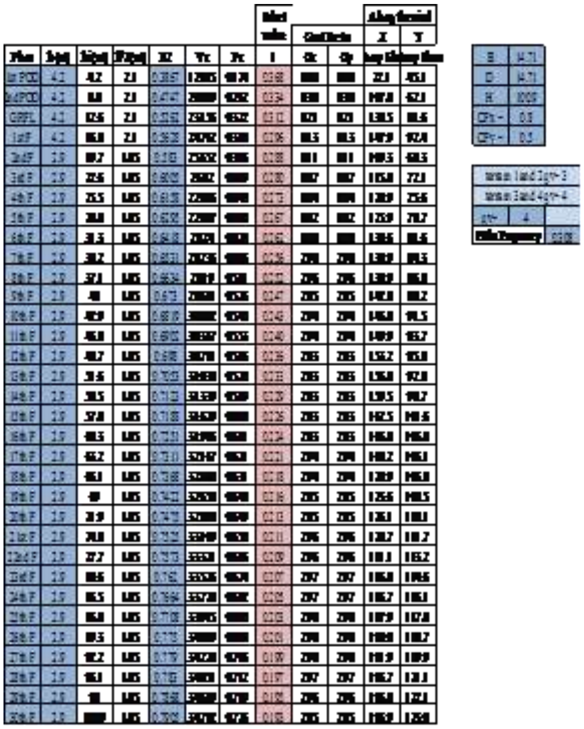

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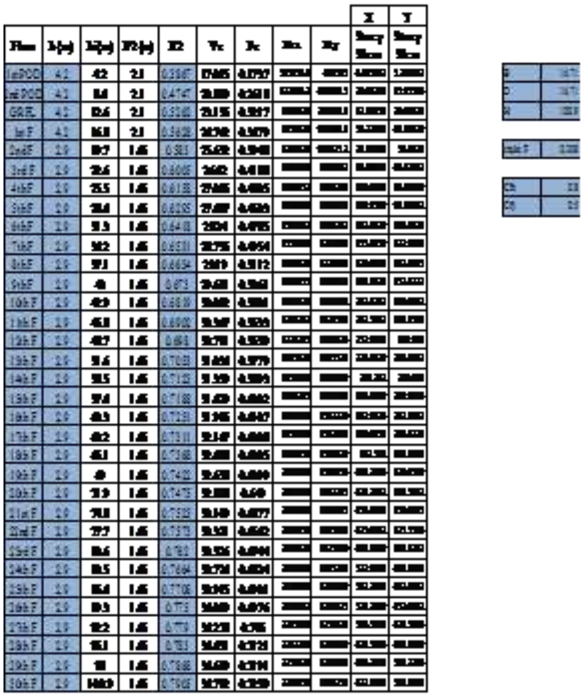
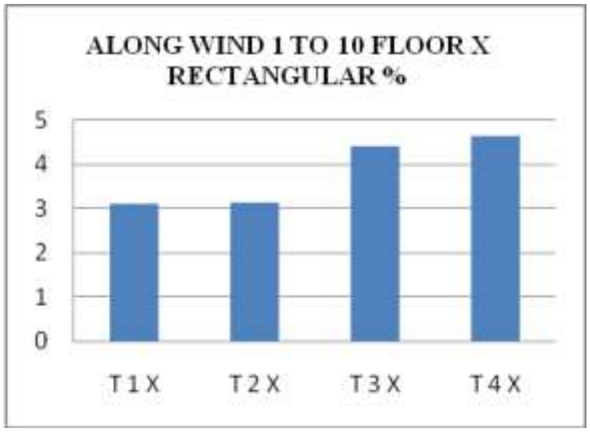
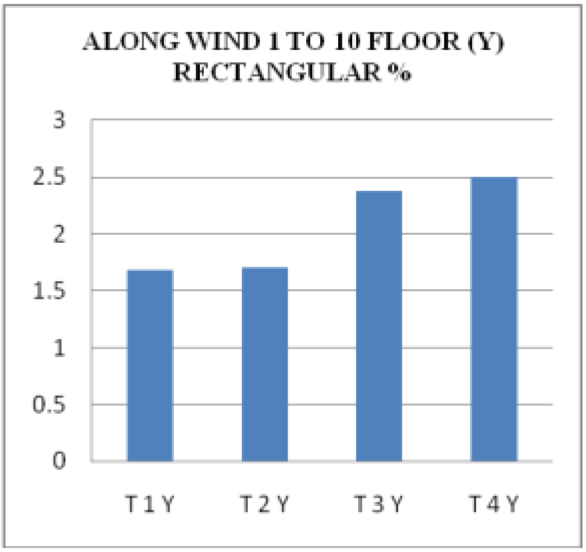
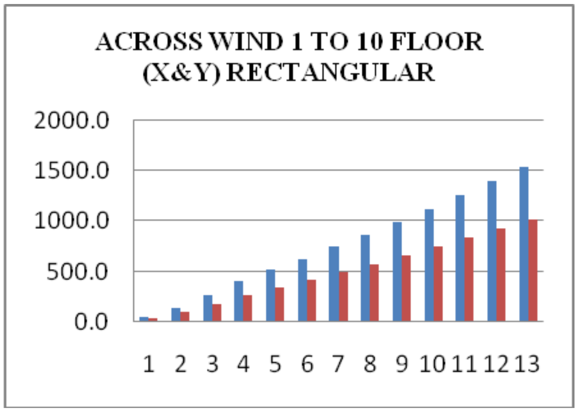


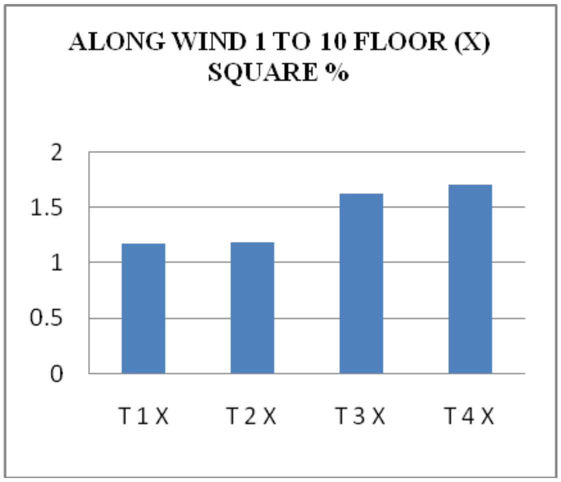
Rectangular plan:

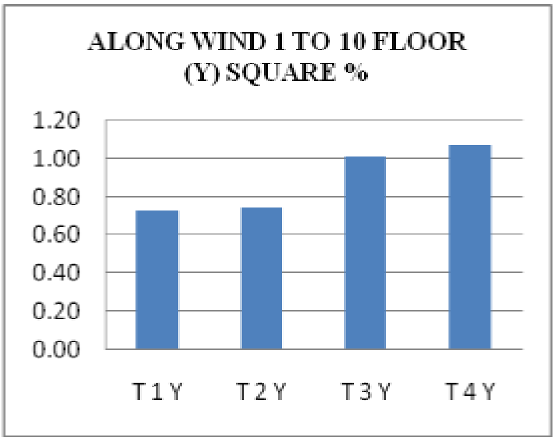


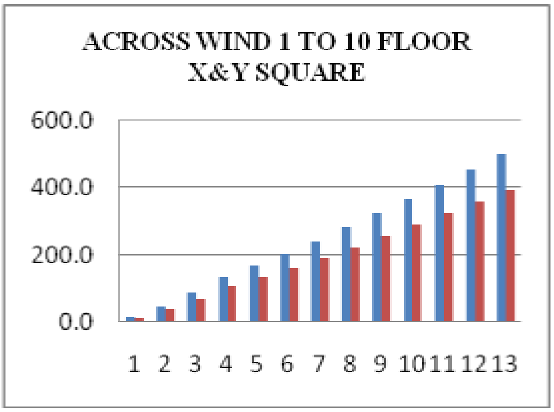




Square plan:







III. CONCLUSION

- As the height of the model increases, deflection on top storey also increases
- The determine wind analysis study high rise building are done MS EXCEL as per is 875 2015 for this purpose wind loading in term of along and across analysis done different condition the results of the analysis are show below in this graph.

IV. FUTURE SCOPE

- Building analysis is done here by taking different condition height of building but it is suggested to exclusive experimental test building will be carried out in wind tunnel test to check and compare the analytical and experimental results.
- Infill walls may be considered and the effect of which can be observed.
- Analysis can be carried out for different heights and remaining wind zones.

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