ASPS Conference Proceedings 1: 1505-1515 (2022)

Proceedings of

12th Structural Engineering Convention-An International Event (SEC 2022)

Available at https://asps-journals.com/index.php/acp

Study of Along and Across Wind Load effects on RCC Chimneys

Gagandeep Singh [1], Kinchit Saxena [2, *], Girish Shenai [3]

[1] Engineer, LWR, Nuclear Power Corporation of India Limited, Mumbai, India
[2] Scientific Officer-E, Bhabha Atomic Research Centre, Mumbai, India
[3] Scientific Officer-H, Bhabha Atomic Research Centre, Mumbai, India

Paper ID - 140433

Abstract

Chimney is a hollow, tall and slender structure to discharge smoke or pollutants at a height so that after dilution due to atmospheric turbulence, their concentration and that of their entrained solid particulates is within acceptable limits on reaching the ground under various atmospheric conditions. As large scale industrial developments are taking place all over the world a large number of chimneys would be required to be constructed. As for chimneys the predominant load is mainly wind load. This paper is aimed at deriving standard curves with the help of which one can easily calculate approximate wind load on chimney in shell completed condition. The curves have been plotted for chimneys of various heights, top internal diameter, taper and located in different wind zones. The importance of these curves would be in finalization of initial sizing of chimney and its supporting structure. Wind Analysis is done as per code IS 4998: 2015 and IS 875 (Part 3): 2015. SAP 2000 software is used to determine mode shapes. MS-Excel spreadsheets are used for loading calculations.

Keywords: Along wind load, Across wind Load, Reinforced cement concrete (RCC) Chimneys, wind zone, wind speed

1. Introduction

Chimneys are very important structures for the emission of poisonous gases in major industries and power plants. The combustion flue gases inside the chimney or stacks are much hotter than the ambient outside air and therefore less dense than ambient air. This causes the bottom of the vertical column of hot flue gases to have a lower pressure than the pressure at the bottom of the corresponding column of outside air. The higher pressure outside the chimney is the driving force that moves the required combustion air into the combustion zone and also moves the flue gas up and out of the chimney. Generally, chimneys are constructed with different type of materials i.e., masonry, concrete, steel.

An RCC chimney poses no boundaries on geometry like steel chimneys. RCC chimneys are preferable for heights larger than 65m (Saida & Narasaiah, 2018), incorporating the applicable criteria that follow.

1.1 Literature Review

The literature review is done on analysis and design of RCC chimneys with consideration to wind loading. The following literatures were available on RCC chimney analysis and design:

(Reddy, Jaiswal, & Godbole, 2011) considered two different tall RCC chimneys of height 220 m and 217 m, one with uniform taper and other with four tapers and analyzed these chimneys for wind and earthquake loading. The methodology for modelling of chimney was also discussed. The analysis concluded that wind loads are always governing the design of chimney. [1]

(Reddy, Srikant & Padmavati, 2012) considered 275m RCC chimney to discuss along and across wind loading in different wind zones. It was found that, for lower wind zone i.e. wind zone I across loads are governing and for higher i.e. wind zone-VI along wind loads are governing.

(Nagar, M, & Soumya, 2015) considered three different profiles of RCC chimney along height- uniform chimney, tapered chimney and uniform-tapered chimney. Both earthquake and wind analysis was performed. Height of chimney used varied from 150 to 300 m. Study concluded that uniform tapered was the best section considering the wind and seismic analysis.

(Shaikh & Khan) analysed 220m high chimney for wind and earthquake loading. Along wind loads were calculated using peak factor method as well as gust factor method while acrtoss wind loas were calculated using simplified procedure as well as by random response method. Analysis concluded that effect of seesmic forces is higher than wind forces only for top most sections (approximately top 1/6th of height). Elsewhere wind forces are governing along height of chimney.

1.2 Loads on Chimney

Chimney is subjected to Dead loads, Lateral earth pressure, Thermal loads, Seismic loads and Wind loads. Wind forms the predominant source of loads in chimneys.

*Corresponding author. Tel: +919869385289; E-mail address: rajkinchit@gmail.com, kinchit@barc.gov.in

Proceedings of the 12th Structural Engineering Convention (SEC 2022), NCDMM, MNIT Jaipur, India| 19-22 December, 2022

Published online: December 19, 2022
doi:10.38208/acp.v1.682

The effect of wind can be divided into two components, along-wind effects and across-wind effects.

A. Along wind effects

- Along wind loads are caused by the 'drag' component of the wind force on the chimney. This is accompanied by 'gust buffeting' causing a dynamic response in the direction of the mean flow. Along-wind effect is due to the direct buffeting action, when the wind acts on the face of a structure.
- For the purpose of estimation of these loads the chimney is modelled as a cantilever fixed at the base. The wind is then modelled to act on the exposed face of the chimney causing predominant moments in the chimney.
- Additional complications arise from the fact that the wind does not generally blow at a fixed rate. Wind generally blows as gusts, this requires that the corresponding loads and hence the response be taken as dynamic.
- True evaluation of the along-wind loads involves modelling the concerned chimney as a bluff body having incident turbulent wind flow. However, the mathematical rigor involved in such an analysis is not acceptable to practicing engineers.
- Hence most codes use an 'equivalent static' procedure known as the gust factor method (GFM). This helps in simplifying the incident load due to the mean wind. The actual wind load is calculated and the results are modified by means of a gust factor to take care of the dynamic nature of the loading. The gust factor is defined as the ratio of the expected peak load to the mean load.

B. Across wind effects

- Across wind loads are caused by the corresponding 'lift' component of the wind force on the chimney. This is associated with the phenomenon of 'vortex shedding' which causes the chimney to oscillate in a direction perpendicular to the direction of wind flow.
- A tall body like the chimney is essentially a bluff body as opposed to a streamlines one. The streamlined body causes the oncoming wind flow to go smoothly past it and hence is not exposed to any extra forces. On the other hand, the bluff body causes the wind to 'separate' from the body. This separated flow causes high negative regions in the wake region behind the chimney. The wake region is a highly turbulent region that gives rise to high speed eddies called vortices. These discrete vortices are shed alternately giving rise to 'lift forces' that act in a direction perpendicular to the incident wind direction. These lift forces cause the chimney to oscillate in a direction perpendicular to the wind flow.
- The phenomena of alternately shedding the vortices formed in the wake region is called vortex shedding. This is the phenomena that give rise to the across-wind forces. This phenomenon was reported by Strouhal, who showed that shedding from a circular cylinder in a laminar flow is describable in terms a non-dimensional number Sn called the Strouhal number.

$Sn = \frac{f.D}{V}$ Where f = shedding frequency, D= diameter of cylinder and V= mean flow velocity.

1.3 Estimation of Wind loads by Codal Provisions

A. Along wind loads

The along-wind response of a chimney shall be computed using the Gust factor approach. In general, the chimney shall be discretized into a number of segments along its height with each segment not exceeding 10 m length. The load at any section shall be calculated by suitably averaging the loads above and below it. The moments are calculated from the sectional forces treating the chimney as a free standing structure.

The along-wind load, F(z) per unit height at any level, z on a chimney is equal to the sum of the mean along wind load, $\overline{F(z)}$ and the fluctuating component of along wind load, F'(z) and shall be calculated as given below:

$$F(z) = \overline{F(z)} + F'(z)$$

Here, the mean along-wind load $\overline{F(z)}$, shall be computed as:

$$\overline{F(z)} = C_d.d(z).\overline{p}(z)$$

Where

Cd = mean drag coefficient taken as 0.8, and

d(z) = outer diameter of chimney at height z.

p(z)= The design wind pressure due to hourly mean wind speed, in N/m^2, corresponding to V(z) shall be computed as follows:

$$p(z) = (1/2).\rho_a.\left(\overline{V}(z)\right)^2$$

Where

$$\overline{V}(z) = V_b k_1 \overline{k}_2 k_3 k_4$$

V_b is basic wind speeds as given by IS: 875 (Part 3): 2015 corresponds to 3 seconds averaged wind speeds. However, for wind analysis of stacks, hourly mean wind speed shall be taken as reference wind speed as per Cl. 5.5.3 of IS 4998: 2015. This is done by suitable modifications in k_2 factor as suggested by IS 4998: 2015.

The value of $\overline{k}_2$ shall be obtained using the following empirical expression for z > 10 m,

$$\overline{k}_2 = 0.1423.(z_0)^{0.0706} \ln\left(\frac{z}{z_0}\right)$$

Where z_0 is the aerodynamic roughness height which shall be taken as 0.02 m for all terrain categories. For less than 10 m the value of $\overline{k}_2$ is kept same as that equal to 10m.

k_1 and k_3 are obtained from IS 875 (Part 3).

k_4 = 1.15 as recommended in IS 875 (Part 3) for Industrial structures.

ρ_a = mass density of air, taken equal to 1.2 kg/m3

The fluctuating component of along-wind, F'(z) in N/m, at height z shall be computed as:

$$F'(z) = 3\frac{(G-1)}{H^2}\left(\frac{z}{H}\right)\int_0^H \overline{F}(z).z.dz$$

Where

H = total height of the chimney above ground level, in m

G = gust response factor (It is the ratio of the expected maximum moment M_0 to the mean moment M_{m0} at the base of the chimney.

$$G = 1 + g_f r_t \sqrt{B + \left(\frac{SE}{\beta}\right)}$$

Where g_f = peak factor, defined as the ratio of expected peak value to root mean square value of the fluctuating load, given by:

$$g_f = \sqrt{2\ln(vt)} + \frac{0.577}{\sqrt{2\ln(vt)}}$$

Where

$$vT = \frac{3600}{\left(1 + \frac{B\beta}{SE}\right)^{1/2}}$$

ν = effective cycling rate

T = sample period taken as 3600 s

r_t = twice the turbulence intensity at the top of chimney given by:

$$r_t = 0.622 - 0.178\log_{10} H$$

B = background factor indicating the slowly varying component of wind load fluctuations, given by:

$$B = \left\{1 + \left(\frac{H}{265}\right)^{0.63}\right\}^{-0.88}$$

E is a measure of available energy in the wind at the natural frequency, given by:

$$E = \frac{\left\{123\left(\frac{f_1}{\overline{V}(10)}\right)H^{0.21}\right\}}{\left\{1 + \left(330\frac{f_1}{\overline{V}(10)}\right)^2 H^{0.42}\right\}^{0.83}}$$

S = size reduction factor, given by:

V (10) = mean hourly wind speed at 10 m height above ground level (m/s),

b = structural damping as a fraction of critical damping to be taken as 0.016 for along-wind loads,

f_1 = natural frequency of unlined chimney in the first mode of vibration, in Hz,

$$f_1 = 0.2\left(\frac{d_0}{H^2}\right)\sqrt{\frac{Eck}{\rho ck}}\left(\frac{t_o}{t_h}\right)^{0.3}$$

where

t_0 = thickness of the shell at bottom, in m;

t_h = thickness of the shell at top, in m;

d_0 = centerline diameter of the shell at bottom in m;

ρ_{ck} = mass density of concrete, kg/m3

E_{ck} = dynamic modulus of elasticity of concrete, in N/m2.

B. Across wind loads

Across-wind loads due to vortex shedding in the first and second modes shall be considered in the design of all chimney shells when the critical wind speed V_{cr} is between $0.5V(z_{ref})$ and $1.3V(z_{ref})$. Across-wind loads need not be considered outside this range. Across-wind loads shall be calculated as given below, which defines the across-wind base bending moment, M_{ac}:

$$M_{ac} = \left[g_{ac} S_s C_l \frac{\rho_a V^2_{cr}}{2} d_e H^2\right] X \left[\frac{\pi}{4(\beta_s + \beta_a)}\right]^{0.5} S_p \left\{\frac{2L}{\left(\left(\frac{H}{d_e}\right) + C_E\right)}\right\}^{0.5}$$

Where S_s = mode shape factor taken as 0.57 for the 1st mode and 0.18 for the 2nd mode.

C_E = end effect factor taken as 3.

g_{ac} = peak factor for across-wind load taken as 4.0.

d_e = effective diameter taken as average outer diameter over top one-third height of chimney (m).

C_L = RMS lift coefficient and is given by:

$C_L = C_{Lo} F_{1B}$

Where C_{Lo} = RMS lift coefficient modified for local turbulence and is given by:

$$C_{Lo} = -0.243 + 5.468 I_{ref} - 18.182\left[I_{ref}\right]^2$$

Where

$$I_{ref} = \frac{1.0}{\ln\left(\frac{z_{ref}}{z_0}\right)}$$

z_{ref} = reference height, given by:

z_{ref} = (5/6) H

$$F_{1B} = -0.089 + 0.337\ln\left(\frac{H}{d_c}\right)$$

F_{1B} shall be between 0.2 and 1.0.

$V_{cr} = \frac{f_1 d_e}{S_t}$ for the first mode, and

= 5. f_2 .d_e for the second mode.

Where f_1 and f_2 are the natural frequencies of unlined chimney in the first and second modes of vibration, respectively in Hz.

$$f_2 = 6 f_1 \left[\frac{d_H t_H}{d_0 t_0} \right]^{0.2}$$

$$S_t = 0.25 F_{1A}$$

Where

$$F_{1A} = 0.333 + 0.206 \ \ln \left(\frac{H}{d_e} \right)$$

F_{1A} shall be between 0.6 and 1.0.

$$\beta_s = 0.01 + \frac{0.10 \left[\overline{V_*} - \overline{V}(z_{ref}) \right]}{\overline{V}(z_{ref})}$$

$\overline{V_*}$ is to be varied between $0.8V_{cr}$ and $1.2V_{cr}$ (at least 10 intervals shall be considered). The maximum value of V* shall be limited to 1.30.

$$\beta_a = \frac{K_a \rho_a d_e^{\ 2}}{m_{ave}}$$

Where m_{ave} = average mass in top one third of chimney per unit height (kg/m)

$K_a = K_{ao} F_{1B}$

Where

$$K_{ao} = \frac{-1.0}{(1+5I_{ref}) \left[1 + \frac{|K-1|}{I_{ref}+0.10} \right]}$$

Where $k = \frac{\overline{V_*}}{V_{cr}}$

$$S_p = \frac{K_{1.5}}{(\pi)^{0.25}\sqrt{Bw}} \exp\left[-0.5 \left(\frac{1-K^{-1}}{Bw} \right)^2 \right]$$

Where

B_w = bandwidth parameter, given by:

$B_w = 0.10 + 2 \ I_{ref}$

L = correlation length coefficient taken as 1.2.

The maximum value of M_{ac} determined in the region of $0.8V_{cr}$ and $1.2V_{cr}$ shall be taken as the design across wind base bending moment. When $\overline{V_*} \geq \overline{V}(z_{ref})$, M_{ac} shall be multiplied by

$$\left\{ 1.0 - 0.95 \left[\frac{\overline{V_*}}{\overline{V}(zref)} - 1 \right] \right\}$$

Using M_{ac}, the across-wind load per unit height at any height, Fac(z) in N/m, shall be calculated based on the corresponding mode shape of the chimney as given below:

$$F_{ac}(z) = \frac{M_{ac} m(z) \varphi_i(z)}{\int_0^H m(z) \varphi_i(z) z dz}$$

Where m(z)= mass per unit height of chimney at level z (kg/m), and

$\varphi_i(z)$ = mode shape corresponding to i^{th} mode.

Using $F_{ac}(z)$, the across-wind bending moments at any height, $M_{ac}(z)$, can be obtained.

2. Methodology

Following procedure has been adopted to achieve the objectives of this paper.

- Understanding the loads acting on the chimney and the calculation of wind loads as per IS 4998:2015.
- Generating an Excel spreadsheet for calculation of along and across wind loads.
- Modelling of stack as vertical cantilever supported at base for selected case of particular height, internal top diameter, bottom diameter, thickness at top and bottom in FE Software SAP 2000.
- Determining the frequency and mode shapes corresponding to first and second modes.
- Computing along and across wind loads for the selected case using Excel Spreadsheet.
- Generating graphs and plots for calculation of approximate wind loads on any selected geometry and location of stack.
- Interpretation of results obtained.

2.1 Variables Involved and their Effects

The determination of wind load has been done by changing 4 variables, which are mostly used in sizing of chimney, one by one keeping others as constant.

Height of chimney

Height is governed by following two considerations:

- To generate a draft which will cause the gases to flow out with desired exit velocity.
- To satisfy local regulation in respect of permissible Ground level concentration of pollutants.

Height should be at least 2.5 times the height of nearby tallest structure within a radius of 5 stack/chimney heights.

Top internal diameter

It is generally fixed considering the design exit velocity. The exit velocity should be at least 1.5 times maximum horizontal wind speed observed at height of stack.

Shape and Base dimensions

The base dimension mainly depends on the structural considerations. Stresses due to dead load together with those due to wind, temperature and earthquake are safely withstood by chimney shell. Generally, the shape is circular. The base dimension is dependent on taper provided.

Location

The country is divided into 6 different wind zones as per IS 875 Part-3. These are corresponding to basic wind speed of 33m/s, 39m/s, 44m/s, 47m/s, 50m/s and 55m/s applicable to 10 m height above mean ground level.

2.2 Details of Chimney Considered

Heights considered for along wind load = 45m, 75m, 100m, 145m, 170m, 200m and 225 m.

Heights considered for across wind load =45m, 100m

Taper considered= 1:25, 1:50

Grade of concrete = M35 Poisson's ratio used = 0.20

Top Diameter = 1.5 m, 2.5 m, 3.5 m and 4 m.

Thickness at top = 300 mm varied uniformly to 500 mm at bottom.

2.3 Mathematical modelling

The physical structure of chimney is transformed into a mathematical model for determining mode shapes corresponding to first and second modes. Two-noded elastic-prismatic 3D frame elements is used for modelling the chimney shell. The entire height except top 1/3rd is discretized at intervals of 1.0m. Top 1/3rd portion of the chimney is discretized at an interval of 0.25m.

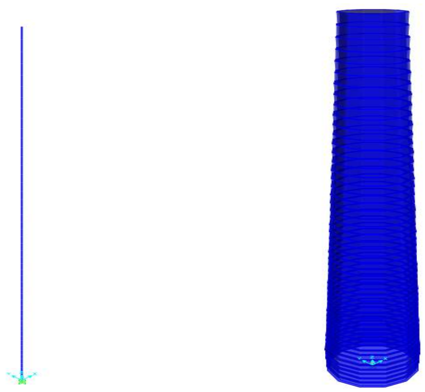


Figure 1: FE Model for chimney using beam elements

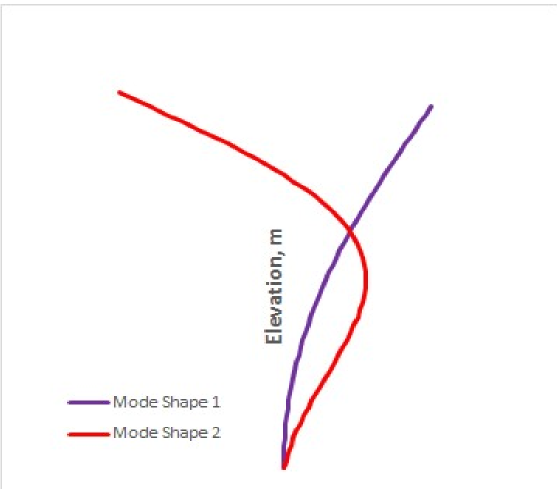


Figure 2: Normalised Mode Shapes for Chimney

3. Results of Wind Load Computations

3.1 Along wind load results for different variables

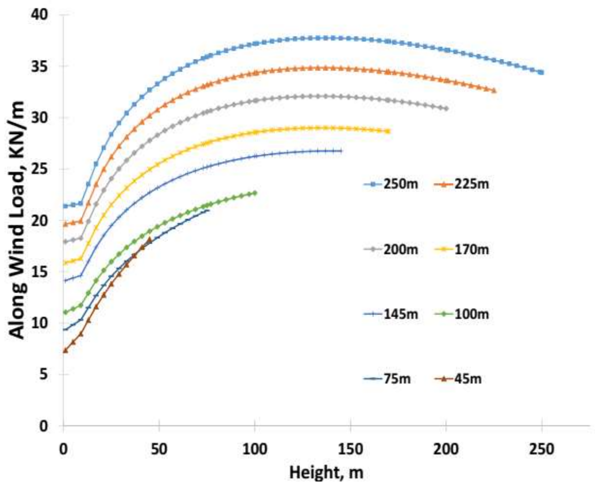


Figure 3: Along wind load for different heights for top diameter of 3.7m, Taper 1:25 and Wind Zone 44m/s

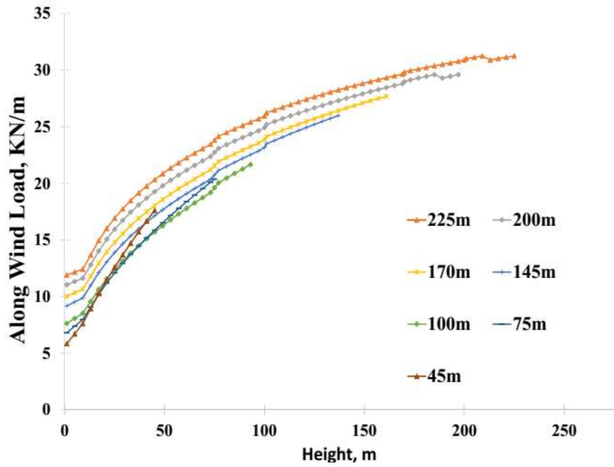


Figure 4: Along wind load for different heights for top diameter of 3.7m, Taper 1:50 and Wind Zone 44m/s

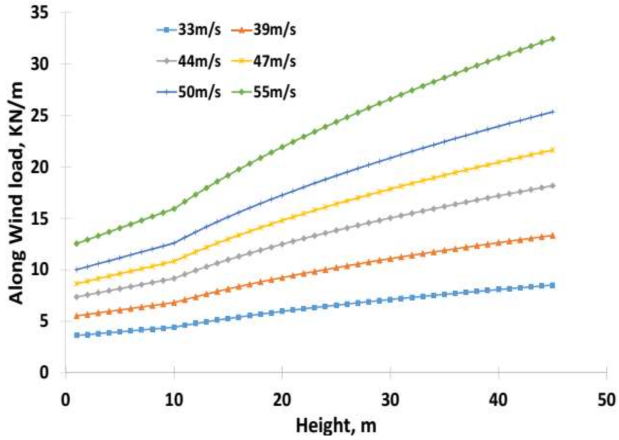


Figure 5: Along wind load for chimney of height 45m for different wind zones for top diameter of 3.7m and taper 1:25

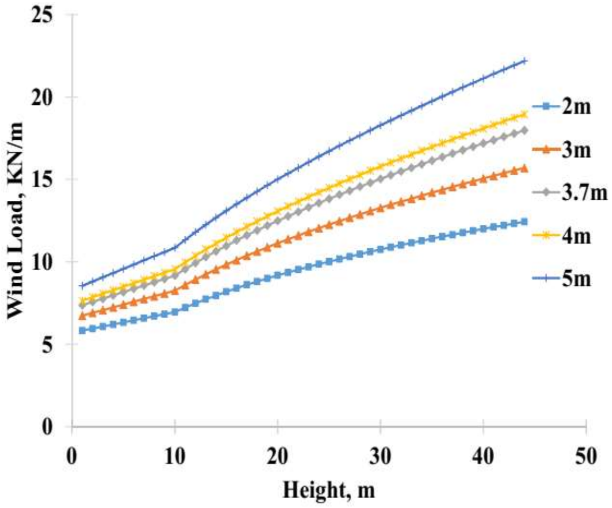


Figure 6: Along wind load for chimney of height 45m, taper 1:25 and wind zone of 44m/s for varying top internal diameter

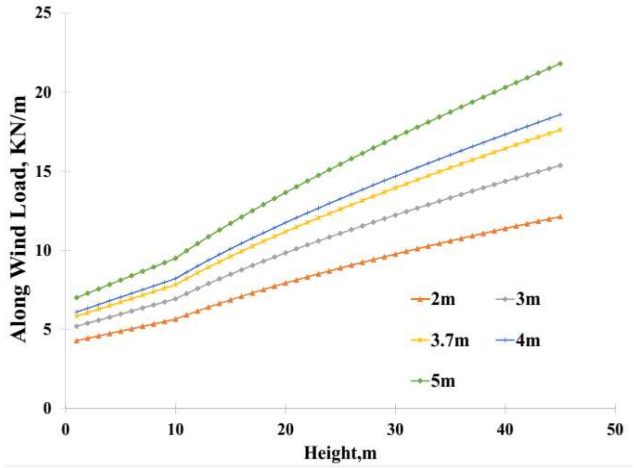


Figure 7: Along wind load for chimney of height 45m, taper 1:50 and wind zone of 44m/s for varying top internal diameter

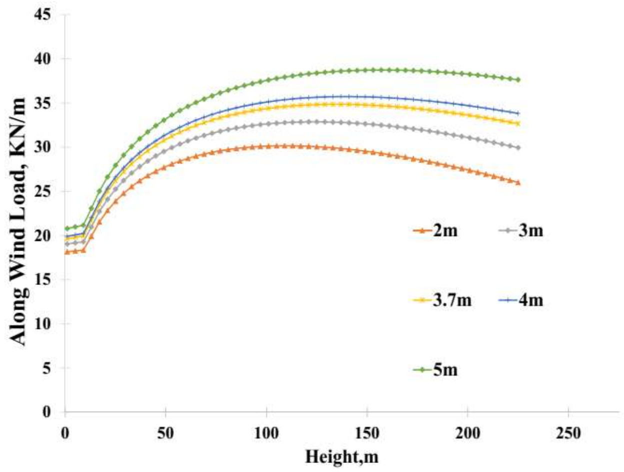


Figure 8: Along wind load for chimney of height of height 225m, taper 1:25 and Wind Zone 44m/s for varying top internal diameter

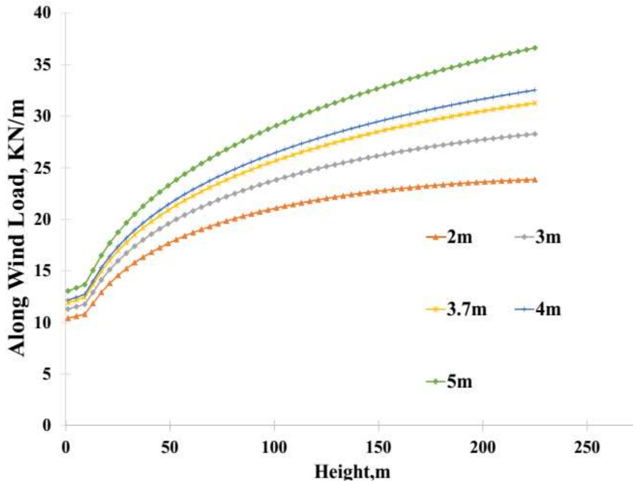


Figure 9: Along wind load for chimney of height of height 225m, taper 1:50 and Wind Zone 44m/s for varying top internal diameter

3.2 Across wind load results for different variables

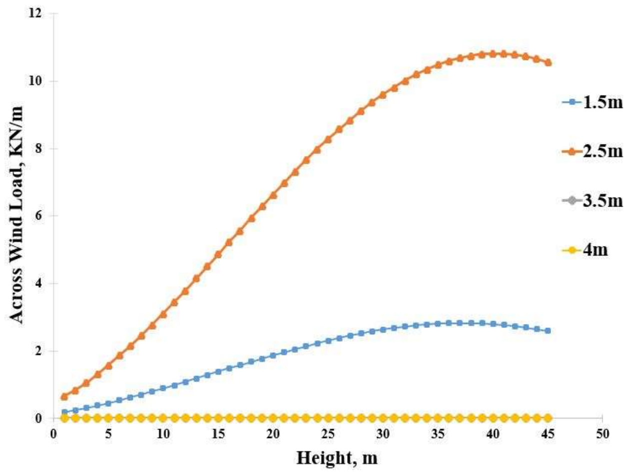


Figure 10: Variation in across wind load for 45m chimney with 1:25 taper, wind zone 33m/s and varying top internal diameter

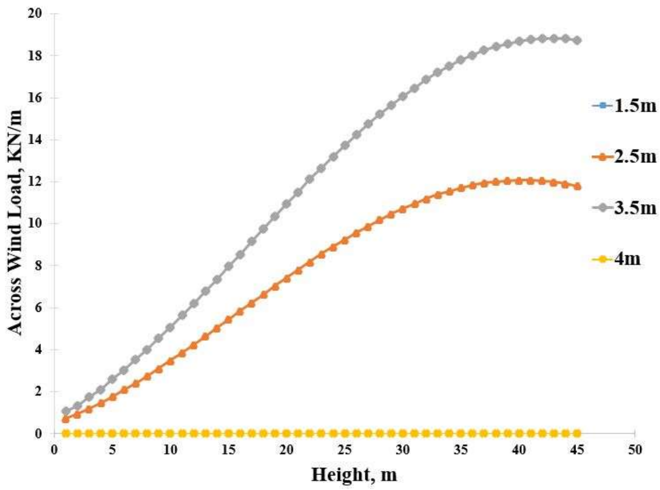


Figure 11: Variation in across wind load for 45m chimney with 1:25 taper, wind zone 39m/s and varying top internal diameter

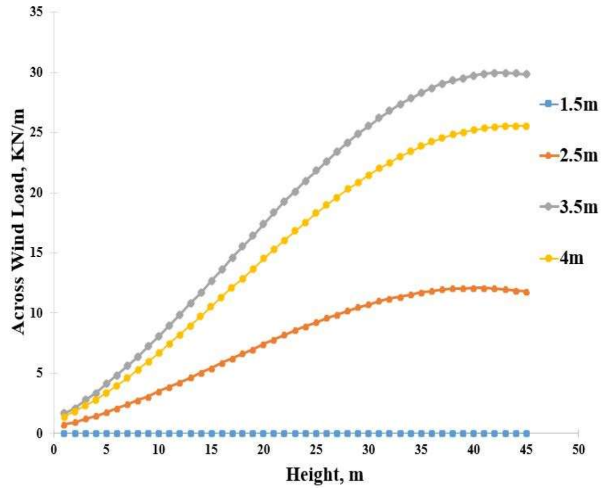


Figure 12: Variation in across wind load for 45m chimney with 1:25 taper, wind zone 44m/s and varying top internal diameter

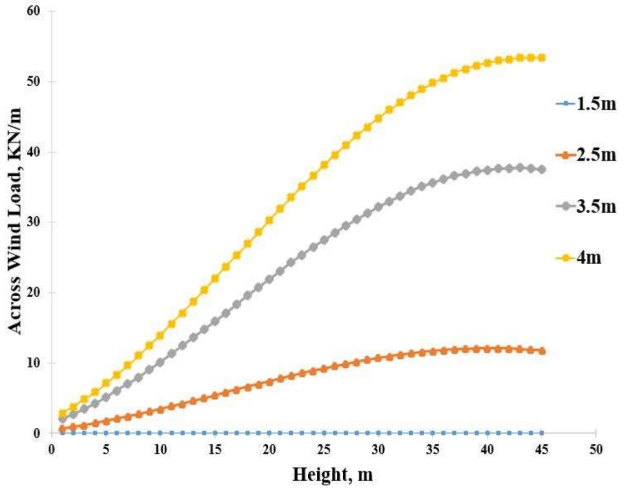


Figure 15: Variation in across wind load for 45m chimney with 1:25 taper, wind zone 55m/s and varying top internal diameter

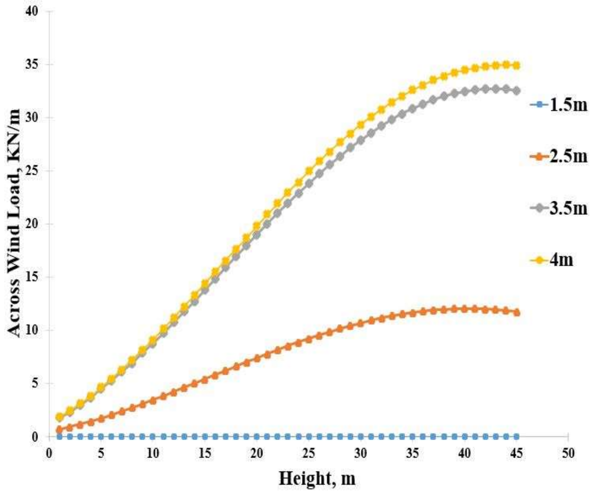
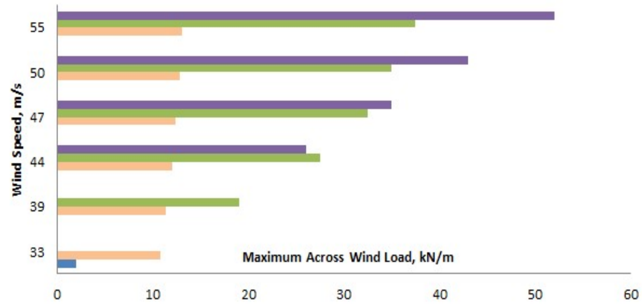


Figure 13: Variation in across wind load for 45m chimney with 1:25 taper, wind zone 47m/s and varying top internal diameter



	33	39	44	47	50	55
4	0	0	26	35	43	52
3.5	0	19	27.5	32.5	35	37.5
2.5	10.8	11.4	12	12.4	12.8	13
1.5	2	0	0	0	0	0

Figure 16: Maximum Across Wind load for Six Wind zone and various top internal diameter

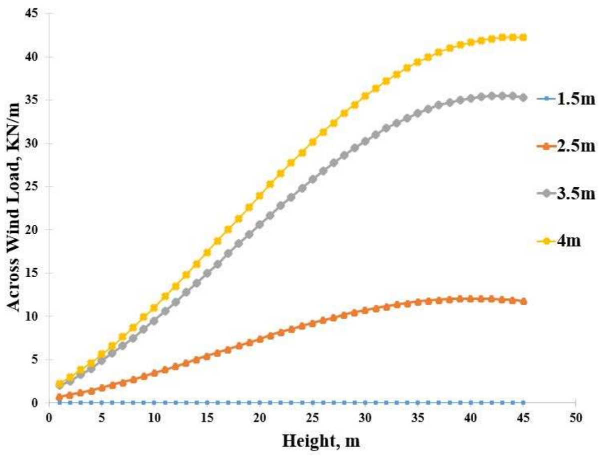


Figure 14: Variation in across wind load for 45m chimney with 1:25 taper, wind zone 50m/s and varying top internal diameter

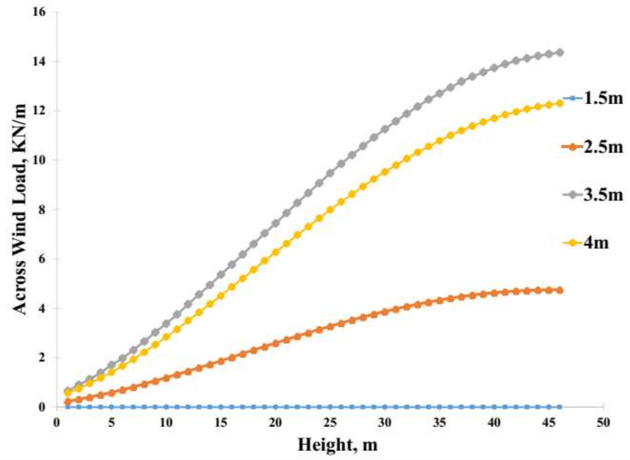


Figure 17: Variation in across wind load for 45m chimney with 1:50 taper, wind zone 33m/s and varying top internal diameter

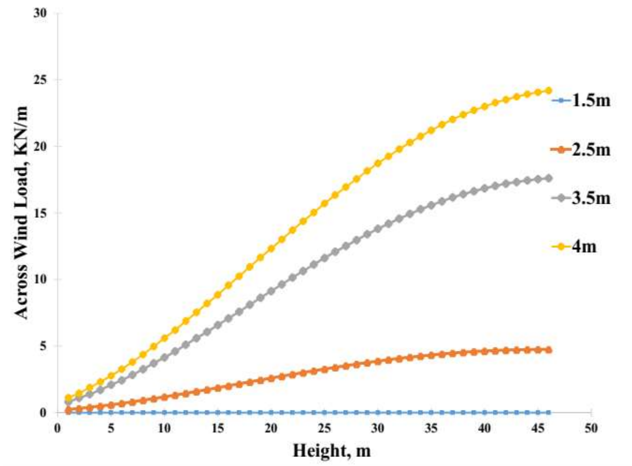


Figure 18: Variation in across wind load for 45m chimney with 1:50 taper, wind zone 39m/s and varying top internal diameter

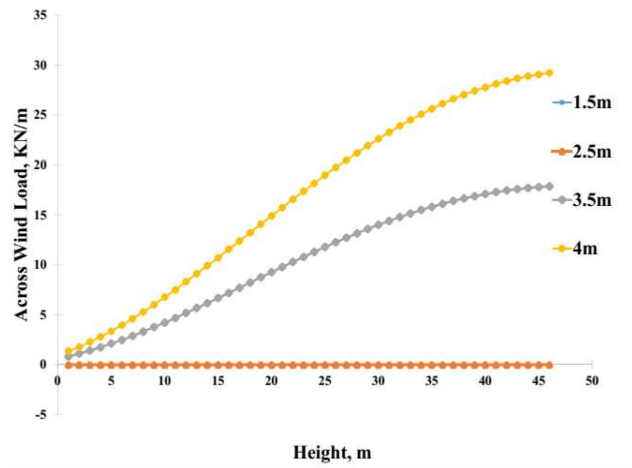


Figure 19: Variation in across wind load for 45m chimney with 1:50 taper, wind zone 44m/s and varying top internal diameter

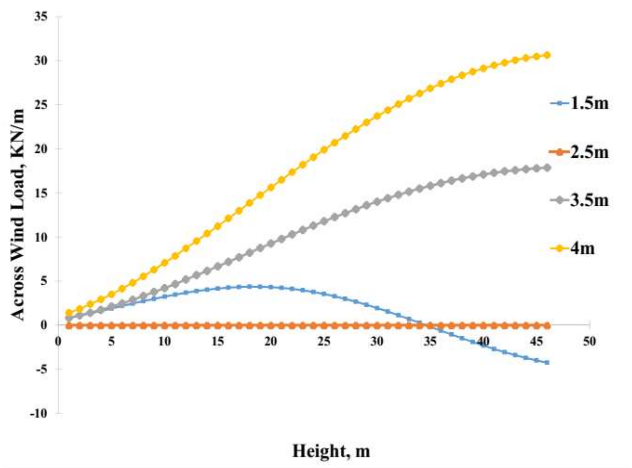


Figure 20: Variation in across wind load for 45m chimney with 1:50 taper, wind zone 47m/s and varying top internal diameter

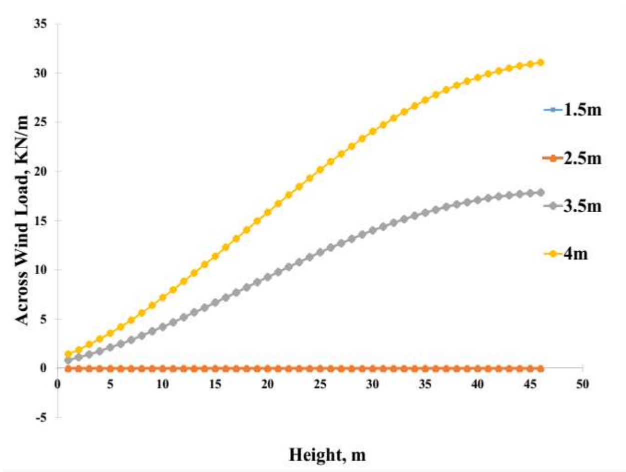


Figure 21: Variation in across wind load for 45m chimney with 1:50 taper, wind zone 50m/s and varying top internal diameter

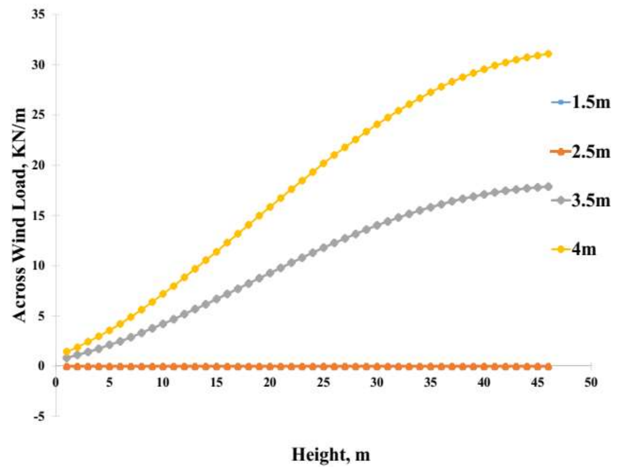
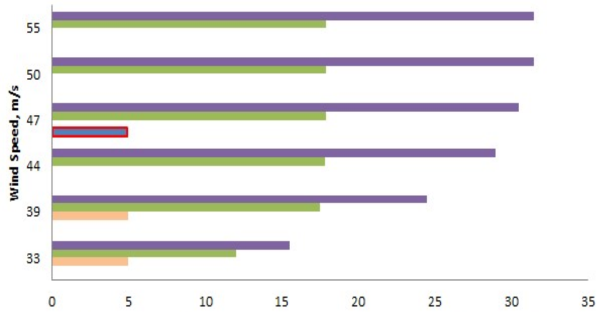


Figure 22: Variation in across wind load for 45m chimney with 1:50 taper, wind zone 55m/s and varying top internal diameter



	33	39	44	47	50	55
4	15.5	24.5	29	30.5	31.5	31.5
3.5	12	17.5	17.8	17.9	17.9	17.9
2.5	5	5	0	0	0	0
1.5	0	0	0	4.9	0	0

Maximum Across Wind Load, kN/m

Figure 23: Maximum Across Wind load for Six Wind zone and various top internal diameter (values with red border indicates maximum across wind load in second mode)

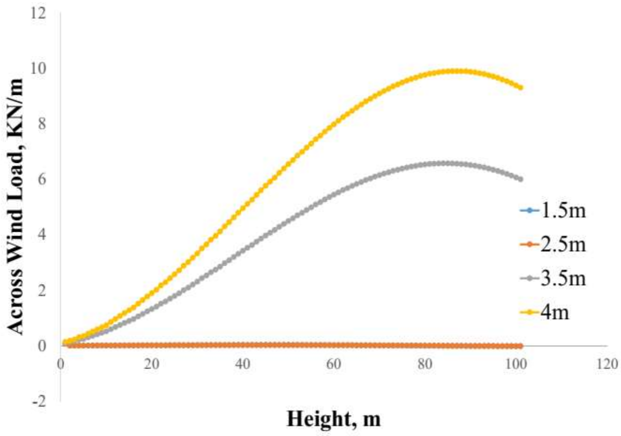


Figure 24: Variation in across wind load for 100m chimney with 1:25 taper, wind zone 33m/s and varying top internal diameter.

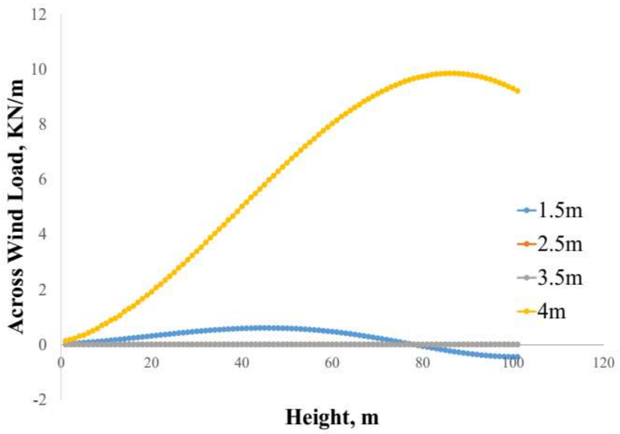


Figure 25: Variation in across wind load for 100m chimney with 1:25 taper, wind zone 39m/s and varying top internal diameter

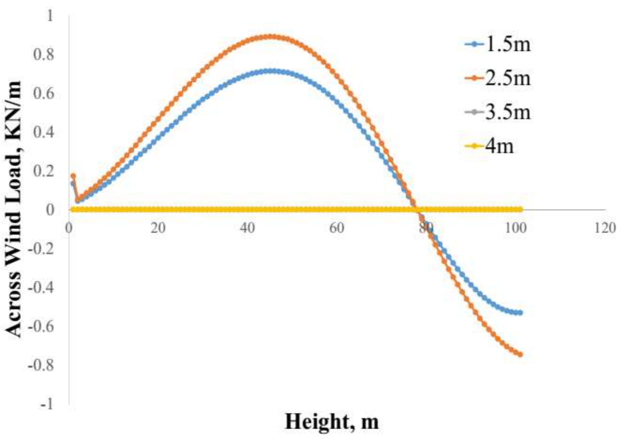


Figure 26: Variation in across wind load for 100m chimney with 1:25 taper, wind zone 44m/s and varying top internal diameter

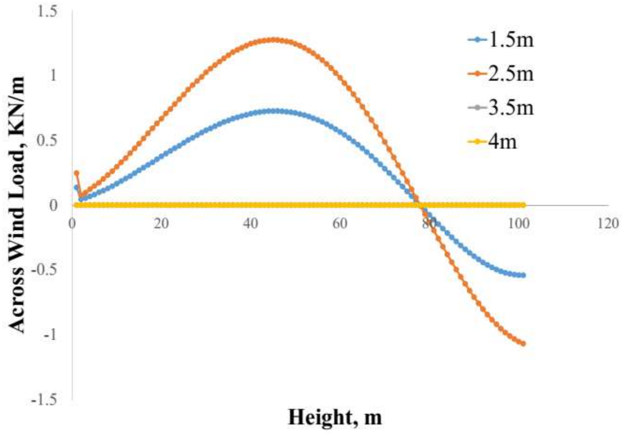


Figure 27: Variation in across wind load for 100m chimney with 1:25 taper, wind zone 47m/s and varying top internal diameter

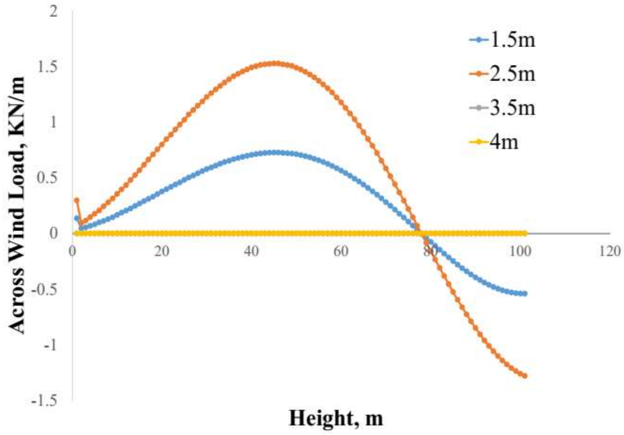


Figure 28: Variation in across wind load for 100m chimney with 1:25 taper, wind zone 50m/s and varying top internal diameter.

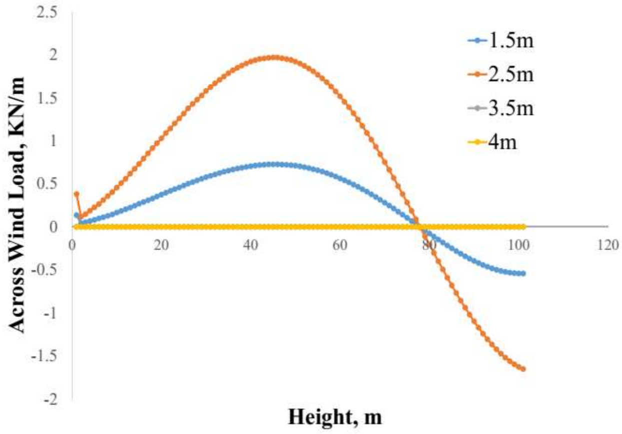


Figure 29: Variation in across wind load for 100m chimney with 1:25 taper, wind zone 55m/s and varying top internal diameter

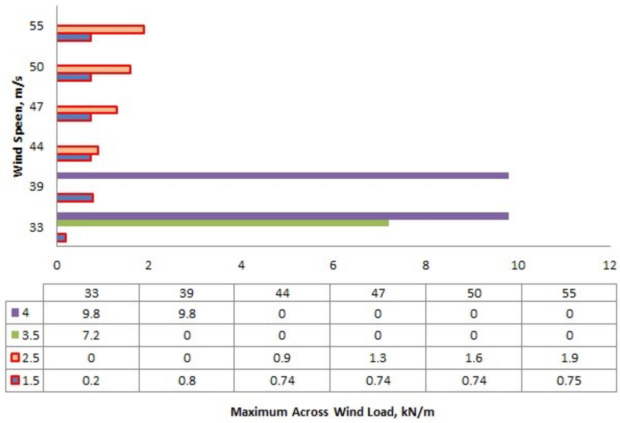


Figure 30: Maximum Across Wind load for Six Wind zone and various top internal diameter (values with red border indicates maximum across wind load in second mode)

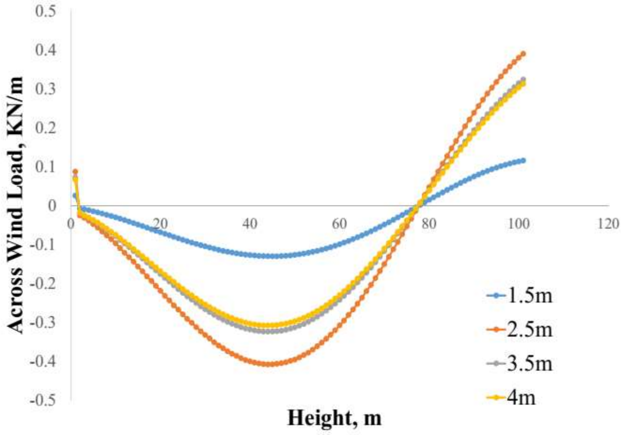


Figure 31: Variation in across wind load for 100m chimney with 1:50 taper, wind zone 33m/s and varying top internal diameter

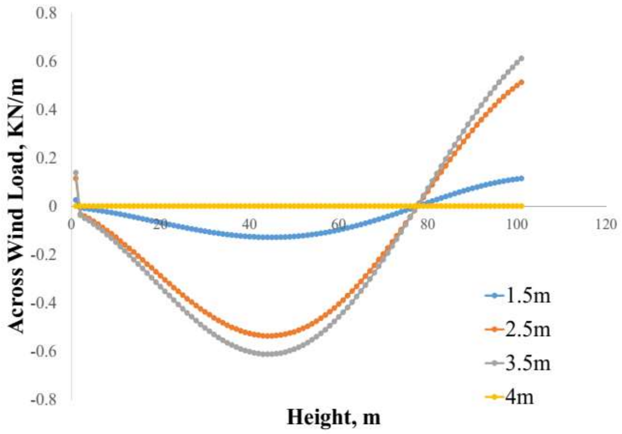


Figure 32: Variation in across wind load for 100m chimney with 1:50 taper, wind zone 39m/s and varying top internal diameter

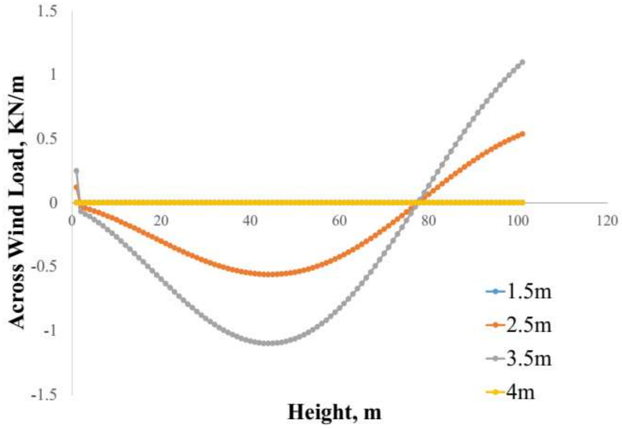


Figure 33: Variation in across wind load for 100m chimney with 1:50 taper, wind zone 44m/s and varying top internal diameter

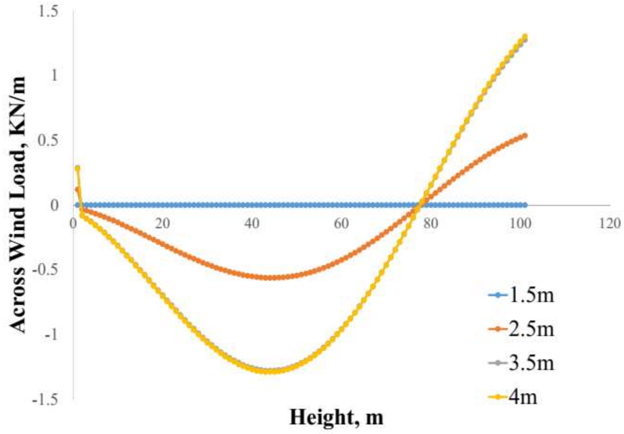


Figure 34: Variation in across wind load for 100m chimney with 1:50 taper, wind zone 47m/s and varying top internal diameter

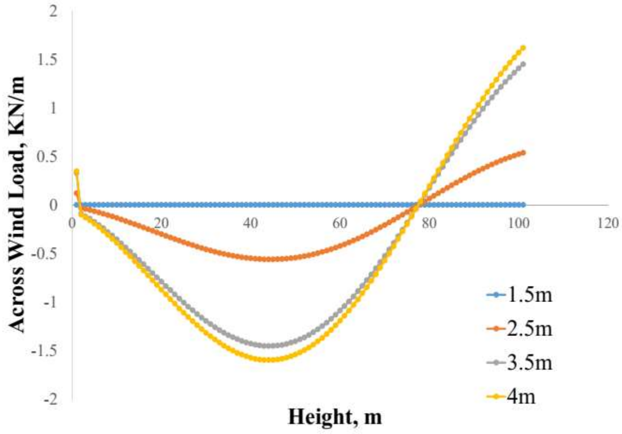


Figure 35: Variation in across wind load for 100m chimney with 1:50 taper, wind zone 50m/s and varying top internal diameter

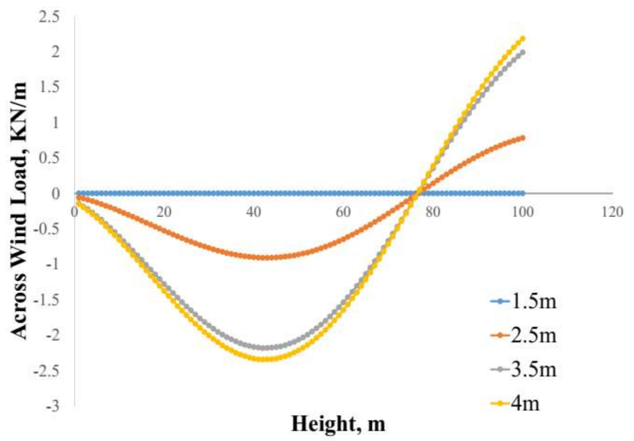
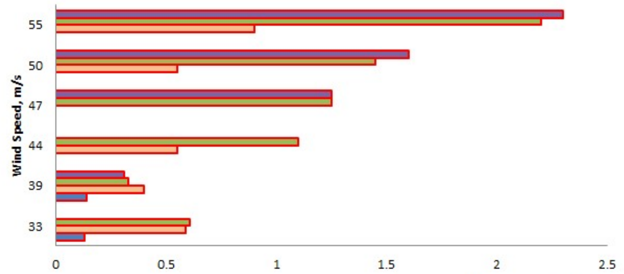


Figure 36: Variation in across wind load for 100m chimney with 1:50 taper, wind zone 55m/s and varying top internal diameter



	33	39	44	47	50	55
4	0	0.31	0	1.25	1.6	2.3
3.5	0.61	0.33	1.1	1.25	1.45	2.2
2.5	0.59	0.4	0.55	0	0.55	0.9
1.5	0.13	0.14	0	0	0	0

Maximum Across Wind Load, kN/m

Figure 37: Maximum Across Wind load for Six Wind zone and various top internal diameter (values with red border indicates maximum across wind load in second mode)

4. Conclusions

- Along wind load increases with the increase in wind zone.
- Wind follows a parabolic relation with height but in very tall tapered stacks, towards the top, the increase in wind speed is offset by the diameter decrease and the along wind load comes down.
- There is an abrupt slope change observed after 10 m in all along wind graphs. This is due to the value of k_2 factor which is kept constant from 0 to 10m.
- For a particular taper for a chimney as the top diameter is increasing the values of along wind loading are increasing almost at a constant rate.
- Across wind load depends on Stack geometric parameters, frequency and design wind speed.

10. .

- For along loads a sort of generalization appears after plotting certain graphs but in case of across loading it is very difficult to generalize it for different cases. For along loads the value of load increases as the wind speed increases but the same is not applicable for across wind loads. It is seen in some cases that across load ceases to exist for higher wind speeds.
- If the critical velocity for vortex formation is falling in the range of $0.8V(z_{ref})$ to $1.3V(z_{ref})$ for first mode, the value of maximum across wind load is increasing with the increase in wind zone. However, this statement is not true for across wind load in second mode

Disclosures

Free Access to this article is sponsored by SARL ALPHA CRISTO INDUSTRIAL.

References

1. Baiju, A., & S, G. (2016). Analysis of Tall RC Chimney as per Indian Standard Code. International Journal of Science and Research (IJSR), 390-394.
2. Code of practice for design loads for buildings and structures, IS: 875 (Part-III):1987. Bureau of Indian standards.
3. Criteria for design of Reinforced concrete chimneys, IS:4998 (Part-I):1992. Bureau of Indian Standards.
4. Manohar, S. (1985). Tall Chimneys. Design and Construction. TATA McGraw Hill Publishing Company Limited 1985.
5. Nagar, A., M, S. S., & Soumya, T. (2015). Non Liner Dynamic Analysis of RCC Chimney. International Journal of Engineering Research & Technology (IJERT), 530-535.
6. Reddy, B. K., Padmavathi, V., & Srikanth, c. (2012). Study of wind load effects on tall rc chimneys. Study of wind load effects on tall rc chimneys, 92-97.
7. Reddy, K., Jaiswal, O., & Godbole, P. (2011, October). Wind and Earthquake Analysis of Tall RC Chimneys. International Journal of Earth Sciences and Engineering, 508-511.
8. Saida, S. K., & Narasaiah, M. V. (2018). Comparative Study on Rcc Industrial Chimneys by Using Existing (Is 4998 Part 1:1992) and Draft Code (Ced 38(7892) Wc. International Journal of Research, 197-202.
9. Shaikh, M., & Khan, H. (n.d.). Governing Loads for Design of A tall RCC Chimney. IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), 12-19