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Response of Mild Steel chimney Under Wind Loads

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Abstract
This paper deals with the study of three chimneys of 55m high above ground level. These chimneys were designed as per IS: 6533–1989 [1] and wind load was calculated as per IS: 875–1987 [2] .Three different wind speeds were considered for the design of chimneys viz., 47m/s, 50m/s & 55m/s respectively. In order to effectively analyse a chimney's response, a deep knowledge of the basic wind engineering concepts is needed. The force exerted by wind on the chimney varies with the wind speed and its associated turbulence. The study parameter of static forces, the dynamic forces, the static moment, dynamic moment and thickness of chimney shell were comrared to three chimney.The results indicated that the forces and moments of C3 is higher than the C1 and C2. The thickness of chimney is remains same even though the three different wind speed was considered.

Key words: *Wind load, static moment, dynamic moment static force, dynamic force, thickness*

1.INTRODUCTION :

A chimney is a vertical channel through which smoke and combustion gases pass out of a building. Chimney are used to emit the exhaust gases higher up in the atmosphere so that diffusion of gases may take place. Chimney may be constructed of steel, R.C.C or masonry. Steel chimney also known as steel stacks and these are mainly used in the sugar factories, food processing industries, thermal plants, vegetable oil factories, rice shelters, chemical industries, etc.

. Stephen et al. [3] Investigated the design of bolts for large chimney and found that 50mm diameter holding bolts made from structural grade mild steel showed good satisfactory performance. Max Zar et al. [4] describes about liners are subject to biaxial compression, an interaction formula is given to cover this situation as present design codes generally cover only uniaxial stress states on very special biaxial states. Hirsch G et al.[5] measurements on steel chimney stacks are presented mainly full-scale tests carried out after rebuilding a 145M high and 6 diameter steel chimney stack which collapsed owing to wind-induced vibrations. Kenneth Irish et al. [6] Concrete chimneys, stiffer, heavier, more highly damped form of construction, free of vibration problems common to steel stacks. However, authors believe that present trends, allowing increasing stresses, combined with more slender structures, may lead to concrete chimney vibration. J. Kawecki et al, [7] Studied about damping properties of the chimney permitted to compare different approaches to the calculation of maximum relative amplitude of vibration. M.R. Tabeshpour. [8] investigated on model simplification that provides sufficient accuracy based on a nonlinear discrete model. Seifedine Kadry [9]. Investigated corrosion of chimney parts made of stainless steel under the conditions of acid environment and also he analyses stainless steel resistance to burning products released by heat burners. W.E. Cowley et al.[10] describes about stacks can be free from corrosion

This paper deals with the behavior of mild steel chimney subjected to wind loads. Three chimney has been considered for this study viz., C1, C2,C3 respectively. These chimneys has subjected to the basic wind speed of 47m/s for Chimney1 (C1), 50m/s for Chimney2 (C2), and 55m/s for Chimney3 (C3). The height of the chimney is kept constant for the three chimney. However these three chimney are divided into six zones, the height of zone1, 2, 3, 4, 5 and 6 is to be 10m, 10m, 9m, 9m, 9m, and 8m respectively. The geometry of the chimney as shown in the table 1.

Table 1 Geometry of Chimney

Chimney	**Basic Wind speed (m/sec)**	**Height of chimney (m)**	**Top Diameter of chimney (m)**	**Bottom Diameter of chimney (m)**	**Flared Height (m)**
1	47	55	1.6	3	20
2	50	55	1.6	3	20

3	55	55	1.6	3	20

2. WIND LOADS

The wind load on chimney depends upon its location and height. As the wind pressure varies with height, the stack is divided into parts and the wind load in each part is calculated. The wind pressure over each part is considered as uniform and resultant is assumed to be acting at mid-height of that portion. The wind loading causes bending moment in steel stack. The design wind pressure at any height above ground level has been obtained by using the following relationship between wind pressure, P_z (N/m²), and the design wind velocity, V_z (m/s):

$P_z = 0.6V_z^2$ ………… (1)

The coefficient 0.6 in Eq. (1) depends upon a number of factors and primarily on the atmospheric pressure and air temperature. The design wind velocity at any height for the chosen structure is obtained from the basic wind speed, V_b, and by including the following factors: (1) risk level, (2) terrain roughness, (3) Height and size of structure and (4) local topography. It can be mathematically expressed as:

$V_z = V_b\ k_1\ K_2\ k_3$ ………… (2)

Where

V_b = basic wind speed which is mensioned for different zones of the country.
k_1 = probability factor (risk coefficient) based on the statistical concepts which take into account the degree of reliability required and the time period of wind exposure i.e. the life of the structure. k_2 = the terrain height and structure size that gives the multiplying factor by which the basic wind speed shall be multiplied to obtain the wind speed at different heights in each terrain category for different sizes of buildings and structures.
k_3 = the topography factor.

3. STATIC FORCE:

Static shear is obtained by the product of design wind pressure, shape factor, height of each zone and the inner diameter of chimney. It can be expressed as follows.

Static shear= p*Cp*h*ϕ ………… (3)

Where p=0.6*Vz^2

Cp= From IS code 6533-1971

P=design wind pressure

Cp=shape factor

H=height of each zone

Φ=inner diameter of chimney

4. STATIC MOMENT:

Static moment is obtained by the product of static shear of the zone and the zone height of the chimney.

5. DYNAMIC FORCE:

Dynamic shear is obtained by the product of dynamic load, shape factor, height of each zone and the inner diameter of chimney. It can be expressed as follows.

Static shear= P dyn*cp*h*ϕ …………… (4)

Where, P dyn= mj*ξ1*ηij*v …………….. (5)

P dyn= Dynamic load

Mj= Mass of jth zone in kg connected at its centre

$\xi 1$= Co-efficient of dynamic influence for steel chimney

ηij= Deduction acceleration in m/s2 of center of jth zone

v= Co-efficient which takes care of spare correlation of wind pulsation speed according to height and vicinity of building structure

Cp= Shape factor

H= Height of each zone

Φ= Inner diameter of chimney

6. DYNAMIC MOMENT:

Static moment is obtained by the product of dynamic shear and the zone height of the chimney.

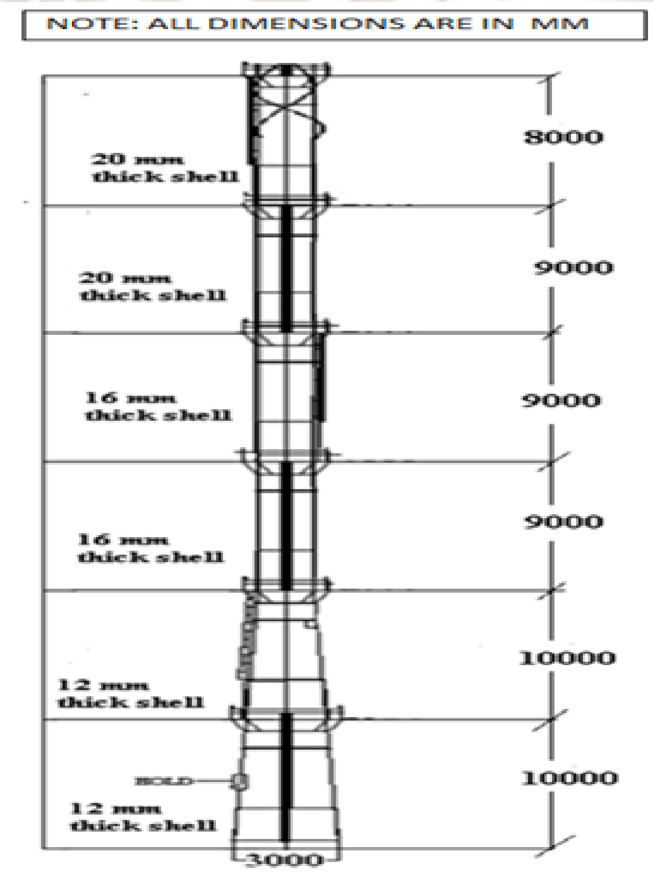


Fig 1. Geometry and Thickness of Chimney

7. RESULTS AND DISCUSSIONS:

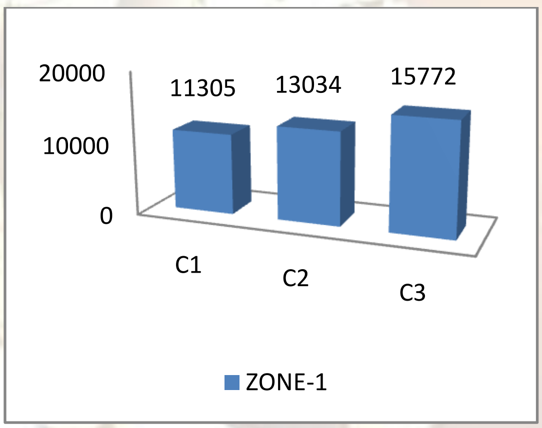
It can be seen from fig.2,compare to the C1 the static force is gradually increasing for C2 and C3 is found to be 15% and 40% for zone1, 15% and 40% for zone2, 15% and 40% for zone3, 15% and 40% for zone4, 15% and 40% for zone5, 15% and 40% for zone6.The static force for the C3 in all the zones are higher than the C1 and C2 due to higher basic wind speed than C1 and C2. And also compared to the C2 the static force is gradually remain same for C1 and C3 is found to be 13% and 21% for zone1, 13% and 21% for zone2, 13% and 21% for zone3, and 13% and 21% for zone4, 13% and 21% for zone5, 13% and 21% for zone6. Finally compared to the C3 the static force is gradually decreasing for C1 and C2 is found to be 28% and 17% for zone1, 28% and 17% for zone2, 28% and 17% for zone3, and 28% and 17% for zone4, 28% and 17% for zone5, 28% and 17% for zone6. The static force for the C3 in all the zones are higher than the C1 and C2 due to higher basic wind speed than C1 and C2.

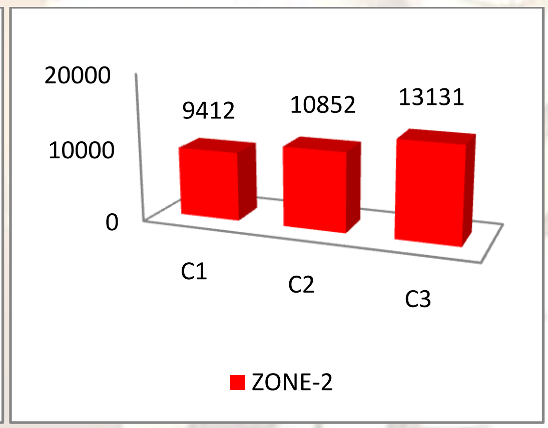
Fig3, Shows that the dynamic force is increased in the range of 4% to 16% for C2 and 4% to 16% for C3 compared with C1.This indicates the basic wind speed is directly proportional to the dynamic forces on chimney. And also dynamic force is varies in the range of 4% to 10% for C1 and 12% to 20% for C3 compared with C2.The dynamic force is decreased in the range of 14% to 20% for C1 and 10% to 20% for C2 compared with C3. This indicates the basic wind speed is directly proportional to the dynamic forces on chimney.

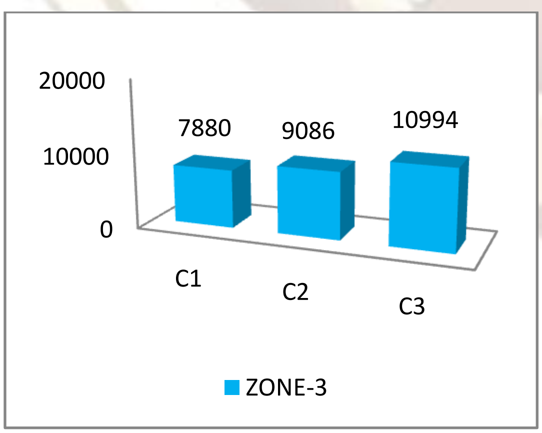
It can be observed from fig 4,the static moment for the C2 and C3 is increased upto 15% and 40% for zone1, zone2, zone3, zone4, zone5 and zone6 respectively.This indicates that the static moment for the six zones are to be same even when the zone height is varying.

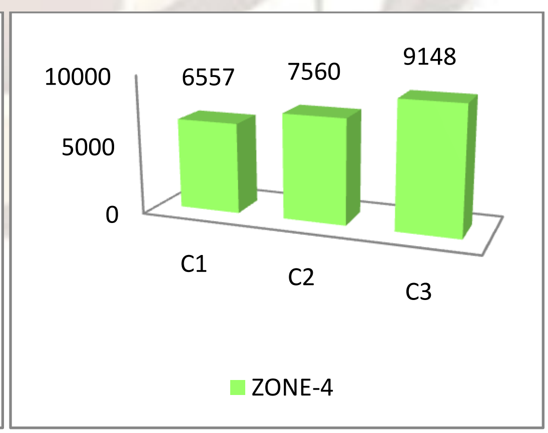
The dynamic moment for the C2 and C3 is increased upto 4% and 16% for zone1, zone2, zone3, zone4, zone5 and zone6 respectively as shown fig 5.This indicates that the dynamic moment for the six zones are to be same even when the zone height is varying.

The thickness of C1, C2, C3 for the zone1, zone2, zone3, zone4, zone5, zone6 is found to be 20mm, 20mm, 16mm, 16mm, 12mm, 12mm respectively as shown in fig 6.This indicates that the thickness of C1, C2, and C3 are same eventhough the basic wind speed is varying.The typical details of chimney as shown in fig 1.









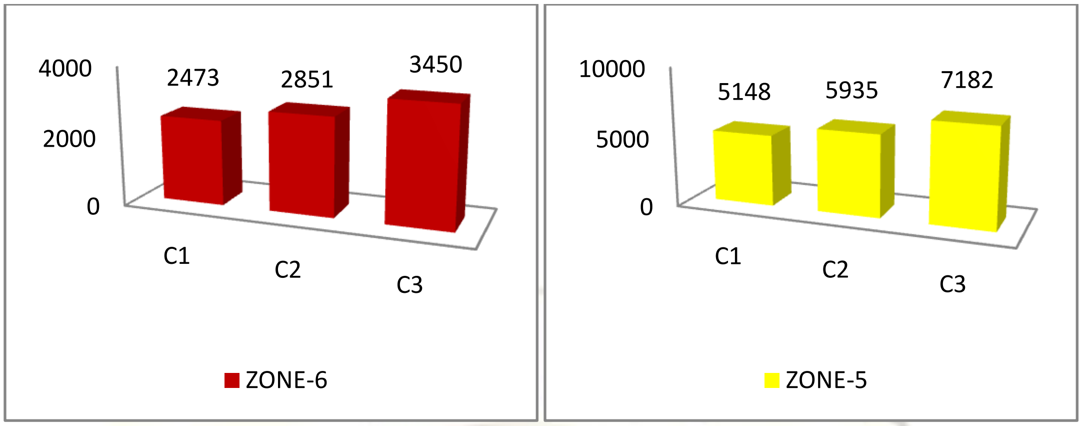
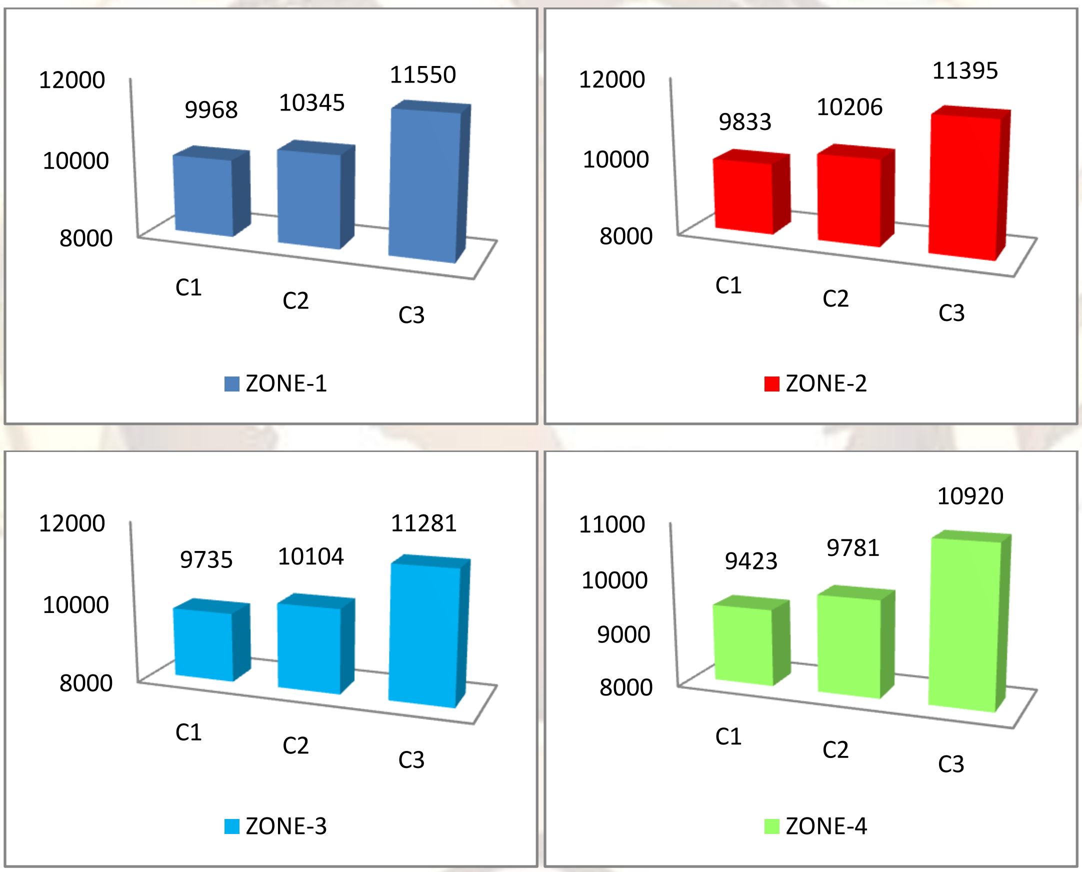


Figure 2 Static Force (kg) Vs Various Wind Loads (m/s)



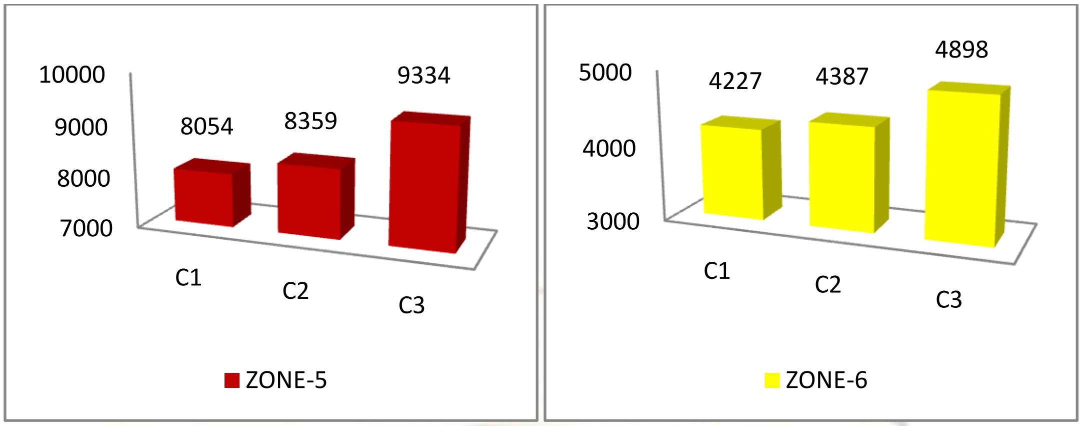
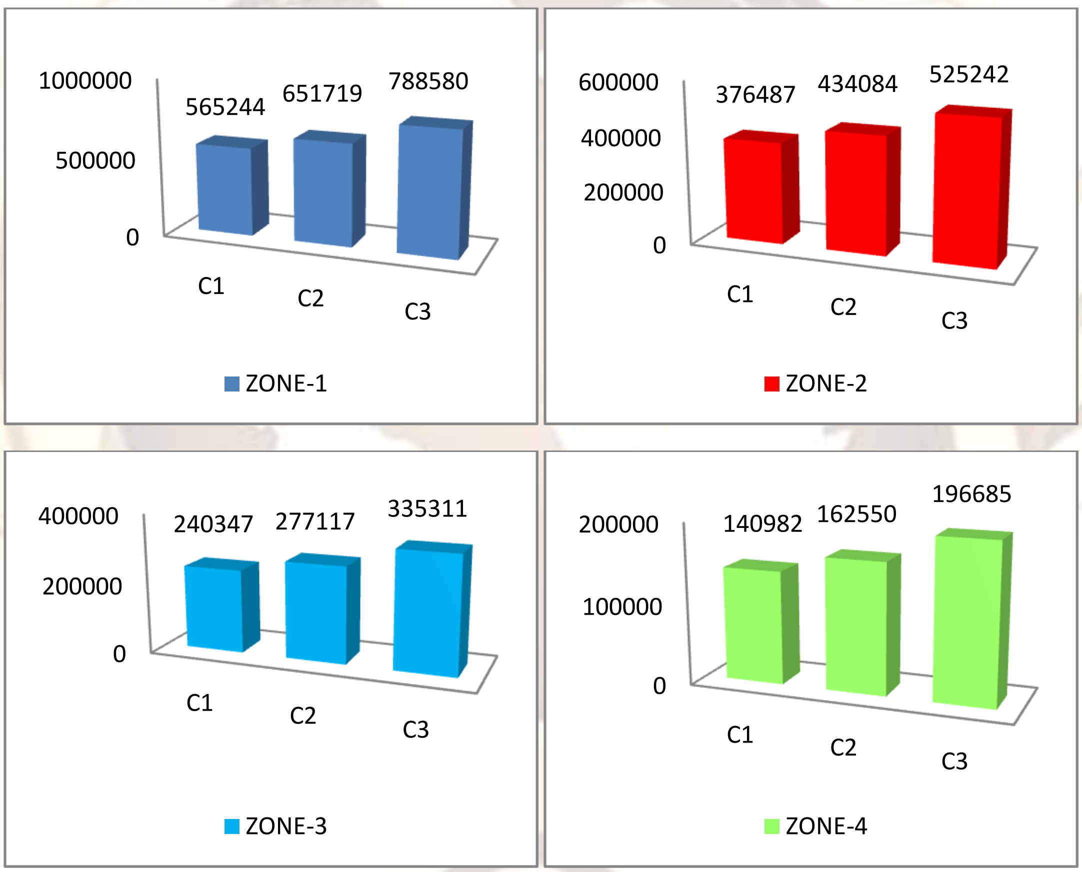


Figure 3 Dynamic Force (kg) Vs Various Wind Loads (m/s)



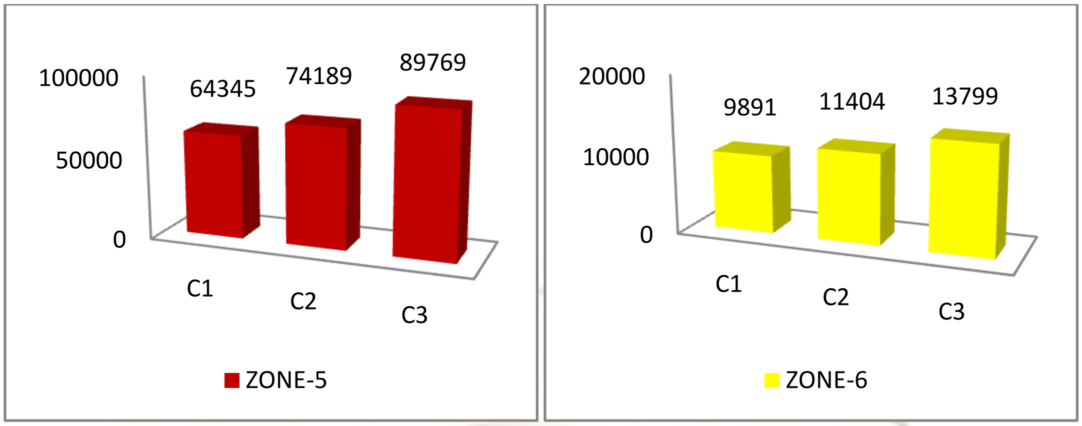


Figure 4 Static Moment (kg-m) Vs Various Wind Loads (m/s)

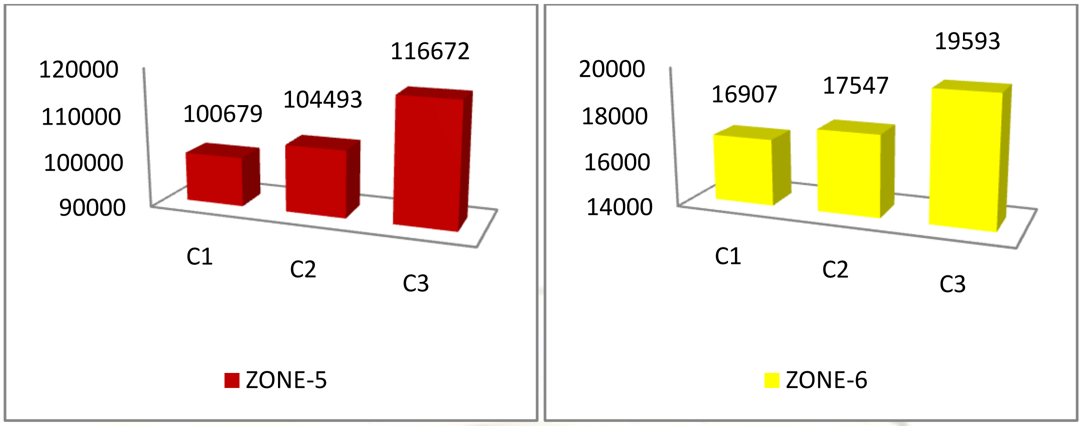
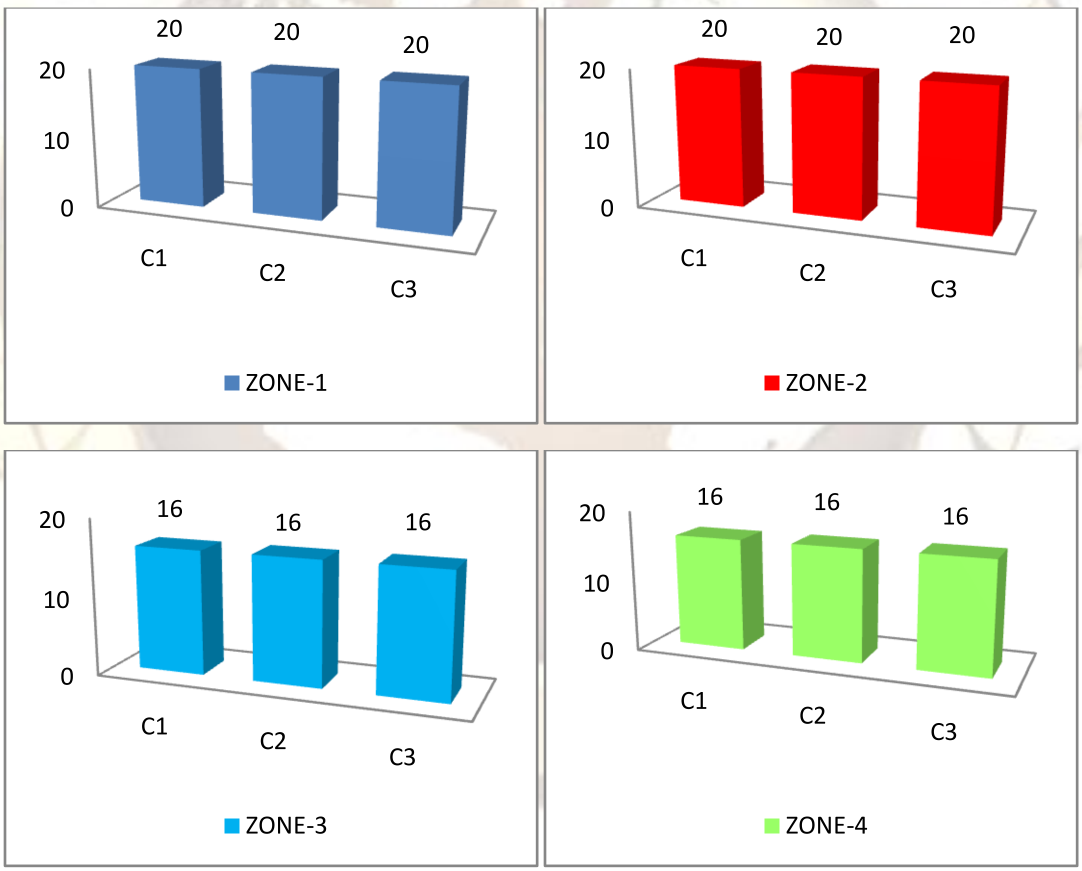


Figure 5 Dynamic Moment (kg-m) Vs Various Wind Loads (m/s)



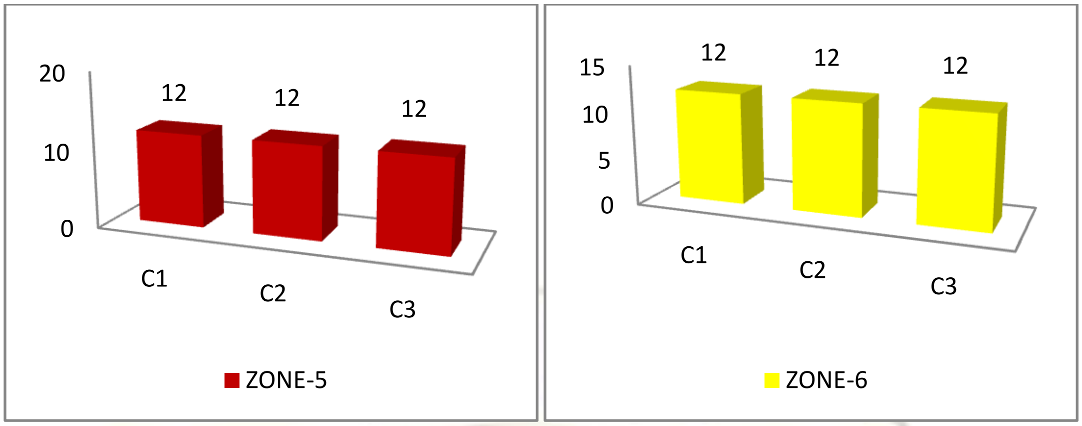


Figure 6 Thickness of Chimney (mm) Vs Various Wind Loads (m/s)

5. CONCLUSION:

Based on the results obtained from the design of chimney the following conclusion are drawn.

1. The static force and static moment for all the zones of C3 is 15% and 21% higher than the C1 and C2.
2. The dynamic force and dynamic moment for all the zones of C3 is increased upto 4% and12% than C1 and C2 respectively.
3. The thickness is found to be same for all the chimneys even the basic wind speed is varying.

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