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Research Paper

A Study on seismic load characteristics and modelling of chimney structure using fem approach

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Abstract

Chimneys are landmarks for power plants and industrial setups for modelling them using FEM approach. Chimneys are vertically and discharge, gaseous products of combustion, chemical wastes gases and exhaust air from and industry to the atmosphere. Rapid growth of industrialisation and increasing need for air pollution control as made RC chimneys as common structure in modern scenarios. With large scale industrialisation number of chimneys and stacks being constructed is increasing year by year. Here the chimney structure can be analysed by finite element analysis using FEM approach. Based on ANSYS Software, the structure can be meshed (discretized into several parts are called elements). At last, we can apply the boundary conditions and calculate its design by applying various loads.

Keywords: *Chimney, modelling, Fem approach, ANSYS*

1. Introduction

FEM approach is widely accepted as a method of analysing and validating performance and safety the of the structures under given load considerations. Here, the chimney structure is analysed using the above said FEM approach and it can be characterized by a seismic load [1-19]. Controllers modelling analysis for non-linear system has been reported [20-32].

2. Modelling

The chimney structure is modelled using CAD software CREO 2. The structure consists of a long hollow pipe which is fixed at bottom end is contact with the earth and closed. At the top end is kept opened towards upward direction. The total height of this chimney is 22010 mm and diameter at the bottom is about 1500 mm. here the tube is segregated into three portions such the first portion tube which is rest at the earth having length 6005 mm with 1500 mm diameter. The middle portion tube having 6010 mm with same 1500 mm diameter but at the each ends of this tube has 1610 mm diameters. At the final stage of the chimney tube which is located at the above middle tube having length is 1610 mm with 1500 mm diameter. The following Fig. ***1*** depicts the CAD model and the components as described earlier.

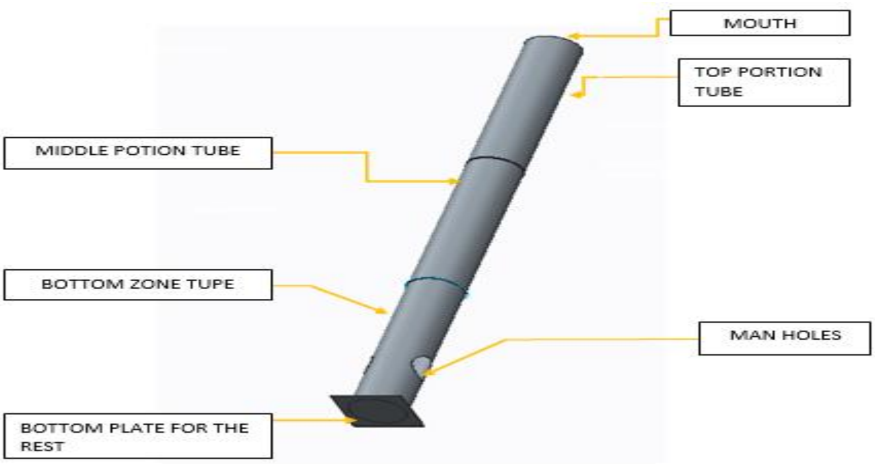

Fig. 1: Chimney and its Components

As seen in the model the bottom tube having two holes having 1220mm diameter and 1400 mm diameter at the ends of the mouth of the hole.

3. Meshing

After the geometry is imported into the analysis software ANSYS, it is meshed (i.e., discretising into several smaller entities called elements) for the purpose of analysing by the Finite Element Method.
The following shows the meshed model generated using ANSYS. The entire structure is discretized into 86,442 number of four nodded quadrilateral brick type elements.

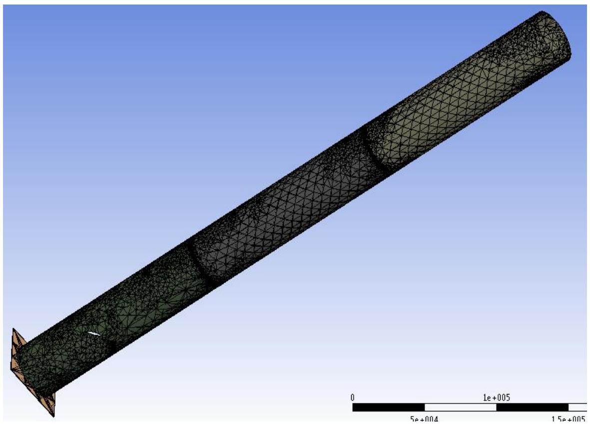

Fig. 2: Meshed Model

4. Boundary Conditions

After meshing, the meshed model is imported for structural analysis and boundary conditions are applied. The boundary conditions represent the degrees of freedom of each part of the actual model and the loads acting on them. The mounting plate along with the posts and their supporting members are constrained for all degrees of freedom.
The load acting on the structure under analysis:
Loads generated due to wind blowing over the surface of the chimney. the load generated due to wind is higher magnitude, the structure is expected to withstand wind speeds up to 55.5m/s. When wind blows over any object with a frontal area, it generates forces. For example, aircrafts, automobiles and bridges. The loads generated due to wind while the chimney is shaken.
Estimation of chimney by using the method of Influence based approach and self-sustaining chimney is divided into various numbers of element and each element having a height should not be more than 10m.The along-wind load, W(z) can be calculated for unit height of chimney at any section, z is equal to the summation of the mean along-wind load, W*(z) and the fluctuating component W'(z) of a long-wind load.

Design calculations:

$\mathbf{W(z) = W''(z) + W'(z)}$

Along wind load

$\mathbf{W''(z) = Cd*D(z)*V(z)}$

Where Cd is drag coefficient = 0.96

D(z) is chimney outer diameter of each section for 1500mm.

$W''(z) = 0.96*1500*55.5$

$\mathbf{W''(z) = 79.920\ m^2/s}$

The design wind speed V(z) can be calculated by multiplying basic wind speed Vb = 55.5 m/s and with modification factors k1 = 1, k2 = 1 andk3 = 1.(coefficients).

$\mathbf{v(z) = Vb*K1*K2*K3}$ (Vb is basic wind speed.)

$v(z) = 55.5*1*1*1$

$\mathbf{v(z) = 55.5\ m/s}$

Therefore,

$\mathbf{W'(z) = 3*\{(G-1)/H^2\}*\{Z/H\}}$

G-Grade of steel = 250N/mm^2

H-1800 mm

Z-Zone factor = 0.9

$W'(z) = 3*\{(250-1)/1800^2\}*\{0.9/1800\}$

$\mathbf{W'(z) = 9.14E10^{-5}\ m^2/s.}$

Hence

$W(z) = W''(z) + W'(z)$

$W(z) = 79.920 + 9.14E10^{-5}$

$\mathbf{W(z) = 79920\ Kg.m/s^2}$

5. Results

Deformation

An average and maximum deformation of 1.6055 mm occurs and the deforming zones are depicted in green and red respectively in the following **Error! Reference source not found.**3.

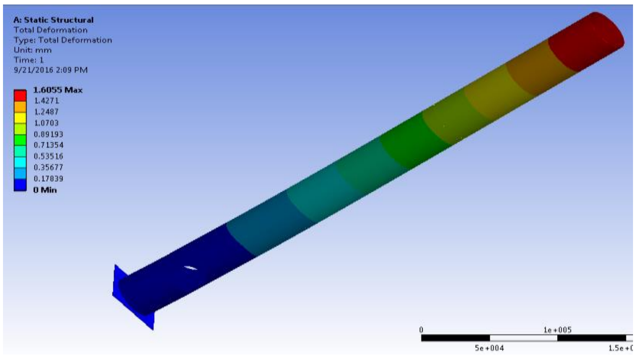

Fig.3: Maximum Deformation

Maximum Equivalent stress

The maximum equivalent or von Misses stress is found to be a maximum of 0.1991 MPa in the structure. The structure is safe to withstand the wind loads with the factor of safety of 3.28.

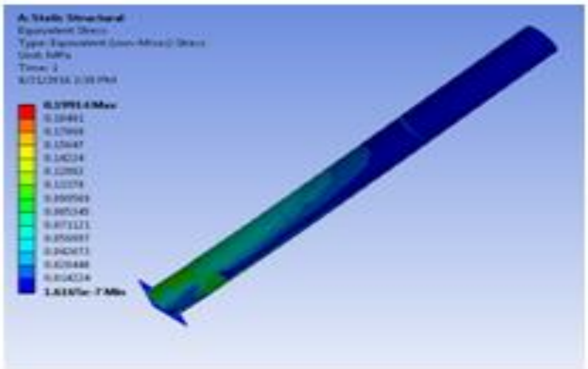

Fig. 4: Equivalent (Von Misses) stress

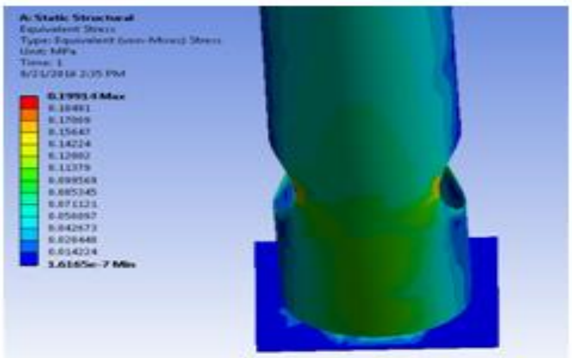

Fig. 5: Equivalent (Von Misses) stress

Directional deformation:

Apart from total deformation, the deformation in each direction (x, y and z) is also obtained. The values were found to be 0.0181 mm along X-axis, 1.605 mm in Y-axis and 0.0882 mm in Z-axis.

These deformation values are well below the maximum allowable standard and recommended values. Reference of Fundamentals of Mechanical Structures by Thomas D. Gillespie

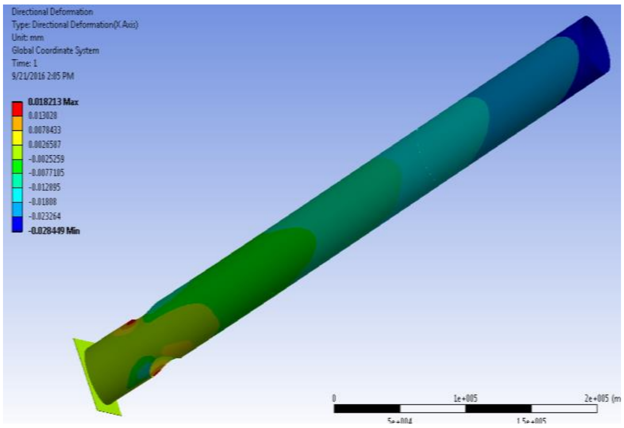

Fig. 7: Directional deformation in X direction

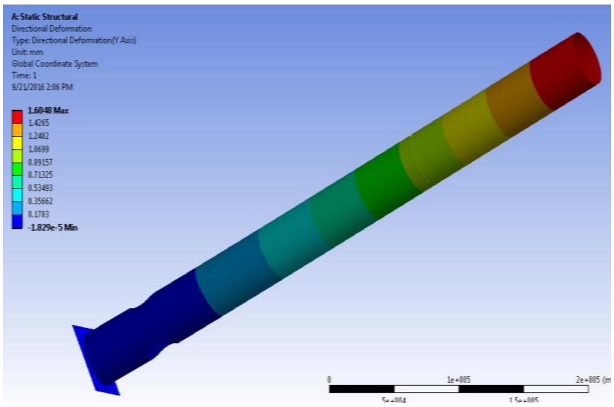

Fig. 8: Directional Deformation in Y-Axis

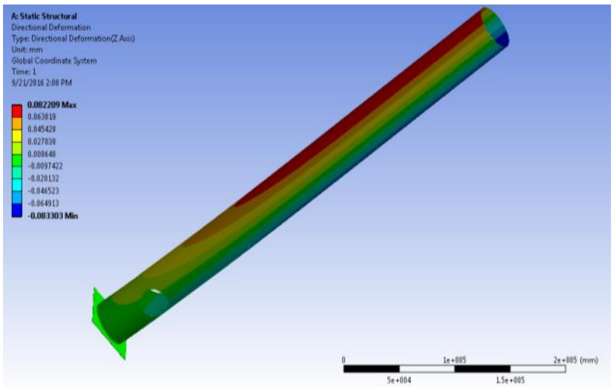

Fig. 9: Directional Deformation in Z-Axis

6. Conclusion

The structural deformation and stress distribution is within standard and recommended values for deformation, Von Misses Stress and Maximum Principal Stress.

Hence, it is concluded that the design of the structure presented for analysis is safe to handle the loads under required performance criteria.

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