FINITE ELEMENT OF STEEL (ANALYSIS OF SELF SUPPORTED STEEL CHIMNEY)

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ABSTRACT

Most of the industrial steel chimneys are tall structures with circular cross-sections. Such slender, lightly damped structures are prone to wind-exited vibration. Geometry of a self-supporting steel chimney plays an important role in its structural behaviour under lateral dynamic loading. This is because geometry is primarily responsible for the stiffness parameters of the chimney. However, basic dimensions of industrial self-supporting steel chimney, such as height, diameter at exit, etc., are generally derived from the associated environmental conditions. To ensure a desired failure mode design code (IS-6533: 1989 Part 2) imposes several criteria on the geometry (top-to-base diameter ratio and height-to base diameter ratio) of steel chimneys. The objective of the present study is to justify the code criteria with regard to basic dimensions of industrial steel chimney. Maximum bending moment and stress for all the chimneys were calculated for dynamic wind load as per the procedure given in IS 6533: 1989 (Part 2). Maximum base moments and associated steel stresses were plotted as a function of top-to-base diameter ratio and height-to-base diameter ratio.

I. INTRODUCTION

This paper deals with the analysis of self-supported-steel chimneys. Tall steel chimneys are presently planned in compliance with various codes of practice (IS 65331, 2, CICIND3 etc.). The chimney is considered as cantilever column with tubular cross section for analysis. Wind loads, temperature loads, seismic loads and dead loads are considered for design purpose. But apart from these loads, wind load is considered as most vital load due to height of the structure.

The effect of wind can be divided into two components: (a) along-wind effect (b) across-wind effect. But the across-wind effect is most critical and unpredictable. The bottom portion of the chimney is constructed as conical flare for better stability and for easy entrance of flue gases. Design forces in a chimney is very sensitive to its geometrical parameters such as base and top diameter of the chimney, height of the flare, height of the chimney and thickness of the chimney shell. Height of the chimney is governed by environmental conditions. As per recommendations of the Ministry of Environment and Forests5, Govt. of India, height of a self-supporting steel chimney should be as follows:

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h= max 6m + *Tallest Building height in location*

30m

Where Q= total SO2 emission from the plant in kg/hr and h = height of the steel chimney in m. As per IS-1653 Part-1: 19891, height of steel chimney is also a function of environmental conditions as follows:

$h= AMFD8\ CV$ 34

Where A = coefficient of temperature gradient of atmosphere responsible for horizontal and vertical mixing of plume,

M = estimated mass rate of emission of pollutants in g/s,

F = dimensionless coefficient of rate of precipitation,

C = maximum permissible ground level concentration of pollutant in mg/m3, gases, m3/s

D = diameter of stack at the exit of the chimney in m. V = estimated volume rates of emission of total flueme. Also, inside diameter of the chimney shell at top as per IS 6533 (Part 1): 1989 is given by:

$D= 4\ Qt\pi\ /Vexit$

Where D = inside diameter of the chimney at top in m,

Qt = Quantity of the gas in m3/s, and

Vexit = Velocity of the flue gas at exit point of chimney in m/s.

However, the diameter shall be so chosen that velocity of the flue gas at exit point of chimney will not exceed 30m/s, under any circumstances.

As per IS 6533 (Part 2): 19892 there are some limitations for the proportions of the basic dimensions from structural engineering considerations as follows

a. Minimum outside diameter of the unlined chimney at the top should be one twentieth of the height of the cylindrical portion of the chimney.

b. Minimum outside diameter of the unlined flared chimney at the base should be 1.6 times the outside diameter of the chimney at top with these parameters; the basic dimensions of the Chimney are checked to understand the code limitations. A lot of 66 of chimneys are considered for the present study.

II. ANALYSES OF THE SELECTED CHIMNEYS

2.1 Effect of Geometry

From the discussions in the previous section it is apparent that top to-base diameter ratio and height-to-base diameter

ratio are the two essential factors that characterize the geometry of a self-supporting chimney. For the selected Chimneys top-to-base diameter ratio and height-to-base diameter ratio varies with constant thickness and flared base diameter. Fig. 1 presents the different parameters of the selected chimneys according to code limitations. This figure shows that the selected chimneys cover wide range of geometry.

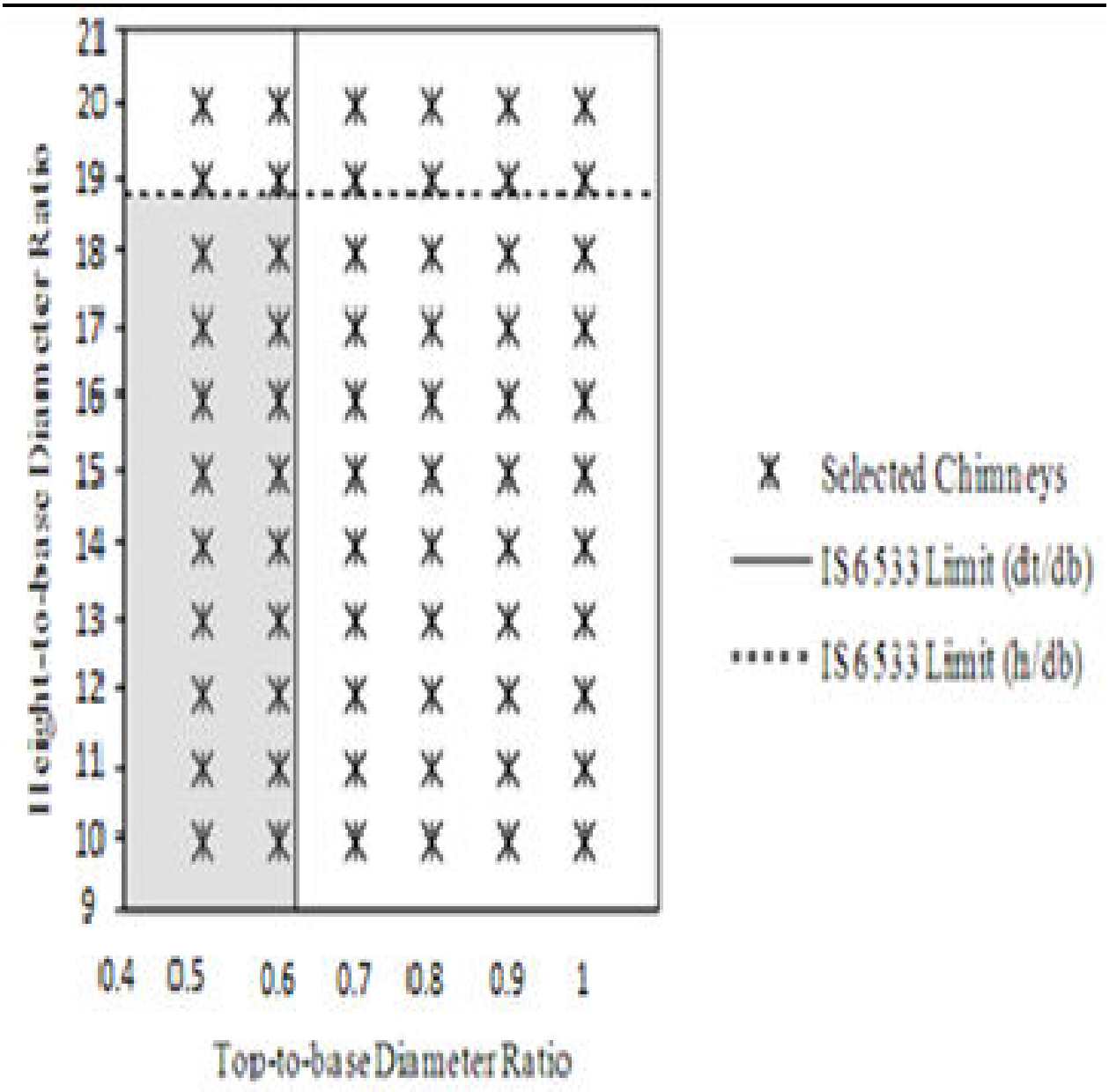

Fig 1:-Geometrical Parameters Distributions

III. RESULTS

In fig.1, it shows about the geometrical parameters which affect the design consideration. The shaded portion in the figure represents the region acceptable by the design code IS 6533 (Part2): 1989. According to code, base diameter should be 1.6 times the top diameter of the chimney. From this relation it is obtained that the maximum limit for top-to-base diameter ratio should be 0.625. Similarly another limitation is minimum top diameter of the chimney should be one twentieth of the height of the cylindrical portion of the chimney. Hence the height-to base diameter ratio as per the code limitation is obtained as 18.75.

IV. CONCLUSIONS

The purpose of this paper was to verify the basis of design code limitations with regard to the basic dimensions of self-supporting unlined flared steel chimney and the effect of inspection manhole on the behavior. It is established from these analyses that maximum moment and the maximum bending stress due to dynamic wind load in a self-supporting steel chimney are continuous functions of the geometry but it does not support the code limitations as mentioned previously.

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