COMPUTERIZED VIRTUAL STUDY ON SELF-SUPPORTING AND GUYED STEEL CHIMNEY

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Scientific discoveries have lead to the establishment of various types of industries. These industries supply smoke and harmful gases in to the atmosphere. Due to heavy industrialization and installation of high capacity power plants together with the growing consciousness about pollution has led to the construction of tall chimneys. It has been undergone a considerable growth of industrial chimney in past few years in terms of structural system as well as method of analysis. Also the height of chimney has been increased for the better control of environment pollution in populated areas. With the increase in height, the wind forces have become predominant forces while analyzing and designing such structures.

However, with the increment in height, the wind actions on it become important as these produce very high stresses. Although chimneys do not present as a great hazard to life and limb as buildings with high human capacity, damage to chimneys may result in shut down of plants and industries, the chimney may be self- supporting or guyed chimney. Here in this paper, an attempt has been made to analyses the industrial steel chimney for the established wind forces and seismic force considering self-supported and guyed steel chimney at various heights 54m,72m&90m at various wind speeds of 33m/s,44m/s&50m/s respectively. Thus maximum lateral displacements and maximum stresses are compared by using software package STAAD.Pro.V8i for the above considered heights and wind speeds.

Key Words: *Environment pollution, Chimney, Lateral displacements, and STAAD.Pro.etc…*

1. INTRODUCTION

The construction of tall stacks has been on the increase in the last couple of decades, due primarily to the increasing demand for air pollution control .These are mainly used in the sugar factories, food processing industries, thermal plants, vegetable oil factories, rice shelters, chemical industries etc. During the Industrial Revolution of the eighteenth and nineteenth centuries, pollution became a major problem with the introduction of the steam engine and a series of technological advances that led to the production of goods shifting from homes and small factories to large industrial factories. Pollution increased because of the more concentrated conditions within the industrializing cities and because of the use of artificially produced power (such as coal) that replaced the natural power of fast-running rivers.

Steel chimneys are also known as steel stacks are ideally suited for process work where a short heat up period and low thermal capacity are required whereas it encourages acid condensation and corrosion, and hence smuting and reduction in life of chimney.Steel chimneys are ideally suited for process work where a short heat-up period and low thermal capacity are required. Reinforced concrete chimneys are more expensive than other forms of construction upto about 45 m height, but above this they are more competitive. Above 65 m height, they are more readily acceptable because their flexibility of shape and flue layouts, in addition to the absence of any limitation on size.

Brick chimneys are suitable in clay industries for use with intermittent kiln firing and with very high exhaust gas temperatures. They are cheaper for smaller heights but require regular attention and therefore involve high maintenance cost. The chimney is a structure for venting hot flue gases or smoke from a boiler, stove, furnace or fireplace to the outside atmosphere. Chimneys are typically vertical, or as near as possible to vertical, to ensure that the gases flow smoothly, drawing air into the combustion in what is known as the stack, or chimney, effect. Due to heavy industrialization and installation of high capacity power plants together with the growing consciousness about pollution has led to the construction of tall chimneys. However, with the increment in height, the wind actions on it become important as these produce very high stresses.

Figure: Self-Supporting Steel Chimney

1.1 Objective of present study

For the design of steel chimney, the basic parameters are constrained according to the requirements of maximum displacements, moments and their stresses. To model the chimney under various loads at different wind speeds and at different heights for both Self-Supported and Guyed Steel Chimney. To study the lateral displacement and stress of the chimney using STADD.Pro.V8i.Finally, compare the results of maximum stress and maximum lateral displacements.

1.2 Scope and limitations of the project

The present study is conducted, with the intention of satisfying the knowledge gap about the selection of self-supporting and guyed steel chimney of specific height in respective of quantity of steel and maximum lateral displacement under dead and wind load combination. Self-supporting flared steel chimney and Guyed steel chimney is considered for the present study. Three various heights i.e 54m, 72m&90m at various basic wind speed of 33m/s, 44m/s&50m/s considered. In Guyed steel chimney uniform thickness is maintained throughout the study. Soil flexibility is not considered in the present study. All chimneys considered here are of single-flue type. Only wind load is taken into consideration for design of the chimney.

2. Design Methodology

This presents procedures to design self-supported steel chimney as per Indian Standard IS 6533 (Part 1 & 2):1989 and guyed steel chimney at three different height i.e 54m,72m&90m at wind speeds of 33m/s,44m/s&50m/s.

Common design parameters

Heights considered	54m, 72m and 90m
Basic wind speeds	33m/s, 44m/s and 50m/s
Terrain type considered	flat
Terrain category	2
Thickness of brick lining	100mm
Top width of chimney	3m
Bottom width of chimney	4.8m
Corrosion allowances	3 mm

Therefore k_1, the risk coefficient and k_3, topography factor k_2 are calculated using IS:875(part 3)1987 at respective heights in each model of chimney.

The horizontal reaction R_c at the collar is found by taking moments about the base.

$$\sum M_{base} = R_c h_1 - P_W H/2 = 0$$
$$R_c = P_W H/2h_1$$

The horizontal reaction at the base is

$$R_b = P_W - R_C = P_W - P_W H/2h$$

The shear just below the collar = $R_c - P_W(H-h_1)/H$
$$= P_W H/2 h_1 - P_W + P_W h_1/H$$

The shear at the base, $R_b = P_W - P_W H/2h_1$

The bending moment at the collar = $-P_W(H-h_1)/2H$

The maximum positive bending moment between collar and base

$$= P_W H(1 - H/2h_1)^2/2$$

And occurs at a point of zero shear = $(H-H^2/2h_1)$ meters above the base.

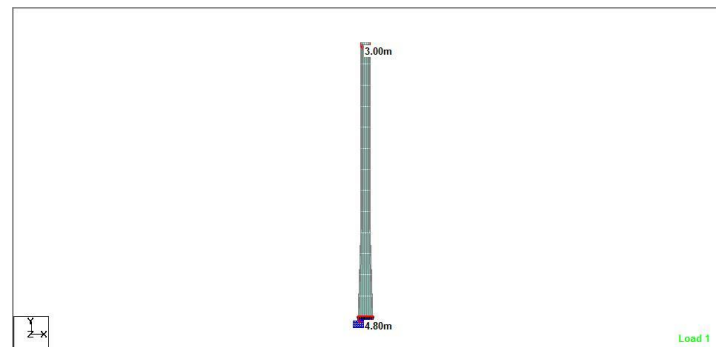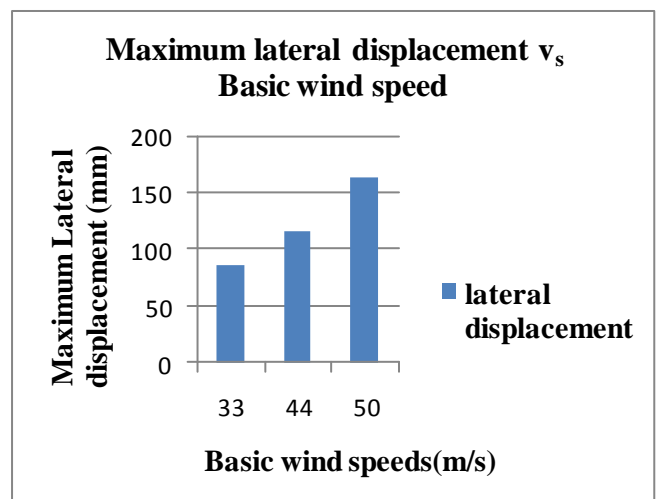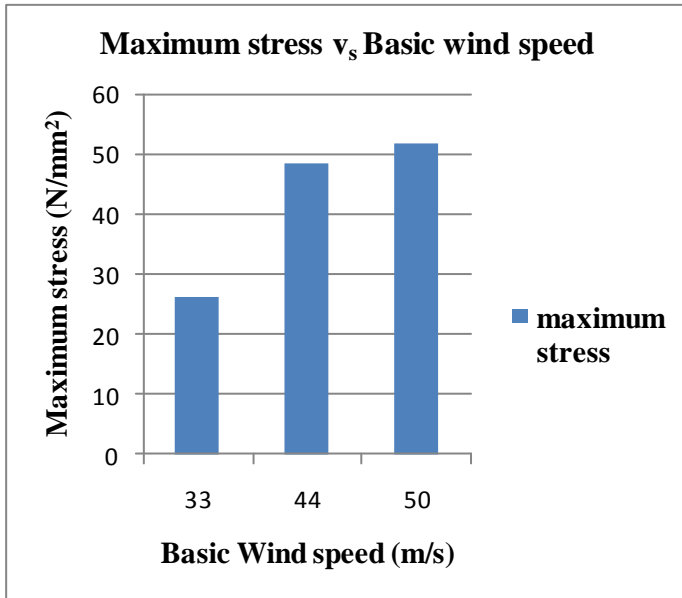**Fig -1**: **Geometry of 54m Self-Supporting Chimney**
Table 1 Maximum lateral displacements and Maximum stress at wind speeds of 33m/s, 44m/s & 50m/s for 54m Self-supporting Chimney

Basic wind speed(m/s)	Maximum lateral displacement(mm)	Maximum stress(N/mm²)
33	86.540	26.3
44	117.449	48.5
50	164.820	51.3

Maximum Lateral Displacement at Basic Wind Speeds of 33, 44&50 m/s for 54 m self-supporting Chimney

Maximum stress vs Basic wind speed

Maximum stress at Basic Wind Speeds of 33, 44&50 m/s for 54 m self-supporting chimney

Table 4.2 Maximum lateral displacements and Maximum stress at wind speeds of 33m/s, 44m/s & 50m/s for 72m Self-supporting chimney

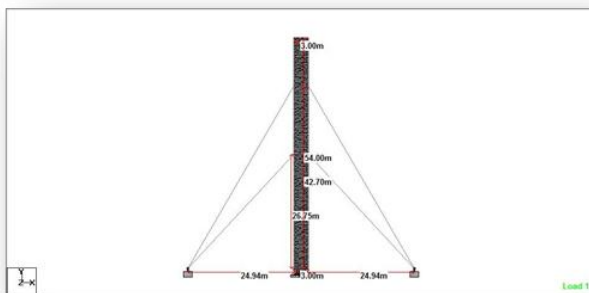| Basic wind speed(m/s)	Maximum lateral displacement(mm)	Maximum stress(N/mm²)
33	205.120	37.2
44	356.752	67.6
50	471.113	89.1

Figure Geometry of 54m Guyed chimney

COMPARISON OF RESULTS

Self-supporting and Guyed chimney at heights 54m, 72m, 90m each at basic wind speed of 33m/s, 44m/s and 50m/s are selected. They are modelled and analysed using STAAD.PRO V8i.The results of maximum lateral displacement, maximum stress for both self-supporting and guyed chimney for the load combination of dead load +wind load are presented and compared.
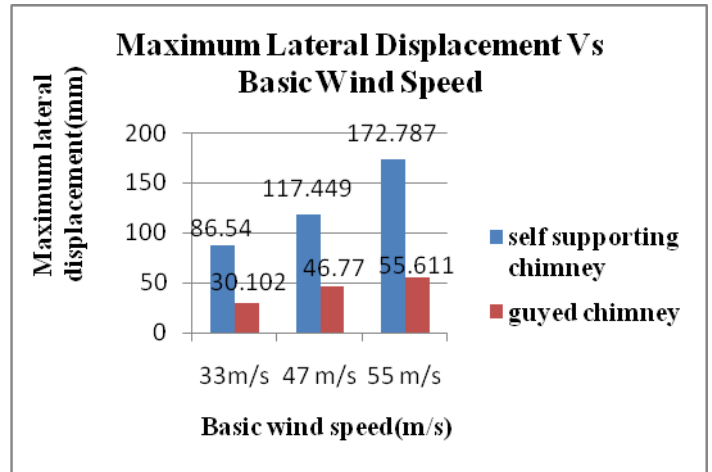

Figure 4.19: Maximum Lateral displacement at basic wind speeds of 33m/s, 44, m/s and 50 m/s of self-supporting and guyed steel chimney for 54 m height.
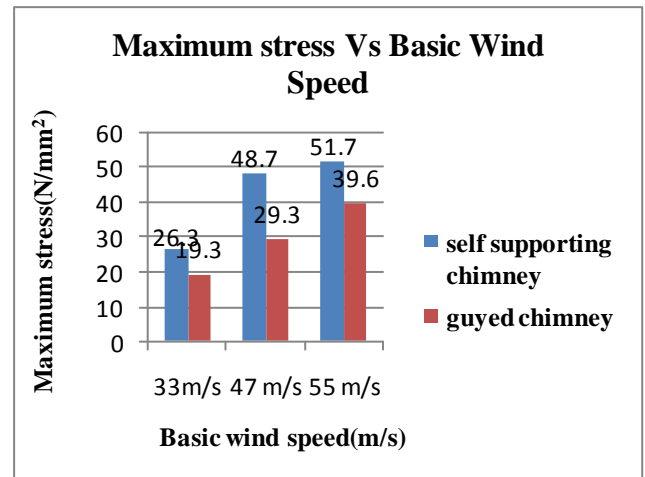

Figure 4.20: Maximum stress at basic wind speeds of 33m/s, 44, m/s and 50 m/s of self- supporting and guyed steel chimney for 54 m height
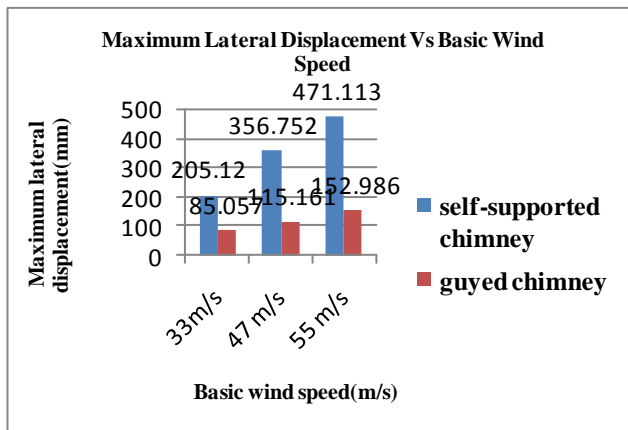
Figure 4.21: Maximum Lateral displacement at basic wind speeds of 33m/s, 44, m/s and 50 m/s of self- supporting and guyed steel chimney for 72 m height.

It is observed that there is an increase in maximum lateral displacement of 26.31% and 47.49% for basic wind speeds of 44m/s and 50m/s respectively when compared to basic wind speed of 33 m/s. It is observed that there is an increase in maximum stress of 45.77% and 48.73% for basic wind speeds of 44m/s and 50m/s respectively when compared to basic wind speed of 33 m/s. Finally we observed that there is an increase in maximum lateral displacement of 42.50% and 56.46% for basic wind speeds of 44 m/s and 50m/s respectively when compared to basic wind speed of 33 m/s.

3. CONCLUSIONS

Maximum lateral displacement
(a) For 54m height chimney, when compared with self-supporting chimney, observed that there was a decrease in lateral displacement of guyed chimney by **73.2%, 69.5 %** and **67.8%** for basic wind speed of 33m/s, 44m/s and 50 m/s respectively.
(b) For 72m height chimney, when compared with self-supporting chimney, observed that there was a decrease in lateral displacement of guyed chimney by **61.05 %, 67.71 %** and **67.52 %** for basic wind speed of 33m/s, 44m/s and 50 m/s respectively.
(c) For 90m height chimney, when compared with self-supporting chimney, observed that there was a decrease in lateral displacement of guyed chimney by **71.44%, 60.51%** and **63.05 %** for basic wind speed of 33m/s, 44m/s and 50 m/s respectively.
(ii) Maximum stress
(a) For 54m height chimney, when compared with self-supporting chimney, observed that there was a decrease in lateral displacement of guyed chimney by **26.61%, 39.58 %** and **30.55 %** for basic wind speed of 33m/s, 44m/s and 50m/s respectively.
(b) For 72m height chimney, when compared with self-supporting chimney, observed that there was a decrease in lateral displacement of guyed chimney by **28.49 %, 37.36 %** and **31.42%** for basic wind speed of 33m/s, 44 m/s and 50 m/s respectively.

(c) For 90m height chimney, when compared with self-supporting chimney, observed that there was a decrease in lateral displacement of guyed mast by **36.73 %, 21.6 %** and **24.25 %** for basic wind speed of 33m/s, 44 m/s and 50 m/s respectively.

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BIOGRAPHIES

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