

Behavior of Steel Chimney in Increasing the Segmentation and Reducing the Section Diameter

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ABSTRACT:In today's highly competent world, it has become very important to design an efficient and cost effective system. Proper analytical and optimum design concepts are needed to design such systems. Steel stacks play an important role in this era of industrialization. Stacks are vertical tall slender structures which discharge chemical waste gases from industries to the atmosphere. The main aim is to minimize total weight and thus, cost of the steel chimney. Our attempt is to generate data and optimize the various design parameters of steel stack. Weight reduction of steel stack will occur by reducing values of the design variables but to an extent such that the steel stack continues to stand and it does not fail in stress analysis. Wind force calculations, stress calculations and deflection calculations have been done in Finite Element Abacus Software & used IS code 875 and IS 6533. The analysis process and optimization of a steel chimney & Result have been summarized and conclusion have been drawn.

KEYWORDS:Chimney, Optimization, Steel Stack, Finite Element Abacus Software, IS code 875 and IS 6533.

I. INTRODUCTION

Chimneys or stacks are very important industrial structures for emission of poisonous gases to a higher elevation such that the gases do not contaminate surrounding atmosphere. These structures are tall, slender and generally with circular cross-sections. Different construction materials, such as concrete, steel or masonry, are used to build chimneys. Steel chimneys are ideally suited for process work where a short heat-up period and low thermal capacity are required. The cross-sectional area of the steel chimney is kept large enough to allow the passage of burnt gases. The cross-sectional area of the steel chimneys depends on the type and quantity of fuels to be used in plant, available draft for carrying the burnt gases up the chimney. The height of the steel chimney is kept to provide the required draft. "The draft is defined as the difference between the absolute gas pressure at any point in the steel chimney and the ambient atmosphere pressure." The draft depends on the height of the steel chimney above sea level, the type of fuel to be burnt, the type of furnace and the temperature of the burnt gases.

The Objectives of Study are

- 1.To study the design steel chimney for industrial structure considering wind loading.
- 2.To decide the single stack in number of small segment to reduce the section diameter.
- 3.To Develop an understanding of optimal design of Steel chimney structure.
- 4.To derive the various combination of segmentation of chimney and compare the performance of chimney.

II. TYPES OF STEEL CHIMNEY

The steel chimneys are of two types:

1. Self-supporting steel chimney
2. Guyed steel chimney

1. Self-supporting Steel Chimney

A self-supporting steel chimney or stack is made of steel plates and supported on foundations. When the lateral forces (wind or seismic forces) are transmitted to the foundation by the cantilever action of the chimney, then the chimney is known as self-supporting. The chimney together with the foundation remains stable under all working

conditions, without any additional support The self-supporting steel chimneys are made up to 10m diameter and from 50 m to 100 m in height.

2. Guyed Steel Chimney

In high steel chimneys, the mild steel wire ropes or guys are attached to transmit the lateral forces. Such steel chimneys are known as "guyed steel chimneys." In guyed steel chimneys, all the externally applied loads (wind, seismic force etc.) are not totally carried by the chimney shell. These attached guys or stays do share these applied loads. These chimneys may be provided with 1, 2, or 3 sets of guys. In each set of guys 3 or 4 m sometimes 6 wires are attached to the collars. A particular type of steel chimney is selected depending on the advantage and disadvantages with reference to economy

III. METHODOLOGY

Design Manual Calculations:

1. Type - Self-supporting steel chimney
2. Height - 72 m
3. Top Diameter - 3m
4. Soil Bearing Capacity - 200kN/m²
5. Thickness of Fire Brick - 100mm
6. Location of terrain category – 2

3.1 Basic dimensions of chimney

Total Height = 72 m

Height of Flare = $\frac{1}{3} \times \text{Total Height} = \frac{1}{3} \times 72 = 24\text{m}$

Diameter of flare = $(1.6 \times 3) = 4.8\text{ m}$

3.2 Computation of Wind Pressure

Design of wind speed (V_z)

$V_z = V_b \times K_1 \times K_2 \times K_3$ [IS875 Part 3, cl. 5.3.]

V_b = Basic wind speed

K_1 = Probability factor

K_2 = Terrain Roughness & height factor

K_3 = Topography Factor

$P_z = 0.6 V_z^2$

$P = P_z \times D \times Z \times S$ [IS875 Part 3, cl. 5.4.]

Where, D = Diameter of Section

Z = Height of Segment

S = Shape Factor = 0.7

3.3 Design of Chimney Shell

1) Stresses due to self-weight (f_s) = $0.0785h$

2) Stresses due to weight of lining (f_l) = $\frac{2h}{t}$

3) Stresses due to wind (f_w) = $\pm \frac{4M_w}{\pi d^2 t}$

IV. RESULTS & DISCUSSIONS

Analysis of Chimney: In this paper we have performed above mentioned wind load force in abacus software. and we are find out the different stress strain and deflection of chimney with different segment.



Table 1:Segment Height 8m

Elevation From Base Height(m)	Stress(N/mm ²)	Strain	Deflection(mm)
8	2.33	0	0
12	5.63	0.0001	8.84
18	11.25	0.0002	17.69
24	16.87	0.0003	26.54
30	22.49	0.0004	35.39
36	28.1	0.0005	44.24
42	33.72	0.0006	53.08
48	39.33	0.0007	61.93
54	44.95	0.0008	70.78
60	50.56	0.0009	79.62
66	56.18	0.001	88.47
70	61.8	0.001	97.32
72	67.41	0.001	106.2

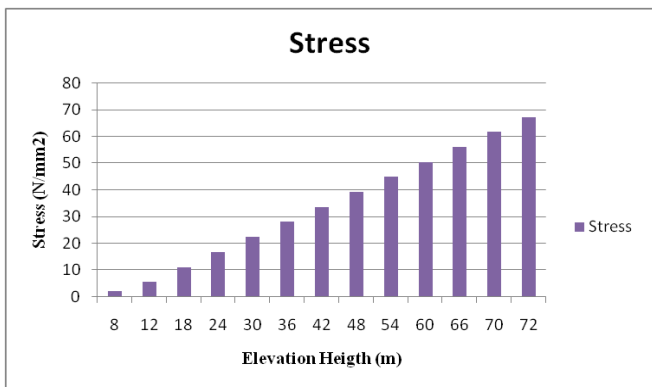


Figure 1-Segment Height 8m Stress

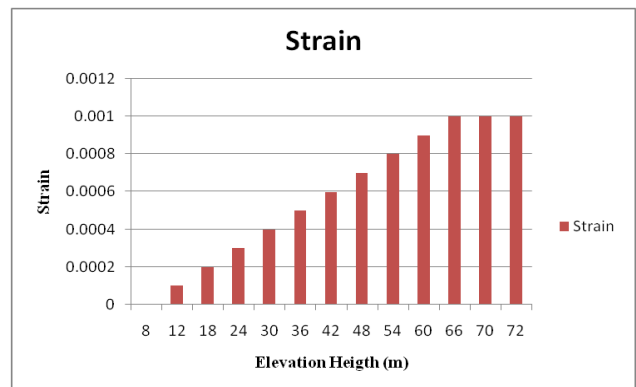


Figure 2- Segment Height 8m Strain

The figure1 shows that the stress in N/mm² at different height of chimney. This Graph shows the stress of chimney at every 8m height. The minimum stress is 2.33 and maximum stress at top of chimney is 67.41&The figure 2 shows that the strain at different height of chimney This Graph shows the strain of chimney at every 8m height at the bottom of the chimney strain negligible and maximum strain at top of chimney is 0.001.

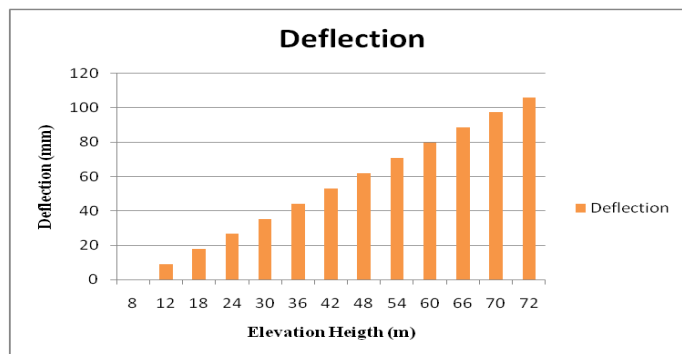


Figure 3-Segment Height 8m Deflection

The figure 3 shows that the deflection of chimney at different height. This Graph shows the deflection of chimney at every 8m height at the bottom of the chimney deflection is zero and maximum deflection at top of chimney is 106.2 mm.

Table 2 Segment Height 18 m

Elevation From Base Height(m)	Stress(N/mm ²)	Strain	Deflection(mm)
8	1.59	0.00001	0
12	5.98	0.0001	9.31
18	11.98	0.0002	18.64
24	17.96	0.0004	27.96
30	23.94	0.0005	37.27
36	29.92	0.0006	46.59
42	35.9	0.0008	55.91
48	41.88	0.0009	65.23
54	47.87	0.001	74.55
60	53.85	0.0012	83.87
66	59.83	0.0013	93.19
70	65.81	0.0014	102.5
72	71.17	0.0016	111.8

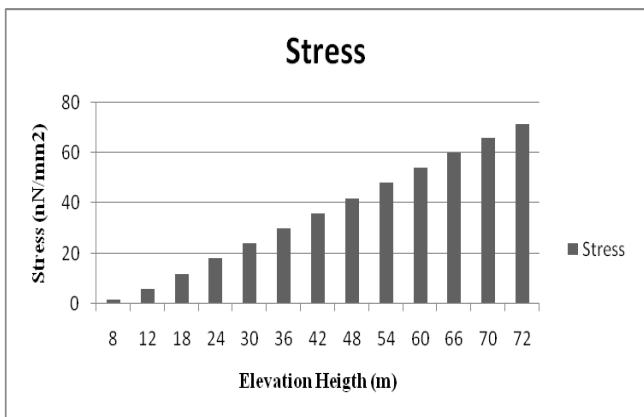


Figure 4-Segment Height 18m Stress

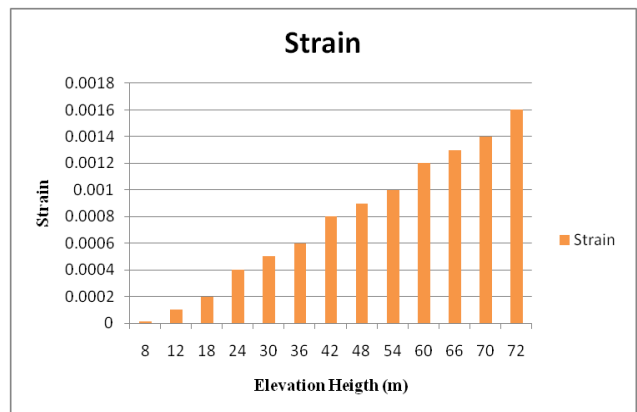


Figure 5- Segment Height 18m Strain

The figure 4 shows that the stress in N/mm² at different height of chimney. This Graph shows the stress of chimney at every 18m height. The minimum stress is 1.59 and maximum stress at top of chimney is 71.17 and The figure 5 shows that the strain at different height of chimney. This Graph shows the strain of chimney at every 18m height at the bottom of the chimney strain negligible i.e. 0.0001 and maximum strain at top of chimney is 0.0016

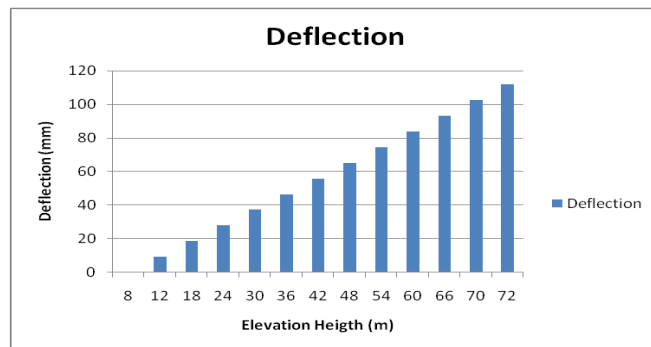


Figure 6-Segment Height 18 m Deflection

The figure 6 shows that the deflection of chimney at different height. This Graph shows the deflection of chimney at every 18m height at the bottom of the chimney deflection is zero and maximum deflection at top of chimney is 111.8 mm.

Table-3 Segment Height 24m

Elevation From Base Height(m)	Stress (N/mm ²)	Strain	Deflection (mm)
8	1.15	0.00004	0
12	7.22	0.00014	11.1
18	14.43	0.00028	22.36
24	21.64	0.00042	33.54
30	28.85	0.00056	44.72
36	36.07	0.0007	55.9
42	43.28	0.00084	67.08
48	50.49	0.00098	78.26
54	57.7	0.00112	89.44
60	64.91	0.00126	100.6
66	72.12	0.0014	111.8
70	79.33	0.00155	123
72	86.54	0.00169	134.2

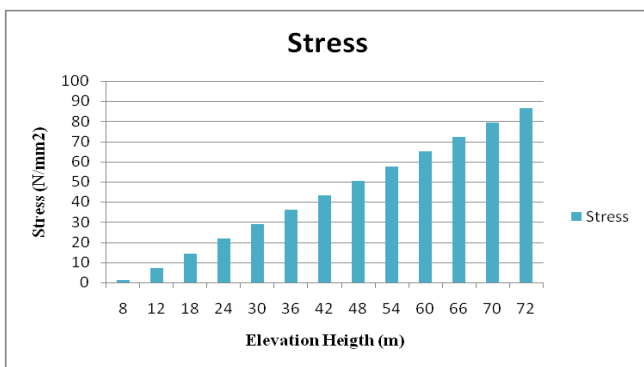


Figure 7-Segment Height 24 m Stress

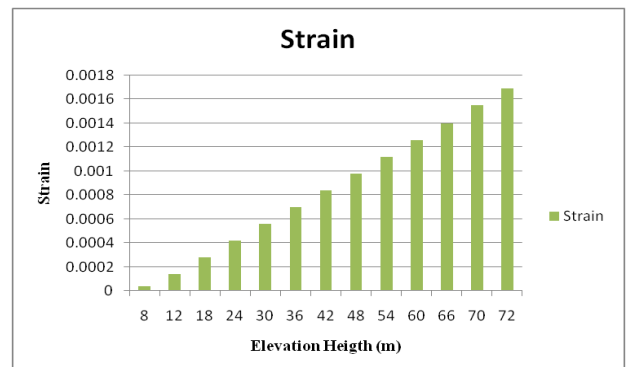


Figure 8-Segment Height 24 m Strain

The figure.7 shows that the stress in N/mm² at different height of chimney. This Graph shows the stress of chimney at every 24m height. The minimum stress is 1.15 and maximum stress at top of chimney is 86.54.&The figure.8 shows that the strain at different height of chimney. This Graph shows the strain of chimney at every 24m height. At the bottom of the chimney strain negligible i.e. 0.00004 and maximum strain at top of chimney is 0.00169.

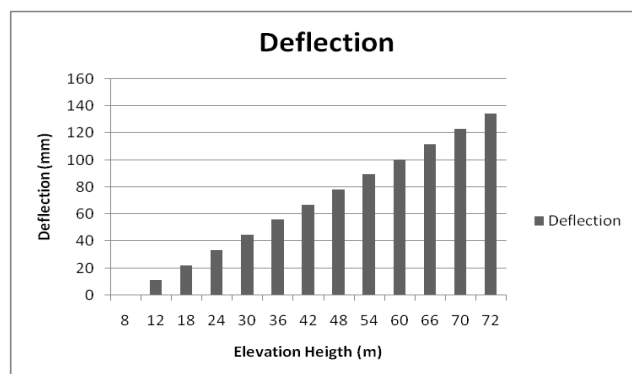


Figure 9-Segment Height 24 m Deflection

The figure 9 shows that the deflection of chimney at different height. This Graph shows the deflection of chimney at every 18m height at the bottom of the chimney deflection is zero and maximum deflection at top of chimney is 134.2 mm.

Table No 4 Deflection Comparisons

Elevation From Base Height(m)	Deflection (8)	Deflection (18)	Deflection (24)
8	0	0	0
12	8.84	9.31	11.1
18	17.69	18.64	22.36
24	26.54	27.96	33.54
30	35.39	37.27	44.72
36	44.24	46.59	55.9
42	53.08	55.91	67.08
48	61.93	65.23	78.26
54	70.78	74.55	89.44
60	79.62	83.87	100.6
66	88.47	93.19	111.8
70	97.32	102.5	123
72	106.2	111.8	134.2

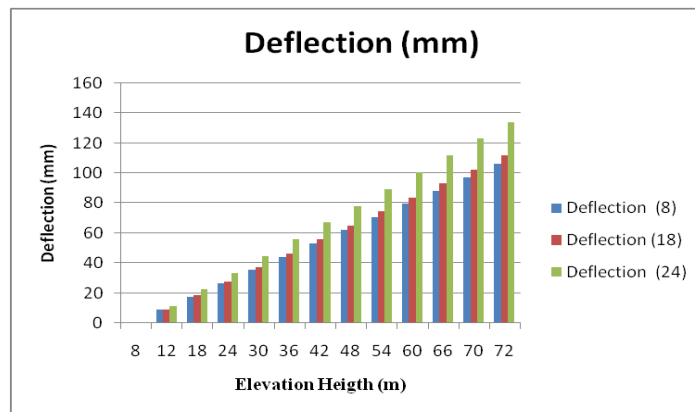


Figure 10-Deflection Comparison

The figure 10-shows that the comparison of deflection of 8 m, 18m and 24m height segment chimney at different height of chimney. This Graph shows the deflection are minimum when segment of chimney increases

V. CONCLUSION

For the designing a structural system conventional and optimum design process are used at different stages of design. In this paper main objective or function has been formed to minimize total cost of chimney and optimization of with safe design. The work is presented for optimal design of 72m steel chimney structure. While doing optimization cases are considered, divided total 72m chimney into seven cases. The analysis of work in Abaqus software in which stress strain and deflection are search with the different segment of chimney.

Following results are shown from the analysis.

- Diameter of chimney reduced the weight of chimney also reduced.
- Segment increases the stress & strain and also deflection is reduced at top of the chimney.
- In the compression shows the segment increase the deflection decreases, its vice versa.

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