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Design and Dynamic Analysis of Steel Chimney in STAAD Pro

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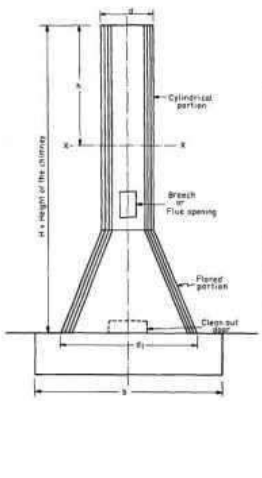
***Abstract:** Chimneys must transport exhaust gases, gaseous products of combustion, may is necessary so that it creates an independent structure capable of withstanding wind loads, seismic loads, dead loads and other forces acting on it. Industrial chimneys are tall, slender structures with a circular section. Different types of steel chimney models are made by varying their height, diameter and geometry. Steel chimneys are generally cylindrical. Loads acting on steel chimneys are easily transferred to the foundation by widened or flared sections, chimneys built today are often susceptible to wind due to their size, shape, flexibility, slenderness and of their lightness. Therefore, special attention should be p aid to the safety and economy of the structure when designing the steel chimney.*

Keywords- R.C. Steel Chimney, WIND Analysis, STAAD- Pro

I -INTRODUCTION

Their flexibility, finesse, shape, size and lightness. Do Not Build These Chimneys Unless Considered 1 the large number of steel chimneys built today are susceptible to wind due to the e-structure. Chimneys are tall, thin structures with a uniform or tapering circulardiameter used to release hot combustion gases or fumes from any furnace, boiler, or industrial hearth into theupper atmosphere. Chimneys are designed as tall vertical structures that gently release unwanted noxious gases by drawing in air for combustion, known as the "chimney effect". Steel chimneys are classified according to their support and shape. Based on the support, they are divided into cable-stayed or built-in chimneys and free- standing chimneys. Freestanding chimneys are widelyused in industrial fields. The shape of a freestanding steel flue plays an important role in its organizational performance in sidewise dynamics. However, the basic geometric parameters of steel chimneys (such as overall height, outlet diameter, etc.) are related to the Steel chimneys to ensure desired failure modes.

1.1) The minimum outside diameter of an unlined top chimneys must be one- twentieth of the height above the chimney.
1.2) The minimum outer diameter of unlined bottom extension chimneys is greater than 1.6 times the outer diameter of the chimney.



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II - TYPE STEEL FIREPLACE STRUCTURE

The type of steel fireplace structure is divided into twomain types, namely:

1. Freestanding steel chimney
2. Stamped steel chimney.

2.1 Freestanding

Steel Chimney When the lateral force (wind force or seismic force) is transmitted to the foundation is the cantilever action of the chimney, this chimney is called a freestanding chimney. The freestanding chimney remains stable with the foundation in all operating conditions without any additional support. The freestanding chimney has a diameter of up to 10 meters ht of 50-100 meters.

2.2 Stamped Steel

Chimneys In tall steel chimneys, low carbon steel cords or heads are attached to transm it lateral forces. This typeof steel chimney is called an inclined chimney.

3 structural steel chimney design

3.1 Steel Chimneys options

3.2 chimney steel plates

3.3 bushings

3.4 steel chimney base

4. The force acting on the steel chimney

4.11 Dead weight of the steel chimney

The deadweight of the steel chimney Ws vertical expression behavior by where: d: diameter of the chimney, m t: thickness of the steel sheet, m h: height of the t op of the steel chimney in meters XX section 79 kN/m2 is the shearing stress in the cost -iron per unit weight of steel

4.2 Wind pressure

The horizontal effect of wind pressure is related to the shape, width, height, location and climatic conditions of buildings. Increase in wind pressure per unit area with the height of the building at ground level, to simplify the design, the steel chimney is divided into several sections of aligned. Each section can exist leveled up to 10 m.

It can be assumed that a strength of the air pressure is uniform over an entire surface segment.corr.wind pressure.

4.3 Seismic pressure

Tectonic pressure acting level at length the construction. To calculate the stress at any poi nt in a steel chimney, consider the following load combinations: 1.constantload + wind load + temperature

2. Dead load + seismic load (earthquake) + temperatureinfluence

Consider only a best combination of seismic force (earthquake) and wind influence.

5 Mathematical Analysis

5.1 A self-supporting steel stack of height of 40m above the ground the diameter of cylindrical part of chimney is 2m the foundation has to rest on medium type of soil having capacity 150kn/m 2 the topography at the is flat ant location is terrain category 2

Design chimney along with foundation

Basic dimension of chimney

Computation / calculation of wind load 3 stress calculation on chimney holding down bolts of Height of chimney = 40mTopography is almost flat

Diameter of chimney =2 m

Step 1: Basic dimension of chimney

Height of flare = $\frac{1}{4} \times 40 = 10$m

Diameter of flax = 1.6 × 2 =3.2m

Step 2: computation / calculation of wind load

The design wind speed at any height " z " is given by ,(V_z)= $V_b\, k_1\, k_2$

Wind velocity, (v_z) = $v_b\, k_1\, k_2\, k_3$ Wind pressure, (p z) =0.6 v 2 Wind force, (f z) =0.7. p z. (area)Segment 1

H = 40m, d =2m

Class of structure = 6

Risk factory, (k_1) =1

(k2) =1.10 + $\frac{0.05}{}$×10 = 1.125

Topography factory, (k_3) =1

Wind velocity, (v_2) =$k_1\, k_2\, k_3\, v_b$ = 1× 1.125 × 1 × 47 =52.875 m/sec

Wind pressure, (p_2) = 0.6 × $(52.875)^2$ = 1.677kn/m^{2}Wind force, (f_2) = 0.7 × 20 × 1.677 =23.478kn

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Segment 2
H =30m, d = 2m
Class of structure = B
$K_1 = k_3 = 1$
$K_2 = 1.10$
Wind pressure, $(p_2) = 0.6 \times (1.10 \times 47)^2 = 1.603 kn/m^2$
Wind force, $(f_2) = 0.7 \times 20 \times 1.603 = 22.442kn$
H = 20m, d =2m
Class of structure = B
$K_1 = k_3 = 1$
$K_2 = 1.05$
Wind force, $(F_Z) = 0.7 \times 1.4161 \times 20 = 20.454kn$
H = 10m, d = $\frac{2+3.2}{2}$ = 2.6
Wind pressure, $(p_2) = 0.6 \times (1.00 \times 47)^2 = 1.3254 kn/m^2$
Wind force, $(f_2) = 0.7 \times 1.3254 \times 20 = 24.115kn$

Step 3: stress calculation on chimney
Stress due to wind moment, $(\sigma_m) = \frac{4m}{\pi d2t}$
Stress due to chimney weight, (σ_m) = 0.079h
Stress due to lining (brick lining), $(\sigma_L) = 0.002 \frac{h}{t}$
Now, the minimum thickness of steel from stability point of view

$$\frac{d}{500} = \frac{2000}{500} = 4mn\ (p4)$$

Let the design of steel 20 year and coal is used to fuel for builder add 4mm to account for corrosion taking 85% efficiency of riveted joint in (p5)
Tension $\sigma_{t\ max} = 0.85 \times (0.6\ f_y)$
$127.5 n/mm^2$

Section $x_1 - x_1$:
He =10m and d =2m
Assuming thickness =6mm
$\frac{he}{d} = \frac{10}{20} = 5$ and $\frac{d}{t} = \frac{2000}{6}$
From the table, the compressive stress $(\sigma) = 78 n/mm^2$
Moment of section $(x_1\text{-}x_1)$, m_{wx} : 117.39knm

$$\sigma_m = \frac{4mw}{\pi dt} = \frac{4 \times 117.39}{\pi \times 2 \times 6} = 6.23 n/mm^2$$

$$\sigma_s = 0.079h = 0.079 \times 10 = 079 n/mm^2$$

$$\sigma_l = 0.002\frac{h}{t} = 0.002 \times \frac{10}{6} = 3.33 n/mm^2$$

Checking all stress:
$\sigma_{c,cal} = 6.23 + 0.79 + 3.33 = 10.35 n/mm^2 < 78 n/mm^2$
$\sigma_{t,cal} = 6.23 - 0.79 = 5.44 < \frac{127.5n}{mn}$

Section x_2- x_2:
He = 20m and d = 2m
Assuming thickness =6mm
$\frac{h}{D} = \frac{20}{2}$ and $\frac{D}{t} = \frac{200}{6}$
From the table compressive stress $(\sigma_c) = 78 n/mm^2$
Moment of section $(x_2\text{-}x_1)$, m_{wx2} : 464.38knm
$\sigma_m = 24.63 n/mm^2$
$\sigma_s = 1.58 n/mm^2$
$\sigma = 6.67 n/mm^2$

$\sigma_{c,cal} = 24.63 + 1.58 + 6.67 = 32.88 n/mm^2 < 78 n/mm^2$
$\sigma_{c,cal} = 24.63 - 1.58\ \frac{23.05n}{mn} < 127.5n/mn$

Section x_3-x_3;
H_e = 30m and d = 2m
Assuming thickness = 8m
$\frac{he}{D} = \frac{30}{2}$ and $\frac{d}{t} = \frac{2000}{8}$
$X_1 = 23.478 \times 5 = 117.39$ knm
$X_2 = 23.478 \times 15 + 22.442 \times 5 = 464.38$ knm
$X_4 = 23.478 \times 25 + 22.442 \times 20.454 \times 15 + 24.115 \times \frac{3.2+2\times2}{3.2+2} \times \frac{10}{3} = 1800.89$ knm
From the table, the maximum compressive stress $\sigma_c = 70 n/mm^2$

Bending moment, (mw base): 1800.89kn/m
$\sigma_m = 22.39 n/mm^2$
$\sigma_s = 3.16 n/mm^2$
$\sigma_l = 8 n/mm^2$

Checking all stress:
$\sigma_{c,cal} = 33.55 < 70 n/mm^2$
$\sigma_{t,cal} = 19.23 < 127.5n/m$

Step4: design of base plate
Maximum compressive stress at base plate
C = $31.55 n/mm^2$
Maximum compressive strength per unit f = $\sigma \times 12$ = $31.55 \times 12 = 315.5kn/m$
Width of base $= \frac{f}{\sigma} = \frac{315.5\times10}{4\times10} = 78.87m$
Leys provide 100m base width
Pressure under base = $\frac{315.5}{100} = 3.155 n/mm^2$
Thickness of base plate

$$T = \frac{c\sqrt{3 \times p}}{185}$$

$$T = \frac{150\sqrt{3 \times 3.155}}{185}$$

T = 33.92 mm
Effective base plate thickness 33.92 – 10 = 23.92mm
Step5: holding down bolts

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Try 45m Ø high tensile bolts = 340n/mm^2
Allowable tensile stress at bolts, (t_f) = 0.6 × fy = 0.6 × 340 = 204n/mm^2
Strength of bolts
(r_1) = 260kn
Weight = π × 2 × 10 × 40 × 78.5
D = 3200+100 = 3300mm
Spacing of anchor bolts = 600mm
Use 45mm Ø bolts at a spacing of 600 mm c/c

Step6: design of foundation

Diameter of cement concrete foundation, p_2 = 6.51mm
Depth of foundation = 2.64m
Provide foundation of diameter and depth 6.6m and depth = 2.64m

III -EXPERIMENTAL VALIDATION

Introduction to analysis with STAAD Pro

The following are key considerations for using STAAD Pro (i.e. Structural Analysis & Design program software) effectively for structural analysis. However, since STAAD is a computer program, you should not blindly trust STAAD or any other engineering program. Therefore, prior to the experience of continuously using STAAD for at least one year, analyze and design structure by performing parallel calculation on important structures.

Fig no.1 design of chimney

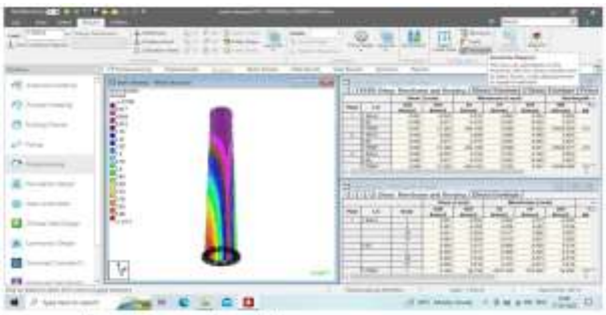

Fig no 2 seismic analysis of plates

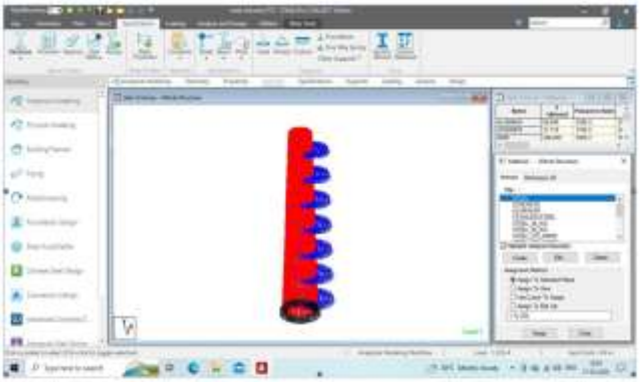

Fig no 3 materials of chimneys

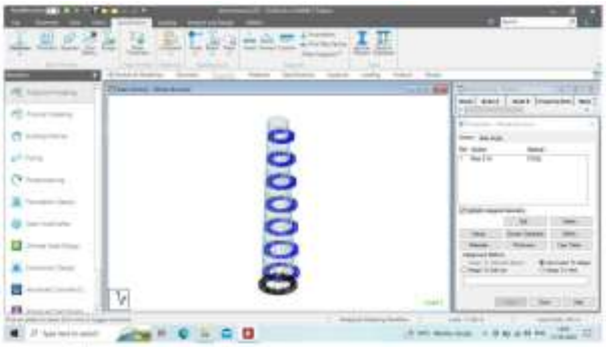

Fig no 4 properties of chimneys

IV-RESULT

Fig no 5 plate stress

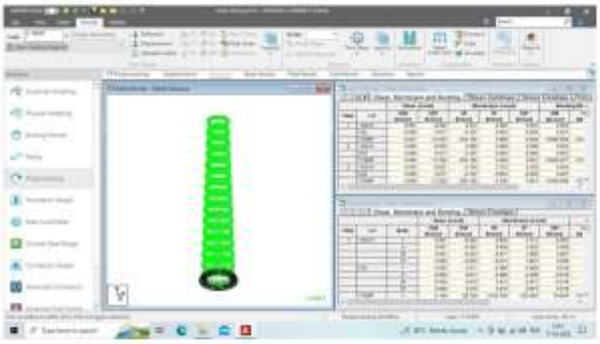

Fig no 6 reaction in temperature

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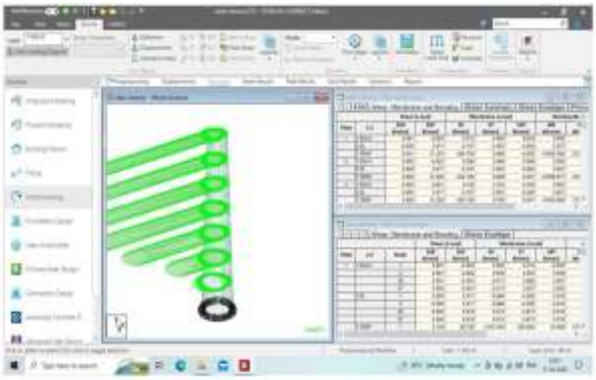

Fig no 7 seismic load

V -CONCLUSION

- For high wind intensity and low risk earthquake zone, wind loads were more prominent. Hence, chimney must be analyzed for wind forces.
- It was observed from the result obtained from manual calculation and software developed in
- STAAD PRO, for maximum moment are similar.
- the maximum bending stress due to wind load in a self-supporting steel chimney are continuous function of the geometry height to base diameter ratio as it is observed that at the ratio increase the stress in the steel chimney also increases.
- when the chimney is analysed by the three effects (flexion, shear and rotational inertia), the number of elements to be discrete no longer influence the estimated responses because the height
- of the elements is controlled by the shear if h/D < 2, and by flexion if $\frac{h}{D}$ > 2 ,the height of the element.
- from the research we understand about the contribution of different research in the field of the tall cylindrical structure system (chimneys), a gap in the research and objective of the research to be conducted. These contribution help to visualize the problem faced by Rc & steel chimney from a new perspective. By evaluating the performance of both type of chimney with different height to base diameter its enhanced economic aspect may be achieved, which shall lead to the direction of the design of safe stronger and more economical chimney.

REFERENCES

[1] *Shiau, "Theoretical and Experimental studies of earthquake response of a chimney "Book on*

[2] *Aeronautics and astronautics, purdue university, Indiana USA, 1241-1244, 1974.*

[3] *Anand S. Arya And D. K. paul, "Earthquake Response Of tall chimneys," School of*

[4] *Research And Training in Earthquake Engineering, University of Roorkee, 1247-1259, 1999.*

[5] *Elias, said Vasant Matsagar, and T. K. Datta. 2016."Effectiveness of Distributed Tuned*

[6] *Mass Dampers for multi-mode control of chimney under Earthquake ."Engineering Structure 124:*

[7] *FJ Pallare's ,A Aguero and M Martrn (2006) Seismic behavior of industrial masonry chimney International Journal of solids and Structures.43, pp.2076 -2090.*

[8] *D Menon and PS Rao (1997), "Uncertainties in codal recommendation for across-wind load analysis of R/C chimneys", Journal of wind Engineering and Industrial Aerodynamics. 72, pp. 455-468.*

[9] *Devi, B. and Singh, S.S, Static and Dynamic Wind force Analysis of Self Supporting Flare Base Circular Steel Stack with Variable Height.*

[10] *IS 1893 (part4):2005 "Criteria for earthquake resistant design of structure,"*

[11] *IS 6533 (part1):1989," Indian standard code for design and constructional of steel chimney", [9] IS 65333(part2):1989," Indian standard code for design and construction of steel chimney".*

[12] *V. Rohini Padmavathi, B. Siva Konda Reddy and Srikant " Study of wind load effects on tall RC chimney ", International Journal of Advanced Engineering Technology, Vol. Issue , April-june 2012pp. 92-97*

[13] *T Subramani, P.Shanmugam,"Seismic Analysisand Design of industrial Chimneys by Using Staad Pro ",International journal of Engineering Research and Applications (IJERA),ISSN; 2248-9622,Vol.2.Issue 4,july –August 2012,pp,154-161.*

[14] *Davenport A G 1984 Proc.5th Industrial Chimney Congress, CICIND ,Essen GERMANY, pp.77-84*

[15] *PN-93/B-03201 1993 Steel structures, Chimneys. Design rules (in polish)*

[16] *Arya A.S.y Paul,D.K.(1997), "Earthquake Response of Tall Chimneys" . Proceedings worldconference on Earthquake Engineering . New Delhi.*