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Analysis of Self Supported Steel Chimney with The Effect Due to Flue Dust Opening and Geometrical Parameter

Sahil Khan[1], Deepak Bandewar[2]
P.G. Scholar[1], Assistant Professor [2]
Department of Civil Engineering, S.I.R.T.S. Bhopal, Madhya Pradesh, India

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ABSTRACT

A large portion of the mechanical steel smokestacks are tall designs with round cross-areas. Such thin, softly damped structures are inclined to wind-left vibration. Calculation of a self-supporting steel fireplace assumes a significant part in its underlying conduct under sidelong unique stacking. This is on the grounds that calculation is essentially answerable for the solidness boundaries of the smokestack. In any case, essential elements of modern self-supporting steel smokestack, like tallness, width at exit, and so forth, are for the most part gotten from the related natural conditions. To guarantee an ideal disappointment mode configuration code (IS-6533: 1989 Part 2) forces a few standards on the calculation (top-to-base measurement proportion and stature to base breadth proportion) of steel stacks. The target of the current investigation is to legitimize the code models concerning essential components of mechanical steel chimney stack. A sum of 66 numbers self-supporting steel erupted unlined smokestacks with various top-to-base measurement proportion and tallness to-base breadth proportion were considered for this examination.

Keywords : Self-Supporting Steel Chimney, Dynamic Wind, Vortex Shedding, Geometry Limitations, Resonance, Stroughal Critical Velocity.

I. INTRODUCTION

Chimney or stacks are tall and round and hollow designs used to release smoke from a kettle, thennal and coal plant industry at higher rise with the goal that it can't pollute encompassing climate. Steel chimneys are of two sort self-upheld chiinneys, and guyed chimneys. Different burdens such as self-weight, wind burden and tremor load influences the underlying strength of the chimney. Static and dynamic burdens are exceptionally huge in the plan of chimney. Due to slenderous state of chimney, wind load is viewed as basic in investigation. For round molded chimneys, streamlined lifts are likewise a significant concern while examining stresses for chimney.

Wind load is considered in two different ways along wind and across wind. Along wind produces delay the

chimney called blast bufficating which causes dynamic reaction toward wind stream. Across wind impact produces vortex shedding on the chimney structure. Because of this chimney vibrates the opposite way to the breeze stream. The plentifulness of vibrations in chimney is subject to power of powers. This makes enormous redirection and extreme harm the design. Fig. 1 shows a self-supporting steel chimney situated in a modern plant.

Figure 1. Self-supporting Steel Chimney

Seismic loads are also major loads acting on the chimney after consideration of wind loads. According to Indian codal provisions, quasi-static methods are used for evaluation of this kind of loading recommend amplification of the normalized response of the chimney with a factor that depending on the soil and intensity of earthquake.

II. OBJECTIVES OF THE STUDY

- Comparative study of self-supporting steel chimney due to wind load and seismic effect on a varying height.
- Assess the geometry limits imposed by IS 6533 Part 2:1989 for designing self-supporting steel chimney due to static and dynamic wind load.
- Analysis with and without inspection manhole.
- Compare both uniform and non uniform diameter of chimney in seismic loading condition.

III. LITERATURE REVIEW

Parth Modi et.al (2019) the research paper analyzed 72m tall self-supporting and guyed chimneys for earthquake and wind loads considering three different soil conditions using SAP2000. Earthquake analysis is performed as per IS 1893-2016 and wind analysis is done as per IS 875(Part 3)-2015. The response of chimney is derived in the form of displacement and base shear for different soil conditions. The objectives behind the research stated study time history analysis of guyed and self-supporting chimneys, dynamic behaviour of chimneys considering fixed base and different kinds of soils such as stiff clay, dense sandy and stiff hard and analyze the effect of wind load on guyed and self-supporting chimneys at different wind speed.

Conclusion drawn from the results stated that Time period of chimney was more in stiff clayey condition in comparison to fixed support, dense sandy & stiff hard soil conditions. The maximum lateral displacement at the top of both chimneys is higher due to wind forces as compared to seismic forces. Base shear in both chimneys under Bhuj earthquake, 2001 is more as compared to response spectrum method and the maximum lateral displacement was less in guyed chimney as compared to self-supported chimney.

M. Pavan Kumar et.al (2017) the research paper presented a computer aided investigation on the seismic and wind effects on chimneys of different heights in the Indian scenario. Self-supporting steel stacks (provided as chimneys) of overall height 90m and 110m subjected to wind and seismic loads was considered in the investigation. The chimneys are analyzed using STAAD.Pro software for seismic Zones II, III, IV and V and wind loads of basic wind speeds 39m/sec, 44msec, 49m/sec, and 50m/sec. Maximum shear force and bending moments developed in the steel stacks along with lateral

displacements and mode shapes was determined and compared to analyze the structural response of steel stacks.

Results stated that the maximum displacements for both the chimneys was observed for earthquake zone V. The maximum displacements for both the chimneys are found in areas with higher wind speed i.e., at 50m/s. There is more impact of wind load on the chimney when compared to seismic load. The value of shear force becomes constant after the 4th segment for both the chimneys. The value of bending moment increases with increase in height of segments from bottom to top and also with increase in seismic zones. The maximum values of shear force and bending moment shows that as the height of chimney increases the intensity of shear force and bending moment values at the bottom segment also increases at a higher rate.

IV. METHODOLOGY

The steps involved in the methodology are stated below

Step-1: To prepare a literature survey related to our study.

Literature Survey was ready for the past examination embraced to date and weaknesses were recognized on which further exploration should be executed. This above and beyond managed to introduce the use of Self Supporting Steel Chimney and its possibilities of general applications in different industries.

Step-2: To prepare geometrical structure of the study as per the parameters assigned in StWizard using analysis tool STAAD.

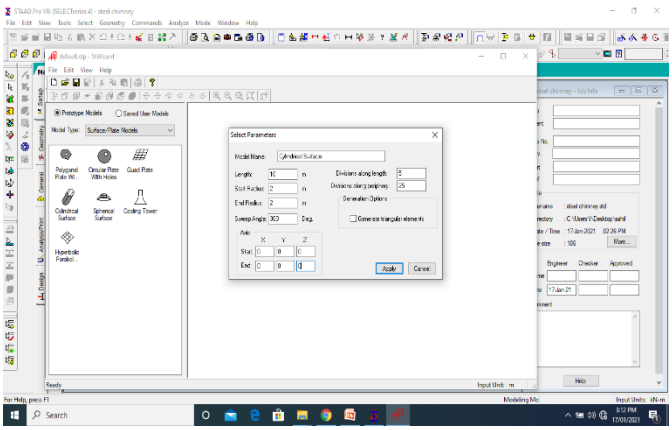


Figure 2. Parameters on Structure Wizard.

Case I Uniform Chimney

Case II- Non-Uniform Chimney

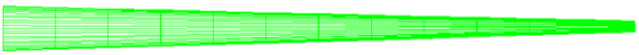


Figure 3. Modelling of Chimney as per the assigned parameters using Staad.Pro.

Step 3 Defining properties of the material and plate thickness

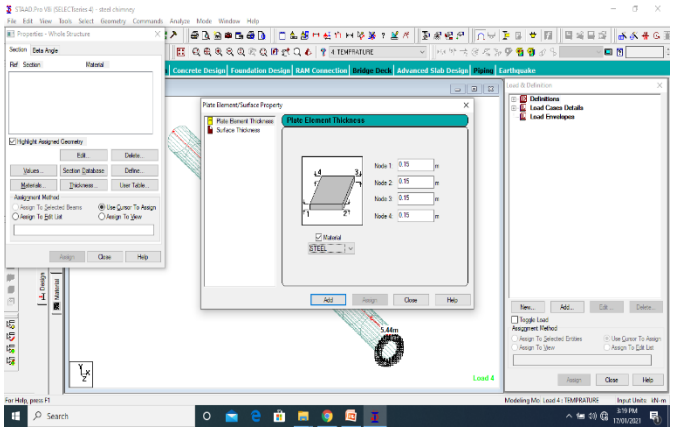


Figure 4. Assigning Section and Material Properties assigning Plate Element Thickness

Step-4 The support is fixed at bottom, pinned at top and weak spring at soil fill area

Step-5 Assigning Primary Loading Condition

Temperature

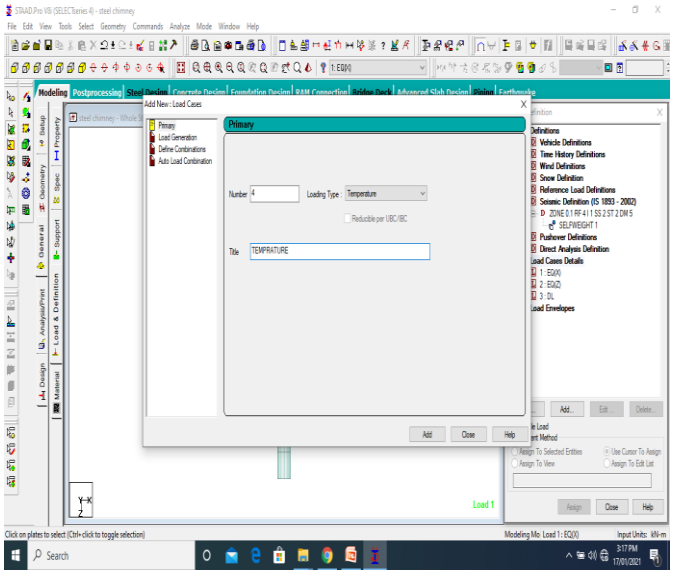


Figure 5. Assigning Temperature load in the both the cases.

Step-6 Assigning Seismic Loading conditions as per IS: 1893-2016

Seismic Loading condition was assigned with conditions as Bhopal Z-0.1 considering Steel Frame with Concentric Braces and soil type was considered as Medium Soil.

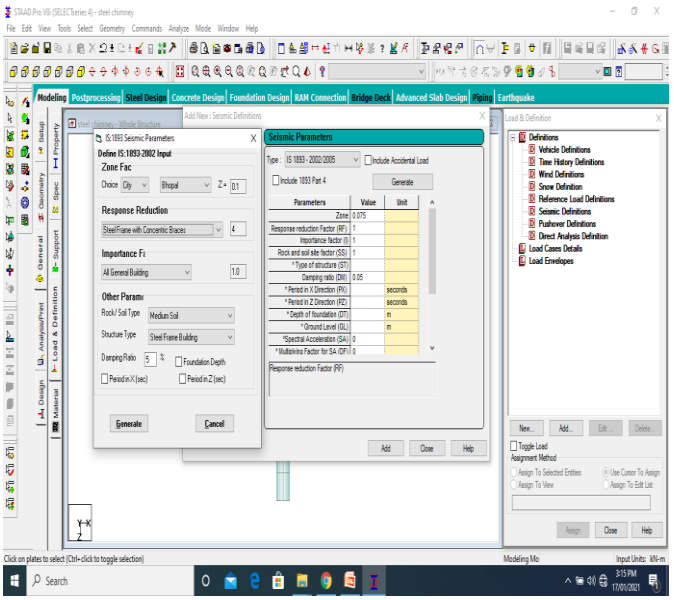


Figure 6. Assigning Seismic Loading condition as per IS :1893-2016

Step-7 Stress Analysis of Chimney in both the cases

Case I Uniform Chimney

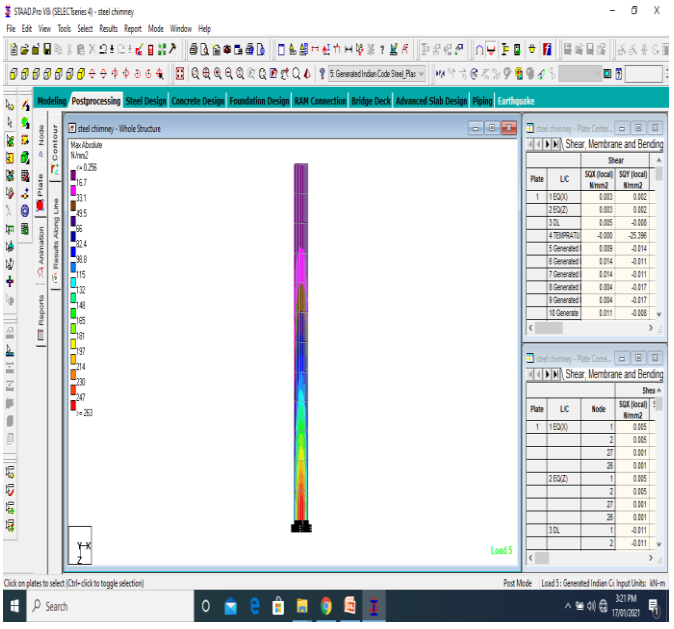


Figure 7. Stress Analysis of Uniform Chimney

Case II Uniform Chimney

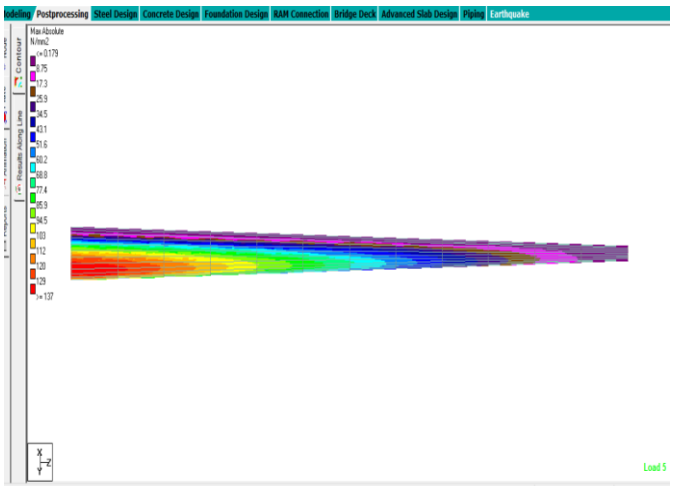
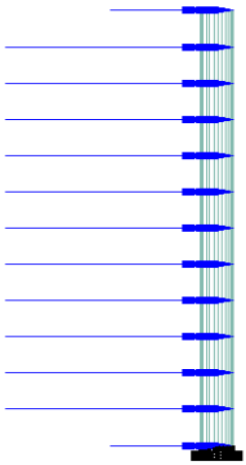
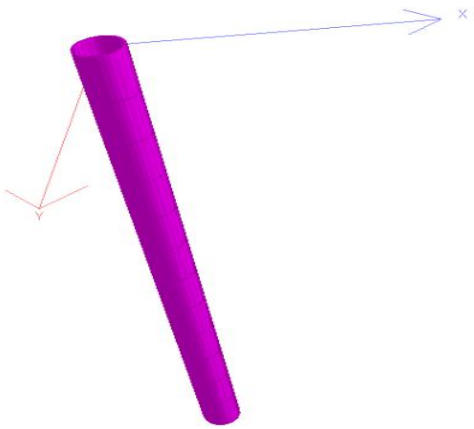


Figure 8. Stress Analysis of Non- Uniform Chimney

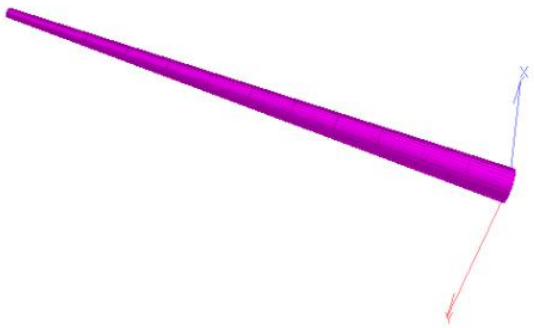
Step-8 Analysis Output



(A)



(B)



(C)

Figure 9. (A) Analysis Output, (B) 3-D model of Case I Uniform Chimney and (C) 3-D mode of Case II Non Uniform Chimney.

Step-9 Generating report of each case in Microsoft Excel for comparative analysis of the two different cases.

Table 1. Plan Dimension of the Structure

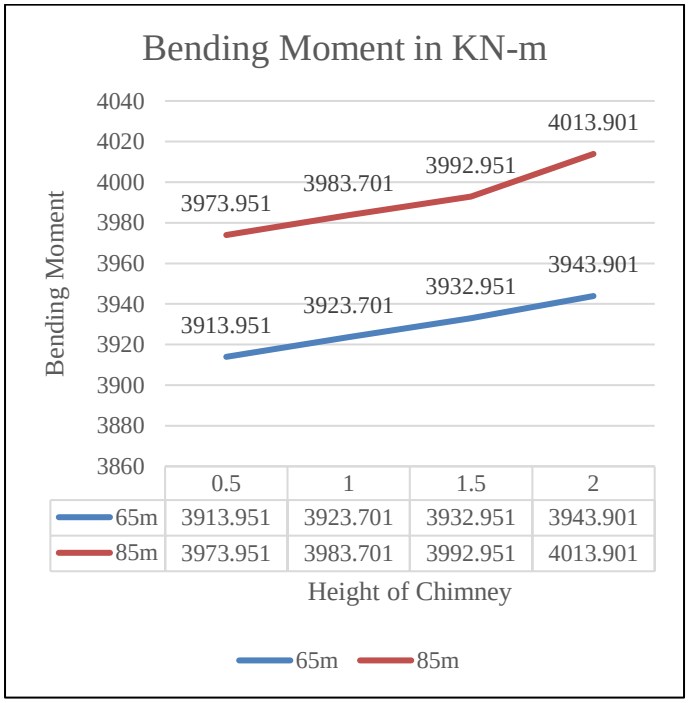
SR.NO.	PARAMETER	DESCRIPATION
1.	HEIGHT OF CHIMNEY	65 M
2.	DIAMETER OF CHIMNEY	UNIFORM CHIMNEY = 2M NON UNIFORM CHIMNEY =0.5 TO 2M
3.	STEEL PLATE THICKNESS	0.15 M
4.	SUPPORT SYSTEM	FIXED SUPPORED

Table 2. Loading Conditions

SR.NO.	PARAMETER	DESCRIPTION
1	DEAD LOAD	SELF WEIGHT OF STEEL CHIMNEY
2	TEMPRATURE LOAD	AS PER CODE IS 6533:1989.
3	SEISMIC LOAD	AS PER CODE IS 1893 : 2002

3.1	ZONE	ZONE -II
3.2	RESPONSE REDUCTION FACTOR	4
3.3	SOIL TYPE	MEDIUM SOIL
3.4	DAMPING	5 %

V. ANALYSIS RESULT



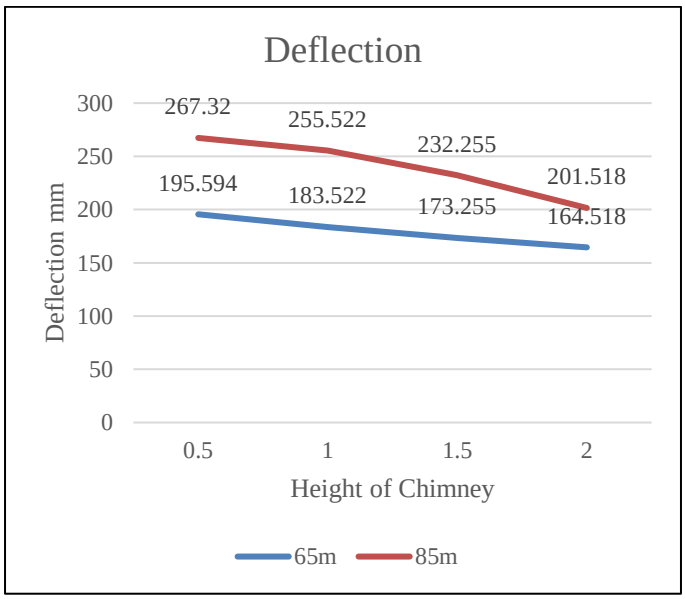


Table 3. Wind response over the structure

Height (m)	Bottom Dia(m)	Top Dia(m)	P (kN)	V (kN)	M (kN.m)	Deflection (mm)
65	2	0.5	517.061	127.03	3913.951	195.594
		1	524.953	128.48	3923.701	183.522
		1.5	532.845	129.91	3932.951	173.255
		2	540.736	131.4	3943.901	164.518
85	2	1	629.953	137.48	3983.701	255.522
		1.5	642.845	138.91	3992.951	232.255
		2	681.736	139.4	4013.901	201.518

VI. CONCLUSION

Bending Moment: The benefit of bending moment increments with expansion in stature of portions from base to top and furthermore with expansion in seismic zones.

Base shear: The estimation of base shear increments with the increment in top distance across of the chimney and rate increment of base shear was 72%.

Stresses: The pressure appropriation is uni-pivotal pressure and there are no pressure fixation areas.

From the second piece of investigation it is tracked down that, The greatest moment and the most extreme bending pressure because of static wind load in a self supporting steel chimney are consistent capacity of the math (top-to-base breadth proportion and tallness to-base distance across proportion).

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