ANALYSIS OF SELF SUPPORTING STEEL CHIMNEY

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ABSTRACT

Each structure is to be designed for strength, limiting deflection, and durability. The function and aesthetics of structures should keep in consideration during achieving this strength, deformation and durability. It may possible when the structural engineer had quite knowledge about architectural requirements. In case of high-rise structure, certain failures may occur due to lateral loads. The lateral loads are almost wind and earthquake, whose main horizontal force component acting on the different members of structure. The lateral force effects due to wind and earthquake loads are usually analyzed as an equivalent static load in most type of high-rise structure. These structures are designed in such a way that its every component must resist two types of loads like vertical Load due to gravity and lateral load due to earthquake and wind. The reinforced concrete chimney shell, which transfer vertical load and lateral load to the foundation. The present study is on the analysis of cantilever reinforced concrete chimney with variation in geometry and different orientation, when they are subjected to the lateral loads.

This report shows the certain design values for different configurations of chimney structures which may take consideration for foundation designing work. The effects of lateral force due to wind and earthquake loads are analyzed by an equivalent static load method and dynamic analysis by response spectrum method. The present study is carried for the region Nashik, district of Maharashtra state in India. According to which wind load and earthquake load parameters were considered as per IS code such as IS 4998(part-1):1992, IS 1893 (part-4):2005 and IS 875(part-3). The present study is carried only to study the merits and demerits of these types of chimney configuration based on the analysis, for such terrain conditions.

Keyword: - reinforced concrete,foundation

1. INTRODUCTION

India has been striving to alleviate the electric power crisis, recently aggravated due to the economic boom in the country. Out of the two major sources of power, i.e. Hydro Power and Thermal Power, the latter has become more popular due to its adaptability towards larger production capability. Thermal power is obtained through burning coal, which is required to operate the steam boilers. When burnt, the coal produces polluting gases that need to be discharged at a high elevation enough to dilute the pollution and to keep it within acceptable limits at ground level. An adequately designed tall chimney serves this purpose. As the pollution norms have become stringent with time, the chimney heights have gone up progressively from 100m to 150m to 220m to 275m.In most thermal power plants, 275m tall concrete chimneys have now become the standard norm. It may be worthwhile mentioning here that a bi-product of burning of coal is fly ash, which is produced in the process line between boiler and chimney. This fly ash is extracted using electrostatic precipitators, which incidentally can be used in blended cement and as mineral admixture in concrete.

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. Also, steel chimneys are economical for height up to 45m.Geometry of a self-supporting steel chimney plays an important role in its structural behavior under lateral dynamic loading. This is because geometry is primarily responsible for the stiffness parameters of the chimney. However, the basic geometrical parameters of the steel chimney (e.g., overall height, diameter at exit, etc.) are associated with the corresponding environmental conditions.

2. CLASSIFICATION OF CHIMNEYS

A] Based on number of flues

i) Single flue (each boiler will have an independent chimney)

ii) Multi flue (Single chimney serves more than one boiler; more flues are housed inside a common concrete windshield)

B] Based on material of construction

i) Concrete (Chimney); Reinforced/Pre-stressed

ii) Steel (stack)

iii) Masonry

C] Based on structural support

i) Guyed stacks (used in steel stacks for deflection control)

ii) Self-supporting (cantilever structures)

D] Based on lining

i) With Lining: Lined chimneys/stacks

ii) Without lining: Unlined chimneys/stacks

3 SCOPE AND OBJECTIVE OF WORK

Scope and Objective of Work

Based on the previous discussions, the objective of the present study has been identified as follows:

1. To carry out computerized analysis on different types of models using ansys.

2. To identify geometry variation parameter such as height to base diameter ratio, tapering of the structure.
3. To study the effect of variation in geometry of cantilever steel chimney
4. To determine the bending stress, lateral displacement and lateral forces for the cantilever steel chimney by analysing the models for static forces.

4. ***LITERATURE REVIEWS***.

G. Murali, B. Mohan[2] 2012- This paper studies analysis and design of three chimneys of 55m high above ground level. The chimneys were designed with three different wind speeds. The force of wind depends upon its speed and turbulence. The parametric study of static and dynamic forces, the static moment and dynamic moment and thickness of chimney shell and a comparison is made for three chimneys. The results showed that the static and dynamic moments are minimum for short chimney with lowest wind speed and more for tall chimney with greatest wind speed. Thickness of chimney is independent of wind speed, height and earthquake zone.

Rajkumar, Vishwanath. B. Patil[3] 2013- The authors discusses about the parametric study of RC chimney of varying heights, diameter, wind zones and earthquake zones, different soil conditions and for various load conditions. The response of chimney to earthquake and wind oscillations becomes more critical influencing response and design of chimney. Microsoft Visual Basic 6.0 software programming were used for the analysis is carried out using. The above cases are compared and the results were extracted. The maximum values for wind and seismic analysis were obtained and reffered for the further design. They concluded that, wind load governs the design of RC chimney. The oscillation is dependent upon the slenderness of chimney. Gust factors should be accounted in the dynamic analysis along with the wind factor. Grade of concrete should be greater than M25.

Kirtikanta Sahoo [4] May 2013- The present study investigates the effect of presence of manhole in terms of stresses, deflection and mode shapes of the chimney. These parameters are calcuted using finite element software ANSYS. From the results, it is seen that the modes shape are considerably different with the presence of manhole in the chimney. Also the chimney without manhole has higher fundamental frequency as compared to chimney with manhole. This is due to the reduction in effective stiffness causes due to the presence of manhole in the chimney.

Rinki, ShashiShekhar Singh; [5] 2016- This paper deals with the study of structural behaviour of the flare base steel stack under equivalent static load and dynamic varying wind load. The static & dynamic wind analysis is carried out by using the Staad. Pro Vi8 Ss5. The parametric study was carried out to find out static and dynamic forces, maximum deflection for flare base steel stack. The comparison is done for three different wind speeds, constant height & shell thickness. It concluded that the increment in the wind speed increases the speedStatic& dynamic wind forces 2. Maximum deflection due to static anddynamc wind force increases as compared with wind speed. Maximum deflections for wind speed due to static wind forces are less as compare to maximum deflection due to dynamic wind force for wind speed.

Hardik D. Lapsiwala[6]2014-This paper deals with the study of literature. The writer has studied different literature based upon the analysis of steel chimney under wind forces and seismic forces. By the study of previous literature, it has been concluded that the the most critical and unpredictable effect is the wind effect on chimney as compared to the earthquake load effect. Hence for the design and analysis of steel chimney, the most critical parameters are height of chimney, top and base diameter of chimney and thickness of chimney. These parameters are carefully considerd before the design of chimneys.

5. ***PROBLEM STATEMENT AND METHODOLOGY***

5.1Overview:

Cantilever steel chimneys experience various loads in vertical and lateral directions. Important loads that a steel chimney often experiences are wind loads, earthquake loads, and temperature loads apart from self-weight, loads from the attachments, imposed loads on the service platforms. Wind effects on chimney plays an important role on its safety as steel chimneys are generally very tall structures. The circular cross section of the chimney subjects to aerodynamic lift under wind load. Again seismic load is a major consideration for chimney as it is considered as natural load. This load is normally dynamic in nature. According to code provision quasi-static methods are used for evaluation of this load and recommend amplification of the normalized response of the chimney with a factor that depending on the soil and intensity of earthquake. In majority of the cases flue gases with very high temperature released inside a chimney. Due to this a temperature gradient with respect to ambient temperature outside is developed and hence caused for stresses in the shell. Therefore, temperature effects are also important factor to be considered in the steel design of chimney.

5.2 Problem statement.

A single flue cantilever chimney is considered for the analysis situated in seismic zone III. The flue gas emission point will be (60m) above the finished floor level. The chimney height and top diameter are governed by exit velocity of gas and dispersion of effluent to a larger area within specified limits of ground level concentration. It is known by test that downwash can be avoided if efflux velocity is greater than 1.5 times the wind speed for this reason, the chimney flue at top is based on minimum exit velocity between 15 to 25m/sec, and the Indian code IS: 4998 gives an empirical formula to calculate the chimney height.

The external profile of the chimney shell is derived from the structural consideration of the super structure and the foundation. The top portion to the extent possible is kept cylindrical followed by linear slopes. The diameter of the chimney shell at the top is kept minimum possible allowing for accommodation of the flue, staircase and the elevator. The bottom diameter of chimney is normally governed by structural requirements, for single flue chimney an outside batter in the range of 1 in 40 to 1 in 80, a ratio of height to base diameter in the range of 10 to 12.Single flue of structural steel is provided to discharge the flue gases from the top of the chimneyDetails of the cantilever steel chimney are as follows

Height of chimney - 60 m

3. Thickness steel chimney - (0.015,0.020& 0.025) m

4. Exit velocity of gas at top - 25.0 m/sec

5. Maximum flue gas temperature - 135 ^{o}C

6. Seismic Zone - III

7. Basic wind Speed - 39 m/sec

8. Foundation Type - RCC circular mat

9. Structure Category - 1

10. Soil Type - Hard Soil

11. Elasticity of steel. - $2.0 \times 10^5 N/mm^2$

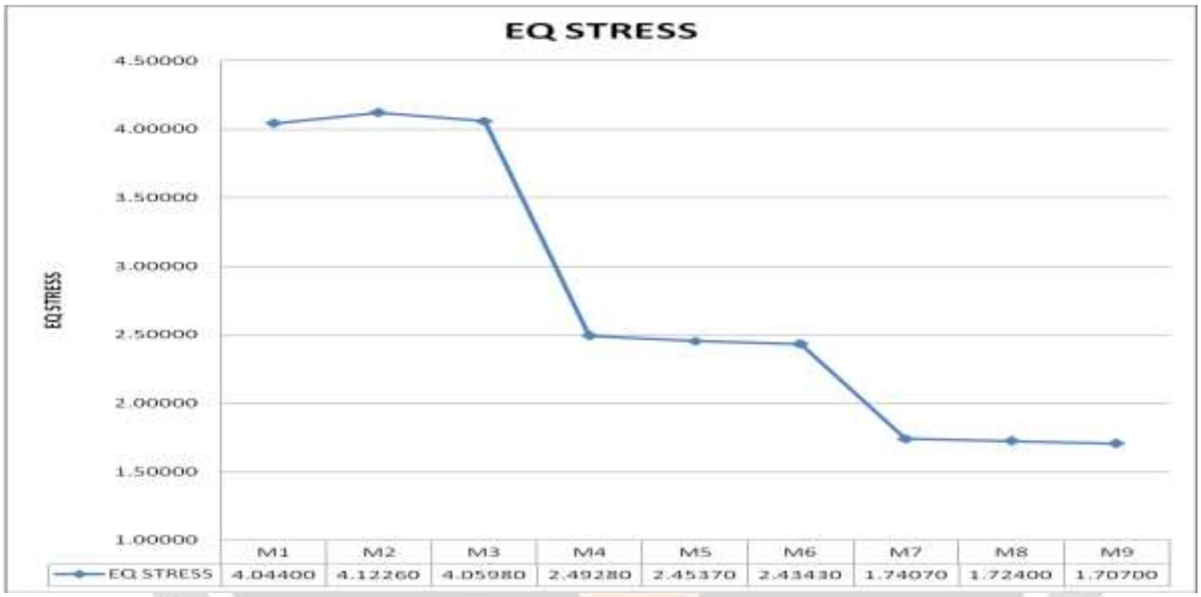
12. Poisson's ratio - 0.3

13. Density of concrete - 25 KN/m^3

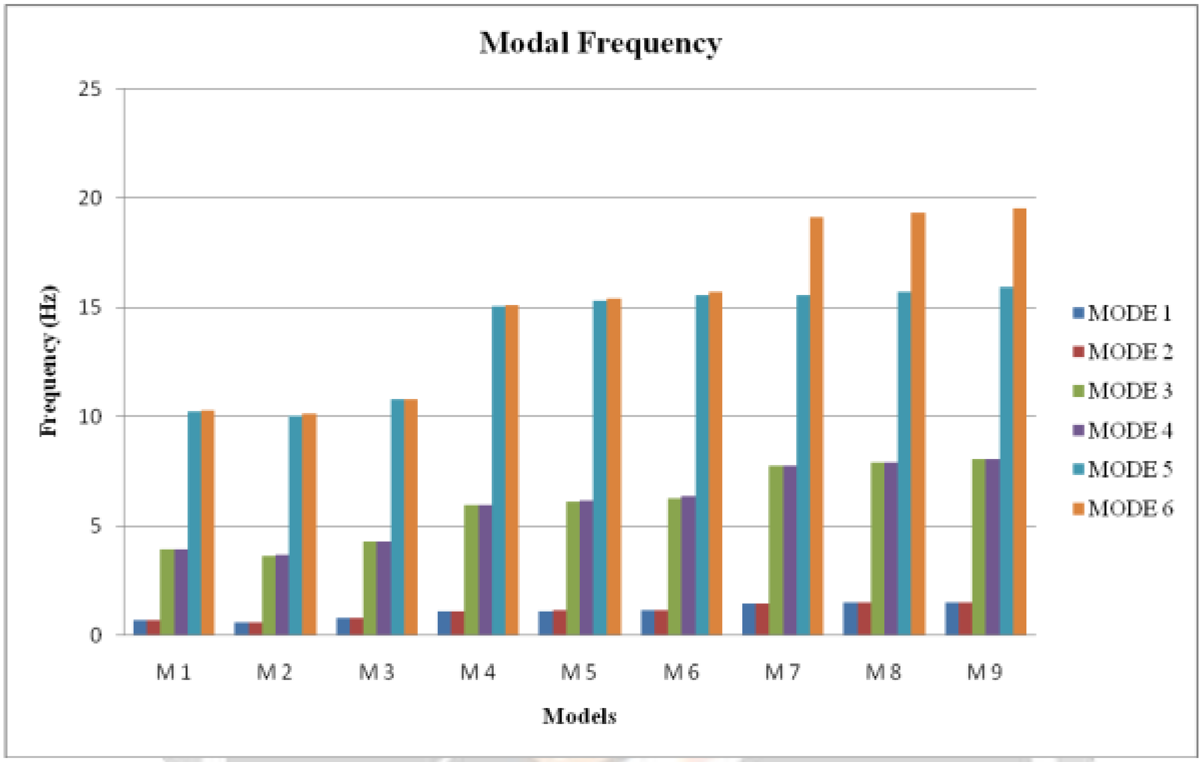
14. Damping - 5 %

6 RESULT

Equivalent Stress in MPA



Shear Stress in MPA



7. Conclusion

1)Chimney model with larger diameter and greater thickness has shown satisfying results.

2)The deformation is decreased by 78.86% in model 9 as compared to M1.

3) Moreover shear stress has been reduced upto 68%.

4) Equivalent stress and strain also shown considerable drop in the value of M9.

5) For vibration analysis it is observed that as the diameter and thichkness increases the modal frequency also increases.

6)It is proved that diameter and thickness are the two governing parameters to control the shear and deformation of the chimney

REFERENCES

1. Aleksandar M. Simonović, Slobodan N. Stupar, Ognjen M. Peković; "*Stress Distribution as a Cause of Industrial Steel Chimney Root Section Failure*"; FME Transactions (2008); VOL. 36, No 3 119-125

2. G.Murali, B.Mohan, P.Sitara and P.Jayasree; "*Response of Mild Steel chimney Under Wind Loads*", International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 , Vol. 2, Issue 2, Mar-Apr 2012, pp.490-498

3. Rajkumar, Vishwanath. B. Patil "*Analysis of Self-Supporting Chimney"*, International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-3, Issue-5, October 2013; pp- 85-91

4. KirtikantaSahoo, PradipSarka, Robin Davis; "*Analysis of Self-supported Steel Chimney with the Effects of Manhole and eometrical Properties*", International Journal of scientific and Engineering Research; Volume 4; Issue 5; ISSN 2229-5518 May 2013; pp-250-253

5. Rinki, ShashiShekhar Singh; "*Response of Flare base Self supporting Steel stack Under the static & dynamic wind loads with variable wind speed"*; International Journal of Engineering Research and General Science Volume 4, Issue 4, July-August, 2016; pp-391-395

6. HardikD.Lapsiwala, Hitesh Dhameliya, HitenKheni, "*A Review Of Analysis Of Industrial Steel Chimne;y*" International Journal of Advance Engineering and Research Development; *Volume 1,Issue 12,* e-ISSN(O): 2348-4470 p-ISSN(P): 2348-6406 *December -2014, pp-169-172*

7. Rakshith B D, Ranjith A, Sanjith J3, Chethan G; "*Analysis of Cantilever Steel Chimney As Per Indian Standards*;" Int. Journal of Engineering Research and Applications; ISSN : 2248-9622, Vol. 5, Issue 5, (Part -5) May 2015, pp.151-162

8. T.Saran Kumar, R.Nagavinothini; Wind Analysis and Analytical Study on Vortex Shedding Effect on Steel Chimney using CFD; International Journal of Science, Engineering and Technology Research (IJSETR), Volume 4, Issue 4, April 2015; ISSN:2278 – 7798; pp-715-718

9. BhagyashreeVananje, NamrataShinde,AshwiniVishe, HarshalaHazare, Mrs. VaibhaviMahtre; "*Comparison between Steel Chimney and R.C.C. Chimney*"; International Journal on Recent and Innovation Trends in Computing and Communication; April 2016; Volume: 4 Issue: 2321-8169; 4,pp- 277 – 279

10. R.kalaimugi, K.Shanthi"*Analysis; "The Effect Of Wind And Seismic Load On Steel Chimney*;" International Journal of Advanced Research in Biology Engineering Science and Technology Vol. 2, Issue 4, ISSN 2395-695X; April 2016; pp-78-84

11. R. Boopathiraja, K. Kayalvizhi, R. Vanathi ;"*Comparative Design and Analysis of Self-Supporting and Guyed Steel Chimney;*" International Journal for Innovative Research in Science & Technology; Volume 3; Issue 07; December 2016 ISSN: 2349-6010; pp-13-21

12. Linda Ann Mathew, "*Couple-Field Analysis of Steel Chimney*;" International Journal of Science and Research (IJSR); Volume 5 Issue 4, April 2016; ISSN 2319-7064; pp- 1699-1701

13. Leonardo E CARRIÓN, Rodrigo A DÜNNER, And Iván*Fernández–Dávila; Seismic Analysis And Design Of Industrial Chimneys*, 12WCC 2000; Chile; 1627