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A Review-Analysis of Self Supporting Steel Chimney with Different Shape Factors for Wind Forces

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ABSTRACT

Present work investigates the performance of self-supported steel chimney considering different shape factors for wind forces at different heights. The work consists two parts, one is the calculation of static wind forces using IS- 875- Part-III-2015 and implementation of chimney using FEA based software ANSYS, considering calculated wind forces. Flared Chimney of 60m height and unflared chimney of 30m height considering different shape factors (Circular, Square, Equilateral Triangle and Regular hexagon) have analyzed using ANSYS.

Keywords: ANSYS, Steel Chimney, IS 875 Part-III 2015, FEA

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. Every structure is designed for strength, serviceability, permissible deflection & durability. While achieving these characteristics the designer should consider the functions and aesthetics too. It may be possible only when a designer had sufficient knowledge about architectural requirements also. In case of tall structure few failures may occur due to the lateral loads. The lateral loads mainly wind and earthquake loads. This type of structure is designed in such a way that its each member must resist two types of load i.e. vertical loads due to gravity force and lateral loads due to wind or earthquake force.

The wind load exerted at any point on a chimney can be considered as the sum of quasistatic and a dynamic load component. The wind load is always dominating the earthquake load or forces. As most of the industrial chimneys are tall structures with circular cross section their structures are slender, light damped structures which are prone to wind excited vibration. Geometrical parameters play an important role in the analysis & design of chimneys and structural behaviour under lateral dynamic loading. The primarily responsible factor for stiffness parameters are geometry

II. LITERATURE REVIEW

Carrion et al. (2000) – In this paper they described about a simplified method of obtaining fundamental period of vibration, lateral displacement, shear force, and bending moment through a set of equilibrium equations. They apply the results of this study on the sets of 9 real chimneys (4 steel and 5 reinforced cement concrete) built in chile. In this study they also find that the criterion of consistent mass gives better results than the criterion of lumped masses as a very important conclusion of a discrete analysis of the model in twenty segments of the beam is satisfactory.

Simonovic et al. (2008) studied failure initiation of the root section of 60m tall industrial steel chimney. Cracks that occurred in steel wall of the wind shield have significantly influenced integrity of the structure. Analytical numerical analysis of failure occurrence was performed. Industrial steel chimneys are exposed to various harmful mechanical-chemical-thermal actions. Complex loads can cause various types of damage influencing the structure integrity as a section with maximum loads, geometrical discontinuities duct flue openings and manufacturing flaws, root sections of the industrial steel chimney are subject to failures occurrence.

Reddy et al. (2011) Studies about the design RC chimney for critical loads produced by earthquake and wind. Later a comparison is done between earthquake and wind loads and come to conclusion that a wind load is always dominating except in earthquake zone vth the earthquake forces are closely matching with wind load in a zone whose basic wind speed is 44 m/s.

Murali et al. (2012)this paper comprises of the study of three chimney of same height above ground level and it is designed as per IS 6533:1989 and wind load was calculated with the help of IS 875:1987 (part –III). The parameters which are considered in this paper was static forces, static moments, dynamic moments and thickness of chimney as a result as a result of this they observed that the basic wind speed is directly proportional to the dynamic forces on chimney.

Reddy et al. (2012) conducted study on along and across wind effects on 275 m tall RCC lined chimney for Ist and VIth zones of India and concluded that across wind forces are governing in zone Ist (i.e., basic wind speed is 33 m/s) and in zone VIth (i.e., basic wind speed is 55 m/s) along wind forces are governing and this analysis is done STAAD PRO and MS excel spread sheet. They also conclude that at critical section, i.e., 1/2 and 1/3rd height from across wind methods are maximum than along wind methods the reason behind this is vortex shedding effect on chimney structure will be more and across wind calculations is directly proportional to the weight of the chimney, frequency and its mode shapes. Across wind load is not increasing with the increasing wind speed and along wind method are increased with increasing wind speed.

Sahoo (2012) conducted study on the effect of man hole & parametric analysis of self –supporting industrial steel chimney in which she took the parameter viz; Top to base diameter ratio & height to base diameter ratio and works on it according to the Indian Standards using Mathcad software and verify the results with the finite element analysis using commercial software ANSYS.

Sule and Nwofor (2012)conducted astudy of the vortex induced vibration of a 50 m steel chimney under the wind excitation is carried out. The chimney is modeled as cantilever structure subjected to two degree of freedom structural system and the analysis is carried out using a lumped mass approach after the analysis they conclude that the fundamental frequency of vibration of the chimney was much lower than the frequency of vortex shedding due to which it shows the possibility of the chimney going into resonance resulting in large displacement and stress which may cause fatigue failure. Guyed cables should be used between the top of the chimney and the ground to minimize the effect of flow induced vibration and the intensity of wind loading is function of the height.

Kumar and Patil (2013) 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 was 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 referred 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.

Lapsiwala et al. (2014) comprises 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 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 considered before the design of chimneys.

Kumar and Nagavinothini (2015) studies five chimney models of different heights and diameters at top and bottom, were designed and wind load was calculated. Strakes are provided at top one-third height of chimney in helical form increasing the dead load of chimney. The chimney with and without strakes are analyzed and Reynolds number was calculated from finite element software ANSYS Fluent. Vortex shedding effect on five chimney models revealed that the vibration induced by wind in the tall chimneys varies with respect to height. The strakes in chimneys reduces the across wind effect on chimneys. As height increases, the Reynolds number increases which indicates the increase of turbulent flow and the provision of the strakes reduces the Reynolds number which further indicates that the flow effect is controlled.

Rakshit et al. (2015) In this paper conducted study on the design of chimney with or without manhole. Basically it was comparative study of two chimneys one is with manhole and another one is without manhole with this they also considered geometrical considerations or geometrical parameters and they conclude that manhole opening is important in analysis and design of cantilever steel chimney.

Kalaimugil and Shanthi (2016) In this paper he designed a steel chimney for wind and earthquake load considering geometry of chimney has important role in structural behavior under lateral dynamic loading and however the basic dimension of industrial chimney such as height, diameter at exit etc. are generally derived from the associated environmental condition. He had done this by using software's Pro E & ANSYS.

Mathew (2016) comprises the study of a steel chimney as cantilever beam with annular cross section is designed considering dead load and wind load. The chimney models with different thicknesses were modeled and analyzed in ANSYS software. The chimney can be made cost effective with lower thickness. Also chimney with lower thickness has more stability as compared to chimney with higher thickness. A couple field analysis was carried out for steel chimney with minimum thickness and compare the same with linear analysis, it was found that, the proposed chimney model for 6 mm thickness was under the safe limit. Also the maximum stress was obtained near the supports and minimum near the top of the chimney.

Boopathiraja and Kayalvizhi (2016) study of the 72 m high self-supporting steel chimney is considered for design and analysis. The foundation of chimney is designed. The comparison in between self-supporting chimney and guyed chimney is done based on the moment at base. It is concluded that the base moment of Guyed chimney is less as compared to self-supporting chimney, hence considered as safe for design and construction.

III. CONCLUSION

Analysis of self-supported steel chimney is carried out for both flared base and without flared base chimney. Modelling of steel chimneys with flared base and without flared base are done and same is taken for analysis through software. When we compare circular chimney with hexagonal chimney on the basis of stress induced in model, we may prefer hexagonal chimney because the maximum stress induced in hexagonal chimney is less than circular chimney. .

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