Comparative Analysis of RC & Steel Chimney with Varying the Height of Stack: Technical Paper

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Abstract - This study deals with the comparative analysis of Reinforced Concrete (RC) & Steel chimneys. Such chimneys (with heights up to 60m) will be analyze and designed in conformity with various codes of practice. The main masses to be thought-about throughout the analysis of tall structures like chimneys are wind forces, temperature loads and seismic loads in addition to the dead loads. The design is finished with limit state ideas (which are nonetheless to be incorporated into IS 4998). The main objective of the present work is to comparative study of geometrical limitations in the analysis of self-supporting RC & steel chimney. Here we analysis and compare of steel chimney and concrete chimney with considering lateral forces and result obtained in term of Node Displacement, Support reaction and support Moment and verifies the various stresses on both kinds of stacks.

Key Words: wind load, height/Base ratio, mode shape & Frequency.

1. INTRODUCTION

Chimneys or stacks are important industrial structures for the emission of toxic gases to a better elevation such the gases don’t contaminate the close atmosphere. These structures are tall, slender and customarily with circular cross-sections. Different construction materials, like concrete, steel or masonry, are accustomed build chimneys. Steel chimneys are ideally fitted to method work wherever a brief heat-up amount and low thermal capability area unit needed. Also, steel chimneys considerable & economical for height up to 45m.

2. Objective of Work

This project deals with the comparative analysis of Reinforced Concrete (RC) & Steel chimneys. Such chimneys (with heights up to 60m) are presently designed in conformity with various codes of practice. The main masses to be thought-about throughout the analysis of tall structures like chimneys are wind masses, temperature loads and seismic loads in addition to the dead loads. The design is finished with limit state ideas (which are nonetheless to be incorporated into IS 4998). Following points consider for present Study

1. Height of industrial chimneys chosen for analysis is 40m, 50m, 60m and height to base diameter ratios of 11, 12.5 & 13 corresponding to each height considered for Both RCC & Steel Chimney.
2. Top diameter to Base diameter ratios preferred is 0.6, Based on these parameters, a total of 6 chimneys were analysed for wind speeds of 44m/s to evaluate wind response and stiffness criteria based on IS 6533:1989.
3. Chimneys are modelled using linear element in STAAD PRO fixed at the base for calculation of mode shapes and frequencies.
4. Wind analysis was carried out to evaluate shear force, bending moment and stiffness criteria of industrial chimneys.
5. Results are presented for top diameter to base diameter ratio, height to base diameter ratio, wind speeds considered. Conclusions are made based on the discussions of obtained results.

3. Methodology

Self-supporting chimneys experience various loads in vertical and lateral directions. Important loads that a 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 play an important role in its safety as chimneys are generally very tall structures. The circular cross section of the chimney subjects to wind load.

3.1 General Consideration

1. Height of Chimney = 60, 55 & 50m
2. Top Diameter = 3m
3. Bottom Diameter = 4.4m
4. No. of Flues = 1
5. Bearing Capacity of Soil (SBC) = 200 kN/m² (Assume)
6. Basic Wind Velocity of Region = 44 m/s
7. Height to base diameter ratio Consider = 11m, 12.5m, 13m

8. Grade of Concrete – M35

9. Grade Of Steel – Fe500

10. Modulus of Elasticity (Steel) – 2.05 X 10⁵ MPa

11. Modulus of Elasticity (Concrete) – 0.26 X 10⁵ MPa

12. Coefficient of Thermal Expansion – 11 X 10⁻⁶ per°C

13. Temperature of Gases above Surrounding - 200°C

3.2 Wind Pressure Calculation

According to IS-875 (Part III) -1987 the structure is lie in terrain category 3rd class “A” structure. For the calculation of wind pressure divide whole structure in seven sections each section has height of 40m.

Design Wind Speed \( V_z = V_b*k_1*k_2*k_3 \)

Where,

\( V_z \) = design wind speed at any height \( z \) in m/s.

\( V_b \) = basic wind velocity of the region in m/s

\( k_1 \) = probability factor (risk coefficient).

\( k_2 \) = terrain, height and structure size factor.

\( k_3 \) = topography factor.

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<th>( H_x ) (M)</th>
<th>( P_z )</th>
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Where

\( H_x = \) Height from Top = N X H

Table 2 Total Load calculation

Table 1 Wind Pressure calculation

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Figure 1 Different height of Stacks
4. RESULT

A. Node Displacement

Graph 1 Node Displacement of RC stack in (mm)

Graph 2 Node Displacement of Steel stack in (mm)

B. Mode Vs Time Period

Graph 3 Mode Vs Time Period of RC stack

Graph 4 Mode Vs Time Period of Steel stack
C. Support Moments

Graph 5 Support Moment in RC stack in KN-m

Graph 6 Support Moment in Steel stack in KN-m

D. Center Shear Stresses

Graph 7 Center Shear Stresses in RC Cylindrical Plate

Graph 8 Center Shear Stresses in Steel Cylindrical Plate

E. Principal Stresses

Graph 9 Principal Stresses in RC Cylindrical Plate

Graph 10 Principal Stresses in Steel Cylindrical Plate
4. Conclusions

The main objective of the present thesis was to comparative study of geometrical limitations in the analysis of self-supporting RC & steel chimney. Here we analysis and compare of steel chimney as well as concrete chimney by considering lateral forces and result obtained in term of Node Displacement, Support reaction and support Moment and verifies the various stresses on both kinds of stacks and following conclusions are drawn:

- It is concluded that from the analysis the node displacement increases with increasing the H/D ratio and RC steel chimney more precise than steel chimney when height of stack will be increases.
- Increase in weight of the structure increases the wind moments, whereas increase in height of the structure and height to the base diameter ratio increase the wind moments both static and dynamic.
- Maximum support Reactions in vertical direction will be increases with increasing with H/D ratio in both type of chimney but when compare both type of stack the RC chimney give most precise result with same geometric features.
- Similarly, Maximum support Moment in all three direction i.e. X, Y and Z will be increases with increasing with H/D ratio in both type of chimney but when compare both type of stack the RC chimney give most precise result with same geometric features.
- The stress distribution is within standard and recommended values for deformation, Centreshear stresses, Von Misses Stress and Maximum Principal Stress in plate shell were found high in steel stack as compare to Rc stack.
REFERENCES


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