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/m^2 (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 10^5 MPa
11. Modulus of Elasticity (Concrete) – 0.26 X 10^5 MPa
12. Coefficient of Thermal Expansion – 11 X 10^{-6} per ^{0}C
13. Temperature of Gases above Surrounding - 200^{0}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 Vz = Vb*k1*k2*k3

Where,

Vz = design wind speed at any height z in m/s.

Vb = 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.

Table 1 Wind Pressure calculation

Hx	Hx (M)	K1	K2	K3	Vb	WIND
				T		PRES.
0.000	0.00	1.07	1.26	1.00	39.000	0.148
0.100	5.00	1.07	1.26	1.000	39.000	0.148
0.200	10.00	1.07	1.26	1.000	39.000	0.148
0.300	15.00	1.07	1.20	1.000	39.000	0.134
0.400	20.00	1.07	1.20	1.000	39.000	0.134
0.500	25.00	1.07	1.20	1.000	39.000	0.134
0.600	30.00	1.07	1.15	1.000	39.000	0.123
0.480	24.00	1.07	1.15	1.000	39.000	0.123
0.700	35.00	1.07	1.15	1.000	39.000	0.123
0.800	40.00	1.07	1.09	1.000	39.000	0.111
0.900	45.00	1.07	1.09	1.000	39.000	0.111
1.000	50.00	1.07	1.05	1.000	39.000	0.103

Table 2 Total Load calculation

Hx	Hx (M)	Pz	SHAPE	WIND	TOTAL
		T/SQ.M	FACTOR	PRES.	LOAD(T) Hsx
0.000	0.00	0.211	0.700	0.148	
0.100	5.00	0.211	0.700	0.148	1.863
0.200	10.00	0.211	0.700	0.148	4.083
0.300	15.00	0.192	0.700	0.134	6.350
0.400	20.00	0.192	0.700	0.134	8.702
0.500	25.00	0.192	0.700	0.134	11.688
0.600	30.00	0.176	0.700	0.123	14.386
0.480	24.00	0.176	0.700	0.123	11.678
0.700	35.00	0.176	0.700	0.123	16.752
0.800	40.00	0.158	0.700	0.111	19.496
0.900	45.00	0.158	0.700	0.111	22.190
1.000	50.00	0.147	0.700	0.103	25.121

Where

Hx = Height from Top = N X H

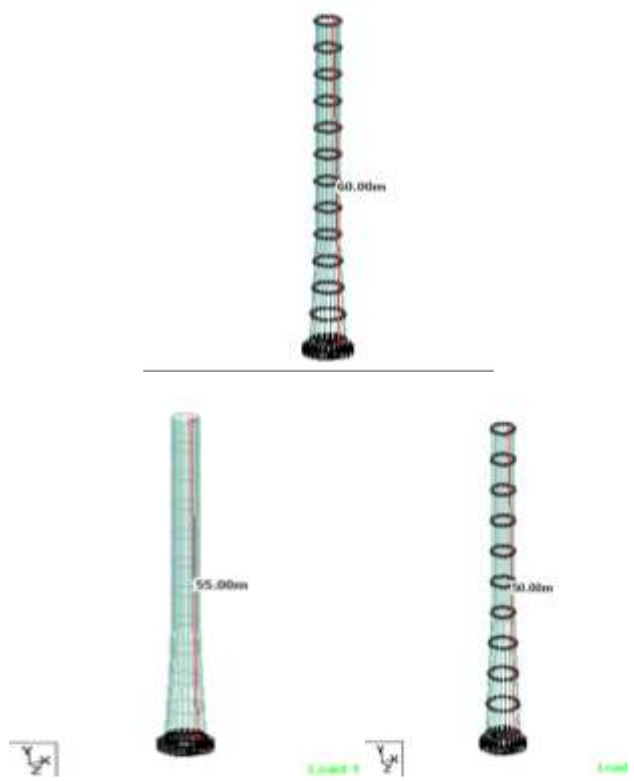


Figure 1 Different height of Stacks

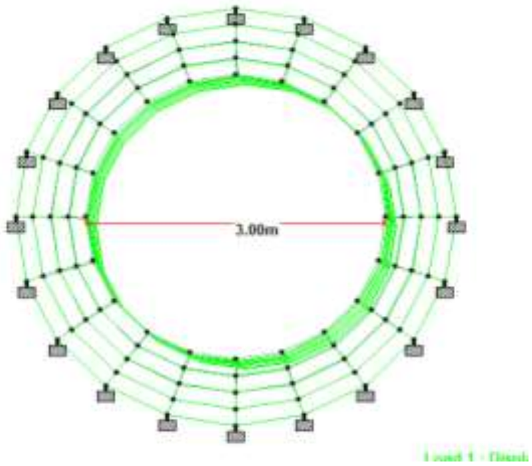


Figure 2 Top Diameter of Stack

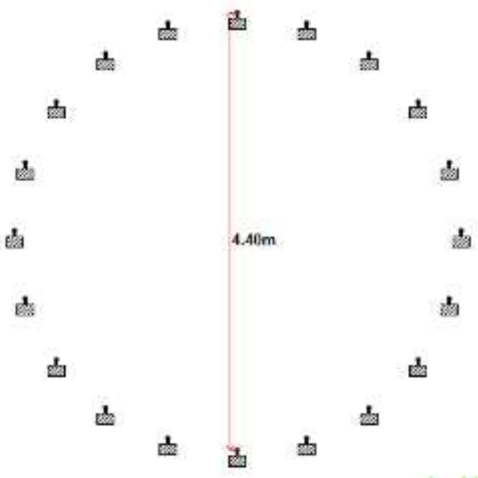
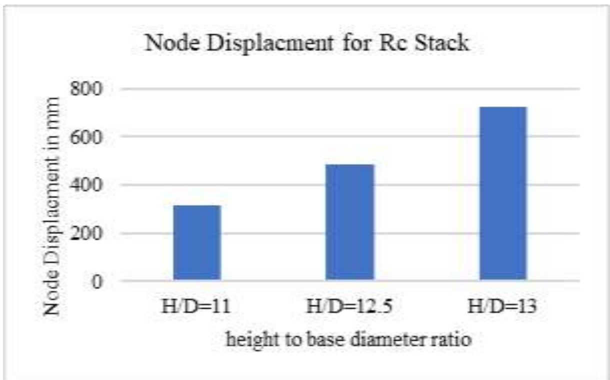


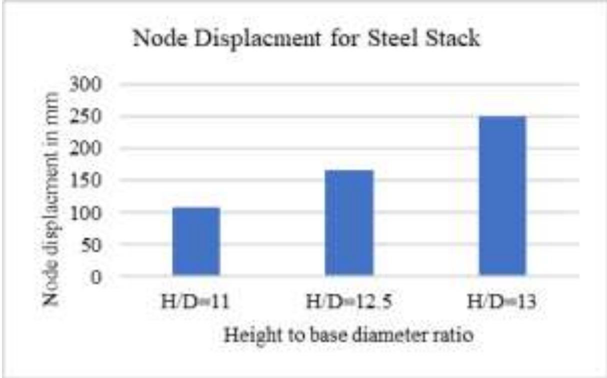
Figure 2 Base Diameter of Stack

4. RESULT

A. Node Displacement

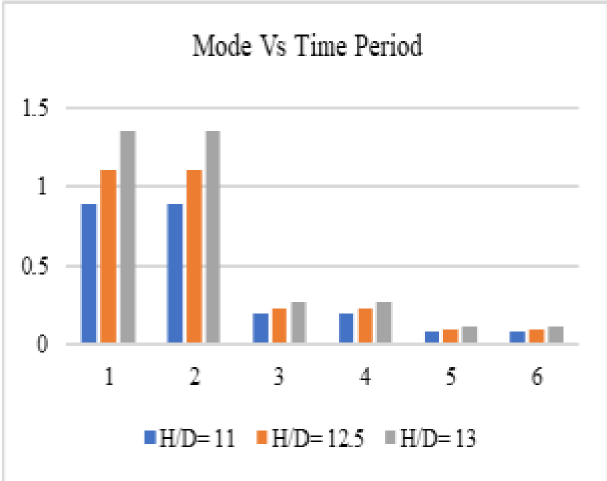


Graph 1 Node Displacement of RC stack in (mm)

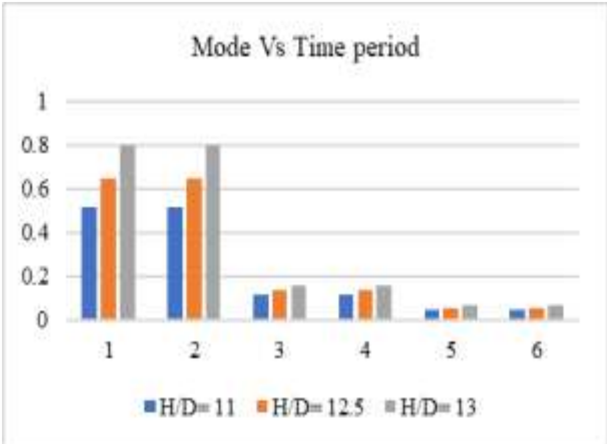


Graph 2 Node Displacement of Steel stack in (mm)

B. Mode Vs Time Period

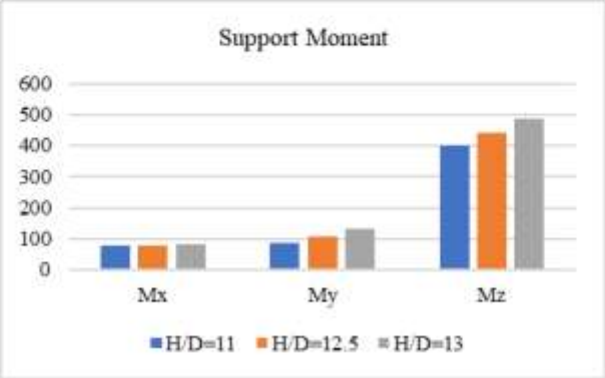


Graph 3 Mode Vs Time Period of RC stack

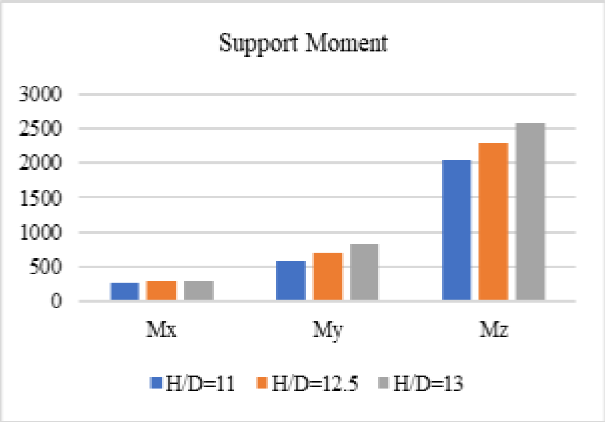


Graph 4 Mode Vs Time Period of Steel stack

C. Support Moments

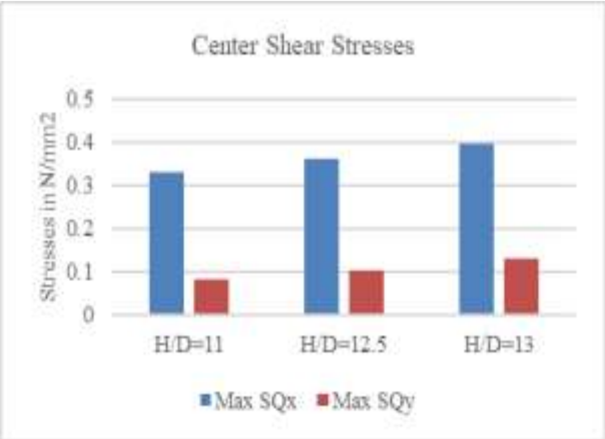


Graph 5 Support Moment in RC stack in KN-m

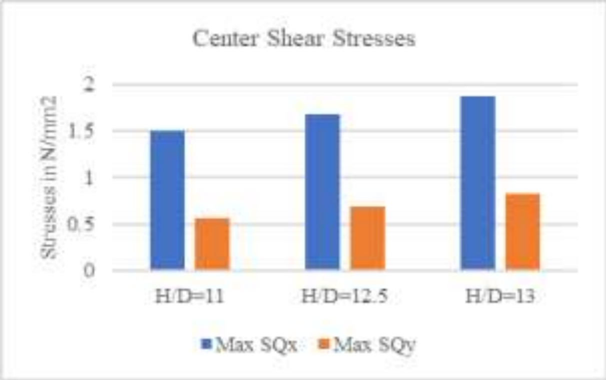


Graph 6 Support Moment in Steel stack in KN-m

D. Center Shear Stresses

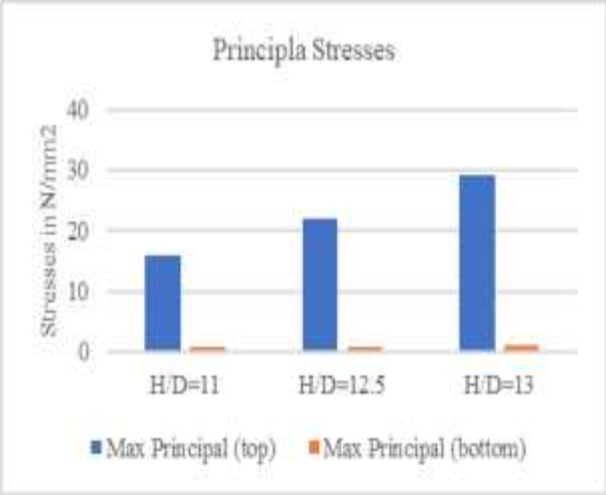


Graph 7 Center Shear Stresses in RC Cylindrical Plate

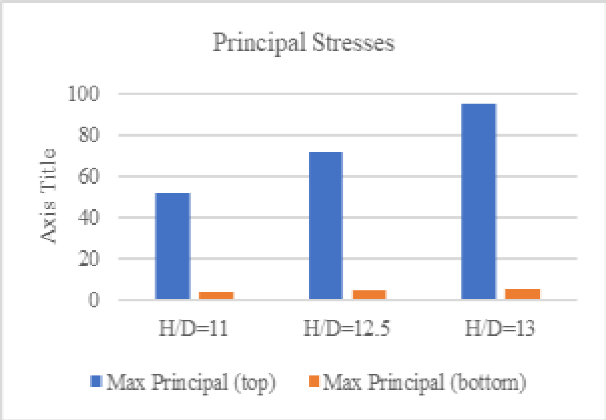


Graph 8 Center Shear Stresses in Steel Cylindrical Plate

E. Principal Stresses

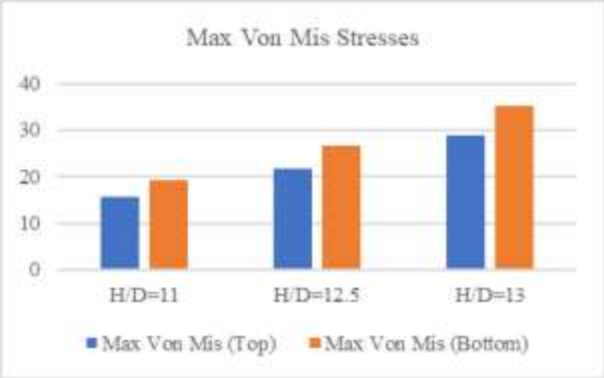


Graph 9 Principal Stresses in RC Cylindrical Plate

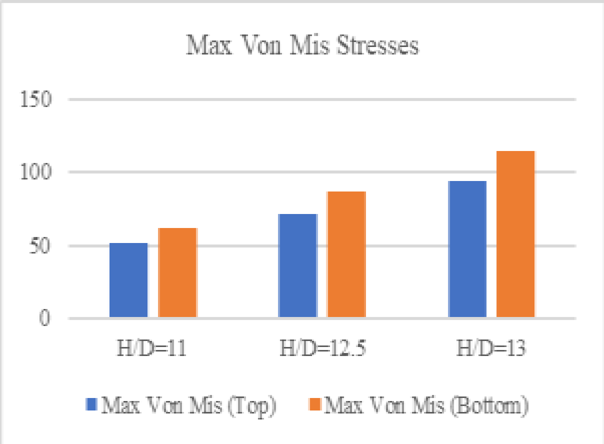


Graph 10 Principal Stresses in Steel Cylindrical Plate

F. Max Von Mis Stresses

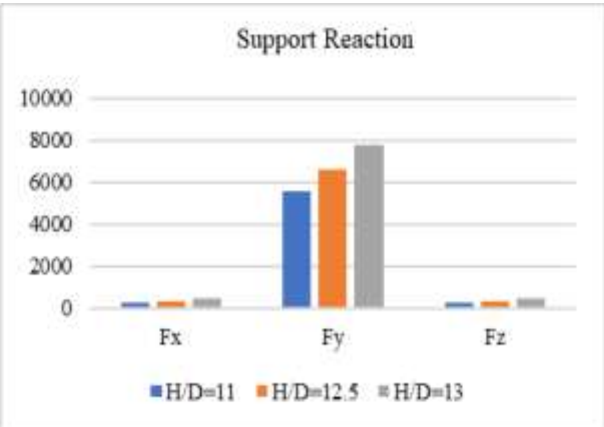


Graph 11 Max Von Mis Stresses in RC Cylindrical Plate

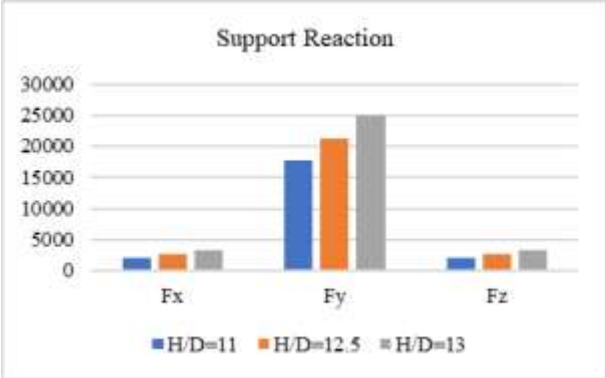


Graph 12 Max Von Mis Stresses in Steel Cylindrical Plate

G. Support Reactions



Graph 13 Support reaction in RC Stacks



Graph 14 Support reaction in Steel Stacks

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 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 and following conclusions are drawn-

- Its concluded that from the analysis the node displacement increases with increasing the H/D ratio and RC steel chimney more precise then 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, Center shear stresses, Von Misses Stress and Maximum Principal Stress in plate shell were found high in steel stack as compare to Rc stack.

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