International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 04 | April - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

Analysis, Design & Cost Estimation of RCC & Steel Chimney

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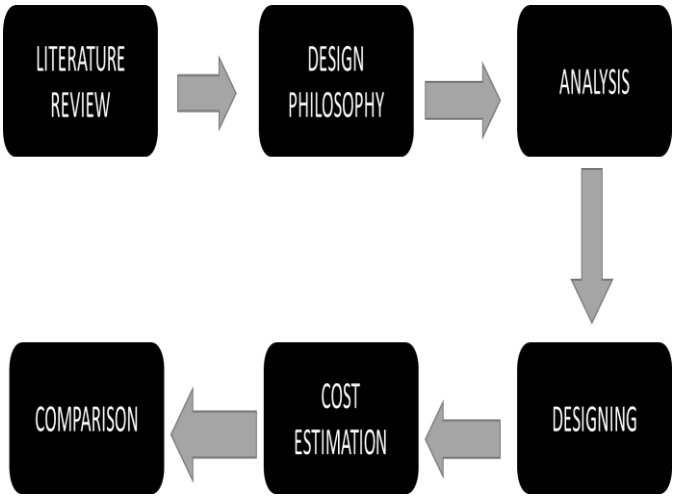
Abstract - Chimneys are tall and slender structures that are used to discharge waste/flue gases at higher elevations with sufficient exit velocity such that the gases and suspended solids(ash) are dispersed into the atmosphere over a defined spread such that their concentration, on reaching the ground is within acceptable limits specified by pollution control regulatory authorities. Fast and economical construction of chimneys is the need of the industries. This project is about the comparison between steel chimneys and R.C.C. chimneys.

Key Word: Economical, stack height, flue gases.

1. INTRODUCTION

As large-scale industrial developments continue to expand, there arises an increasing need for the construction of numerous tall chimneys annually. The principal purpose of these chimneys is to expel pollutants into the atmosphere at heights and velocities that maintain pollutant concentrations within acceptable limits at ground level. Over recent decades, the height of chimneys has steadily increased in response to the growing demands of air pollution control. This trend is expected to persist for valid reasons. However, due to their tall and slender nature, chimneys pose unique structural challenges that necessitate specialized treatment distinct from other tower structures. Constructing such tall chimneys requires a comprehensive understanding of the loads they experience and their structural behavior. Modern construction techniques, such as slip-form construction, and materials like reinforced concrete, which are widely favored for chimney construction, are employed to efficiently address these challenges. The proper design and construction of tall chimneys are essential to ensure they are self-supporting structures capable of withstanding wind loads and other external forces. Typically, wind and earthquake effects are considered separately during the design process. This paper focuses on the analysis of reinforced concrete tall chimneys, particularly comparing wind analysis results with seismic analysis findings to determine appropriate design criteria. Wind analysis is conducted for both along-wind and across-wind scenarios (with the shell completed), and the obtained results are juxtaposed with those from seismic analysis.

2.METHODOLOGY



2.1.DESIGN PHILOSOPHY

When designing an RCC chimney using the Working Stress Method (WSM) for a height of 90 meters, several key considerations come into play. Here's an overview of the design philosophy and steps involved:

1. Load Calculation:

Determine the dead load (weight of the chimney structure itself), live load (wind loads), and any other relevant loads like equipment loads or maintenance loads.

Apply appropriate load factors as per the design codes (such as Indian Standards IS 4995 Part 1 for reinforced concrete structures).

2. Material Properties:

Use standard material properties for concrete and reinforcement as specified in relevant codes and standards (e.g., IS 456 for concrete and IS 1786 for reinforcement steel in India).

3. Analysis:

Perform structural analysis using manual calculations or similar to simulate the behavior of the chimney under different loads including wind and self-weight.

4. Design Criteria:

Follow the guidelines and design criteria specified in the relevant design codes (e.g., IS 4995 Part 2 for reinforced concrete chimneys in India).

5. Cross-Sectional Design:

Determine the appropriate cross-sectional dimensions (such as base diameter and wall thickness) based on the applied loads, and material strengths. Consider factors like the shape of the chimney (circular, rectangular, etc.) and any architectural or aesthetic requirements.

6. Reinforcement Design:

Design the reinforcement layout for the chimney walls, considering both vertical and horizontal reinforcement. Provide additional reinforcement at critical sections such as the base and top of the chimney.

7. Foundation Design:

Design the foundation considering the loads from the chimney and the soil bearing capacity.

Ensure proper detailing and reinforcement of the foundation to prevent settlement and ensure overall stability.

Loads and Load Combinations: -

The various loads and load combinations for the design of the chimney are: -

- Dead Load
- Wind Load
- Dead Load + Wind Load

Fig -1: Industrial Structures-Chimneys

2.2. DESIGN PARAMETERS

Details of the chimney are as follows,

1. Height of the chimney – 90m
2. Outer diameter of chimney at bottom – 4.8m
3. Outer diameter of chimney at top – 3m
4. Thickness of shell at bottom –0.97m
5. Thickness of shell at top – 0.77m
7. Thickness of fire brick lining – 0.1m
8. Grade of concrete – M35 N/mm^2
9. Height to base diameter ratio – 11
10. Top diameter to base diameter ratio – 0.6
11. Basic wind speed – 44m/s
12. Foundation type – RCC circular mat
13. Diameter of flare=4.8 m
14. Height of flare=30 m

3. CONCLUSIONS

The main object of the present study was to explain the comparison between RCC and steel chimneys on the grounds of design, analysis, and estimation. A detailed literature review is carried out as a part of this present study on the design and analysis of steel and RCC chimneys.

In the project, it was studied the stimulation and design Procedure of 90-meter height, steel, and RCC chimneys.

1. The total weight of the chimney is more for RCC when compared to steel for some height.
2. The maximum moment at the base is higher for steel chimneys when compared to RCC chimneys. Whereas shear force is higher for RCC chimneys than steel chimneys.
3. Abstract cost estimation is slightly higher for steel chimneys than for the RCC chimney.
4. RCC chimneys are preferable for chimneys of height, waiting up to 300 meters.
5. In full contrast, steel chimneys are limited to lower heights, such as up to 60 to 90.

4. FUTURE SCOPE

1. Self-supporting flared RCC chimneys are considered for the present study.
2. Chimneys are considered to be fixed at their support. Soil flexibility is not consideredin the present study.
3. The chimney considered here is of single-flue type.
4. The same analysis can be done by taking into account any other different wind speedsand of different heights.
5. This study can be extended by taking earthquake forces into account.

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