Study on Response of RC Twin Flue Chimney using Staad.Pro

Ms. Ismat Afreen Mazumder
Post-graduate Student-M.Tech (Civil Engineering),
PES University, Banashankari III stage ,
Bengaluru-560085, India,

Mr. B V Ramesh
Associate Professor, Dept of Civil Engineering
PES University Banshankari III Stage,
Benagluru-560085, India

***Abstract*—In the present study, a reinforced concrete twin flue chimney of a super critical thermal plant corresponding to an installed capacity of 2 x 800 MW is considered. The modelling and analysis of the RC twin flue chimney is carried out using STAAD.Pro V8i. The superstructure of the twin flue chimney is modelled using plate elements and the substructure (foundation) is modelled using solid elements. Wind load and seismic load are considered for the study. Modal analysis is carried out to find the mode shape which is used for the computation of across wind load. Along wind load and across wind load are computed by using Random Response Method and Simplified Method as per IS 4998:1992 (Part-1). Seismic analysis is carried out using response spectrum method. P-Δ analysis of the twin flue chimney model is carried out for all load combinations. After analyzing the chimney for all the load combinations, results for deflection and lateral drift are discussed. The results show that the deflections are within the permissible limit and load combination E (seismic) has the highest deflection. The lateral drift is maximum at the topmost platform level for all the load combinations. In this study, seismic load is found to be governing.**

Keywords*— Twin flue chimney, along wind, across wind, gust.

I. INTRODUCTION

One of the major components of thermal power stations to dispose off environmentally detrimental poisonous gases (flue gas) are tall chimneys. The poisonous gases which include oxides of sulphur, oxygen, nitrogen and other obnoxious gases that create severe health hazards for people living around the plant, need to be dispersed in large area at specified height as per the stipulations of MOEFF (Ministry Of Environmental Forest & Fisheries) such that rate of dispersion is limited to permissible limit of 50mg/Nm³. The ability of the chimney to transfer flue gases to the external environment via stack effect is greatly influenced by the height of the chimney. The chimney can be categorized based on various parameters mainly height, material of construction, number of flues, structural support and lining.

In the present thesis, a 275m tall reinforced concrete twin flue chimney of a super critical thermal plant corresponding to an installed capacity of 2 x 800MW is chosen.

Twin flue chimney avoids construction of two separate chimneys, thereby saving the land area. It disposes the flue gases from a thermal plant at a very fast rate in large quantity and reduces particulate deposit to permissible limit. Three dimensional modelling of chimney is done using STAAD.Pro V8i software. The superstructure of the twin flue chimney is modelled using plate elements and the substructure (foundation) is modelled using solid elements. P-Δ analysis are performed for wind loads (along wind, along wind with gust, along + across wind using random response and simplified method) as per IS 4998(Part-1): 1992 and seismic load assuming that the chimney is located in Zone-III as per IS 1893. Wind & seismic loads are applied separately.

The components of a twin flue chimney are-

i. two numbers of flue cans
ii. platforms at various levels
iii. one large opening at base/ground level for construction activities like erection of flue cans
iv. two duct openings on either sides of chimney for connecting the two flue cans to the thermal power plant
v. stair case & lifts are provided from ground to top
vi. a top slab covering the chimney
vii. hopper at bottom
viii. steel flue liners

II. MODELLING OF THE TWIN FLUE

The twin flue chimney is modelled using the software STAAD Pro V8i SS6. The super structure is modelled with plate elements with grade of concrete M40 and reinforcement is Fe 500. The flue cans are corresponding to Fe 250. The diameter of the base is 30 m to accommodate two flue cans of 8.12 m with insulation material. There are six intermediate platforms each at a distance of 39.291m center to center.

Walkway is provided at all the platforms all-round the flue cans. The width of the walkway is 1.5 m at the ends with widths varying from 1.5 m to 2.0 m near the shell.

The raft is modeled as 3D solid/brick element having a diameter of 52.5 m and a thickness of 4.5 m. The grade of concrete is M25. The solid elements are discretized in radial direction & rotated around 360 degree to cover entire raft. Chimney base is fixed on top of raft with no release & top portion of the chimney is free.

- Large opening at base/ground level of 8.5 m x 8.5 m for construction activities.
- Provision of openings on either sides of chimney at 16 m height from ground level for connecting induced draught ducts of size 16.0 m x 6.5 m.
- Platforms at different elevation for supporting two numbers of flue cans.
- Top slab covering the chimney at elevation 271 m.

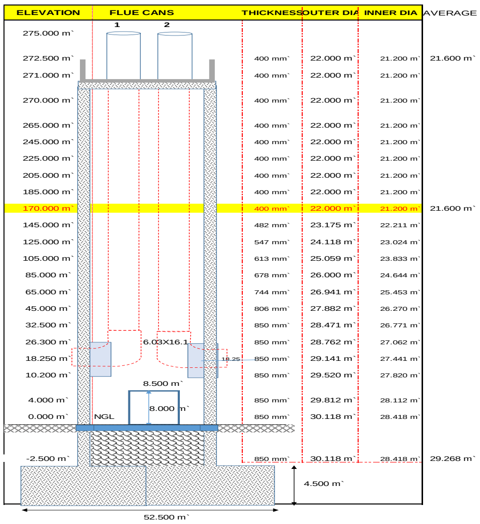

Figure 1- Chimney parameters

As per IS 4998 (Part 1): 1992, Clause 4, following loads are considered-

a) Dead load
b) Imposed load
c) Wind load (Along and Across)
d) Earthquake loads

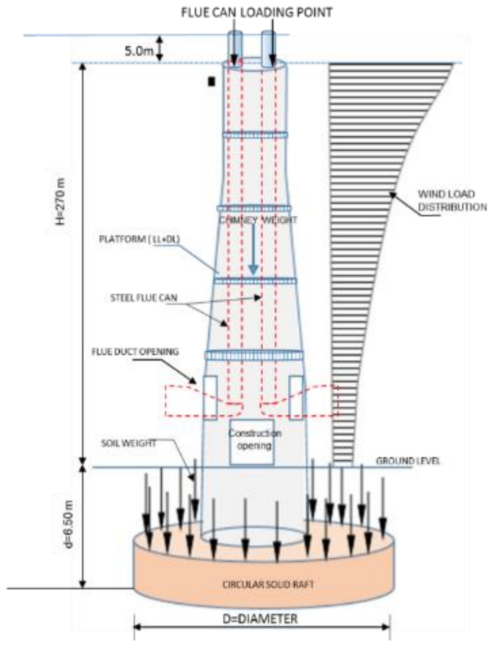

Figure 2- Various loadings of chimney

The chimney is analyzed based on the guidelines of IS 4998 (Part 1) and IS 875 (Part 3) for the following load combinations:

- Load combination A- Dead load (including imposed load) + Along Wind load
- Load combination B- Dead load (including imposed load) + Along Wind load with Gust
- Load combination C- Dead load (including imposed load) + (Along Wind load + Across Wind load) using Random Response Method
- Load combination D- Dead load (including imposed load) + (Across Wind + Along Wind) using Simplified Method.
- Load combination E- Dead load (including imposed load) + Seismic load

The above loads and load combinations are applied on to the 3D FE model of RC twin flue chimney developed in STAAD Pro. V8i.

Figure 3 shows the 3D STAAD model of the twin flue chimney with construction opening and ducts openings.

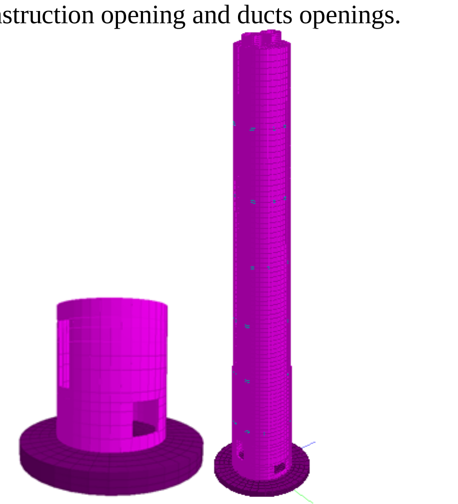

Figure 3- 3D STAAD model of the twin flue chimney with openings.

III. ANALYSIS OF THE TWIN FLUE CHIMNEY.

To ensure the safety of the structure under stringent condition, the following standard analysis of the twin flue chimney are performed-

a) Modal Analysis
b) P- Δ Analysis

Modal analysis is carried out to find the mode shape which is used for the computation of across wind load. As the structure is a tall cantilever with base fixed condition, p-Δ analysis is the most preferred analysis. Further, as the large vertical weights of twin flue cans are supported at every platform, there is an appreciable influence of p-delta analysis.

IV. RESULTS AND DISCUSSION

The results of the analysis are shown in this section. Figure 4 shows the deflection of the twin flue chimney for load combinations A, B, C, D and E from p-Δ analysis.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 07, July-2019

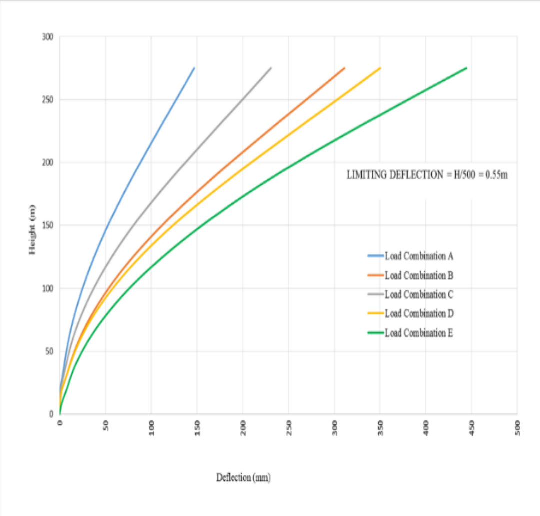

Figure 4- Deflection along the height of the Twin Flue Chimney from p-Δ analysis.

From figure 4, it is observed that load combination A has the lowest deflection and load combination E has the highest deflection. As per IS 4998:2015, Clause-6.3.1, the limiting deflection is H/500=550 mm. The deflections are found to be within the permissible limit.

Figure 4, figure 5, figure 6, figure 7 and figure 8 shows the lateral drift for load combination A from static and p-Δ analysis.

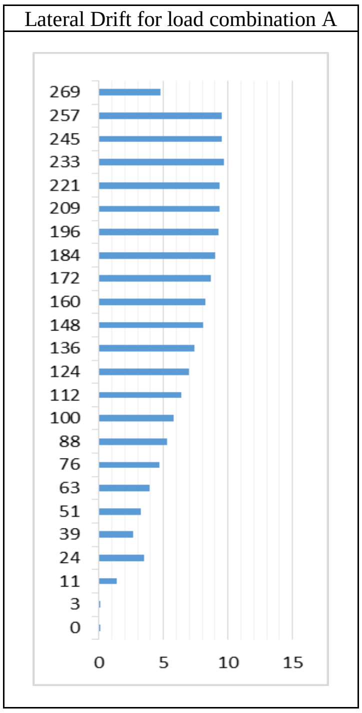

Figure 7- Lateral drift for load combination A from p-Δ analysis.

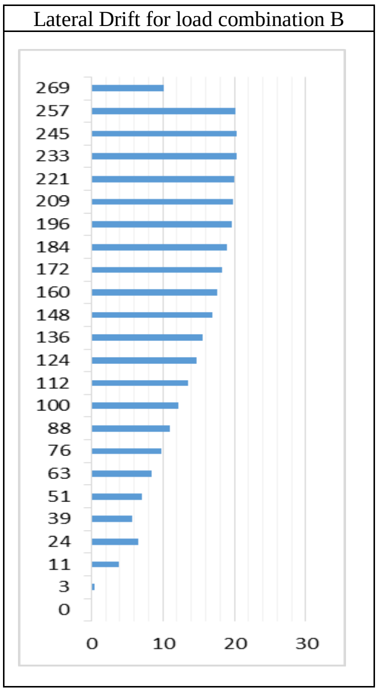

Figure 8- Lateral drift for load combination B from p-Δ analysis.

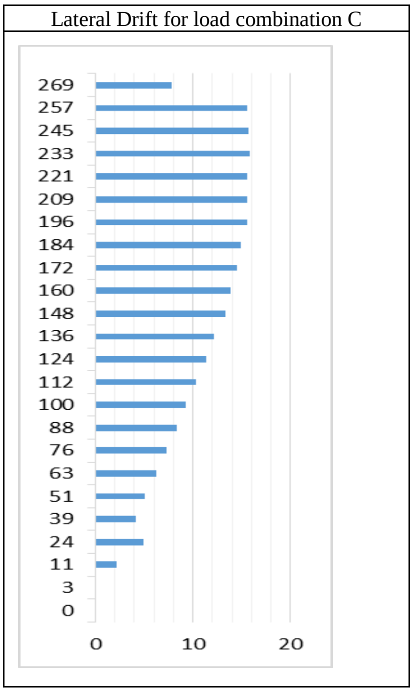

Figure 9- Lateral drift for load combination C from p-Δ analysis.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 07, July-2019

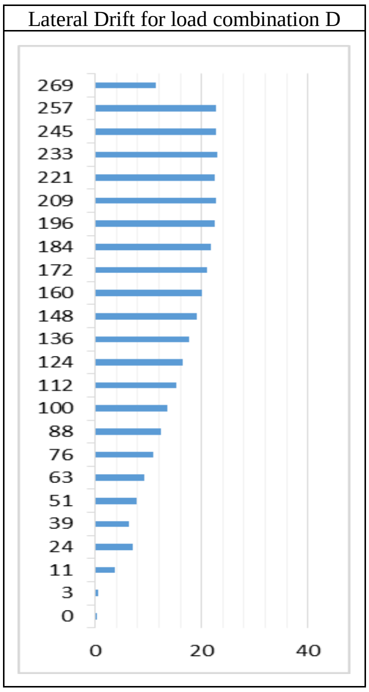

Figure 10- Lateral drift for load combination D from p-Δ analysis.

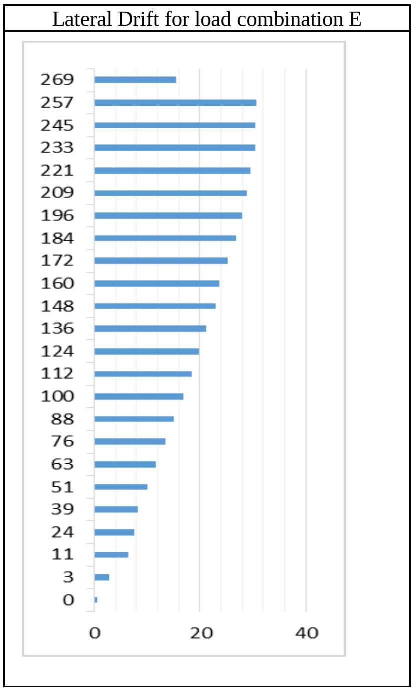

Figure 11- Lateral drift for load combination E from p-Δ analysis.

It is observed from figure 7, figure 8, figure 9, figure 10 and figure 11 that the lateral drift of the chimney is found to be maximum at the topmost platform level (i.e., 232.69 m) for all the other load combinations, lateral drifts are found to be maximum at the same level.

V. CONCLUSION

Since the chimney is an important structure, its failure will result in huge loss of power which will be more than 35 million units per day leading to huge financial loss. It takes a minimum of two years to restore the chimney. Failure of the chimney will also cause huge loss of life and damage to the surrounding important structures. Under these circumstances, it is necessary to carry out p-delta analysis for both wind load and seismic load with critical load combinations.

From P-Δ analysis following results are observed:

- The deflection is found to be maximum at the highest elevation of the chimney i.e., at 275 m height for all the load combinations. It is found that displacement increases with the increase of height. Load combination A has the lowest deflection of about 147.014 mm and load combination E (i.e., seismic case) has the highest deflection of about 444.465 mm. However, the deflections are within the permissible limit of 550 mm.
- The drift is found to be maximum at the topmost platform level (i.e., 232.692 m) for all the load combinations. The lateral drift is found to be highest for load combination E (i.e., seismic case).
- In the present study, seismic load is found to be governing. Therefore, emphasis should be given for both wind and seismic load for this type of structure.

VI. REFERENCES

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