



Design Of Stack Supporting Steel Framed Structure In Fgd System

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Abstract: Flue Gas Desulphurization (FGD) system is required to be provided for all operational thermal power plants and the new plants being operational in future for meeting the new guidelines laid by Ministry of Environment Forest and Climate Change (MoEF&CC). FGD system provides the “Environmental Sustainability” by reducing the SO₂ gas liberated to the atmosphere, which is a health hazard causing respiratory infections, eye irritation, breathing difficulty, asthma, etc. FGD is a system which reduces the SO_x in flue gas through chemical treatment converting the captured SO_x into a by-product which is used by some other industry. To achieve acceptable dispersion of SO_x emission from thermal power plants, Chimney height criteria has been adopted in India based on the emission rate of the SO_x. This paper highlights the sustainable design aspects considered in the design of 125m tall Chimney with structural frames for a 2x600MW power plant.

Index Terms - Flue Gas De-Sulphurisation, FGD, SO_x, MOEF, Air-pollution, Chimney, Sustainability, Flue Can.

I. INTRODUCTION

Flue Gas De-Sulphurisation (FGD) system is a requirement for thermal power plants to reduce the air-pollution caused by SO_x generated due to burning of coal and release of fuel gases from the boilers. Ministry of Environment Forest and Climate Change (MoEF&CC) have formulated guidelines to reduce the content of SO_x present in flue gas which will be released to atmosphere. It has become mandatory to install FGD system in the existing and upcoming thermal power plants for meeting the new guidelines set by MoEF&CC. FGD is a system which reduces the SO_x in flue gas through chemical treatment and converting the captured SO_x into a by-product which is used by some other industry. In the process of this De-Sulphurisation, flue gases are led to the Chimney for discharge of the residual gases at a sufficient elevation so that the concentration of SO_x will be in acceptable limit after dilution into atmosphere. To achieve acceptable dispersion of SO_x emission from thermal power plants, Chimney height criteria has been adopted in India based on the emission rate of the SO_x. A RCC Chimney is generally adopted for height above 100m and a steel Chimney is used for a smaller height below 90m. The required height of Chimney for a Power Plant with capacity of 500MW and above is 275m without FGD and the same reduces to around 125m when a FGD system is installed. Normal practice to provide RCC Shell for Chimney height more than 100m. Recent times in addition to cost saving and construction time saving, sustainability design is getting more importance. An attempt has been made in the design of a 125m tall Chimney considering sustainability aspects with due consideration for space saving in the compact layout. This paper highlights the sustainable design aspects considered in the design of 125m tall Chimney for a 2 x 600MW power plant.

Another design aspect in the installation of FGD system in existing plant is to accommodate the facility within available space.

This paper highlights the design approach of frame type supporting structure of Flue Can, design of titanium lined flue can, consideration of bearings for supporting arrangement, design criteria of frame structure, design of foundation for frame structure, optimisation and reduction of FGD footprint, reduction of carbon footprint and reduction of construction cost.



DESIGN REQUIRMENT

2.1 The OEM requirement is to support a Titanium lined Steel Flue Can (Internal diameter 7.69 m) at various levels.

2.2 To provide platform arrangement at supporting levels.

2.3 To optimise the available area for accommodating other structure (Recirculation Pump House & independent Staircase for Chimney) and to reduce the footprint of other structure's foundations which are in close vicinity of the FGD structures.

2.4 To provide arrangement of the assembly that can reduce the overall erection cost and time.

II. DESIGN APPROACH

In a conventional Chimney construction, steel flue/brick flue (Refer Fig 3) is generally supported inside the concrete shell. Construction of concrete shell for the Chimney of the height 125m is time consuming and higher cost involved. To avoid this, steel flue can with steel frame support arrangement is an option which is adopted in 2x600MW Plant.

The arrangement in Fig 1 shows steel flue can of internal diameter of 7.69 m which is supported at breach level (i.e. EL 34.0 m) and intermediate levels (i.e. EL 50.0 m, EL 58.0 m, EL 85.5 m & EL 123.0 M) (Refer Fig 1 & 2). Vertical supports of the flue can are considered at two level (i.e. EL 58.0 m & EL 125.0 M) by calculating expansion of flue can whereas horizontal support guides are taken at each level.

To prevent the contact of steel flue can with flue gas, titanium clad plate with 1.2mm thick Ti & 10mm thick MS is utilised. Glass mineral rock wool insulation is provided outside the flue can for cooling the surface and achieve a proper condensation of the droplets in the wet flue. Bearings are designed to restrict the horizontal movement caused by wind action.

Flue can self-weight is taken at two different levels (i.e. EL 58 m and EL 123 m) through bearings. Supporting frame structure is designed as lattice tower with inclination (86.10 with horizontal) for columns upto EL 58m. Above EL 58 m columns are aligned vertical.

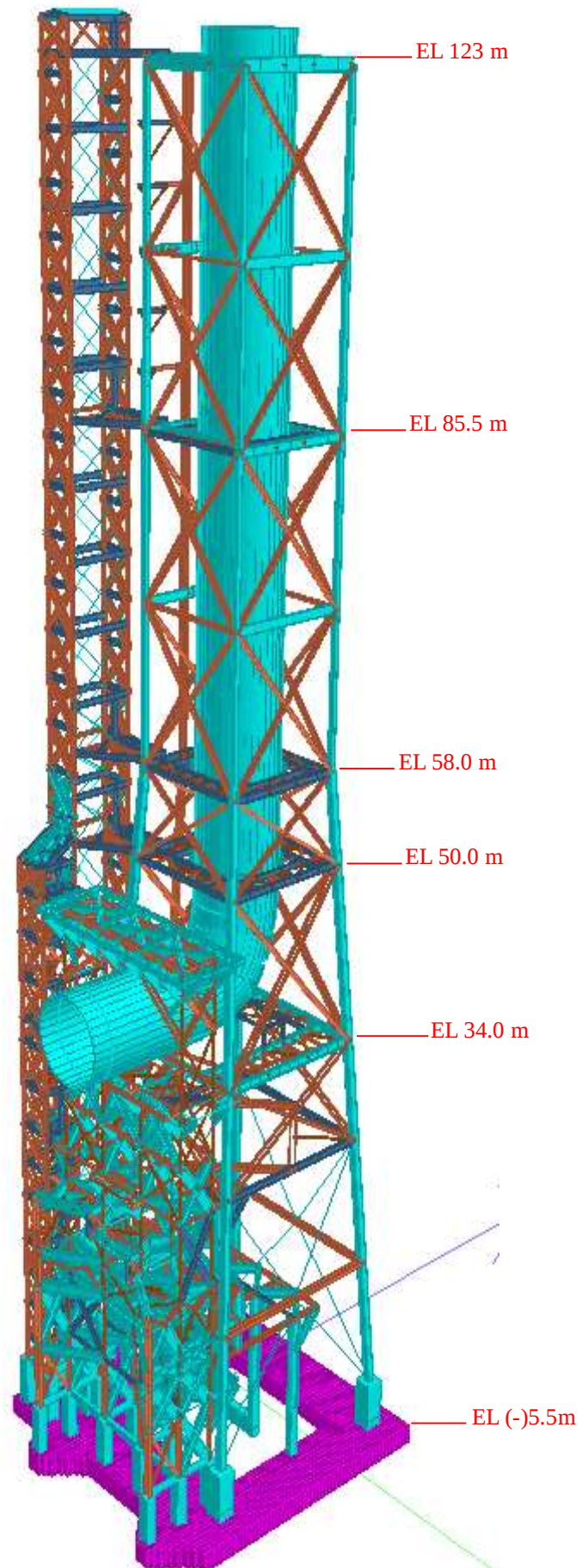


Fig. 1. 3D REPRESENTATION OF MODEL

Base dimension of the tower at EL 0.00 m is 20 x 20 m, which is further reduced to 12 x 12 m at EL 58 m. Breach level is at EL 39.816 m. Access floors are at EL 34 m, EL 50 m, EL 58 m, EL 85.5 m & EL 123 m. Steel gratings of suitable span is provided for all the access floors.

For approaching the access floors, one independent Staircase tower and one elevator is provided adjacent to the Chimney Frame Structure.

Horizontal stay is taken from Chimney tower for both Staircase and elevator.

Flue can is projected 2 m above the EL 123 m i.e. the top of the tower to avoid the steel structure coming in the path of the Flue.

Continuous Emission Monitoring System ports are attached to the flue can at about EL 85.5 m level platform.

Individual flue can is designed for wind load and thermal expansion. Frame structure is designed for dead load, live load, duct load, wind load and seismic load.

Common raft foundation is designed for all the three structure i.e. Chimney Tower Frame, Staircase for Chimney and Re-circulation Pump House. Bottom of foundation is considered in line with approved soil report and foundation placed at EL (-) 5.50 m.

A 3-dimensional model using beam, element and plate element is created for FEM analysis (Refer Fig 1). Structural steel of grade E250 is considered for design confirming IS 800-2007 and concrete of grade M30 is considered based on exposure conditions as per IS 456 – 2000 with reinforcement Fe 500 confirming IS 1786 – 2008.

III. DESIGN CRITERIA

Frame structure is designed confirming all design aspect of IS 800-2007 as stated below,

Serviceability criteria taken for the design of steel structure

4.1 Maximum horizontal deflection of tower = Height of structure/500 mm

4.2 Maximum vertical deflection = Length of beam/325 mm

Serviceability criteria taken for the design of foundation

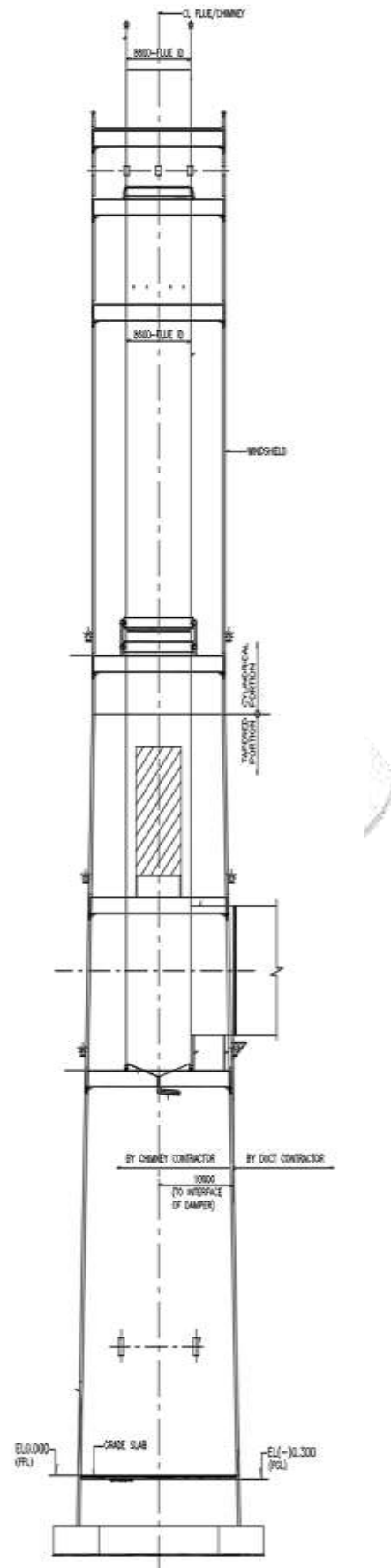
4.3 Sliding factor = 1.4

Serviceability criteria taken for the design of flue can

4.4 Corrosion allowance = 4 mm

4.5 Permitted horizontal deflection at platform level = 5 mm

Fig. 3. Conventional RC Chimney Structure



IV. LOAD CALCULATION

All the load calculation is considered for analysis are in line with latest clauses of IS codes as stated below,

5.1 Dead Load – This load includes the load due to self-weight of the structure along with its various platforms including the weight of grating.

5.2 Live Load – This load is arising due to live load on the platforms.

5.3 Duct Load – This Load is generated for supporting of flue can.

5.4 Wind Load – This load is action on the surface of flue can and on the beam elements as open structure wind. Same loading is parallelly checked with a wind tunnel study conducted at national accredited Laboratory (Refer Fig 4). Gust factor is considered for wind load calculations.

5.5 Seismic Load – This load is generated due to mass of the structure.

5.6 Diagonal wind load – Diagonal wind load is applied as a resultant of wind loads in two adjacent directions at a 45° angle in all diagonal direction with a factor of 1.2



Fig. 4. Wind Tunnel Study of Chimney Frame Structure

V. LOAD COMBINATION

All the load combinations are considered in line with IS 875: Part 5. Design is performed as per IS800 provisions for strength and serviceability criteria. RCC shallow foundation is designed considering the superstructure analysis results and geotechnical recommendations and provided raft foundation supporting all steel columns of tower.

VI. DISCUSSION

7.1 By adopting this frame type support, Recirculation (RC) pump house (Size 16.5(L) x 14.75(B) x 24(H)) could be accommodated inside the frame structure to facilitate Recirculation pipes. The columns of the RC Pump House are extended further to support the Emergency Quenching Tank. Because of this, structural footprint for FGD system has been reduced.

7.2 Frame type stack supporting structure can be reused or material can be recycled in steel manufacturing, in future after life span of FGD plant. Reuse of the steel frame and foundation will reduce the carbon footprint of the construction and it will reduce the cost of future construction.

7.3 Skeleton type open frame steel structure is guided by wind load (Dynamic effect of wind is considered) hence seismic load is not governing. Effect of seismic load due to RCC super structure weight can be reduced by adopting the frame structure concept. In addition to that frame structure has less obstruction area compared to concrete shell type Chimney for wind load. Hence, net wind force is also less compared to conventional Chimney shell. As the force is less, foundation size is also reduced by adopting this type of frame structure. The cost of the foundation for the framed Chimney is comparatively less than the conventional RCC Chimney with similar flue configuration.

7.4 In a comparative study it is noted that there is a reduction of 15% construction cost and 23% reduction in carbon emission in framed Chimney when compared to conventional RCC Shell type Chimney.

7.5 The reusability of steel in framed Chimney is observed as 9% higher than RCC shell type Chimney.

VII. CONCLUSION

It can be concluded that the framed structure is suitable for Chimney of height less than 150m with considerable engineering, economic and environmental sustainability benefits as stated in the discussion.

VIII. ACKNOWLEDGEMENT

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