The Wind Load Analysis on Chimney With Different Designs Using CFD

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Abstract - *The heavy winds tend to cause damage on civil structures. The current research investigates the wind load analysis on chimney with different designs using CFD. The design and simulation of chimney is conducted using ANSYS software. From the CFD analysis, the pressure distribution and velocity distribution plots are generated for both designs of chimney i.e. chimney with sharp edge and chimney with smooth edges. The pressure induced on chimney structure is evaluated and the CFD results have shown that filleted chimney structure has significantly lower induced pressure as compared to sharp edged chimney.*

Key Words: Aerodynamics, chimney design, Drag force

1.INTRODUCTION

The chimney structures are used in thermal power plants, chemical plants, plastic units. The chimney elevations have gone up progressively from 100 m to more than 400 m due to the high demand of pollution control. Chimneys have "unique geometrical features of slender dimensions and tapering geometry and, therefore, the analysis and design of such kind of structure should be treated separately from other forms of tower structures. These tall chimneys are very sensitive to wind loads" [7].

2. LITERATURE REVIEW

Kalpesh Dhopat et al (2018)[1] have conducted research on steel chimneys using FEA tool. The FEA tool used for the analysis is Staad Pro and the wind load conditions are applied on the chimney as per IS 6533 and IS 1893 codal provisions. The effect of geometric parameters are investigated.

Kalagouda R Patil et al (2017)[2] have conducted research on different designs of chimneys as per different codes of Indian. The chimney heights are varied and the FEA analysis is conducted using Staad pro and ANSYS simulation software. The "author had taken a practical case study and carried out design calculations by using the rules of codes viz., IS: 4533 part 1 and 2, IS: 875 part-3, IS: 1893 part1 and 4. Further to get full insight into the design of the steel stacks, a complete 3-D finite element analysis was carried out by using ANSYS software" [2].

M. Pavan Kumar et al (2017) [3] have conducted numerical investigation on chimney under different wind loading conditions. The analysis of chimney was conducted for different zones i.e. zone 2, zone 3, zone 4. The FEA results have shown that shear force is maximum near the steel stacks.

Nimisha Ann Sunny et al (2017)[4] have conducted research on interaction of building with soil under different types of loading conditions. The research was conducted using ANSYS simulation package and the research findings have shown that pile raft foundation has significant effect on building deformation under high wind loads.

Rakshith B D et al (2015) [5] have conducted research on cantilever steel chimney using Staad pro simulation package. The analysis is conducted as per different Indian codal provisions. Two different chimneys were analysed i.e. the chimney with manhole and chimney without manhole. Different output parameters related to structural parameters were evaluated.

B. R. Jayalekshmi et al (2015)[6] have conducted research on 300m high chimney. The soil structure interaction analysis along with wind load is conducted on chimney using ANSYS FEA simulation package. The analysis was conducted as per IS:4997 codal provisions. From the FEA analysis, the chimney responses were evaluated i.e. deformation, stresses, bending moment etc. which accounted for more than 73% of total cases.

3. OBJECTIVES

The current research investigates the wind load analysis on chimney with different designs using CFD. The design and simulation of chimney is conducted using ANSYS software.

4. METHODOLOGY

The model of chimney is developed and imported in design modeller of ANSYS simulation package. The chimney model is enclosed using enclosure as shown in figure 2. The enclosure is modelled with 10m*10m*10m dimensions.

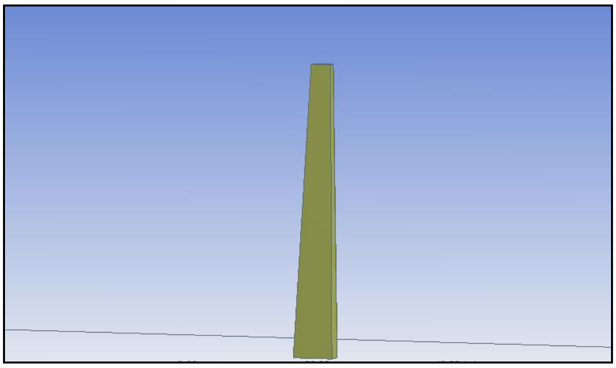

Figure 1: Chimney design

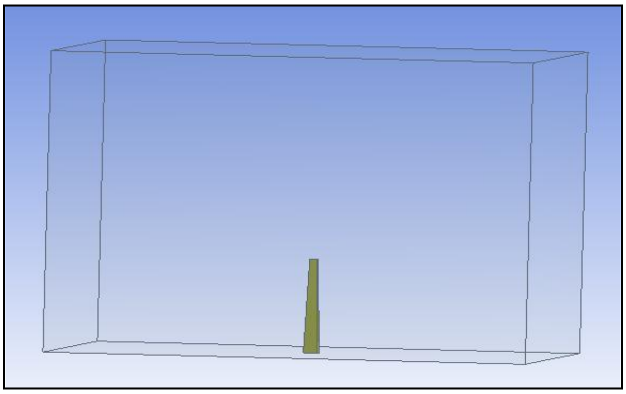

Figure 2: Enclosure modelling

The enclosed model of chimney is meshed with tetrahedral element type. For meshing the relevance is set to fine with relevance value of 99. From meshing the number of elements generated is 605412 and number of nodes generated is 111461. The inflation is set to normal and growth rate is set to 1.2.

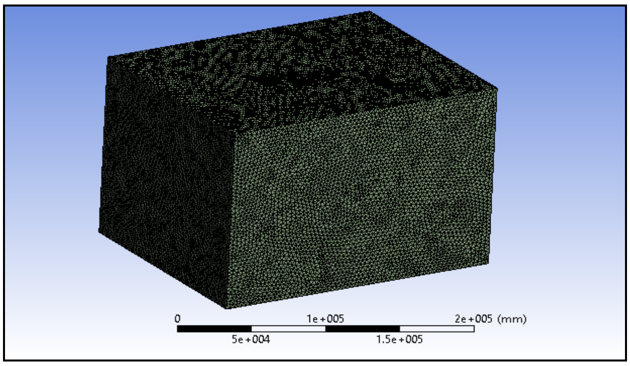

Figure 3: Meshed model of enclosure

The geometry model of enclosure is applied with loads and boundary conditions. In 1st stage, the enclosure domain is defined as fluid type. The material for this domain is set to air and reference pressure for the enclosure domain is set to 1atm. The turbulence model is set to k-epsilon type.

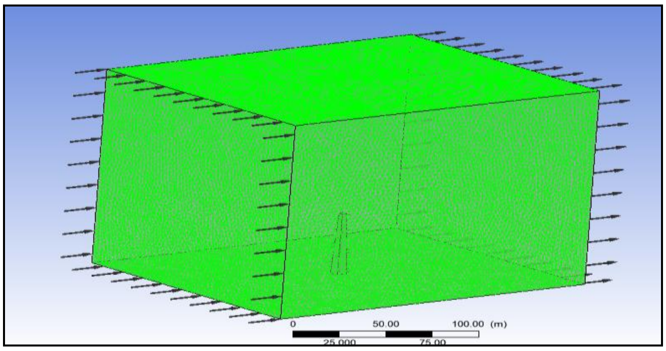

Figure 4: Domain definition

The domain definition of enclosure is shown in figure 4. The air inlet boundary condition is defined for enclosure wherein the air velocity is defined as 42m/s and turbulence intensity is set to medium. The air outlet boundary condition is also defined wherein the relative pressure difference is set to 0 Pa as shown in figure 6.

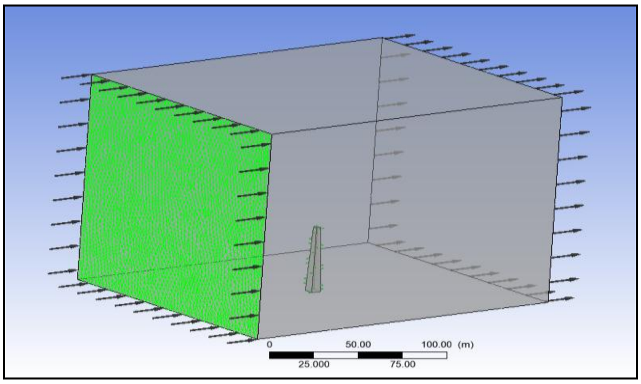

Figure 5: Air inlet definition

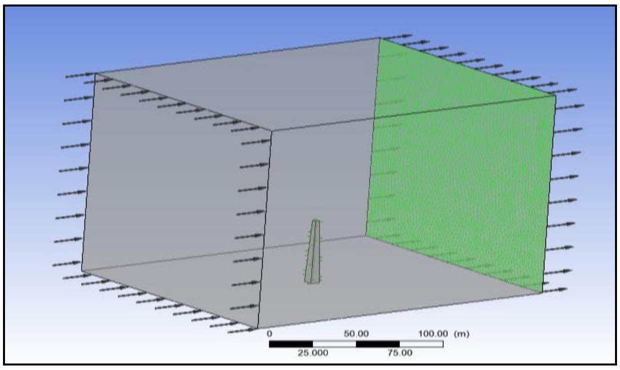

Figure 6: Air outlet definition

After defining loads and boundary condition, the solver settings are defined which include setting up iterations and solver type. The simulation is run and nodal values of pressure and velocity are obtained.

5. RESULTS AND DISCUSSION

The CFD simulation is run to determine pressure and velocity plot for different designs i.e. sharp edged chimney and filleted edge chimney.

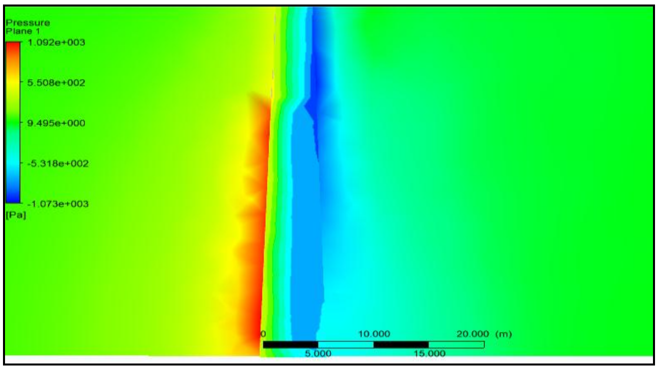

Figure 7: Pressure distribution plot for sharp edge chimney

From the pressure distribution across sharp edged chimney (figure 7) the pressure is maximum at the windward side of the chimney and is minimum at the leeward side of the chimney. The pressure value is more than 557Pa at the windward side. The pressure at the rear of the structure is lower than atmospheric pressure which tends to bend the structure.

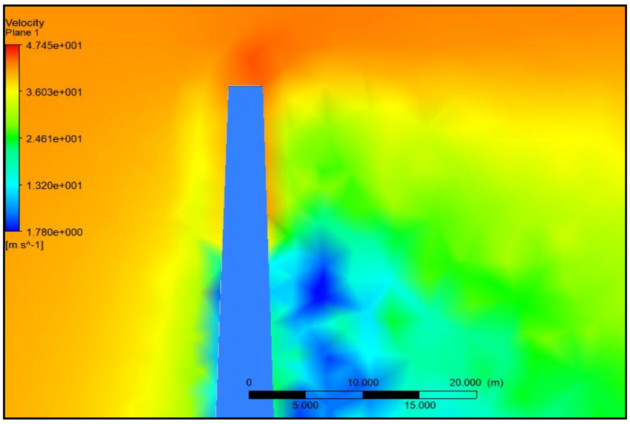

Figure 8: Velocity distribution plot for sharp edge chimney

The velocity distribution plot is obtained for sharp edged chimney as shown in figure 8 above. The velocity of air is higher at the tip of the chimney wherein the magnitude is more than 44m/s. The air velocity the leeward side is lesser than 12m/s as shown in dark blue coloured region.

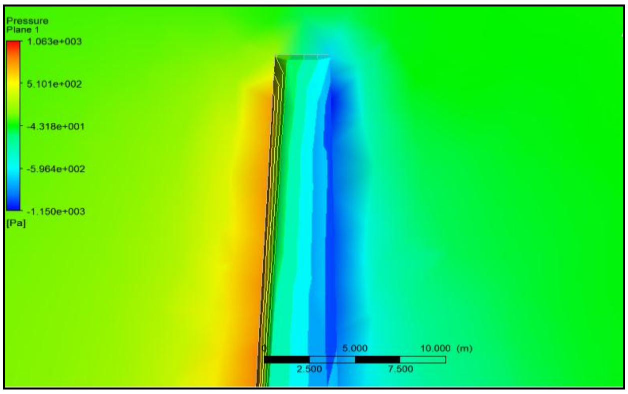

Figure 9: Pressure distribution plot for filleted chimney

From the pressure distribution across filleted edged chimney (figure 9) the pressure is maximum at the windward side of the chimney and is minimum at the leeward side of the chimney. The pressure value is more than 1062Pa at the windward side. The pressure at the rear of the structure is lower than atmospheric pressure which tends to bend the structure.

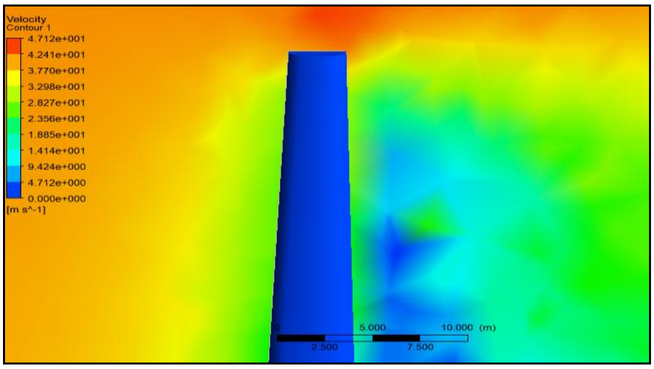

Figure 8: Velocity distribution plot for filleted chimney

The velocity distribution plot is obtained for filleted edged chimney as shown in figure 8 above. The velocity of air is higher at the tip of the chimney wherein the magnitude is more than 46m/s. The air velocity the leeward side is lesser than 14m/s as shown in dark blue coloured region.

6. CONCLUSIONS

From the CFD analysis, the pressure distribution and velocity distribution plots are generated for both designs of chimney i.e. chimney with sharp edge and chimney with smooth edges. The pressure induced on chimney structure is evaluated and the CFD results have shown that filleted chimney structure has significantly lower induced pressure as compared to sharp edged chimney.

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