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Wind Load Analysis Of Chimney Structure Using Computational Fluid Domain Technique

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Abstract: The chimney structures are tall and generally placed in regions of high gust. The design of chimney has significant effect on wind load bearing characteristics of chimney. The research is intended to investigate the effect of wind load on structural characteristics of chimney. The wind load analysis of chimney structure is conducted using techniques of Computational Fluid Dynamics. The CAD modeling and CFD simulation of chimney is conducted using ANSYS CFX software. The lateral deformation and induced pressure is evaluated for different chimneys. The edge treatment on tapered chimney has significant effect on magnitude of induced pressure and drag force on chimney. By changing the sharp edged chimney to filleted edge chimney the drag force and shear stress reduced significantly.

Key Words: *Chimney, wind load*

1. INTRODUCTION

Chimneys are structures that are built to greater heights as tall slender structures. In the early days, as household vents and over the years; they are popularly called chimneys. Chimneys or stacks are used as a medium to transfer highly polluted gases to the atmosphere at higher altitudes. Over the years, due to the development of large industries, a large number of tall slender chimneys need to be designed every year. Chimneys are responsible for industrial growth in any country, and changes in various parameters in any country, and changes in various parameters or dimensions, such as increasing the height of chimneys, are more independent of structural analysis, such as earthquake response, are increasingly critical. criteria. The diameter of the upper part of the chimney and the height of the chimney, exit speed at the top, dispersion of gases are within permissible limits. Above all, the lower diameter is also controlled by various requirements for the construction of both the concrete shell and the base of the chimney. For the development of large industries across the country, a huge number of tall buildings are designed every year across the country, and due care must be taken in the design of chimneys.

Figure 1: Industrial chimney

2. LITERATURE REVIEW

Kalpesh Dhopat et al (2018) [1] have conducted numerical investigation on chimney using Staad Pro simulation package. The effect of height to base ratio on structural behavior of chimney is investigated. The analysis is conducted as per IS :6533 and IS 1893 code. The research findings have shown that height to base ratio has significant effect on lateral deformation of chimney.

Kalagouda R Patil et al (2017)[2] have conducted numerical analysis on chimneys on chimney design made of steel material. The analysis is conducted using Staad pro and ANSYS simulation package. The chimney diameter is kept constant and height of chimney is varied. The author took a "practical case study and performed design calculations using code rules viz. IS: 4533 part 1 and 2, IS: 875 part-3, IS: 1893 part 1 and 4. complete 3D finite element analysis was done to the design of steel chimneys using ANSYS software" [2].

M. Pavan Kumar et al (2017) [3] have conducted CAE analysis on self-supporting steel chimney of 110m height using Staad Pro software. The analysis of chimney is conducted under wind load and seismic loads. The seismic zone considered for the analysis is zones II, III, IV and V with wind loads of 44m/s and 50m/s. The lateral deformation and base shear of steel chimney is evaluated.

Nimisha Ann Sunny et al (2017)[4] have conducted analysis on soil structure interaction of chimney using ANSYS v17.0 simulation software. The FEA analysis of piled raft foundation is conducted to determine equivalent stress and lateral deformation. The research findings have shown that soil structure interaction has significant effect on behavior of structure.

Rakshith B D et al (2015)[5] have conducted research on chimney structure incorporated with hatch and without hatch. The analysis is conducted on above mentioned structures using Staad pro simulation package. The effect of geometric constraints on structural deformation and stress induced on chimney is evaluated.

B. R. Jayalekshmi et al (2015)[6]have conducted research on SSI investigation on 250m high reinforced concrete stacks. The analysis is conducted under downward wind direction. In all 4 different soil types considered for the analysis. The effect of downwinds are evaluated using IS:4998 code. The FE simulation package ANSYS is used for evaluating linear elastic behavior. The bending moment, deformation at the tip is evaluated from the analysis. The research findings have shown that underground elasticity has significant effect on response in the chimney stack.

3. OBJECTIVE

The research is intended to investigate the effect of wind load on structural characteristics of chimney. The wind load analysis of chimney structure is conducted using techniques of Computational Fluid Dynamics.

4. METHODOLOGY

The wind load analysis on chimney is conducted using CFD simulation package i.e. CFX. The CAD design of taper chimney is developed in design software. The design is converted in .iges file format to make it compatible with CFX simulation package.

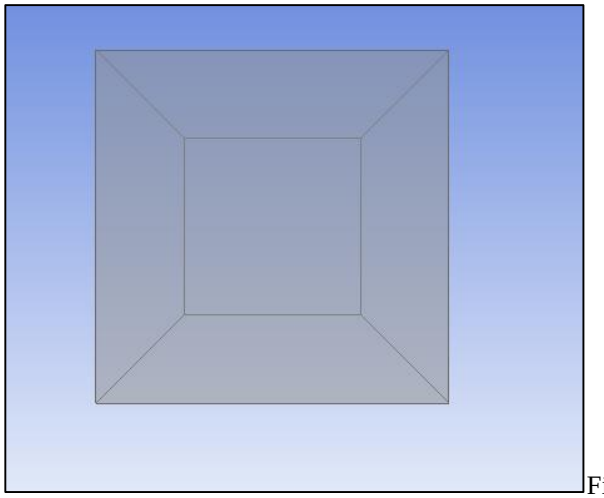

Figure 2: Imported CAD design of chimney

The chimney design is imported in .iges file format as shown in figure 2 above. The model is checked for imperfections on surface and hard edges.

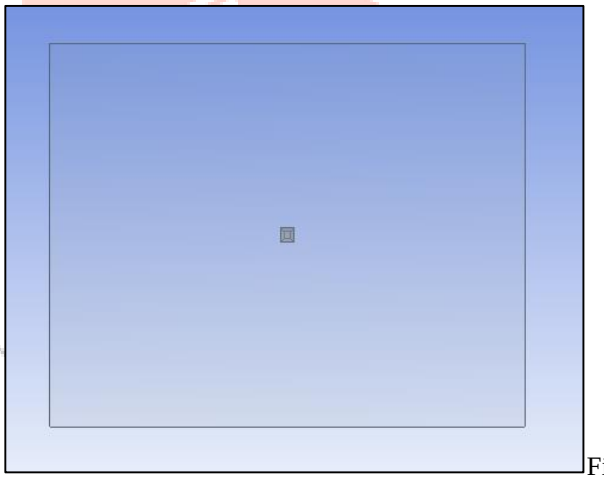

Figure 3: Enclosure modeled surrounding chimney

The enclosure is modeled to limit the volume for analysis. The limited volume for computation would limit the space and mesh density. The enclosure model is shown in figure 3 and figure 4.

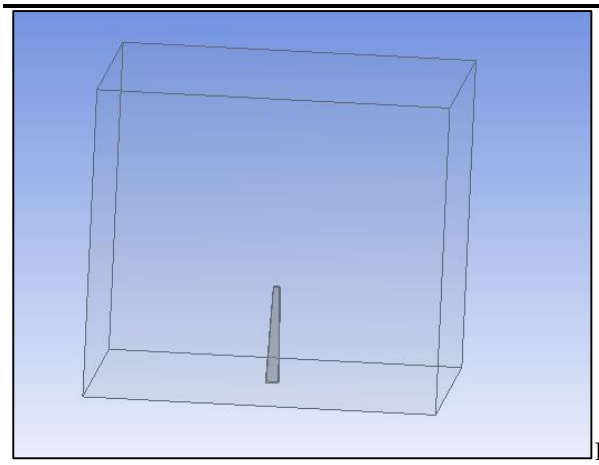

Figure 3: Side view of enclosure modeled surrounding chimney

The next step of simulation involves defining boundary conditions for computational domain. The fluid set for space is air and the properties of air is taken at 25^0C. The initial pressure is defined as 1 atm and inlet/outlet boundary conditions are defined. For air inlet boundary condition, the air inlet velocity is defined and for outlet boundary condition the gauge pressure is set to null.

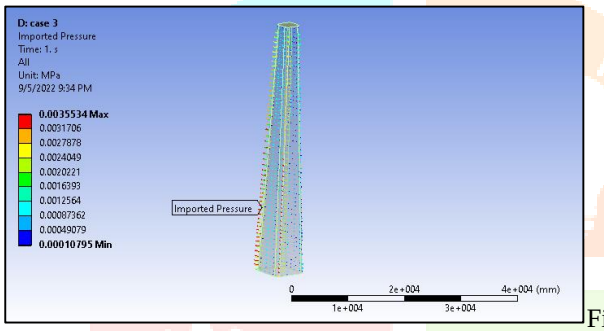

Figure 4: Imported pressure for FSI studies

The fluid structure interaction studies are conducted on chimney by mapping pressure value on side surface. The mapped pressure value on side surface is shown in figure 4.

4. RESULTS AND DISCUSSION

The wind load and FSI studies are conducted on chimney to determine pressure distribution and velocity distribution plot. The induced pressure on chimney structure is shown in figure 5. The plot shows higher pressure on mid-section of chimney structure wherein the magnitude is more than 659.1Pa.

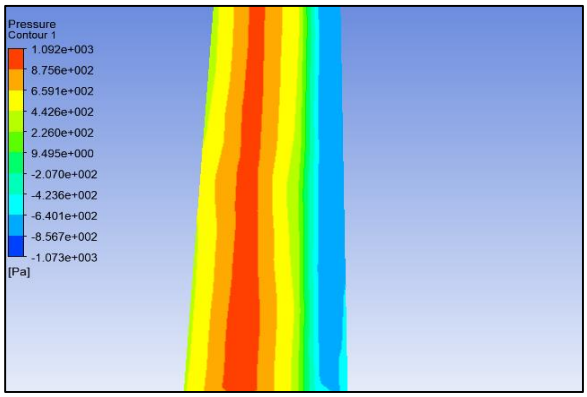

Figure 5: Induced pressure on chimney structure

The pressure is lower on other side of chimney wherein the magnitude is 9.4Pa. The velocity distribution plot is shown in figure 6 below. The distribution shows higher magnitude of 38.31m/s on windward side of chimney.

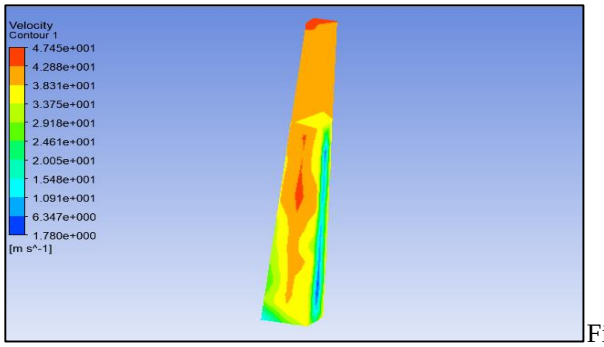

Figure 6: Velocity plot on chimney structure

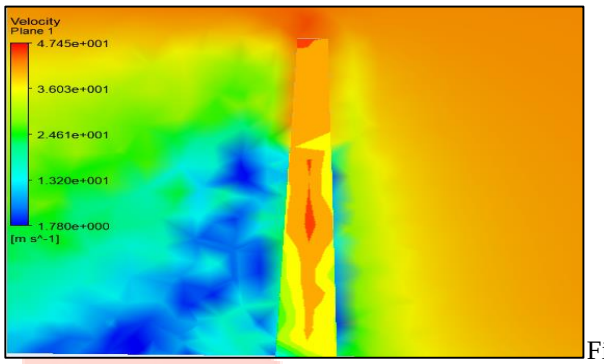

Figure 7: Velocity field across chimney structure

The velocity field is plotted across lateral plane as shown in figure 7 above. The plot shows velocity lesser than 13.1m/s at the rear end of chimney. The pressure value of 36.03m/s is observed on windward side of the chimney.

5. CONCLUSION

The wind load has significant effect on pressure distribution and velocity field across chimney. The lateral deformation and induced pressure is evaluated for different chimneys. The edge treatment on tapered chimney has significant effect on magnitude of induced pressure and drag force on chimney. By changing the sharp edged chimney to filleted edge chimney the drag force and shear stress reduced significantly.

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