International Journal of Innovative Research in Engineering and Management (IJIREM)
ISSN (Online): 2350-0557, Volume-10, Issue-4, August, 2023
https://doi.org/10.55524/ijirem.2023.10.4.18
Article ID IJIR2447, Pages 148-151
www.ijirem.org

# Structural Stability Analysis of Multistory Building Structure under Wind Load Conditions

**Rahul Sabharwal[1], Er. Susheel Kumar[2], Er. Madhu Bala[3], Dr. Sandeep Kumar Chandel[4], and Er. Harish Sharma[5]**

[1] M.Tech Scholar, Department of Civil Engineering, SBBS University, Khiala, Jalandhar, Punjab, India
[2, 3, 4, 5] Assistant Professor, Department of Civil Engineering, SBBS University, Khiala, Jalandhar, Punjab, India

**ABSTRACT-** In the current research the effect of wind load on structural stability of building structure is evaluate using techniques of Computational Fluid Dynamics. The CFD analysis on building is conducted using ANSYS simulation package. The FSI simulations considered the complex interactions between the structural components and the surrounding fluid flow, providing valuable insights into the structural response and its vulnerability to external loading conditions. Through a combination of computational tools and numerical methods, the study was able to accurately predict the structural response, including deformations, stresses, and critical failure points.

**KEYWORDS-** CFD, Building load, Wind Load

## I. INTRODUCTION

Buildings experience horizontal pressures due to the atmospheric pressure in their surroundings. The external structures and exposed sections of buildings are affected by both horizontal and vertical wind forces. The bending of these parts provides immediate resistance against the pressure exerted on the exposed surfaces of the walls and columns. The infill walls serve as vertical plates, supported by floor timbers at both the top and bottom. This arrangement enables the infill walls to effectively transfer stresses at the slab level. The parapet wall of the terrace has been specifically designed to utilise a cantilever structure. This design feature serves the purpose of effectively distributing wind stresses onto the surface slab. For the purpose of simplicity, it is assumed that both higher and lower levels possess the ability to withstand the wind pressures exerted on the exposed surfaces of a specific story.

## II. LITERATURE REVIEW

Kijewski and Kareem [1] extensively examined the structural response, employing various wind code regulations and wind turbine measurements. The Equivalent Static Wind Loads (ESWL) method is employed in the design and construction of structures to account for wind loads. The wind design principles may not provide a precise representation of the distribution of wind loads on buildings that are up to 200 metres in height. According to established guidelines, tall buildings that are susceptible to wind and possess unconventional designs should rely on pressure measurements obtained from a wind tunnel (WT).

Whalen et al. (2000) [2]. The Database-Assisted Design (DAD) method was initially developed specifically for the calculation of wind loads in low-rise buildings. The National Institute of Standards and Technology (NIST) has made significant advancements in the construction industry, enabling the development of tall and flexible buildings. The utilisation of a significant quantity of concurrent pressure time-histories derived from wind tunnel data facilitates the execution of dynamic reaction analysis and the development of structural designs. The impact of wind directionality can be effectively managed through a transparent analytical process, eliminating the necessity for peak combination criteria for loads or reaction parameters.

Iancovici (2019) [3] The time-domain mathematical method for analysing the linear-elastic behaviour of tall buildings is extensively described in the 2019 report by [3]. In order to facilitate the achievement of objectives in the field of structural engineering, a comprehensive plan for conducting nonlinear dynamic analysis is currently being developed. The software possesses the capability to effectively model a diverse array of damage caused by various factors, which are typically challenging to detect using existing mathematical methodologies. The amount of damage at each part, element, story, and general structure level was recorded and tracked using a significant number of nonlinear dynamic studies. The nonlinear time-domain analysis method employed the Incremental Dynamic Analysis (IDA) approach tool to provide straightforward predictions of structural vulnerabilities and loss assessment [4].

Stathopoulos and Luchian et. al. [5]In cases where the roof slope at the soffit is below 10 degrees, it is common practice to employ Cp numbers for wind protection. The investigation focused on the impact of wind on roof overhangs with slopes exceeding 10 degrees. The study utilized the Building Aerodynamics laboratory at Concordia University. The outer layer is equipped with a wind tunnel. A scale of 1:400 was utilized for mathematical calculations. During each review process, the assessment of open land exposure was considered. A power-law exponent of 0.15 was employed to illustrate the speed curve. At the height of the gradient, the wind tunnel recorded a maximum wind speed of 13 metres per second. The study conducted revealed that the established standards for this particular roof type in Canada and the United States were deemed excessively elevated.

Wiik and Hansen [6] In order to investigate the phenomena, both tests and computer simulations were used. a combination of the two was used. Experiments were conducted on the University of Hertfordshire campus in the United Kingdom, which is home to a commercial wind tunnel. The wind tunnel was used to study the effects of different wind speeds. The length of this wind tunnel is 4.7 meters, and it may be utilized for many types of testing. The boundary layer of the atmosphere was simulated by placing a barrier at the entrance of the wind tunnel and boards with varying degrees of roughness on the floor of the wind tunnel. This created an environment that was similar to the real atmosphere's boundary layer. Both variants included an overhang, the difference between them being that one featured a very modest one (0.3 meters), while the other featured a huge one (3.4 meters).

## III. OBJECTIVES

In the current research the effect of wind load on structural stability of building structure is evaluate using techniques of Computational Fluid Dynamics. The CFD analysis on building is conducted using ANSYS simulation package.

## IV. METHODOLOGY

The structural stability of building structure is conducted using FSI technique which determines the effect of wind load on lateral deformation and inducted stress on building. The FSI studies involves CFD analysis and structural analysis. The CFD analysis is based on Navier Stokes equation. The Navier-Stokes equations are a set of fundamental partial differential equations that describe the motion of fluids, such as liquids and gases.

Conservation of Mass (Continuity equation):

$$\nabla \cdot v = 0$$

This equation states that the divergence of the velocity field (v) is zero, indicating that the fluid is incompressible, and mass is considered.

Conservation of Momentum (Navier-Stokes equation):

$$\rho(\partial v/\partial t + v \cdot \nabla v) = -\nabla P + \mu\nabla^2 v + F$$

Here: “ρ is the density of the fluid, v is the velocity vector of the fluid, t is time, ∇ represents the gradient operator (del), P is the pressure, μ is the dynamic viscosity of the fluid, and F represents any external body forces (such as gravity) acting on the fluid”[7].

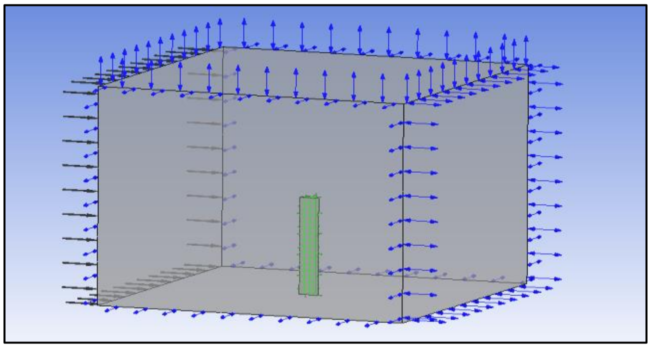

Figure 1: Enclosure Surrounding Building

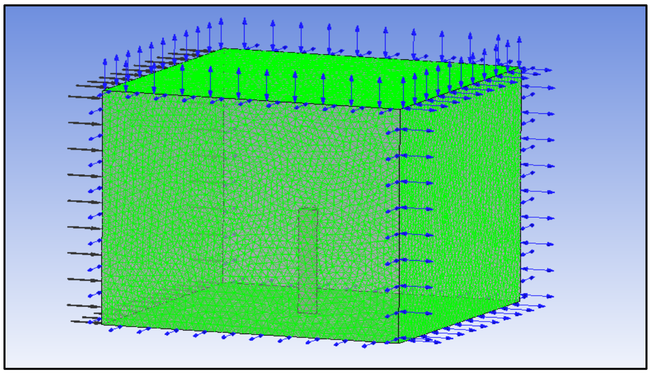

Figure 2: Domain Definition

The analysis process involves modelling followed by importing design in ANSYS design modeller. An enclosure surrounding building structure is developed which defines our computational domain as shown in figure 1. The domain type is defined as fluid with air as material as shown in figure 2.

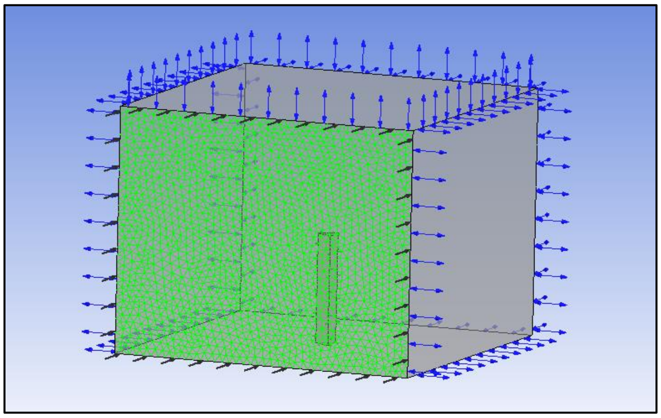

Figure 3: Air Inlet Boundary Condition

The boundary conditions are defined for the enclosure which is our computational volume. The boundary condition includes inlet boundary condition, opening boundary condition as shown in figure 3. The air inlet boundary condition includes velocity definition and turbulence boundary condition.

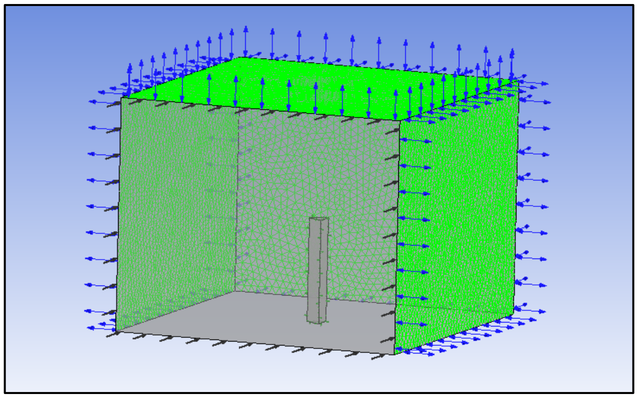

Figure 4: Air Opening Boundary Condition

The opening type boundary condition is defined for computational volume which includes definition relative pressure at 0 Pa as shown in figure 4. After defining opening boundary condition, the solver settings and convergence settings are defined. The solver settings include defining “upwind interpolation scheme” and RMS residual target values of .0001.

## V. RESULTS AND DISCUSSION

From the CFD simulation, the fluid flow parameters are evaluated for building structure. These parameters include induced pressure, velocity profile and eddy dissipation.

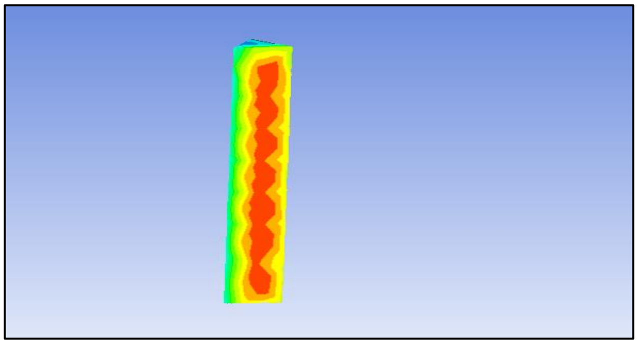

Figure 5: Pressure Plot on Building Structure

With the incoming air flow, the pressure is induced on the building structure. The pressure is higher at the central zone of the building. The magnitude of this pressure is more than 808.2Pa. The pressure is lower on the edges of the building wherein the pressure is 25.33 Pa (negative). The negative pressure represents below atmospheric pressure.

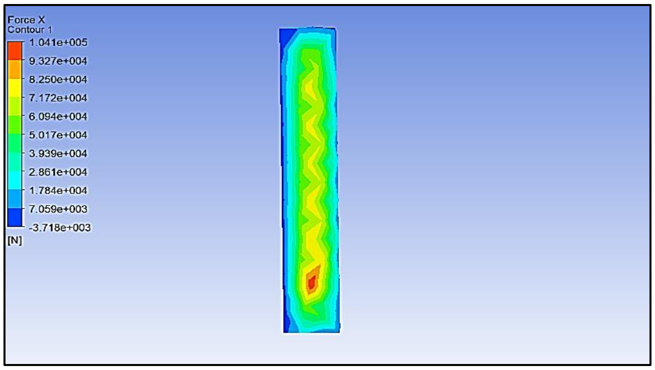

Figure 6: Drag Force Induced on Building Structure

The induced drag force is evaluated for the building structure as shown in figure 6 above. The drag force is higher at the base of the building and higher on the windward side of the building wherein magnitude of drag force is more than 9327N.

## VI. CONCLUSION

In this comprehensive study, a series of Fluid-Structure Interaction (FSI) analyses were conducted to investigate the behavior and performance of a building structure. The FSI simulations considered the complex interactions between the structural components and the surrounding fluid flow, providing valuable insights into the structural response and its vulnerability to external loading conditions. Through a combination of computational tools and numerical methods, the study was able to accurately predict the structural response, including deformations, stresses, and critical failure points. The results highlighted the significance of considering FSI effects in the design and assessment of building structures, as they can significantly influence the overall performance and safety. Moreover, the study's findings contribute to the advancement of FSI analysis techniques and provide a solid foundation for further research in this critical area of engineering and fluid dynamics. Ultimately, this study serves as a valuable reference for engineers, architects, and researchers involved in building design and risk assessment, paving the way for more robust and resilient structures in the face of fluid-induced loads.

## CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

## REFERENCES

[1] D. Kwon, A. Kareem, Comparative study of major international wind codes and standards for wind effects on tall buildings, Eng. Struct. 51 (2013) 23–35.

[2] T.M. Whalen, V. Shah, J.-S. Jang, A Pilot Project for Computer-Based Design of Low-Rise Buildings for Wind Loads – the WiLDE-LRS Users’s Manual, NIST GCR00-802, National Institute of Standards and Technology (NIST), Gaithersburg, Maryland, 200

[3] M. Iancovici, Integrated platform for the analysis and design

of tall buildings for wind loads, Math. Model Civ. Eng. 4 (2019) 1- 17-2019, https://doi.org/ 10.2478/mmce-2019-0009.

[4] D. Vamvatsikos, C.A. Cornell, Incremental dynamic analysis, Earthq. Eng. Struct. Dynam. 31 (3) (2002) 491–514.

[5] Stathopoulos T, Luchian H. Wind induced forces on eaves of low building. J Wind Eng Ind Aerodyn 1994;52:249–61.

[6] Wiik T, Hansen EWM. The assessment of wind loads on roof overhang of low-rise Buildings. J Wind Eng Ind Aerodyn 1997;67&68:687–96.