

Abstract

Designing a super high-rise building requires careful consideration of wind loads. The across wind load plays a critical role for super high-rise buildings. The magnitude of the across wind load is contingent upon various parameters, including the building's geometrical characteristics, structural properties, and the prevailing wind conditions. However, the precise impact of these parameters on across wind load is still an area of active research. Understanding how these parameters impact the across wind load is of paramount importance as it enables accurate estimation and facilitates the creation of more realistic building designs. Therefore, this study focuses on investigating the effects of geometrical, structural, and wind parameters on across wind loading specifically in the context of super high-rise buildings. Geometrical parameters considered are plan aspect ratio and height aspect ratio. The present study looks into the relative variation of along and across wind Equivalent Static Wind Load (ESWL), for varying plan aspect ratios (0.5 to 2) and height aspect ratios (4 to 9), keeping the height fixed at 300m for all the cases. The plot of design forces *versus* the height of the building shows that the across-wind forces exceed the along-wind forces at heights above 175 m for buildings with plan aspect ratios of 1 to 2. The magnitude of the across-wind forces is higher than corresponding along-wind forces by about 18% to 9% at the tip of the buildings for plan aspect ratios of 1 and 2, respectively. However, for increasing height aspect ratio, the across-wind load increases exponentially. Here, across-wind forces at the tip of the buildings have increased by about 18% to 277% over the corresponding value of maximum along-wind force for the height aspect ratios of 6 to 9. The findings of our study indicate that square-plan buildings exhibit a higher susceptibility to crosswind loads when compared to their rectangular-plan counterparts.

To investigate and quantify the impact of wind and structural parameters on the across-wind load of super high-rise buildings the same have been varied within a practical range. Out of structural parameters, the Natural frequency of the structure (f) and structural damping ratio (ζ_s) are selected due to their key role in the calculation of across wind load. Four parameters (Exponent of mean velocity profile (α), turbulence intensity (I_H), peak factor for resonant response (g_R), and the background peak factor (g_B)) are selected out of wind parameters because of their significance in defining the characteristics of wind approaching the structure. A hypothetical 300 m super high-rise building with a square cross-section, assumed to be located in urban terrain, is adopted for the analysis. In order to comprehend the range of parameters, several international codes and research works are used for each parameter evaluation. For suitability, we have referred to the codes that explicitly provided the corresponding parameters. The findings notably underscore the significance of the natural frequency of the structure, which dictates the responsiveness of the building to varying wind conditions. Moreover, the exponent of mean velocity profile (α) emerges as the most dominant parameter impacting cross-wind loads, highlighting its pivotal role in wind-induced effects on high-rise structures. Furthermore, the investigation highlights the relevance of the

structural damping ratio in the mitigation of cross-wind loads. Higher damping ratios yield notable reductions in the across-wind ESWL, offering a promising avenue for improving building resilience. Noteworthy is the minimal impact of turbulence intensity on the across-wind load, signifying its relative insignificance in comparison to other influential parameters. Additionally, the study draws attention to the pronounced influence of peak factors, particularly peak factor for resonant response, on the magnitude of across-wind ESWL. This finding emphasizes the necessity of precise consideration of such factors in load calculations for accurate and robust high-rise building designs.

Aerodynamic adaptations, such as corner modifications, were implemented on a square-shaped model through the utilization of Computational Fluid Dynamics (CFD) simulations executed with the ANSYS Fluent software. The modifications made to the corners include chamfering, rounding, recessing, and double recessing. In each of these corner modification techniques, an additional four models are created. In these models, the length of each side of the square is reduced by 5%, 10%, 15%, and 20%. Thus a total of sixteen different models with corner modifications were analyzed in this study. Through CFD analysis and subsequent comparisons with the original square model, a comprehensive picture has emerged. Notably, These findings collectively illuminate the potential of corner modifications as efficient strategies for mitigating wind loads on square-plan tall buildings. It is observed from the results that, for a 5% corner reduction, chamfering emerges as the optimal approach, resulting in a substantial 25.97% reduction in overall wind load and a noteworthy 13.41% reduction in across-wind load. In cases with a 10% reduction, rounded and recessed corners excel, attaining reductions of 33.85% and 32.71% in overall wind load, respectively. Meanwhile, chamfered and rounded corners demonstrate commendable performance in decreasing across-wind load, with reductions of 18.60% and 18.34%, respectively. Furthermore, for a 15% reduction in corners, rounded and chamfered corners prove most effective in minimizing overall wind load with reductions of 38.20% and 35.50% respectively. Recessed corners, on the other hand, excel in reducing across-wind load, achieving a substantial 23.03% reduction. Lastly, when corners are reduced by 20%, rounded corners display exceptional efficacy in diminishing overall wind load by 40.73, while recessed corners effectively curtail the across-wind load by 26.92%.

High-rise tubular buildings experience torsional wind load due to windy environment. The effects of torsional wind loading patterns on framed-tubed buildings are studied. Six load cases are taken from American and Canadian codes to analyse the wind load effects on a 40-storeyed tubular building. The results indicate that axial force distribution changes significantly with changes in the loading patterns of the building. A difference in axial force distribution is observed between torsional and non-torsional load cases. Axial force in columns in the case of uniform loading is more significant as compared to partial loading cases. Due to loading on half of the face, axial force distribution becomes unsymmetrical, and a minimum axial force in corner columns is observed. Also, notable differences can be seen in the axial force distribution of load

cases having both direction loadings compared to single-direction loadings. Axial force distributions in cases of both face loading are unsymmetrical for the central column.

Keywords: Across wind Equivalent Static Wind Loads (ESWL); CFD simulation, Code provisions, Computational fluid dynamics (CFD), CFD simulation, Corner modification, Framed-tube buildings, Force coefficient, Height aspect ratio, High rise building, , Plan aspect ratio, Pressure coefficient, Wind loading, Wind and Structural parameters, Torsional Wind load.

