THE IMPACTS OF NATURALLY VENTILATED DOUBLE-SKIN FACADE CONFIGURATIONS ON ENERGY PERFORMANCE FOR SUPER-TALL OFFICE BUILDINGS

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Abstract

Super-tall office buildings (i.e., buildings above 1,000 feet) are on the rise worldwide, and their energy efficiency has become an important concern, given the current environmental challenges. Natural ventilation has proven to be an effective passive strategy in saving energy in many types of buildings, yet it is still a challenge to apply the strategy in super-tall office buildings due to unique unfavorable outdoor conditions, such as strong winds that are experienced at high levels. Double-skin facade (DSF) systems can provide an opportunity to regulate the wind speed and pressure for the indoor spaces. The current research and practice face several barriers: 1) lack of information on airflow behavior at upper floors within a super-tall office building with a DSF and in different locations, 2) limitations of modeling naturally ventilated buildings with DSFs, and 3) the difficulty of assessing building performance in early design stage.

This study will investigate the impact of naturally ventilated double-skin facade (NVDSF) configurations on indoor airflow and energy performance of super-tall office buildings in eight major cities with different climatic conditions defined in the ASHRAE standard. Specifically, this project will optimize the configuration (e.g., building segmentation, opening size and location, shading device location, and cavity depth) based on desirable airflow rate, indoor air velocity, and air change rate under climatic conditions in different cities. CFD (computational fluid dynamics) simulation, wind tunnel test, and building energy simulation (BES) will be conducted: 1) to determine the wind pressure coefficient on air inlets, outlets, and operable windows and airflow rate; 2) to analyze the detailed information on the airflow, such as temperature, velocity, pressure, and direction in three dimensions both inside cavities and indoor spaces; 3) to validate the CFD data by comparing with the wind tunnel data; and 4) to assess the energy performance in BES affected by the input data from CFD.

The optimum configuration with quantified natural ventilation and energy performance will lead to a better understanding of how NVDSF should be designed for each climatic condition to improve performance. The integrated framework will help bridge the gap between research and practice and provide a useful evaluation tool for the early design stage in which iterative and rapid design decisions are made.