HARVARD
CENTER FOR GREEN
BUILDINGS AND CITIES

Investigating the boundary condition of neighborhood scale CFD simulation for natural ventilation design

PROBLEM

Natural ventilation is one of the most important design options for green buildings as it can reduce energy use and improve thermal comfort. Computational Fluid Dynamics (CFD) simulations have been increasingly used to contribute to natural ventilation design in urban neighborhoods. However, the accuracy of such simulations relies largely on how the CFD domain is chosen.
Within the CFD domain, the central region is defined as the area where buildings are explicitly modeled to adequately capture the turbulent flow field around the targeted building. In general, if the modeled central region is larger, the CFD domain needs to be larger and therefore, more computational time is required. Meanwhile, underrepresenting the surroundings leads to incorrect prediction of the pressure distribution at the targeted building. For example, the pressure distribution of an isolated building will be considerably different from that of a buildings surrounded by a group of buildings. Often, early design efforts justify the selection of the central region that adequately captures the effect of surroundings, yet maintains a reasonable computational cost.

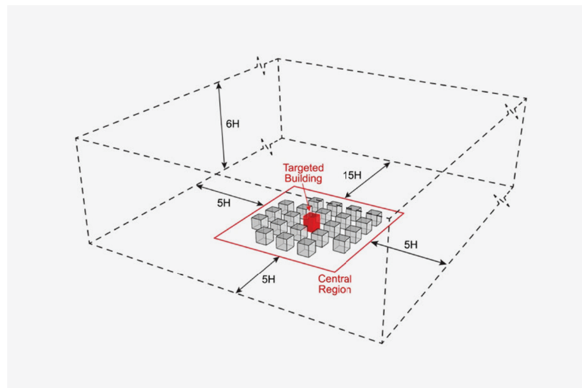

Figure 1. Graphic illustration of the CFD domain and central region. Hmax is the height of tallest building in the central region

GUIDING QUESTIONS

This research inquires into the relationships between boundary conditions and simulation accuracy by asking:

How are the boundary conditions of neighborhood scale CFD simulation selected?

How does the surrounding environment affect the pressure distribution on building facades?

PROJECT DESCRIPTION

In this study, we derived the minimum sizes of the central region under various urban scenarios by quantifying the impact of a number of urban parameters on building pressure coefficients (Cp) such as surrounding obstacles, street canyon aspect ratio, and wind condition. This study demonstrates the need for assessing the sensitivity of selected central regions in CFD simulation to reduce modeling errors and computing expense.

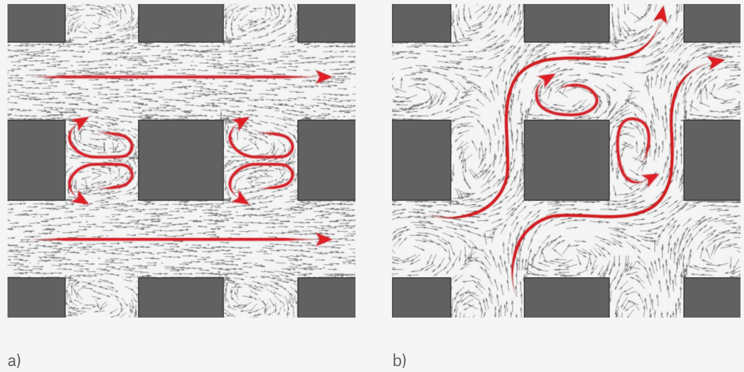

Figure 2. Vector plot of the flow field under a) normal and b) oblique (45°) oncoming wind directions

IMPACT

The objective of this study is to provide recommended guidelines to CFD practitioners for the design of naturally ventilated buildings at the neighborhood scale.

Avoid unintended modeling error, and reduce the unnecessary computational cost in natural ventilation design.

Promote the use of computational tools for natural ventilation design.

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CONTACT

20 Sumner Road
Cambridge, MA 02138
tel. 617-495-8807
fax. 617-496-4408
email: cgbc@gsd.harvard.edu