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Discussion on the Applicability of Urban Morphology Index System for Block Natural Ventilation Research

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Abstract

Studies are still required to understand the relationship between the wind situation and the block form. Yet prior to this kind of study, selecting an urban spatial morphology indicator system that could not only describe the change of block form precisely but also have a good relativity with the changing mean wind speed caused by the former, which is a reasonable breakthrough point for exploring the relationship between the block form and the wind environment, is necessary. Consequently, this paper intends to find a series of proper urban spatial morphology indicator systems, and then and to discuss the applicability of these systems for block ventilation research. Through extensive literature survey, two groups of urban spatial morphology indicator systems are selected. One of the systems consists of rugosity, porosity, and sinuosity, which is proposed by Luc Adolphe. Another system is obstruction ratio, which is more popular in China, and appears in urban residential thermal environment design standards. The method of CFD is introduced to quantitatively analyze the link between the changing wind condition and the changing block form. Finally, we establish the relationship between urban spatial morphology indicator systems and the wind condition to select the proper indicator system for block ventilation research.

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Keywords: natural ventilation; urban morphology; index system

1. Introduction

Artificialized city underlying surface and disorganized building plans become more popular. This phenomenon has negative impact upon natural ventilation that could ease the urban heat island effect. Yet prior to this kind of study, selecting an urban spatial morphology indicator system that could not only describe the change of block form precisely but also have a good relativity with the changing mean wind speed caused by the former, which is a reasonable breakthrough point for exploring the relationship between the block form and the wind environment, is necessary. In

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the present study, there are two authoritative indicator systems. One system consists of rugosity, porosity, sinuosity, which is proposed by Luc Adolphe [1,2]. Another one is obstruction ratio, which is more popular in China, appears in urban residential thermal environment design standards. This research compares these two indicator systems comprehensively by means of correlation analysis, and then select one which is more suitable for block natural ventilation research.

2. Methodology

Firstly, setting different kinds of idealized block form, the numerical statement of its urban morphology index system is established. And next, the method of CFD is introduced to quantitatively analyze the link between the changing wind condition and the changing block form. Finally, we establish the relationship between urban spatial morphology indicator systems and the wind condition to select the proper indicator system for block ventilation research, which could not only describe the change of block form precisely but also have a good relativity with the changing mean wind speed caused by the former, which is also a reasonable breakthrough point for exploring the relationship between the block form and the wind environment.

2.1. Urban morphology index system

Urban morphology index system is a tool to quantitatively describe the urban form. This paper compares two indicator systems, i.e. Luc Adolphe's system and urban residential thermal environment design standards' system for the applicability of block natural ventilation research.

2.1.1. Luc Adolphe' s system

Luc Adolphe proposes using rugosity, porosity and sinuosity as a set of evaluation criteria for urban morphology description in the articles [1] and [2] in which he established a simple geometric city model with these urban morphology system.

2.1.1.1. Definition of rugosity and calculation methods

Rugosity could be divided into absolute rugosity and relative rugosity. Absolute rugosity represents the average height of urban canopy. Relative rugosity describes the variance of average height of urban canopy (including construction and non-construction elements) from the given direction, and is determined by the weight of every related elements' width on the canopy cross section.

Absolute rugosity and relative rugosity can be calculated respectively as follows:

$$H_m = \frac{\sum_{built} A_i h_i}{\sum_{built} Ai + \sum_{non\ built} A_j} \quad (1)$$

H_m - absolute rugosity
A_i - area of building element i
h_i - height of building element i
A_j - area of non-building element j

$$R_\alpha = \frac{\left[\sum_i (h_i - h_\alpha)^2 {l_i}^2\right]^{1/2}}{\sum_i l_i} \quad (2)$$

R_α - absolute rugosity
h_α - average height of urban canopy from the direction of α
h_i - height of urban canopy (including construction and non-construction elements)
l_i - average height of urban canopy from the direction of α
$\sum l_i$ - equivalent diameter of urban canopy

2.1.1.2. Definition of Porosity and calculation methods

Porosity refers to a ratio between the open volume and the total volume of a certain area. Undoubtedly, in the research of block ventilation, the open volume means the volume of non-buildings elements, and the total volume