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Improving building facade design using integrated simulation of daylighting, thermal performance and natural ventilation

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Abstract

The opening of building facade has a strong influence on energy consumption. However, making full use of solar energy and natural wind to reduce energy consumption is a challenge for architects. The aim of this study is to investigate the influence of the facade design on energy consumption from an operable aspect. The evaluation comes from an integrated approach combining daylighting, thermal performance and natural ventilation. The study is based on computer simulation technique utilizing simulation tools EnergyPlus and Fluent. To facilitate the use of EnergyPlus, a simple graphic user interface has been developed by Matlab. The interface can set the parameters of EnergyPlus and process the wind pressure coefficients calculated by Fluent. With this interface, three type facade configurations with different areas or position changes have been modelled. The results show that opening area, compared with opening positions, exerts a greater influence on energy consumption. The opening position changes have a positive influence; however, this influence is small: at around 2%.

Keywords

building facade design,
daylighting,
thermal performance,
natural ventilation,
energy simulation

Article History

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1 Introduction

The opening design on building facades has a great influence on daylighting, solar heat gain and natural ventilation, which are closely related to the lighting and air conditioning energy consumption. However, in designing building facades, architects usually pay more attention to the aesthetic aspects, while neglecting the influence of opening forms on energy consumption. Since the oil crisis in 1970s, greater social focus has been placed on energy and environmental problems. Architects have also considered how to effectively use solar energy and natural wind to reduce energy consumption, thus the relationship between the opening forms of building facades and energy consumption requires intensive research.

Based on computer simulation technology, researchers have already analyzed the relationship between design factors (window size, glass material) and energy consumption (Zain-Ahmed et al. 2002; Li et al. 2005, Ravikumar and Prakash 2011), and some simple experiential models have been established to quickly predict the energy consumption (Catalina et al. 2008; Jaffal et al. 2009, Rijal et al.2011). However, in these studies, there is not enough attention paid to facade design from an operable aspect. Moreover, researchers often use abstract design control parameters, such as the ratio of the volume to the exterior wall area, window-to-wall ratio, or heat transfer coefficients, etc. In practical construction activities, however, those abstract parameters are of little use to detailed design. Meanwhile, simple facade opening forms (e.g., a simple middle rectangular window) cannot meet designers' requirements on variable building facade designs. Therefore, the principle that the change of the opening shape and position of building facade affects energy consumption needs to be analyzed more intensively, with possible facade design strategies explored. The facade opening in the building design domain contains abundant content, like the fixed window which can only get daylight, operable window which can get daylight and natural ventilation, ventilation cave which can only get natural ventilation. In this research, the facade opening is window opening, including the fixed and operable window.

To accurately quantify the influence of opening forms of building facades on the integrated lighting, heating and cooling energy consumption, computer simulation techniques

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