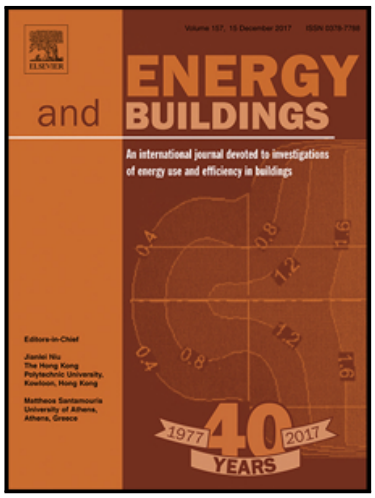

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Performance, Prediction, Optimization, and User Behavior of Night Ventilation

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Abstract

Previous studies have demonstrated a potential reduction in cooling load and improvement in comfort from the implementation of night ventilation. This paper describes the performance, in terms of indoor environmental conditions, of three buildings from both the U.S. and India that use night ventilation as their primary cooling method. The research methods used the following approach: 1) Assess the cooling strategy in relation to the adaptive comfort model; 2) Develop a hybrid model, using both first principle equations and the collected data, to predict the instantaneous air and mass temperatures within each building and use the model to assess performance of the cooling strategy; 3) Determine an optimized ventilation control strategy for each building to minimize energy and maintain comfortable temperatures. 4) Develop a statistical model using collected data to predict the window opening pattern for occupants of a building using natural night ventilation. The study yielded the following results: 1) The buildings in the mild climate are successfully keeping the indoor temperature low, but also tend to be overcooling; 2) The night ventilation strategy has very little impact on indoor conditions of the buildings in the mild climate; 3) The impact of night ventilation is less significant when there is low internal loads and heavy mass; 4) The building in the hot and humid climate is keeping the indoor temperature within the comfort bounds for 88% of the year; 5) The night ventilation strategy has advantageous impact on indoor conditons of the building in the hot and humid climate, but not enough to cool the space on its own; 6) Model predictive control has the potential to further improve the performance of night ventilation. 7) Window opening behavior for the building using natural night ventilation is most heavily dependent on indoor air temperature and mass temperature.

Keywords: Night ventilation; Passive cooling; Model predictive control; User behavior

1. Introduction

1.1 Background

Many developing countries currently undergoing economic growth and urbanization are also experiencing increased energy consumption due to the following of western design practices, such as mechanical cooling. The prevalence of air conditioning in both the developed and developing world has also had the consequence of increased comfort expectations. As the developing world continues to urbanize and their energy regulations continue to get more stringent, it will become even more necessary to find low-energy solutions to cooling before the use of energy-intensive mechanical cooling becomes the norm all over the world. One passive design strategy that has been of interest to researchers for the last 30 years or so is night ventilation. Night ventilation is a passive or semi-passive cooling technique that utilizes the outdoor diurnal temperature swing and the building's thermal mass to pre-cool a building through increased outdoor airflow at night. At night, when the outdoor air temperature is lower than during the daytime, the increased airflow cools down the mass, allowing it to release the heat that was stored during the previous day. During the following day, the cooler mass serves as a heat sink to absorb

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