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ScienceDirect
Energy and Buildings xxx (2007) xxx–xxx
ENERGY and BUILDINGS
www.elsevier.com/locate/enbuild

Using results from field surveys to predict the effect of open windows on thermal comfort and energy use in buildings

H.B. Rijal [a,*], P. Tuohy [b], M.A. Humphreys [a], J.F. Nicol [a], A. Samuel [b], J. Clarke [b]

[a] *Oxford Institute for Sustainable Development, Oxford Brookes University, Oxford OX3 0BP, UK*
[b] *Energy Systems Research Unit, University of Strathclyde, Glasgow G1 1XJ, UK*

Abstract

Windows are one of the major means by which building occupants control the indoor environment. This research uses results from field surveys to formulate a method for simulation of office buildings to include the effects of window opening behaviour on comfort and energy use. The paper focuses on: (1) what is general window opening behaviour? (2) how can we frame an ''adaptive algorithm'' to predict whether windows are open? (3) how can the algorithm be used within a simulation to allow the effects of window opening on comfort and energy use to be quantified? We have found that: (1) the proportion of windows open depends on indoor and outdoor conditions, (2) logistic regression analysis can be used to formulate an adaptive algorithm to predict the likelihood that windows are open, (3) the algorithm when embedded in simulation software provides insights not available using more usual simulation methods and allows the quantification of the effect of building design on window opening behaviour, occupant comfort and building energy use.

Keywords: Thermal comfort; Adaptation; Behaviour; Building controls; Window; Simulation; ESP-r

1. Introduction

The principle which underlies the adaptive approach to human thermal comfort indicates that ''If a change occurs such as to produce discomfort, people react in ways which tend to restore their comfort'' [1]. This principle implies that if people are uncomfortable they will take actions – including the use of building controls – which they think will improve their comfort. If the action is successful they will reduce or avoid discomfort.

In temperate climates the window is possibly the most common thermal control device in any building. If people feel hot and want to feel cooler indoors, they often open the window to cool the indoor environment: if they are too cool and the window is open they will close it. This window opening behaviour is not only useful for energy saving in summer, by reducing the need for mechanical cooling or heating, but also provides for a beneficial interaction between the indoor and the outdoor environments [2]. The results of this project contribute to the current debate over how best to use natural ventilation to achieve sustainable building design.

The use of simulation tools in building design and building energy performance certification is becoming standard practice. The impact of occupant behaviour on the operational energy use of buildings is potentially very large but it is not well represented in simulation models. The literature shows that a variety of assumptions have been made by modellers about the window-opening behaviour of occupants:

(1) A schedule of windows open is assumed, based on occupancy, with or without evidence from the field [3–8].
(2) Window opening is assumed to be controlled by temperatures, humidity, wind, rain, based on assumptions about behaviour [9–14]. Again evidence from the field is often absent.
(3) Windows are controlled to produce a given air flow rate or air exchange rate [15–17], may be more related to indoor air quality or minimum ventilation rather than thermal comfort. This approach assumes the occupant will utilize the window openings to achieve the design ventilation rates.

Such window opening assumptions do not necessarily express the occupants' actual behaviour. Thus it is necessary to use an algorithm for window opening based on field investigations in real offices. The main purpose of the research

* Corresponding author. Tel.: +44 1865 483427; fax: +44 1865 483298.
E-mail address: hrijal@brookes.ac.uk (H.B. Rijal).

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doi:10.1016/j.enbuild.2007.02.003