Building and Environment 46 (2011) 824–834

Contents lists available at ScienceDirect

Building and Environment

journal homepage: www.elsevier.com/locate/buildenv

Building envelope regulations on thermal comfort in glass facade buildings and energy-saving potential for PMV-based comfort control

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A R T I C L E I N F O

Article history:
Received 28 July 2010
Received in revised form
22 September 2010
Accepted 9 October 2010

Keywords:
Indoor thermal comfort
Cooling energy consumption
Building envelope regulation
PMV-based comfort control

A B S T R A C T

This paper presents an investigation of the effect of building envelope regulation on thermal comfort and on the energy-saving potential for PMV-based comfort control in glass facade buildings. Occurrences and severity of overheating, based on the PMV-PPD model contained in ISO 7730, were used for the thermal comfort assessment. Parametric study simulations for an actual building with a large glass facade were carried out to predict the changes in thermal comfort levels in a space due to different glazing types, depths of overhang and glazing areas, which are the key parameters of the building envelope regulation index, named ENVLOAD, in Taiwan. The result demonstrates that the ENVLOAD has significant effect on thermal comfort. Additionally, comparative simulations between PMV-based comfort control and conventional thermostatic control were performed to investigate the changes in the energy-saving potential of a thermal comfort-controlled space due to changes of its ENVLOAD. The results demonstrate that the energy-saving potential in a PMV-based controlled space increases with low ENVLOAD conditions.

1. Introduction

Increasing numbers of offices and public buildings in Taiwan have built envelopes with large areas of glass facade for aesthetic appearance in recent years. However, in addition to consuming considerable amounts of energy, the large amount of solar radiation passing through the glass facade often causes occupants to experience thermal discomfort. A high intensity of solar radiation is unfavorable, as it increases the temperature of the glazed interior surface, which then influences the mean radiant temperature and ultimately the thermal comfort level. In addition, solar radiation exacerbates discomfort when it directly falls on occupants. An individual in contact with direct solar radiation can experience a heat gain equivalent to an 11 °C rise in mean radiant temperature [1].

Heating, ventilating and air-conditioning (HVAC) systems are designed to respond to air temperature sensors, but do not respond to solar radiation problems. In a building's glazed perimeter zones, solar radiation and window performance influence the thermal comfort level of occupants heavily [2]. The Fenestration chapter of the ASHRAE Handbook of Fundamentals [3] offers basic guidance about windows and comfort for the designer: *In cooling-dominated climates or for orientations where cooling loads are of concern, windows with the lowest rise in surface temperature (for a given SHGC) tend to give the best comfort outcomes*. This advice promotes the positive impact of high performance glazing on thermal comfort. A number of studies have investigated the effects of solar radiation and window performance on thermal comfort, as well as examining how window performance has an impact on energy breakdown and thermal comfort. By sub-dividing the thermal comfort index Predicted Mean Vote (PMV) into two sections to better define how surface temperature and solar radiation effects contribute to the thermal comfort index, Lyons [2] and Sullivan [4] suggested a method to calculate the traditional PMV that only considered the surface temperature effect, which then also accounted for the solar radiation effect. Gennusa et al. [5,6] presented a comprehensive method to compute of the mean radiant temperature of individuals in thermal moderate indoor environments in the presence of solar radiation. Zmeureanu et al. [7] presented the development and validation of a computer model, designed as a practical tool, for the evaluation of the impact of radiation from windows on individuals' thermal sensation. Chaiyapinunt et al. [8] performed an investigation on the different thermal performance ratings of glass windows with respect to the effect on thermal comfort and heat transmission. The authors showed that for most glass windows, Predicted Percentage of Dissatisfied People (PPD) due to the effect of solar radiation were much larger than that of PPD due to the effect of surface

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doi:10.1016/j.buildenv.2010.10.009