

EFFECT OF VENTILATION ON INDOOR THERMAL COMFORT

IA Raja, GS Virk, D Azzi and IW Matthews

Department of Electrical and Electronic Engineering
University of Portsmouth
Portsmouth, Hampshire PO1 3DJ
(e-mail: iftikhar.raja@port.ac.uk, Tel. 023 9284 6175)

ABSTRACT

Adequate ventilation and good air quality are essential for the comfort of occupants and productivity. Excessive ventilation however, may result in discomfort and high energy loss. A study was carried out to examine the influence of ventilation on indoor thermal conditions. The results show that ventilation has profound effect on lowering the indoor temperature, particularly the night time ventilation. Derived PMV is compared with actual votes (thermal sensation) and found that PMV is lower than actual votes.

KEYWORDS

Indoor thermal comfort, ventilation, thermal sensation, PMV, night cooling, outdoor temperature

INTRODUCTION

Ventilation in buildings is a process of changing air in the internal spaces and it is required for many different reasons to meet certain requirements [ASHRAE 1991]. The ventilation need varies with the use of the building; for example, in residential buildings the comfort of the occupants is highly related to ventilation where it modifies the indoor thermal environment. In addition, ventilation of buildings has other objectives, namely:

- to support occupancy within a comfortable environment with enough oxygen
- to remove odours and smells by dilution
- to remove toxic/explosive gases and vapours
- to ensure combustion process when needed
- to lower moisture contents and reduce risk of condensation

- to reduce the bacteria count
- to control humidity for human comfort satisfaction
- to maintain a thermal balance between indoor and outdoor for human comfort

Total control of internal environmental conditions is achievable only with mechanically air conditioning, however due to increasing pressure to reduce the use of energy in the built environment, more passive techniques are being used. In naturally ventilated buildings cooling and ventilation is done by naturally occurring weather driven forces. The ranges of conditions inside the buildings are much wider than those achievable through mechanical ventilation.

The building occupants can modify the indoor thermal conditions by manipulating various controls available to them. The ventilation rate is one of the best means of improving the indoor thermal conditions in warm or hot weather and is more effective if the outdoor temperature is lower than the indoor temperature. It also improves the indoor air quality to achieve higher satisfaction for occupant comfort. In this study the effect of internal environment on the sensations of comfort of occupants are examined. The influence of night ventilation on indoor thermal conditions and variation in indoor temperature with outdoor temperature are studied.

EXPERIMENTAL SET-UP

The study was conducted in the naturally ventilated Portland Street building at the University of Portsmouth to demonstrate the influence of ventilation on indoor thermal conditions and air quality. A single office zone was chosen for the tests. The room located on the south wing of the building is 3.6m x 3.1m x 2.7m. A single externally exposed wall is fitted with a window (0.91m x 1.3m). The window is top mounted and allows opening at 30mm and 60mm. The entrance is by a door from an internal corridor.

The test was carried out over a period of eight days during the summer of 1999. Indoor thermal conditions and air quality were monitored. The number of occupants and the window opening was varied in a random manner over the day, with 0, 1 and 2 occupants, and the window was closed and opened again in a random manner for 30mm and 60mm. During the occupancy period, the occupants were asked to fill in questionnaires about the suitability of their environment at half hourly intervals. Thermal sensation, activity and clothing were also recorded. In total, 190 questionnaires were collected. Apart from subjective response temperature and CO₂ levels in the room was also recorded at five-minute intervals. The outdoor weather data for the test period was obtained from the University's weather station, operated by the BMS Group in the Department of Electrical and Electronic Engineering. Details of the sensors used for measuring various parameters have been given by the authors elsewhere [Raja et al 2000].

VENTILATION AND INDOOR THERMAL CONDITION

Night ventilation decreases the indoor temperature. The reduction in temperature depends on the external temperature and ventilation rate. To demonstrate the effect of night ventilation on indoor thermal conditions the results of present study are presented elsewhere [Raja et al 2000]. A plot of indoor and outdoor temperatures measured over one day is shown in Figure 1. The data recorded over five-minute intervals were averaged for quarter of an hour. In the graph, solid circles represent the indoor temperature and hollow circles to outdoor temperature.

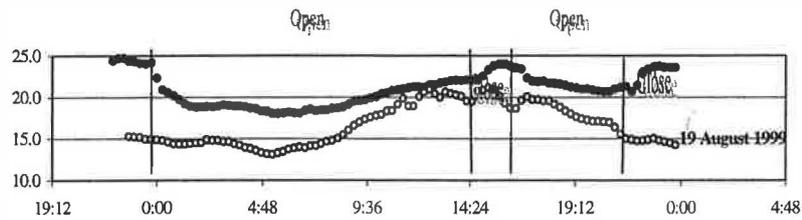


Figure 1: Effect of night ventilation

THERMAL COMFORT

Actual Comfort Vote and Predicted Mean Vote (PMV)

The basic parameters (activity, clothing insulation, air temperature, mean radiant temperature, relative humidity and air velocity) required for calculating 'Predict Mean Vote' (PMV) are recorded during the present study. Using Fanger' PMV equation [Fanger 1970] with measured input parameters, the PMV values are calculated and plotted against corresponding measured comfort votes in Figure 2.

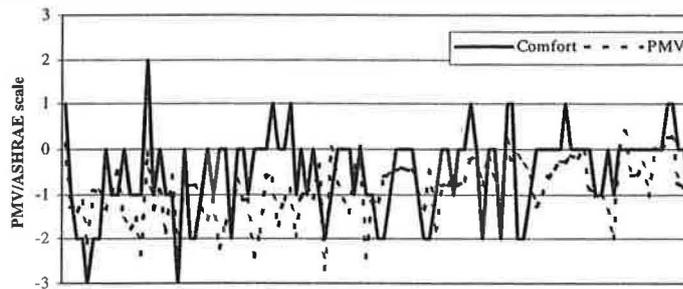


Figure 2: A comparison of PMV and Actual Comfort Votes

Dependence of Actual Mean Vote to Predict Mean Vote

The regression of Actual Mean Vote (AMV) on indoor Predicted Mean Vote (PMV) was performed which resulted in a linear relation bearing a correlation coefficient of 0.88. The regression relation is:

$$AMV = 1.5 + 2.2 PMV$$

AMV values are plotted against derived PMV data and the results are shown in Figure 3.

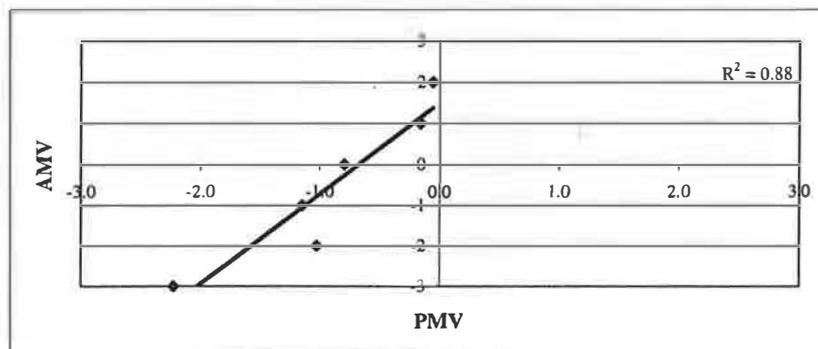


Figure 3: Actual Mean Vote Vs Predicted Mean Vote

DISCUSSION

The influence of outdoor temperature on indoor thermal conditions is demonstrated in Figure 1. The night ventilation lowers indoor temperature to a temperature difference of 3 °C between indoor and outdoor. An appropriate rate of night ventilation can provide a useful level of cooling for comfort in most conventional buildings. To enhance cooling, various types of night cooling ventilators are available. These provide local control by closing automatically once the target temperature is achieved, preventing over-cooling or, in extreme weather conditions rain ingress.

Thermal sensation recorded by the occupants is generally higher than that expected from the PMV. The Actual Mean Vote is recorded at ASHRAE thermal sensation scale. As units of PMV index are the same as that of the ASHRAE thermal sensation scale, the gradient of regression is expected to be unity. However, as indicated from the relation that the actual mean thermal sensations appear to be more sensitive than PMV predicted, in contrary to de Dear's finding [de Dear et. al. 1997]. The PMV predicted that the occupants would be feeling slightly cool, while the actual occupants reported that they were comfortable. The reason for this could be several factors, not least that the occupants were able to adjust their clothing and activity thus having some control of the environment. It has been shown that where occupants feel that they have control of their environments they will find a wider range of conditions as acceptable [Nicol & Raja 1997, Oseland 1998].

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