Energy and Buildings 40 (2008) 2215–2223

Contents lists available at ScienceDirect

Energy and Buildings

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

Comparison of thermal comfort algorithms in naturally ventilated office buildings

Bassam Moujalled *, Richard Cantin, Gérard Guarracino

Ecole Nationale des Travaux Publics de l'Etat, CNRS, URA 1652, Département Génie Civil et Bâtiment, Université de Lyon, 3 rue Maurice Audin, Vaulx-en-Velin F-69120, France

ARTICLE INFO

Article history:
Received 16 November 2007
Received in revised form 30 May 2008
Accepted 18 June 2008

Keywords:
Thermal comfort
Adaptive algorithm
Natural ventilation
Office buildings

ABSTRACT

With the actual environmental issues of energy savings in buildings, there are more efforts to prevent any increase in energy use associated with installing air-conditioning systems. The actual standard of thermal comfort in buildings ISO 7730 is based on static model that is acceptable in air-conditioned buildings, but unreliable for the case of naturally ventilated buildings. The different field studies have shown that occupants of naturally ventilated buildings accept and prefer a significantly wider range of temperatures compared to occupants of air-conditioned buildings. The results of these field studies have contributed to develop the adaptive approach. Adaptive comfort algorithms have been integrated in EN15251 and ASHRAE standards to take into account the adaptive approach in naturally ventilated buildings. These adaptive algorithms seem to be more efficient for naturally ventilated buildings, but need to be assessed in field studies. This paper evaluates different algorithms from both static and adaptive approach in naturally ventilated buildings across a field survey that has been conducted in France in five naturally ventilated office buildings. The paper presents the methodology guidelines, and the thermal comfort algorithms considered. The results of application of different algorithms are provided with a comparative analysis to assess the applied algorithms.

© 2008 Elsevier B.V. All rights reserved.

1. Introduction

The energy consumption in office buildings is mainly used to create and maintain comfort conditions in the indoor environment, which also affect health and productivity of the occupants. In France, the HVAC systems account for more than 60% of energy consumption in these buildings. Also the recent years have shown a rise in the number of air-conditioning systems which creates supplementary loads during the warm season.

With the urgent need to reduce the economic and environmental costs of energy consumption, the European and national French institutes gives top priority to the energy efficiency in the building sector. However, energy saving measures should be realized without detriment to the occupant's comfort. Hence, the latest revision of the French thermal regulation aims to reduce the energy consumption due to air conditioning during the warm season and encourages passive cooling techniques such as natural ventilation which increases indoor air speed and improves the comfort by cooling down the human body and the building structure [1].

Naturally ventilated buildings typically use less than half as much as energy than those with air conditioning [2]. Several research projects [3,4] have shown that these buildings can be comfortable all over the year. Occupants of naturally ventilated buildings were found to accept and prefer a significantly wider range of temperatures that fall out of the standard comfort zone defined by ISO 7730. The standard's comfort zones are based on laboratory experiments, and are suitable for air-conditioned buildings where the thermal conditions are static. In naturally ventilated buildings, indoor temperatures are variable and cycle or drift in response to the natural swings of the outdoor and indoor climate, especially in the warm season, as in the cold season these buildings are generally heated [5]. Thus, an adaptive approach has been developed using the results of the field studies. This approach considers that occupants of naturally ventilated buildings have different expectations and are able to adapt themselves to their thermal environments in buildings that afford them greater degrees of control over thermal conditions [6]. Adaptive comfort algorithms have been set for naturally ventilated buildings depending on the climatic conditions represented by the outdoor temperature. These algorithms have been introduced in the ASHRAE standard 55-2005 and the European standard EN15251 for the case of naturally ventilated buildings during warm season [7].

The purpose of this paper is to evaluate different algorithms from both static and adaptive approach in naturally ventilated

* Corresponding author. Tel.: +33 4 72 04 72 61; fax: +33 4 72 04 70 41.
E-mail addresses: moujalled@entpe.fr, bassam.moujalled@gmail.com (B. Moujalled), cantin@entpe.fr (R. Cantin), guarracino@entpe.fr (G. Guarracino).

0378-7788/$ – see front matter © 2008 Elsevier B.V. All rights reserved.
doi:10.1016/j.enbuild.2008.06.014

Fig. 1. Buildings E1 and E2.

office buildings for the French climatic context. Therefore a field survey has been conducted in five naturally ventilated office buildings. First the paper presents the methodology guidelines, and the thermal comfort algorithms considered in this study. Then, results of application of different algorithms are provided with an analysis of the indoor climates in the surveyed buildings. Finally a comparative analysis is developed which allows us to evaluate the applied algorithms.

2. Methodology guidelines

2.1. Characteristics of surveyed buildings

In order to cover a wide interval of indoor conditions, the transversal survey type [6] was adopted with multiple visits in each of the surveyed buildings. Five buildings were surveyed. They are located in the southeast region of France near Lyon (Fig. 1).

The buildings have a low-rise concrete structure (3 up to 4 levels) and the buildings' facades are largely glazed. They were chosen for this study upon the following selection criteria: the use of natural ventilation for cooling during hot period with an important thermal mass, solar protection for exposed glazing and optional local fan in the local, besides the availability and will of people to take part in the investigation. The surveyed buildings are presented in Table 1.

In each building, offices have been selected in order to have various orientations and conditions encountered within the building. Participants were selected in order to have a sample representative of the occupants in the offices. Fig. 2 presents the frequency distribution of the sample by age and gender.

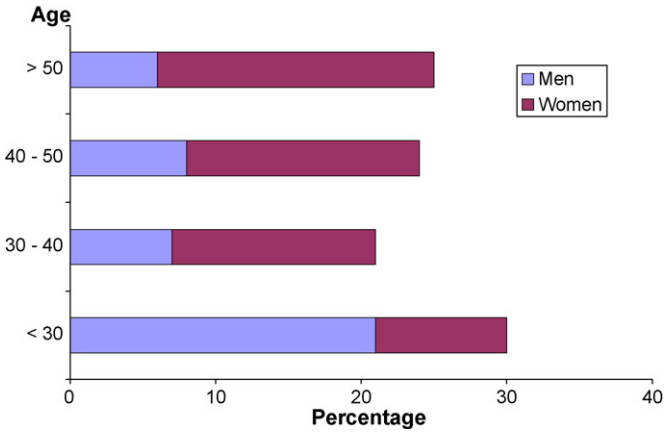

Fig. 2. Frequency distribution of participants by age and gender.

2.2. Physical measurements of indoor climate

The field investigation was realized according to the level II [8] respecting the specifications set out in the ISO standard 7726 [9]. The level II consists of physical measurements of variables that are necessary for the calculation of thermal comfort indices. These measurements are accompanied by comfort questionnaires collected at the same time and place.

The physical measurements aim at quantifying indoor climate and in particular thermal environment. In this investigation, the main thermal comfort parameters have been measured during each visit near each participant in order to calculate different thermal comfort indices, especially the PMV index.

To achieve these measurements, Vivo equipment has been chosen for several reasons. It offers portable and robust devices that measure air temperature, operative temperature, relative humidity and air velocity in compliance to the specifications of the ISO 7726 standard. These devices have an important capacity of data storage up to 20,000 measurements. A battery ensures the energy autonomy for one day of full measurements. The devices can be programmed and controlled with a handheld device via an infrared port. Fig. 3 shows the measurement equipments.

The meteorological data were obtained from the weather station that is located on the roof of the building E1. Data include the records of air temperature, relative humidity, wind speed and direction and solar radiations, and can be downloaded on the internet via the following link "http://idmp.entpe.fr/vaulx/mesfr.htm".

Table 1
Presentation of the investigated NV buildings

Code	Building	City	Survey period	No. of observations
E1	ENTPE existant	Vaulx-en-Velin	August 2004 and March 2005	95
E2	ENTPE extension	Vaulx-en-Velin	August 2004 and March 2005	51
C	CETE	L'Isle d'Abeau	September 2004 and March 2005	110
L	LASH	Vaulx-en-Velin	August 2004 and March 2005	37
P	Palais de justice	Lyon	June 2005	37

Download English Version:

https://daneshyari.com/en/article/264952

Download Persian Version:

https://daneshyari.com/article/264952

Daneshyari.com