Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 121 (2015) 544 – 551

Procedia Engineering

www.elsevier.com/locate/procedia

9th International Symposium on Heating, Ventilation and Air Conditioning (ISHVAC) and the 3rd International Conference on Building Energy and Environment (COBEE)

The Dynamic Thermal Comfort Index Analysis under the Air Supply Vent Coupled with the Cross-Flow

Lihui Wang[a,]*, Xinhui Bai[a], Rui Chen[a] and Jianshun Zhang[b]

[a.] *School of Environment and Architecture, University of Shanghai for Science and Technology, 516 Jungong Road, Shanghai, 200093, China,*
[b.] *Building Energy and Environmental Systems Laboratory, Department of Mechanical and Aerospace Engineering, Syracuse University, 263 Link Hall, Syracuse, NY, 13244, U.S.A.*

Abstract

In thermal environment where occupants stopover, the air supply jet easily dynamical changes due to some cross-flow interferences, influencing the dynamic human thermal comfort. RWI and PD are selected as the human dynamic thermal comfort indexes here. Based on the theory analysis on RWI and PD, the supply air temperature can be increased by improving the velocity in some extends. This will bring obvious energy saving of the air conditioning system. For example, based on RWI and PD within dynamic thermal comfort range, the supply air temperature could be 32 ℃ with air velocity between 0.6-4 m/s. Experimental studies on the RWI and PD characteristics beneath the vent are developed, affected by the unstable cross-flow. According to the experimental results of typical testing points under the vent in vertical direction and horizontal direction at 1.5 m height, the values of RWI and PD are close to the comfort zone coupling with the dynamic cross-flow and the dynamic thermal comfort below the air conditioning vent is improved.

© 2015 Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license
(http://creativecommons.org/licenses/by-nc-nd/4.0/).
Peer-review under responsibility of the organizing committee of ISHVAC-COBEE 2015

Keywords: Air supply; Cross-flow; Dynamic thermal comfort; RWI; PD

1. Introduction

There are many conditions in indoor thermal environment that air supply jets are disturbed by unsteady cross-flows. For example, the air-conditioning air jets are affected by intermittent piston wind on the subway platform without PSD. Supplying air from roof diffusers in some convenience stores are also affected by intermittent draft during door's

* Corresponding author. Tel.: +86-13816498129; fax: +86-021-55271045.
E-mail address: wanglh@usst.edu.cn

1877-7058 © 2015 Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license
(http://creativecommons.org/licenses/by-nc-nd/4.0/).
Peer-review under responsibility of the organizing committee of ISHVAC-COBEE 2015
doi:10.1016/j.proeng.2015.08.1029

opening and closing. The supplying airs in pedestrian corridor of semi-underground spaces or large space showrooms are affected by outdoor season-dominant wind intermittently. The demand of the dynamic human comfort in the staff stopover environment is different from that in traditional steady thermal environment. The reasonable selection of comfortable evaluation index and its characteristics are less studied by now. However, the relative research will provide important theoretical support for the design and energy-saving operation of the air conditioning system in the transitional region.

Studies about the dynamic thermal comfort mainly include two aspects, one is thermal comfort study under the direct fluctuation between airflow and temperature, and the other is the mutation of temperature and wind speed as well as the effect of gradual change to human's thermal comfort. In late 1950s, Rohles [1] firstly found that the air flow had a great influence on thermal comfort in his experiment and suggested that the limit rate of air flow should be 0.8m/s. Fanger studied the direction of the wind blowing [2], turbulence frequency [3], air turbulence intensity[4] on human thermal comfort and validated that the impact of air flow rate on thermal comfort was consistent with that of thermal comfort equation. Toftum [5] and others' experiments showed that these people with cooler thermal comfort were more likely to feel uncomfortable than those with neutral feeling under the same local air rate. The study of Gong [6] found that air velocity with a certain range, higher or lower air flow rate will lead participants satisfied. Yamashita [7] found that the decreased thermal comfort of head is proportional to the cooling capacity of local gas, while the optical thermal comfort of head appears at a certain air velocity. Xia [8] and other studies have found that the wind speed of achieving thermal comfort is lower in the steady flow of high intensity than that in low intensity.

This paper theoretically analyzes the dynamic thermal comfort index RWI and PD values varied with air temperature and velocity. Using experiment, the dynamic thermal comfort is studied before and after the steady air jets coupling with the unsteady cross-flow. This study comes from the phenomenon that coupling between the supply air and the unstable piston wind on the subway platform without PSD.

2. Index picking to evaluate the dynamic thermal comfort

According to the coupled dynamic characteristics of unsteady cross-flow and state supplying air jet, RWI and PD are selected to evaluate the human dynamic thermal comfort. ASHRAE and US Department of Transportation proposed the relative index RWI for warmer environment based on the experimental data. RWI is the thermal comfort index of design parameters in transitional spaces such as subway platform, station hall and train. PD index contains the standard deviation of wind speed, and it reflects the fluctuations in wind speed and the dynamic thermal comfort of human in the entire period. Specific definition of the two indicators is in the following.

2.1. Thermal comfort index RWI in transitional activities state

The relative thermal index RWI is a dimensionless parameter, based on a large number of experimental results. Its definition is shown in formula (1). The acceptable thermal range of RWI is 0-0.15.

$$\mathrm{RWI} = \frac{M(\tau)\left[I_{CW}(\tau) + I_a\right] + 6.42(t_a - 35) + RI_a}{234} \qquad P_{\mathrm{a}} \le 2269 P_a \quad , \tag{1}$$

Where, RWI- relative thermal index, dimensionless quantity; R- the average radiation heat gain, W/m^2; $M(\tau)$ - energy metabolism in the human body during the transitional environment, W/m^2; P_a-water vapor press, Pa; τ -time, s; t_a-dry bulb temperature of ambient air,℃; $I_{CW}(\tau)$ - personal actual clothing insulation, clo; I_a- air boundary layer resistance, clo, I_a=0.0392$V_a^{-0.4294}$, V_a is the inducing speed.

2.2. Unsatisfactory rate PD by draft sensation

Unsatisfactory rate PD caused by draft sensation has been used as a thermal comfort index in dynamic thermal environment in ASHRAE55-92 standard. PD<20% is the acceptable range for most of people. Its definition is

Download English Version:

https://daneshyari.com/en/article/854923

Download Persian Version:

https://daneshyari.com/article/854923

Daneshyari.com