Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 146 (2016) 24 – 31

Procedia Engineering

www.elsevier.com/locate/procedia

8th International Cold Climate HVAC 2015 Conference, CCHVAC 2015

Human Thermal Adaptation in University Classrooms and Dormitories in Chinese Severe Cold Area in Winter

Zhaojun Wang[a]*, Xuexiang Zhang[a], Haoran Ning[a], Yuchen Ji[a]

[a]*School of Municipal and Environmental Engineering, Harbin Institute of Technology, Harbin, China*

Abstract

The heating period is very long in Harbin in China. This paper describes a field study in university classrooms and dormitories in heating period in Harbin. The survey shows that the neutral temperature in classrooms at 3 periods was 17.7℃, 19.3℃ and 19.4℃, and in dormitories the neutral thermal temperatures were 20.9℃, 21.8℃ and 21.2℃, respectively. The neutral temperatures were on the rising trend, which reflected human thermal adaptation to the heating environment. The different neutral temperatures in classrooms and dormitories were mainly caused by 2 aspects: Classrooms were warmer than dormitories, so more students could not accept classroom environment psychologically; Students have different regulative methods to the indoor environment. Clothing insulation in classrooms was bigger than in dormitories. Because of above reasons, students felt more comfortable in dormitories than in classrooms.

Peer-review under responsibility of the organizing committee of CCHVAC 2015

Keywords: Thermal environment; Thermal adaptation; University classroom; University dormitory; Severe cold area

1. Introduction

People spent most of time indoors. Many researches show that thermal environment has great influences on peoples' comfort and efficiency of work and study. In order to create a more comfortable indoor environment, further studies of indoor thermal environment and peoples' thermal adaptation are necessary.

In China, more and more researchers focus on thermal comfort. Yao et al.[1] had a survey about occupants' adaptive responses in naturally conditioned university classrooms. She found that the adaptive comfort range was

* Corresponding author. Tel.: +86-451-86282123.
E-mail address: wangzhaojun@hit.edu.cn

Peer-review under responsibility of the organizing committee of CCHVAC 2015
doi:10.1016/j.proeng.2016.06.348

broader than that of the ASHRAE Standard, but in the extreme cold and hot months, the range was narrower. Cao et al.[2] found that if the indoor temperature was high, people felt uncomfortable in Beijing campus buildings in winter. Zhang[3-4] found that the neutral temperatures in naturally ventilated buildings and split air-conditioned were all higher than 24℃ based on his studies on occupants, thermal comfort in hot-humid area of China. There are several climatic regions in China, researchers should use people's adaption to different indoor and outdoor environment, built more comfortable environment.

The heating period is about 6 months in Chinese severe cold area. The outdoor temperature fluctuates greatly, and indoor temperature also has certain changes during the heating period in this area. So heating energy consumption is great in Harbin. Some field surveys have been conducted in winter in Harbin. Wang et al. pointed out the indoor temperature in heating season was higher than Chinese indoor design heating temperature (18℃) in winter[5-6], even higher than the upper limit of the ASHRAE 55 (2013)[7] standard (24 ℃). If the indoor temperature was high, people would take measures to adjust their comfort, such as opening windows and reducing their clothes. These behavioural regulations showed that there were energy wastes in Harbin.

The indoor temperature in northern universities in China is generally high in heating period. Because of the different layouts and heating conditions, thermal environments in university classrooms and dormitories are different. The personnel density in university classrooms is greater than in dormitories, and students' activities and dresses are different, and these have an impact on students' thermal sensation. So what similarities and differences are of the thermal sensation and adaptation between the two environments? Which environment is more comfortable? In this paper, the authors focus on analysing people's adaptation in university classrooms and dormitories in Harbin.

2. Methods

In October 2013 to April 2014, the authors conducted a survey about indoor environment and thermal responses of the subjects in classrooms and dormitories in a university in Harbin. Based on the outdoor temperature and heating time, the survey was divided into 3 periods: early heating period, middle heating period and late heating period.

The study was conducted at the same time in classrooms and dormitories. The distribution of subjects and their convenience were fully considered. 5 classrooms and 11 dormitories were selected. The subjective survey was longitudinal. The subjects were 30 juniors, and the ratio of male to female was 1:1. The subjects had adapted to the cold winter of Harbin, they were asked to fill in the subjective questionnaires once a week. Table 1 shows the background of the subjects.

Table 1. Background data of subjects.

	Age	Living time (*a*)
Average	20.2	5.1
Std Dev	0.94	6.89
Maximum	22	21
Minimum	18	2

Test of environmental parameters included field test and continuous monitoring. Field test parameters included air temperature, black globe temperature, air velocity, relative humidity and surface temperature of building envelopes. Table 2 shows the equipment and resolutions. Air temperature was measured at the height of 0.1 m, 0.6 m, and 1.1m. Humidity, air velocity, and black globe temperature were measured at 0.6m. A temperature and humidity logger was placed in every dormitory for continuous monitoring, and it recorded test data every 5 minutes. Figure 1 shows the measurements in the university.