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An introduction to the Chinese Evaluation Standard for the indoor thermal environment

Baizhan Li[a,b,*], Runming Yao[c,a,**], Qinqing Wang[d], Yungang Pan[e]

[a] National Centre for International Research of Low-Carbon Green Buildings, Ministry of Science and Technology, Chongqing University, 400045, PR China
[b] Key Laboratory of the Three Gorges Reservoir Region's Eco-Environment, Ministry of Education, Chongqing University, Chongqing 400045, PR China
[c] School of Construction Management and Engineering, The University of Reading, Whiteknights, PO Box 219, Reading RG6 6AW, UK
[d] China Academy of Building Research, Beijing 100013, PR China
[e] China Architecture Design & Research Group, Beijing 100044, PR China

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ABSTRACT

Designing for indoor thermal environmental conditions is one of the key elements in the energy efficient building design process. This paper introduces a development of the Chinese national Evaluation Standard for indoor thermal environments (Evaluation Standard). International standards including the ASHRAE55, ISO7730, DIN EN, and CIBSE Guide-A have been reviewed and referenced for the development of the Evaluation Standard. In addition, over 28,000 subjects participated in the field study from different climate zones in China and over 500 subjects have been involved in laboratory studies. The research findings reveal that there is a need to update the Chinese thermal comfort standard based on local climates and people's habitats. This paper introduces in detail the requirements for the thermal environment for heated and cooled buildings and free-running buildings in China.

1. Introduction

China has diverse climatic characteristics that have been classified into five climate zones for buildings' environmental system design. These climate zones comprise the very cold zone, cold zone, hot summer and cold winter zone, hot summer and warm winter zone, and mild zone [1], which are demonstrated in Fig. 1. The central heating systems only apply to the 'very cold' and 'cold' zones in winter. There is little guidance on indoor air temperature settings of a stand-alone air-conditioner/heating appliance for cooling/heating. Therefore, the temperature setting for heating/cooling is usually dependent on occupants' preferences when it is in operation. There has been a greatly increasing trend in energy consumption for heating and cooling buildings in recent years due to the growing demand for improving living standards [2]. The Chinese central government set the target in the 11th Five-Year Plan (2006–2010) to reduce the energy consumption by 20% per unit of gross domestic product (GDP) at the 2005 basis (http://www.gov.cn). In order to meet the goal, the Chinese government is strengthening the legal, administrative and institutional framework to improve energy efficiency in buildings through a series of national laws and ordinances. In 2007, China's State Council issued an ordinance [3], which states that the minimum indoor air temperature for office buildings using air-conditioning for cooling should not be set lower than 26 °C in summer. In order to provide more detailed guidance on the evaluation of indoor thermal environments at the design and in-use stages, the new code 'Evaluation standard for indoor thermal environments in civil buildings GB/T50785-2012' (Evaluation Standard thereafter) was issued on 28 May 2012 and commenced on the 1 October 2012.

2. Method

The method implemented in developing standard included expert consultation, literature review, field study, chamber experimental study and theoretical modeling and analysis.

2.1. Development process

The Evaluation Standard has been produced by the experts in the thermal comfort field from the universities, research

* Corresponding author at: National Centre for International Research of Low-Carbon Green Buildings, Ministry of Science and Technology, Chongqing University, 400045, PR China.
** Corresponding author at: School of Construction Management and Engineering, The University of Reading, Whiteknights, PO Box 219, Reading RG6 6AW, UK. Tel.: +44 1183788606.
E-mail addresses: baizhanli@cqu.edu.cn, baizhanli09@gmail.com (B. Li), r.yao@reading.ac.uk (R. Yao).

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Fig. 1. Five climate zones for building design in China.

institutions and industry led by Chongqing University and the China Academy of Building Research. The Working Group worked closely with domestic experts and consulted with international experts who are members from international standard committees such as ASHRAE, ISO, EU and CIBSE. The consultation workshops were held in London and Chongqing in 2010 and 2011 with support from the network for comfort and energy use in buildings (NCEUB http://nceub.commoncense.info/).

The whole process of producing the Evaluation Standard consists of five stages; which are listed in Table 1.

In stage one, the Evaluation Standard working group was formed with an approval by the Ministry of Housing and Urban-Rural Development (Construction Standard Notification Document [2008] No. 28 and the first group meeting was held in November 2008. The work tasks were distributed and the work plan was set up. The major tasks included an extensive literature review of the relevant existing international standards, nationwide thermal comfort field surveys, laboratory and theoretical studies.

In stage two, the extensive literature was reviewed with specific focus on the international standards and assessment methods. At this stage, a nationwide thermal comfort condition survey and experimental study had been conducted. The existing data collected during the period from 2003–2007 at the laboratory in Chongqing University in conjunction with new data collected during the period of 2008–2010 have been analysed.

In stage three, a draft version had been produced for consultation through workshops held domestically and internationally.

In stage four, a new revised version was circulated to the design institutions and experts for further comments.

In stage five, the new version for approval was produced for the expert committee to review.

The following sections will introduce the progress of developing the Evaluation Standard in detail.

Table 1
Five-stage process for the production of the Evaluation Standard.

Stage No.	Process	Date
1	Forming the working group	November 2008
2	Groundwork including the literature review, field and laboratory studies	November 2008–June 2010 extend to November 2011
3	Drafting the first version of the Evaluation Standard and consultations	September 2010
4	Revision, completion and report	November 2011
5	Expert committee assessment and approval	28 May 2012

2.2. Review of international thermal comfort standards

Thermal comfort standards play an important role in achieving building energy efficiency as well as indoor thermal comfort. There are three well-known and most widely accepted thermal comfort international standards: American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standard-55 [4,9], the International Organization for Standardization (ISO) standard-7730 [5,8], and the European standard EN15251 [6]. In the United Kingdom, the Chartered Institution of Building Services Engineers (CIBSE) provides thermal comfort guidance on building environmental design [7]. The predicted mean vote (PMV) and predicted percentage of dissatisfied (PPD) method, which is based on steady-state, human body heat balance theory [10] has been challenged by adaptive models. It is claimed that energy saving will be achieved by switching from the traditional PMV–PPD-based comfort standard to an adaptive comfort standard [11]. Thereafter, an adaptive model for the thermal comfort assessment has been amended to the ASHRAE Standard-55 [12] and the ISO standard-7730 [5]. The latest version of ISO standard-7730 [5] considers the adaptations of occupants and includes the method for the long-term evaluation of general thermal comfort conditions. The ISO standard includes three acceptable categories (A, B and C) for thermal comfort. The level of thermal comfort in each category should be decided by the individual country or contract between client and designer [13]. The CIBSE Guide-A [7] provides the adaptive thermal comfort approach and presents the corresponding adaptive thermal comfort temperature ranges based on the outdoor running mean temperature for offices. Table 2 lists design criteria for thermal comfort in office workplaces.

The international comfort standards, such as the ASHRAE and ISO, are almost all based on North American and northern European subjects [5,14]. However, it has not been clarified in the aforementioned standards whether they are applicable to different environmental conditions especially China with a set of entirely different climate zones. Therefore, this study intended to develop a thermal comfort standard based on intensive studies in the China context.

2.3. Review of the thermal comfort study in China

In the last decade, a set of laboratory and field studies has been conducted within the context of thermal comfort. These studies broadly cover different types of buildings and climate zones in China [15–27]. These studies generally agree that there are discrepancies between people's real thermal sensation and the predicted thermal sensation, especially for naturally ventilated buildings. It was found that the Chinese people have a broader range of tolerance to thermal stress. To some extent, the PMV model over/underestimates thermal sensations in summer and winter respectively in free-running buildings. As a result, the guidance on thermal environment design based on the PMV–PPD concept could lead to excessive use of energy for thermal comfort in indoor environments. Chinese people are very active in adapting the indoor thermal environment by behavioral adaptation, in particular those who live in hot and humid climate areas. The previous thermal experience and psychological expectations also play a role in adapting thermal environments in real conditions in China. This is mainly due to the fact that there was no heating/cooling policy in southern China. However, the situation could change due to the gradually growing demand for improvements to the indoor thermal environment as a result of the increasing economic affordability of energy in recent years.

The new standard attempts to emphasize the evaluation of indoor thermal environments, taking into account the great diversities of climatic characteristics and significant sensation variations